From: "Barrett, Melinda" <MBARRETT@ladpw.org>
To: "Ivar Ridgeway" <iridgeway@waterboards.ca.gov>
Date: 12/15/05 2:53:43 PM
Subject: RE: K-12 Storm Water Education Funding

The Los Angeles County Dept. of Public Works spends approximately $2.1 million per year on K-12 environmental education. The student population is 1.5 million. Our NPDES Permit requires us to "reach" 375,000 students per year with environmental education.

Our programs range from assemblies to teacher professional development so the cost per student ranges from $5 to $12 per student.

-----Original Message-----
From: Ivar Ridgeway [mailto:iridgeway@waterboards.ca.gov]
Sent: Thursday, December 15, 2005 2:39 PM
To: Barrett, Melinda
Subject: K-12 Storm Water Education Funding

Melinda,

I'm looking at costs associated with storm water programs and I'm hoping you could provide me with some additional information. Could you tell me how much Los Angeles County spends per student for K-12 storm water education? Any value you have for any of the past 2-3 years would be extremely helpful.

Ivar K. Ridgeway
Environmental Scientist
California Environmental Protection Agency
California Regional Water Quality Control Board
Los Angeles Region
Storm Water Section
(213) 620-2150
iridgeway@waterboards.ca.gov

theAgency

Ventura County
Watershed Protection District

LAUNCH CAMPAIGN -- October 2005

Newspaper	# Planned Insertions	# Actual Insertions	Planned Impressions	Actual Impressions	Cost	$/Impression
Ventura County Star 1/4 Page 4/C Thurs/Fri	2	2	248,000	248,000	$4,065	$0.016
Mi Estrella 1/2 Page 4/C rsday	2	2	28,416	28,416	$1,214	$0.043
ˌAngeles Times - VC Edition Page 4/C rs/Fri	2	2	92,306	95,283	$3,355	$0.035
ıtura County Reporter Page 4/C ırsday	2	2	70,000	70,000	$2,144	$0.031

A012168

ɔle Television	# Planned Spots	# Actual Spots*	Planned Impressions	Actual Impressions**	Cost	$/Impression
E, AMC, Bravo, Food TV, FX, HGTV, tory Channel, Travel Channel, USA, Discovery ue-Add: Community Billboard	117	164	173,771	172,555	$6,743	$0.039

..ıcludes only the first week of bonus spots
**** Does not include impressions from bonus spots**

Outdoor*	# Boards Planned	# Actual Boards	Planned Impressions	Actual Impressions	Cost	$/Impression
Mall Kiosks: Pacific View Mall - Ventura The Oaks Mall - Thousand Oaks	2	2	182,000	182,000	$1,667	$0.009
Bus Shelters Simi Valley Oxnard (Spanish/English)	6	12	305,760	611,520	$2,333	$0.004

*** Impressions for outdoor represent 10% of reported gross impressions.**

Tot-' 'mpressions	133	186	1,100,253	1,407,774	$21,521	$0.015

OldPC: Main Identity

From: "Trish Isom" <Trish.Isom@adelphia.com>
To: <heidi@agency2.com>
Cc: "Lisa Hannon" <lisa@agency2.com>
Sent: Wednesday, November 09, 2005 2:15 PM
Subject: Gross Impressions

The total Gross Impressions for your schedule with County of Ventura Watershed Protection Agency for the October 10-30, 2005 flight is 172,555.

All The Best!

Trish Isom
Account Executive

Adelphia Media Services
751 Daily Drive, Suite 302
Camarillo, CA 93010
Phone: 805-384-2148
FAX: 805-987-7916

www.itsalltv.com

Ventura County's Premier Media Choice

Affidavit of Performance

Client Name: Co. of VTA Watershed Protection
Remarks: VTA (VC)
Bill Cycle: 10/05
Agency: The Agency

Contract ID: 85949
Contract Type: Standard

Date	Weekday	Network	Zone	Air Time	Spot Name	Spot Len	Con Line	Billing Status	Spot Cost
10/10/05	Monday	BRV	Ave Ventura/5169/V	10:07pm	Fido Summer	00:00:30	32	Charged	1.51
10/10/05	Monday	FOOD	Ave Ventura/5169/V	2:18am	Fido Summer	00:00:30	38	Charged	0.85
10/10/05	Monday	FOXN	Ave Ventura/5169/V	4:47pm	Fido Summer	00:00:30	2	Charged	3.54
10/10/05	Monday	HGTV	Ave Ventura/5169/V	9:46pm	Fido Summer	00:00:30	56	Charged	5.10
10/10/05	Monday	BRV	Camarillo/5168/VWC	11:06pm	Fido Summer	00:00:30	34	Charged	4.53
10/10/05	Monday	FOOD	Camarillo/5168/VWC	8:19pm	Fido Summer	00:00:30	40	Charged	2.55
10/10/05	Monday	FOXN	Camarillo/5168/VWC	4:20pm	Fido Summer	00:00:30	4	Charged	10.62
10/10/05	Monday	FOXN	Camarillo/5168/VWC	5:46pm	Fido Summer	00:00:30	4	Charged	10.62
10/10/05	Monday	HGTV	Camarillo/5168/VWC	4:47pm	Fido Summer	00:00:30	58	Charged	15.29
10/10/05	Monday	BRV	Ojai/5855/VWC	7:07pm	Fido Summer	00:00:30	31	Charged	1.89
10/10/05	Monday	FOOD	Ojai/5855/VWC	8:28am	Fido Summer	00:00:30	37	Charged	1.06
10/10/05	Monday	FOXN	Ojai/5855/VWC	4:20pm	Fido Summer	00:00:30	1	Charged	4.42
10/10/05	Monday	FOXN	Ojai/5855/VWC	4:48pm	Fido Summer	00:00:30	1	Charged	4.42
10/10/05	Monday	HGTV	Ojai/5855/VWC	4:47pm	Fido Summer	00:00:30	55	Charged	6.37
10/10/05	Monday	HGTV	Ojai/5855/VWC	5:48pm	Fido Summer	00:00:30	55	Charged	6.37
10/10/05	Monday	BRV	Simi Valley/1571/VE	6:07pm	Fido Summer	00:00:30	36	Charged	5.94
10/10/05	Monday	FOOD	Simi Valley/1571/VE	7:48pm	Fido Summer	00:00:30	42	Charged	3.35
10/10/05	Monday	FOXN	Simi Valley/1571/VE	9:50pm	Fido Summer	00:00:30	6	Charged	13.94
10/10/05	Monday	HGTV	Simi Valley/1571/VE	5:48pm	Fido Summer	00:00:30	60	Charged	20.07
10/10/05	Monday	BRV	Thousand Oaks/890/	7:08pm	Fido Summer	00:00:30	33	Charged	7.93
10/10/05	Monday	FOOD	Thousand Oaks/890/	3:20am	Fido Summer	00:00:30	39	Charged	4.46
10/10/05	Monday	FOXN	Thousand Oaks/890/	5:47pm	Fido Summer	00:00:30	3	Charged	18.58
10/10/05	Monday	BRV	Ventura/1614/VWC	5:06pm	Fido Summer	00:00:30	35	Charged	10.20
10/10/05	Monday	FOOD	Ventura/1614/VWC	12:53am	Fido Summer	00:00:30	41	Charged	5.73
10/10/05	Monday	FOXN	Ventura/1614/VWC	11:48pm	Fido Summer	00:00:30	5	Charged	23.90
10/10/05	Monday	HGTV	Ventura/1614/VWC	4:46pm	Fido Summer	00:00:30	59	Charged	34.41
10/11/05	Tuesday	BRV	Ave Ventura/5169/V	4:37pm	Fido Summer	00:00:30	32	Charged	1.51
10/11/05	Tuesday	FOOD	Ave Ventura/5169/V	8:28am	Fido Summer	00:00:30	38	Charged	0.85
10/11/05	Tuesday	FOXN	Ave Ventura/5169/V	7:22pm	Fido Summer	00:00:30	2	Charged	3.54
10/11/05	Tuesday	FOXN	Ave Ventura/5169/V	11:49pm	Fido Summer	00:00:30	2	Charged	3.54
10/11/05	Tuesday	HGTV	Ave Ventura/5169/V	4:46pm	Fido Summer	00:00:30	56	Charged	5.10
10/11/05	Tuesday	BRV	Camarillo/5168/VWC	7:06pm	Fido Summer	00:00:30	34	Charged	4.53
10/11/05	Tuesday	FOOD	Camarillo/5168/VWC	12:22am	Fido Summer	00:00:30	40	Charged	2.55
10/11/05	Tuesday	BRV	Ojai/5855/VWC	4:37pm	Fido Summer	00:00:30	31	Charged	1.89
10/11/05	Tuesday	FOOD	Ojai/5855/VWC	11:20pm	Fido Summer	00:00:30	37	Charged	1.06
10/11/05	Tuesday	FOXN	Ojai/5855/VWC	11:50pm	Fido Summer	00:00:30	1	Charged	4.42
10/11/05	Tuesday	HGTV	Ojai/5855/VWC	4:46pm	Fido Summer	00:00:30	55	Charged	6.37
10/11/05	Tuesday	HGTV	Ojai/5855/VWC	5:17pm	Fido Summer	00:00:30	55	Charged	6.37
10/11/05	Tuesday	BRV	Simi Valley/1571/VE	4:37pm	Fido Summer	00:00:30	36	Charged	5.94
10/11/05	Tuesday	FOOD	Simi Valley/1571/VE	10:17pm	Fido Summer	00:00:30	42	Charged	3.35
10/11/05	Tuesday	FOXN	Simi Valley/1571/VE	4:48pm	Fido Summer	00:00:30	6	Charged	13.94
10/11/05	Tuesday	FOXN	Simi Valley/1571/VE	5:46pm	Fido Summer	00:00:30	6	Charged	13.94
10/11/05	Tuesday	FOXN	Simi Valley/1571/VE	7:22pm	Fido Summer	00:00:30	6	Charged	13.94
10/11/05	Tuesday	HGTV	Simi Valley/1571/VE	4:46pm	Fido Summer	00:00:30	60	Charged	20.07
10/11/05	Tuesday	BRV	Thousand Oaks/890/	5:08pm	Fido Summer	00:00:30	33	Charged	7.93
10/11/05	Tuesday	FOOD	Thousand Oaks/890/	12:18pm	Fido Summer	00:00:30	39	Charged	4.46
10/11/05	Tuesday	FOXN	Thousand Oaks/890/	4:20pm	Fido Summer	00:00:30	3	Charged	18.58
10/11/05	Tuesday	FOXN	Thousand Oaks/890/	4:48pm	Fido Summer	00:00:30	3	Charged	18.58
10/11/05	Tuesday	HGTV	Thousand Oaks/890/	4:15pm	Fido Summer	00:00:30	57	Charged	26.76
10/11/05	Tuesday	HGTV	Thousand Oaks/890/	4:46pm	Fido Summer	00:00:30	57	Charged	26.76
10/11/05	Tuesday	HGTV	Thousand Oaks/890/	5:17pm	Fido Summer	00:00:30	57	Charged	26.76
10/11/05	Tuesday	BRV	Ventura/1614/VWC	11:08pm	Fido Summer	00:00:30	35	Charged	10.20
10/11/05	Tuesday	FOOD	Ventura/1614/VWC	1:18pm	Fido Summer	00:00:30	41	Charged	5.73

10/11/05	Tuesday	FOXN	Ventura/1614/VWC	11:50pm	Fido Summer	00:00:30	5	Charged	23.90
10/11/05	Tuesday	HGTV	Ventura/1614/VWC	10:16pm	Fido Summer	00:00:30	59	Charged	34.41
10/12/05	Wednesday	FOOD	Ave Ventura/5169/V	10:45am	Fido Summer	00:00:30	38	Charged	0.85
10/12/05	Wednesday	FOXN	Ave Ventura/5169/V	10:20pm	Fido Summer	00:00:30	2	Charged	3.54
10/12/05	Wednesday	HGTV	Ave Ventura/5169/V	6:14pm	Fido Summer	00:00:30	56	Charged	5.10
10/12/05	Wednesday	FOOD	Camarillo/5168/VWC	1:18am	Fido Summer	00:00:30	40	Charged	2.55
10/12/05	Wednesday	FOXN	Camarillo/5168/VWC	4:49pm	Fido Summer	00:00:30	4	Charged	10.62
10/12/05	Wednesday	FOXN	Camarillo/5168/VWC	5:47pm	Fido Summer	00:00:30	4	Charged	10.62
10/12/05	Wednesday	HGTV	Camarillo/5168/VWC	4:47pm	Fido Summer	00:00:30	58	Charged	15.29
10/12/05	Wednesday	FOOD	Ojai/5855/VWC	11:57pm	Fido Summer	00:00:30	37	Charged	1.06
10/12/05	Wednesday	FOXN	Ojai/5855/VWC	4:49pm	Fido Summer	00:00:30	1	Charged	4.42
10/12/05	Wednesday	HGTV	Ojai/5855/VWC	4:47pm	Fido Summer	00:00:30	55	Charged	6.37
10/12/05	Wednesday	FOOD	Simi Valley/1571/VE	8:18pm	Fido Summer	00:00:30	42	Charged	3.35
10/12/05	Wednesday	HGTV	Simi Valley/1571/VE	5:47pm	Fido Summer	00:00:30	60	Charged	20.07
10/12/05	Wednesday	FOOD	Thousand Oaks/890/	4:45am	Fido Summer	00:00:30	39	Charged	4.46
10/12/05	Wednesday	FOXN	Thousand Oaks/890/	4:49pm	Fido Summer	00:00:30	3	Charged	18.58
10/12/05	Wednesday	HGTV	Thousand Oaks/890/	4:46pm	Fido Summer	00:00:30	57	Charged	26.76
10/12/05	Wednesday	HGTV	Thousand Oaks/890/	5:47pm	Fido Summer	00:00:30	57	Charged	26.76
10/12/05	Wednesday	FOOD	Ventura/1614/VWC	1:47pm	Fido Summer	00:00:30	41	Charged	5.73
10/12/05	Wednesday	FOXN	Ventura/1614/VWC	5:47pm	Fido Summer	00:00:30	5	Charged	23.90
10/12/05	Wednesday	FOXN	Ventura/1614/VWC	8:47pm	Fido Summer	00:00:30	5	Charged	23.90
10/12/05	Wednesday	HGTV	Ventura/1614/VWC	5:48pm	Fido Summer	00:00:30	59	Charged	34.41
10/13/05	Thursday	FOOD	Ave Ventura/5169/V	8:50pm	Fido Summer	00:00:30	38	Charged	0.85
10/13/05	Thursday	HGTV	Ave Ventura/5169/V	6:15pm	Fido Summer	00:00:30	56	Charged	5.10
10/13/05	Thursday	FOOD	Camarillo/5168/VWC	12:55am	Fido Summer	00:00:30	40	Charged	2.55
10/13/05	Thursday	HGTV	Camarillo/5168/VWC	4:46pm	Fido Summer	00:00:30	58	Charged	15.29
10/13/05	Thursday	FOOD	Ojai/5855/VWC	7:59am	Fido Summer	00:00:30	37	Charged	1.06
10/13/05	Thursday	FOOD	Simi Valley/1571/VE	4:16am	Fido Summer	00:00:30	42	Charged	3.35
10/13/05	Thursday	HGTV	Simi Valley/1571/VE	4:18pm	Fido Summer	00:00:30	60	Charged	20.07
10/13/05	Thursday	FOOD	Thousand Oaks/890/	12:25am	Fido Summer	00:00:30	39	Charged	4.46
10/13/05	Thursday	HGTV	Thousand Oaks/890/	4:46pm	Fido Summer	00:00:30	57	Charged	26.76
10/13/05	Thursday	FOOD	Ventura/1614/VWC	11:16am	Fido Summer	00:00:30	41	Charged	5.73
10/13/05	Thursday	HGTV	Ventura/1614/VWC	8:15pm	Fido Summer	00:00:30	59	Charged	34.41
10/14/05	Friday	BRV	Ave Ventura/5169/V	7:13pm	Fido Summer	00:00:30	32	Charged	1.51
10/14/05	Friday	FOOD	Ave Ventura/5169/V	2:16pm	Fido Summer	00:00:30	38	Charged	0.85
10/14/05	Friday	FOOD	Ave Ventura/5169/V	6:47pm	Fido Summer	00:00:30	50	Charged	3.73
10/14/05	Friday	HGTV	Ave Ventura/5169/V	9:47pm	Fido Summer	00:00:30	56	Charged	5.10
10/14/05	Friday	USA	Ave Ventura/5169/V	4:51pm	Fido Summer	00:00:30	86	Charged	4.96
10/14/05	Friday	BRV	Camarillo/5168/VWC	6:18pm	Fido Summer	00:00:30	34	Charged	4.53
10/14/05	Friday	FOOD	Camarillo/5168/VWC	3:52am	Fido Summer	00:00:30	40	Charged	2.55
10/14/05	Friday	FOOD	Camarillo/5168/VWC	6:47pm	Fido Summer	00:00:30	52	Charged	11.19
10/14/05	Friday	HGTV	Camarillo/5168/VWC	4:47pm	Fido Summer	00:00:30	58	Charged	15.29
10/14/05	Friday	HGTV	Camarillo/5168/VWC	5:47pm	Fido Summer	00:00:30	58	Charged	15.29
10/14/05	Friday	USA	Camarillo/5168/VWC	4:51pm	Fido Summer	00:00:30	88	Charged	14.87
10/14/05	Friday	BRV	Ojai/5855/VWC	7:13pm	Fido Summer	00:00:30	31	Charged	1.89
10/14/05	Friday	FOOD	Ojai/5855/VWC	2:19am	Fido Summer	00:00:30	37	Charged	1.06
10/14/05	Friday	FOOD	Ojai/5855/VWC	6:47pm	Fido Summer	00:00:30	49	Charged	4.66
10/14/05	Friday	HGTV	Ojai/5855/VWC	4:48pm	Fido Summer	00:00:30	55	Charged	6.37
10/14/05	Friday	USA	Ojai/5855/VWC	5:11pm	Fido Summer	00:00:30	85	Charged	6.20
10/14/05	Friday	BRV	Simi Valley/1571/VE	5:13pm	Fido Summer	00:00:30	36	Charged	5.94
10/14/05	Friday	FOOD	Simi Valley/1571/VE	7:59am	Fido Summer	00:00:30	42	Charged	3.35
10/14/05	Friday	FOOD	Simi Valley/1571/VE	6:47pm	Fido Summer	00:00:30	54	Charged	14.67
10/14/05	Friday	HGTV	Simi Valley/1571/VE	5:17pm	Fido Summer	00:00:30	60	Charged	20.07
10/14/05	Friday	BRV	Thousand Oaks/890/	9:08pm	Fido Summer	00:00:30	33	Charged	7.93
10/14/05	Friday	FOOD	Thousand Oaks/890/	12:50am	Fido Summer	00:00:30	39	Charged	4.46
10/14/05	Friday	FOOD	Thousand Oaks/890/	6:47pm	Fido Summer	00:00:30	51	Charged	19.58
10/14/05	Friday	BRV	Ventura/1614/VWC	6:48pm	Fido Summer	00:00:30	35	Charged	10.20
10/14/05	Friday	FOOD	Ventura/1614/VWC	2:17pm	Fido Summer	00:00:30	41	Charged	5.73
10/14/05	Friday	FOOD	Ventura/1614/VWC	6:47pm	Fido Summer	00:00:30	53	Charged	25.17
10/15/05	Saturday	AEN	Ave Ventura/5169/V	8:51am	Fido Summer	00:00:30	14	Charged	3.82
10/15/05	Saturday	AEN	Ave Ventura/5169/V	6:12pm	Fido Summer	00:00:30	20	Charged	4.81
10/15/05	Saturday	AMC	Ave Ventura/5169/V	3:06am	Fido Summer	00:00:30	26	Charged	0.24
10/15/05	Saturday	BRV	Ave Ventura/5169/V	5:46pm	Fido Summer	00:00:30	32	Charged	1.51

10/15/05	Saturday	FOOD	Ave Ventura/5169/V	1:17pm	Fido Summer	00:00:30	38	Charged	0.85
10/15/05	Saturday	HGTV	Ave Ventura/5169/V	4:18pm	Fido Summer	00:00:30	56	Charged	5.10
10/15/05	Saturday	HIST	Ave Ventura/5169/V	7:47pm	Fido Summer	00:00:30	74	Charged	0.61
10/15/05	Saturday	TRAV	Ave Ventura/5169/V	6:45am	Fido Summer	00:00:30	8	Charged	0.38
10/15/05	Saturday	USA	Ave Ventura/5169/V	7:43pm	Fido Summer	00:00:30	86	Charged	4.96
10/15/05	Saturday	AEN	Camarillo/5168/VWC	1:46pm	Fido Summer	00:00:30	16	Charged	11.47
10/15/05	Saturday	AEN	Camarillo/5168/VWC	11:39pm	Fido Summer	00:00:30	22	Charged	14.44
10/15/05	Saturday	AMC	Camarillo/5168/VWC	2:45pm	Fido Summer	00:00:30	28	Charged	0.71
10/15/05	Saturday	BRV	Camarillo/5168/VWC	4:13pm	Fido Summer	00:00:30	34	Charged	4.53
10/15/05	Saturday	FOOD	Camarillo/5168/VWC	12:19am	Fido Summer	00:00:30	40	Charged	2.55
10/15/05	Saturday	HIST	Camarillo/5168/VWC	3:14pm	Fido Summer	00:00:30	76	Charged	1.84
10/15/05	Saturday	TRAV	Camarillo/5168/VWC	7:38am	Fido Summer	00:00:30	10	Charged	1.13
10/15/05	Saturday	USA	Camarillo/5168/VWC	4:18pm	Fido Summer	00:00:30	88	Charged	14.87
10/15/05	Saturday	USA	Camarillo/5168/VWC	5:15pm	Fido Summer	00:00:30	88	Charged	14.87
10/15/05	Saturday	AEN	Ojai/5855/VWC	11:47am	Fido Summer	00:00:30	13	Charged	4.78
10/15/05	Saturday	AEN	Ojai/5855/VWC	4:51pm	Fido Summer	00:00:30	19	Charged	6.02
10/15/05	Saturday	AMC	Ojai/5855/VWC	2:46pm	Fido Summer	00:00:30	25	Charged	0.30
10/15/05	Saturday	BRV	Ojai/5855/VWC	9:10pm	Fido Summer	00:00:30	31	Charged	1.89
10/15/05	Saturday	FOOD	Ojai/5855/VWC	4:13am	Fido Summer	00:00:30	37	Charged	1.06
10/15/05	Saturday	HGTV	Ojai/5855/VWC	4:47pm	Fido Summer	00:00:30	55	Charged	6.37
10/15/05	Saturday	HIST	Ojai/5855/VWC	1:50pm	Fido Summer	00:00:30	73	Charged	0.77
10/15/05	Saturday	TRAV	Ojai/5855/VWC	9:37am	Fido Summer	00:00:30	7	Charged	0.47
10/15/05	Saturday	TRAV	Ojai/5855/VWC	9:50pm	Fido Summer	00:00:30	7	Charged	0.47
10/15/05	Saturday	USA	Ojai/5855/VWC	5:34pm	Fido Summer	00:00:30	85	Charged	6.20
10/15/05	Saturday	AEN	Simi Valley/1571/VE	2:43pm	Fido Summer	00:00:30	18	Charged	15.05
10/15/05	Saturday	AEN	Simi Valley/1571/VE	9:49pm	Fido Summer	00:00:30	24	Charged	18.95
10/15/05	Saturday	AMC	Simi Valley/1571/VE	6:10am	Fido Summer	00:00:30	30	Charged	0.92
10/15/05	Saturday	BRV	Simi Valley/1571/VE	8:36pm	Fido Summer	00:00:30	36	Charged	5.94
10/15/05	Saturday	FOOD	Simi Valley/1571/VE	2:52pm	Fido Summer	00:00:30	42	Charged	3.35
10/15/05	Saturday	HGTV	Simi Valley/1571/VE	4:18pm	Fido Summer	00:00:30	60	Charged	20.07
10/15/05	Saturday	HIST	Simi Valley/1571/VE	5:59am	Fido Summer	00:00:30	78	Charged	2.42
10/15/05	Saturday	TRAV	Simi Valley/1571/VE	6:28pm	Fido Summer	00:00:30	12	Charged	1.49
10/15/05	Saturday	TRAV	Simi Valley/1571/VE	11:21pm	Fido Summer	00:00:30	12	Charged	1.49
10/15/05	Saturday	USA	Simi Valley/1571/VE	4:42pm	Fido Summer	00:00:30	90	Charged	19.50
10/15/05	Saturday	AEN	Thousand Oaks/890/	9:50am	Fido Summer	00:00:30	15	Charged	20.07
10/15/05	Saturday	AEN	Thousand Oaks/890/	9:10pm	Fido Summer	00:00:30	21	Charged	25.28
10/15/05	Saturday	AMC	Thousand Oaks/890/	12:21am	Fido Summer	00:00:30	27	Charged	1.24
10/15/05	Saturday	BRV	Thousand Oaks/890/	11:30pm	Fido Summer	00:00:30	33	Charged	7.93
10/15/05	Saturday	FOOD	Thousand Oaks/890/	2:17am	Fido Summer	00:00:30	39	Charged	4.46
10/15/05	Saturday	HIST	Thousand Oaks/890/	3:13pm	Fido Summer	00:00:30	75	Charged	3.22
10/15/05	Saturday	TRAV	Thousand Oaks/890/	6:42pm	Fido Summer	00:00:30	9	Charged	1.98
10/15/05	Saturday	TRAV	Thousand Oaks/890/	9:50pm	Fido Summer	00:00:30	9	Charged	1.98
10/15/05	Saturday	USA	Thousand Oaks/890/	4:18pm	Fido Summer	00:00:30	87	Charged	26.02
10/15/05	Saturday	USA	Thousand Oaks/890/	5:34pm	Fido Summer	00:00:30	87	Charged	26.02
10/15/05	Saturday	AEN	Ventura/1614/VWC	11:48am	Fido Summer	00:00:30	17	Charged	25.81
10/15/05	Saturday	AEN	Ventura/1614/VWC	11:39pm	Fido Summer	00:00:30	23	Charged	32.50
10/15/05	Saturday	AMC	Ventura/1614/VWC	12:21am	Fido Summer	00:00:30	29	Charged	1.59
10/15/05	Saturday	BRV	Ventura/1614/VWC	5:47pm	Fido Summer	00:00:30	35	Charged	10.20
10/15/05	Saturday	FOOD	Ventura/1614/VWC	3:56am	Fido Summer	00:00:30	41	Charged	5.73
10/15/05	Saturday	HGTV	Ventura/1614/VWC	5:13pm	Fido Summer	00:00:30	59	Charged	34.41
10/15/05	Saturday	HGTV	Ventura/1614/VWC	5:44pm	Fido Summer	00:00:30	59	Charged	34.41
10/15/05	Saturday	HIST	Ventura/1614/VWC	9:14am	Fido Summer	00:00:30	77	Charged	4.14
10/15/05	Saturday	TRAV	Ventura/1614/VWC	11:40am	Fido Summer	00:00:30	11	Charged	2.55
10/15/05	Saturday	TRAV	Ventura/1614/VWC	9:50pm	Fido Summer	00:00:30	11	Charged	2.55
10/15/05	Saturday	USA	Ventura/1614/VWC	4:18pm	Fido Summer	00:00:30	89	Charged	33.45
10/15/05	Saturday	USA	Ventura/1614/VWC	5:34pm	Fido Summer	00:00:30	89	Charged	33.45
10/15/05	Saturday	USA	Ventura/1614/VWC	6:31pm	Fido Summer	00:00:30	89	Charged	33.45
10/16/05	Sunday	AEN	Ave Ventura/5169/V	10:11am	Fido Summer	00:00:30	14	Charged	3.82
10/16/05	Sunday	AEN	Ave Ventura/5169/V	5:39pm	Fido Summer	00:00:30	20	Charged	4.81
10/16/05	Sunday	AMC	Ave Ventura/5169/V	9:49am	Fido Summer	00:00:30	26	Charged	0.24
10/16/05	Sunday	FOOD	Ave Ventura/5169/V	10:52pm	Fido Summer	00:00:30	38	Charged	0.85
10/16/05	Sunday	HGTV	Ave Ventura/5169/V	9:15am	Fido Summer	00:00:30	68	Charged	4.34
10/16/05	Sunday	HGTV	Ave Ventura/5169/V	10:17pm	Fido Summer	00:00:30	56	Charged	5.10
10/16/05	Sunday	HIST	Ave Ventura/5169/V	5:29am	Fido Summer	00:00:30	74	Charged	0.61
10/16/05	Sunday	HIST	Ave Ventura/5169/V	7:52pm	Fido Summer	00:00:30	80	Charged	1.98
10/16/05	Sunday	TRAV	Ave Ventura/5169/V	11:29am	Fido Summer	00:00:30	8	Charged	0.38

10/16/05	Sunday	TRAV	Ave Ventura/5169/V	8:27pm	Fido Summer	00:00:30	8	Charged	0.38
10/16/05	Sunday	USA	Ave Ventura/5169/V	6:47pm	Fido Summer	00:00:30	86	Charged	4.96
10/16/05	Sunday	AEN	Camarillo/5168/VWC	9:15am	Fido Summer	00:00:30	16	Charged	11.47
10/16/05	Sunday	AEN	Camarillo/5168/VWC	7:11pm	Fido Summer	00:00:30	22	Charged	14.44
10/16/05	Sunday	AMC	Camarillo/5168/VWC	4:19pm	Fido Summer	00:00:30	28	Charged	0.71
10/16/05	Sunday	FOOD	Camarillo/5168/VWC	3:21am	Fido Summer	00:00:30	40	Charged	2.55
10/16/05	Sunday	HGTV	Camarillo/5168/VWC	9:15am	Fido Summer	00:00:30	70	Charged	13.03
10/16/05	Sunday	HGTV	Camarillo/5168/VWC	4:46pm	Fido Summer	00:00:30	58	Charged	15.29
10/16/05	Sunday	HGTV	Camarillo/5168/VWC	11:19pm	Fido Summer	00:00:30	58	Charged	15.29
10/16/05	Sunday	HIST	Camarillo/5168/VWC	12:11am	Fido Summer	00:00:30	76	Charged	1.84
10/16/05	Sunday	HIST	Camarillo/5168/VWC	11:19pm	Fido Summer	00:00:30	82	Charged	5.95
10/16/05	Sunday	TRAV	Camarillo/5168/VWC	7:36am	Fido Summer	00:00:30	10	Charged	1.13
10/16/05	Sunday	TRAV	Camarillo/5168/VWC	9:43am	Fido Summer	00:00:30	10	Charged	1.13
10/16/05	Sunday	USA	Camarillo/5168/VWC	5:02pm	Fido Summer	00:00:30	88	Charged	14.87
10/16/05	Sunday	AEN	Ojai/5855/VWC	10:48am	Fido Summer	00:00:30	13	Charged	4.78
10/16/05	Sunday	AEN	Ojai/5855/VWC	8:50pm	Fido Summer	00:00:30	19	Charged	6.02
10/16/05	Sunday	AMC	Ojai/5855/VWC	12:20am	Fido Summer	00:00:30	25	Charged	0.30
10/16/05	Sunday	FOOD	Ojai/5855/VWC	3:20pm	Fido Summer	00:00:30	37	Charged	1.06
10/16/05	Sunday	HGTV	Ojai/5855/VWC	9:15am	Fido Summer	00:00:30	67	Charged	5.43
10/16/05	Sunday	HIST	Ojai/5855/VWC	7:06am	Fido Summer	00:00:30	73	Charged	0.77
10/16/05	Sunday	HIST	Ojai/5855/VWC	11:18pm	Fido Summer	00:00:30	79	Charged	2.48
10/16/05	Sunday	TRAV	Ojai/5855/VWC	4:24pm	Fido Summer	00:00:30	7	Charged	0.47
10/16/05	Sunday	USA	Ojai/5855/VWC	4:18pm	Fido Summer	00:00:30	85	Charged	6.20
10/16/05	Sunday	USA	Ojai/5855/VWC	5:02pm	Fido Summer	00:00:30	85	Charged	6.20
10/16/05	Sunday	USA	Ojai/5855/VWC	5:33pm	Fido Summer	00:00:30	85	Charged	6.20
10/16/05	Sunday	AEN	Simi Valley/1571/VE	7:14am	Fido Summer	00:00:30	18	Charged	15.05
10/16/05	Sunday	AEN	Simi Valley/1571/VE	9:39pm	Fido Summer	00:00:30	24	Charged	18.95
10/16/05	Sunday	AMC	Simi Valley/1571/VE	10:40am	Fido Summer	00:00:30	30	Charged	0.92
10/16/05	Sunday	FOOD	Simi Valley/1571/VE	12:20am	Fido Summer	00:00:30	42	Charged	3.35
10/16/05	Sunday	HGTV	Simi Valley/1571/VE	9:15am	Fido Summer	00:00:30	72	Charged	17.09
10/16/05	Sunday	HGTV	Simi Valley/1571/VE	5:43pm	Fido Summer	00:00:30	60	Charged	20.07
10/16/05	Sunday	HIST	Simi Valley/1571/VE	12:12am	Fido Summer	00:00:30	78	Charged	2.42
10/16/05	Sunday	HIST	Simi Valley/1571/VE	5:39pm	Fido Summer	00:00:30	84	Charged	7.80
10/16/05	Sunday	TRAV	Simi Valley/1571/VE	7:36am	Fido Summer	00:00:30	12	Charged	1.49
10/16/05	Sunday	USA	Simi Valley/1571/VE	8:10pm	Fido Summer	00:00:30	90	Charged	19.50
10/16/05	Sunday	USA	Simi Valley/1571/VE	11:28pm	Fido Summer	00:00:30	90	Charged	19.50
10/16/05	Sunday	AEN	Thousand Oaks/890/	1:47pm	Fido Summer	00:00:30	15	Charged	20.07
10/16/05	Sunday	AEN	Thousand Oaks/890/	9:10pm	Fido Summer	00:00:30	21	Charged	25.28
10/16/05	Sunday	AMC	Thousand Oaks/890/	1:54pm	Fido Summer	00:00:30	27	Charged	1.24
10/16/05	Sunday	FOOD	Thousand Oaks/890/	8:49am	Fido Summer	00:00:30	39	Charged	4.46
10/16/05	Sunday	HGTV	Thousand Oaks/890/	9:15am	Fido Summer	00:00:30	69	Charged	22.80
10/16/05	Sunday	HGTV	Thousand Oaks/890/	5:18pm	Fido Summer	00:00:30	57	Charged	26.76
10/16/05	Sunday	HIST	Thousand Oaks/890/	12:47am	Fido Summer	00:00:30	75	Charged	3.22
10/16/05	Sunday	HIST	Thousand Oaks/890/	11:19pm	Fido Summer	00:00:30	81	Charged	10.41
10/16/05	Sunday	TRAV	Thousand Oaks/890/	12:38pm	Fido Summer	00:00:30	9	Charged	1.98
10/16/05	Sunday	USA	Thousand Oaks/890/	5:02pm	Fido Summer	00:00:30	87	Charged	26.02
10/16/05	Sunday	AEN	Ventura/1614/VWC	1:47pm	Fido Summer	00:00:30	17	Charged	25.81
10/16/05	Sunday	AEN	Ventura/1614/VWC	4:42pm	Fido Summer	00:00:30	23	Charged	32.50
10/16/05	Sunday	AMC	Ventura/1614/VWC	12:20am	Fido Summer	00:00:30	29	Charged	1.59
10/16/05	Sunday	FOOD	Ventura/1614/VWC	8:17am	Fido Summer	00:00:30	41	Charged	5.73
10/16/05	Sunday	HGTV	Ventura/1614/VWC	9:15am	Fido Summer	00:00:30	71	Charged	29.31
10/16/05	Sunday	HGTV	Ventura/1614/VWC	11:48pm	Fido Summer	00:00:30	59	Charged	34.41
10/16/05	Sunday	HIST	Ventura/1614/VWC	12:11am	Fido Summer	00:00:30	77	Charged	4.14
10/16/05	Sunday	HIST	Ventura/1614/VWC	4:49pm	Fido Summer	00:00:30	83	Charged	13.38
10/16/05	Sunday	TRAV	Ventura/1614/VWC	12:27pm	Fido Summer	00:00:30	11	Charged	2.55
10/17/05	Monday	BRV	Ave Ventura/5169/V	5:12pm	Fido Summer	00:00:30	32	Charged	1.51
10/17/05	Monday	BRV	Ave Ventura/5169/V	10:33pm	Fido Summer	00:00:30	32	Charged	1.51
10/17/05	Monday	FOOD	Ave Ventura/5169/V	8:19pm	Fido Summer	00:00:30	38	Charged	0.85
10/17/05	Monday	FOOD	Ave Ventura/5169/V	9:49pm	Fido Summer	00:00:30	103	Charged	3.67
10/17/05	Monday	FOXN	Ave Ventura/5169/V	6:22pm	Fido Summer	00:00:30	92	Charged	3.54
10/17/05	Monday	HGTV	Ave Ventura/5169/V	9:44pm	Fido Summer	00:00:30	56	Charged	5.10
10/17/05	Monday	BRV	Camarillo/5168/VWC	6:08pm	Fido Summer	00:00:30	34	Charged	4.53
10/17/05	Monday	BRV	Camarillo/5168/VWC	11:08pm	Fido Summer	00:00:30	34	Charged	4.53
10/17/05	Monday	FOOD	Camarillo/5168/VWC	2:17pm	Fido Summer	00:00:30	40	Charged	2.55
10/17/05	Monday	FOOD	Camarillo/5168/VWC	9:49pm	Fido Summer	00:00:30	104	Charged	11.01
10/17/05	Monday	FOXN	Camarillo/5168/VWC	4:18pm	Fido Summer	00:00:30	94	Charged	10.62

10/17/05	Monday	BRV	Ojai/5855/VWC	4:16pm	Fido Summer	00:00:30	31	Charged	1.89
10/17/05	Monday	BRV	Ojai/5855/VWC	9:06pm	Fido Summer	00:00:30	31	Charged	1.89
10/17/05	Monday	FOOD	Ojai/5855/VWC	12:52am	Fido Summer	00:00:30	37	Charged	1.06
10/17/05	Monday	FOOD	Ojai/5855/VWC	9:49pm	Fido Summer	00:00:30	105	Charged	4.59
10/17/05	Monday	FOXN	Ojai/5855/VWC	4:18pm	Fido Summer	00:00:30	91	Charged	4.42
10/17/05	Monday	BRV	Simi Valley/1571/VE	4:16pm	Fido Summer	00:00:30	36	Charged	5.94
10/17/05	Monday	FOOD	Simi Valley/1571/VE	10:20am	Fido Summer	00:00:30	42	Charged	3.35
10/17/05	Monday	FOOD	Simi Valley/1571/VE	9:49pm	Fido Summer	00:00:30	106	Charged	14.68
10/17/05	Monday	FOXN	Simi Valley/1571/VE	4:18pm	Fido Summer	00:00:30	96	Charged	13.94
10/17/05	Monday	BRV	Thousand Oaks/890/	7:34pm	Fido Summer	00:00:30	33	Charged	7.93
10/17/05	Monday	BRV	Thousand Oaks/890/	10:07pm	Fido Summer	00:00:30	33	Charged	7.93
10/17/05	Monday	FOOD	Thousand Oaks/890/	3:17am	Fido Summer	00:00:30	39	Charged	4.46
10/17/05	Monday	FOOD	Thousand Oaks/890/	9:49pm	Fido Summer	00:00:30	107	Charged	19.27
10/17/05	Monday	FOXN	Thousand Oaks/890/	5:47pm	Fido Summer	00:00:30	93	Charged	18.58
10/17/05	Monday	HGTV	Thousand Oaks/890/	4:46pm	Fido Summer	00:00:30	57	Charged	26.76
10/17/05	Monday	BRV	Ventura/1614/VWC	4:15pm	Fido Summer	00:00:30	35	Charged	10.20
10/17/05	Monday	FOOD	Ventura/1614/VWC	4:48pm	Fido Summer	00:00:30	41	Charged	5.73
10/17/05	Monday	FOOD	Ventura/1614/VWC	9:49pm	Fido Summer	00:00:30	108	Charged	24.78
10/17/05	Monday	FOXN	Ventura/1614/VWC	4:18pm	Fido Summer	00:00:30	95	Charged	23.90
10/17/05	Monday	HGTV	Ventura/1614/VWC	7:43pm	Fido Summer	00:00:30	59	Charged	34.41
10/18/05	Tuesday	BRV	Ave Ventura/5169/V	8:44pm	Fido Summer	00:00:30	32	Charged	1.51
10/18/05	Tuesday	FOOD	Ave Ventura/5169/V	11:20pm	Fido Summer	00:00:30	38	Charged	0.85
10/18/05	Tuesday	FOXN	Ave Ventura/5169/V	9:49pm	Fido Summer	00:00:30	92	Charged	3.54
10/18/05	Tuesday	HGTV	Ave Ventura/5169/V	11:47pm	Fido Summer	00:00:30	56	Charged	5.10
10/18/05	Tuesday	BRV	Camarillo/5168/VWC	8:14pm	Fido Summer	00:00:30	34	Charged	4.53
10/18/05	Tuesday	FOOD	Camarillo/5168/VWC	12:22am	Fido Summer	00:00:30	40	Charged	2.55
10/18/05	Tuesday	FOXN	Camarillo/5168/VWC	4:19pm	Fido Summer	00:00:30	94	Charged	10.62
10/18/05	Tuesday	BRV	Ojai/5855/VWC	10:43pm	Fido Summer	00:00:30	31	Charged	1.89
10/18/05	Tuesday	FOOD	Ojai/5855/VWC	7:59am	Fido Summer	00:00:30	37	Charged	1.06
10/18/05	Tuesday	FOXN	Ojai/5855/VWC	11:49pm	Fido Summer	00:00:30	91	Charged	4.42
10/18/05	Tuesday	BRV	Simi Valley/1571/VE	5:42pm	Fido Summer	00:00:30	36	Charged	5.94
10/18/05	Tuesday	BRV	Simi Valley/1571/VE	9:46pm	Fido Summer	00:00:30	36	Charged	5.94
10/18/05	Tuesday	FOOD	Simi Valley/1571/VE	8:28am	Fido Summer	00:00:30	42	Charged	3.35
10/18/05	Tuesday	FOXN	Simi Valley/1571/VE	11:21pm	Fido Summer	00:00:30	96	Charged	13.94
10/18/05	Tuesday	HGTV	Simi Valley/1571/VE	5:47pm	Fido Summer	00:00:30	60	Charged	20.07
10/18/05	Tuesday	BRV	Thousand Oaks/890/	11:14pm	Fido Summer	00:00:30	33	Charged	7.93
10/18/05	Tuesday	FOOD	Thousand Oaks/890/	8:28am	Fido Summer	00:00:30	39	Charged	4.46
10/18/05	Tuesday	FOXN	Thousand Oaks/890/	4:47pm	Fido Summer	00:00:30	93	Charged	18.58
10/18/05	Tuesday	BRV	Ventura/1614/VWC	4:41pm	Fido Summer	00:00:30	35	Charged	10.20
10/18/05	Tuesday	FOOD	Ventura/1614/VWC	7:29am	Fido Summer	00:00:30	41	Charged	5.73
10/18/05	Tuesday	FOXN	Ventura/1614/VWC	9:50pm	Fido Summer	00:00:30	95	Charged	23.90
10/18/05	Tuesday	HGTV	Ventura/1614/VWC	9:18pm	Fido Summer	00:00:30	59	Charged	34.41
10/19/05	Wednesday	FOOD	Ave Ventura/5169/V	1:49pm	Fido Summer	00:00:30	38	Charged	0.85
10/19/05	Wednesday	FOXN	Ave Ventura/5169/V	10:47pm	Fido Summer	00:00:30	92	Charged	3.54
10/19/05	Wednesday	HGTV	Ave Ventura/5169/V	4:47pm	Fido Summer	00:00:30	56	Charged	5.10
10/19/05	Wednesday	FOOD	Camarillo/5168/VWC	4:17am	Fido Summer	00:00:30	40	Charged	2.55
10/19/05	Wednesday	FOXN	Camarillo/5168/VWC	5:47pm	Fido Summer	00:00:30	94	Charged	10.62
10/19/05	Wednesday	HGTV	Camarillo/5168/VWC	4:46pm	Fido Summer	00:00:30	58	Charged	15.29
10/19/05	Wednesday	HGTV	Camarillo/5168/VWC	5:17pm	Fido Summer	00:00:30	58	Charged	15.29
10/19/05	Wednesday	HGTV	Camarillo/5168/VWC	5:48pm	Fido Summer	00:00:30	58	Charged	15.29
10/19/05	Wednesday	FOOD	Ojai/5855/VWC	12:21am	Fido Summer	00:00:30	37	Charged	1.06
10/19/05	Wednesday	FOXN	Ojai/5855/VWC	11:49pm	Fido Summer	00:00:30	91	Charged	4.42
10/19/05	Wednesday	HGTV	Ojai/5855/VWC	4:46pm	Fido Summer	00:00:30	55	Charged	6.37
10/19/05	Wednesday	FOOD	Simi Valley/1571/VE.	12:21am	Fido Summer	00:00:30	42	Charged	3.35
10/19/05	Wednesday	FOXN	Simi Valley/1571/VE	4:21pm	Fido Summer	00:00:30	96	Charged	13.94
10/19/05	Wednesday	HGTV	Simi Valley/1571/VE	5:17pm	Fido Summer	00:00:30	60	Charged	20.07
10/19/05	Wednesday	HGTV	Simi Valley/1571/VE	8:16pm	Fido Summer	00:00:30	60	Charged	20.07
10/19/05	Wednesday	FOOD	Thousand Oaks/890/	1:16am	Fido Summer	00:00:30	39	Charged	4.46
10/19/05	Wednesday	FOXN	Thousand Oaks/890/	4:21pm	Fido Summer	00:00:30	93	Charged	18.58
10/19/05	Wednesday	FOOD	Ventura/1614/VWC	9:45pm	Fido Summer	00:00:30	41	Charged	5.73
10/19/05	Wednesday	FOXN	Ventura/1614/VWC	11:48pm	Fido Summer	00:00:30	95	Charged	23.90
10/20/05	Thursday	FOOD	Ave Ventura/5169/V	5:49pm	Fido Summer	00:00:30	38	Charged	0.85
10/20/05	Thursday	HGTV	Ave Ventura/5169/V	7:44pm	Fido Summer	00:00:30	56	Charged	5.10
10/20/05	Thursday	FOOD	Camarillo/5168/VWC	12:23am	Fido Summer	00:00:30	40	Charged	2.55

10/20/05	Thursday	HGTV	Camarillo/5168/VWC	9:48pm	Fido Summer	00:00:30	58	Charged	15.29
10/20/05	Thursday	FOOD	Ojai/5855/VWC	12:23am	Fido Summer	00:00:30	37	Charged	1.06
10/20/05	Thursday	HGTV	Ojai/5855/VWC	5:17pm	Fido Summer	00:00:30	55	Charged	6.37
10/20/05	Thursday	FOOD	Simi Valley/1571/VE	12:23am	Fido Summer	00:00:30	42	Charged	3.35
10/20/05	Thursday	FOOD	Thousand Oaks/890/	12:23am	Fido Summer	00:00:30	39	Charged	4.46
10/20/05	Thursday	HGTV	Thousand Oaks/890/	4:16pm	Fido Summer	00:00:30	57	Charged	26.76
10/20/05	Thursday	FOOD	Ventura/1614/VWC	12:23am	Fido Summer	00:00:30	41	Charged	5.73
10/21/05	Friday	BRV	Ave Ventura/5169/V	11:19pm	Fido Summer	00:00:30	32	Charged	1.51
10/21/05	Friday	FOOD	Ave Ventura/5169/V	2:48pm	Fido Summer	00:00:30	38	Charged	0.85
10/21/05	Friday	FOOD	Ave Ventura/5169/V	6:48pm	Fido Summer	00:00:30	50	Charged	3.73
10/21/05	Friday	HGTV	Ave Ventura/5169/V	4:17pm	Fido Summer	00:00:30	56	Charged	5.10
10/21/05	Friday	USA	Ave Ventura/5169/V	6:12pm	Fido Summer	00:00:30	86	Charged	4.96
10/21/05	Friday	BRV	Camarillo/5168/VWC	4:11pm	Fido Summer	00:00:30	34	Charged	4.53
10/21/05	Friday	FOOD	Camarillo/5168/VWC	4:16am	Fido Summer	00:00:30	40	Charged	2.55
10/21/05	Friday	FOOD	Camarillo/5168/VWC	6:48pm	Fido Summer	00:00:30	52	Charged	11.19
10/21/05	Friday	HGTV	Camarillo/5168/VWC	4:17pm	Fido Summer	00:00:30	58	Charged	15.29
10/21/05	Friday	USA	Camarillo/5168/VWC	4:49pm	Fido Summer	00:00:30	88	Charged	14.87
10/21/05	Friday	BRV	Ojai/5855/VWC	4:39pm	Fido Summer	00:00:30	31	Charged	1.89
10/21/05	Friday	FOOD	Ojai/5855/VWC	1:52am	Fido Summer	00:00:30	37	Charged	1.06
10/21/05	Friday	FOOD	Ojai/5855/VWC	6:48pm	Fido Summer	00:00:30	49	Charged	4.66
10/21/05	Friday	BRV	Simi Valley/1571/VE	4:11pm	Fido Summer	00:00:30	36	Charged	5.94
10/21/05	Friday	FOOD	Simi Valley/1571/VE	12:47pm	Fido Summer	00:00:30	42	Charged	3.35
10/21/05	Friday	FOOD	Simi Valley/1571/VE	6:48pm	Fido Summer	00:00:30	54	Charged	14.67
10/21/05	Friday	BRV	Thousand Oaks/890/	4:11pm	Fido Summer	00:00:30	33	Charged	7.93
10/21/05	Friday	FOOD	Thousand Oaks/890/	12:25am	Fido Summer	00:00:30	39	Charged	4.46
10/21/05	Friday	FOOD	Thousand Oaks/890/	6:48pm	Fido Summer	00:00:30	51	Charged	19.58
10/21/05	Friday	HGTV	Thousand Oaks/890/	4:17pm	Fido Summer	00:00:30	57	Charged	26.76
10/21/05	Friday	HGTV	Thousand Oaks/890/	5:18pm	Fido Summer	00:00:30	57	Charged	26.76
10/21/05	Friday	HGTV	Thousand Oaks/890/	6:47pm	Fido Summer	00:00:30	57	Charged	26.76
10/21/05	Friday	USA	Thousand Oaks/890/	6:11pm	Fido Summer	00:00:30	87	Charged	26.02
10/21/05	Friday	BRV	Ventura/1614/VWC	5:13pm	Fido Summer	00:00:30	35	Charged	10.20
10/21/05	Friday	BRV	Ventura/1614/VWC	9:14pm	Fido Summer	00:00:30	35	Charged	10.20
10/21/05	Friday	FOOD	Ventura/1614/VWC	12:47pm	Fido Summer	00:00:30	41	Charged	5.73
10/21/05	Friday	FOOD	Ventura/1614/VWC	6:48pm	Fido Summer	00:00:30	53	Charged	25.17
10/22/05	Saturday	AEN	Ave Ventura/5169/V	10:39am	Fido Summer	00:00:30	14	Charged	3.82
10/22/05	Saturday	AEN	Ave Ventura/5169/V	10:47pm	Fido Summer	00:00:30	20	Charged	4.81
10/22/05	Saturday	AMC	Ave Ventura/5169/V	7:25am	Fido Summer	00:00:30	26	Charged	0.24
10/22/05	Saturday	BRV	Ave Ventura/5169/V	7:19pm	Fido Summer	00:00:30	32	Charged	1.51
10/22/05	Saturday	FOOD	Ave Ventura/5169/V	12:17pm	Fido Summer	00:00:30	38	Charged	0.85
10/22/05	Saturday	HGTV	Ave Ventura/5169/V	10:17pm	Fido Summer	00:00:30	56	Charged	5.10
10/22/05	Saturday	HIST	Ave Ventura/5169/V	8:14am	Fido Summer	00:00:30	74	Charged	0.61
10/22/05	Saturday	TRAV	Ave Ventura/5169/V	9:45pm	Fido Summer	00:00:30	98	Charged	0.38
10/22/05	Saturday	USA	Ave Ventura/5169/V	4:16pm	Fido Summer	00:00:30	86	Charged	4.96
10/22/05	Saturday	AEN	Camarillo/5168/VWC	2:40pm	Fido Summer	00:00:30	16	Charged	11.47
10/22/05	Saturday	AEN	Camarillo/5168/VWC	8:37pm	Fido Summer	00:00:30	22	Charged	14.44
10/22/05	Saturday	AMC	Camarillo/5168/VWC	12:48am	Fido Summer	00:00:30	28	Charged	0.71
10/22/05	Saturday	BRV	Camarillo/5168/VWC	11:18pm	Fido Summer	00:00:30	34	Charged	4.53
10/22/05	Saturday	FOOD	Camarillo/5168/VWC	1:17pm	Fido Summer	00:00:30	40	Charged	2.55
10/22/05	Saturday	HIST	Camarillo/5168/VWC	1:16pm	Fido Summer	00:00:30	76	Charged	1.84
10/22/05	Saturday	TRAV	Camarillo/5168/VWC	6:23am	Fido Summer	00:00:30	100	Charged	1.13
10/22/05	Saturday	AEN	Ojai/5855/VWC	9:09am	Fido Summer	00:00:30	13	Charged	4.78
10/22/05	Saturday	AEN	Ojai/5855/VWC	10:09pm	Fido Summer	00:00:30	19	Charged	6.02
10/22/05	Saturday	AMC	Ojai/5855/VWC	1:51pm	Fido Summer	00:00:30	25	Charged	0.30
10/22/05	Saturday	BRV	Ojai/5855/VWC	6:17pm	Fido Summer	00:00:30	31	Charged	1.89
10/22/05	Saturday	FOOD	Ojai/5855/VWC	12:19am	Fido Summer	00:00:30	37	Charged	1.06
10/22/05	Saturday	HGTV	Ojai/5855/VWC	4:19pm	Fido Summer	00:00:30	55	Charged	6.37
10/22/05	Saturday	HGTV	Ojai/5855/VWC	4:46pm	Fido Summer	00:00:30	55	Charged	6.37
10/22/05	Saturday	HIST	Ojai/5855/VWC	12:19pm	Fido Summer	00:00:30	73	Charged	0.77
10/22/05	Saturday	TRAV	Ojai/5855/VWC	6:23am	Fido Summer	00:00:30	97	Charged	0.47
10/22/05	Saturday	USA	Ojai/5855/VWC	4:17pm	Fido Summer	00:00:30	85	Charged	6.20
10/22/05	Saturday	AEN	Simi Valley/1571/VE	9:38am	Fido Summer	00:00:30	18	Charged	15.05
10/22/05	Saturday	AEN	Simi Valley/1571/VE	8:37pm	Fido Summer	00:00:30	24	Charged	18.95
10/22/05	Saturday	AMC	Simi Valley/1571/VE	10:06am	Fido Summer	00:00:30	30	Charged	0.92
10/22/05	Saturday	BRV	Simi Valley/1571/VE	11:41pm	Fido Summer	00:00:30	36	Charged	5.94
10/22/05	Saturday	FOOD	Simi Valley/1571/VE	10:47am	Fido Summer	00:00:30	42	Charged	3.35

10/22/05	Saturday	HGTV	Simi Valley/1571/VE	5:18pm	Fido Summer	00:00:30	60	Charged	20.07
10/22/05	Saturday	HGTV	Simi Valley/1571/VE	5:43pm	Fido Summer	00:00:30	60	Charged	20.07
10/22/05	Saturday	HGTV	Simi Valley/1571/VE	11:16pm	Fido Summer	00:00:30	60	Charged	20.07
10/22/05	Saturday	HIST	Simi Valley/1571/VE	5:59am	Fido Summer	00:00:30	78	Charged	2.42
10/22/05	Saturday	TRAV	Simi Valley/1571/VE	8:53am	Fido Summer	00:00:30	102	Charged	1.49
10/22/05	Saturday	USA	Simi Valley/1571/VE	4:17pm	Fido Summer	00:00:30	90	Charged	19.50
10/22/05	Saturday	USA	Simi Valley/1571/VE	11:38pm	Fido Summer	00:00:30	90	Charged	19.50
10/22/05	Saturday	AEN	Thousand Oaks/890/	9:38am	Fido Summer	00:00:30	15	Charged	20.07
10/22/05	Saturday	AMC	Thousand Oaks/890/	12:20am	Fido Summer	00:00:30	27	Charged	1.24
10/22/05	Saturday	BRV	Thousand Oaks/890/	6:49pm	Fido Summer	00:00:30	33	Charged	7.93
10/22/05	Saturday	FOOD	Thousand Oaks/890/	12:19am	Fido Summer	00:00:30	39	Charged	4.46
10/22/05	Saturday	HIST	Thousand Oaks/890/	11:18am	Fido Summer	00:00:30	75	Charged	3.22
10/22/05	Saturday	TRAV	Thousand Oaks/890/	2:44pm	Fido Summer	00:00:30	99	Charged	1.98
10/22/05	Saturday	USA	Thousand Oaks/890/	4:48pm	Fido Summer	00:00:30	87	Charged	26.02
10/22/05	Saturday	AEN	Ventura/1614/VWC	8:42am	Fido Summer	00:00:30	17	Charged	25.81
10/22/05	Saturday	AEN	Ventura/1614/VWC	5:52pm	Fido Summer	00:00:30	23	Charged	32.50
10/22/05	Saturday	AMC	Ventura/1614/VWC	4:55am	Fido Summer	00:00:30	29	Charged	1.59
10/22/05	Saturday	BRV	Ventura/1614/VWC	10:52pm	Fido Summer	00:00:30	35	Charged	10.20
10/22/05	Saturday	FOOD	Ventura/1614/VWC	11:19am	Fido Summer	00:00:30	41	Charged	5.73
10/22/05	Saturday	HGTV	Ventura/1614/VWC	5:18pm	Fido Summer	00:00:30	59	Charged	34.41
10/22/05	Saturday	HGTV	Ventura/1614/VWC	5:43pm	Fido Summer	00:00:30	59	Charged	34.41
10/22/05	Saturday	HGTV	Ventura/1614/VWC	7:18pm	Fido Summer	00:00:30	59	Charged	34.41
10/22/05	Saturday	HIST	Ventura/1614/VWC	9:11am	Fido Summer	00:00:30	77	Charged	4.14
10/22/05	Saturday	TRAV	Ventura/1614/VWC	7:42pm	Fido Summer	00:00:30	101	Charged	2.55
10/22/05	Saturday	USA	Ventura/1614/VWC	6:05pm	Fido Summer	00:00:30	89	Charged	33.45
10/23/05	Sunday	AEN	Ave Ventura/5169/V	3:09pm	Fido Summer	00:00:30	14	Charged	3.82
10/23/05	Sunday	AEN	Ave Ventura/5169/V	8:40pm	Fido Summer	00:00:30	20	Charged	4.81
10/23/05	Sunday	AMC	Ave Ventura/5169/V	11:12pm	Fido Summer	00:00:30	26	Charged	0.24
10/23/05	Sunday	FOOD	Ave Ventura/5169/V	8:48am	Fido Summer	00:00:30	38	Charged	0.85
10/23/05	Sunday	FOOD	Ave Ventura/5169/V	10:18pm	Fido Summer	00:00:30	109	Charged	3.67
10/23/05	Sunday	HGTV	Ave Ventura/5169/V	9:15am	Fido Summer	00:00:30	68	Charged	4.34
10/23/05	Sunday	HGTV	Ave Ventura/5169/V	8:47pm	Fido Summer	00:00:30	115	Charged	4.33
10/23/05	Sunday	HGTV	Ave Ventura/5169/V	11:48pm	Fido Summer	00:00:30	56	Charged	5.10
10/23/05	Sunday	HIST	Ave Ventura/5169/V	6:40am	Fido Summer	00:00:30	74	Charged	0.61
10/23/05	Sunday	HIST	Ave Ventura/5169/V	4:50pm	Fido Summer	00:00:30	80	Charged	1.98
10/23/05	Sunday	TRAV	Ave Ventura/5169/V	8:20pm	Fido Summer	00:00:30	98	Charged	0.38
10/23/05	Sunday	USA	Ave Ventura/5169/V	11:30pm	Fido Summer	00:00:30	86	Charged	4.96
10/23/05	Sunday	AEN	Camarillo/5168/VWC	12:10pm	Fido Summer	00:00:30	16	Charged	11.47
10/23/05	Sunday	AEN	Camarillo/5168/VWC	9:09pm	Fido Summer	00:00:30	22	Charged	14.44
10/23/05	Sunday	AMC	Camarillo/5168/VWC	1:22pm	Fido Summer	00:00:30	28	Charged	0.71
10/23/05	Sunday	FOOD	Camarillo/5168/VWC	10:17am	Fido Summer	00:00:30	40	Charged	2.55
10/23/05	Sunday	FOOD	Camarillo/5168/VWC	10:18pm	Fido Summer	00:00:30	110	Charged	11.01
10/23/05	Sunday	HGTV	Camarillo/5168/VWC	9:15am	Fido Summer	00:00:30	70	Charged	13.03
10/23/05	Sunday	HGTV	Camarillo/5168/VWC	9:46pm	Fido Summer	00:00:30	116	Charged	12.99
10/23/05	Sunday	HIST	Camarillo/5168/VWC	2:49pm	Fido Summer	00:00:30	76	Charged	1.84
10/23/05	Sunday	HIST	Camarillo/5168/VWC	8:13pm	Fido Summer	00:00:30	82	Charged	5.95
10/23/05	Sunday	TRAV	Camarillo/5168/VWC	1:17pm	Fido Summer	00:00:30	100	Charged	1.13
10/23/05	Sunday	USA	Camarillo/5168/VWC	4:22pm	Fido Summer	00:00:30	88	Charged	14.87
10/23/05	Sunday	AEN	Ojai/5855/VWC	11:11am	Fido Summer	00:00:30	13	Charged	4.78
10/23/05	Sunday	AEN	Ojai/5855/VWC	7:11pm	Fido Summer	00:00:30	19	Charged	6.02
10/23/05	Sunday	AMC	Ojai/5855/VWC	5:37am	Fido Summer	00:00:30	25	Charged	0.30
10/23/05	Sunday	FOOD	Ojai/5855/VWC	3:52pm	Fido Summer	00:00:30	37	Charged	1.06
10/23/05	Sunday	FOOD	Ojai/5855/VWC	10:18pm	Fido Summer	00:00:30	111	Charged	4.59
10/23/05	Sunday	HGTV	Ojai/5855/VWC	9:15am	Fido Summer	00:00:30	67	Charged	5.43
10/23/05	Sunday	HGTV	Ojai/5855/VWC	5:16pm	Fido Summer	00:00:30	55	Charged	6.37
10/23/05	Sunday	HGTV	Ojai/5855/VWC	9:18pm	Fido Summer	00:00:30	117	Charged	5.41
10/23/05	Sunday	HIST	Ojai/5855/VWC	10:44am	Fido Summer	00:00:30	73	Charged	0.77
10/23/05	Sunday	HIST	Ojai/5855/VWC	11:02pm	Fido Summer	00:00:30	79	Charged	2.48
10/23/05	Sunday	TRAV	Ojai/5855/VWC	1:17pm	Fido Summer	00:00:30	97	Charged	0.47
10/23/05	Sunday	AEN	Simi Valley/1571/VE	3:49pm	Fido Summer	00:00:30	18	Charged	15.05
10/23/05	Sunday	AEN	Simi Valley/1571/VE	9:09pm	Fido Summer	00:00:30	24	Charged	18.95
10/23/05	Sunday	AMC	Simi Valley/1571/VE	12:55am	Fido Summer	00:00:30	30	Charged	0.92
10/23/05	Sunday	FOOD	Simi Valley/1571/VE	1:18am	Fido Summer	00:00:30	42	Charged	3.35
10/23/05	Sunday	FOOD	Simi Valley/1571/VE	10:52pm	Fido Summer	00:00:30	112	Charged	14.68
10/23/05	Sunday	HGTV	Simi Valley/1571/VE	9:15am	Fido Summer	00:00:30	72	Charged	17.09
10/23/05	Sunday	HGTV	Simi Valley/1571/VE	6:18pm	Fido Summer	00:00:30	60	Charged	20.07

10/23/05	Sunday	HGTV	Simi Valley/1571/VE	9:46pm	Fido Summer	00:00:30	118	Charged	17.32
10/23/05	Sunday	HIST	Simi Valley/1571/VE	11:17am	Fido Summer	00:00:30	78	Charged	2.42
10/23/05	Sunday	HIST	Simi Valley/1571/VE	5:50pm	Fido Summer	00:00:30	84	Charged	7.80
10/23/05	Sunday	TRAV	Simi Valley/1571/VE	10:41am	Fido Summer	00:00:30	102	Charged	1.49
10/23/05	Sunday	USA	Simi Valley/1571/VE	9:29pm	Fido Summer	00:00:30	90	Charged	19.50
10/23/05	Sunday	AEN	Thousand Oaks/890/	11:11am	Fido Summer	00:00:30	15	Charged	20.07
10/23/05	Sunday	AEN	Thousand Oaks/890/	5:11pm	Fido Summer	00:00:30	21	Charged	25.28
10/23/05	Sunday	AMC	Thousand Oaks/890/	10:42am	Fido Summer	00:00:30	27	Charged	1.24
10/23/05	Sunday	FOOD	Thousand Oaks/890/	9:17am	Fido Summer	00:00:30	39	Charged	4.46
10/23/05	Sunday	FOOD	Thousand Oaks/890/	10:52pm	Fido Summer	00:00:30	113	Charged	19.27
10/23/05	Sunday	HGTV	Thousand Oaks/890/	9:15am	Fido Summer	00:00:30	69	Charged	22.80
10/23/05	Sunday	HGTV	Thousand Oaks/890/	8:47pm	Fido Summer	00:00:30	119	Charged	22.73
10/23/05	Sunday	HIST	Thousand Oaks/890/	1:41pm	Fido Summer	00:00:30	75	Charged	3.22
10/23/05	Sunday	HIST	Thousand Oaks/890/	10:48pm	Fido Summer	00:00:30	81	Charged	10.41
10/23/05	Sunday	TRAV	Thousand Oaks/890/	11:38pm	Fido Summer	00:00:30	99	Charged	1.98
10/23/05	Sunday	USA	Thousand Oaks/890/	5:41pm	Fido Summer	00:00:30	87	Charged	26.02
10/23/05	Sunday	AEN	Ventura/1614/VWC	7:22am	Fido Summer	00:00:30	17	Charged	25.81
10/23/05	Sunday	AEN	Ventura/1614/VWC	6:12pm	Fido Summer	00:00:30	23	Charged	32.50
10/23/05	Sunday	AMC	Ventura/1614/VWC	1:50am	Fido Summer	00:00:30	29	Charged	1.59
10/23/05	Sunday	FOOD	Ventura/1614/VWC	1:52am	Fido Summer	00:00:30	41	Charged	5.73
10/23/05	Sunday	FOOD	Ventura/1614/VWC	10:52pm	Fido Summer	00:00:30	114	Charged	24.78
10/23/05	Sunday	HGTV	Ventura/1614/VWC	9:15am	Fido Summer	00:00:30	71	Charged	29.31
10/23/05	Sunday	HGTV	Ventura/1614/VWC	6:18pm	Fido Summer	00:00:30	59	Charged	34.41
10/23/05	Sunday	HGTV	Ventura/1614/VWC	8:47pm	Fido Summer	00:00:30	59	Charged	34.41
10/23/05	Sunday	HGTV	Ventura/1614/VWC	9:46pm	Fido Summer	00:00:30	120	Charged	29.22
10/23/05	Sunday	HIST	Ventura/1614/VWC	12:18am	Fido Summer	00:00:30	77	Charged	4.14
10/23/05	Sunday	HIST	Ventura/1614/VWC	4:50pm	Fido Summer	00:00:30	83	Charged	13.38
10/23/05	Sunday	TRAV	Ventura/1614/VWC	9:22am	Fido Summer	00:00:30	101	Charged	2.55
10/23/05	Sunday	USA	Ventura/1614/VWC	4:49pm	Fido Summer	00:00:30	89	Charged	33.45
10/23/05	Sunday	USA	Ventura/1614/VWC	5:41pm	Fido Summer	00:00:30	89	Charged	33.45
10/24/05	Monday	BRV	Ave Ventura/5169/V	4:13pm	Fido Summer	00:00:30	32	Charged	1.51
10/24/05	Monday	FOOD	Ave Ventura/5169/V	4:59am	Fido Summer	00:00:30	38	Charged	0.85
10/24/05	Monday	FOOD	Ave Ventura/5169/V	9:47pm	Fido Summer	00:00:30	103	Charged	3.67
10/24/05	Monday	FOXN	Ave Ventura/5169/V	6:49pm	Fido Summer	00:00:30	92	Charged	3.54
10/24/05	Monday	HGTV	Ave Ventura/5169/V	11:50pm	Fido Summer	00:00:30	56	Charged	5.10
10/24/05	Monday	BRV	Camarillo/5168/VWC	11:33pm	Fido Summer	00:00:30	34	Charged	4.53
10/24/05	Monday	FOOD	Camarillo/5168/VWC	12:18am	Fido Summer	00:00:30	40	Charged	2.55
10/24/05	Monday	FOOD	Camarillo/5168/VWC	9:47pm	Fido Summer	00:00:30	104	Charged	11.01
10/24/05	Monday	HGTV	Camarillo/5168/VWC	4:18pm	Fido Summer	00:00:30	58	Charged	15.29
10/24/05	Monday	HGTV	Camarillo/5168/VWC	5:18pm	Fido Summer	00:00:30	58	Charged	15.29
10/24/05	Monday	HGTV	Camarillo/5168/VWC	6:48pm	Fido Summer	00:00:30	58	Charged	15.29
10/24/05	Monday	BRV	Ojai/5855/VWC	11:09pm	Fido Summer	00:00:30	31	Charged	1.89
10/24/05	Monday	FOOD	Ojai/5855/VWC	9:47pm	Fido Summer	00:00:30	105	Charged	4.59
10/24/05	Monday	FOOD	Ojai/5855/VWC	11:19pm	Fido Summer	00:00:30	37	Charged	1.06
10/24/05	Monday	FOXN	Ojai/5855/VWC	4:48pm	Fido Summer	00:00:30	91	Charged	4.42
10/24/05	Monday	BRV	Simi Valley/1571/VE	7:08pm	Fido Summer	00:00:30	36	Charged	5.94
10/24/05	Monday	FOOD	Simi Valley/1571/VE	9:47pm	Fido Summer	00:00:30	106	Charged	14.68
10/24/05	Monday	FOOD	Simi Valley/1571/VE	11:57pm	Fido Summer	00:00:30	42	Charged	3.35
10/24/05	Monday	FOXN	Simi Valley/1571/VE	4:20pm	Fido Summer	00:00:30	96	Charged	13.94
10/24/05	Monday	FOXN	Simi Valley/1571/VE	4:48pm	Fido Summer	00:00:30	96	Charged	13.94
10/24/05	Monday	HGTV	Simi Valley/1571/VE	8:47pm	Fido Summer	00:00:30	60	Charged	20.07
10/24/05	Monday	BRV	Thousand Oaks/890/	6:14pm	Fido Summer	00:00:30	33	Charged	7.93
10/24/05	Monday	FOOD	Thousand Oaks/890/	12:18am	Fido Summer	00:00:30	39	Charged	4.46
10/24/05	Monday	FOOD	Thousand Oaks/890/	9:47pm	Fido Summer	00:00:30	107	Charged	19.27
10/24/05	Monday	FOXN	Thousand Oaks/890/	4:20pm	Fido Summer	00:00:30	93	Charged	18.58
10/24/05	Monday	FOXN	Thousand Oaks/890/	5:47pm	Fido Summer	00:00:30	93	Charged	18.58
10/24/05	Monday	HGTV	Thousand Oaks/890/	5:18pm	Fido Summer	00:00:30	57	Charged	26.76
10/24/05	Monday	BRV	Ventura/1614/VWC	10:07pm	Fido Summer	00:00:30	35	Charged	10.20
10/24/05	Monday	FOOD	Ventura/1614/VWC	5:59am	Fido Summer	00:00:30	41	Charged	5.73
10/24/05	Monday	FOOD	Ventura/1614/VWC	9:47pm	Fido Summer	00:00:30	108	Charged	24.78
10/24/05	Monday	FOXN	Ventura/1614/VWC	10:48pm	Fido Summer	00:00:30	95	Charged	23.90
10/24/05	Monday	HGTV	Ventura/1614/VWC	5:48pm	Fido Summer	00:00:30	59	Charged	34.41
10/24/05	Monday	HGTV	Ventura/1614/VWC	8:16pm	Fido Summer	00:00:30	59	Charged	34.41
10/25/05	Tuesday	BRV	Ave Ventura/5169/V	6:39pm	Fido Summer	00:00:30	32	Charged	1.51
10/25/05	Tuesday	FOOD	Ave Ventura/5169/V	10:46pm	Fido Summer	00:00:30	38	Charged	0.85

10/25/05	Tuesday	FOXN	Ave Ventura/5169/V	10:22pm	Fido Summer	00:00:30	92	Charged	3.54
10/25/05	Tuesday	HGTV	Ave Ventura/5169/V	8:49pm	Fido Summer	00:00:30	56	Charged	5.10
10/25/05	Tuesday	BRV	Camarillo/5168/VWC	10:47pm	Fido Summer	00:00:30	34	Charged	4.53
10/25/05	Tuesday	FOOD	Camarillo/5168/VWC	2:17am	Fido Summer	00:00:30	40	Charged	2.55
10/25/05	Tuesday	FOXN	Camarillo/5168/VWC	4:46pm	Fido Summer	00:00:30	94	Charged	10.62
10/25/05	Tuesday	FOXN	Camarillo/5168/VWC	5:20pm	Fido Summer	00:00:30	94	Charged	10.62
10/25/05	Tuesday	HGTV	Camarillo/5168/VWC	4:19pm	Fido Summer	00:00:30	58	Charged	15.29
10/25/05	Tuesday	HGTV	Camarillo/5168/VWC	4:46pm	Fido Summer	00:00:30	58	Charged	15.29
10/25/05	Tuesday	HGTV	Camarillo/5168/VWC	5:48pm	Fido Summer	00:00:30	58	Charged	15.29
10/25/05	Tuesday	BRV	Ojai/5855/VWC	9:12pm	Fido Summer	00:00:30	31	Charged	1.89
10/25/05	Tuesday	FOOD	Ojai/5855/VWC	12:18pm	Fido Summer	00:00:30	37	Charged	1.06
10/25/05	Tuesday	FOXN	Ojai/5855/VWC	4:47pm	Fido Summer	00:00:30	91	Charged	4.42
10/25/05	Tuesday	FOXN	Ojai/5855/VWC	7:47pm	Fido Summer	00:00:30	91	Charged	4.42
10/25/05	Tuesday	HGTV	Ojai/5855/VWC	4:19pm	Fido Summer	00:00:30	55	Charged	6.37
10/25/05	Tuesday	HGTV	Ojai/5855/VWC	5:18pm	Fido Summer	00:00:30	55	Charged	6.37
10/25/05	Tuesday	BRV	Simi Valley/1571/VE	6:40pm	Fido Summer	00:00:30	36	Charged	5.94
10/25/05	Tuesday	FOOD	Simi Valley/1571/VE	11:21pm	Fido Summer	00:00:30	42	Charged	3.35
10/25/05	Tuesday	FOXN	Simi Valley/1571/VE	11:51pm	Fido Summer	00:00:30	96	Charged	13.94
10/25/05	Tuesday	HGTV	Simi Valley/1571/VE	7:18pm	Fido Summer	00:00:30	60	Charged	20.07
10/25/05	Tuesday	BRV	Thousand Oaks/890/	8:13pm	Fido Summer	00:00:30	33	Charged	7.93
10/25/05	Tuesday	FOOD	Thousand Oaks/890/	4:16am	Fido Summer	00:00:30	39	Charged	4.46
10/25/05	Tuesday	FOXN	Thousand Oaks/890/	4:46pm	Fido Summer	00:00:30	93	Charged	18.58
10/25/05	Tuesday	HGTV	Thousand Oaks/890/	4:46pm	Fido Summer	00:00:30	57	Charged	26.76
10/25/05	Tuesday	HGTV	Thousand Oaks/890/	5:18pm	Fido Summer	00:00:30	57	Charged	26.76
10/25/05	Tuesday	HGTV	Thousand Oaks/890/	5:48pm	Fido Summer	00:00:30	57	Charged	26.76
10/25/05	Tuesday	BRV	Ventura/1614/VWC	5:13pm	Fido Summer	00:00:30	35	Charged	10.20
10/25/05	Tuesday	FOOD	Ventura/1614/VWC	10:46pm	Fido Summer	00:00:30	41	Charged	5.73
10/25/05	Tuesday	FOXN	Ventura/1614/VWC	11:50pm	Fido Summer	00:00:30	95	Charged	23.90
10/25/05	Tuesday	HGTV	Ventura/1614/VWC	10:46pm	Fido Summer	00:00:30	59	Charged	34.41
10/26/05	Wednesday	FOOD	Ave Ventura/5169/V	9:17pm	Fido Summer	00:00:30	38	Charged	0.85
10/26/05	Wednesday	FOXN	Ave Ventura/5169/V	8:46pm	Fido Summer	00:00:30	92	Charged	3.54
10/26/05	Wednesday	HGTV	Ave Ventura/5169/V	9:18pm	Fido Summer	00:00:30	56	Charged	5.10
10/26/05	Wednesday	FOOD	Camarillo/5168/VWC	2:47pm	Fido Summer	00:00:30	40	Charged	2.55
10/26/05	Wednesday	FOXN	Camarillo/5168/VWC	5:46pm	Fido Summer	00:00:30	94	Charged	10.62
10/26/05	Wednesday	HGTV	Camarillo/5168/VWC	5:48pm	Fido Summer	00:00:30	58	Charged	15.29
10/26/05	Wednesday	FOOD	Ojai/5855/VWC	9:46pm	Fido Summer	00:00:30	37	Charged	1.06
10/26/05	Wednesday	HGTV	Ojai/5855/VWC	4:16pm	Fido Summer	00:00:30	55	Charged	6.37
10/26/05	Wednesday	HGTV	Ojai/5855/VWC	4:48pm	Fido Summer	00:00:30	55	Charged	6.37
10/26/05	Wednesday	HGTV	Ojai/5855/VWC	5:17pm	Fido Summer	00:00:30	55	Charged	6.37
10/26/05	Wednesday	HGTV	Ojai/5855/VWC	7:16pm	Fido Summer	00:00:30	55	Charged	6.37
10/26/05	Wednesday	FOOD	Simi Valley/1571/VE	7:59am	Fido Summer	00:00:30	42	Charged	3.35
10/26/05	Wednesday	HGTV	Simi Valley/1571/VE	5:17pm	Fido Summer	00:00:30	60	Charged	20.07
10/26/05	Wednesday	FOOD	Thousand Oaks/890/	2:16am	Fido Summer	00:00:30	39	Charged	4.46
10/26/05	Wednesday	FOOD	Ventura/1614/VWC	1:14am	Fido Summer	00:00:30	41	Charged	5.73
10/26/05	Wednesday	FOXN	Ventura/1614/VWC	11:46pm	Fido Summer	00:00:30	95	Charged	23.90
10/26/05	Wednesday	HGTV	Ventura/1614/VWC	5:48pm	Fido Summer	00:00:30	59	Charged	34.41
10/27/05	Thursday	FOOD	Ave Ventura/5169/V	8:21pm	Fido Summer	00:00:30	38	Charged	0.85
10/27/05	Thursday	HGTV	Ave Ventura/5169/V	10:17pm	Fido Summer	00:00:30	56	Charged	5.10
10/27/05	Thursday	FOOD	Camarillo/5168/VWC	7:59am	Fido Summer	00:00:30	40	Charged	2.55
10/27/05	Thursday	FOOD	Ojai/5855/VWC	12:21am	Fido Summer	00:00:30	37	Charged	1.06
10/27/05	Thursday	FOOD	Simi Valley/1571/VE	12:21am	Fido Summer	00:00:30	42	Charged	3.35
10/27/05	Thursday	HGTV	Simi Valley/1571/VE	6:17pm	Fido Summer	00:00:30	60	Charged	20.07
10/27/05	Thursday	FOOD	Thousand Oaks/890/	12:21am	Fido Summer	00:00:30	39	Charged	4.46
10/27/05	Thursday	HGTV	Thousand Oaks/890/	4:47pm	Fido Summer	00:00:30	57	Charged	26.76
10/27/05	Thursday	HGTV	Thousand Oaks/890/	5:47pm	Fido Summer	00:00:30	57	Charged	26.76
10/27/05	Thursday	FOOD	Ventura/1614/VWC	12:21am	Fido Summer	00:00:30	41	Charged	5.73
10/28/05	Friday	BRV	Ave Ventura/5169/V	10:39pm	Fido Summer	00:00:30	32	Charged	1.51
10/28/05	Friday	FOOD	Ave Ventura/5169/V	6:47pm	Fido Summer	00:00:30	50	Charged	3.73
10/28/05	Friday	FOOD	Ave Ventura/5169/V	11:56pm	Fido Summer	00:00:30	38	Charged	0.85
10/28/05	Friday	HGTV	Ave Ventura/5169/V	7:19pm	Fido Summer	00:00:30	56	Charged	5.10
10/28/05	Friday	USA	Ave Ventura/5169/V	11:42pm	Fido Summer	00:00:30	86	Charged	4.96
10/28/05	Friday	BRV	Camarillo/5168/VWC	9:05pm	Fido Summer	00:00:30	34	Charged	4.53
10/28/05	Friday	FOOD	Camarillo/5168/VWC	2:56am	Fido Summer	00:00:30	40	Charged	2.55
10/28/05	Friday	FOOD	Camarillo/5168/VWC	6:47pm	Fido Summer	00:00:30	52	Charged	11.19

10/28/05	Friday	BRV	Ojai/5855/VWC	11:34pm	Fido Summer	00:00:30	31	Charged	1.89
10/28/05	Friday	FOOD	Ojai/5855/VWC	6:47pm	Fido Summer	00:00:30	49	Charged	4.66
10/28/05	Friday	FOOD	Ojai/5855/VWC	7:47pm	Fido Summer	00:00:30	37	Charged	1.06
10/28/05	Friday	USA	Ojai/5855/VWC	5:04pm	Fido Summer	00:00:30	85	Charged	6.20
10/28/05	Friday	BRV	Simi Valley/1571/VE	6:19pm	Fido Summer	00:00:30	36	Charged	5.94
10/28/05	Friday	FOOD	Simi Valley/1571/VE	12:21am	Fido Summer	00:00:30	42	Charged	3.35
10/28/05	Friday	FOOD	Simi Valley/1571/VE	6:47pm	Fido Summer	00:00:30	54	Charged	14.67
10/28/05	Friday	HGTV	Simi Valley/1571/VE	5:48pm	Fido Summer	00:00:30	60	Charged	20.07
10/28/05	Friday	USA	Simi Valley/1571/VE	8:18pm	Fido Summer	00:00:30	90	Charged	19.50
10/28/05	Friday	BRV	Thousand Oaks/890/	4:13pm	Fido Summer	00:00:30	33	Charged	7.93
10/28/05	Friday	FOOD	Thousand Oaks/890/	12:21am	Fido Summer	00:00:30	39	Charged	4.46
10/28/05	Friday	FOOD	Thousand Oaks/890/	6:47pm	Fido Summer	00:00:30	51	Charged	19.58
10/28/05	Friday	USA	Thousand Oaks/890/	5:04pm	Fido Summer	00:00:30	87	Charged	26.02
10/28/05	Friday	BRV	Ventura/1614/VWC	9:05pm	Fido Summer	00:00:30	35	Charged	10.20
10/28/05	Friday	FOOD	Ventura/1614/VWC	12:21am	Fido Summer	00:00:30	41	Charged	5.73
10/28/05	Friday	FOOD	Ventura/1614/VWC	6:47pm	Fido Summer	00:00:30	53	Charged	25.17
10/28/05	Friday	HGTV	Ventura/1614/VWC	4:48pm	Fido Summer	00:00:30	59	Charged	34.41
10/29/05	Saturday	AEN	Ave Ventura/5169/V	10:10am	Fido Summer	00:00:30	14	Charged	3.82
10/29/05	Saturday	AEN	Ave Ventura/5169/V	11:17pm	Fido Summer	00:00:30	20	Charged	4.81
10/29/05	Saturday	AMC	Ave Ventura/5169/V	10:44pm	Fido Summer	00:00:30	26	Charged	0.24
10/29/05	Saturday	BRV	Ave Ventura/5169/V	9:36pm	Fido Summer	00:00:30	32	Charged	1.51
10/29/05	Saturday	FOOD	Ave Ventura/5169/V	10:47am	Fido Summer	00:00:30	38	Charged	0.85
10/29/05	Saturday	HGTV	Ave Ventura/5169/V	5:14pm	Fido Summer	00:00:30	56	Charged	5.10
10/29/05	Saturday	HIST	Ave Ventura/5169/V	2:10am	Fido Summer	00:00:30	74	Charged	0.61
10/29/05	Saturday	TRAV	Ave Ventura/5169/V	6:23pm	Fido Summer	00:00:30	98	Charged	0.38
10/29/05	Saturday	USA	Ave Ventura/5169/V	4:19pm	Fido Summer	00:00:30	86	Charged	4.96
10/29/05	Saturday	AEN	Camarillo/5168/VWC	7:51am	Fido Summer	00:00:30	16	Charged	11.47
10/29/05	Saturday	AEN	Camarillo/5168/VWC	9:46pm	Fido Summer	00:00:30	22	Charged	14.44
10/29/05	Saturday	AMC	Camarillo/5168/VWC	10:22am	Fido Summer	00:00:30	28	Charged	0.71
10/29/05	Saturday	BRV	Camarillo/5168/VWC	9:13pm	Fido Summer	00:00:30	34	Charged	4.53
10/29/05	Saturday	FOOD	Camarillo/5168/VWC	8:47am	Fido Summer	00:00:30	40	Charged	2.55
10/29/05	Saturday	HGTV	Camarillo/5168/VWC	4:46pm	Fido Summer	00:00:30	58	Charged	15.29
10/29/05	Saturday	HGTV	Camarillo/5168/VWC	5:14pm	Fido Summer	00:00:30	58	Charged	15.29
10/29/05	Saturday	HIST	Camarillo/5168/VWC	1:10pm	Fido Summer	00:00:30	76	Charged	1.84
10/29/05	Saturday	TRAV	Camarillo/5168/VWC	7:45am	Fido Summer	00:00:30	100	Charged	1.13
10/29/05	Saturday	AEN	Ojai/5855/VWC	10:10am	Fido Summer	00:00:30	13	Charged	4.78
10/29/05	Saturday	AEN	Ojai/5855/VWC	7:40pm	Fido Summer	00:00:30	19	Charged	6.02
10/29/05	Saturday	AMC	Ojai/5855/VWC	12:23am	Fido Summer	00:00:30	25	Charged	0.30
10/29/05	Saturday	BRV	Ojai/5855/VWC	8:13pm	Fido Summer	00:00:30	31	Charged	1.89
10/29/05	Saturday	FOOD	Ojai/5855/VWC	11:47am	Fido Summer	00:00:30	37	Charged	1.06
10/29/05	Saturday	HIST	Ojai/5855/VWC	12:12am	Fido Summer	00:00:30	73	Charged	0.77
10/29/05	Saturday	TRAV	Ojai/5855/VWC	11:21pm	Fido Summer	00:00:30	97	Charged	0.47
10/29/05	Saturday	AEN	Simi Valley/1571/VE	10:10am	Fido Summer	00:00:30	18	Charged	15.05
10/29/05	Saturday	AEN	Simi Valley/1571/VE	9:46pm	Fido Summer	00:00:30	24	Charged	18.95
10/29/05	Saturday	AMC	Simi Valley/1571/VE	4:36am	Fido Summer	00:00:30	30	Charged	0.92
10/29/05	Saturday	BRV	Simi Valley/1571/VE	10:37pm	Fido Summer	00:00:30	36	Charged	5.94
10/29/05	Saturday	FOOD	Simi Valley/1571/VE	12:21am	Fido Summer	00:00:30	42	Charged	3.35
10/29/05	Saturday	FOOD	Simi Valley/1571/VE	4:46am	Fido Summer	00:00:30	42	Charged	3.35
10/29/05	Saturday	HGTV	Simi Valley/1571/VE	4:46pm	Fido Summer	00:00:30	60	Charged	20.07
10/29/05	Saturday	HIST	Simi Valley/1571/VE	12:12am	Fido Summer	00:00:30	78	Charged	2.42
10/29/05	Saturday	TRAV	Simi Valley/1571/VE	10:40pm	Fido Summer	00:00:30	102	Charged	1.49
10/29/05	Saturday	AEN	Thousand Oaks/890/	2:51pm	Fido Summer	00:00:30	15	Charged	20.07
10/29/05	Saturday	AEN	Thousand Oaks/890/	4:10pm	Fido Summer	00:00:30	21	Charged	25.28
10/29/05	Saturday	AEN	Thousand Oaks/890/	5:11pm	Fido Summer	00:00:30	21	Charged	25.28
10/29/05	Saturday	AMC	Thousand Oaks/890/	1:24am	Fido Summer	00:00:30	27	Charged	1.24
10/29/05	Saturday	BRV	Thousand Oaks/890/	11:13pm	Fido Summer	00:00:30	33	Charged	7.93
10/29/05	Saturday	FOOD	Thousand Oaks/890/	9:47am	Fido Summer	00:00:30	39	Charged	4.46
10/29/05	Saturday	HGTV	Thousand Oaks/890/	4:18pm	Fido Summer	00:00:30	57	Charged	26.76
10/29/05	Saturday	HGTV	Thousand Oaks/890/	9:18pm	Fido Summer	00:00:30	57	Charged	26.76
10/29/05	Saturday	HIST	Thousand Oaks/890/	12:46am	Fido Summer	00:00:30	75	Charged	3.22
10/29/05	Saturday	TRAV	Thousand Oaks/890/	12:37pm	Fido Summer	00:00:30	99	Charged	1.98
10/29/05	Saturday	AEN	Ventura/1614/VWC	6:29am	Fido Summer	00:00:30	17	Charged	25.81
10/29/05	Saturday	AEN	Ventura/1614/VWC	4:49pm	Fido Summer	00:00:30	23	Charged	32.50
10/29/05	Saturday	AMC	Ventura/1614/VWC	12:24am	Fido Summer	00:00:30	29	Charged	1.59
10/29/05	Saturday	BRV	Ventura/1614/VWC	7:12pm	Fido Summer	00:00:30	35	Charged	10.20
10/29/05	Saturday	FOOD	Ventura/1614/VWC	1:48pm	Fido Summer	00:00:30	41	Charged	5.73

10/29/05	Saturday	HGTV	Ventura/1614/VWC	7:17pm	Fido Summer	00:00:30	59	Charged	34.41
10/29/05	Saturday	HIST	Ventura/1614/VWC	12:46am	Fido Summer	00:00:30	77	Charged	4.14
10/29/05	Saturday	TRAV	Ventura/1614/VWC	5:38pm	Fido Summer	00:00:30	101	Charged	2.55
10/30/05	Sunday	AEN	Ave Ventura/5169/V	7:13am	Fido Summer	00:00:30	14	Charged	3.82
10/30/05	Sunday	AEN	Ave Ventura/5169/V	10:49pm	Fido Summer	00:00:30	20	Charged	4.81
10/30/05	Sunday	AMC	Ave Ventura/5169/V	6:20pm	Fido Summer	00:00:30	26	Charged	0.24
10/30/05	Sunday	DISC	Ave Ventura/5169/V	4:17pm	Fido Summer	00:00:30	121	Charged	5.22
10/30/05	Sunday	DISC	Ave Ventura/5169/V	5:48pm	Fido Summer	00:00:30	121	Charged	5.22
10/30/05	Sunday	DISC	Ave Ventura/5169/V	7:49pm	Fido Summer	00:00:30	121	Charged	5.22
10/30/05	Sunday	DISC	Ave Ventura/5169/V	9:12pm	Fido Summer	00:00:30	121	Charged	5.22
10/30/05	Sunday	DISC	Ave Ventura/5169/V	10:50pm	Fido Summer	00:00:30	121	Charged	5.22
10/30/05	Sunday	FOOD	Ave Ventura/5169/V	4:19pm	Fido Summer	00:00:30	38	Charged	0.85
10/30/05	Sunday	FOOD	Ave Ventura/5169/V	10:21pm	Fido Summer	00:00:30	109	Charged	3.67
10/30/05	Sunday	HGTV	Ave Ventura/5169/V	9:15am	Fido Summer	00:00:30	68	Charged	4.34
10/30/05	Sunday	HGTV	Ave Ventura/5169/V	4:18pm	Fido Summer	00:00:30	56	Charged	5.10
10/30/05	Sunday	HGTV	Ave Ventura/5169/V	9:46pm	Fido Summer	00:00:30	115	Charged	4.33
10/30/05	Sunday	HIST	Ave Ventura/5169/V	6:41am	Fido Summer	00:00:30	74	Charged	0.61
10/30/05	Sunday	HIST	Ave Ventura/5169/V	5:11pm	Fido Summer	00:00:30	80	Charged	1.98
10/30/05	Sunday	TRAV	Ave Ventura/5169/V	6:22am	Fido Summer	00:00:30	98	Charged	0.38
10/30/05	Sunday	USA	Ave Ventura/5169/V	11:26pm	Fido Summer	00:00:30	86	Charged	4.96
10/30/05	Sunday	AEN	Camarillo/5168/VWC	2:39pm	Fido Summer	00:00:30	16	Charged	11.47
10/30/05	Sunday	AEN	Camarillo/5168/VWC	4:09pm	Fido Summer	00:00:30	22	Charged	14.44
10/30/05	Sunday	AMC	Camarillo/5168/VWC	10:06am	Fido Summer	00:00:30	28	Charged	0.71
10/30/05	Sunday	DISC	Camarillo/5168/VWC	4:36pm	Fido Summer	00:00:30	122	Charged	15.67
10/30/05	Sunday	DISC	Camarillo/5168/VWC	6:35pm	Fido Summer	00:00:30	122	Charged	15.67
10/30/05	Sunday	DISC	Camarillo/5168/VWC	8:30pm	Fido Summer	00:00:30	122	Charged	15.67
10/30/05	Sunday	DISC	Camarillo/5168/VWC	10:15pm	Fido Summer	00:00:30	122	Charged	15.67
10/30/05	Sunday	DISC	Camarillo/5168/VWC	11:16pm	Fido Summer	00:00:30	122	Charged	15.67
10/30/05	Sunday	FOOD	Camarillo/5168/VWC	8:18am	Fido Summer	00:00:30	40	Charged	2.55
10/30/05	Sunday	FOOD	Camarillo/5168/VWC	10:51pm	Fido Summer	00:00:30	110	Charged	11.01
10/30/05	Sunday	HGTV	Camarillo/5168/VWC	9:15am	Fido Summer	00:00:30	70	Charged	13.03
10/30/05	Sunday	HGTV	Camarillo/5168/VWC	8:48pm	Fido Summer	00:00:30	116	Charged	12.99
10/30/05	Sunday	HIST	Camarillo/5168/VWC	4:50pm	Fido Summer	00:00:30	76	Charged	1.84
10/30/05	Sunday	HIST	Camarillo/5168/VWC	10:12pm	Fido Summer	00:00:30	82	Charged	5.95
10/30/05	Sunday	TRAV	Camarillo/5168/VWC	12:52pm	Fido Summer	00:00:30	100	Charged	1.13
10/30/05	Sunday	USA	Camarillo/5168/VWC	5:00pm	Fido Summer	00:00:30	88	Charged	14.87
10/30/05	Sunday	USA	Camarillo/5168/VWC	5:47pm	Fido Summer	00:00:30	88	Charged	14.87
10/30/05	Sunday	AEN	Ojai/5855/VWC	10:16am	Fido Summer	00:00:30	13	Charged	4.78
10/30/05	Sunday	AEN	Ojai/5855/VWC	5:40pm	Fido Summer	00:00:30	19	Charged	6.02
10/30/05	Sunday	AMC	Ojai/5855/VWC	12:16am	Fido Summer	00:00:30	25	Charged	0.30
10/30/05	Sunday	DISC	Ojai/5855/VWC	5:14pm	Fido Summer	00:00:30	123	Charged	6.53
10/30/05	Sunday	DISC	Ojai/5855/VWC	7:13pm	Fido Summer	00:00:30	123	Charged	6.53
10/30/05	Sunday	DISC	Ojai/5855/VWC	8:30pm	Fido Summer	00:00:30	123	Charged	6.53
10/30/05	Sunday	DISC	Ojai/5855/VWC	10:15pm	Fido Summer	00:00:30	123	Charged	6.53
10/30/05	Sunday	DISC	Ojai/5855/VWC	11:53pm	Fido Summer	00:00:30	123	Charged	6.53
10/30/05	Sunday	FOOD	Ojai/5855/VWC	12:22am	Fido Summer	00:00:30	37	Charged	1.06
10/30/05	Sunday	FOOD	Ojai/5855/VWC	10:51pm	Fido Summer	00:00:30	111	Charged	4.59
10/30/05	Sunday	HGTV	Ojai/5855/VWC	9:15am	Fido Summer	00:00:30	67	Charged	5.43
10/30/05	Sunday	HGTV	Ojai/5855/VWC	8:48pm	Fido Summer	00:00:30	117	Charged	5.41
10/30/05	Sunday	HIST	Ojai/5855/VWC	7:12pm	Fido Summer	00:00:30	79	Charged	2.48
10/30/05	Sunday	HIST	Ojai/5855/VWC	10:49pm	Fido Summer	00:00:30	73	Charged	0.77
10/30/05	Sunday	TRAV	Ojai/5855/VWC	8:17am	Fido Summer	00:00:30	97	Charged	0.47
10/30/05	Sunday	USA	Ojai/5855/VWC	5:17pm	Fido Summer	00:00:30	85	Charged	6.20
10/30/05	Sunday	USA	Ojai/5855/VWC	5:47pm	Fido Summer	00:00:30	85	Charged	6.20
10/30/05	Sunday	AEN	Simi Valley/1571/VE	2:12pm	Fido Summer	00:00:30	18	Charged	15.05
10/30/05	Sunday	AEN	Simi Valley/1571/VE	5:40pm	Fido Summer	00:00:30	24	Charged	18.95
10/30/05	Sunday	AMC	Simi Valley/1571/VE	11:35pm	Fido Summer	00:00:30	30	Charged	0.92
10/30/05	Sunday	DISC	Simi Valley/1571/VE	5:31pm	Fido Summer	00:00:30	124	Charged	20.90
10/30/05	Sunday	DISC	Simi Valley/1571/VE	6:34pm	Fido Summer	00:00:30	124	Charged	20.90
10/30/05	Sunday	DISC	Simi Valley/1571/VE	8:12pm	Fido Summer	00:00:30	124	Charged	20.90
10/30/05	Sunday	DISC	Simi Valley/1571/VE	9:34pm	Fido Summer	00:00:30	124	Charged	20.90
10/30/05	Sunday	DISC	Simi Valley/1571/VE	10:50pm	Fido Summer	00:00:30	124	Charged	20.90
10/30/05	Sunday	FOOD	Simi Valley/1571/VE	10:51pm	Fido Summer	00:00:30	112	Charged	14.68
10/30/05	Sunday	HGTV	Simi Valley/1571/VE	9:15am	Fido Summer	00:00:30	72	Charged	17.09
10/30/05	Sunday	HGTV	Simi Valley/1571/VE	9:46pm	Fido Summer	00:00:30	118	Charged	17.32
10/30/05	Sunday	HGTV	Simi Valley/1571/VE	11:49pm	Fido Summer	00:00:30	60	Charged	20.07

10/30/05	Sunday	HIST	Simi Valley/1571/VE	12:49pm	Fido Summer	00:00:30	78	Charged	2.42
10/30/05	Sunday	HIST	Simi Valley/1571/VE	11:14pm	Fido Summer	00:00:30	84	Charged	7.80
10/30/05	Sunday	TRAV	Simi Valley/1571/VE	4:26pm	Fido Summer	00:00:30	102	Charged	1.49
10/30/05	Sunday	USA	Simi Valley/1571/VE	4:28pm	Fido Summer	00:00:30	90	Charged	19.50
10/30/05	Sunday	USA	Simi Valley/1571/VE	5:00pm	Fido Summer	00:00:30	90	Charged	19.50
10/30/05	Sunday	AEN	Thousand Oaks/890/	10:42am	Fido Summer	00:00:30	15	Charged	20.07
10/30/05	Sunday	AEN	Thousand Oaks/890/	5:10pm	Fido Summer	00:00:30	21	Charged	25.28
10/30/05	Sunday	AMC	Thousand Oaks/890/	12:43am	Fido Summer	00:00:30	27	Charged	1.24
10/30/05	Sunday	DISC	Thousand Oaks/890/	4:17pm	Fido Summer	00:00:30	125	Charged	27.42
10/30/05	Sunday	DISC	Thousand Oaks/890/	6:52pm	Fido Summer	00:00:30	125	Charged	27.42
10/30/05	Sunday	DISC	Thousand Oaks/890/	8:12pm	Fido Summer	00:00:30	125	Charged	27.42
10/30/05	Sunday	DISC	Thousand Oaks/890/	9:35pm	Fido Summer	00:00:30	125	Charged	27.42
10/30/05	Sunday	DISC	Thousand Oaks/890/	11:16pm	Fido Summer	00:00:30	125	Charged	27.42
10/30/05	Sunday	FOOD	Thousand Oaks/890/	8:46am	Fido Summer	00:00:30	39	Charged	4.46
10/30/05	Sunday	FOOD	Thousand Oaks/890/	10:21pm	Fido Summer	00:00:30	113	Charged	19.27
10/30/05	Sunday	HGTV	Thousand Oaks/890/	9:15am	Fido Summer	00:00:30	69	Charged	22.80
10/30/05	Sunday	HGTV	Thousand Oaks/890/	5:46pm	Fido Summer	00:00:30	57	Charged	26.76
10/30/05	Sunday	HGTV	Thousand Oaks/890/	9:16pm	Fido Summer	00:00:30	119	Charged	22.73
10/30/05	Sunday	HIST	Thousand Oaks/890/	4:29am	Fido Summer	00:00:30	75	Charged	3.22
10/30/05	Sunday	HIST	Thousand Oaks/890/	4:50pm	Fido Summer	00:00:30	81	Charged	10.41
10/30/05	Sunday	TRAV	Thousand Oaks/890/	10:57pm	Fido Summer	00:00:30	99	Charged	1.98
10/30/05	Sunday	USA	Thousand Oaks/890/	4:28pm	Fido Summer	00:00:30	87	Charged	26.02
10/30/05	Sunday	USA	Thousand Oaks/890/	5:47pm	Fido Summer	00:00:30	87	Charged	26.02
10/30/05	Sunday	AEN	Ventura/1614/VWC	10:16am	Fido Summer	00:00:30	17	Charged	25.81
10/30/05	Sunday	AEN	Ventura/1614/VWC	5:40pm	Fido Summer	00:00:30	23	Charged	32.50
10/30/05	Sunday	AMC	Ventura/1614/VWC	12:16am	Fido Summer	00:00:30	29	Charged	1.59
10/30/05	Sunday	DISC	Ventura/1614/VWC	4:55pm	Fido Summer	00:00:30	126	Charged	35.26
10/30/05	Sunday	DISC	Ventura/1614/VWC	5:14pm	Fido Summer	00:00:30	126	Charged	35.26
10/30/05	Sunday	DISC	Ventura/1614/VWC	7:32pm	Fido Summer	00:00:30	126	Charged	35.26
10/30/05	Sunday	DISC	Ventura/1614/VWC	8:52pm	Fido Summer	00:00:30	126	Charged	35.26
10/30/05	Sunday	DISC	Ventura/1614/VWC	10:50pm	Fido Summer	00:00:30	126	Charged	35.26
10/30/05	Sunday	FOOD	Ventura/1614/VWC	1:48pm	Fido Summer	00:00:30	41	Charged	5.73
10/30/05	Sunday	FOOD	Ventura/1614/VWC	10:51pm	Fido Summer	00:00:30	114	Charged	24.78
10/30/05	Sunday	HGTV	Ventura/1614/VWC	9:15am	Fido Summer	00:00:30	71	Charged	29.31
10/30/05	Sunday	HGTV	Ventura/1614/VWC	4:18pm	Fido Summer	00:00:30	59	Charged	34.41
10/30/05	Sunday	HGTV	Ventura/1614/VWC	9:46pm	Fido Summer	00:00:30	120	Charged	29.22
10/30/05	Sunday	HIST	Ventura/1614/VWC	12:13am	Fido Summer	00:00:30	77	Charged	4.14
10/30/05	Sunday	HIST	Ventura/1614/VWC	4:50pm	Fido Summer	00:00:30	83	Charged	13.38
10/30/05	Sunday	TRAV	Ventura/1614/VWC	12:40pm	Fido Summer	00:00:30	101	Charged	2.55
10/30/05	Sunday	USA	Ventura/1614/VWC	4:28pm	Fido Summer	00:00:30	89	Charged	33.45
10/30/05	Sunday	USA	Ventura/1614/VWC	5:47pm	Fido Summer	00:00:30	89	Charged	33.45
10/30/05	Sunday	USA	Ventura/1614/VWC	8:52pm	Fido Summer	00:00:30	89	Charged	33.45
								Grand Total	7,675.02

Channel Summary

Network	Zone	Total Spots	Gross Revenue
AEN	Ave Ventura/5169/VWC	12	$51.78
AEN	Camarillo/5168/VWC	12	$155.46
AEN	Ojai/5855/VWC	12	$64.80
AEN	Simi Valley/1571/VEC	12	$204.00
AEN	Thousand Oaks/890/VEC	12	$272.10
AEN	Ventura/1614/VWC	12	$349.86
AMC	Ave Ventura/5169/VWC	6	$1.44
AMC	Camarillo/5168/VWC	6	$4.26
AMC	Ojai/5855/VWC	6	$1.80
AMC	Simi Valley/1571/VEC	6	$5.52
AMC	Thousand Oaks/890/VEC	6	$7.44
AMC	Ventura/1614/VWC	6	$9.54
BRV	Ave Ventura/5169/VWC	13	$19.63
BRV	Camarillo/5168/VWC	13	$58.89
BRV	Ojai/5855/VWC	13	$24.57
BRV	Simi Valley/1571/VEC	13	$77.22
BRV	Thousand Oaks/890/VEC	13	$103.09
BRV	Ventura/1614/VWC	13	$132.60
DISC	Ave Ventura/5169/VWC	5	$26.10
DISC	Camarillo/5168/VWC	5	$78.35

DISC	Ojai/5855/VWC	5	$32.65
DISC	Simi Valley/1571/VEC	5	$104.50
DISC	Thousand Oaks/890/VEC	5	$137.10
DISC	Ventura/1614/VWC	5	$176.30
FOOD	Ave Ventura/5169/VWC	28	$43.72
FOOD	Camarillo/5168/VWC	28	$131.16
FOOD	Ojai/5855/VWC	28	$54.60
FOOD 28	Simi Valley/1571/VEC	28	$173.08
FOOD	Thousand Oaks/890/VEC	28	$229.48
FOOD	Ventura/1614/VWC	28	$294.96
FOXN	Ave Ventura/5169/VWC	10	$35.40
FOXN	Camarillo/5168/VWC	10	$106.20
FOXN	Ojai/5855/VWC	10	$44.20
FOXN 10	Simi Valley/1571/VEC	10	$139.40
FOXN	Thousand Oaks/890/VEC	10	$185.80
FOXN	Ventura/1614/VWC	10	$239.00
HGTV	Ave Ventura/5169/VWC	26	$128.78
HGTV 26	Camarillo/5168/VWC	26	$386.16
HGTV	Ojai/5855/VWC	23	$141.77
HGTV	Simi Valley/1571/VEC	26	$507.38
HGTV	Thousand Oaks/890/VEC	26	$675.82
HGTV	Ventura/1614/VWC	26	$868.98
HIST	Ave Ventura/5169/VWC	9	$9.60
HIST	Camarillo/5168/VWC	9	$28.89
HIST 9	Ojai/5855/VWC	9	$12.06
HIST	Simi Valley/1571/VEC	9	$37.92
HIST	Thousand Oaks/890/VEC	9	$50.55
HIST	Ventura/1614/VWC	9	$64.98
TRAV	Ave Ventura/5169/VWC	7	$2.66
TRAV 7	Camarillo/5168/VWC	7	$7.91
TRAV	Ojai/5855/VWC	7	$3.29
TRAV	Simi Valley/1571/VEC	7	$10.43
TRAV	Thousand Oaks/890/VEC	7	$13.86
TRAV	Ventura/1614/VWC	7	$17.85
USA	Ave Ventura/5169/VWC	9	$44.64
USA 9	Camarillo/5168/VWC	8	$118.96
USA	Ojai/5855/VWC	9	$55.80
USA	Simi Valley/1571/VEC	9	$175.50
USA	Thousand Oaks/890/VEC	9	$234.18
USA	Ventura/1614/VWC	9	$301.05
	Grand Total	746	$7,675.02

41,67 Spots Per Week

125 Total Spots

A012182

Affidavit Of Performance

Co. of VTA Watershed Protection #12710

Adelphia week #1 Value Ad

ATTN: % The Agency /CIA Client

Reporting From : 10/10/05 To 10/16/05

Date	Time	Zone	Network	Ad Copy	Value
10/10/2005	00:53:06	Simi Valley/1571/VEC	FOOD	Fido Summer	0.00
10/10/2005	01:18:47	Camarillo/5168/VWC	HGTV	Fido Summer	0.00
10/10/2005	01:50:12	Camarillo/5168/VWC	FOXN	Fido Summer	0.00
10/10/2005	02:19:20	Ventura/1614/VWC	FOXN	Fido Summer	0.00
10/10/2005	02:19:41	Camarillo/5168/VWC	FOXN	Fido Summer	0.00
10/10/2005	02:41:38	Simi Valley/1571/VEC	BRV	Fido Summer	0.00
10/10/2005	02:42:08	Ave Ventura/5169/VWC	BRV	Fido Summer	0.00
10/10/2005	02:46:47	Simi Valley/1571/VEC	HGTV	Fido Summer	0.00
10/10/2005	02:47:18	Ave Ventura/5169/VWC	HGTV	Fido Summer	0.00
10/10/2005	02:50:16	Ave Ventura/5169/VWC	FOXN	Fido Summer	0.00
10/10/2005	02:50:16	Thousand Oaks/890/VEC	FOXN	Fido Summer	0.00
10/10/2005	03:20:15	Ventura/1614/VWC	FOOD	Fido Summer	0.00
10/10/2005	03:48:53	Ojai/5855/VWC	FOXN	Fido Summer	0.00
10/10/2005	04:28:30	Thousand Oaks/890/VEC	FOOD	Fido Summer	0.00
10/10/2005	04:29:01	Ave Ventura/5169/VWC	FOOD	Fido Summer	0.00
10/10/2005	04:29:32	Ojai/5855/VWC	FOOD	Fido Summer	0.00
10/10/2005	04:45:50	Thousand Oaks/890/VEC	BRV	Fido Summer	0.00
10/10/2005	04:50:57	Simi Valley/1571/VEC	FOXN	Fido Summer	0.00
10/10/2005	05:22:09	Camarillo/5168/VWC	FOXN	Fido Summer	0.00
10/10/2005	05:22:09	Ave Ventura/5169/VWC	FOXN	Fido Summer	0.00
10/10/2005	05:29:32	Camarillo/5168/VWC	FOOD	Fido Summer	0.00
10/10/2005	05:51:29	Camarillo/5168/VWC	FOXN	Fido Summer	0.00
10/10/2005	06:28:30	Simi Valley/1571/VEC	FOOD	Fido Summer	0.00
10/10/2005	06:48:44	Ventura/1614/VWC	FOXN	Fido Summer	0.00
10/10/2005	07:29:31	Ventura/1614/VWC	FOOD	Fido Summer	0.00
10/10/2005	07:30:01	Ave Ventura/5169/VWC	FOOD	Fido Summer	0.00
10/10/2005	07:48:13	Ventura/1614/VWC	HGTV	Fido Summer	0.00
10/10/2005	07:49:56	Thousand Oaks/890/VEC	FOXN	Fido Summer	0.00
10/10/2005	08:29:30	Thousand Oaks/890/VEC	FOOD	Fido Summer	0.00
10/10/2005	08:59:01	Camarillo/5168/VWC	BRV	Fido Summer	0.00
10/10/2005	09:30:01	Ave Ventura/5169/VWC	FOOD	Fido Summer	0.00
10/10/2005	09:30:01	Ojai/5855/VWC	FOOD	Fido Summer	0.00
10/10/2005	09:46:22	Ojai/5855/VWC	HGTV	Fido Summer	0.00
10/10/2005	09:47:35	Simi Valley/1571/VEC	FOOD	Fido Summer	0.00
10/10/2005	10:20:13	Camarillo/5168/VWC	FOOD	Fido Summer	0.00
10/10/2005	10:51:32	Ojai/5855/VWC	FOXN	Fido Summer	0.00
10/10/2005	11:08:10	Ventura/1614/VWC	BRV	Fido Summer	0.00
10/10/2005	11:46:52	Ojai/5855/VWC	HGTV	Fido Summer	0.00
10/10/2005	12:39:10	Ojai/5855/VWC	BRV	Fido Summer	0.00
10/10/2005	12:50:41	Ave Ventura/5169/VWC	FOXN	Fido Summer	0.00
10/10/2005	14:08:10	Ave Ventura/5169/VWC	BRV	Fido Summer	0.00
10/10/2005	15:34:18	Simi Valley/1571/VEC	BRV	Fido Summer	0.00
10/10/2005	23:21:13	Ave Ventura/5169/VWC	FOXN	Fido Summer	0.00
10/11/2005	00:46:46	Ventura/1614/VWC	HGTV	Fido Summer	0.00
10/11/2005	00:47:56	Ventura/1614/VWC	FOXN	Fido Summer	0.00
10/11/2005	01:21:20	Thousand Oaks/890/VEC	FOXN	Fido Summer	0.00
10/11/2005	01:47:13	Camarillo/5168/VWC	FOOD	Fido Summer	0.00
10/11/2005	01:47:31	Simi Valley/1571/VEC	FOXN	Fido Summer	0.00
10/11/2005	02:22:11	Simi Valley/1571/VEC	FOXN	Fido Summer	0.00
10/11/2005	02:22:11	Ojai/5855/VWC	FOXN	Fido Summer	0.00
10/11/2005	02:39:09	Thousand Oaks/890/VEC	BRV	Fido Summer	0.00
10/11/2005	02:45:33	Simi Valley/1571/VEC	HGTV	Fido Summer	0.00
10/11/2005	02:51:57	Simi Valley/1571/VEC	FOXN	Fido Summer	0.00
10/11/2005	03:16:54	Ave Ventura/5169/VWC	HGTV	Fido Summer	0.00
10/11/2005	03:45:20	Thousand Oaks/890/VEC	HGTV	Fido Summer	0.00
10/11/2005	03:57:06	Ventura/1614/VWC	FOOD	Fido Summer	0.00
10/11/2005	04:16:06	Thousand Oaks/890/VEC	FOOD	Fido Summer	0.00
10/11/2005	04:22:42	Ventura/1614/VWC	FOXN	Fido Summer	0.00
10/11/2005	04:33:37	Ojai/5855/VWC	BRV	Fido Summer	0.00
10/11/2005	04:52:42	Ave Ventura/5169/VWC	FOXN	Fido Summer	0.00
10/11/2005	05:07:42	Simi Valley/1571/VEC	BRV	Fido Summer	0.00
10/11/2005	05:29:31	Simi Va[illegible]	[illegible]	[illegible]	0.00
10/11/2005	05:51:38	Ave Ve[illegible]	[illegible]	[illegible]	0.00

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10/11/2005	05:52:24	Simi Valley/1571/VEC	FOXN	Fido Summer	0.00
10/11/2005	05:59:01	Ave Ventura/5169/VWC	FOOD	Fido Summer	0.00
10/11/2005	06:08:38	Camarillo/5168/VWC	BRV	Fido Summer	0.00
10/11/2005	06:08:38	Ventura/1614/VWC	BRV	Fido Summer	0.00
10/11/2005	06:48:46	Simi Valley/1571/VEC	FOXN	Fido Summer	0.00
10/11/2005	07:30:02	Ventura/1614/VWC	FOOD	Fido Summer	0.00
10/11/2005	07:30:03	Camarillo/5168/VWC	FOOD	Fido Summer	0.00
10/11/2005	07:50:10	Thousand Oaks/890/VEC	FOXN	Fido Summer	0.00
10/11/2005	08:29:32	Ojai/5855/VWC	FOOD	Fido Summer	0.00
10/11/2005	09:44:38	Thousand Oaks/890/VEC	HGTV	Fido Summer	0.00
10/11/2005	09:50:13	Ave Ventura/5169/VWC	FOOD	Fido Summer	0.00
10/11/2005	09:50:13	Thousand Oaks/890/VEC	FOOD	Fido Summer	0.00
10/11/2005	09:51:42	Simi Valley/1571/VEC	FOXN	Fido Summer	0.00
10/11/2005	09:52:12	Ventura/1614/VWC	FOXN	Fido Summer	0.00
10/11/2005	09:59:01	Ave Ventura/5169/VWC	BRV	Fido Summer	0.00
10/11/2005	10:16:22	Ojai/5855/VWC	HGTV	Fido Summer	0.00
10/11/2005	10:46:47	Ojai/5855/VWC	HGTV	Fido Summer	0.00
10/11/2005	10:49:00	Ave Ventura/5169/VWC	FOXN	Fido Summer	0.00
10/11/2005	10:49:00	Ojai/5855/VWC	FOXN	Fido Summer	0.00
10/11/2005	12:20:32	Ave Ventura/5169/VWC	FOXN	Fido Summer	0.00
10/11/2005	13:18:56	Simi Valley/1571/VEC	FOOD	Fido Summer	0.00
10/11/2005	13:20:33	Camarillo/5168/VWC	HGTV	Fido Summer	0.00
10/11/2005	18:49:08	Ventura/1614/VWC	HGTV	Fido Summer	0.00
10/11/2005	21:07:42	Thousand Oaks/890/VEC	BRV	Fido Summer	0.00
10/11/2005	22:47:52	Ave Ventura/5169/VWC	FOXN	Fido Summer	0.00
10/12/2005	00:18:51	Simi Valley/1571/VEC	HGTV	Fido Summer	0.00
10/12/2005	01:21:01	Ventura/1614/VWC	HGTV	Fido Summer	0.00
10/12/2005	01:46:25	Ojai/5855/VWC	FOXN	Fido Summer	0.00
10/12/2005	01:46:55	Ventura/1614/VWC	FOXN	Fido Summer	0.00
10/12/2005	01:47:26	Ave Ventura/5169/VWC	FOXN	Fido Summer	0.00
10/12/2005	02:22:11	Camarillo/5168/VWC	FOXN	Fido Summer	0.00
10/12/2005	02:48:52	Ventura/1614/VWC	FOXN	Fido Summer	0.00
10/12/2005	02:49:23	Camarillo/5168/VWC	FOXN	Fido Summer	0.00
10/12/2005	03:20:56	Ave Ventura/5169/VWC	FOOD	Fido Summer	0.00
10/12/2005	04:18:04	Thousand Oaks/890/VEC	FOOD	Fido Summer	0.00
10/12/2005	04:46:27	Ventura/1614/VWC	FOOD	Fido Summer	0.00
10/12/2005	04:52:12	Ave Ventura/5169/VWC	FOXN	Fido Summer	0.00
10/12/2005	04:52:43	Thousand Oaks/890/VEC	FOXN	Fido Summer	0.00
10/12/2005	05:28:31	Camarillo/5168/VWC	FOOD	Fido Summer	0.00
10/12/2005	05:51:00	Ventura/1614/VWC	FOXN	Fido Summer	0.00
10/12/2005	07:13:24	Camarillo/5168/VWC	HGTV	Fido Summer	0.00
10/12/2005	07:29:32	Ojai/5855/VWC	FOOD	Fido Summer	0.00
10/12/2005	07:59:31	Simi Valley/1571/VEC	FOOD	Fido Summer	0.00
10/12/2005	08:19:40	Ventura/1614/VWC	FOXN	Fido Summer	0.00
10/12/2005	08:30:02	Ventura/1614/VWC	FOOD	Fido Summer	0.00
10/12/2005	08:59:31	Ave Ventura/5169/VWC	FOOD	Fido Summer	0.00
10/12/2005	09:29:32	Camarillo/5168/VWC	FOOD	Fido Summer	0.00
10/12/2005	11:20:20	Thousand Oaks/890/VEC	HGTV	Fido Summer	0.00
10/12/2005	13:47:59	Ojai/5855/VWC	FOXN	Fido Summer	0.00
10/12/2005	14:43:53	Thousand Oaks/890/VEC	HGTV	Fido Summer	0.00
10/12/2005	14:44:24	Ave Ventura/5169/VWC	HGTV	Fido Summer	0.00
10/12/2005	14:51:40	Ave Ventura/5169/VWC	FOXN	Fido Summer	0.00
10/13/2005	01:45:20	Thousand Oaks/890/VEC	FOOD	Fido Summer	0.00
10/13/2005	02:19:55	Ventura/1614/VWC	HGTV	Fido Summer	0.00
10/13/2005	02:47:49	Simi Valley/1571/VEC	FOOD	Fido Summer	0.00
10/13/2005	04:17:25	Ventura/1614/VWC	FOOD	Fido Summer	0.00
10/13/2005	05:29:32	Ojai/5855/VWC	FOOD	Fido Summer	0.00
10/13/2005	05:30:02	Camarillo/5168/VWC	FOOD	Fido Summer	0.00
10/13/2005	07:47:08	Camarillo/5168/VWC	HGTV	Fido Summer	0.00
10/13/2005	08:29:32	Ave Ventura/5169/VWC	FOOD	Fido Summer	0.00
10/13/2005	08:59:31	Simi Valley/1571/VEC	FOOD	Fido Summer	0.00
10/13/2005	09:30:02	Thousand Oaks/890/VEC	FOOD	Fido Summer	0.00
10/13/2005	16:19:33	Ventura/1614/VWC	FOOD	Fido Summer	0.00
10/14/2005	00:20:22	Camarillo/5168/VWC	BRV	Fido Summer	0.00
10/14/2005	01:23:51	Camarillo/5168/VWC	USA	Fido Summer	0.00
10/14/2005	01:34:06	Ventura/1614/VWC	BRV	Fido Summer	0.00
10/14/2005	01:49:25	Camarillo/5168/VWC	HGTV	Fido Summer	0.00
10/14/2005	02:08:08	Thousand Oaks/890/VEC	BRV	Fido Summer	0.00
10/14/2005	02:33:36	Simi Valley/1571/VEC	BRV	Fido Summer	0.00
10/14/2005	03:13:43	Ojai/5855/VWC	BRV	Fido Summer	0.00
10/14/2005	03:20:24	Camarillo/5168/VWC	HGTV	Fido Summer	0.00
10/14/2005	03:22:20	Simi Valley/1571/VEC	FOOD	Fido Summer	0.00
10/14/2005	03:22:21	Ventura/1614/VWC	FOOD	Fido Summer	0.00
10/14/2005	04:17:44	Tl		ıer	0.00
10/14/2005	04:18:14	Ca		ıer	0.00

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10/14/2005	04:18:15	Ventura/1614/VWC	FOOD	Fido Summer	0.00
10/14/2005	04:44:38	Ojai/5855/VWC	FOOD	Fido Summer	0.00
10/14/2005	05:29:01	Simi Valley/1571/VEC	FOOD	Fido Summer	0.00
10/14/2005	06:30:03	Ave Ventura/5169/VWC	FOOD	Fido Summer	0.00
10/14/2005	07:30:03	Ojai/5855/VWC	FOOD	Fido Summer	0.00
10/14/2005	07:47:19	Ave Ventura/5169/VWC	HGTV	Fido Summer	0.00
10/14/2005	07:59:01	Ave Ventura/5169/VWC	FOOD	Fido Summer	0.00
10/14/2005	08:37:46	Ojai/5855/VWC	USA	Fido Summer	0.00
10/14/2005	08:59:31	Thousand Oaks/890/VEC	FOOD	Fido Summer	0.00
10/14/2005	08:59:32	Camarillo/5168/VWC	FOOD	Fido Summer	0.00
10/14/2005	09:29:01	Ave Ventura/5169/VWC	BRV	Fido Summer	0.00
10/14/2005	09:30:02	Simi Valley/1571/VEC	FOOD	Fido Summer	0.00
10/14/2005	09:30:03	Ventura/1614/VWC	FOOD	Fido Summer	0.00
10/14/2005	10:20:51	Ventura/1614/VWC	FOOD	Fido Summer	0.00
10/14/2005	10:29:01	Ventura/1614/VWC	BRV	Fido Summer	0.00
10/14/2005	10:42:17	Ave Ventura/5169/VWC	USA	Fido Summer	0.00
10/14/2005	12:43:52	Thousand Oaks/890/VEC	BRV	Fido Summer	0.00
10/14/2005	13:15:23	Simi Valley/1571/VEC	BRV	Fido Summer	0.00
10/14/2005	14:51:20	Ojai/5855/VWC	BRV	Fido Summer	0.00
10/14/2005	15:01:48	Camarillo/5168/VWC	USA	Fido Summer	0.00
10/14/2005	15:19:15	Simi Valley/1571/VEC	FOOD	Fido Summer	0.00
10/14/2005	17:41:24	Ave Ventura/5169/VWC	BRV	Fido Summer	0.00
10/15/2005	00:08:53	Ave Ventura/5169/VWC	BRV	Fido Summer	0.00
10/15/2005	00:12:19	Thousand Oaks/890/VEC	AEN	Fido Summer	0.00
10/15/2005	00:12:19	Ventura/1614/VWC	AEN	Fido Summer	0.00
10/15/2005	00:12:50	Camarillo/5168/VWC	AEN	Fido Summer	0.00
10/15/2005	00:26:22	Thousand Oaks/890/VEC	USA	Fido Summer	0.00
10/15/2005	00:50:12	Ventura/1614/VWC	HIST	Fido Summer	0.00
10/15/2005	00:51:12	Simi Valley/1571/VEC	HGTV	Fido Summer	0.00
10/15/2005	01:05:11	Camarillo/5168/VWC	BRV	Fido Summer	0.00
10/15/2005	01:14:07	Simi Valley/1571/VEC	AEN	Fido Summer	0.00
10/15/2005	01:17:10	Camarillo/5168/VWC	FOOD	Fido Summer	0.00
10/15/2005	01:21:11	Thousand Oaks/890/VEC	USA	Fido Summer	0.00
10/15/2005	01:21:11	Ojai/5855/VWC	USA	Fido Summer	0.00
10/15/2005	01:22:10	Camarillo/5168/VWC	AMC	Fido Summer	0.00
10/15/2005	01:34:15	Simi Valley/1571/VEC	BRV	Fido Summer	0.00
10/15/2005	01:40:23	Ventura/1614/VWC	AEN	Fido Summer	0.00
10/15/2005	01:40:24	Ojai/5855/VWC	AEN	Fido Summer	0.00
10/15/2005	01:44:11	Camarillo/5168/VWC	USA	Fido Summer	0.00
10/15/2005	01:50:42	Ojai/5855/VWC	HIST	Fido Summer	0.00
10/15/2005	01:50:42	Thousand Oaks/890/VEC	HIST	Fido Summer	0.00
10/15/2005	02:09:45	Ojai/5855/VWC	AEN	Fido Summer	0.00
10/15/2005	02:42:52	Thousand Oaks/890/VEC	AEN	Fido Summer	0.00
10/15/2005	02:53:13	Thousand Oaks/890/VEC	AMC	Fido Summer	0.00
10/15/2005	02:55:30	Camarillo/5168/VWC	USA	Fido Summer	0.00
10/15/2005	03:12:04	Simi Valley/1571/VEC	AEN	Fido Summer	0.00
10/15/2005	03:12:35	Ave Ventura/5169/VWC	AEN	Fido Summer	0.00
10/15/2005	03:49:11	Simi Valley/1571/VEC	USA	Fido Summer	0.00
10/15/2005	03:49:12	Ventura/1614/VWC	USA	Fido Summer	0.00
10/15/2005	03:50:00	Ave Ventura/5169/VWC	HGTV	Fido Summer	0.00
10/15/2005	04:08:43	Camarillo/5168/VWC	AEN	Fido Summer	0.00
10/15/2005	04:09:14	Ave Ventura/5169/VWC	AEN	Fido Summer	0.00
10/15/2005	04:13:53	Simi Valley/1571/VEC	FOOD	Fido Summer	0.00
10/15/2005	04:22:44	Simi Valley/1571/VEC	AMC	Fido Summer	0.00
10/15/2005	04:34:12	Ventura/1614/VWC	USA	Fido Summer	0.00
10/15/2005	04:49:28	Ventura/1614/VWC	AEN	Fido Summer	0.00
10/15/2005	05:02:57	Ventura/1614/VWC	USA	Fido Summer	0.00
10/15/2005	05:20:04	Thousand Oaks/890/VEC	USA	Fido Summer	0.00
10/15/2005	05:28:31	Ventura/1614/VWC	FOOD	Fido Summer	0.00
10/15/2005	05:29:01	Thousand Oaks/890/VEC	FOOD	Fido Summer	0.00
10/15/2005	05:29:31	Camarillo/5168/VWC	AEN	Fido Summer	0.00
10/15/2005	05:29:31	Thousand Oaks/890/VEC	AEN	Fido Summer	0.00
10/15/2005	05:29:32	Ojai/5855/VWC	FOOD	Fido Summer	0.00
10/15/2005	05:35:33	Ojai/5855/VWC	BRV	Fido Summer	0.00
10/15/2005	05:42:02	Ojai/5855/VWC	AMC	Fido Summer	0.00
10/15/2005	05:59:32	Camarillo/5168/VWC	FOOD	Fido Summer	0.00
10/15/2005	06:13:28	Thousand Oaks/890/VEC	BRV	Fido Summer	0.00
10/15/2005	06:13:29	Ventura/1614/VWC	BRV	Fido Summer	0.00
10/15/2005	06:43:20	Ave Ventura/5169/VWC	HIST	Fido Summer	0.00
10/15/2005	06:59:00	Ventura/1614/VWC	AEN	Fido Summer	0.00
10/15/2005	07:42:04	Thousand Oaks/890/VEC	AEN	Fido Summer	0.00
10/15/2005	07:48:21	Ave Ventura/5169/VWC	FOOD	Fido Summer	0.00
10/15/2005	07:49:17	Thousand Oaks/890/VEC	TRAV	Fido Summer	0.00
10/15/2005	08:28:4[illegible]	[illegible]	[illegible]	[illegible]ummer	0.00
10/15/2005	08:51:2[illegible]	[illegible]	[illegible]	[illegible]ummer	0.00

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10/15/2005	09:20:25	Camarillo/5168/VWC	USA	Fido Summer	0.00
10/15/2005	09:20:25	Ave Ventura/5169/VWC	USA	Fido Summer	0.00
10/15/2005	10:13:02	Camarillo/5168/VWC	AEN	Fido Summer	0.00
10/15/2005	10:18:17	Thousand Oaks/890/VEC	USA	Fido Summer	0.00
10/15/2005	10:48:06	Ventura/1614/VWC	TRAV	Fido Summer	0.00
10/15/2005	11:12:19	Simi Valley/1571/VEC	AEN	Fido Summer	0.00
10/15/2005	11:36:21	Camarillo/5168/VWC	USA	Fido Summer	0.00
10/15/2005	11:40:41	Ave Ventura/5169/VWC	TRAV	Fido Summer	0.00
10/15/2005	11:41:10	Simi Valley/1571/VEC	BRV	Fido Summer	0.0
10/15/2005	11:41:11	Ave Ventura/5169/VWC	BRV	Fido Summer	0.0
10/15/2005	11:52:09	Ojai/5855/VWC	TRAV	Fido Summer	0.00
10/15/2005	11:52:39	Simi Valley/1571/VEC	TRAV	Fido Summer	0.00
10/15/2005	13:19:41	Ave Ventura/5169/VWC	AEN	Fido Summer	0.00
10/15/2005	13:22:58	Ventura/1614/VWC	USA	Fido Summer	0.00
10/15/2005	13:46:57	Ave Ventura/5169/VWC	AEN	Fido Summer	0.00
10/15/2005	13:47:28	Ojai/5855/VWC	AEN	Fido Summer	0.00
10/15/2005	14:43:04	Ojai/5855/VWC	AEN	Fido Summer	0.00
10/15/2005	14:43:35	Ventura/1614/VWC	AEN	Fido Summer	0.00
10/15/2005	15:51:22	Camarillo/5168/VWC	BRV	Fido Summer	0.00
10/15/2005	16:51:10	Ave Ventura/5169/VWC	AMC	Fido Summer	0.00
10/15/2005	18:28:55	Ventura/1614/VWC	TRAV	Fido Summer	0.00
10/15/2005	18:42:17	Ventura/1614/VWC	AEN	Fido Summer	0.00
10/15/2005	18:42:17	Camarillo/5168/VWC	AEN	Fido Summer	0.00
10/15/2005	22:49:27	Ave Ventura/5169/VWC	AEN	Fido Summer	0.00
10/15/2005	23:14:42	Ave Ventura/5169/VWC	AEN	Fido Summer	0.00
10/16/2005	00:47:34	Ventura/1614/VWC	HIST	Fido Summer	0.00
10/16/2005	00:54:58	Ventura/1614/VWC	FOOD	Fido Summer	0.00
10/16/2005	00:55:09	Camarillo/5168/VWC	AEN	Fido Summer	0.00
10/16/2005	00:55:09	Ojai/5855/VWC	AEN	Fido Summer	0.00
10/16/2005	00:55:09	Thousand Oaks/890/VEC	AEN	Fido Summer	0.00
10/16/2005	01:04:53	Thousand Oaks/890/VEC	AMC	Fido Summer	0.00
10/16/2005	01:10:12	Ventura/1614/VWC	AEN	Fido Summer	0.00
10/16/2005	01:12:03	Ave Ventura/5169/VWC	HIST	Fido Summer	0.00
10/16/2005	01:12:33	Camarillo/5168/VWC	HIST	Fido Summer	0.00
10/16/2005	01:19:25	Simi Valley/1571/VEC	HGTV	Fido Summer	0.00
10/16/2005	01:20:43	Thousand Oaks/890/VEC	FOOD	Fido Summer	0.00
10/16/2005	01:49:00	Ventura/1614/VWC	HGTV	Fido Summer	0.00
10/16/2005	01:49:25	Ventura/1614/VWC	AEN	Fido Summer	0.00
10/16/2005	01:49:26	Ojai/5855/VWC	AEN	Fido Summer	0.00
10/16/2005	01:49:56	Camarillo/5168/VWC	AEN	Fido Summer	0.00
10/16/2005	01:49:56	Simi Valley/1571/VEC	AEN	Fido Summer	0.00
10/16/2005	01:51:25	Camarillo/5168/VWC	AMC	Fido Summer	0.00
10/16/2005	01:51:44	Simi Valley/1571/VEC	FOOD	Fido Summer	0.00
10/16/2005	01:51:55	Ojai/5855/VWC	AMC	Fido Summer	0.00
10/16/2005	02:22:40	Ventura/1614/VWC	AMC	Fido Summer	0.00
10/16/2005	02:29:35	Camarillo/5168/VWC	USA	Fido Summer	0.00
10/16/2005	02:29:35	Thousand Oaks/890/VEC	USA	Fido Summer	0.00
10/16/2005	02:29:35	Ojai/5855/VWC	USA	Fido Summer	0.00
10/16/2005	02:47:25	Camarillo/5168/VWC	HGTV	Fido Summer	0.00
10/16/2005	02:48:57	Simi Valley/1571/VEC	AEN	Fido Summer	0.00
10/16/2005	02:49:27	Thousand Oaks/890/VEC	AEN	Fido Summer	0.00
10/16/2005	03:03:16	Ojai/5855/VWC	USA	Fido Summer	0.00
10/16/2005	03:16:46	Ave Ventura/5169/VWC	AMC	Fido Summer	0.00
10/16/2005	03:22:16	Ojai/5855/VWC	USA	Fido Summer	0.00
10/16/2005	03:39:58	Camarillo/5168/VWC	AEN	Fido Summer	0.00
10/16/2005	03:48:36	Simi Valley/1571/VEC	HIST	Fido Summer	0.00
10/16/2005	04:18:33	Simi Valley/1571/VEC	AMC	Fido Summer	0.00
10/16/2005	04:30:02	Camarillo/5168/VWC	FOOD	Fido Summer	0.00
10/16/2005	04:35:49	Simi Valley/1571/VEC	USA	Fido Summer	0.00
10/16/2005	04:49:41	Camarillo/5168/VWC	AEN	Fido Summer	0.00
10/16/2005	04:49:41	Ojai/5855/VWC	AEN	Fido Summer	0.00
10/16/2005	04:49:41	Thousand Oaks/890/VEC	AEN	Fido Summer	0.00
10/16/2005	05:24:43	Simi Valley/1571/VEC	USA	Fido Summer	0.00
10/16/2005	05:29:00	Ventura/1614/VWC	AEN	Fido Summer	0.00
10/16/2005	05:29:01	Ojai/5855/VWC	FOOD	Fido Summer	0.00
10/16/2005	05:59:00	Ojai/5855/VWC	HIST	Fido Summer	0.00
10/16/2005	05:59:00	Ventura/1614/VWC	AEN	Fido Summer	0.00
10/16/2005	05:59:01	Ojai/5855/VWC	AEN	Fido Summer	0.00
10/16/2005	05:59:31	Thousand Oaks/890/VEC	FOOD	Fido Summer	0.00
10/16/2005	05:59:31	Thousand Oaks/890/VEC	HIST	Fido Summer	0.00
10/16/2005	06:16:48	Thousand Oaks/890/VEC	USA	Fido Summer	0.00
10/16/2005	06:29:32	Ventura/1614/VWC	FOOD	Fido Summer	0.00
10/16/2005	06:37:45	Thousand Oaks/890/VEC	TRAV	Fido Summer	0.00
10/16/2005	06:[illegible]	[illegible]	[illegible]	do Summer	0.00
10/16/2005	07:[illegible]	[illegible]	[illegible]	do Summer	0.00

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10/16/2005	07:48:39	Simi Valley/1571/VEC	FOOD	Fido Summer	0.00
10/16/2005	08:17:10	Ave Ventura/5169/VWC	FOOD	Fido Summer	0.00
10/16/2005	08:17:14	Camarillo/5168/VWC	AMC	Fido Summer	0.00
10/16/2005	08:20:34	Simi Valley/1571/VEC	AEN	Fido Summer	0.00
10/16/2005	08:48:13	Ave Ventura/5169/VWC	AEN	Fido Summer	0.00
10/16/2005	09:15:30	Ave Ventura/5169/VWC	AEN	Fido Summer	0.00
10/16/2005	09:15:30	Simi Valley/1571/VEC	AEN	Fido Summer	0.00
10/16/2005	09:23:36	Ojai/5855/VWC	TRAV	Fido Summer	0.00
10/16/2005	09:49:49	Thousand Oaks/890/VEC	AMC	Fido Summer	0.00
10/16/2005	10:22:00	Ventura/1614/VWC	TRAV	Fido Summer	0.00
10/16/2005	11:11:23	Thousand Oaks/890/VEC	AEN	Fido Summer	0.00
10/16/2005	12:27:17	Ave Ventura/5169/VWC	TRAV	Fido Summer	0.00
10/16/2005	13:13:53	Ave Ventura/5169/VWC	USA	Fido Summer	0.00
10/16/2005	13:46:55	Ave Ventura/5169/VWC	HIST	Fido Summer	0.00
10/16/2005	13:47:46	Ave Ventura/5169/VWC	HGTV	Fido Summer	0.00
10/16/2005	14:09:04	Thousand Oaks/890/VEC	AEN	Fido Summer	0.00
10/16/2005	14:09:04	Camarillo/5168/VWC	AEN	Fido Summer	0.00
10/16/2005	14:39:17	Ave Ventura/5169/VWC	TRAV	Fido Summer	0.00
10/16/2005	15:04:10	Ojai/5855/VWC	USA	Fido Summer	0.00
10/16/2005	15:16:07	Ojai/5855/VWC	AEN	Fido Summer	0.00
10/16/2005	15:39:24	Ventura/1614/VWC	AEN	Fido Summer	0.00
10/16/2005	16:09:17	Ventura/1614/VWC	AEN	Fido Summer	0.00
10/16/2005	16:09:17	Camarillo/5168/VWC	AEN	Fido Summer	0.00
10/16/2005	16:19:26	Ave Ventura/5169/VWC	AMC	Fido Summer	0.00
10/16/2005	16:34:25	Thousand Oaks/890/VEC	TRAV	Fido Summer	0.00
10/16/2005	17:11:05	Ojai/5855/VWC	AEN	Fido Summer	0.00
10/16/2005	17:11:05	Simi Valley/1571/VEC	AEN	Fido Summer	0.00
10/16/2005	17:18:35	Ave Ventura/5169/VWC	HGTV	Fido Summer	0.00
10/16/2005	18:12:20	Ave Ventura/5169/VWC	AEN	Fido Summer	0.00
10/16/2005	18:30:21	Simi Valley/1571/VEC	TRAV	Fido Summer	0.00
10/16/2005	20:15:10	Ave Ventura/5169/VWC	AEN	Fido Summer	0.00
10/16/2005	20:15:10	Simi Valley/1571/VEC	AEN	Fido Summer	0.00

Grand Total **0.00**

Zone	Network	Spots
Ave Ventura/5169/VWC	AEN	10
Camarillo/5168/VWC	AEN	11
Ojai/5855/VWC	AEN	10
Simi Valley/1571/VEC	AEN	10
Thousand Oaks/890/VEC	AEN	9
Ventura/1614/VWC	AEN	12
Ave Ventura/5169/VWC	AMC	3
Camarillo/5168/VWC	AMC	3
Ojai/5855/VWC	AMC	2
Simi Valley/1571/VEC	AMC	2
Thousand Oaks/890/VEC	AMC	3
Ventura/1614/VWC	AMC	1
Ave Ventura/5169/VWC	BRV	7
Camarillo/5168/VWC	BRV	5
Ojai/5855/VWC	BRV	5
Simi Valley/1571/VEC	BRV	7
Thousand Oaks/890/VEC	BRV	6
Ventura/1614/VWC	BRV	5
Ave Ventura/5169/VWC	FOOD	12
Camarillo/5168/VWC	FOOD	12
Ojai/5855/VWC	FOOD	9
Simi Valley/1571/VEC	FOOD	15
Thousand Oaks/890/VEC	FOOD	12
Ventura/1614/VWC	FOOD	15
Ave Ventura/5169/VWC	FOXN	12
Camarillo/5168/VWC	FOXN	6
Ojai/5855/VWC	FOXN	6
Simi Valley/1571/VEC	FOXN	7
Thousand Oaks/890/VEC	FOXN	5
Ventura/1614/VWC	FOXN	9
Ave Ventura/5169/VWC	HGTV	7
Camarillo/5168/VWC	HGTV	7
Ojai/5855/VWC	HGTV	4
Simi Valley/1571		
Thousand Oaks/		

A012187

Ventura/1614/VWC	HGTV	7
Ave Ventura/5169/VWC	HIST	3
Camarillo/5168/VWC	HIST	1
Ojai/5855/VWC	HIST	2
Simi Valley/1571/VEC	HIST	1
Thousand Oaks/890/VEC	HIST	2
Ventura/1614/VWC	HIST	2
Ave Ventura/5169/VWC	TRAV	3
Ojai/5855/VWC	TRAV	2
Simi Valley/1571/VEC	TRAV	2
Thousand Oaks/890/VEC	TRAV	3
Ventura/1614/VWC	TRAV	3
Ave Ventura/5169/VWC	USA	3
Camarillo/5168/VWC	USA	8
Ojai/5855/VWC	USA	7
Simi Valley/1571/VEC	USA	3
Thousand Oaks/890/VEC	USA	6
Ventura/1614/VWC	USA	4
	Grand Total	320

These announcements were Cablecast at the above times as entered in the system's program log. Sworn to and subscribed before me, and in my presence on this _____ day of ________________ 2005.

Signature of System Official ____________________________________

Notary Name: Alicia L. Warner Title: Billing & Collections Coord. Exp. Date: 11-13-2005

Notary Signature ____

Note: Program Names may vary due to alterations in network scheduling.

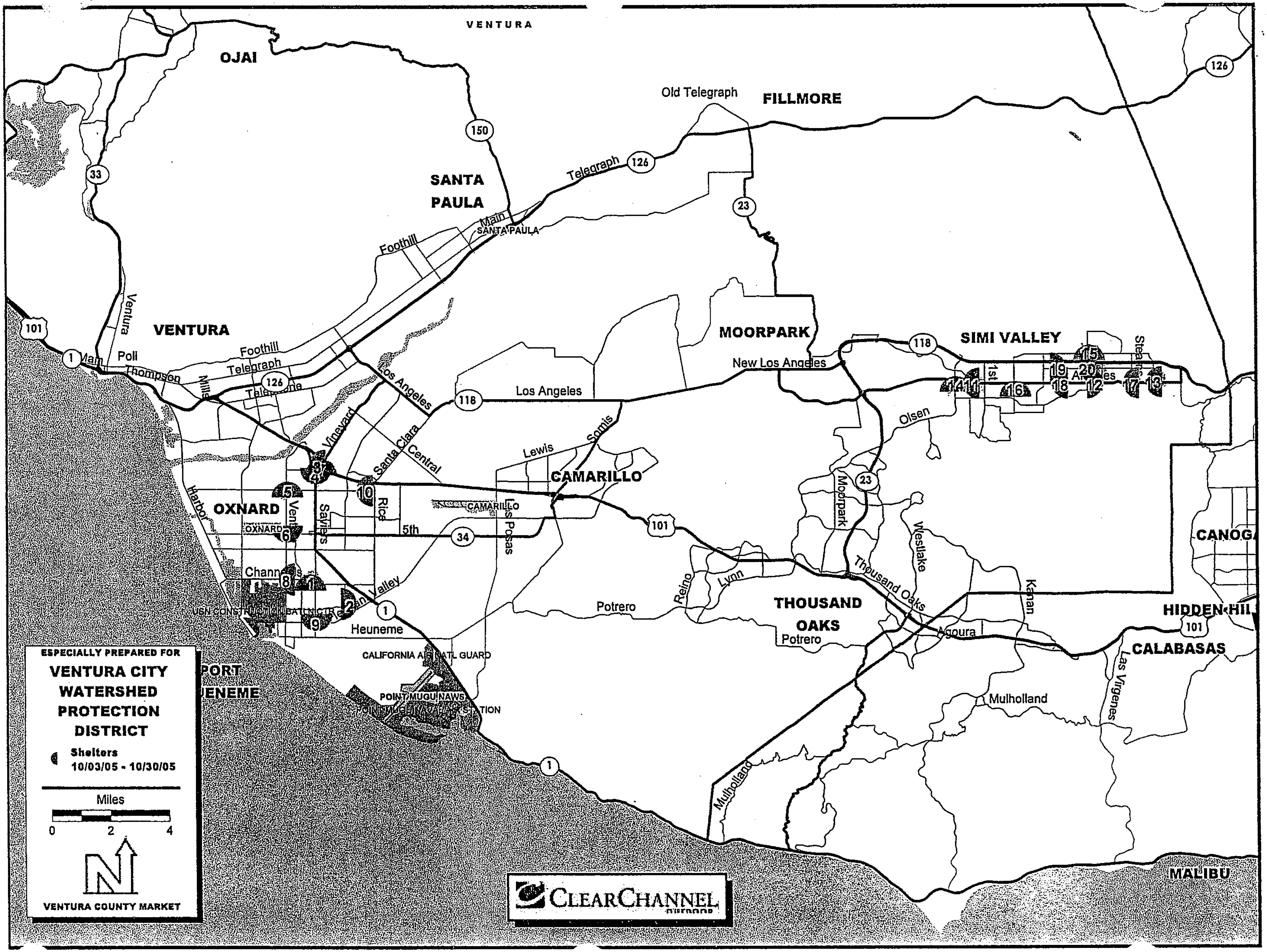
Bus Shelters

Oxnard

Map #	Address
1.	C St. ES 1ft N/O Channel Islands #2 F/S
2.	Oxnard College Entrance #2 WS 90 ft N/O Bard F/W
3.	Esplanade NS 518 ft W/O Vineyard #2 F/E
5.	Ventura ES 1ft N/O Gonzales F/S
6.	Ventura WS 1 ft S/O 5th F/N
7.	Vineyard WS 1 ft S/O Esplanade F/S

Simi Valley

Map #	Address
11.	Los Angeles SS 1ft E/O Sinaloa F/E
13.	Los Angeles NS 1ft W/O Yosemite F/E
14.	Madera WS 1 ft S/O Los Angeles F/S
15.	Tapo Canyon ES 1ft N/O Alamo F/S
17.	Los Angeles SS 1ft W/O Metro Link Depot F/E
20.	Cochran NS 1 ft W/O Tapo Canyon F/E


ESPECIALLY PREPARED FOR
VENTURA CITY WATERSHED PROTECTION DISTRICT
Shelters 10/03/05 - 10/30/05
Miles
0 2 4
VENTURA COUNTY MARKET
CLEARCHANNEL
VENTURA
OJAI
FILLMORE
SANTA PAULA
VENTURA
MOORPARK
SIMI VALLEY
OXNARD
CAMARILLO
THOUSAND OAKS
PORT HUENEME
CANOGA
HIDDEN HILLS
CALABASAS
MALIBU
Old Telegraph
Telegraph
Foothill
Main
Poli
Thompson
Mills
Los Angeles
New Los Angeles
Vineyard
Santa Clara
Central
Lewis
Somis
Rice
Saviers
5th
Los Posas
Potrero
Reino
Lynn
Olsen
Moorpark
Westlake
Thousand Oaks
Kanan
Agoura
Mulholland
Las Virgenes
Harbor
Heuneme
Channel Islands
CALIFORNIA AIR NATL GUARD
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A012190

CLEARCHANNEL MALLS

Performance Report

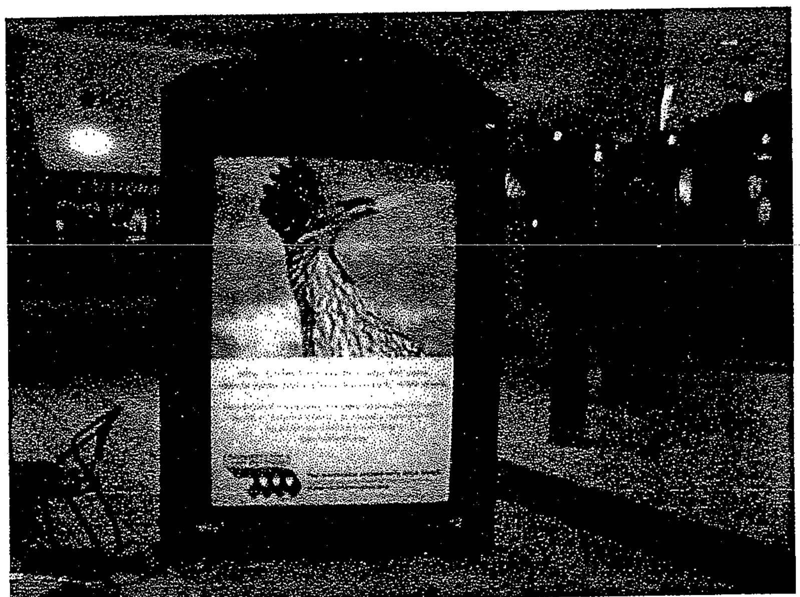
Clear Channel Malls

Date:	10/31/2005	**Agency:**	theAgency
Advertiser:	Ventura County Watershed Protection	**CCO Contract:**	7199
Product Type:	Backlit (Backlit Directory 47.5x68.5)	**Client Contract:**	
		Account Exec:	Rick Graf
Report To:	Lisa Hannon theAgency 900 Avenida Acaso, Suite L Camarillo, CA 93012		

Paper Received:
Quantity Received: 0
Start Date: 10/3/2005
Posted On: 10/7/2005
Total DEC: 0.00
Total Illuminated: 2 **Un Illuminated:** 0

Plant Avg. Daily Effective Circulation :
Backlit Illum : 0 Un Illum : 0

Member of the Traffic Audit Bureau :
Last TAB Audit



The information in this report is according to Clear Channel Outdoor records and complies with the American Association of Advertising Agencies completion report standards. If you need any additional information regarding the execution of this contract, please contact your representative. We appreciate your business and hope our service to you is satisfactory.

Location	Description	FAC	DEC
0239DA01	Pacific View		0
Design	Litter. Garden Fertilizers. Persticides.	**Size**	68.5 x 47.5

Signature Jennifer S. Mener

Clear Channel Photographic Service Policy: Within 5 business days of the completion of the initial posting or any copy changes, Clear Channel will provide 1 unaltered close-up and 1 unaltered approach photo for each permanent bulletin, wallscape, or premiere product location. Clear Channel will provide 1 unaltered close-up and 1 unaltered approach photo for each start location for rotary bulletins. Clear Channel will not photo each rotation cycle unless copy changes. Clear Channel will provide 1 unaltered close-up photo for each poster/transit shelter/other format campaign design. Print sizes provided will either be 3"x5" or 4"x6". Additional photography requests will be billed to the advertiser. Service Charges: Location Photography $15.00 ea.; Slide Transparency $14.00 ea.; 8"x10" Print $18.00 ea.; 5"x7" Print $14.00 ea.; 4"x6" Print $1.25 ea.; 3"x5" Print $1.00 ea. Attached is a detailed list of all locations posted for this campaign. The list includes the actual date of installation and design of each location.

CLEARCHANNEL MALLS

Performance Report

Clear Channel Malls

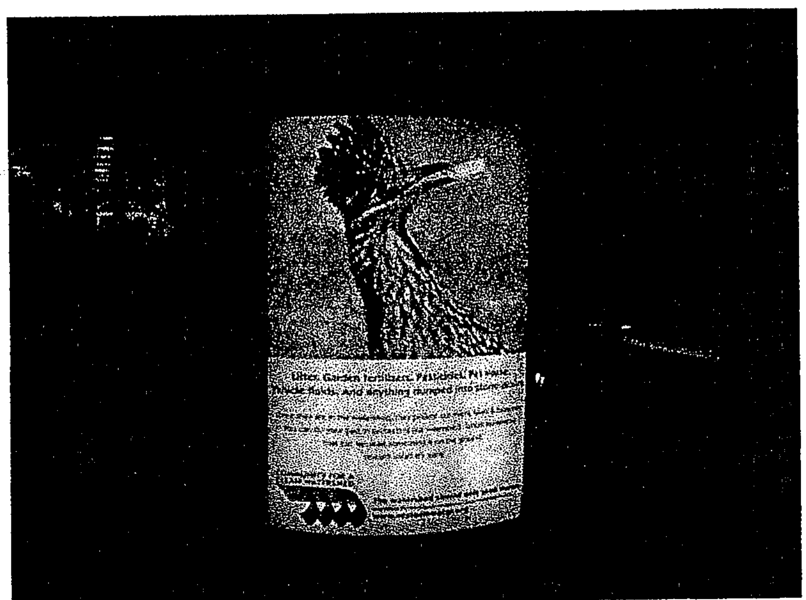
Date: 10/31/2005
Advertiser: Ventura County Watershed Protection
Product Type: Backlit
(Backlit Directory 47.5x68.5)
Report To: Lisa Hannon
theAgency
900 Avenida Acaso,
Suite L
Camarillo, CA 93012

Agency: theAgency
CCO Contract: 7199
Client Contract:
Account Exec: Rick Graf

Paper Received:
Quantity Received: 0
Start Date: 10/3/2005
Posted On: 10/7/2005
Total DEC: 0.00
Total Illuminated: 2 **Un Illuminated:** 0

Plant Avg. Daily Effective Circulation :
Backlit Illum : 0 Un Illum : 0

Member of the Traffic Audit Bureau :
Last TAB Audit



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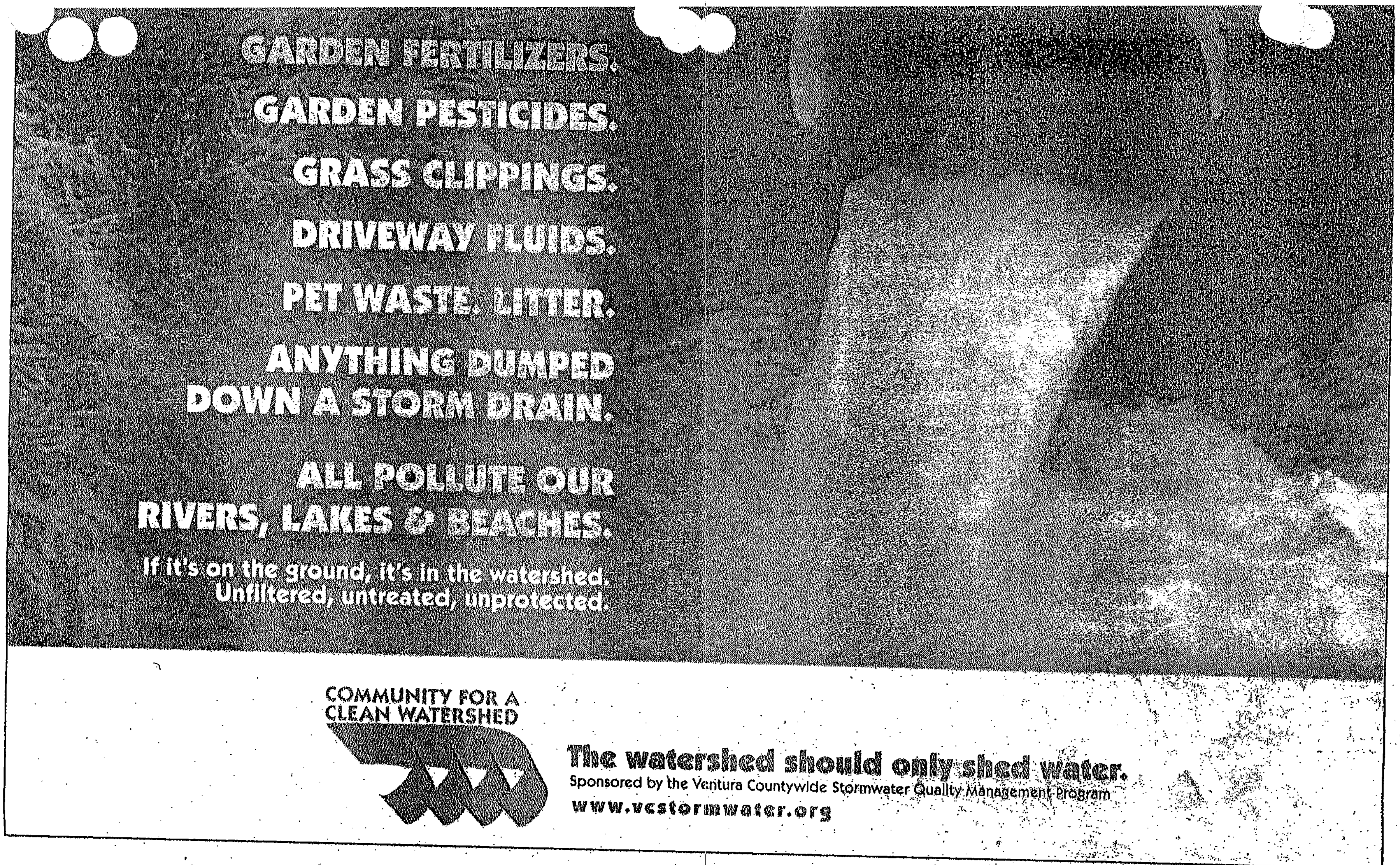
Location	Description	FAC	DEC
0247DB10	Oaks Shopping Center		0
Design	Litter. Garden Fertilizers. Persticides.	Size	68.5 x 47.5

Signature Jennifer S. Mener

Clear Channel Photographic Service Policy: Within 5 business days of the completion of the initial posting or any copy changes, Clear Channel will provide 1 unaltered close-up and 1 unaltered approach photo for each permanent bulletin, wallscape, or premiere product location. Clear Channel will provide 1 unaltered close-up and 1 unaltered approach photo for each start location for rotary bulletins. Clear Channel will not photo each rotation cycle unless copy changes. Clear Channel will provide 1 unaltered close-up photo for each poster/transit shelter/other format campaign design. Print sizes provided will either be 3"x5" or 4"x6". Additional photography requests will be billed to the advertiser. Service Charges: Location Photography $15.00 ea.; Slide Transparency $14.00 ea.; 8"x10" Print $18.00 ea.; 5"x7" Print $14.00 ea.; 4"x6" Print $1.25 ea.; 3"x5" Print $1.00 ea. Attached is a detailed list of all locations posted for this campaign. The list includes the actual date of installation and design of each location.



Ventura City Reporter 10/20/05

A012193

Ventura City Reporter 10/13/05

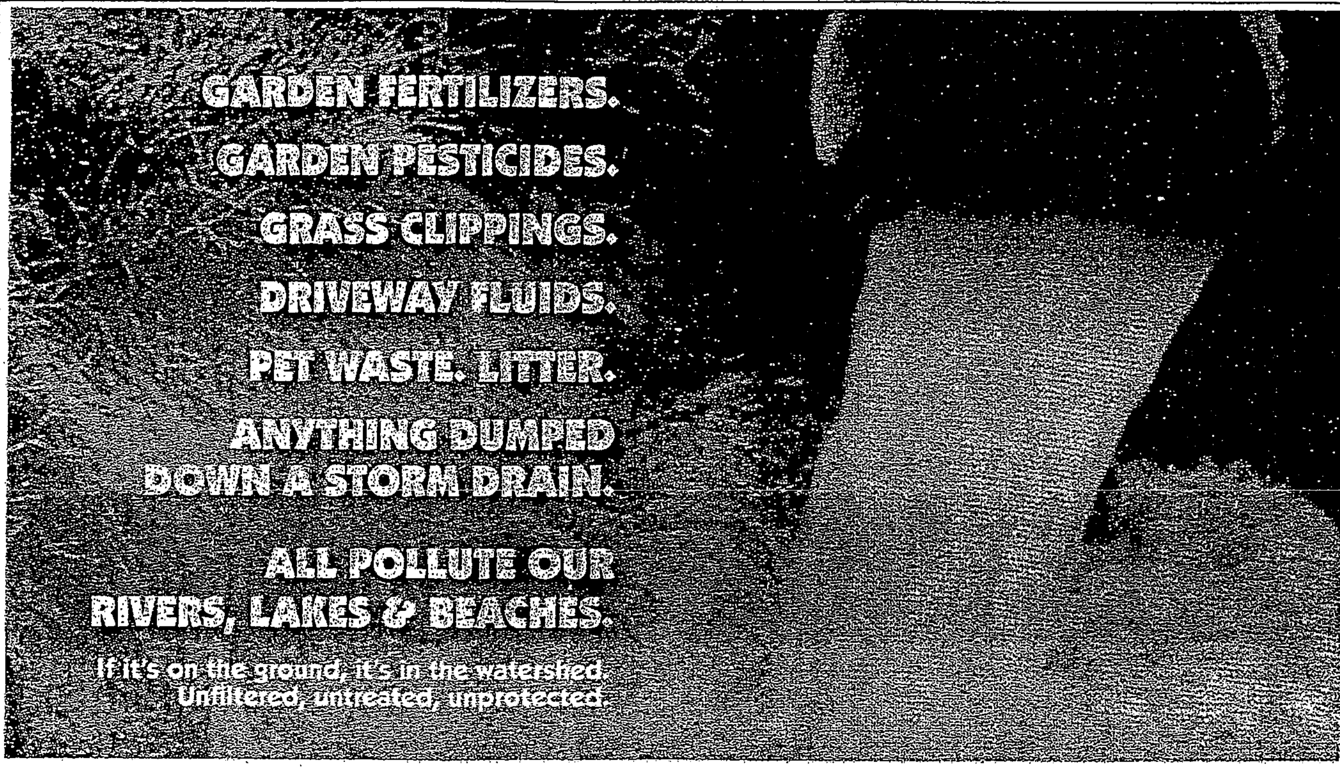
decks, trucks and Steve-O ... can't go too late ... DVDs, but rather in the 2,600 ... "The first show is going to

—Matthew Singer
Got a tip?
E-mail it to Mole4Life@aol.com.

— Matthew Singer

with heightened confidence, more muscle and slightly darker tones.
— Matthew Singer

A012194



COMMUNITY FOR A CLEAN WATERSHED

The watershed should only shed water.

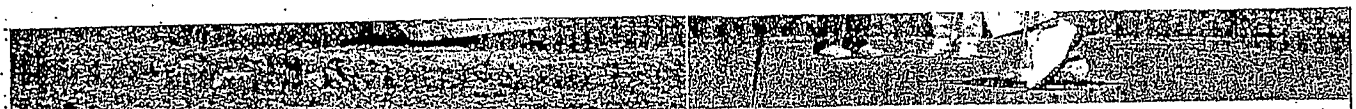
Sponsored by the Ventura Countywide Stormwater Quality Management Program

www.vcstormwater.org

LA Times
10/14/05

A012195

LA Tmes 10/20/05



What You See. What Will Be.

To the casual observer, the buzz of activity on the future site of University Village appears to be just the initial stages of a large construction project. But to future residents, it marks the beginning of their exciting new retirement lifestyle.

Grading is well underway to bring Thousand Oaks its first and only *Continuing Life*® retirement community. Much of University Village's 65-acre grounds will remain natural open space, affording residents the opportunity to enjoy this highly rewarding lifestyle in the ideal location. Beautiful homes, attentive services, engaging activities, and most importantly, long-term care is available — including assisted living and skilled nursing, if ever needed. It's peace of mind for the future.

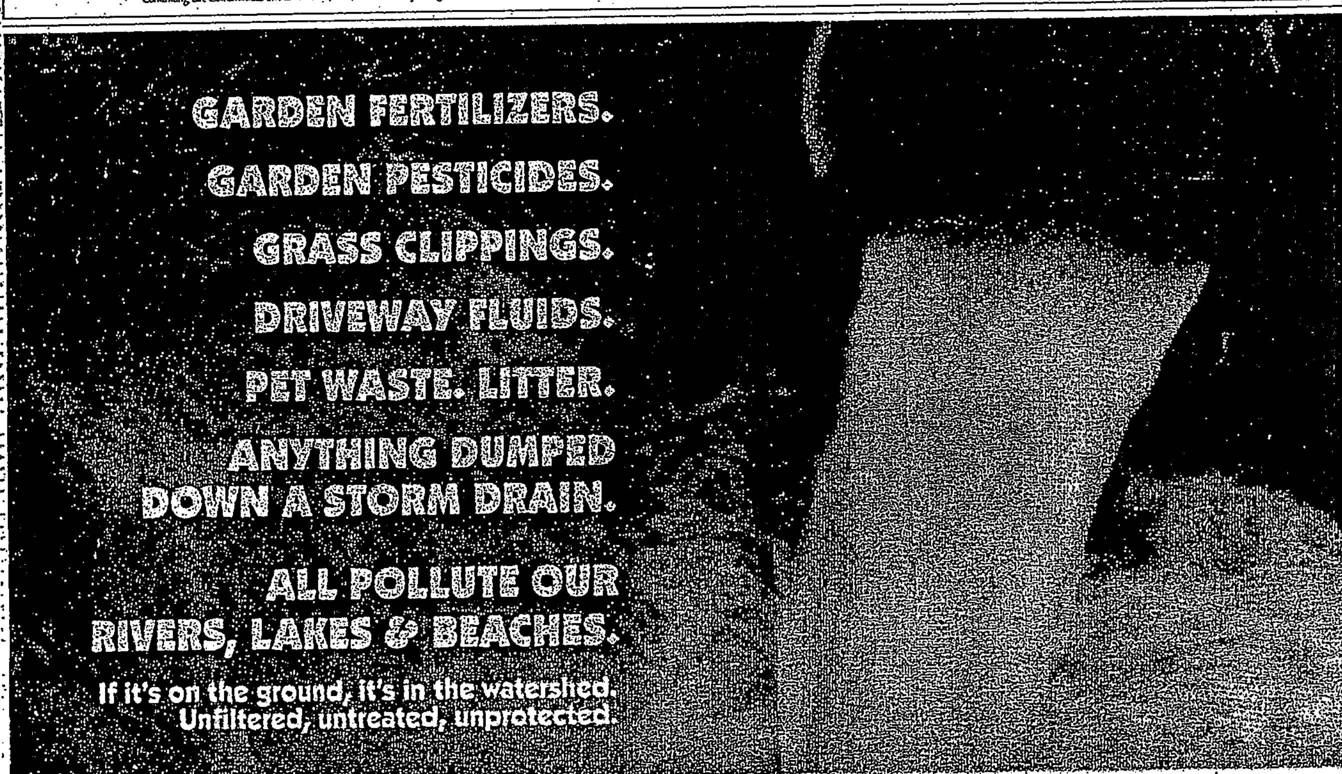
With construction underway, now is the perfect time to consider your move to University Village. See our available villa and apartment homes by making an appointment — call (800) 671-8509 today.

UNIVERSITY VILLAGE
THOUSAND OAKS
A Continuing Life® Retirement Community

An Exciting, New Retirement Lifestyle Unlike Anything from Los Angeles to Santa Barbara.

3721 Campus Drive • Thousand Oaks, CA 91360
(800) 671-8509 • uvto.com

Continuing Life Communities Thousand Oaks, LLC, dba University Village Thousand Oaks, has filed a licensing application and has been issued a permit to sell Deposit Agreements by the State of California, Department of Social Services, Continuing Care Branch.



COMMUNITY FOR A CLEAN WATERSHED

The watershed should only shed water.

Sponsored by the Ventura Countywide Stormwater Quality Management Program

www.vcstormwater.org

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Los

Katrina, la antiinmigrante

Un sobreviviente originario de Guanajuato narra cómo en Nueva Orleans la pelea por la comida es hasta a balazos, mientras la familia del michoacano que murió por el huracán pide ayuda.

Alfredo Villaseñor Ávalos, un inmigrante mexicano, falleció en Luisiana [illegible] Katrina. Ávalos estaba construyendo una casa en Michoacán. Deja a una viuda y cuatro hijos [illegible].

Por Jorge Escalante
Agencia Reforma

LEÓN.– "Estamos viviendo algo espantoso, la gente se está matando por comida, por agua, no hay respeto por nadie y si no matas te matan; ésa es la situación en Nueva Orleans que se ha convertido en una ciudad sin ley", narró ayer entre llanto Mario Navarro Rojas.

El lunes, él y su hermano César lograron escapar de las balas que les dispararon jóvenes, quienes en busca de comida ingresaron en el restaurante donde trabajaban y se refugiaban, luego de la inundación que dejó el huracán "Katrina" en Nueva Orleans.

"¡Gracias a Dios estamos vivos!" fue la primera expresión que lanzó, entre llanto, Mario cuando habló por teléfono con su esposa, Josefina Álvarez.

El indocumentado estuvo como desaparecido, pero ayer al mediodía se comunicó con su familia, que radica en la Colonia Brasilia, de León.

El guanajuatense de 35 años de edad, quien tiene dos hijos en este municipio, relató que el lunes por la mañana un grupo de jóvenes ingresó al restaurante disparando.

"Nos sorprendieron, a pesar de que estamos inundados nos refugiamos en un lugar donde estábamos a la espera de ayuda, pero escuchamos disparos, nos dispararon, nos tiraron a matar y no quedó más remedio que escapar nadando.

"En el restaurante teníamos alimentos, sobre todo enlatados y agua, estábamos con nuestro patrón, pero nos obligaron a dejar el lugar que fue

KATRINA
continúa en la página 14

mi Estella 10/15/05

BREVES DEL CONDADO

SANTA PAULA

Hombre arrestado después de evadir a la policía

Arrestaron a un hombre de Santa Paula en la tarde del 9 de octubre después de que él condujo una persecución con las autoridades en carro y de pie a través de las calles de Santa Paula y de Ventura, la policía dijo esta semana. Reggie Anthony Contreraz, de 26 años, conducía un carro cerca de las calles 12 y Saticoy alrededor de las 11:40 p.m. cuando un oficial intentó pararlo por una violación de tráfico. La policía dice que Contreraz continuó conduciendo por las calles de Santa Paula, hacia el oeste en la calle Main.

Contreraz después condujo al oeste en la calle Telegraph Road, hacia Ventura, a una velocidad de más de 100 millas por hora, afirmaron los oficiales. Luego condujo al sur en la calle Kimball hasta llegar al oeste en la calle Telephone y entró en la carretera 126 que dirigía al este de nuevo rumbo a Santa Paula.

Él se salió en la carretera Peck Road y condujo al este en la calle de Santa María antes de que abandonara el carro cerca de Laurie Lane, e intentó correr sobre la carretera en el puente peatonal, señalaron los oficiales. Dos oficiales lo pararon y lo detuvieron. Lo arrestaron y fue llevado a la cárcel del condado con cargos de varias violaciones, incluyendo el crimen de evadir a las autoridades, resistencia de arresto, conduciendo con una licencia suspendida y tener órdenes de detención, los oficiales comentaron.

NEWBURY PARK

Grupo llevará a cabo talleres de derechos de Inquilinos

El centro de Derechos de Inquilinos presentará un taller de los derechos de Inquilinos a partir de las 6 a 8 p.m. el miércoles, 19 de oct., en la biblioteca Newbury Park, 2331 Borchard Road, Newbury Park. El programa ofrece la información sobre la vivienda y alquiler justo, desalojos, depósitos de seguridad, reparaciones y aumentos de renta. Para más detalles, comuníquese con Karina Arabolaza al 1 (800) 477-5977, extensión 26.

OXNARD

Ex Sacerdote de Oxnard es llamado para ser misionero

Han designado a Anthony Guillen como misionero hispano para la Iglesia Episcopal Nacional. Él comenzará su ministerio en el centro de la iglesia episcopal en la cuidad de Nueva York el 15 de noviembre. Guillen era el rector de toda la iglesia de los santos en Oxnard por los ultimos12 años. Antes de venir a Todos Los Santos, él se desempeñó en servicios para San Clementes By-the-Sea en San Clemente y como misionero en la diócesis de México occidental, donde estableció dos misiones y trabajó como coordinador diocesano de la juventud. Él es un graduado del seminario Teológico episcopal del sudoeste y de la universidad de Phoenix. Él era un estudiante en el seminario de San Andrés en Guadalajara y estudió en el National Institute for Lay Training.

PORT HUENEME

Hannah-Beth Jackson habla con los demócratas

Hannah-Beth Jackson será la discursaste en la junta de Greater Oxnard Organization of Democrats (Organización de demócratas de la Mayoría de Oxnard) el 19 de oct. en el ayuntamiento. Jackson, previo miembro de la asamblea del distrito 35, es al presente presidente del Institute for the Renewal of the California Dream (instituto del renovar del sueño de California) y disputara las iniciativas especiales de votación. Ella enfocara las proposiciones 76, 78, y 80.

El publico esta invitado al la junta de las 7 p.m. en el Veterans of Foreign Wars hall, 300 S. Surfside Drive.

Habrá refrigerios. Para informes en ingles llamen a Jim Hensley al 382-7659 o correo electrónico al hensleyjim@adelphia.net. Para informes en español llamen a Gloria Roman al 488-0422.

CONDADO DE VE

Feria de ciudada... [illegible]ada

Hermandad Mexicana-Frank Lacayo Youth & Family Center presentara la feria de ciudadanía de las 9 a.m. hasta las 2 p.m. sábado 29 de oct. en 520 W. Fifth St., Suite D, Oxnard.

Participantes recibirán asistencia gratuita en sus aplicaciones de ciudadanía. Requisitos: 18 años de edad, cinco años de residencia permanente o tres si son casados con un ciudadano estadounidense, buena conducta moral, habilidad de entender, leer y escribir ingles básico, y numero de "Selective Service" con fecha de registración para los hombres menores de 31 años.

Participantes se les sugiere que traigan su tarjeta de permanencia residencial, domicilios del trabajo y hogar, por los previos cinco años, información personal de sus cónyuges, fechas de viajes fuera de Estados Unidos, y cualquier récord de arresto, con un cheque o giro postal de $390 hecho a B.C.I.S. Para mas detalles llamen a Alicia Flores al 483-4620.

A012198

10/22/05

A012199

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... Hermandad Mexi... Lacayo Youth & Fan... presentara la feria d... de las 9 a.m. hasta las 2 p.m. ...ado 29 de oct. en 520 W. Fifth St., Suite D, Oxnard.

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...broken up. Twenty-three... through razor-wire fences around the Spanish enclaves of Melilla and Ceuta on the northern Moroccan coast and other places in Morocco.

"They caught me after I jumped over," said Adama Coulibaly, 25. He said he immediately felt disappointment. "I had hoped it would be the end of my suffering.

"It's so sad to go back this way," he said just before being sent home. "My future is now dark."

Another flight, arranged by the International Organization for Migration, a Geneva-based intergovernmental group, left later in the day, bringing to more than 600 the number of Malians deported Wednesday and Thursday.

On the later flight Thursday, all passengers were men aged 19 to 38. They signed a statement ... got into Ceuta and six more died in clashes with Moroccan security forces at the Melilla border last week.

Moroccan officials have faulted European nations and neighbor Algeria for not doing enough to help stem the flow of Africans seeking to reach Europe.

Morocco has come under fire for initially abandoning migrants in desert areas after they were expelled by Spain.

Spanish newspaper El Pais reported Thursday that U.N. helicopters have been flying over the Western Sahara desert searching for about 250 abandoned Africans.

Some Malians deported Thursday said they had been living in woods near Melilla for up to three years, waiting for what they saw as an opportunity to rush the barrier.

Spielberg will help develop video games

SAN JOSE (AP) — Coming soon to a game console near you: a Steven Spielberg video game.

The acclaimed film director and producer has agreed to develop three new games under a long-term exclusive deal with video game maker Electronic Arts Inc. The deal is to be announced today.

Financial terms of the agreement were not disclosed, but Redwood City-based EA, the world's largest game maker behind blockbusters such as "Madden NFL" and "The Sims," said it will own the intellectual property behind the Spielberg games and publish them.

The deal involves much more than the Hollywood director merely putting his stamp on a game or popping in for quick consultations, said Neil Young, vice president and studio head of EA's Los Angeles studio.

Instead, Spielberg will work side-by-side with game developers to create original gaming content.

AD LOOKS CO OR ADVERTISING SCALE INCHES 1 2 3

A012200

Ad Looks Inc. of 4300 Anthony Court Suite H, R[illegible] CA, 95677 certifies that this tear sheet is from an original scanned image of the newspaper show[illegible] proof of publication of advertising.

graders, 22 percent of Californians tested proficient, compared with 29 percent nationwide.

There was some good news mixed into the math scores, ing an effect.

ifornia fourth-graders tested proficient, compared with 30 percent nationwide. Among eighth-graders, it was 21 percent, compared with 29 percent

gap in average math scores for Hispanic and white fourth-graders was 25 points. In 1992, it was 31 points.

Teachers noted that they not ing an effect.

Education Secretary Margaret Spellings said she was heartened to see narrowing academic gaps between whites and

sues."

On the other hand, Patricia Sullivan, director of the independent Center on Education Policy, questioned why gains

contributed to this report.

On the Net: http://nces.ed.gov/nationsreportcard

AD LOOKS CO-OP ADVERTISING SCALE

INCHES 1 2 3

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theAgency

Ventura County
Watershed Protection District

COASTAL CLEAN-UP -- September 2005

	# Planned Insertions	# Actual Insertions	Planned Impressions	Actual Impressions	Cost	$/Impression
Monthly Publications						
Happenings	1	1	20,000	20,000	$844	$0.042
Ventura County Parent	1	1	40,000	40,000	$844	$0.021
Weekly Publicatons						
Vida (1 Spanish, 1 English)	1	1	35,000	35,000	$361	$0.010
Mi Estrella (Spanish)	1	1	14,208	14,208	$191	$0.013
VC Reporter	1	1	35,000	35,000	$1,069	$0.031
Daily Publications						
L.A. Times Ventura County Edition	2	2	126,313	126,313	$1,231	$0.010
Ventura County Star	2	2	345,171	345,171	$2,044	$0.006
Total Impressions	9	9	615,692	615,692	$6,584	$0.011

A012202

9/05

Ventura County Parent

2005 COASTAL CLEANUP DAY

Turn the Tide on Trash!

Join us

Saturday, September 17 • 9 a.m. – Noon for Coastal Cleanup Day to clean our Ventura County beaches, creeks, rivers & parks.

For coastal and inland waterway cleanup events in your area call 1-800-Cleanup or visit www.coastal.ca.gov

Keep Our Waterways Pollution Free !

COMMUNITY FOR A CLEAN WATERSHED

Reliant Energy

GOLD COAST BROADCASTING LLC

CALIFORNIA COASTAL COMMISSION

Adelphia

MSE Environmental

***Presented by** the Ventura County Coalition for Coastal & Inland Waterways – California Coastal Commission; Cities of Camarillo, Moorpark, Oxnard, Simi Valley, Thousand Oaks and Ventura; Ventura County Energy & Environmental Resources Department; Ventura Countywide Stormwater Quality Management Program and Watershed Protection District.*

A012203

...nado ...Controller

ABEL MALDONADO REACHING OUT: L-R: Senator Abel Maldonado and Edwina Camarillo.

SHOWING SUPPORT FOR SENATOR MALDONADO: L-R Roxanne and Eduardo Mirnada and Lilia Ruvalcaba.

an immi-
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his values
ly influ-
commu-
the privi-
work with
tate Con-
ent from
member to
, to state
senator.
bout edu-
immigra-
ecting the
l how he

school graduates who do not wish to continue college. This will certainly allow them to work, live and raise a family here in California.

Maldonado shared his plans to work with the department of immigration to somehow allow immigrants to legally enter the country to work and eventually after a certain amount of time be able to apply for residency and have the opportunity to become a citizen of this country.

Encouraged by his father's

A012204

Happening Magazine 9/05

2005 COASTAL CLEANUP DAY

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for Coastal Cleanup Day to clean our Ventura County beaches, creeks, rivers and parks.

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Presented by *the Ventura County Coalition for Coastal & Inland Waterways – California Coastal Commission; Cities of Camarillo, Moorpark, Oxnard, Port Hueneme, Simi Valley, Thousand Oaks and Ventura; Ventura County Energy & Environmental Resources Department; Ventura Countywide Stormwater Quality Management Program and Watershed Protection District.*

do
: Estatal

RON ACTO DE PRESENCIA: Miem- : la Asociación de Oficiales por La Paz, Miranda y Hector Villanueva.

POSANDO: para las cámaras del Periodico VIDA, de izq. a der. Rosario Cervantes, Blanca Martinez, Efrain Almanza, Esperanza caballero y Anna Prado.

ie además les permita trabajar para man- a su familia.

otra parte, Maldonado compartió sus s de trabajar con el departamento de in- ación para encontrar la forma de permi- os inmigrantes la entrada legal para tra- en el país y eventualmente, después de tiempo, poder solicitar la residencia anente y tener la oportunidad de conver- en un ciudadano legal de este país.

alentado por el apoyo de su padre y el consejo de siempre trabajar duro y con s, con deseo y voluntad. Mencionó que abajadores inmigrantes solamente quie- ue se les dé una oportunidad de ser me- en este país lleno de riqueza y oportuni- s. "Todo lo que queremos es que nos den portunidad" dijo Maldonado a la audien- una oportunidad que le devolveremos al que nos la dé".

no trabajadores del campo, pizcando fre- s padres de Abel Maldonado nunca ima- on que su hijo se vería involucrado en la ca y menos como candidato a Contralor al de California. La ambición y el deseo bel así como sus ganas, lo han llevado a r por lo que su padre y muchos otros es como él trabajaron tan fuerte y creye- urante esos años de braceros.

Senador Abel sigue viviendo y trabajan- on los mismos valores que se le inculca- e chico y espera tener la oportunidad de Contralor del Estado para dar a su vez, una oportunidad a mucha gente trabajadora que se lo merece.

A012206

THE WATERSHED SHOULD ONLY SHED WATER

The Community for a Clean Watershed program was established to protect Ventura County's watersheds by preventing stormwater pollution. For more information on keeping our watersheds clean, go to www.vcstormwater.org or contact your community's participating agency.

Camarillo	388-5338
Fillmore	524-3701
Moorpark	517-6253
Ojai	640-2560
Oxnard	488-3517
Port Hueneme	986-6561
Santa Paula	933-4256
Simi Valley	583-6462
Thousand Oaks	449-7283
Ventura	677-4136
Unincorporated areas of Ventura County	650-4064

COMMUNITY FOR A CLEAN WATERSHED

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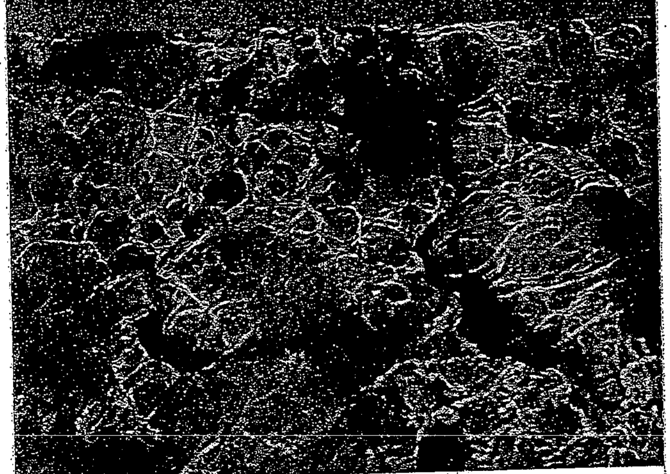
Watershed Protection Tips for Residents

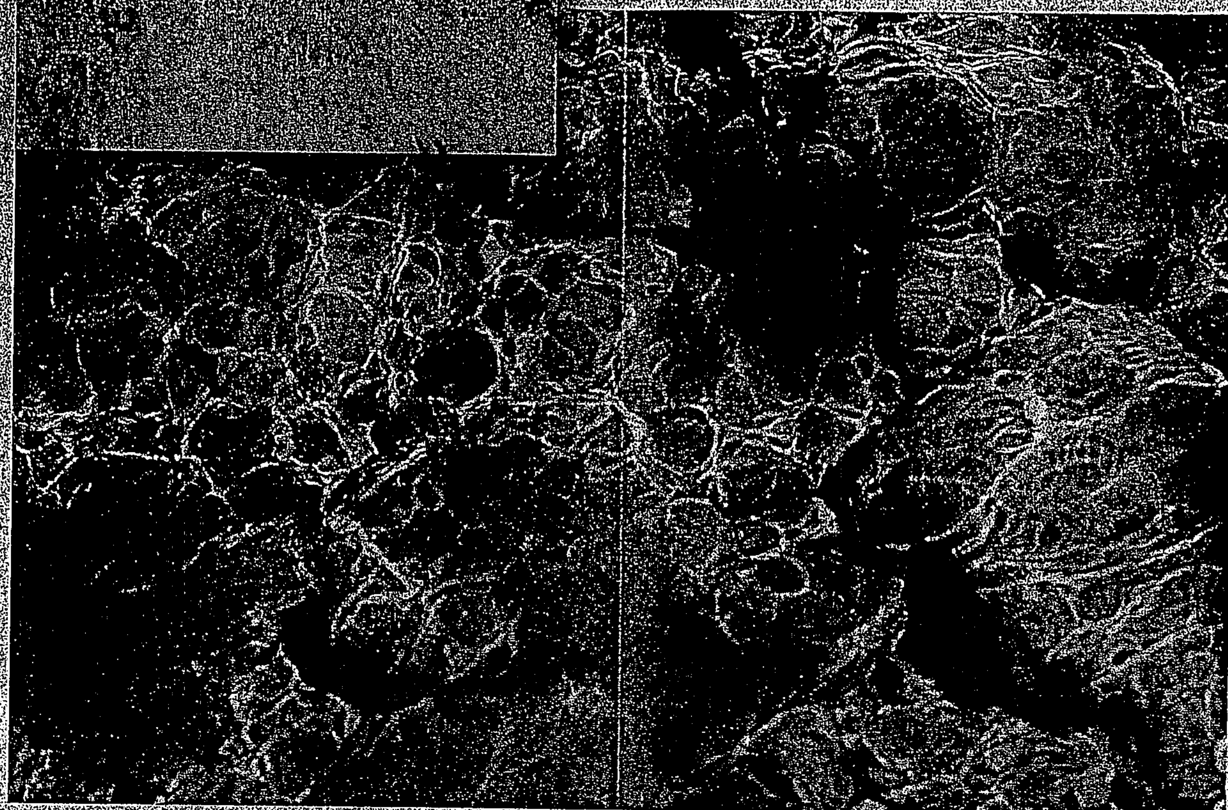


Learn more about the watershed and how you can help protect it.

COMMUNITY FOR A CLEAN WATERSHED

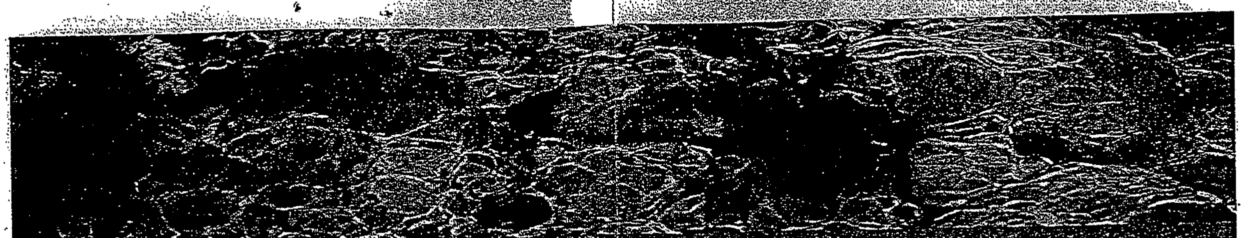
"We have met the enemy and he is us"

W. Kelly



The watershed is everyone's responsibility.

Inside you'll learn how we all, unknowingly, contribute to its contamination and how we can stop.

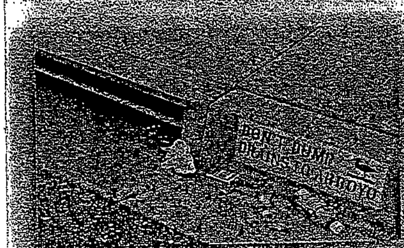


Clean Living in Our Watershed

What Is Our Watershed?

The watershed is the total land area from which rainwater drains into a stream, river or body of water. In Ventura County our primary watersheds include the Ventura and Santa Clara Rivers, Malibu and Calleguas Creeks, and the bays and estuaries—all of which empty into the Pacific Ocean. The watershed includes all of the natural terrain and neighborhoods surrounding these major water bodies, including your home.

How can I help keep our watershed clean?



Do the right thing by keeping preventable pollutants from entering the storm drain system. The storm drain system is a vast network of gutters, pipes and open channels designed for flood control, which directs untreated rainwater straight into the watershed.

What are preventable pollutants?

Preventable pollutants are both seen and unseen materials that accumulate in our gutters and streets and damage our watersheds. Even simple changes in the way we care for our homes can make a big difference in keeping our watersheds clean.

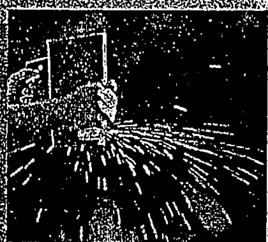
HOME

Household Chemicals – Take all unwanted household hazardous waste (HHW), such as paint, solvent and toxic cleaning products, to local collection events. Call your local recycling coordinator for more information.

Repairs & Construction – Prevent pollutants from leaving your property during remodeling and repair projects, especially concrete work and painting. Before work begins, discuss wastewater disposal options with your contractor.

YARD

Fertilizers & Pesticides – Overuse of any pesticide or fertilizer is a key contributor to stormwater pollution. Apply only as needed and as directed on the label, and always store under cover, out of the rain. Or better still, visit your nursery for less toxic options.



Watering – Save water and money by automating your sprinkler system. Irrigate early in the day when less water is lost to wind and evaporation. Perform regular maintenance to minimize runoff that can carry preventable pollutants into the storm drain.

Pool/Spa – Pool chemicals can be deadly to our watershed. Never dispose of acid wash wastewater, pool filter backwash or other pool cleaning wastewater into the storm drain. Before a pool is drained, all chlorine must be removed and your city may require a permit.

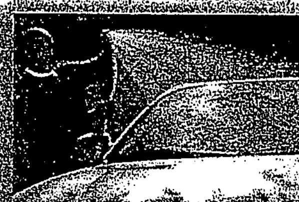
Maintenance – Clear, remove and dispose of any debris, including leaves and grass cuttings, in your yard waste container or by composting. Even organic waste, when introduced into the watershed, reduces oxygen levels and increases harmful bacteria in our waters, hurting both animal and human life.

Pet Waste – The same bacteria responsible for beach closings is found in pet waste. Always pick up after your pet and dispose of pet waste in the trash.

CAR

Fluids – Use drip pans to catch all oil, brake and transmission fluids. Clean up any spills immediately, using dry cleaning methods like kitty litter or rags. Take all waste material to local HHW collection events. If changing automotive fluids at home, be sure to dispose of used fluids at an approved recycling center.

Wash – If possible take your car to a self-serve or full-serve car wash, where the wastewater will be treated. If you do wash your car at home, use as little water as possible to reduce runoff and use a phosphate-free, biodegradable detergent. Consider washing your car on your lawn to keep our watershed clean.



Our watershed is invaluable to the health and beauty of our community. Simple precautions can protect and preserve our watershed, streams, lakes and beaches. Please remember, **the watershed should only shed water.**

THE WATERSHED SHOULD ONLY SHED WATER

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Ventura	677-4136
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COMMUNITY FOR A CLEAN WATERSHED

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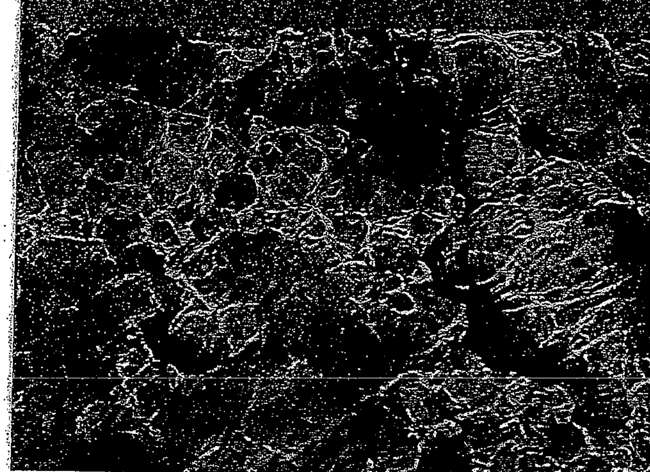
Illicit Discharge Prevention for Business Owners

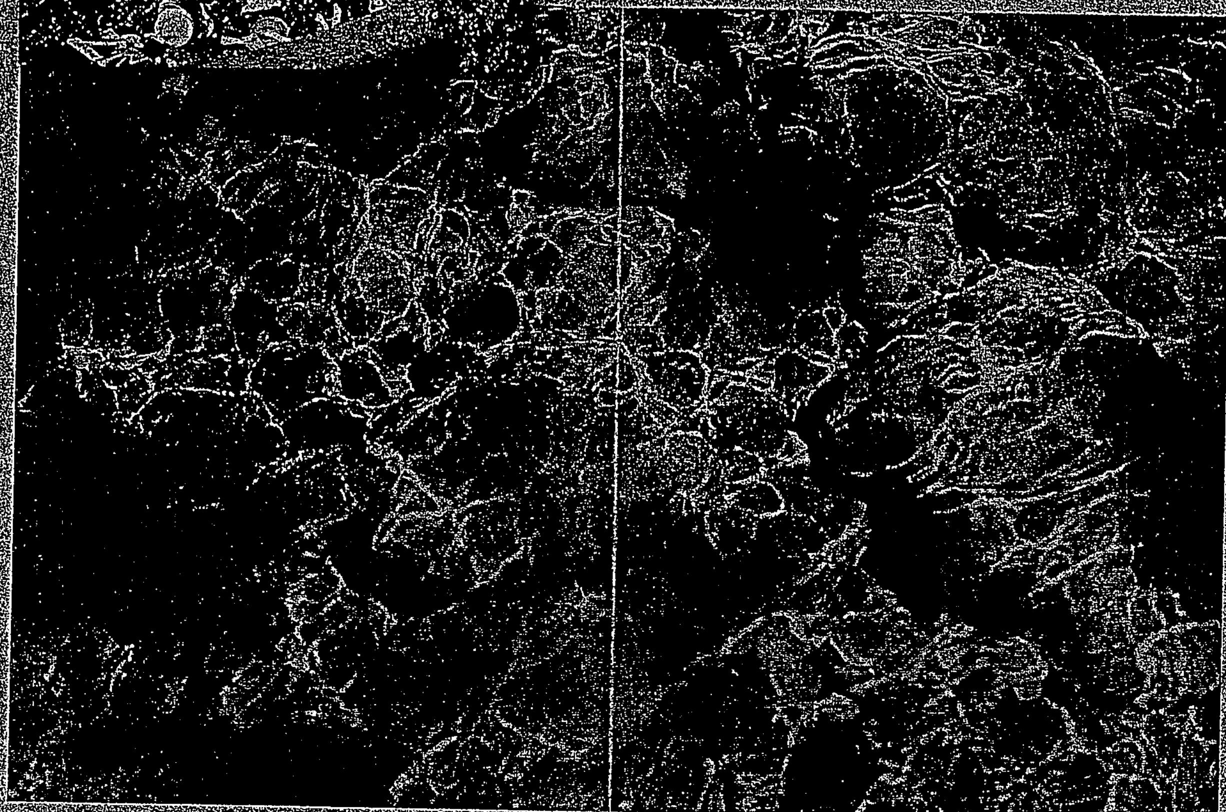


Learn more about the watershed and how you can help protect it.

COMMUNITY FOR A CLEAN WATERSHED

A012211

"We have met the enemy and he is us"
W. Kelly



The watershed is everyone's responsibility.

Inside you'll learn how we all, unknowingly, contribute to its contamination and how we can stop.

Clean Working in Our Watershed

Our Watershed & Stormwater Pollution

The watershed is the total land area from which rainwater drains into a stream, river or body of water. The watershed includes all of the natural terrain and neighborhoods surrounding these major water bodies, including your business. When it rains, stormwater moves quickly, transporting untreated pollutants directly into our watershed. A simple rain event can result in one big "illicit discharge."

So what is an illicit discharge?

An illicit discharge is any activity or event that results in a release, flow, spill, escape or disposal of any material other than rainwater (including liquids or solids) into the storm drain system.

When you think of "illicit discharges," large oil, sewage and chemical spills come to mind. These are easy to spot and easy to prevent, but they are not the biggest sources of stormwater pollution. We all affect the health of our watershed in many ways that are not so obvious.

Make your business part of the clean watershed equation with these illicit discharge prevention guidelines:

STORAGE

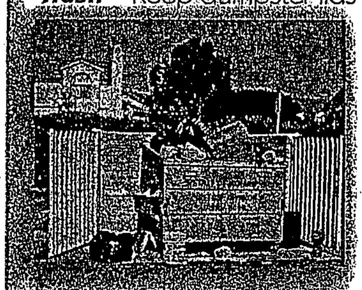
Appropriate storage of liquids and solids can help prevent pollutants from getting into the storm drain system. Inside or under cover is best.

Cleaners – Store cleaning products where they are protected from rain, and prevent spills from reaching the storm drain system.

Chemicals – Any material used or waste generated must be managed according to state regulations. Use secondary containment to prevent accidental discharges or leaks.

Equipment – Store materials like batteries and machinery in trays or with drip pans to contain potential leaks and spills.

Trash – Keep dumpster lids closed and place covers on all waste containers. Never put liquid waste into a dumpster. Store outdoor waste receptacles under cover to reduce exposure to rain that could wash pollutants into the storm drain system.



Recycling & Disposal – For general information on Ventura County recycling and disposal programs for businesses, call 805.289.3333 or visit www.wasteless.org.

MAINTENANCE

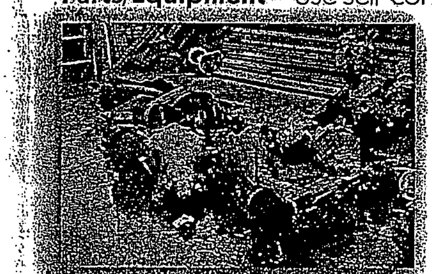
Regular maintenance can prevent pollution and can ensure that your activities aren't contributing to stormwater pollution.

Surface Cleaning – Regularly sweeping parking lots and areas around your business prevents pollution. Hosing oil, grease, soap and other pollutants into the storm drain system can result in a fine.

Wash Water – All cleaning solutions can harm wildlife, even if labeled nontoxic or biodegradable. Dispose of all nonhazardous wash water into indoor drains like sinks and toilets.

Hazardous Spills – Keep spill kits near stored chemicals or bulk cleaning agents. Use absorbent mats or socks to prevent accidental spills from reaching the street or storm drain system.

Parts/Equipment – Use self-contained sinks and tanks when cleaning parts with degreasing solvents. Consider switching to a water-based cleaning solution. Use pans to catch leaks when working on engines or machinery.



REPAIRS & CONSTRUCTION

Take precautions to prevent illicit discharges during all building repair or remodeling, especially concrete work and painting. You can be held responsible for problems created by your contractor. Before work begins, be sure your contractor knows where to properly dispose of all wastes created.

Nothing but rainwater may be discharged to a storm drain. It is illegal, as well as harmful, to allow wastes, wash water, cleaning agents or materials of any kind into the storm drain system.

A012214

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

NOV 22 2002

OFFICE OF WATER

MEMORANDUM

SUBJECT: Establishing Total Maximum Daily Load (TMDL) Wasteload Allocations (WLAs) for Storm Water Sources and NPDES Permit Requirements Based on Those WLAs

FROM: Robert H. Wayland, III, Director
Office of Wetlands, Oceans and Watersheds

James A. Hanlon, Director
Office of Wastewater Management

TO: Water Division Directors
Regions 1 - 10

This memorandum clarifies existing EPA regulatory requirements for, and provides guidance on, establishing wasteload allocations (WLAs) for storm water discharges in total maximum daily loads (TMDLs) approved or established by EPA. It also addresses the establishment of water quality-based effluent limits (WQBELs) and conditions in National Pollutant Discharge Elimination System (NPDES) permits based on the WLAs for storm water discharges in TMDLs. The key points presented in this memorandum are as follows:

- NPDES-regulated storm water discharges must be addressed by the wasteload allocation component of a TMDL. See 40 C.F.R. § 130.2(h).

- NPDES-regulated storm water discharges may not be addressed by the load allocation (LA) component of a TMDL. See 40 C.F.R. § 130.2 (g) & (h).

- Storm water discharges from sources that are not currently subject to NPDES regulation may be addressed by the load allocation component of a TMDL. See 40 C.F.R. § 130.2(g).

- It may be reasonable to express allocations for NPDES-regulated storm water discharges from multiple point sources as a single categorical wasteload allocation when data and information are insufficient to assign each source or outfall individual WLAs. See 40 C.F.R. § 130.2(i). In cases where wasteload allocations are developed for categories of discharges, these categories should be defined as narrowly as available information allows.

The WLAs and LAs are to be expressed in numeric form in the TMDL. See 40 C.F.R. § 130.2(h) & (i). EPA expects TMDL authorities to make separate allocations to NPDES- regulated storm water discharges (in the form of WLAs) and unregulated storm water (in the form of LAs). EPA recognizes that these allocations might be fairly rudimentary because of data limitations and variability in the system.

NPDES permit conditions must be consistent with the assumptions and requirements of available WLAs. See 40 C.F.R. § 122.44(d)(1)(vii)(B).

WQBELs for NPDES-regulated storm water discharges that implement WLAs in TMDLs may be expressed in the form of best management practices (BMPs) under specified circumstances. See 33 U.S.C. §1342(p)(3)(B)(iii); 40 C.F.R. §122.44(k)(2)&(3). If BMPs alone adequately implement the WLAs, then additional controls are not necessary.

EPA expects that most WQBELs for NPDES-regulated municipal and small construction storm water discharges will be in the form of BMPs, and that numeric limits will be used only in rare instances.

When a non-numeric water quality-based effluent limit is imposed, the permit's administrative record, including the fact sheet when one is required, needs to support that the BMPs are expected to be sufficient to implement the WLA in the TMDL. See 40 C.F.R. §§ 124.8, 124.9 & 124.18.

The NPDES permit must also specify the monitoring necessary to determine compliance with effluent limitations. See 40 C.F.R. § 122.44(i). Where effluent limits are specified as BMPs, the permit should also specify the monitoring necessary to assess if the expected load reductions attributed to BMP implementation are achieved (e.g., BMP performance data).

The permit should also provide a mechanism to make adjustments to the required BMPs as necessary to ensure their adequate performance.

This memorandum is organized as follows:

(I). Regulatory basis for including NPDES-regulated storm water discharges in WLAs in TMDLs;

(II). Options for addressing storm water in TMDLs; and

(III). Determining effluent limits in NPDES permits for storm water discharges consistent with the WLA

(I). Regulatory Basis for Including NPDES-regulated Storm Water Discharges in WLAs in TMDLs

As part of the 1987 amendments to the CWA, Congress added Section 402(p) to the Act to cover discharges composed entirely of storm water. Section 402(p)(2) of the Act requires permit coverage for discharges associated with industrial activity and discharges from large and medium municipal separate storm sewer systems (MS4), i.e., systems serving a population over 250,000 or systems serving a population between 100,000 and 250,000, respectively. These discharges are referred to as Phase I MS4 discharges.

In addition, the Administrator was directed to study and issue regulations that designate additional storm water discharges, other than those regulated under Phase I, to be regulated in order to protect water quality. EPA issued regulations on December 8, 1999 (64 FR 68722), expanding the NPDES storm water program to include discharges from smaller MS4s (including all systems within "urbanized areas" and other systems serving populations less than 100,000) and storm water discharges from construction sites that disturb one to five acres, with opportunities for area-specific exclusions. This program expansion is referred to as Phase II.

Section 402(p) also specifies the levels of control to be incorporated into NPDES storm water permits depending on the source (industrial versus municipal storm water). Permits for storm water discharges associated with industrial activity are to require compliance with all applicable provisions of Sections 301 and 402 of the CWA, i.e., all technology-based and water quality-based requirements. See 33 U.S.C. §1342(p)(3)(A). Permits for discharges from MS4s, however, "shall require controls to reduce the discharge of pollutants to the maximum extent practicable ... and such other provisions as the Administrator or the State determines appropriate for the control of such pollutants." See 33 U.S.C. §1342(p)(3)(B)(iii).

Storm water discharges that are regulated under Phase I or Phase II of the NPDES storm water program are point sources that must be included in the WLA portion of a TMDL. See 40 C.F.R. § 130.2(h). Storm water discharges that are not currently subject to Phase I or Phase II of the NPDES storm water program are not required to obtain NPDES permits. 33 U.S.C. §1342(p)(1) & (p)(6). Therefore, for regulatory purposes, they are analogous to nonpoint sources and may be included in the LA portion of a TMDL. See 40 C.F.R. § 130.2(g).

(II). Options for Addressing Storm Water in TMDLs

Decisions about allocations of pollutant loads within a TMDL are driven by the quantity and quality of existing and readily available water quality data. The amount of storm water data available for a TMDL varies from location to location. Nevertheless, EPA expects TMDL authorities will make separate aggregate allocations to NPDES-regulated storm water discharges (in the form of WLAs) and unregulated storm water (in the form of LAs). It may be reasonable to quantify the allocations through estimates or extrapolations, based either on knowledge of land use patterns and associated literature values for pollutant loadings or on actual, albeit limited, loading information. EPA recognizes that these allocations might be fairly rudimentary because of data limitations.

EPA also recognizes that the available data and information usually are not detailed enough to determine waste load allocations for NPDES-regulated storm water discharges on an outfall-specific basis. In this situation, EPA recommends expressing the wasteload allocation in the TMDL as either a single number for all NPDES-regulated storm water discharges, or when information allows, as different WLAs for different identifiable categories, e.g., municipal storm water as distinguished from storm water discharges from construction sites or municipal storm water discharges from City A as distinguished from City B. These categories should be defined as narrowly as available information allows (e.g., for municipalities, separate WLAs for each municipality and for industrial sources, separate WLAs for different types of industrial storm water sources or dischargers).

(III). Determining Effluent Limits in NPDES Permits for Storm Water Discharges Consistent with the WLA

Where a TMDL has been approved, NPDES permits must contain effluent limits and conditions consistent with the requirements and assumptions of the wasteload allocations in the TMDL. See 40 CFR § 122.44(d)(1)(vii)(B). Effluent limitations to control the discharge of pollutants generally are expressed in numerical form. However, in light of 33 U.S.C. §1342(p)(3)(B)(iii), EPA recommends that for NPDES-regulated municipal and small construction storm water discharges effluent limits should be expressed as best management practices (BMPs) or other similar requirements, rather than as numeric effluent limits. See *Interim Permitting Approach for Water Quality-Based Effluent Limitations in Storm Water Permits*, 61 FR 43761 (Aug. 26, 1996). The Interim Permitting Approach Policy recognizes the need for an iterative approach to control pollutants in storm water discharges. Specifically, the policy anticipates that a suite of BMPs will be used in the initial rounds of permits and that these BMPs will be tailored in subsequent rounds.

EPA's policy recognizes that because storm water discharges are due to storm events that are highly variable in frequency and duration and are not easily characterized, only in rare cases will it be feasible or appropriate to establish numeric limits for municipal and small construction storm water discharges. The variability in the system and minimal data generally available make it difficult to determine with precision or certainty actual and projected loadings for individual dischargers or groups of dischargers. Therefore, EPA believes that in these situations, permit limits typically can be expressed as BMPs, and that numeric limits will be used only in rare instances.

Under certain circumstances, BMPs are an appropriate form of effluent limits to control pollutants in storm water. See 40 CFR § 122.44(k)(2) & (3). If it is determined that a BMP approach (including an iterative BMP approach) is appropriate to meet the storm water component of the TMDL, EPA recommends that the TMDL reflect this.

EPA expects that the NPDES permitting authority will review the information provided by the TMDL, see 40 C.F.R. § 122.44(d)(1)(vii)(B), and determine whether the effluent limit is appropriately expressed using a BMP approach (including an iterative BMP approach) or a numeric limit. Where BMPs are used, EPA recommends that the permit provide a mechanism to require use of expanded or better-tailored BMPs when monitoring demonstrates they are necessary to implement the WLA and protect water quality.

Where the NPDES permitting authority allows for a choice of BMPs, a discussion of the BMP selection and assumptions needs to be included in the permit's administrative record, including the fact sheet when one is required. 40 C.F.R.§§ 124.8, 124.9 & 124.18. For general permits, this may be included in the storm water pollution prevention plan required by the permit. See 40 C.F.R. § 122.28. Permitting authorities may require the permittee to provide supporting information, such as how the permittee designed its management plan to address the WLA(s). See 40 C.F.R. § 122.28. The NPDES permit must require the monitoring necessary to assure compliance with permit limitations, although the permitting authority has the discretion under EPA's regulations to decide the frequency of such monitoring. See 40 CFR § 122.44(i). EPA recommends that such permits require collecting data on the actual performance of the BMPs. These additional data may provide a basis for revised management measures. The monitoring data are likely to have other uses as well. For example, the monitoring data might indicate if it is necessary to adjust the BMPs. Any monitoring for storm water required as part of the permit should be consistent with the state's overall assessment and monitoring strategy.

The policy outlined in this memorandum affirms the appropriateness of an iterative, adaptive management BMP approach, whereby permits include effluent limits (e.g., a combination of structural and non-structural BMPs) that address storm water discharges, implement mechanisms to evaluate the performance of such controls, and make adjustments (i.e., more stringent controls or specific BMPs) as necessary to protect water quality. This approach is further supported by the recent report from the National Research Council (NRC), *Assessing the TMDL Approach to Water Quality Management* (National Academy Press, 2001). The NRC report recommends an approach that includes "adaptive implementation," i.e., "a cyclical process in which TMDL plans are periodically assessed for their achievement of water quality standards" . . . and adjustments made as necessary. *NRC Report* at ES-5.

This memorandum discusses existing requirements of the Clean Water Act (CWA) and codified in the TMDL and NPDES implementing regulations. Those CWA provisions and regulations contain legally binding requirements. This document describes these requirements; it does not substitute for those provisions or regulations. The recommendations in this memorandum are not binding; indeed, there may be other approaches that would be appropriate in particular situations. When EPA makes a TMDL or permitting decision, it will make each decision on a case-by-case basis and will be guided by the applicable requirements of the CWA and implementing regulations, taking into account comments and information presented at that time by interested persons regarding the appropriateness of applying these recommendations to the particular situation. EPA may change this guidance in the future.

If you have any questions please feel free to contact us or Linda Boornazian, Director of the Water Permits Division or Charles Sutfin, Director of the Assessment and Watershed Protection Division.

cc:
Water Quality Branch Chiefs
Regions 1 - 10

Permit Branch Chiefs
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STATE WATER RESOURCES CONTROL BOARD

RESOLUTION NO. 68-16

STATEMENT OF POLICY WITH RESPECT TO MAINTAINING HIGH QUALITY OF WATERS IN CALIFORNIA

WHEREAS the California Legislature has declared that it is the policy of the State that the granting of permits and licenses for unappropriated water and the disposal of wastes into the waters of the State shall be so regulated as to achieve highest water quality consistent with maximum benefit to the people of the State and shall be controlled so as to promote the peace, health, safety and welfare of the people of the State; and

WHEREAS water quality control policies have been and are being adopted for waters of the State; and

WHEREAS the quality of some waters of the State is higher than that established by the adopted policies and it is the intent and purpose of this Board that such higher quality shall be maintained to the maximum extent possible consistent with the declaration of the Legislature;

NOW, THEREFORE, BE IT RESOLVED:

1. Whenever the existing quality of water is better than the quality established in policies as of the date on which such policies become effective, such existing high quality will be maintained until it has been demonstrated to the State that any change will be consistent with maximum benefit to the people of the State, will not unreasonably affect present and anticipated beneficial use of such water and will not result in water quality less than that prescribed in the policies.

2. Any activity which produces or may produce a waste or increased volume or concentration of waste and which discharges or proposes to discharge to existing high quality waters will be required to meet waste discharge requirements which will result in the best practicable treatment or control of the discharge necessary to assure that (a) a pollution or nuisance will not occur and (b) the highest water quality consistent with maximum benefit to the people of the State will be maintained.

3. In implementing this policy, the Secretary of the Interior will be kept advised and will be provided with such information as he will need to discharge his responsibilities under the Federal Water Pollution Control Act.

BE IT FURTHER RESOLVED that a copy of this resolution be forwarded to the Secretary of the Interior as part of California's water quality control policy submission.

CERTIFICATION

The undersigned, Executive Officer of the State Water Resources Control Board, does hereby certify that the foregoing is a full, true, and correct copy of a resolution duly and regularly adopted at a meeting of the State Water Resources Control Board held on October 24, 1968.

Dated: October 28, 1968

Kerry W. Mulligan
Executive Officer
State Water Resources
Control Board

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Printer Friendly Version

Beaches Appendices

Division of Drinking Water and Environmental Management

California Beaches—Regulations and Guidance

Last Update: March 21, 2006

DHS has prepared the following material to assist local health agencies in addressing microbiological contamina of beaches and recreational waters:

- Guidance for Salt Water Beaches [Click here for regulations]
- Guidance for Fresh Water Beaches
  also see Information on Cyanobacteria (Blue-Green Algae) Blooms
- Appendices for Salt Water and Fresh Water Beaches

DHS' regulations for public beaches and ocean water-contact sports areas include health-protective standards, monitoring requirements, and actions to be taken when standards are exceeded. They also include specific requirements for certain beaches from April 1 through October 31. Also see Recommended Analytical Methods public beaches and ocean water-contact sports areas.

The annual State budget provides funding to local agencies with beaches that meet certain statutory criteria. (Appendix A of DHS' beaches guidance contains pertinent statutes.) Local agencies receiving funding for beacl monitoring programs provide reports on beach postings and closures to the State Water Resources Control Boa

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Division of Drinking Water and Environmental Management

Draft Guidance for Saltwater Beaches

Last Update: July 27, 2000

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Glossary

AB 411: Assembly Bill 411 (Statutes of 1997, Chapter 765), amended Health and Safety Code Sections 11588C 115885, and 115915. These amendments include requirements for the Department of Health Services (DHS) t adopt regulations for public beaches (Health and Safety Code Section 155880—see Appendix A). Particular provisions apply to public beaches that are visited by more than 50,000 people annually and are adjacent to sto drains that flow in the summer. Health and Safety Code Sections 115885 and 115915 include requirements for l health officers.

Closure: The placement of signs at an area of a public beach that informs the public that the area is closed to swimming and water contact. These signs should indicate the nature of the public health concern (e.g., sewage and should, by nature of their language, color, and design, enable the recreating public to differentiate from advi provided by posting. Closure is envisioned to occur when health risks are considered greater than those associa with posting, as with sewage spills or at areas at which monitoring results show that multiple indicator organism standards are exceeded, for both single sample and 30-day average values. Closure is required by Health and S Code Section 115885(f) when an untreated sewage release is known to have reached recreational waters.

Posting: The placement of a sign or signs at an area of a public beach that informs the public of contamination c recreational water and the risk of possible illness, and advises against swimming and/or water contact (see Sec 8.2). The placement of signs may be temporary, as a result of monitoring that indicates a single microbiological indicator standard is exceeded (e.g., for a public beach subject to AB 411), or more permanent, where monitorir indicates regular or sporadic contamination (e.g., a storm drain), or where sources of contamination are identifia and can be explained (e.g., storm drain water, or residential marine mammals or seabirds). Posting is required t Health and Safety Code Section 115915(a) for certain public beaches whenever standards for microbiological indicator organisms are exceeded.

Storm drain: A conveyance through which water flows onto or adjacent to a public beach, and includes rivers, cr and streams, whether in natural or in man-made channels. The presence of a storm drain that flows in the sumn one criterion that identifies a public beach as being subject to AB 411.

1.0 Introduction

The purpose of this document is to provide guidance for local health agencies with regard to the sanitation and healthfulness of recreational waters and beaches. It includes guidance for developing a protocol for recreational waters, proposed standards for microbiological indicator organisms, discussions of beach posting, closure, and reopening, comments about public notification, and suggested language for signs used for posting and closure. includes other recommendations related to beach cleanliness.

The appendices to this guidance include a review of current standards and guidance for ocean and fresh water recreation, as well as other related material. Appendices A, B, and C present state statutes and regulations, fed guidance, and local guidance and ordinances, respectively. Appendix D discusses the microbiological indicator organisms in standards and guidance. Appendix E provides a brief review of epidemiological studies associated ocean and fresh water recreation.

1.1 Sources of Microbiological Contamination of Recreational Waters

Microbiological contamination of recreational waters is generally associated human sewage or non-human wast long as recreational areas are isolated from those wastes, contamination by disease-causing microorganisms is unlikely. However, there are a number of pathways by which such contamination may occur.

Sewage—Potential sources of microbiological contamination of recreational waters may be associated with syst failures in human sewage treatment facilities, leaking sewer lines, or with rainfall and resulting surface water rur

When excessive rainfall occurs and sewage systems are not able to process the volume of water that enters the flooding may occur and releases of untreated sewage may occur.

Treatment processes that include secondary treatment followed by filtration and disinfection will be more protec public health than those that do not include the latter steps.

Other Sources of Sewage—Other sewage retaining systems that are specific for recreational areas may be a potential source of microbiological contamination of recreational waters if they are poorly maintained or if their contents are otherwise released through accident, error, or deliberate action. Sources of possible contamination include releases from boat and recreational vehicle holding tanks, pumping stations, sewer line leaks, and porta toilets.

Septic Systems—Leachate from septic systems may be a potential source of microbiological contamination of recreational waters, particularly from septic systems that are poorly maintained, or during flooding. Although a s home septic system alone may pose a small risk of environmental contamination, in areas where septic system predominate, shabby maintenance and flooding may be more significant.

Animal Wastes—Animal wastes may also contribute to microbiological contamination of recreational waters the is generally assumed that such contamination represents a less substantial human risk than contaminatior sewage. To the extent that animals may be allowed on beaches or other recreational properties, such as eq trails, their wastes may add to the microbiological burden of recreational waters.

Even the practice of "curbing" one's dog may result in an added microbiological burden during times of surface r that ultimately reaches a recreational water body.

Feedlots, dairy farms, pasture land, forests and other "natural" areas, and urban surfaces may be sources of microbiological contamination. Animals, both wild and domestic, may also serve as vectors for microbiological parasites of public health concern, such as Giardia and Cryptosporidium.

Sewage Sludge—The distribution of treated sewage sludge, provided that treatment adequately destroys any microbiological components that may be present, should not pose a potential for microbiological contamination of recreational waters. Organisms in inadequately treated sewage sludge, which should not be disposed of on lanc be present in runoff associated with rainfall or with landscape or agricultural irrigation practices.

Surface Water Runoff—As mentioned previously, surface water runoff can contribute significantly to the census microbes in a recreational body of water, particularly in times of heavy rains, in which street gutters and storm d systems that often contain decaying organic matter are flushed out by large volumes of water.

In addition, sanitary sewers systems and septic systems may be overwhelmed by stormwater that may enter the situations with common storm drains and sewer drains, or leaking sewer drains, heavy rains are obvious problei

Dry weather urban runoff may also contain high levels of indicator organisms.

In addition to urban runoff, surface runoff from other land surfaces may also contain microbes, and land on whic wildlife or domestic animals are in dense populations may contribute to high microbial densities in runoff.

Swimmer-to-Swimmer Contamination—Another source of microbiological contamination of marine recreational w are the individuals who are using those waters for recreation. Constituents of residual fecal matter may be the body on contact with water, with most of it washed off within a relatively short time after submersion. H swimmers, bathers, waders, surfers, the fishing population, and others who may come into full- or most-body co may all contribute to contamination to which they are exposed.

Infants and young children, and other individuals may also contribute significantly to microbiological contaminati accidental fecal releases. Others may cause contamination by intentional fecal releases, because of a lack of pr sanitary facilities at or near the recreational area, or because such facilities, though present, are not used.

Recreational users at beaches with limited tidal influence or wave action will likely be subject to a greater swimn swimmer contamination than those at beaches with more tidal exchange and more wave action, where water circulation would be greater.

2.0 Protocol Development

Protocols should be developed for the following:

- Sanitary survey
- Sewage spills
- Stormwater runoff
- Sampling and laboratory analyses
- Beach posting, closure and reopening procedures

2.1 Sanitary Survey

A sanitary survey should be performed that identifies actual or potential sources of microbiological contaminatio the recreational waters and beach areas. Information that is collected for purposes of the Drinking Water Sourc Assessment and Protection (DWSAP) Program or other watershed-related activities could contribute to a sanita survey. The DWSAP Program document contains a checklist of possible contaminating activities for surface wa sources that may be helpful in this regard.

Sources of contamination near recreational areas may indicate a need for increased monitoring of microbiologic indicator organisms.

For recreational area with poor water circulation (e.g., the Salton Sea or certain bay or estuarine situations), the sanitary survey should include a discussion of the impact of bather load on recreational areas. Because of the p water circulation, heavy bather loads can cause significant elevation in bacterial counts for total and fecal colifor enterococcus bacteria.

High use areas with poor water circulation may also indicate a need for increased monitoring of microbiological indicator organisms.

2.2 Sewage Spills

A protocol should be developed that sets forth procedures for closing recreational waters and beach areas in th event of a sewage spill, including language that is used in public notification and signage, and monitoring requirements for reopening the affected recreational waters and beach areas (e.g., sampling indicates that stan are being met). The protocol should also indicate the extent of beach closure in terms of distance, based on the amount of sewage estimated to be discharged or spilled.

2.3 Stormwater Runoff

A protocol should be developed that sets forth procedures for public notification about beach contamination whe significant amounts of rainfall result in urban runoff that enters recreational waters and beach areas.

The public notification should include press releases and updates of a telephone hotline that is accessible to the public. Other means of public access may also be utilized. The notification should inform the public that body co with stormwater runoff should be avoided for a minimum of 72 hours following significant rainfall because of microbiological contamination. The 72-hour period should be adequate to dissipate microbiological contaminatic

The protocol should include the language that is used in public notification and the means by which the informat distributed.

2.4 Sampling and Analysis Plan

A sampling and analysis plan should be developed that includes location of sampling sites, frequency of sampli duration of sampling period, and depth of sampling. The plan should also include other pertinent information, su containers for sampling, packaging samples for transport, references for analytic methods, reporting of data, requirements for repeat sampling. The plan should be developed in conjunction with the local Public Health Laboratory.

Location of Sampling Sites—Sampling sites should include areas used for water contact sports. In addition, are known to be regularly or chronically contaminated, e.g., stormwater drains, should be included in the sampling p

Frequency of Sampling—Sampling no less frequently than weekly is recommended, and is required by AB 411 Appendix A). However, a minimum frequency of sampling should be established locally, based upon historical records, usage, current situations, and the potential of health hazards.

When samples are above standards or guidance levels, more frequent or daily sampling is appropriate, to deter whether the area should be closed to recreational use. Subsequent sampling is also needed to determine when reopen the recreational area.

Time of Sampling—Sampling should occur at each location at generally the same time of day.

For crowded beaches at which bather-to-bather contamination may be a significant route of microbiological exp for example, where the wave and tidal actions that tend to refresh open ocean beaches are lacking, sampling w recreational use is highest may be appropriate (e.g., mid-afternoon).

Duration of Sampling Period—The sampling period should cover the period of recreational use. AB 411 requires sampling from April 1 through October 31.

Depth of Sampling—Samples should be taken from just below the water surface, in ankle- to knee-depth water, approximately 12 to 24 inches deep.

Sampling from boats is inadequate for beach monitoring, since water depths would exceed those common to be related recreational water sports activities, especially for young children. However, local health agencies may de to assess water quality away from the shore in additional areas where surfing, windsurfing, or other activities ma occur.

Indicator Organisms—Indicator organisms should include total coliform bacteria, fecal coliform bacteria, and enterococcus bacteria. These three are required by AB 411.

2.5 Laboratories and Laboratory Analyses

All samples are to be submitted for analyses to a laboratory certified by the Department of Health Services' Environmental Laboratory Accreditation Program (ELAP), in microbiology for methods appropriate for the analys the sample type. [See recommended analytical methods for recreational marine water for AB 411.]

Transportation conditions, holding time limits, and analysis of samples shall be in accordance with those metho appear on the certificate listing for microbiology of ELAP.

Analyses should be completed expeditiously after they are received in the laboratory. Preliminary results should available from the laboratory as soon as possible, and, if they exceed the standards for microbiological indicato organism, the laboratory should telephone the appropriate local agency. Written results should be provided with week after sampling.

Use of Escherichia coli as a surrogate for fecal coliforms—When a test method measures E. coli to be us a surrogate for fecal coliforms, laboratories should split samples between such a method and either the mul.. fermentation or membrane filtration method with standard confirmation steps, and run the two tests in parallel, to identify an appropriate correction factor to apply to the E. coli-derived values (e.g., E. coli per 100 ml x 1.2 = fec coliforms per 100 ml). Such parallel testing should include enough samples to develop a scientifically credible correlation between the two methods. It should occur at least once per year (for example, early summer) or twic each year (for example, early spring and late summer), and ideally should be done for each type of water sourc is subject to the sampling program (for example, ocean beach and estuarine beach). The most recently derived correction factor should be applied to the E. coli values to determine compliance with the fecal coliform standard Laboratories should retain the results of the parallel testing in their files, consistent with their record retention procedures.

Data Reporting—The sampling and analysis plan should indicate how data are to be reported, particularly if the outside the reporting range. For example, samples below the testing range for the most probable number (MPN e.g., <20 MPN, should be reported as "<20 MPN" and not as "zero."

The sampling and analysis plan should also indicate how data outside the testing range are used in the calculat 30-day averages. For example, a sample that is <20 MPN may appropriately be designated "10 MPN" (half the range for the sample) for purposes of assigning a numeric value that can be used for determining the monthly v

2.6 Posting, Closure and Reopening Procedure

The protocol should include procedures for posting and closing beaches and recreational areas, public notificati and procedures for determining whether posting and/or closure should continue.

2.7 Reporting to Water Board Requirements

Pursuant to Health and Safety Code Section 115910, coastal health officers with beaches subject to AB 411 will required to report postings and closures to the State Water Resources Control Board on a monthly basis, begin

2001.

3.0 Corrective Action

When recreational waters fail to meet standards or guidance, the local health officer may need to take correctivє action. In some cases, the actions of the local health officer are discretionary, in that after taking into considerati causes for the elevation of microbiological indicators, he or she may close, post with warning signs, or otherwisє restrict use of the recreational area until corrective action has been taken and standards or guidance levels are

In other situations, such as ocean beaches that are subject to the provisions of AB 411, the local health officer c not have such discretion.

4.0 Sewage Spills and Closing Recreational Beaches

Immediate beach closure is the appropriate corrective action whenever sewage releases or spills occur. The clo should continue until after the spill or release has been stopped, and until monitoring indicates that the contamir levels meet appropriate standards (see Section 5.0)

5.0 Indicator Organism Levels and Posting/Closure

Appendices A and B present existing state and federal numeric standards and guidance for indicator organisms Appendix C presents a brief summary of local guidance and ordinances.

Decisions about posting and closing beaches should be based upon the most recent single samples. Thirty-day averages allow determinations to be made of the natural fluctuations of the numbers of those organisms. Longe evaluations also provide an understanding of the presence of indicator organisms, in terms of their association \ rainfall, stormwater runoff, dry urban runoff, recreational use, or other conditions specific to a particular beach or recreational area. The proposed AB 411 regulations instruct the local health officer to utilize both single sample 30-day averages in determining whether to close or otherwise restrict the use of a beach or a portion thereof.

Areas that are consistently contaminated may be appropriate for long-term or permanent posting. Those that ar highly contaminated with exceedances of single sample and 30-day standards for multiple indicator organisms r be appropriate for closure.

5.1 Single Sample Values

Beach posting is recommended (and required for certain beaches under Health and Safety Code Section 11591 the AB 411-implementing regulations) when indicator organisms exceed any of the following levels:

- Total coliforms: 10,000 per 100 ml
- Total coliforms: 1,000 per 100 ml, if the ratio of fecal/total coliforms is greater and 0.1. The fecal/total is an indicator of health risk, and a ratio that increases from 0.1 towards 1.0 may indicate a greater ris illness.
- Fecal coliforms: 400 per 100 ml
- Enterococcus: 104 per 100 ml

5.2 Thirty-Day Average Values

Additional sanitary surveys and other related evaluations, including more frequent sampling if levels appear to b an increasing trend, are recommended when indicator organisms exceed any of the levels given below, based c log mean of at least 5 equally spaced samples in any 30-day period:

- Total coliforms: 1,000 per 100 ml
- Fecal coliforms: 200 per 100 ml
- Enterococcus: 35 per 100 ml

6.0 Reopening Closed Beaches

The standards of Section 5.0 should be used to determine the appropriateness of continuing to post or close be or recreational areas, or portions thereof.

7.0 Prohibition of Diapers from Beaches and Recreational Waters

Because of the likelihood of contamination of recreational waters by fecal matter, diaper-wearing infants should prohibited from water contact.

Public notification may be used to inform parents and others about the prohibition of individuals wearing diapers water contact. Methods of public notification may include, but are not limited to, signs, notices, or flyers.

8.0 Public Notification

Notification may be provided to the public by signs, press releases, and electronic access. Health and Safety Cc Section 115885(c)(2) requires the local health officer to establish a telephone hotline to provide public informatic

Appropriate language for signs and their placement along a beach is best determined by local experience. Health and Safety Code Section 115915 does have some specific posting requirements.

8.1 Signs

Signs should be present near the portion of the recreational area at which water contact will occur, and elsewhe (e.g., along walkways to the beach, park entrances) where they are likely to be read. Signs should be large enoı be clearly seen and legible. They should be posted in English and other language(s) as appropriate.

Other signage than those examples given below may be appropriate, as determined by local agencies. A variati the international sign, with a graphic depiction of a swimmer in a red circle with a diagonal hash mark, may be u in some locations. Signs in a second language may be appropriate if a large percentage of recreational water us only speak that language.

POSTING

Signs for Beach Posting Associated with Storm Drains—If a storm drain at a recreational area is chronically contaminated, the area affected by the storm drain should be posted with language similar to the following:

WARNING!
STORM DRAIN WATER MAY CAUSE ILLNESS.
NO SWIMMING IN STORM DRAIN WATER

or

WARNING!
CONTAMINATED STORM DRAIN WATER.
NO SWIMMING IN STORM DRAIN WATER

Signs for Beach Posting Not Associated with Storm Drains—If a beach or recreational area is contaminated, the should be posted with language similar to the following:

WARNING!
CONTAMINATED WATER
SWIMMING NOT ADVISED

Signs for Beach Posting Associated with Contamination by Populations of Marine Mammals or Seabirds—If a b or recreational area is contaminated by marine animals or birds, the area should be posted with language simila the following:

WARNING!
WATER CONTAMINATED BY MARINE MAMMALS
SWIMMING NOT ADVISED

or

WARNING!
CONTAMINATED WATER BY BIRDS
SWIMMING NOT ADVISED

CLOSURE

Signs Indicating Beach Closure—If a beach or recreational area is closed because of a sewage spill or other sir contamination, signs should be used to indicate the closure. Signs for closure should be easily recognized (by v of their color, shape, wording, symbols) as of different from those used for posting. Language should be similar following:

WARNING!
UNTREATED SEWAGE SPILL
BEACH CLOSED

or

WARNING!
CLOSED TO SWIMMING.
BEACH/SWIMMING AREA IS CONTAMINATED
AND MAY CAUSE ILLNESS

8.2 Press Releases

Notification of beach postings or closures because of rainfall and urban runoff, sewage spills, or other public hea concerns by print and electronic media is appropriate. Such notification should be considered supplemental to p and closure, if those activities are required.

All press releases should come from the health authority.

8.3 Electronic Access

Notification of beach postings or closures because of rainfall and urban runoff, sewage spills, or other public hea concerns by means of recorded messages accessible by a telephone hotline is recommended (and required by 411). Additional public information may be provided by electronic bulletin boards, the Internet, and local radio ar television.

8.4 Other Information

To minimize person-to-person microbiological contamination, local health agencies may provide visitor educatio programs and present information on sanitary practices, consisting of notices posted at the beach/park entrance flyers given to individuals.

An example of such information is alerting the public that children should not be allowed to wear diapers in recreational waters.

Because of the likelihood of microbiological contamination of recreational waters by the recreating public the a public education campaign (postings, brochures, public service announcements) might be implemented. Such program could encourage good hygiene practices, avoidance of swimming while ill, control (where feasible) of accidental fecal releases among infants and young children (including recommendations for no diaper wearing i recreational waters, as discussed in Section 7.0). It could also discuss the increased probability of sharing pathogenic organisms when large numbers of people share recreational waters.

8.5 Notification Associated with a Rainfall Event

In the event of rainfall that occurs between April 1 and October 31 and leads to runoff that reaches public beach subject to AB 411, local health officers may choose to utilize a combination of posted warnings and telephone h information required for AB 411-regulated beaches adjacent to storm drains, and press releases that advise aga water contact for 72 hours after rainfall ceases (see Section 2.3). In this way the local health officers can meet tl obligation to post warnings around storm drains and provide information via their hotlines, but are able to make their discretion in taking corrective action at beaches not adjacent to storm drains. Such an approach is reasona and assures that local health agencies need not expend valuable and limited resources by posting and taking d warnings with changing weather.

Initial Draft: November 1997

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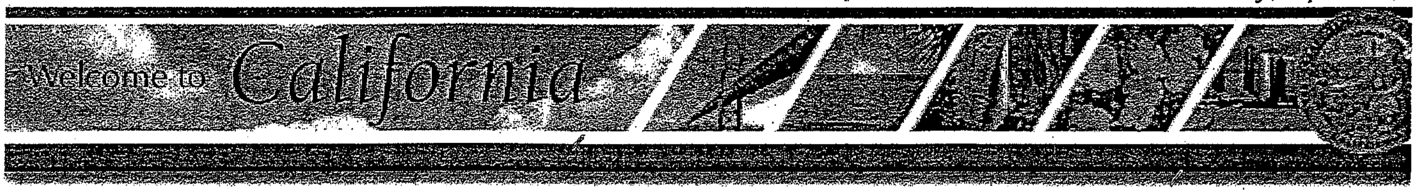

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Division of Drinking Water and Environmental Management

Draft Guidance for Freshwater Beaches

Last Update: March 27, 2006

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Glossary

Closure: The placement of signs at an area of a public beach that informs the public that the area is closed to swimming and water contact. These signs should indicate the nature of the public health concern (e.g., sewage and should, by nature of their language, color, and design, enable the recreating public to differentiate from advi provided by posting. Closure is envisioned to occur when health risks are considered greater than those associa with posting, as with sewage spills or at areas at which monitoring results show that multiple indicator organism standards are exceeded, for both single sample and 30-day average values.

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1.0 Introduction

The purpose of this document is to provide guidance for local health agencies with regard to the sanitation and healthfulness of recreational waters and beaches. It includes guidance for developing a protocol for recreational waters, a discussion of recommended levels of contamination for public notification and beach closure, levels fo reopening closed beaches, and suggested language for public notification. It also includes other recommendatic related to beach cleanliness.

The appendices to this guidance include a review of current standards and guidance for ocean and fresh water recreation, as well as other related material. Appendices A, B, and C present state statutes and regulations, fed guidance, and local guidance and ordinances, respectively. Appendix D discusses the microbiological indicator organisms in standards and guidance. Appendix E provides a brief review of epidemiological studies associated ocean and fresh water recreation. Appendix F provides information and current World Health Organization (WH guidelines on cyanobacteria (blue-green algae) in fresh water.

1.1 Sources of Microbiological Contamination of Recreational Waters

Microbiological contamination of recreational waters is generally associated human sewage or non-human wast long as recreational areas are isolated from those wastes, contamination by disease-causing microorganisms is unlikely. However, there are a number of pathways by which such contamination may occur.

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Feedlots, dairy farms, pasture land, forests and other "natural" areas, and urban surfaces may be sources of microbiological contamination. Animals, both wild and domestic, may also serve as vectors for microbiological parasites of public health concern, such as Giardia and Cryptosporidium.

Sewage Sludge—The distribution of treated sewage sludge, provided that treatment adequately destroys any microbiological components that may be present, should not pose a potential for microbiological contamination (recreational waters. Organisms in inadequately treated sewage sludge, which should not be disposed of on lanc be present in runoff associated with rainfall or with landscape or agricultural irrigation practices.

Surface Water Runoff—As mentioned previously, surface water runoff can contribute significantly to the census microbes in a recreational body of water, particularly in times of heavy rains, in which street gutters and storm d systems that often contain decaying organic matter are flushed out by large volumes of water.

In addition, sanitary sewers systems and septic systems may be overwhelmed by stormwater that may enter the situations with common storm drains and sewer drains, or leaking sewer drains, heavy rains are obvious proble

Dry weather urban runoff may also contain high levels of indicator organisms.

In addition to urban runoff, surface runoff from other land surfaces may also contain microbes, and land on whic wildlife or domestic animals are in dense populations may contribute to high microbial densities in runoff.

Swimmer-to-Swimmer Contamination—Another source of microbiological contamination of marine recreational \ are the individuals who are using those waters for recreation. Constituents of residual fecal matter may be wash the body on contact with water, with most of it washed off within a relatively short time after submersion. Hence, swimmers, bathers, waders, surfers, the fishing population, and others who may come into full- or most-body co may all contribute to contamination to which they are exposed.

Infants and young children, and other individuals may also contribute significantly to microbiological contaminati accidental fecal releases. Others may cause contamination by intentional fecal releases, because of a lack of pı sanitary facilities at or near the recreational area, or because such facilities, though present, are not used.

Recreational users at beaches with limited water circulation will likely be subject to a greater swimmer-to-swimn contamination than those at beaches where water circulation is greater.

1.2 Cyanobacteria (Blue-Green Algae) Blooms in Recreational Waters

Cyanobacteria blooms reflect their environment in which the cyanobacteria exist. Hence, conditions of the fresh body such as water flow, temperature, and the presence of nutrients influence the types of cyanobacteria that m present, as well as their growth and toxicity.

2.0 Protocol Development

Protocols should be developed for the following:

- Sanitary survey
- Sewage spills
- Stormwater runoff
- Sampling and analysis
- Beach posting, closure and reopening procedures

2.1 Sanitary Survey

A sanitary survey should be performed that identifies actual or potential sources of microbiological contaminatio the recreational waters and beach areas. Information that is collected for purposes of the Drinking Water Sourc Assessment and Protection (DWSAP) Program or other watershed-related activities could contribute to a sanita survey. The DWSAP Program document contains a checklist of possible contaminating activities for surface wa sources that may be helpful in this regard.

Sources of contamination near recreational areas may indicate a need for increased monitoring of microbiologic indicator organisms.

For recreational area with poor water circulation, the sanitary survey should include a discussion of the impa bather load on recreational areas. Because of the poor water circulation, heavy bather loads can cause significa elevation in bacterial counts for total and fecal coliform and enterococcus bacteria.

High use areas with poor water circulation may also indicate a need for increased monitoring of microbiological indicator organisms, and for attention to be paid to the potential for blue-green algal blooms.

2.2 Sewage Spills

A protocol should be developed that sets forth procedures for closing recreational waters and beach areas in th event of a sewage spill, including language that is used in public notification and signage, and monitoring requirements for reopening the recreational waters and beach areas (e.g., consecutive sampling indicates that standards are being met and area can be reopened for recreational use). The protocol should also indicate the of beach closure in terms of distance, based on the amount of sewage estimated to be discharged or spilled.

2.3 Stormwater Runoff

A protocol should be developed that sets forth procedures for public notification about beach contamination whe significant amounts of rainfall result in urban runoff that enters recreational waters and beach areas.

The public notification should include press releases and updates of a telephone hotline that is accessible to the public. Other means of public access may also be utilized. The notification should inform the public that body co with stormwater runoff should be avoided for a minimum of 72 hours following significant rainfall because of microbiological contamination. The 72-hour period should be adequate to dissipate microbiological contaminatic

The protocol should include the language that is used in public notification and the means by which the informat distributed.

2.4 Sampling and Analysis Plan

A plan should be developed that includes location of sampling sites, frequency of sampling, duration of sampling period, and depth of sampling. The plan should also include other pertinent information, such as containers for sampling, packaging samples for transport, references for analytic methods, reporting of data, requirements for sampling. The plan should be developed in conjunction with the local Public Health Laboratory.

Location of Sampling Sites—Sampling sites should include areas used for water contact sports. In addition, are known to be regularly or chronically contaminated should be included in the sampling plan.

Frequency of Sampling—Sampling no less frequently than weekly is recommended. However, a minimum frequ of sampling should be established locally, based upon historical records, usage, current situations, and the pote of health hazards.

When samples are above standards or guidance levels, more frequent or daily sampling is appropriate, to deter whether the area should be closed to recreational use.

Subsequent sampling is also needed to determine when to reopen the recreational area.

Time of Sampling—Sampling should occur at each location at generally the same time of day.

For crowded beaches at which bather-to-bather contamination may be a significant route of microbiological exp sampling when recreational use is highest may be appropriate (e.g., mid-afternoon).

Duration of Sampling Period—The sampling period should cover the period of recreational use, for example, Ap through October.

Depth of Sampling —Samples should be taken from just below the water surface, in ankle- to knee-depth water.

approximately 12 to 24 inches deep.

Sampling from boats is inadequate for beach monitoring, since water depths would exceed those common to be related recreational water sports activities occur, especially for young children.

Indicator Organisms —Indicator organisms should include total coliform bacteria and fecal coliform bacteria, anc either enterococcus bacteria or Escherichia coli.

Cyanobacteria and chlorophyll-a—Sampling for cyanobacteria and chlorophyll-a should be conducted in accord with Method 10200 of Standard Methods for the Examination of Water and Wastewater.

2.5 Laboratories and Laboratory Analyses

All samples are to be submitted for analyses to a laboratory certified by the Department of Health Services' Environmental Laboratory Accreditation Program (ELAP), pursuant to Health and Safety Code Section 100825, microbiology for methods appropriate for the analysis of the sample type.

Transportation conditions, holding time limits, and analysis of samples shall be in accordance with those methoc appear on the certificate listing for microbiology of ELAP.

Analyses should be completed expeditiously after they are received in the laboratory. Preliminary results should available from the laboratory as soon as possible, and, if they exceed the standards for microbiological indicatoı organism, the laboratory should telephone the appropriate local agency. Written results should be provided with week after sampling.

Use of Escherichia coli as a surrogate for fecal coliforms—When a test method measures E. coli to be used as a surrogate for fecal coliforms, laboratories should split samples between such a method and either the multiple tu fermentation or membrane filtration method with standard confirmation steps, and run the two tests in parallel, tc identify an appropriate correction factor to apply to the E. coli-derived values (e.g., E. coli per 100 ml x 1.2 = fec coliforms per 100 ml). Such parallel testing should include enough samples to develop a scientifically credible correlation between the two methods. It should occur at least once per year (for example, early summer) or twic each year (for example, early spring and late summer), and ideally should be done for each type of water sourc is subject to the sampling program (for example, lake beach and river beach). The most recently derived correct factor should be applied to the E. coli values to determine compliance with the fecal coliform standard. Laborato should retain the results of the parallel testing in their files, consistent with their record retention procedures.

Data Reporting—The sampling and analysis plan should indicate how data are to be reported, particularly if they outside the reporting range. For example, samples below the testing range for the most probable number (MPN e.g., <20 MPN, should be reported as "<20 MPN" and not as "zero."

The sampling and analysis plan should also indicate how data outside the testing range are used in the calculat 30-day averages. For example, a sample that is <20 MPN may appropriately be designated "10 MPN" (half the range for the sample) for purposes of assigning a numeric value that can be used for determining the monthly v

Cyanobacteria and chlorophyll-a—Sampling for cyanobacteria and chlorophyll-a should be conducted in accord with Method 10200 of Standard Methods for the Examination of Water and Wastewater.

2.6 Posting, Closure and Reopening Procedure

The protocol should include procedures for posting and/or closing beaches and recreational areas, public notific and procedures for determining whether posting and/or closure should continue.

3.0 Corrective Action

When recreational waters fail to meet guidance levels, the local health officer may choose to take corrective acti Such actions may include, after taking into consideration the causes for the elevation of microbiological indicato posting the beach with warning signs, closing the beach or otherwise restricting its use until corrective action ha been taken and guidance levels are met.

4.0 Sewage Spills and Closing Recreational Beaches

Immediate beach closure is the appropriate corrective action whenever sewage releases or spills occur. The clo should continue until after the spill or release has been stopped, and until monitoring indicates that the contamir levels meet appropriate guidance levels (see Section 5.0)

5.0 Indicator Organism Levels, Cyanobacteria Levels and Posting/Closure

Appendices A and B present existing state and federal numeric standards and guidance for indicator organisms Appendix C presents a brief summary of local guidance and ordinances. Appendix F provides information on cyanobacteria in fresh water.

Decisions about posting and closing beaches should be based upon the most recent single samples. Thirty-day averages allow determinations to be made of the natural fluctuations of the numbers of those organisms. Longe evaluations also provide an understanding of the presence of indicator organisms, in terms of their association \ rainfall, stormwater runoff, dry urban runoff, recreational use, or other conditions specific to a particular beach oı recreational area.

Areas that are highly or consistently contaminated require special attention. For example, portions of beaches t are associated with areas that fail to meet standards more often than not, because of local conditions, may be appropriate for posting and/or closing on a long-term basis. Creeks, streams, and rivers, whether natural or in r made channels, may contain elevated levels of indicator organisms, particularly if their flow is influenced by stormwater or dry weather urban runoff.

A sewage spill or other occurrence that poses similar high health risk should prompt immediate beach clos

5.1 Single Sample Values

Beach posting is recommended when indicator organisms exceed any of the following levels:

- Total coliforms: 10,000 per 100 ml
- Fecal coliforms: 400 per 100 ml
- Either Enterococcus: 61 per 100 ml, or E. coli: 235 per 100 ml

Beach posting is recommended when cyanobacteria exceed the following levels:

- Visual presence of a cyanobacteria bloom
- Either 20,000 cyanobacterial cells per milliliter, or 10 µg chlorophyll-a per liter with dominance of cyanobacteria

5.2 Thirty-Day Average Values

Additional sanitary surveys and other related evaluations, including more frequent sampling if levels appear to b an increasing trend, are recommended when indicator organisms exceed any of the following, based on the log of at least 5 equally spaced samples in a 30-day period:

- Total coliforms: 1,000 per 100 ml
- Fecal coliforms: 200 per 100 ml
- Either Enterococcus: 33 per 100 ml, or E. coli: 126 per 100 ml

6.0 Reopening Posted or Closed Beaches

The levels of Section 5.0 should be used to determine the appropriateness of continuing to post or close beache recreational areas, or portions thereof.

7.0 Prohibition of Diapers from Beaches and Recreational Waters

Because of the likelihood of contamination of recreational waters by fecal matter, diaper-wearing infants should prohibited from water contact.

Public notification may be used to inform parents and others about the prohibition of individuals wearing diapers water contact. Methods of public notification may include, but are not limited to, signs, notices, or flyers.

8.0 Public Notification

Notification may be provided to the public by signs, press releases, and electronic access.

Appropriate language for signs and their placement along a beach is best determined by local experience.

8.1 Signs

Signs should be present near the portion of the recreational area at which water contact will occur, and elsewhe (e.g., along walkways to the beach, park entrances) where they are likely to be read. Signs should be large enoı be clearly seen and legible. They should be posted in English and other language(s) as appropriate.

Other signage than those examples given below may be appropriate, as determined by local agencies. A variati the international sign, with a graphic depiction of a swimmer in a red circle with a diagonal hash mark, may be u in some locations. Signs in a second language may be appropriate if a large percentage of recreational water us only speak that language.

POSTING

Signs for Beach Posting Associated with Storm Drains—If a storm drain at a recreational area is chronically contaminated, the area affected by the storm drain should be posted with language similar to the following:

WARNING! STORM DRAIN WATER
MAY CAUSE ILLNESS.
NO SWIMMING IN STORM DRAIN WATER

or

WARNING!
CONTAMINATED STORM DRAIN WATER.
NO SWIMMING IN STORM DRAIN WATER

Signs for Beach Posting Not Associated with Storm Drains—If a beach or recreational area is contaminated, the should be posted with language similar to the following:

WARNING!
CONTAMINATED WATER
SWIMMING NOT ADVISED

Signs for Beach Posting Associated with Contamination by Populations of Animals—If a beach or recreational a contaminated animal waste, the area should be posted with language similar to the following:

WARNING!
WATER CONTAMINATED BY WILDLIFE
SWIMMING NOT ADVISED

or

WARNING!
CONTAMINATED WATER BY ANIMALS
SWIMMING NOT ADVISED

or

WARNING!
CONTAMINATED WATER BY BIRDS
SWIMMING NOT ADVISED

Signs for Beach Posting Associated with Cyanobacteria Blooms—If a beach or recreational area is experiencing blue-green algae bloom, the area should be posted with language similar to the following:

WARNING!
BLUE-GREEN ALGAE BLOOM
SWIMMING, WADING NOT ADVISED

CLOSURE

Signs Indicating Beach Closure—If a beach or recreational area is closed because of a sewage spill or other sir contamination, signs should be used to indicate the closure. Signs for closure should be easily recognized (by v of their color, shape, wording, symbols) as of different from those used for posting. Language should be sim̈ilar following:

WARNING!
UNTREATED SEWAGE SPILL
BEACH CLOSED

or

WARNING! CLOSED TO SWIMMING.
BEACH/SWIMMING AREA IS CONTAMINATED
AND MAY CAUSE ILLNESS

Signs Indicating Beach Closure due to Cyanobacteria Blooms—If a beach or recreational area is closed becau: the presence of a blue-green algae bloom, signs should be used to indicate the closure. Signs for closure shou easily recognized (by virtue of their color, shape, wording, symbols) as of different from those used for posting. Language should be similar to the following:

WARNING!
BLUE-GREEN ALGAE BLOOM
BEACH CLOSED

or

WARNING! CLOSED TO SWIMMING AND BODY CONTACT
BEACH/SWIMMING AREA HAS BLUE-GREEN ALGAE BLOOM
WATER CONTACT MAY CAUSE ILLNESS

8.2 Press Releases

Notification of beach postings or closures because of rainfall and urban runoff, sewage spills, or other public hea concerns by print and electronic media is appropriate. Such notification should be considered supplemental to p of warning or and closure signs, if those activities are required.

All press releases should come from the health authority.

8.3 Electronic Access

Notification of beach postings or closures because of rainfall and urban runoff, sewage spills, or other public hea concerns by means of recorded messages accessible by a telephone hotline is recommended. Additional public information may be provided by electronic bulletin boards, the Internet, and local radio and television.

8.4 Other Information

To minimize person-to-person microbiological contamination, local health agencies may provide visitor educatio programs and present information on sanitary practices, consisting of notices posted at the beach/park entrance flyers given to individuals.

An example of such information is alerting the public that children should not be allowed to wear diapers in recreational waters.

Because of the likelihood of microbiological contamination of recreational waters by the recreating public thems a public education campaign (postings, brochures, public service announcements) might be implemented. Such program could encourage good hygiene practices, avoidance of swimming while ill, control (where feasible) of accidental fecal releases among infants and young children, (including recommendations for no diaper wearing recreational waters, as discussed in Section 7.0). It could also discuss the increased probability of sharing pathc organisms when large numbers of people share recreational waters.

8.5 Notification Associated with a Rainfall Event

In the event of rainfall that occurs during recreational months, local health officers may choose to utilize a combi of posted warnings and/or closure signs, telephone hotline information, and press releases that advise against v contact for 72 hours after rainfall ceases (see Section 2.3).

8.6 Notification of Drinking Water Systems

When a beach posting, closure or other restriction or public notification occurs because guidance levels for microbiological indicators are not met in a freshwater body that is used as a source of drinking water by a public system, the public water system should be notified by the local health officer.

Parents and others about the prohibition of individuals wearing diapers from water contact. Methods of public notification may include, but are not limited to, signs, notices, or flyers.

Initial draft: November 1997

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Division of Drinking Water and Environmental Management

Regulations for Public Beaches and Ocean Water-Contact Sports Areas

The California Department of Health Services' (DHS') regulations for public beaches and ocean water-contact s| areas include those developed in response to requirements of Health and Safety Code §115880 (Assembly Bill Statutes of 1997, Chapter 765). The text of AB 411 is included in Appendix A to DHS' beaches guidance docum

The AB 411-implementing regulations, which follow, are described and explained in the regulation's Statement c Reasons.

Title 17 of the California Code of Regulations

Group 10. Sanitation, Healthfulness and Safety of Ocean Water-Contact Sports Areas

Article 2. Definitions

7956. Storm Drain.

"Storm drain" means a conveyance through which water flows onto or adjacent to a public beach and includes r creeks, and streams, whether in natural or in man-made channels.

NOTE: Authority cited: Sections 100275, 115880, and 116075, Health and Safety Code. Reference: Sections 1 116075, and 116080, Health and Safety Code.

HISTORY:

1. New section filed 7-26-99 as an emergency; operative 7-26-99 (Register 99, No. 31). A Certificate of Complia must be transmitted to OAL by 11-23-99 or emergency language will be repealed by operation of law on the follı day.

2. Certificate of Compliance as to 7-26-99 order transmitted to OAL 10-15-99 and filed 11-30-99 (Register 99, N

Article 4. Healthfulness

7957. Physical Standard.

No sewage, sludge, grease, or other physical evidence of sewage discharge shall be visible at any time on any beaches or water-contact sports areas.

NOTE: Authority cited: Sections 208, and 24156, Health and Safety Code. Reference: Sections 24156, Health a Safety Code.

HISTORY:

1. New NOTE filed 3-20-84 (Register 84, No. 12).

7958. Bacteriological Standards.

(a) The minimum protective bacteriological standards for waters adjacent to public beaches and public wa sports areas shall be as follows:

(1) Based on a single sample, the density of bacteria in water from each sampling station at a public be public water contact sports area shall not exceed:

(A) 1,000 total coliform bacteria per 100 milliliters, if the ratio of fecal/total coliform bacteria exce 0.1; or

(B) 10,000 total coliform bacteria per 100 milliliters; or

(C) 400 fecal coliform bacteria per 100 milliliters; or

(D) 104 enterococcus bacteria per 100 milliliters.

(2) Based on the mean of the logarithms of the results of at least five weekly samples during any 30-day sampling period, the density of bacteria in water from any sampling station at a public beach or public w contact sports area, shall not exceed:

(A) 1,000 total coliform bacteria per 100 milliliters; or

(B) 200 fecal coliform bacteria per 100 milliliters; or

(C) 35 enterococcus bacteria per 100 milliliters.

(b) Water samples shall be submitted for bacteriological analyses to a laboratory certified by the Environmental Laboratory Accreditation Program, California Department of Health Services in microbiology for methods for the analysis of the sample type. [see recommended methods]

NOTE: Authority cited: Sections 100275, 115880, and 116075, Health and Safety Code. Reference: Sectio 116075, and 116080, Health and Safety Code.

HISTORY:

1. Amendment filed 7-15-85; effective thirtieth day thereafter (Register 85, No. 29).

2. Repealer and new section and amendment of Note filed 7-26-99 as an emergency; operative 7-26-99 (Regist No. 31). A Certificate of Compliance must be transmitted to OAL by 11-23-99 or emergency language will be repealed by operation of law on the following day.

3. Certificate of Compliance as to 7-26-99 order transmitted to OAL 10-15-99 and filed 11-30-99 (Register 99, N

7959. Bacteriological Sampling.

(a) In order to determine that the bacteriological standards specified in Section 7958 above are being met in a w contact sports area designated by a Regional Water Quality Control Board in waters affected by a waste discha water samples shall be collected at such sampling stations and at such frequencies as may be specified by said board in its waste discharge requirements.

(b) In waters of a public beach or water-contact sports area that has not been so designated by a Regional Wat Quality Control Board, water samples shall be collected at such frequencies as may be determined by the local officer or Department. Local health officers shall be responsible for the proper collection and analysis of water samples in such areas.

NOTE: Authority cited: Sections 208, and 24156, Health and Safety Code. Reference: Sections 24156 and 241 Health and Safety Code.

HISTORY:

1. Amendment filed 7-15-85; effective thirtieth day thereafter (Register 85, No. 29).

7960. Corrective Action.

(a) When a public beach or public-water-contact sports area fails to meet any of the standards as set forth in Se 7957 or 7958 above, the local health officer or the Department, after taking into consideration the causes thereft may at his or its discretion close, post with warning signs, or otherwise restrict use of said public beach or public water-contact sports area, until such time as corrective action has been taken and the standards as set forth in : and 7958 above are met.

NOTE: Authority cited: Sections 208, and 24156, Health and Safety Code. Reference: Sections 24156 and 241: Health and Safety Code.

HISTORY:

1. Amendment filed 7-15-85; effective thirtieth day thereafter (Register 85, No. 29).

7961. Public Beaches Visited by More than 50,000 People Annually and Adjacent to Storm Drains.

(a) Waters adjacent to a public beach shall be tested for bacteria identified in Section 7958 on at least a weekly from April 1 to October 31, inclusive, if the beach is

(1) Visited by more than 50,000 people annually, and

(2) Located adjacent to a storm drain that flows in the summer.

(b) Water samples shall be taken from locations that include areas affected by storm drains. Samples shall be ta in ankle- to knee-deep water, approximately 4 to 24 inches below the water surface.

(c) When testing reveals that the waters adjacent to a public beach fail to meet any of the standards set forth in Section 7958(a)(1), the local health officer shall post the beach pursuant to Health and Safety Code Section 115 and shall use the standards of Sections 7958(a)(1) and (2) in determining the necessity to restrict the use of or (the public beach or portion thereof.

(d) In the event of a known release of untreated sewage into waters adjacent to a public beach, the local health shall:

(1) Immediately post and close the beach or a portion thereof, or otherwise restrict its use until the sourc the sewage release is eliminated;

(2) Sample the affected waters; and

(3) Continue closure or restriction of the beach or a portion thereof and posting the beach until testing re establish that the standards of Sections 7958(a)(1) are satisfied.

NOTE: Authority cited: Sections 100275, 115880, and 116075, Health and Safety Code. Reference: Sections 1' 116075, and 116080, Health and Safety Code.

HISTORY:

1. New section filed 7-26-99 as an emergency; operative 7-26-99 (Register 99, No. 31). A Certificate of Complia must be transmitted to OAL by 11-23-99 or emergency language will be repealed by operation of law on the foll day.

2. Certificate of Compliance as to 7-26-99 order transmitted to OAL 10-15-99 and filed 11-30-99 (Register 99, N

7962. Duties Imposed on a Local Public Officer or Agency.

(a) Pursuant to Health and Safety Code Sections 115880(h), 115885(g), and 115915(c), any duty imposed upor local public officer or agency by Section 7961 shall be mandatory only during a fiscal year in which the Legislatu has appropriated sufficient funds, as determined by the State Director of Health Services, in the annual Bu otherwise for local agencies to cover the costs to those agencies associated with performance of these du

NOTE: Authority cited: Section 100275, Health and Safety Code. Reference: Sections 115880, 115885, and 11 Health and Safety Code.

HISTORY:

1. New section filed 7-26-99 as an emergency; operative 7-26-99 (Register 99, No. 31). A Certificate of Complia must be transmitted to OAL by 11-23-99 or emergency language will be repealed by operation of law on the foll day.

2. Certificate of Compliance as to 7-26-99 order transmitted to OAL 10-15-99 and filed 11-30-99 (Register 99, N

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Division of Drinking Water and Environmental Management

Initial Statement of Reasons- Standards for Public Beaches

The following text, which describes and explains the regulations required by Health and Safety Code §115880 (Assembly Bill 411, Statutes of 1997, Chapter 765), is from the regulations' Initial Statement of Reasons filed wi Office of Administrative Law in July 1999.

Title 17, California Code of Regulations

Group 10. Sanitation, Healthfulness and Safety of Public Beaches and Ocean Water-Contact Sports Areas

Article 2. Definitions.

7956. Storm Drain Defined

This section defines the term "storm drain." Health & Safety Code 115880(c)(4)(B) refers to storm drains in the c of beaches that are subject to Department regulations, i.e., "The beach is located on an area adjacent to a storm drain that flows in the summer." Such a definition is necessary, since the term "storm drain" is vague.

The Department defines a storm drain as a conveyance through which water flows onto or adjacent to a public t or into an ocean water-contact sports area, and includes rivers, creeks, and streams, whether they are in man-n channels or in natural channels. The Department included both man-made and natural channels in this definitioi since water in either of them can be subject to microbiological contamination.

Article 4. Healthfulness.

7958. Bacteriological Standards

Section 7958(a), prior to the regulation adopted by emergency, established numeric standards for total coliform bacteria only. Section 7958(b), prior to the emergency regulation, cited the American Public Health Association': methods that are to be used in meeting the microbiological standards. Both have been deleted and replaced wit language. Section 7958(a) now includes numeric standards for three bacterial indicators, and Section 7958(b) n addresses requirements for laboratories and their methods by referring to contemporary certification requiremer

Health and Safety Code Section 115880(c)(2) requires the establishment of protective minimum standards for tc coliform, fecal coliform, and enterococci bacteria.

Section 7958(a) in the emergency regulation provides numeric standards for total coliform bacteria, fecal colifon bacteria and enterococcus bacteria. These bacterial organisms are good indicators of microbiological contamin and are used by health authorities as surrogates for disease-causing organisms that are likely to be present in sewage, but are difficult to analyze for directly.

Section 7958(a)(1) establishes four numeric standards, two for total coliform bacteria, and one each for fecal co bacteria and enterococcus bacteria. Section 7558(a)(2) establishes three numerical standards, one each for tota coliform bacteria, fecal coliform bacteria, and enterococcus bacteria.

Total coliform bacteria

The Department's regulation includes a single sample standard of 10,000 total coliforms per 100 milliliters and ε day average (mean of the logarithms of the results of at least five weekly samples over the prior 30 days) of 1 0 total coliforms per 100 milliliters. The numeric standards for total coliform are numerically identical to the p standard and derived from earlier standards that sought to protect the public from the health threats from e. si sewage contamination. However, there are slight changes in the additional requirements that accompany the nu standards in the existing regulations.

The numeric standards are derived from studies in the 1940's and 1950's by the US Public Health Service, as summarized by the US EPA (1986). Studies of fresh- and saltwater (of bathers and bathing waters in Lake Mich the Ohio River, and Long Island Sound) investigated illness (gastrointestinal illness, respiratory, skin irritation) a related to the concentration of total coliform bacteria. Among the studies at Lake Michigan, no excess illnesses found in swimmers at beaches with median coliforms densities of 91 and 180 per 100 milliliters compared to illn in the total study population. A second method of analysis compared the illness observed following three days o coliform density with that observed following three days of low coliform density. There was a significantly greate of illness when the geometric mean coliform density was 2,300 coliforms per 100 milliliters when compared to th who swam when the density was 43 coliforms per 100 milliliters, but there was no difference when densities compared were 732 versus 32 coliforms per 100 milliliters. Data from the Ohio River showed increased rates of gastrointestinal illness in swimmers in water with a median coliform density of 2,300 coliforms per 100 milliliters.

Two marine bathing beach studies showed no association between illness and swimming in water containing 39 815 coliforms per 100 milliliters.

These data support the standards for total coliforms. The standard is numerically the same as the previous stan that was replaced by the emergency regulation, 1,000 coliforms per 100 milliliters for the average total coliform concentration. The emergency regulation uses the mean of the logarithms of not less than five previous weekly samples from the prior 30 days, whereas the prior regulation used a standard of not to exceed 20 percent of the samples in the prior 30 days.

This 1,000-organism value is less than the concentration of 2,300 coliforms per 100 milliliters, which was shown related to gastrointestinal illness in freshwater areas. Saltwater concentrations approaching this value (815 colifi per 100 milliliters) were not shown to be associated with illness.

The single sample standard of 10,000 total coliform bacteria per 100 milliliter serves to limit exposures to potent disease-causing organisms by providing an overall ceiling for the total coliform concentration. Without a sir ceiling, very high concentrations could occasionally occur in between very low values, and the 30-day stand still be met. However, because the very high concentrations could be indicative of the presence of potential pathogens at the time of the sampling, it is important that a single standard be present.

The single sample level of 10,000 total coliforms per 100 milliliter level is reasonable, based on an epidemiologi study of approximately 15,000 swimmers in Santa Monica Bay (Haile, et al., 1996; SMBRP, 1996) at beaches affected by storm drains. Investigators found that exposures to levels greater than 10,000 total coliforms per 10(milliliters were related to a 200 percent increase in the risk of skin rash.

The single sample level of 10,000 total coliforms per 100 milliliter level is numerically the same as the previous regulation. The current regulation, however, no longer requires verification by a repeat sample within 48 hours. the Department first proposed removing the requirement for verification of a result that is above the standard, sc local environmental health officials questioned the value of this change. They pointed out that repeat sampling is used to confirm that samples elevated above standards are not the result of laboratory error. However, in the Department's view, because of the relationship of elevated indicator organisms and the potential for the presenc pathogens, corrective action should be taken when results show levels of indicators that are above the standard addition, because of the time required to obtain analytical results (up to two or three days), verification samples delay action by the local health officer considerably. The weekly testing required by Health and Safety Code Se 155880 for certain beaches provides a "verification" sample for the sample taken a week earlier.

An additional single sample value for total coliforms is used. This value is 1,000 total coliforms per 100 milliliters ratio of fecal/total coliforms is greater than 0.1.

The Santa Monica Bay investigators found that the ratio of total to fecal coliforms was related to an increase in i Illness included significant respiratory disease (SRD), with symptoms of fever and nasal congestion, fever and s throat, and cough with sputum, and also included highly credible gastrointestinal illness (HCGI). HCGI was defir HCGI-1 (vomiting, diarrhea and fever, stomach pain and fever) and HCGI-2 (vomiting and fever).

The investigators found the number of cases of swimmers near storm drains increased as the ratio of total/fecal coliforms decreased below 10, i.e., when the fecal coliforms represented a larger proportion of the total coliform risk increased. The highest numbers of cases of illness occurred when the ratio was 2, with SRD at about 220 e cases per 10,000 swimmers at that ratio (excess refers to the number of cases expected among controls, those swam 400 or more yards away from storm drains), HCGI-1 at about 170 per 10,000, and HCGI-2 at about 110 p 10,000, when total coliforms exceeded 1,000 per 100 ml.

Additional analyses of the data from the Santa Monica Bay study compared the risk of illness among swimmers water at different total/fecal ratios and at two levels of total coliform bacteria, 5,000 per 100 ml. and 1,000 per m (Haile and Witte, undated). At a total coliform count greater than 5,000 per ml., a total/fecal ratio of 10 (one-tentl the total coliforms are fecal) was related to risks of 107-657 per 10,000 swimmers for eight different effects (feve discomfort, ear discomfort, skin rash, nausea, diarrhea, stomach pain, runny nose). At a total coliform count gre than 1,000 per 100 ml., a total/fecal ratio of 10 was related to risks of 117-281 per 10,000 swimmers for three di effects (chills, nausea, diarrhea).

The Department incorporated the ratio of the two coliform indicator organisms into the standards to be used. However, the regulations use an inverted ratio (fecal/total instead of total/fecal, as used in the Santa Monica Ba study) to express the relative concentrations, so that exceeding the ratio of 0.1 would indicate a health concern.

The results of the Santa Monica Bay study showed that the ratio of total to fecal coliforms was more predictive c illness than the enterococcus concentration.

The 30-day average value for total coliform bacteria of 1,000 per 100 milliliters of water, replaces the old standa not to exceed 1,000 per 100 milliliters of water in 20% of samples taken in a 30-period. For all practical purpose two standards are the same, since one sample of five taken in a 30-day period is 20 % of the samples. Using th mean of the logarithms of the results may result in fewer findings of levels higher than the not to exceed 1,000 t coliform standard, but interpreting their analyses will be consistent with the expanded number of indicator organ which are to be used in determining whether beach closure or other restrictions are needed. Further, even if the mean results in fewer findings greater than the 1,000 total coliform value, the single sample value that is associ with an increased fecal/total coliform ratio in Section 7658(a)(1), if exceeded, could, prompt a requirement for be posting.

In addition to consistency with Department regulations for total coliforms that existed prior to the emergency regulation, the standard of 10,000 total coliforms per 100 ml for a single sample and 1,000 total coliforms per 1C for a 30-day average are consistent with the water contact standards of the California Ocean Plan of the State V Resources Control Board (1997).

Fecal coliform bacteria

The Department's regulation includes a single sample standard of 400 fecal coliforms per 100 milliliters, and a 3 average (mean of the logarithms of the results of at least five weekly samples over the prior 30 days) of 200 tota coliforms per 100 milliliters.

The numeric standard for fecal coliform is derived from studies used for the total coliform standard from the Ohi River study mentioned in the previous section. Fecal coliforms are considered to be more specific to the presen feces and less subject to variation than total coliforms (which are greatly influenced by storm water runoff). Abo percent of the coliforms in the Ohio River study were found to be fecal coliforms. This 18 percent proportion was to determine that the concentration of 2,300 coliforms per 100 milliliters that was associated with gastrointestina illness was equivalent to about 400 fecal coliforms (2,300 x 0.18) (USEPA, 1986). As described by USEPA (198 the National Technical Advisory Committee (NTAC) of the Department of Interior, the agency that made recommendations about recreational water at that time, felt that a detectable increase in disease was unaccept Therefore, one-half of the density at which a health risk occurred, or 200 fecal coliforms, was proposed. The NT also suggested that the use of the water should not cause a detectable health effect more than 10 percent of the It proposed that no more of than 10 percent of the total samples during any monthly period should exceed 400 p 100 milliliters.

The standards of 400 fecal coliforms per 100 ml for a single sample and 200 fecal coliforms per 100 ml for a 30- average are consistent with the water contact standards of the California Ocean Plan of the State Water Resour Control Board (1997), and with guidance issued by the US EPA (1986). The numeric standards for fecal colifom numerically identical to the levels of these other agencies. However, as with the total coliforms, there are slight changes in the application of the numeric standards. The State Water Resources Control Board's Ocean Plan (uses a fecal coliform density of 200 per 100 milliliters, based on the geometric mean of not less than 5 samples any 30-day period, and a density of 400 coliform bacteria per 100 milliliters that is not to be exceeded by more t 10 percent of the total samples during any 60-day period. US EPA guidance (1986) recommends that 400 fecal coliforms not be exceeded by more than 10 percent of the total samples during any 30-day period.

The single sample level of 400 fecal coliforms per 100 milliliter level is reasonable, based on the epidemiolo...a study in Santa Monica Bay (Haile, et al., 1996; SMBRP, 1996) at beaches affected by storm drains. Investigator found that exposures to levels greater than 400 total coliforms per 100 milliliters were related to an 88 percent increase in the risk of skin rash.

Enterococcus bacteria

The Department's regulations include a single sample standard of 104 enterococcus bacteria per 100 milliliters, 30-day average (mean of the logarithms of the results of at least five weekly samples over the prior 30 days) of enterococcus bacteria per 100 milliliters.

In the 1970s, the USEPA performed epidemiological studies at several beaches in the United States (Cabelli, 1ᵋ From these studies of approximately 27,000 bathers in New York, Louisiana, and Massachusetts, the author concluded that concentrations of enterococcus bacteria were the best indicator organism for the prediction of hu illness associated with recreational bathing. For example, for total highly credible gastrointestinal symptoms (voi diarrhea, or stomach ache or nausea with fever), the mean enterococcus density had correlation coefficients of 0.96, compared to 0.12 - 0.46 for total coliform bacterial and minus 0.01 - 0.51 for fecal coliforms. For total gastrointestinal symptoms, the mean enterococcus density had correlation coefficients of 0.81 - 0.84, compared 0.12 - 0.46 for total coliform bacterial and 0.01 - 0.36 for fecal coliforms. From these studies, a recommended he effects criterion for marine recreation waters was described by the equation, log X = 0.0456Y + 0.677. The repo Cabelli was used by the US EPA (1986) to estimate that exposures to water at the fecal coliform standard of 20 100 milliliters, containing enterococcus bacteria at an average concentration of 35 per 100 milliliters, would resu 19 cases of effects (such as gastrointestinal illness or other effects) per 1,000 people so exposed. An average c per 100 milliliters was considered to pose the same risk as a single exposure to 104 enterococcus bacteria per milliliters.

The Santa Monica Bay study found concentrations of enterococcus greater than the single sample level (that st used 106 enterococci as the reference point instead of 104) to show an increase in gastrointestinal effects. The investigators found a 323 percent increased in diarrhea with blood, and a 44 percent increase in vomiting and fe associated with exceeding the enterococcus value.

The enterococcus standards, in concert with those for total coliforms and fecal coliforms and the ratio of the ...o coliforms, represent a spectrum of indicator organisms that provides for the protection of public health.

The standards of 104 enterococcus bacteria per 100 ml for a single sample and 35 enterococcus bacteria per 1 for a 30-day average are values that are derived from USEPA guidance (1986). The California Ocean Plan of th State Water Resources Control Board (1997) also requires monitoring for enterococcus, and requires a survey t determine if a discharger is responsible for the contamination when the 30-day average (geometric mean) enterococcus level exceeds 24 per 100 ml (or 12 per 100 ml for a six-month period).

Other microbiological indicators

Health and Safety Code Subsections 155880(c)(1) and (2) direct the Department's regulations to require testing other microbiological indicators and to establish standards for them, if alternative indicators are as protective of health as total coliform, fecal coliform, and enterococci bacteria. Although research is being performed within th scientific community with regard to health risks from the recreational marine waters and on "better" indicators of disease-causing organisms, available scientific studies and the weight of the evidence do not suggest that alternatives that are as protective are yet identified. However, the Department will continue to follow developme research on other potential indicators of disease associated with marine water exposures.

Single sample and 30-day averages

One of the points of discussion in early meetings the Department had with local environmental health officials centered on the value of single most recent samples and 30-day averages of concentrations of microbiological indicator organisms to local health officers in determining whether beaches should posted, closed, or otherwise restricted. Many of California's local environmental health officers indicated that they find the most recent of sinc samples taken weekly to be more helpful than the average (mean of the logarithms) of five weekly samples ove day period, which is also used in analyzing monitoring data. The single most recent sample enables a more pro response to elevated levels. As a result, the regulation does not utilize the 30-day averages as triggers for beac posting, as discussed below in Section 7961. However, the 30-day averages are used for determining whether a beach should be restricted as to its use, or whether it should be closed, either partially or entirely. The 30-day av of monitoring data may also be of value in providing information that may be of value in identifying sources of microbiological contamination, and in identifying areas of chronic contamination. Since the weekly collection of c enables 30-day averages to be calculated easily, the average values can readily be evaluated by local agencies

Laboratory analyses

Section 7658(c) requires that samples are to be submitted to laboratories certified in microbiology by the Environmental Laboratory Accreditation Program (ELAP) of the Department. The ELAP certification addresses methods to be used in bacteriological analyses. The laboratory accreditation process assures that laboratories r certain standards with regard to laboratory procedures and practices. The competence that is demonstrated by accreditation process gives users of data from laboratory analysis confidence in the accuracy and validity of the The use of prescribed methods that are part of the certification process of the laboratory adds to the confidence laboratory results and their interpretation.

Section 7961. Public Beaches Visited by More than 50,000 People Annually and Adjacent to Storm Drains

Section 7961(a) requires that waters adjacent to public beaches be sampled weekly from April1 through Octobe each year if the beach is visited by more than 50,000 people annually and if this beach is located on an area ad to a storm drain that flows in the summer. Health and Safety Code Section 115880(c)(4) requires that the regula include the requirement for weekly testing of beaches that are visited by more than 50,000 people annually and are located on an area adjacent to a storm drain that flows in the summer. As a result, this part of the regulation duplicates the statutory requirement, contrary to the Administrative Procedure Act's nonduplication standard. However, given the statutory requirement and the opportunity to focus the regulation on the specific public beac that are subject to these regulations, such duplication is reasonable.

Health and Safety Code Section 115880(c)(3) requires that the Department's regulations establish protocols for monitoring site locations and monitoring frequency, based on risks to public health.

Section 7961(b) covers the location of the sampling. In developing this regulation, the Department considered proposing specific locations for sampling at public beaches and areas adjacent to storm drains. However, such specificity was not included for several reasons. First, California's many beaches differ in terms of their size, sha use patterns, and the extent to which they are affected by storm drains. Second, the size and flow patterns of st drains varies from beach to beach. Third, the proximity of recreational use to storm drains may also vary from be to beach. For these reasons, the Department believes that local health officers have site-specific knowledge abc beaches, storm drains, and recreational use that is useful in addressing concerns about localized contamination may be associated with storm drains. It is appropriate that the sampling locations be established by the local he officer, who will be able to include them in the weekly sampling areas of public beaches. It is obvious and need r mentioned in the regulation that sampling of waters adjacent to public beaches includes areas used by the recre public.

Sampling sites need to provide data for water that is affected by a storm drain, as well as water that is not affect a storm drain, so that the extent of storm drain influence can be determined. The regulation points out that such waters affected by storm drains should be included in the weekly sampling. The exact location of sampling with respect to the storm drain waters must be left to the local health officer, because the area influenced by storm d waters depends on a number of site-specific variables, including the volume and rate of flow of water from the s drain, the nature of the receiving coastal area, the influence of currents, tides, and other natural conditions.

The regulation also includes appropriate sampling depths for waters adjacent to public beaches. It states that sa should be taken from just below the water surface, in ankle- to knee-depth water, approximately 4- to 24- inches deep. This depth of sampling is appropriate and representative of exposures to water at public beaches, particu for children who would be wading and playing in shallow waters. This depth also provides for consistency of sar among various individuals and programs.

Posting beaches, closing and reopening beaches

Health and Safety Code Section 115880(c)(3) requires that the Department's regulations establish protocols for making decisions regarding public notification of health hazards, including, but not limited to the posting, closing reopening of public beaches.

Section 7961(c) requires, for beaches subject to Health and Safety Code Section 115880, that the local health c post a public beach pursuant to Health and Safety Code Section 115915 whenever any of the four standards in

Section 7958(b) are exceeded. Because each of the standards is protective of public health, exceedance of any them is reasonable to require posting for the protection of public health.

Section 7961(c) also requires that the local health officer utilize the standards of Sections 7958(a)(1) and 79... to determine whether it is necessary to close or otherwise restrict use of a public beach with elevated levels of microbiological indicators. Although the single sample standard is to be used for purposes of posting, the longer (30-day average) samples will provide additional information to the local health officer that will be helpful in iden possible additional actions (closure or use restriction). For example, the longer term results may help the local h officer identify a specific area of a public beach that may warrant long-term permanent posting or closure (e.g., a area affected by a storm drain that always exceeds standards).

Response to sewage spills

Section 7961(d) includes regulations that apply to known releases of untreated sewage into waters adjacent to a public beach. Since sewage releases are likely to contain disease-causing organisms, the regulation requires th local health officer to immediately post the beach, and to close the beach (or parts of it) or otherwise restrict its u the public. Posting, and closure or restrictions are required to continue until the source of the known sewage rel is eliminated. This requirement ensures that exposures to sewage by water contact will not occur.

The local health officer is also required to sample the affected waters and test them for total coliform bacteria, fe coliform bacteria and enterococcus, and to use the standards of 7958(a)(1) for those indicator organisms to det whether posting, restriction, and/or closure of the beach should continue. Such testing will also enable the local officer to make decisions about whether the area that is posted and closed or restricted can be reduced in size, allowing beach users to use portions of the public beach that no longer pose a risk of exposure to microbiologic contamination.

Section 7962. Duties Imposed on a Local Public Officer or Agency

Health and Safety Code Sections 115880(h), 115885(g), and 115915(c) provide limits on the mandates of any d imposed upon a local public officer or agency by these regulations. Pursuant to those sections, such a duty shal mandatory only during a fiscal year in which the Legislature has appropriated sufficient funds in the annual Bud or otherwise for local agencies to cover the costs to those agencies associated with performance of these duties

This part of the regulation duplicates statutory language, contrary to the Administrative Procedure Act's nonduplication standard. However, given the statutory requirement for development of regulations and the oppo to focus the regulation on the specific public beaches that are subject to these regulations, and the budgetary limitations that dictate whether the regulations are to be implemented by local health officers, such duplication is reasonable.

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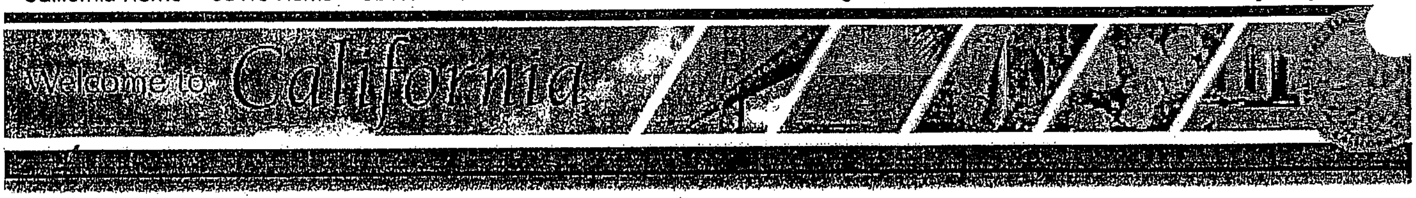

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APPENDIX A. STATE REGULATION OF BEACHES AND RECREATIONAL WATERS

A.1. OCEAN BEACHES AND OCEAN WATER-CONTACT SPORTS AREAS

A.1.1. Statutory Authority

Health and Safety Code Sections 100275, 115880, 116075, and 116080 authorize the Department of Health Services to adopt regulations pertaining to beach safety.

A.1.1.1 Statutes Related to Beaches

The following sections from the Health and Safety Code address beaches and water contact sports areas.

115875. "Public beach," as used in Sections 115875 to 115895, inclusive, means any beach area used by the public for recreational purpose that is owned, operated, or controlled by the state, any state agency, any local agency, or any private person in this state.

115880. (a) The department shall by regulation, in consultation with local health officers and the public, establish minimum standards for the sanitation of public beaches, including, but not limited to, the removal of refuse, as it determines are reasonably necessary for the protection of the public health and safety.

(b) Prior to final adoption by the department, the regulations and standards required by this section shall undergo an external comprehensive review process similar to the process set forth in Section 57004 of the Health and Safety Code.

(c) The regulations shall, at a minimum, do all of the following, by December 31, 1998:

(1) Require the testing of the waters adjacent to all public beaches for microbiological contaminants, including, but not limited to, total coliform, fecal coliform, and enterococci bacteria. The department may require the testing of waters adjacent to all public beaches for microbiological indicators other than those set forth in this paragraph, or a subset of those set forth in this paragraph, if the department affirmatively establishes, based on the best available scientific studies and the weight of the evidence, that the alternative indicators are as protective of the public health.

(2) Establish protective minimum standards for total coliform, fecal coliform, and enterococci bacteria, or for other microbiological indicators that the department determines are appropriate for testing pursuant to paragraph (1).

(3) Establish protocols for all of the following:

(A) Determining monitoring site locations and monitoring frequency based on risks to public health.

(B) Making decisions regarding public notification of health hazards, including, but not limited to the posting, closing, and reopening of public beaches.

(4) Require that the waters adjacent to public beaches be tested for total coliform, fecal coliform, and enterococci bacteria, or for other microbiological indicators that the department determines are appropriate for testing pursuant to paragraph (1). Except as set forth in paragraph (5), testing shall be conducted on at least a weekly basis, from April 1 to October 31, inclusive, of each year, beginning in 1999, if all of the following apply:

(A) The beach is visited by more than 50,000 people annually.

(B) The beach is located on an area adjacent to a storm drain that flows in the summer.

(5) The monitoring frequency and locations established pursuant to this subdivision and related regulations may only be reduced or altered after the testing required pursuant to paragraph (4) reveals levels of microbiological contaminants that do not exceed for a period of two years the minimum protective standards established pursuant to paragraph (2).

(d) The local health officer shall be responsible for testing the waters adjacent to, and coordinating the testing of, all public beaches within his or her jurisdiction.

(e) The local health officer may meet the testing requirements of this section by utilizing test results from other agencies conducting microbiological contamination testing of the waters under his or her jurisdiction.

(f) Any city or county may adopt standards for the sanitation of public beaches within its jurisdiction that are stricter than the standards adopted by the state department pursuant to this section.

(g) For purposes of this section, "public beach" means any public beach located within the coastal zone, as defined in Section 30103 of the Public Resources Code.

(h) Any duty imposed upon a local public officer or agency pursuant to this section shall be mandatory only during a fiscal year in which the Legislature has appropriated sufficient funds, as determined by the State Director of Health Services, in the annual Budget Act or otherwise for local agencies to cover the costs to those agencies associated with the performance of these duties. The State Director of Health Services shall annually, within 15 days after enactment of the Budget Act, file a written statement with the Secretary of the Senate and with the Chief Clerk of the Assembly memorializing whether sufficient funds have been appropriated.

115885. The health officer having jurisdiction over the area in which a public beach is created shall:

(a) Inspect the public beach to determine whether the standards established pursuant to Section 115880 are being complied with. If the health officer finds any violation of the standards, he or she may restrict the use of, or close, the public beach or portion thereof in which the violation occurs until the standard is complied with.

(b) Investigate any complaint of a person of a violation of any standard established by the department pursuant to Section 115880. If the health officer finds any violation of the standards prescribed by the department, he or she may restrict the use of, or close, the public beach or portion thereof until the standard is complied with. If the person who made the complaint is not satisfied with the action taken by the health officer, he or she may report the violation to the department. The department shall investigate the reported violation, and, if it finds that the violation exists, it may restrict the use of or close the public beach or portion thereof until the standard violated is complied with.

(c) (1) Whenever a beach is posted, closed, or otherwise restricted in accordance with Section 115915, the health officer shall inform the agency responsible for the operation and maintenance of the public beach within 24 hours of the posting, closure, or restriction.

(2) The health officer shall establish a telephone hotline to inform the public of all beaches currently closed, posted, or otherwise restricted. The hotline shall be updated as needed in order to convey changes in public health risks.

(d) Report any violation of the standards established pursuant to Section 115880 to the district attorney, or if the violation occurred in a city and, pursuant to Section 41803.5 of the Government Code, the city attorney is authorized to prosecute misdemeanors, to the city attorney.

(e) In the event of a known untreated sewage release, the local health officer shall immediately test the waters adjacent to the public beach and to take action pursuant to regulations established under Section 115880.

(f) Notwithstanding any other provision of law, in the event of an untreated sewage release that is known to have reached recreational waters adjacent to a public beach, the local health officer shall immediately close those waters until it has been determined by the local health officer that the waters are in compliance with the standards established pursuant to Section 115880.

(g) Any duty imposed upon a local public officer or agency pursuant to this section shall be mandatory only during a fiscal year in which the Legislature has appropriated sufficient funds, as determined by the State Director of Health Services, in the annual Budget Act or otherwise for local agencies to cover the costs to those agencies associated with the performance of these duties. The State Director of Health Services shall annually, within 15 days after enactment of the Budget Act, file a written statement with the Secretary of the Senate and with the Chief Clerk of the Assembly memorializing whether sufficient funds have been appropriated.

115890. Prior to restricting the use of or closing a public beach or portion thereof alleged to be in violation of standards, the health officer, or the department as the case may be, shall give reasonable notice of the violation to the owner of, or person or agency in charge of, the beach.

115895. Any private person who violates any regulation adopted by the state department pursuant to Section 115880 is guilty of a misdemeanor.

115900. For the purposes of Sections 115900 to 115915, inclusive, the following definitions apply:

(a) "Beach" means any public beach of the ocean waters and bays of the state where water-contact sports are engaged in by the public.

(b) "Board" means the State Water Resources Control Board.

(c) "Health officer" means the legally appointed health officer or director of environmental health of the county or city having jurisdiction of the area in which a public saltwater beach is located.

115905. The Legislature finds and declares all of the following:

(a) California's world-famous beaches are an invaluable economic, environmental, and recreational resource that must be protected for present and future generations. Millions of residents and visitors alike visit the state's beaches annually.

(b) Pollution from toxic spills, untreated municipal sewage, and agricultural and urban runoff threatens this critical resource.

(c) During 1989 through 1991 alone, at least 400 of the state's beaches had to be posted "off-limits" due to dangerous levels of bacterial and toxic contamination.

(d) Due to this pollution, local health officials were forced to close one or more beaches between San Diego and Mendocino Counties for all but 18 days in 1991.

(e) This contamination of our beaches poses serious threats to the public's health, increasing the risk that persons who use the beaches will suffer from hepatitis, gastroenteritis, and other dangerous illnesses.

(f) Notwithstanding the importance and potential severity of this problem, the state has never conducted a statewide survey to document annual beach closings.

(g) The state does not have uniform testing protocols that must be followed to ensure that the public is never exposed to dangerous contamination at the state's beaches.

(h) The state does not have uniform standards requiring beach postings when California Ocean Plan bathing water standards, as adopted by the board pursuant to Section 13170.2 of the Water Code, are exceeded.

(i) The state does not have uniform requirements mandating the frequency with which beach waters must be tested to ensure public safety. Beach water sampling currently varies greatly from county to county. For example, Los Angeles County tests its beaches every week of the year while other coastal counties test much less frequently.

(j) More accurate and centralized record keeping on the relative contributions of pollutant sources to beach closures would enable more effective targeting of corrective actions to keep our beaches safe and our coastal areas economically strong.

115910. (a) On or before the 15th day of each month, each health officer shall submit to the board a survey documenting all beach postings and closures resulting from implementation of Section 115915 that occurred during the preceding month. The survey shall, at a minimum, include the following information:

(1) Identification of the beaches in each county subject to testing conducted pursuant to Section 115885 and the amount and types of monitoring conducted at each beach.

(2) Identification of the geographic location, areal extent, and type of action taken for each incident of posting or closure conducted pursuant to Section 115915. Geographic location and areal extent shall be noted in sufficient detail to determine on a common map, or by latitude and longitude, the approximate boundaries of the affected beaches.

(3) Identification of the standards exceeded and the causes and sources of the pollution, if known. Exceeded standards shall be identified with sufficient particularity to determine which types of tests and biological indicators were used to determine that an exceeded standard exists. Causes of pollution shall be identified with sufficient particularity to determine what substances, in addition to any water carrying the substances, were responsible for the exceeded standard. Sources shall be identified with sufficient particularity to determine the most specific geographical origin of the pollution sources available to the health officer at the time of the posting or closure.

(b) Surveys conducted pursuant to subdivision (a) shall be in a specific format established by the board on or before February 1, 2001. The board shall make the format easily accessible to the health officer through means that will enable the health officer to most effectively carry out the requirements of this section and enable the board to develop consistent, statewide data concerning the effect and status of beach postings and closures in a particular calendar year.

(c) On or before the 30th day of each month, the board shall make available to the public the information provided by the health officers. Based upon the data provided pursuant to subdivision (a), the report shall, at a minimum, include the location and duration of each beach closure and the suspected sources of the contamination that caused the closure, if known.

(d) On or before July 30 of each year, the board shall publish a statewide report documenting the beach posting and closure data provided to the board by the health officers for the preceding calendar year. Based upon the data provided pursuant to subdivision (a), the report shall, at a minimum, include the location and duration of each beach closure and the suspected sources of the contamination that caused the closure, if known.

(e) Within 30 days of publication of the annual report, the board shall distribute copies of the report to the Governor, the Legislature, and major media organizations, and copies of the report shall be made available to the public by a variety of means typically available to the board.

115915. (a) Whenever any beach fails to meet the bacteriological standards established pursuant to subdivision (b) of Section 115880, the health officer shall, at a minimum, post the beach with conspicuous warning signs to inform the public of the nature of the problem and the possibility of risk to public health.

(b) A warning sign shall be visible from each legal primary beach access point, as identified in the coastal access inventory prepared and updated pursuant to Section 30531 of the Public Resources Code, and any additional access points identified by the health officer.

(c) Any duty imposed upon a local public officer or agency pursuant to this section shall be mandatory only during a fiscal year in which the Legislature has appropriated sufficient funds, as determined by the State Director of Health Services, in the annual Budget Act or otherwise for local agencies to cover the costs to those agencies associated with the performance of these duties. The State Director of Health Services shall annually, within 15 days after enactment of the Budget Act, file a written statement with the Secretary of the Senate and with the Chief Clerk of the Assembly memorializing whether sufficient funds have been appropriated.

116070. As used in this article, water-contact sport means any sport in which the body of a person comes into physical contact with water, including but not limited to swimming, surfboarding, paddleboarding, skin diving, and water-skiing. It does not include boating or fishing.

116075. The department has supervision of sanitation, healthfulness, and safety of the public beaches and public water-contact sport areas of the ocean waters and bays of the state and, except as provided in Section 18930, the department may make and enforce regulations pertaining thereto as it deems proper.

116080. Regulations made pursuant to this article shall include suitable standards of safe bacteria count for water-contact sports areas specified by the State Water Pollution Control Board or regional water pollution control boards, which standards shall be applied to all public water-contact sport areas of the ocean waters and bays of the state.

116085. Every person who violates any rule or regulation adopted pursuant to this article is guilty of a misdemeanor.

116090. Nothing contained in this article shall be construed to give the department the authority to fix the areas wherein water-contact sports may be engaged in or to affect the authority of the State Water Pollution Control Board or regional water pollution control boards to fix appropriate areas for various uses.

A.1.2 Regulations

A.1.2.1 Department of Health Services [Also see DHS' Guidance for Salt Water Beaches]

Regulations for recreational use of ocean waters are published in Title 17 of the California Code of Regulations, in Group 10. Sanitation, Healthfulness and Safety of Ocean Water-Contact Sports Areas.

Title 17 of the California Code of Regulations

Group 10. Sanitation, Healthfulness and Safety of Ocean Water-Contact Sports Areas

Article 2. Definitions

7952. Public Water-Contact Sports Area Defined.

Public water-contact sports area means any area so designated (1) by a regional water pollution control board, or (2) by any other authorized and responsible public agency.

7956. Storm Drain.
"Storm drain" means a conveyance through which water flows onto or adjacent to a public beach and includes rivers, creeks, and streams, whether in natural or in man-made channels.

Article 4. Healthfulness

7957. Physical Standard.
No sewage, sludge, grease, or other physical evidence of sewage discharge shall be visible at any time on any public beaches or water-contact sports areas.

7958. Bacteriological Standards.
(a) The minimum protective bacteriological standards for waters adjacent to public beaches and public water-contact sports areas shall be as follows:

(1) Based on a single sample, the density of bacteria in water from each sampling station at a public beach or public water contact sports area shall not exceed:

(A) 1,000 total coliform bacteria per 100 milliliters, if the ratio of fecal/total coliform bacteria exceeds 0.1; or

(B) 10,000 total coliform bacteria per 100 milliliters; or

(C) 400 fecal coliform bacteria per 100 milliliters; or

(D) 104 enterococcus bacteria per 100 milliliters.

(2) Based on the mean of the logarithms of the results of at least five weekly samples during any 30-day sampling period, the density of bacteria in water from any sampling station at a public beach or public water contact sports area, shall not exceed:

(A) 1,000 total coliform bacteria per 100 milliliters; or

(B) 200 fecal coliform bacteria per 100 milliliters; or

(C) 35 enterococcus bacteria per 100 milliliters.

(b) Water samples shall be submitted for bacteriological analyses to a laboratory certified by the Environmental Laboratory Accreditation Program, California Department of Health Services in microbiology for methods for the analysis of the sample type.

7959. Bacteriological Sampling.
(a) In order to determine that the bacteriological standards specified in Section 7958 above are being met in a water-contact sports area designated by a Regional Water Quality Control Board in waters affected by a waste discharge, water samples shall be collected at such sampling stations and at such frequencies as may be specified by said board in its waste discharge requirements.

(b) In waters of a public beach or water-contact sports area that has not been so designated by a Regional Water Quality Control Board, water samples shall be collected at such frequencies as may be determined by the local health officer or Department. Local health officers shall be responsible for the proper collection and analysis of water samples in such areas.

7960. Corrective Action.
(a) When a public beach or public-water-contact sports area fails to meet any of the standards as set forth in Section 7957 or 7958 above, the local health officer or the Department, after taking into consideration the causes therefor, may at his or its discretion close, post with warning signs, or otherwise restrict use of said public beach or public water-contact sports area, until such time as corrective action has been taken and the standards as set forth in 7957 and 7958 above are met.

7961. Public Beaches Visited by More than 50,000 People Annually and Adjacent to Storm Drains.
(a) Waters adjacent to a public beach shall be tested for bacteria identified in Section 7958 on at least a weekly basis from April 1 to October 31, inclusive, if the beach is

(1) Visited by more than 50,000 people annually, and

(2) Located adjacent to a storm drain that flows in the summer.

(b) Water samples shall be taken from locations that include areas affected by storm drains. Samples shall be taken in ankle- to knee-deep water, approximately 4 to 24 inches below the water surface.

(c) When testing reveals that the waters adjacent to a public beach fail to meet any of the standards set forth in Section 7958(a)(1), the local health officer shall post the beach pursuant to Health and Safety Code Section 115915, and shall use the standards of Sections 7958(a)(1) and (2) in determining the necessity to restrict the use of or close the public beach or portion thereof.

(d) In the event of a known release of untreated sewage into waters adjacent to a public beach, the local health officer shall:

(1) Immediately post and close the beach or a portion thereof, or otherwise restrict its use until the source of the sewage release is eliminated;

(2) Sample the affected waters; and

(3) Continue closure or restriction of the beach or a portion thereof and posting the beach until testing results establish that the standards of Sections 7958(a)(1) are satisfied.

7962. Duties Imposed on a Local Public Officer or Agency.
(a) Pursuant to Health and Safety Code Sections 115880(h), 115885(g), and 115915(c), any duty imposed upon a local public officer or agency by Section 7961 shall be mandatory only during a fiscal year in which the Legislature has appropriated sufficient funds, as determined by the State Director of Health Services, in the annual Budget Act or otherwise for local agencies to cover the costs to those agencies associated with performance of these duties.

Regulations for the sanitation of public beaches are published in Title 17 of the California Code of Regulations, in Group 10.1

Group 10.1 Sanitation of Public Beaches

Article 2. Definitions and Exemptions

7972. Saltwater Body.
Saltwater Body means the ocean, a marine bay, estuary or lagoon.

7973. Freshwater Body.
Freshwater Body means a natural or artificial lake, river, reservoir, stream or canal.

7974. Refuse.
Refuse means domestic or industrial garbage, rubbish, or other debris adversely affecting public health and safety as specified by the Health Officer.

7975. Sanitation.
Sanitation means the maintenance of a safe and healthful environmental by means of removal of refuse; provision of sanitary toilet and handwashing facilities; disposal of sewage and liquid wastes; protection of bathing water quality; provision of pure, wholesome and potable drinking water; and control of harmful insects, rodents and animals.

7976. Recreational Purposes.
Recreational purposes include but are not limited to, swimming, camping, scenic enjoyment, fishing, shellfish gathering, surfing, scuba or snorkel diving, boating, equestrianship, use of recreational vehicles, jogging, walking, and beachcombing.

7977. Public Health and Safety.
Public health and safety means the maintenance of an environmental that contributes to human well being, and in which there is an absence of human disease, ill health or injury.

7978. Health Officer.
Health Officer means the legally appointed Health Officer of the county or city having jurisdiction of the area in which a public beach is located.

7979. Exemption.
Sections 7981 through 7991 of Title 17 shall not apply when the Health Officer determines that the beach is maintained primarily as an open space. The criteria, among others, that may be evidence of open space is lack of developed access, lack of parking facilities, lack of lifeguard services, or where casual use normally does not exceed 50 people per mile of shoreline.

7980. Review by Health Officer.
No persons shall begin construction, reconstruction or alteration of any public beach sanitation facility without first submitting plans, specifications and other such information, as may be required, to the Health Officer for his review and written approval. If no action is taken within fifteen (15) days of submission of plans, the project shall be deemed approved. If the Health Officer disapproves, the reason shall be so stated in writing.

Article 3. Day Use Beaches

7981. Application.
The provisions of this article shall be applicable to public beaches where overnight camping is not permitted.

7982. Toilets.
Toilets shall conform to the State Plumbing Code, Part 5, Title 24, California Administrative Code. Portable toilets may be substituted for plumbed toilets.

7983. Water Supply.
Water when provided for drinking, showers, or handwashing shall be from a source approved by the Health Officer.

7984. Maintenance.
Toilets shall be available to the public at all times the beach is officially open for use. All facilities must be maintained in a clean and sanitary condition at all times.

7985. Refuse Handling.
(a) Refuse containers approved by the Health Officer shall be provided at all public beaches.

(b) All refuse shall be stored in the container in a manner which will not create a nuisance.

(c) Containers shall be emptied at frequencies sufficient to prevent overflow and to be maintained in a sanitary condition.

(d) Every public beach shall be maintained in a clean condition free of refuse.

7985.1 Animals.
No person shall bring onto or allow any animal, except guide dogs used by the blind, to remain on any beach which has been designated a public swimming beach by the state, or any city, county, or city and county and where life guards are provided, except that horses may be ridden on designated equestrian trails and areas.

This regulation is not intended to prohibit or supersede any local ordinance not in effect or which may be enacted.

Article 4. Beaches Allowing Overnight Camping

7987. Application.
The provisions of this article shall be applicable to public beaches used for overnight camping.

7988. Refuse Handling.
(a) Refuse containers approved by the Health Officer shall be provided in every camping area.

(b) All refuse shall be stored and removed in a manner which will not create a nuisance.

(c) Beach areas and areas set aside for camping shall, at all times, be maintained in a clean condition free of refuse.

7988.1 Animals.
No person shall bring onto or allow any animal, except guide dogs used by the blind, to remain on any beach which has been designated a public swimming beach by the state, or any city, county, or city and county and where life guards are provided, except that horses may be ridden on designated equestrian trails and areas.

This regulation is not intended to prohibit or supersede any local ordinance not in effect or which may be enacted.

7989. Campsites.
(a) No travel trailer, camp car, recreational vehicle or tent shall be located closer than six feet from any building or travel trailer, camp car, recreational vehicle or tent on an adjacent lot or campsite.

(b) Each vehicular lot or campsite in a camping area shall have direct access.

7990. Sanitary Facilities.
(a) Toilets shall conform to the State Plumbing Code, Part 5, Title 24, California Administrative Code.

(b) Shower baths or other bathing facilities are not required; however, when provided, they shall conform to the State Plumbing Code, Part 5, Title 24, California Administrative Code.

7991. Maintenance.
All sanitary facilities shall be maintained in a clean and safe condition.

7992. Disposal of Sewage Wastes.
(a) Wastewater or material from plumbing fixtures shall not be permitted to be deposited upon the ground.

(b) Campsites not provided with a drain inlet shall not be occupied by a travel trailer, camp car, or recreational vehicle equipped with plumbing unless the drain outlet of the vehicle is capped or as otherwise provided by part (c) of this section. Each campsite for use by vehicles equipped with toilets, unless self-contained shall be provided with a three-inch drain inlet.

(c) Other means of disposing of liquid wastes, not including human wastes, may be approved by the Health Officer.

(d) Trailer sanitation stations approved by the Health Officer and designed to receive the discharge of sewage holding tanks of self-contained vehicles shall be installed or available in an accessible location to every public beach campground area in which there are campsites not provided with drain inlets designed to receive the discharge of sewage wastes. Trailer sanitation stations shall be provided on the basis of one station for each 100 such campsites or portion thereof.

(e) Trailer sanitation stations shall be designed and constructed as required by Sections 5570 through 5580, Title 25, California Administrative Code.

7993. Laundry Facilities.
Laundry facilities are not required; however, when provided they shall conform to the State Plumbing Code, Part 5, Title 24, California Administrative Code.

7994. Water Supply.
When provided, potable water shall be from a source approved by the Health Officer and obtainable from faucets installed not more than 400 feet from each campsite. Potable water shall be adequate for all the requirements of the camping area.

A.1.2.2 State Water Resources Control Board (SWRCB)

The SWRCB's Ocean Plan (SWRCB, 1997) establishes the following Water Quality Objectives for microbiological contamination (the sections dealing with kelp beds and shellfish harvesting area have not been included):

II. Water Quality Standards

A. Bacterial Characteristics

1. Water Contact Standards

Within a zone bounded by the shoreline and a distance of 1,000 feet from the shoreline or the 30-foot depth contour, whichever is further from the shoreline, and in areas outside this zone used for water contact sports, as determined by the Regional Board, but including all kelp beds, the following bacterial objectives shall be maintained throughout the water column:

a. Samples of water from each sampling station shall have a density of total coliform organisms less than 1,000 per 100 ml (10 per ml); provided that not more than 20 percent of the samples of any sampling station, in any 30-day period, may exceed 1,000 per 100 ml (10 per ml), and provided further than no single sample when verified by a repeat sample taken within 48 hours shall exceed 10,000 per 100 (100 per ml).

b. The fecal coliform density based on a minimum of not less than five samples for any 30-day period, shall not exceed a geometric mean of 200 per 100 ml nor shall more than 10 percent of the total samples during any 60-day period exceed 400 per 100 ml.

B. Bacterial Assessment and Remedial Action Requirements

The requirements listed below shall be used to 1) determine the occurrence and extent of any impairment of a beneficial use due to bacterial contamination; 2) generate information which can be used in the development of an enterococcus standard; and 3) provide the basis for remedial actions necessary to minimize or eliminate any impairment of a beneficial use.

Measurement of enterococcus density shall be conducted at all stations where measurement of total and fecal coliforms are required. In addition to the requirements of Section II.A.I, if a shore station consistently exceeds a coliform objective or exceeds a geometric mean enterococcus density of 24 organisms per 100 ml for a 30-day period or 12 organisms per 100 ml for a six-month period, the Regional Board shall require the appropriate agency to conduct a survey to determine if that agency's discharge is the source of the contamination. The geometric mean shall be a moving average based on no less than five samples per month, spaced evenly over the time interval. When a sanitary survey identifies a controllable source of indicator organisms associated with a discharge of sewage, the Regional Board shall take action to control the source.

Waste discharge requirements shall require the discharger to conduct sanitary surveys when so directed by the Regional Board. Waste discharge requirements shall contain provisions requiring the discharger to control any controllable discharges identified in a sanitary survey.

The Ocean Plan's Standard Monitoring Procedures (Appendix II) provide guidance on monitoring:

Chapter II. A. Bacterial Standards:
For all bacterial analyses, sample dilutions should be performed so the range of values extends from 2 to 16,000. The detection methods used for each analysis shall be reported with the results of the analysis.

Detection methods used for coliforms (total and fecal) shall be those presented in the most recent edition of *Standard Methods for the Examination of Water and Wastewater* or any improved method determined by the Regional Board (and approved by EPA) to be appropriate.

Detection methods used for enterococcus shall be those presented in EPA publication EPA 600/4-85/076, *Test Methods for Escherichia coli and Enterococci in Water by Membrane Filter Procedure* or any improved method determined by the Regional Board to be appropriate.

A.2 FRESH WATER BEACHES

A.2.1 Department of Health Services

Regulations for public beaches are published in Title 17 of the California Code of Regulations, Group 10.1 Sanitation of Public Beaches, beginning with Section 7972. They provide definitions of terms, and address the provision of water supply, toilets and sanitary facilities, maintenance, refuse handling, campsites and animals. These regulations are presented above. [Also, see DHS' non-regulatory **Guidance for Fresh Water Beaches**.

A.2.2 State Water Resources Control Board

The SWRCB's Inland Waters Plan (SWRCB, 1993) and the Enclosed Bays and Estuaries Plan (SWRCB, 1995b) do not address microbiological contamination.

Initial draft: November 1997

REFERENCES

See http://www.dhs.ca.gov/ps/ddwem/beaches/pdfs/references.pdf

APPENDIX B. US EPA GUIDANCE FOR RECREATIONAL WATERS AND BEACHES

This section provides guidance from the United States Environmental Protection Agency, which released a planning document for beaches and recreational waters, *Action Plan for Beaches and Recreational Waters* (US EPA, 1999). US EPA also held regional conferences in 1999 on beach programs, and published the conference proceedings (US EPA, 2000).

B.1 THE FEDERAL WATER QUALITY CRITERION FOR RECREATIONAL WATERS

The federal water quality criterion for recreational waters was established in 1968 by the Department of the Interior's National Technical Advisory Committee (NTAC, 1968). This criterion was recommended again by the US EPA in 1976 and 1986 (EPA, 1976, 1986). This criterion is as follows:

Fecal coliforms should be used as the indicator organism for evaluating the microbiological suitability of recreation waters. As determined by multiple-tube fermentation or membrane filter procedures and based on a minimum of not less than five samples taken over not more than a 30-day period, the fecal coliform content of primary contact recreation waters shall not exceed a log mean of 200 per 100 ml, nor shall more than 10 percent of total samples during any 30-day period exceed 400 per 100 ml.

The value of 400 fecal coliforms per 100 ml was derived from a concentration of 2300 total coliforms per 100 ml, which corresponded to the density at which a statistically significant increase in swimming-associated gastrointestinal illness was observed. Fecal coliforms comprised about 18 percent of the total coliforms.

B.2 MARINE WATERS

The US EPA evaluated health effects of microbiological contamination on recreational use of marine waters (Cabelli, 1983). Subsequently it published guidance on water quality for recreational use in *Ambient Water Quality Criteria for Bacteria - 1986* (US EPA, 1986).

EPA's guidance for marine recreational waters is based upon an "Acceptable Swimming Associated Gastroenteritis Rate" of 19 cases/1000 swimmers. Its steady state geometric mean indicator density at the acceptable rate is 35 enterococci per 100 ml. The rate of 19 cases of illness per 1000 swimmers is estimated to result from exposures to waters containing bacteria using the fecal coliform indicator group at the maximum geometric mean of 200 per 100 ml.

EPA's criterion (US EPA, 1986) for bathing (full body contact) recreational waters for marine water is as follows:

Based on a statistically sufficient number of samples (generally not less than 5 samples equally spaced over a 30-day period), the geometric mean of the enterococci densities should not exceed 35 per 100 ml.

No sample should exceed a one-sided confidence limit (CL), using the following as guidance:

Designated bathing beach area	upper 75% CL
Moderate full body contact recreation	upper 82% CL
Lightly used full body contact recreation	upper 90% CL
Infrequently used full body contact recreation	upper 95% CL

based on a site-specific log standard deviation, or if site data are insufficient to establish a log standard deviation, then using 0.7 as the log standard deviation.
From the EPA's guidance document, single sample limits (in enterococci per 100 ml.) are:

Designated bathing beach area	= 104 enterococci per 100 ml.
Moderate full body contact recreation	= 124 enterococci per 100 ml.
Lightly used full body contact recreation	= 276 enterococci per 100 ml.
Infrequently used full body contact recreation	= 500 enterococci per 100 ml.

The above recommendations notwithstanding, the US EPA did not recommend a change in the stringency of its bacterial criteria for recreational waters, finding that such a change did not appear warranted until more information on the new indicators was accumulated.

B.3 FRESH WATER

The US EPA evaluated health effects of microbiological contamination on recreational use of fresh waters (Dufour, 1984). Subsequently it published guidance on water quality for fresh water recreational use (US EPA, 1986).

EPA's guidance for fresh recreational waters is based upon an "Acceptable Swimming Associated Gastroenteritis Rate" of 8 cases/1000 swimmers at a steady state geometric mean indicator density of 33 enterococci per 100 ml or 126 *E. coli* per 100 ml. The rate of 8 cases of illness per 1000 swimmers is estimated to result from exposures to waters containing bacteria using the fecal coliform indicator group at the maximum geometric mean of 200 per 100 ml.

EPA's criterion for bathing (full body contact) recreational waters for fresh water is as follows (US EPA, 1986):

Based on a statistically sufficient number of samples (generally not less than 5 samples equally spaced over a 30-day period), the geometric mean of the enterococci densities should not exceed one or the other of the following (Note that only one indicator should be used. The regulatory agency should select the appropriate indicator for its conditions.):

E. coli, at a concentration of 126 per 100 ml., or
enterococci, at a concentration of 33 per 100 ml.

No sample should exceed a one-sided confidence limit (CL), using the following as guidance:

Designated bathing beach area	upper 75% CL
Moderate full body contact recreation	upper 82% CL
Lightly used full body contact recreation	upper 90% CL
Infrequently used full body contact recreation	upper 95% CL

based on a site-specific log standard deviation, or if site data are insufficient to establish a log standard deviation, then using 0.4 as the log standard deviation.
From the EPA's guidance document, the single sample limits (in *E. coli* per 100 ml., or in enterococci per 100 ml.) are:

Designated bathing beach area	= 235 *E. coli* per 100 ml., or 61 enterococci per 100 ml.
Moderate full body contact recreation	= 298 *E. coli* per 100 ml., or 89 enterococci per 100 ml.
Lightly used full body contact recreation	= 406 *E. coli* per 100 ml., or 108 enterococci per 100 ml.
Infrequently used full body contact recreation	= 576 *E. coli* per 100 ml., or 151 enterococci per 100 ml.

As mentioned above, the US EPA did not recommend a change in the stringency of its bacterial criteria for recreational waters, finding that such a change did not appear warranted until more information on the new indicators was accumulated.

B.3.1 Specific Standards Set by US EPA for Colville Indian Reservation, Washington.

The US EPA (40 Code of Federal Regulations 131.35) has established fresh (surface) water quality criteria for several classes of water, as follows:

Class I (Extraordinary), including these designated uses: Water supply (domestic, industrial, agricultural); stock watering; fish and shellfish—migration, rearing, spawning, and harvesting, of salmonids and other fish; wildlife habitat; ceremonial and religious water use; recreation (primary contact recreation, sport fishing, boating and aesthetic enjoyment); and commerce and navigation.

For Class I water the bacteriological criteria are: The geometric mean of the enterococci bacteria densities in samples taken over a 30-day period shall not exceed 8 per 100 ml, nor shall any single sample exceed an enterococci density of 35 per 100 milliliters. This limits are calculated as the geometric mean of the collected samples approximately equally spaced over a 30-day period.

Class II (Excellent), including these designated uses: Water supply (domestic, industrial, agricultural); stock watering; fish and shellfish—migration, rearing, spawning, and harvesting, of salmonids and other fish, and crayfish rearing, spawning and harvesting; wildlife habitat; ceremonial and religious water use; recreation (primary contact recreation, sport fishing, boating and aesthetic enjoyment); and commerce and navigation.

For Class II water the bacteriological criteria are: The geometric mean of the enterococci bacteria densities in samples taken over a 30-day period shall not exceed 16 per 100 ml, nor shall any single sample exceed an enterococci density of 75 per 100 milliliters. This limits are calculated as the geometric mean of the collected samples approximately equally spaced over a 30-day period.

Class III (Good), including these designated uses: Water supply (industrial, agricultural); stock watering; fish and shellfish—migration, rearing, spawning, and harvesting, of salmonids and other fish, and crayfish rearing, spawning and harvesting; wildlife habitat; recreation (secondary contact recreation, sport fishing, boating and aesthetic enjoyment); and commerce and navigation.

For Class III water the bacteriological criteria are: The geometric mean of the enterococci bacteria densities in samples taken over a 30-day period shall not exceed 33 per 100 ml, nor shall any single sample exceed an enterococci density of 150 per 100 milliliters. This limits are calculated as the geometric mean of the collected samples approximately equally spaced over a 30-day period.

Class IV (Fair), including these designated uses: Water supply (industrial); stock watering; fish migration of salmonids and other fish; recreation (secondary contact recreation, sport fishing, boating and aesthetic enjoyment); and commerce and navigation.

For Class IV water no bacteriological criteria are identified. No streams are identified as Class IV.

Lake Class, including these designated uses: Water supply (domestic, industrial, agricultural); stock watering; fish and shellfish—migration, rearing, spawning, and harvesting, of salmonids and other fish, and crayfish rearing, spawning, and harvesting; wildlife habitat; ceremonial and religious water use; recreation (primary contact recreation, sport fishing, boating and aesthetic enjoyment); and commerce and navigation.

For Lake Class water the bacteriological criteria are: The geometric mean of the enterococci bacteria densities in samples taken over a 30-day period shall not exceed 33 per 100 ml, nor shall any single sample exceed an enterococci density of 150 per 100 milliliters. This limits are calculated as the geometric mean of the collected samples approximately equally spaced over a 30-day period.

Initial draft: November 1997

REFERENCES

See http://www.dhs.ca.gov/ps/ddwem/beaches/pdfs/references.pdf

APPENDIX C. LOCAL GUIDANCE AND ORDINANCES

DHS polled local environmental health departments about the status of their recreational water programs. The following summarizes the responses DHS received, as of May 1997, for counties that utilize specific numeric levels for monitoring and corrective action. Those who are interested in the current status of local programs should contact the local environmental health programs directly.

C.1 OCEAN BEACHES

[Certain beaches are subject to monitoring and posting requirements from April 1 through October 31of each year. The statutory and regulatory requirements are in Appendix A.]

C.1.1 Los Angeles County

Los Angeles County has a comprehensive ocean water contact sports area regulatory program. LA County's policy directs the health officer to close a affected portions of a beach and post "Beach Closed" signs "when there is a known incident of sewage pollution or chemical contamination, and ... a health risk exists to persons engaging in water contact activities."

Beaches that are affected by sewage shall be closed for a minimum of 48 hours. Guidelines for closure, in terms of gallons of sewage spilled or discharged, are:

Less than 1,000 gallons	= 1/4 mile each side of discharge
1,000 - 10,000 gallons	= 1/2 mile each side of discharge
10,000 - 100,000 gallons	= 1 mile each side of discharge
100,000 - 1 million gallons	= 3 miles each side of discharge
1 million - 2 million gallons	= 5 miles each side of discharge
More than 2 million gallons	= 10 miles or more on each side of discharge

Subsequent sampling will be done at locations to be determined on the basis of the reported volume of the spill, prevailing winds and currents, location of the discharge, and extent of the closure. The Protocol includes sampling points in relation to the size of the sewage spill (e.g., a spill less than 1,000 gallons would be sampled at three locations: at the spill and 1/4 mile on either side of the spill). Beaches will be reopened when data from bacteriological analyses indicate bacteria counts are within acceptable health levels.

The following bacterial standards are used in the LA County protocol:

1. California total coliform standard (Title 17, California Code of Regulations, Section 7958): No single sample when verified by a repeat sample taken within 48 hours shall exceed 10,000 cfu per 100 ml., nor shall more than 20 percent of the samples within a 30-day period at any sampling station exceed 1,000 cfu per 100 ml.

2. US EPA recommendation for enterococcus: No single sample shall exceed 104 colony forming units (cfu) per 100 ml., nor shall the log mean of five or more samples taken over a 30-day period exceed 35 cfu per 100 ml.

3. Santa Monica Bay Epidemiology Study: No single sample with a total coliform level that exceed 5,000 cfu per 100 ml shall have a total coliform to fecal coliform ratio of 5 or less. (See Haile *et al.*, 1996).

Bacterial levels are considered to be elevated when two consecutive samples reveal the following:

1. Total coliform exceeds 10,000 cfu per 100 ml.

2. Enterococcus exceeds 104 cfu per 100 ml. in combination with total coliform that exceeds 1,000 cfu per 100 ml.

3. Total coliform exceeds 5,000 cfu per 100 ml. in combination with total coliform to fecal coliform ratio of 5 or less.

An evaluation is to be conducted to determine the cause that includes, but is not limited to, an evaluation of the bacteriological data, an on-site field investigations and consultation with monitoring personnel.

LA County also has a public notification process that issues public advisories to wire services whenever a significant beach area is closed to the public. Public advisories are also issued when significant rain storm is predicted or occurs, explaining that storm drain flows may cause elevated bacterial counts for approximately 72 hours and ocean water contact, especially in areas adjacent to storm drain flows, should be avoided.

C.1.2 Mendocino County

Mendocino County reopens beaches following sewage spills when total coliforms are less than 1000 per 100 ml, fecal coliforms are less than 200 per 100 ml, and enterococci are less than 35 per 100 ml.

C.1.3 Orange County

Orange County samples from many regular sampling stations, samples are taken from water ankle-deep in the surf zone, waist-deep or deeper in harbors. Samples are taken 6-12 inches below the water surface. The county issues beach advisory press releases after 0.2 inches of rain, and posts warning signs at creek or drain mouths due to fluctuating coliform values. It closes beaches after sewage spills or when total 20 percent of coliforms exceed 1000 per 100 ml., and reopens beaches when two consecutive sampling days show levels "well below" 1000 total coliforms per 100 ml.

C.1.4 Monterey County

Monterey County posts warnings on ocean beaches when fecal coliforms meet or exceed 200 per 100 ml., or total coliforms meet or exceed 1000 per 100 ml. Beaches are closed when the standard is exceeded, with visual presence of chemicals or human waste.

C.1.5 San Diego County

San Diego County samples approximately monthly, for total and fecal coliforms. Levels for posting warnings, beach closure, and reopening beaches are 1000 total coliforms and 200 fecal coliforms per 100 ml.

C.1.6 San Francisco

San Francisco samples regularly from shoreline sampling stations at high use areas, and areas adjacent to outfalls. Analyzes for total and fecal coliforms, enterococci, and *E. coli*. Follows 17 CCR §7958 for posting, closure and reopening beaches.

C.1.7 San Luis Obispo County

San Luis Obispo County samples as needed, generally during the rainy season, during heavy rainfall periods. Sampling is also done if a major sewage spill occurs in the watershed supplying stream sources that reach the ocean beach areas. . Analyzes for total and *E. coli*. Follows 17 CCR §7957 for posting, closure and reopening beaches.

C.1.8 San Mateo County

San Mateo samples year round along coastal area under the influence of water water treatment plants. Beaches are closed when total coliforms exceed 1000 per 100 ml, or when fecal coliforms exceed 200 per 100 ml.

C.1.9 Santa Cruz County

Santa Cruz County samples one/week or one/month, according to location, some stations all year, some May-September. The county has one regular sampling station per beach, and samples water at ankle depth. Analysis is for fecal coliforms, and there is also extensive parallel testing of total, enterococci, E. coli and fecal streptococcus. Warnings are issued when two consecutive samples of fecal coliforms are over 200 MPN per 100 ml. Beach closure occurs with a significant raw sewage spill. Reopening occurs when samples return to 200 MPN per 100 ml for fecal coliforms.

C.2 INLAND SALT WATER BEACHES (Salton Sea)

C.2.1 Imperial County

Imperial County samples monthly, two samples per beach, from regular sampling stations, taken from waist-deep water.. Sampling is from areas most frequented by people, or from sampling grids. Analyzes for total and fecal coliforms. For posting warnings, the county uses regional water board criteria, coupled with evidence of source of human pollution. It has no guidance for closure/reopening. Uses board authority of health officer to post warnings, in the absence of inland water standards.

C.2.2 Riverside County

Riverside County samples weekly, about four samples per beach, from regular sampling stations, chosen because they represent heavy use areas. Samples are taken from 6 inches below water surface, and analyzed for total and fecal coliforms. Levels for posting warnings and closing beaches are 200 fecal coliforms per 100 ml two weeks in a row. Beaches are reopened with samples lower than 200 per 100 ml.

C.3 FRESH WATER BEACHES

C.1 Kern County

Kern County samples its lakes and reservoirs twice per month, from May through August, three samples per beach/recreational area, from regular sampling stations. Samples are analyzed for total and fecal coliforms. Posting warnings, beach closure, and reopening beaches are based on a total coliform level of 1000 per 100 ml.

C.2 Los Angeles County

For freshwater recreational areas, Los Angeles County's Code uses the following:

(1) Total coliform: No single sample shall exceed 10,000 cfu per 100 ml. Not more than 10 percent of the samples tested shall exceed 1,000 cfu per 100 ml. Of all samples collected over a 30 day period, the mean shall not exceed 500 cfu per 100 ml.

(2) Total coliform/fecal coliform ratio: No single sample with a total coliform level of 5,000 cfu per 100 ml. or greater shall have a total coliform/fecal coliform ratio of 5 or less.

(3) Enterococci: No single sample shall exceed 61 cfu per 100 ml. A minimum of 5 samples equally spaced over a 30-day period shall not exceed a log mean of 33 cfu per 100 ml.

C.3 Riverside County

Riverside County samples weekly, about four samples per beach, from regular sampling stations, chosen because they represent heavy use areas. Samples are taken from 6 inches below water surface, and analyzed for total and fecal coliforms. Levels for posting warnings and closing beaches are 200 fecal coliforms per 100 ml two weeks in a row. Beaches are reopened with samples lower than 200 per 100 ml.

C.4 San Bernardino County

Santa Bernardino County has an ordinance that applies to all water contact recreation resorts (WCRR), where the definition of an WCRR includes all public water contact recreation facilities for which direct or indirect fee is charged for the use of the facility. WCRRs include water theme parks, swim or wave lagoons, natural and man-made lakes and water courses, and similar public water contact recreational places (Ordinance No. 3020). Microbiological quality, which is regulated by the county Department of Environmental Health Services (DEHS) is addressed in section 31.054(b). The regulation calls for routine sampling and analysis at a frequency, and from representative locations, as determined by the DEHS. The fecal coliform density from any consecutive sets of samples collected within any thirty (30) days shall not exceed an arithmetic mean of two hundred (200) organisms per one hundred (100) ml. When fecal coliform density of any sample collected exceeds one thousand (1,000) per one hundred ml, the DEHS shall order the closure of the water contact area and follow-up daily sampling shall be immediately commenced with waters analyzed for fecal coliform for at least two (2) consecutive days. If any follow-up daily sample exceeds one thousand (1,000) per one hundred (100) ml., the water contact area shall remain closed, and with the appropriate signs posted and maintained by the owner/operator, and shall not reopen without prior written approval being obtained from the DEHS. The DEHS may also direct sampling for specific pathogens. WCRRs that utilize an approved filtration and disinfection system may, upon approval by the DEHS, maintain a daily log of disinfectant and pH test reading in lieu of microbiological sampling. Fecal coliform sampling shall be conducted prior to the commencement of each season's use and as requested by the DEHS. Routine water samples shall be obtained from representative portions of the swim area at a depth of two (2) feet.

C.5 San Joaquin County

San Joaquin County samples its lakes/reservoirs and rivers once per week May through September, one sample per beach from regular sampling stations. Samples are taken from waist-deep water, and analyzed for total and fecal coliforms. Levels for beach closure: one sample exceeding 400 fecal coliform/ per 100 ml or five consecutive samples taken within a 30-day period exceeding a mean of 200 fecal coliforms per 100 ml.

C.6 Santa Cruz County

Santa Cruz County's county ordinance (Ord 1472, 11/25/69) establishes Section 7.72.0030 as the bacteriological standard for freshwater contact sports areas: Samples of water from each sampling station at such a freshwater contact sports area shall have a count of fecal coliform organisms less than 200 organisms per 100 milliliters, provided that not more than 20 percent of the samples at any sampling station, in any 30-day period, may exceed 200 per 100 milliliters.

C.7 Solano County

Solano County samples as needed for complaints during May-September, and routinely analyses for shistosoma complaints only.

C.8 Tuolomne County

Tuolomne County's lakes/reservoirs, rivers, and artificial impoundments are sampled on a volunteer basis, at about 10 organized beaches. Sampling is once per month, one to three samples per beach from regular sampling stations, April through September. Samples are taken six inches deep one foot away from structures/shore, and analyzed for total and fecal coliforms. Warnings and closures occur in response to sewage spills. Beaches are reopened when fecal and total coliforms are back to background levels. The county uses an advisory level for discontinuing water contact of 1200 MPN fecal coliforms per 100 ml., in the absence of sewage contamination.

C.9 Yolo County

Yolo County's rivers and creeks are sampled only when there is a complaint or when an incident of pollution occurs. For warning and closure, the county uses a standard of not to exceed a daily average of 2400 coliforms per 100 ml. Repeated testing at least on two consecutive days is required to establish a warning/closure action, and the same procedure is required for removal of such order.

Initial draft: November 1997

REFERENCES

See http://www.dhs.ca.gov/ps/ddwem/beaches/pdfs/references.pdf

APPENDIX D. MICROBIOLOGICAL INDICATOR ORGANISMS IN STANDARDS AND GUIDANCE

To protect the recreating public from exposure to microorganisms associated with the presence of sewage in at beaches and in recreational waters, health agencies use microorganisms such as total coliform bacteria, fecal coliform bacteria, enterococci, or *E. coli* as indicators of water quality. Though they are not considered disease-causing agents, their presence above certain numeric levels is suggestive of the presence of other, difficult to detect and quantify pathogenic microorganisms that can cause health effects. The use of the general indicators is an inexpensive, effective way of monitoring the overall well-being of recreational waters.

The use of indicator organisms is public health protective. However, using surrogates as monitoring endpoints makes quantitative risk assessments difficult, and does not enable development of dose/effect relationships, traditional risk assessments (as used in the regulation of chemical contaminants, for example), and predictions of actual risk from disease-causing organisms in recreational waters. The difficulty arises from:

- determining exposure to the disease-causing microbes (the "dose"), which requires quantitation of the specific organism under actual recreating circumstances, which, even if possible analytically, is expensive. For example, monitoring for specific pathogens such as *Giardia* or *Cryptosporidium* is costly and appears not to yield predictable, reliable results.

- determining the risk of illness (the "effect"), which requires epidemiological studies of the recreating public in parallel with water analyses for specific. Epidemiological studies of recreational bathers that have been done generally use indicator organisms, though case-histories of specific disease outbreaks are more specific (see Appendix E).

D.1 Microbiological Indicator Organisms

D.1.1. Total Coliform Bacteria

The term total coliform bacteria refers to a number of bacteria including *Escherichia, Klebsiella, Citrobacter and Enterobacter.* They are able to grow at 35° C and ferment lactose. These are all gram negative asporogenous rods and have been associated with feces of warm-blooded animals. They are also present in soil.

D.1.2 Fecal Coliform Bacteria

Fecal coliform bacteria are a subgroup of the total coliform group. They are able to grow at 44.5° C and ferment lactose. These bacteria have found use as indicators of fecal contamination, because the are restricted to the intestinal tract of warm-blooded animals. Their use enables separation of bacteria of soil and fecal origin.

Among the fecal coliform group, *E. coli*, an indicator of fresh fecal pollution, has also found some use as an indicator organism (US EPA, 1986).

D.1.3 Streptococcus Bacteria (and Enterococcus Group)

The table below indicates the *Streptococcus* species and subspecies that are used as indicators of fecal contamination.

Indicator organism	Enterococcus group*	Streptococcus group
Group D antigen		
*Streptococcus faecalis***	X	X
S. faecalis subsp. *liquefaciens*	X	X
S. faecalis subsp. *zymogenes*	X	X
*S. faecium***	X	X
S. bovis		X
S. equinus		X
Group Q antigen		
S. avium		X

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* excludes *S. bovis*, *S. equinus*, and Group Q organisms.
**also includes some Group Q antigen reactive types that occur in humans, dogs, and pigs.

The normal habitat of fecal streptococci is the intestines of humans and animals; therefore these microorganisms are indicators of fecal pollution. (*Standard Methods for the Examination of Water and Wastewater,* American Public Health Association, 1985). The enterococcus group is a subgroup that is considered more indicative of pollution associated with human sewage. The streptococcus group, when there is a predominance of *S. bovis* and *S. equinus*, is considered to be related to the excreta of nonhuman, warm-blooded animals, as might be related to meat-processing plants, dairy wastes, and feedlot and farmland runoff. *S. faecalis* subsp. *liquefaciens*, besides being associated with mammalian feces, is also associated with vegetation, insects, and certain soils, and may predominate when counts are low (less than 100 per 100 ml).

D.1.4 Other Indicators

A number of possible indicator organisms other than those presented above have been evaluated for marine waters. As summarized by US EPA (1986), other microorganisms that were evaluated for their correlation with swimming-associated gastroenteritis included *Klebsiella*, *Enterobacter/Citrobacter*, *Clostridium perfringens*, *Pseudomonas aeruginosa*, *Aeromonas hydrophila*, *Vibrio parahemolyticus*, and Staphylococci. Because of poor correlation, none of these was considered helpful as an indicator organism.

Initial draft: November 1997

REFERENCES

See http://www.dhs.ca.gov/ps/ddwem/beaches/pdfs/references.pdf

APPENDIX E. EPIDEMIOLOGICAL AND OTHER STUDIES RELATED TO OCEAN WATER AND FRESH WATER RECREATION

E.1 OCEAN WATER

This section presents a brief overview of epidemiological studies of swimmers and other studies in ocean water and fresh water.

Cabelli, 1983

This study evaluated health effects of microbiological contamination on recreational use of marine waters and developed US EPA criteria, based on the mathematical relationship of the swimming-associated rate of gastrointestinal symptoms among bathers to the quality of their water. Enterococci were used as a fecal indicator.

The data, based on 26,686 subjects who responded to follow-up interviews, were collected in an epidemiological research program of the US EPA from beaches in three areas: (1) New York City, New York, in 1972, 1973 and 1974, 15,882 respondents; (2) Lake Pontchartrain, New Orleans, Louisiana, in 1977 and 1978, 6,751 respondents; and (3) Boston Harbor, Massachusetts, in 1978, 4,053 respondents. Water samples were collected from chest-high depths.

The recommended health effects criterion for marine recreation waters was described by the equation

$$\log X = 0.0456Y + 0.677 \qquad \text{[Equation 1]}$$

where:

X is the mean enterococcus density per 100 ml., and

Y is the swimming-associated rate per 1000 people for gastroenteritis (highly credible gastrointestinal symptoms).

Subsequent to the Cabelli study, US EPA developed guidance (US EPA, 1986) for marine recreational waters. This guidance is based upon an "Acceptable Swimming Associated Gastroenteritis Rate" of 19 cases/1000 swimmers, developed from the Cabelli study. The rate of 19 cases of illness per 1000 swimmers is estimated to result from exposures to waters containing bacteria using the fecal coliform indicator group at the maximum geometric mean of 200 per 100 ml. Its steady state geometric mean indicator density at the acceptable rate is 35 enterococci per 100 ml. An acceptable one-time exposure is 104 enterococci per 100 ml.

Cheung *et al.*, 1993

This study of bathers in Hong Kong found *E. coli* to be the best indicator of illness.

Corbett *et al.*, 1993

This study found fecal coliforms to be the best indicator of health effects among Australian swimmers, better than fecal streptococci.

Fleisher *et al.*, 1993

These authors found no difference in health effects between British bathers and non-bathers at fecal streptococci densities less than 40 per 100 ml.

Fleisher *et al.*, 1996

This study of British swimmers found thresholds for febrile respiratory effects and ear effects at 60 and 100 fecal streptococci per 100 ml., respectively.

Kay *et al.*, 1994

In a randomized experimental epidemiological study in which British swimmers were assigned to exposed or unexposed groups, fecal streptococci were the best predictor of gastroenteritis effects. The threshold for GI effects was 33 fecal streptococci per 100 ml.

Haile *et al.*, 1996

This study evaluated health effects of microbiological contamination on recreational use of beaches at Santa Monica Bay in southern California, with attention to proximity of swimmers to large drains that empty onto the beaches. Total coliform, fecal coliform, enterococci, and *E. coli* were used as indicator organisms. The data, collected in 1995 and based on 13,278 subjects who responded to follow-up interviews, were collected at various distances from beach drains: 0, 100 yards downcoast, 100 yards upcoast, and 400 yards upcoast in three different areas: (1) Santa Monica Beach near Ashland Avenue, Will Rogers Beach at Santa Monica Canyon, and Surfrider Beach near Malibu Creek, respondents. Water samples were collected from ankle-high depths.

The authors concluded that swimming in (or near) storm drains resulted in a higher risk of gastrointestinal and respiratory illness, compared to swimming at a distance (~ 400 meters) from those drains. These authors considered the best predictor of swimming-related illness to be the ratio of total coliform organisms/fecal coliform organisms when this ratio was less than 5, when the total coliform level was greater than 5000 per 100 ml. Subsequent analyses (Haile and Witte, undated) showed increased illness when the ratio was lower (e.g., as low as 10 to 18), and when the total coliform level was greater than 1,000 per 100 ml.

Prüss, 1998

This evaluation of health risks associated with poor microbiological quality of recreational water reviews 22 epidemiological investigations, including 15 studies of marine waters and one study of fresh and marine waters.

Spear *et al.*, 1996

The SWRCB (1995a) identified the choice of indicator organism (*i.e.*, coliform vs. enterococcus) for the water-contact bacterial standard and increased stringency of the water-contact fecal coliform standard as an issue to be addressed in its triennial review of the Ocean Plan. The SWRCB in 1990 required dischargers, if ordered by Regional Water Quality Control Boards (RWQCBs) to: (1) monitor for both coliform and enterococcus organisms, and (2) conduct sanitary surveys when either the coliform standards or a specified enterococcus level was exceeded. This approach, it was thought, would provide information on which organism was best for use in California. However, this was a controversial approach, so in 1992, the SWRCB convened an independent technical group, the Microbiological Advisory Committee (MAC), to provide advice on how to investigate the issue. Subsequently, a study was done under contract with the University of California, Berkeley to investigate the presence of each indicator organism at monitoring stations from two major ocean dischargers (City of San Diego and City and County of San Francisco). Those investigators found good correlation between enterococcus and coliform monitoring, and recommended no change from the total and fecal coliform monitoring, (Spear *et al.*, 1996).

E.2 FRESH WATER

Dufour, 1984

This study evaluated health effects of microbiological contamination on recreational use of freshwaters and developed US EPA criteria. These criteria were based on the mathematical relationship of the swimming-associated rate of gastrointestinal symptoms among bathers to the quality of their water. Enterococci and *Escherichia coli* were used as fecal indicators.

The data, based on 34,598 subjects who responded to follow-up interviews, were collected in an epidemiological research program of from beaches in two areas: (1) Lake Erie, Erie, Pennsylvania, in 1979, 1980 and 1982, 18,299 respondents; (2) Keystone Lake, near Tulsa, Oklahoma, in 1979 and 1980, 16,299 respondents.

The recommended health effects criteria for fresh recreation waters were described by the following equations:

$$\log Y = 1.464 + 0.0687 X \quad \text{[Equation 2]}$$

where

X is the swimming-associated rate per 1000 people for gastroenteritis (highly credible gastrointestinal symptoms), and

Y is the mean *E. coli* density per 100 ml.

$$\log Y = 0.938 + 0.059 X \quad \text{[Equation 3]}$$

where

X is the swimming-associated rate per 1000 people for gastroenteritis (highly credible gastrointestinal symptoms), and

Y is the mean enterococcus density per 100 ml.

Subsequent to the Dufour study, US EPA developed guidance (US EPA, 1986) for fresh recreational waters. EPA's guidance for fresh recreational waters is based upon an "Acceptable Swimming Associated Gastroenteritis Rate" of 8 cases/1000 swimmers. The rate of 8 cases of illness per 1000 swimmers is estimated to result from exposures to waters containing bacteria using the fecal coliform indicator group at the maximum geometric mean of 200 per 100 ml. Its steady state geometric mean indicator density at the acceptable rate is 33 enterococci per 100 ml. . An acceptable one-time exposure is 65 enterococci per 100 ml.

Calderon *et al.*, 1991

In this study of recreational swimmers using a pond (Calderon *et al.*, 1991) found a greater correlation between infectious disease and the number of other swimmers/bathers than it did between infectious disease and various microbiological indicators.

Fresno County Community Health Department, 1996

A cryptosporidiosis outbreak at a water park in Fresno County was attributed to the ingestion of pool water that may have been contaminated by *Cryptosporidium* oocysts from fecal accidents by infected individuals(s) or from the rinsing off of water from an untreated pond adjacent to the pool area (Fresno County Community Health Department, 1996).

Kramer *et al.*, 1996

The Centers for Disease Control (Kramer *et al.*, 1996) reported 14 outbreaks of gastroenteritis in the US in 1993-1994, 10 of which were attributable to protozoan parasites in recreational water (e.g., *Cryptosporidium parvum* or *Giardia lamblia*) and the rest to *Shigella* spp., or *E. coli* O157:H7). Seven of these outbreaks occurred in lakes, one in a river, and six in pools.

Levy *et al.*, 1998

The Centers for Disease Control (Levy *et al.*, 1998) reported 37 outbreaks in the US in 1995-1996. Of these, 22 were gastroenteritis outbreaks; causes included *Cryptosporidium parvum* (6), *Giardia* (1), *E. coli* O157:H7 (6), *Shigella sonnei*(3), and *Salmonella* sertoype Java (1). Thirteen of the 22 gastroenteritis outbreaks were associated with lake water, eight with swimming or wading pools, and one with a hot spring. There were nine dermatitis outbreaks, of which two were lake-associated (swimmer's itch caused by *Schistosoma* species) and seven were hot tub-associated

(*Pseudomonas*). The final six were single cases of primary amebic meningoencephalitis (all fatal, five in Texas and one in Florida, associated with a shallow lake, river, pond, or canal), caused by *Naegleria fowleri*.
Human feces appeared to be related to outbreaks associated with several lake-associated outbreaks.

Prüss, 1998

This evaluation of health risks associated with poor microbiological quality of recreational water reviews 22 epidemiological investigations, including six studies of fresh waters and one of fresh and marine waters.

Warrner *et al.*, 1996

This outbreak, associated with *E. coli* O157:H7, involved 12 individuals who had visited an Illinois state park with a lake swimming beach.

REFERENCES

See http://www.dhs.ca.gov/ps/ddwem/beaches/pdfs/references.pdf

Appendix F. INFORMATION AND WORLD HEALTH ORGANIZATION GUIDANCE FOR CYANOBACTERIA

Activities at the local, state, national and international level demonstrate an increasing interest in health concerns related to blue-green algae (cyanobacteria) and harmful algal blooms. In response, we're providing information and links to other sites that will be helpful to the public and to local, regional, and state public health and environmental health officials.

What is the concern about blue-green algae?

When some blue-green algae blooms occur in water bodies, exposure to algae and their toxins can pose risks to humans, pets, livestock and wildlife. Exposure may occur by ingestion, dermal contact, and aspiration or inhalation.

Risks to people may occur when recreating in water in which a blue-green algae bloom is present, or from the use of drinking water that uses a surface water source in which a blue-green algae bloom is present.

What are the possible health effects related to blue-green algae?

Exposure to blue-green algae can cause rashes, skin and eye irritation, allergic reactions, gastrointestinal upset, and other effects. At high levels, exposure can result in serious illness or death.

Depending on the particular cyanobacterium, and the amount to which one is exposed, blue-green algae have the potential to cause a variety of adverse health effects, including liver toxicity (*e.g., Microcystis aeruginosa*) and neurotoxicity (*e.g., Anabaena circinalis*). Microcystin toxins may also promote tumor growth.

Destruction of cells may release the toxins into surrounding waters, so care must be taken in dealing with blue-green algae blooms.

Are these effects just theoretical?

No. Several dog deaths have been reported following the dogs' exposure to blue-green algae in Humboldt County water bodies (see the Humboldt County 2005 press release and fact sheet)

Worldwide animal poisonings and adverse human health effects have been reported (see links below, especially this from the World Health Organization (WHO)).

What is the best way to minimize risks from blue green algae in recreational water?

Avoid body contact with blue-green algal blooms. This includes swimming, wading, water-skiing.

Children especially should avoid contact. Their small body weight means their exposures to blue green algae will be higher than adults, given the same volume of water intake.

Local health and environmental agencies are encouraged to and generally do post recreational areas with signs and brochures to inform the public of the presence of blue-green algae blooms. Some examples of information from various states are presented below.

What about fish caught in water experiencing a blue-green algae bloom?

If one is going to consume fish, it's best to remove the internal organs, which would likely contain more of the algae/toxin.

There have been some reports of blue-green algae toxin in fish tissues, but anadromous fish that are migrating into a water body with a bloom may not have had an opportunity to concentrate much of the toxin.

What about pets?

Keep pets out of water with blue-green algae blooms.

Dog deaths have been reported, some apparently related to ingestion associated with licking algae from their fur after wading/swimming in water with blue-green algae blooms.

What is the regulatory status of blue-green algae in recreational water?

There aren't any state or federal standards for blue-green algae in recreational water.

The WHO guidelines for recreation summarized in the following table:

Guidelines for Algae and Cyanobacteria in Fresh Water
(from WHO Guidelines for Safe Recreational Water Environments, Table 8.3, Guidelines for Safe Practice in Managing Recreational Waters, page 150)

Probability of adverse health effects	Guidance level or situation	How guidance level derived	Health Risks	Typical Actions
Relatively low	20,000 cyanobacterial cells/ml *or* 10 µg/ chlorophyll-a/liter with dominance of cyanobacteria	From human bathing epidemiological study	Short-term adverse health outcomes, e.g., skin irritations, gastrointestinal illness	Post on-site risk advisory signs Inform relevant authorities
Moderate	100,000 cyanobacterial cells/ml *or* 50 µg chlorophyll-a/liter with dominance of cyanobacteria	From provisional drinking-water guideline value for microcystin-LR [= 1 µg/L] and data concerning other cyanotoxins	Potential for long-term illness with some cyanobacterial species Short-term adverse health outcomes, e.g., skin irritations, gastrointestinal illness	Watch for scums or conditions conducive to scums Discourage swimming and further investigate hazard Post on-site risk advisory signs Inform relevant authorities
High	Cyanobacterial scum formation in areas where whole-body contact and/or risk of ingestion/aspiration occur	Inference from oral animal lethal poisonings Actual human illness case histories	Potential for acute poisoning Potential for long-term illness with some cyanobacterial species Short-term	Immediate action to control contact with scums; possible prohibition of swimming and other water

			adverse health outcomes, e.g., skin irriations, gastrointestinal illness	contact activities Public health follow-up investigation Inform public and relevant authorities
*Actual action taken should be determined in light of extent of use and public health assessment of hazard.				

What are other states doing about blue-green algae?

Some states have developed informational materials about blue-green algae. Here are a few examples: Indiana, Michigan, Minnesota, Nebraska, New Hampshire, New York, Oregon, Vermont, Washington, Wisconsin

More information is available from DHS Cyanobacteria website.

LINKS

- Cyanosite - A webserver for cyanobacterial research (Purdue University)
- Introduction to the Cyanobacteria (UC Berkeley Museum of Paleontology)
- Toxic algal blooms and further reading (Australia Academy of Science)
- Blue-Green Algae (Cyanobacteria) in Inland Waters: Assessment and Control of Risks to Public Health (Scottish Executive Health Department)

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- WHO, 2004. Microcystin LR, from Chemical Fact Sheets, Guidelines for Drinking Water, World Health Organization, Geneva.

OTHER REFERENCES FOR BEACHES GUIDANCE

See http://www.dhs.ca.gov/ps/ddwem/beaches/pdfs/references.pdf

Initial draft: March 2006

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Federal Register

Thursday,
May 18, 2000

Part III

Environmental Protection Agency

40 CFR Part 131

Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants for the State of California; Rule

A012296

ENVIRONMENTAL PROTECTION AGENCY

40 CFR Part 131

[FRL–6587–9]

RIN 2040–AC44

Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants for the State of California

AGENCY: Environmental Protection Agency.

ACTION: Final rule.

SUMMARY: This final rule promulgates: numeric aquatic life criteria for 23 priority toxic pollutants; numeric human health criteria for 57 priority toxic pollutants; and a compliance schedule provision which authorizes the State to issue schedules of compliance for new or revised National Pollutant Discharge Elimination System permit limits based on the federal criteria when certain conditions are met.

EPA is promulgating this rule based on the Administrator's determination that numeric criteria are necessary in the State of California to protect human health and the environment. The Clean Water Act requires States to adopt numeric water quality criteria for priority toxic pollutants for which EPA has issued criteria guidance, the presence or discharge of which could reasonably be expected to interfere with maintaining designated uses.

EPA is promulgating this rule to fill a gap in California water quality standards that was created in 1994 when a State court overturned the State's water quality control plans which contained water quality criteria for priority toxic pollutants. Thus, the State of California has been without numeric water quality criteria for many priority toxic pollutants as required by the Clean Water Act, necessitating this action by EPA. These Federal criteria are legally applicable in the State of California for inland surface waters, enclosed bays and estuaries for all purposes and programs under the Clean Water Act.

EFFECTIVE DATE: This rule shall be effective May 18, 2000.

ADDRESSES: The administrative record for today's final rule is available for public inspection at the U.S. Environmental Protection Agency, Region 9, Water Division, 75 Hawthorne Street, San Francisco, California 94105, between the hours of 8:00 a.m. and 4:30 p.m. For access to the administrative record, call Diane E. Fleck, P.E., Esq. at 415 744–1984 for an appointment. A reasonable fee will be charged for photocopies.

FOR FURTHER INFORMATION CONTACT: Diane E. Fleck, P.E., Esq. or Philip Woods, U.S. Environmental Protection Agency, Region 9, Water Division, 75 Hawthorne Street, San Francisco, California 94105, 415–744–1984 or 415–744–1997, respectively.

SUPPLEMENTARY INFORMATION: This preamble is organized according to the following outline:

A. Potentially Affected Entities

Citizens concerned with water quality in California may be interested in this rulemaking. Entities discharging pollutants to waters of the United States in California could be affected by this rulemaking since water quality criteria are used by the State in developing National Pollutant Discharge Elimination System (NPDES) permit limits. Categories and entities that ultimately may be affected include:

Category	Examples of potentially affected entities
Industry	Industries discharging pollutants to surface waters in California or to publicly-owned treatment works.
Municipalities	Publicly-owned treatment works discharging pollutants to surface waters in California

This table is not intended to be exhaustive, but rather provides a guide for readers regarding entities likely to be affected by this action. This table lists the types of entities that EPA is now aware could potentially be affected by this action. Other types of entities not listed in the table could also be affected. To determine whether your facility might be affected by this action, you should carefully examine the applicability criteria in § 131.38(c). If you have questions regarding the applicability of this action to a particular entity, consult the persons listed in the preceding **FOR FURTHER INFORMATION CONTACT** section.

B. Introduction and Overview

1. Introduction

This section introduces the topics which are addressed in the preamble and provides a brief overview of EPA's basis and rationale for promulgating Federal criteria for the State of California. Section C briefly describes the evolution of the efforts to control toxic pollutants; these efforts include the changes enacted in the 1987 CWA Amendments, which are the basis for this rule. Section D summarizes California's efforts since 1987 to implement the requirements of CWA section 303(c)(2)(B) and describes EPA's procedure and actions for determining whether California has fully implemented CWA section 303(c)(2)(B). Section E provides the rationale and approach for developing this final rule, including a discussion of EPA's legal basis for this final rule. Section F describes the development of the criteria included in this rule. Section G summarizes the provisions of the final rule and discusses implementation issues. Sections H, I, J, K , L, M, N, O, P, and Q briefly address the requirements of Executive Order 12866, the Unfunded Mandates Reform Act of 1995, the Regulatory Flexibility Act, the Paperwork Reduction Act, the Endangered Species Act, the Congressional Review Act, Executive Order 13084, Consultation and Coordination with Indian Tribal Governments, the National Technology Transfer and Advancement Act, and Executive Order 13132, Federalism, respectively.

The proposal for this rulemaking was published in the **Federal Register** on August 5, 1997. Changes from the proposal are generally addressed in the body of this preamble and specifically addressed in the response to comments document included in the administrative record for this rulemaking. EPA responded to all comments on the proposed rule, including comments received after the September 26, 1997, deadline. Although EPA is under no legal obligation to respond to late comments, EPA made a policy decision to respond to all comments.

Since detailed information concerning many of the topics in this preamble was published previously in the **Federal Register** in preambles for this and other rulemakings, references are frequently made to those preambles. Those rulemakings include: Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants for the State of California; Proposed Rule, 62 FR 42159, August 5, 1997 (referred to as the "proposed CTR"); Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants, 57 FR 60848, December 22, 1992 (referred to as the "National Toxics Rule" or "NTR"); and the NTR as amended by Administrative Stay of Federal Water Quality Criteria for Metals and Interim Final Rule, Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants; States' Compliance—Revision of Metals Criteria, 60 FR 22228, May 4, 1995 (referred to as the "National Toxics Rule [NTR], as amended"). The NTR, as amended, is codified at 40 CFR 131.36. A copy of the proposed CTR and its preamble, and the NTR, as amended, and its preambles are contained in the administrative record for this rulemaking.

EPA is making this final rule effective upon publication. Under the Administrative Procedure Act, 5 U.S.C. 553(d)(3), agencies must generally publish a rule no more than 30 days prior to the effective date of the rule except as otherwise provided for by the Agency for good cause. The purpose of the 30-day waiting period is to give affected parties a reasonable time to adjust their behavior before the final rule takes effect. See *Omnipoint Corp.* v. *F.C.C.*, 78 F.3d 620, 630–631 (D.C. Cir. 1996); *Riverbend Farms, Inc.* v. *Madigan*, 958 F.2d 1479, 1485 (9th Cir. 1992).

In this instance, EPA finds good cause to make the final rule effective upon publication. In order to find good cause, an Agency needs to find that the 30-day period would be: (1) Impracticable, (2) unnecessary, or (3) contrary to the public interest. Here EPA is relying on the second reason to support its finding of good cause. EPA also notes that the State has requested EPA to make the rule immediately effective.

EPA finds that in this instance, waiting 30 days to make the rule effective is unnecessary. As explained in further detail elsewhere in this preamble, this rule is not self implementing; rather it establishes ambient conditions that the State of California will implement in future permit proceedings. These permit proceedings will, by regulation, take longer than 30 days to complete. This means that although the rule is immediately effective, no discharger's conduct would be altered under the rule in less than 30 days, and therefore the 30-day period is unnecessary.

2. Overview

This final rule establishes ambient water quality criteria for priority toxic pollutants in the State of California. The criteria in this final rule will supplement the water quality criteria promulgated for California in the NTR, as amended. In 1991, EPA approved a number of water quality criteria (discussed in section D), for the State of California. Since EPA had approved these criteria, it was not necessary to include them in the 1992 NTR for these criteria. However, the EPA-approved criteria were subsequently invalidated in State litigation. Thus, this final rule contains criteria to fill the gap created by the State litigation.

This final rule does not change or supersede any criteria previously promulgated for the State of California in the NTR, as amended. Criteria which EPA promulgated for California in the NTR, as amended, are footnoted in the final table at 131.38(b)(1), so that readers may see the criteria promulgated in the NTR, as amended, for California and the criteria promulgated through this rulemaking for California in the same table. This final rule is not intended to apply to waters within Indian Country. EPA recognizes that there are possibly waters located wholly or partly in Indian Country that are included in the State's basin plans. EPA will work with the State and Tribes to identify any such waters and determine whether further action to protect water quality in Indian Country is necessary.

This rule is important for several environmental, programmatic and legal reasons. Control of toxic pollutants in surface waters is necessary to achieve the CWA's goals and objectives. Many of California's monitored river miles, lake acres, and estuarine waters have elevated levels of toxic pollutants. Recent studies on California water bodies indicate that elevated levels of toxic pollutants exist in fish tissue which result in fishing advisories or bans. These toxic pollutants can be attributed to, among other sources, industrial and municipal discharges.

Water quality standards for toxic pollutants are important to State and EPA efforts to address water quality problems. Clearly established water quality goals enhance the effectiveness of many of the State's and EPA's water programs including permitting, coastal water quality improvement, fish tissue quality protection, nonpoint source controls, drinking water quality protection, and ecological protection. Numeric criteria for toxic pollutants allow the State and EPA to evaluate the adequacy of existing and potential control measures to protect aquatic ecosystems and human health. Numeric criteria also provide a more precise basis for deriving water quality-based effluent limitations (WQBELs) in

National Pollutant Discharge Elimination System (NPDES) permits and wasteload allocations for total maximum daily loads (TMDLs) to control toxic pollutant discharges. Congress recognized these issues when it enacted section 303(c)(2)(B) to the CWA.

While California recognizes the need for applicable water quality standards for toxic pollutants, its adoption efforts have been stymied by a variety of factors. The Administrator has decided to exercise her CWA authorities to move forward the toxic control program, consistent with the CWA and with the State of California's water quality standards program.

Today's action will also help restore equity among the States. The CWA is designed to ensure all waters are sufficiently clean to protect public health and/or the environment. The CWA allows some flexibility and differences among States in their adopted and approved water quality standards, but it should be implemented in a manner that ensures a level playing field among States. Although California has made important progress toward satisfying CWA requirements, it has not satisfied CWA section 303(c)(2)(B) by adopting numeric water quality criteria for toxic pollutants. This section was added to the CWA by Congress in 1987. Prior to today, the State of California had been the only State in the Nation for which CWA section 303(c)(2)(B) had remained substantially unimplemented after EPA's promulgation of the NTR in December of 1992. Section 303(c)(4) of the CWA authorizes the EPA Administrator to promulgate standards where necessary to meet the requirements of the Act. The Administrator determined that this rule was a necessary and important component for the implementation of CWA section 303(c)(2)(B) in California.

EPA acknowledges that the State of California is working to satisfy CWA section 303(c)(2)(B). When the State formally adopts, and EPA approves, criteria consistent with statutory requirements, as envisioned by Congress in the CWA, EPA intends to stay this rule. If within the applicable time frame for judicial review, the States' standards are challenged, EPA will withdraw this rule after such judicial review is complete and the State standards are sustained.

C. Statutory and Regulatory Background

The preamble to the August 5, 1997, proposed rule provided a general discussion of EPA's statutory and regulatory authority to promulgate water quality criteria for the State of California. See 62 FR 42160–42163. EPA is including that discussion in the record for the final rule. Commenters questioned EPA's authority to promulgate certain aspects of the proposal. EPA is responding to those comments in the appropriate sections of this preamble, and in the response to comments document included in the administrative record for this rulemaking. Where appropriate, EPA's responses expand upon the discussion of statutory and regulatory authority found in the proposal.

D. California Water Quality Standards Actions

1. California Regional Water Quality Control Board Basin Plans, and the Inland Surface Waters Plan (ISWP) and the Enclosed Bays and Estuaries Plan (EBEP) of April 1991

The State of California regulates water quality through its State Water Resources Control Board (SWRCB) and through nine Regional Water Quality Control Boards (RWQCBs). Each of the nine RWQCBs represents a different geographic area; area boundaries are generally along watershed boundaries. Each RWQCB maintains a Basin Plan which contains the designated uses of the water bodies within its respective geographic area within California. These designated uses (or "beneficial uses" under State law) together with legally-adopted criteria (or "objectives" under State law), comprise water quality standards for the water bodies within each of the Basin areas. Each of the nine RWQCBs undergoes a triennial basin planning review process, in compliance with CWA section 303. The SWRCB provides assistance to the RWQCBs.

Most of the Basin Plans contain conventional pollutant objectives such as dissolved oxygen. None of the Basin Plans contains a comprehensive list of priority toxic pollutant criteria to satisfy CWA section 303(c)(2)(B). The nine RWQCBs and the SWRCB had intended that the priority toxic pollutant criteria contained in the three SWRCB statewide plans, the Inland Surface Waters Plan (ISWP), the Enclosed Bays and Estuaries Plan (EBEP), and the Ocean Plan, apply to all basins and satisfy CWA section 303(c)(2)(B).

On April 11, 1991, the SWRCB adopted two statewide water quality control plans, the ISWP and the EBEP. These statewide plans contained narrative and numeric water quality criteria for toxic pollutants, in part to satisfy CWA section 303(c)(2)(B). The water quality criteria contained in the SWRCB statewide plans, together with the designated uses in each of the Basin Plans, created a set of water quality standards for waters within the State of California.

Specifically, the two plans established water quality criteria or objectives for all fresh waters, bays and estuaries in the State. The plans contained water quality criteria for some priority toxic pollutants, provisions relating to whole effluent toxicity, implementation procedures for point and nonpoint sources, and authorizing compliance schedule provisions. The plans also included special provisions affecting waters dominated by reclaimed water (labeled as Category (a) waters), and waters dominated by agricultural drainage and constructed agricultural drains (labeled as Category (b) and (c) waters, respectively).

2. EPA's Review of California Water Quality Standards for Priority Toxic Pollutants in the ISWP and EBEP, and the National Toxics Rule

The EPA Administrator has delegated the responsibility and authority for review and approval or disapproval of all new or revised State water quality standards to the EPA Regional Administrators (see 40 CFR 131.21). Thus, State actions under CWA section 303(c)(2)(B) are submitted to the appropriate EPA Regional Administrator for review and approval.

In mid-April 1991, the SWRCB submitted to EPA for review and approval the two statewide water quality control plans, the ISWP and the EBEP. On November 6, 1991, EPA Region 9 formally concluded its review of the SWRCB's plans. EPA approved the narrative water quality criterion and the toxicity criterion in each of the plans. EPA also approved the numeric water quality criteria contained in both plans, finding them to be consistent with the requirements of section 303(c)(2)(B) of the CWA and with EPA's national criteria guidance published pursuant to section 304(a) of the CWA.

EPA noted the lack of criteria for some pollutants, and found that, because of the omissions, the plans did not fully satisfy CWA section 303(c)(2)(B). The plans did not contain criteria for all listed pollutants for which EPA had published national criteria guidance. The ISWP contained human health criteria for only 65 pollutants, and the EBEP contained human health criteria for only 61 pollutants for which EPA had issued section 304(a) guidance criteria. Both the ISWP and EBEP contained aquatic life criteria for all pollutants except cyanide and chromium III (freshwater only) for which EPA has CWA section

304(a) criteria guidance. The SWRCB's administrative record stated that all priority pollutants with EPA criteria guidance were likely to be present in California waters. However, the SWRCB's record contained insufficient information to support a finding that the excluded pollutants were not reasonably expected to interfere with designated uses of the waters of the State.

Although EPA approved the statewide selenium objective in the ISWP and EBEP, EPA disapproved the objective for the San Francisco Bay and Delta, because there was clear evidence that the objective would not protect the designated fish and wildlife uses (the California Department of Health Services had issued waterfowl consumption advisories due to selenium concentrations, and scientific studies had documented selenium toxicity to fish and wildlife). EPA restated its commitment to object to National Pollutant Discharge Elimination System (NPDES) permits issued for San Francisco Bay that contained effluent limits based on an objective greater than 5 parts per billion (ppb) (four day average) and 20 ppb (1 hour average), the freshwater criteria. EPA reaffirmed its disapproval of Californias' site-specific selenium objective for portions of the San Joaquin River, Salt Slough, and Mud Slough. EPA also disapproved of the categorical deferrals and exemptions. These disapprovals included the disapproval of the State's deferral of water quality objectives to effluent dominated streams (Category a) and to streams dominated by agricultural drainage (Category b), and the disapproval of the exemption of water quality objectives to constructed agricultural drains (Category c). EPA found the definitions of the categories imprecise and overly broad which could have led to an incorrect interpretation.

Since EPA had disapproved portions of each of the California statewide plans which were necessary to satisfy CWA section 303(c)(2)(B), certain disapproved aspects of California's water quality standards were included in EPA's promulgation of the National Toxics Rule (NTR) (40 CFR 131.36, 57 FR 60848). EPA promulgated specific criteria for certain water bodies in California.

The NTR was amended, effective April 14, 1995, to stay certain metals criteria which had been promulgated as total recoverable. Effective April 15, 1995, EPA promulgated interim final metals criteria as dissolved concentrations for those metals which had been stayed (Administrative Stay of Federal Water Quality Criteria for Metals and Interim Final Rule, Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants; States' Compliance—Revision of Metals Criteria; 60 FR 22228, 22229, May 4, 1995 [the NTR, as amended]). The stay was in response to a lawsuit against EPA challenging, among other issues, metals criteria expressed as total recoverable concentrations. A partial Settlement Agreement required EPA to stay specific metals criteria in the NTR. EPA then promulgated certain metals criteria in the dissolved form through the use of conversion factors. These factors are listed in the NTR, as amended. A scientific discussion of these criteria is found in a subsequent section of this preamble.

Since certain criteria have already been promulgated for specific water bodies in the State of California in the NTR, as amended, they are not within the scope of today's final rule. However, for clarity in reading a comprehensive rule for the State of California, these criteria are incorporated into 40 CFR 131.38(d)(2). Footnotes to the Table in 40 CFR 131.38(b)(1) and 40 CFR 131.38(d)(3) clarify which criteria (and for which specific water bodies) were promulgated by the NTR, as amended, and are therefore excluded from this final rule. The appropriate (freshwater or saltwater) aquatic life criteria which were promulgated in the NTR, as amended, for all inland surface waters and enclosed bays and estuaries include: chromium III and cyanide. The appropriate (water and organism or organism only) human health criteria which were promulgated in the NTR, as amended, for all inland surface waters and enclosed bays and estuaries include:

antimony
thallium
asbestos
acrolein
acrylonitrile
carbon tetrachloride
chlorobenzene
1,2-dichloroethane
1,1-dichloroethylene
1,3-dichloropropylene
ethylbenzene
1,1,2,2-tetrachloroethane
tetrachloroethylene
1,1,2-trichloroethane
trichloroethylene
vinyl chloride
2,4-dichlorophenol
2-methyl-4,6-dinitrophenol
2,4-dinitrophenol
benzidine
bis(2-chloroethyl)ether
bis(2-ethylhexyl)phthalate
3,3-dichlorobenzidine
diethyl phthalate
dimethyl phthalate
di-n-butyl phthalate
2,4-dinitrotoluene
1,2-diphenylhydrazine
hexachlorobutadiene
hexachlorocyclopentadiene
hexachloroethane
isophorone
nitrobenzene
n-nitrosodimethylamine
n-nitrosodiphenylamine

Other pollutant criteria were promulgated in the NTR, as amended, for specific water bodies, but not all inland surface waters and enclosed bays and estuaries.

3. Status of Implementation of CWA Section 303(c)(2)(B)

Shortly after the SWRCB adopted the ISWP and EBEP, several dischargers filed suit against the State alleging that it had not adopted the two plans in compliance with State law. The plaintiffs in a consolidated case included: the County of Sacramento, Sacramento County Water Agency; Sacramento Regional County Sanitation District; the City of Sacramento; the City of Sunnyvale; the City of San Jose; the City of Stockton; and Simpson Paper Company.

The dischargers alleged that the State had not adopted the ISWP and EBEP in compliance with the California Administrative Procedures Act (Gov Code. Section 11340, *et seq.*), the California Environmental Quality Act (Pub. Re Code, Section 21000, *et seq.*), and the Porter-Cologne Act (Wat. Code, Section 13200, *et seq.*). The allegation that the State did not sufficiently consider economics when adopting water quality objectives, as allegedly required by Section 13241 of the Porter Cologne Act, was an important issue in the litigation.

In October of 1993, the Superior Court of California, County of Sacramento, issued a tentative decision in favor of the dischargers. In March of 1994, the Court issued a substantively similar final decision in favor of the dischargers. Final judgments from the Court in July of 1994 ordered the SWRCB to rescind the ISWP and EBEP. On September 22, 1994, the SWRCB formally rescinded the two statewide water quality control plans. The State is currently in the process of readopting water quality control plans for inland surface waters, enclosed bays and estuaries.

CWA section 303(c)(2)(B) was fully implemented in the State of California from December of 1992, when the NTR was promulgated, until September of 1994, when the SWRCB was required to rescind the ISWP and EBEP. The provisions for California in EPA's NTR together with the approved portions of

California's ISWP and EBEP implemented the requirements of CWA section 303(c)(2)(B). However, since September of 1994, when the SWRCB rescinded the ISWP and EBEP, the requirements of section 303(c)(2)(B) have not been fully implemented in California.

The scope of today's rule is to re-establish criteria for the remaining priority toxic pollutants to meet the requirements of section 303(c)(2)(B) of the CWA. Pursuant to section 303(c)(4), the Administrator has determined that it is necessary to include in today's action criteria for priority toxic pollutants, which are not covered by the NTR, as amended, or by the State through EPA-approved site-specific criteria, for waters of the United States in the State of California.

4. State-Adopted, Site-Specific Criteria for Priority Toxic Pollutants

The State has the discretion to develop site-specific criteria when appropriate e.g., when statewide criteria appear over-or under-protective of designated uses. Periodically, the State through its RWQCBs will adopt site-specific criteria for priority toxic pollutants within respective Basin Plans. These criteria are intended to be effective throughout the Basin or throughout a designated water body. Under California law, these criteria must be publicly reviewed and approved by the RWQCB, the SWRCB, and the State's Office of Administrative Law (OAL). Once this adoption process is complete, the criteria become State law.

These criteria must be submitted to the EPA Regional Administrator for review and approval under CWA section 303. These criteria are usually submitted to EPA as part of a RWQCB Basin Plan Amendment, after the Amendment has been adopted under the State's process and has become State law.

a. State-Adopted Site-Specific Criteria Under EPA Review

The State of California has recently reviewed and updated all of its RWQCB Basin Plans. All of the Basin Plans have completed the State review and adoption process and have been submitted to EPA for review and approval. Some of the Basin Plans contain site-specific criteria. In these cases, the State-adopted site-specific criteria are used for water quality programs.

EPA has not yet concluded consultation under the Endangered Species Act with the U.S. Department of Interior, Fish and Wildlife Service, and the U.S. Department of Commerce, National Marine Fisheries Service, on EPA's tentative approval/disapproval actions on the RWQCB Basin Plans. In this situation, the more stringent of the two criteria (the State-adopted site-specific criteria in the RWQCB Basin Plans, or the Federal criteria in this final rule), would be used for water quality programs including the calculation of water quality-based effluent criteria in National Pollutant Discharge Elimination System (NPDES) permits.

b. State-Adopted Site-Specific Criteria With EPA Approval

In several cases, the EPA Regional Administrator has already reviewed and approved State-adopted site-specific criteria within the State of California. Several of these cases are discussed in this section. All of the EPA approval letters referenced in today's preamble are contained in the administrative record for today's rule.

Sacramento River: EPA has approved site-specific acute criteria for copper, cadmium and zinc in the Sacramento River, upstream of Hamilton City, in the Central Valley Region (RWQCB for the Central Valley Region) of the State of California. EPA approved these site-specific criteria by letter dated August 7, 1985. Specifically, EPA approved for the Sacramento River (and tributaries) above Hamilton City, a copper criterion of 5.6 µg/l (maximum), a zinc criterion of 16 µg/l (maximum) and a cadmium criterion of 0.22 µg/l (maximum), all in the dissolved form using a hardness of 40 mg/l as $CaCO_3$. (These criteria were actually adopted by the State and approved by EPA as equations which vary with hardness.) These "maximum" criteria correspond to acute criteria in today's final rule. Therefore, Federal acute criteria for copper, cadmium, and zinc for the Sacramento River (and tributaries) above Hamilton City are not necessary to protect the designated uses and are not included in the final rule. However, the EPA Administrator is making a finding that it is necessary to include chronic criteria for copper, cadmium and zinc for the Sacramento River (and tributaries) above Hamilton City, as part of the statewide criteria promulgated in today's final rule.

San Joaquin River: The selenium criteria in this rule are not applicable to portions of the San Joaquin River, in the Central Valley Region, because selenium criteria have been either previously approved by EPA or previously promulgated by EPA as part of the NTR. EPA approved and disapproved State-adopted site-specific selenium criteria in portions of the San Joaquin River, in the Central Valley Region of the State of California (RWQCB for the Central Valley Region). EPA's determination on these site-specific criteria is contained in a letter dated April 13, 1990.

Specifically, EPA approved for the San Joaquin River, mouth of Merced River to Vernalis, an aquatic life selenium criterion of 12 µg/l (maximum with the understanding that the instantaneous maximum concentration may not exceed the objective more than once every three years). Today's final rule does not affect this Federally-approved, State-adopted site-specific acute criterion, and it remains in effect for the San Joaquin River, mouth of Merced River to Vernalis. Therefore, an acute criterion for selenium in the San Joaquin River, mouth of Merced River to Vernalis is not necessary to protect the designated use and thus is not included in this final rule.

By letter dated April 13, 1990, EPA also approved for the San Joaquin River, mouth of Merced River to Vernalis, a State-adopted site-specific aquatic life selenium criterion of 5 µg/l (monthly mean); however, EPA disapproved a State-adopted site-specific selenium criterion of 8 µg/l (monthly mean—critical year only) for these waters. Subsequently, EPA promulgated a chronic selenium criterion of 5 µg/l (4 day average) for waters of the San Joaquin River from the mouth of the Merced River to Vernalis in the NTR. This chronic criterion applies to all water quality programs concerning the San Joaquin River, mouth of Merced River to Vernalis. Today's final rule does not affect the Federally-promulgated chronic selenium criterion of 5 µg/l (4 day average) set forth in the NTR. This previously Federally-promulgated criterion remains in effect for the San Joaquin River, mouth of Merced River to Vernalis.

Grassland Water District, San Luis National Wildlife Refuge, and Los Banos State Wildlife Refuge: EPA approved for the Grassland Water District, San Luis National Wildlife Refuge, and Los Banos State Wildlife Refuge, a State-adopted site-specific aquatic life selenium criterion of 2 µg/l (monthly mean) by letter dated April 13, 1990. This Federally-approved, State-adopted site-specific chronic criterion remains in effect for the Grassland Water District, San Luis National Wildlife Refuge and Los Banos State Wildlife Refuge. Therefore it is not necessary to include in today's final rule, a chronic criterion for selenium for the Grassland Water District, San Luis National Wildlife Refuge and Los Banos State Wildlife Refuge, and thus, it is not included in this final rule.

San Francisco Regional Board Basin Plan of 1986: EPA approved several priority toxic pollutant objectives (CWA criteria) that were contained in the1986 San Francisco Regional Board Basin Plan, as amended by SWRCB Resolution Numbers 87–49, 87–82 and 87–92, by letters dated September 2, 1987 and December 24, 1987. This Basin Plan, the SWRCB Resolutions, and the EPA approval letters are contained in the administrative record for this rulemaking. It is not necessary to include these criteria for priority toxic pollutants that are contained in the San Francisco Regional Board's 1986 Basin Plan as amended, and approved by EPA. Priority pollutants in this situation are footnoted in the matrix at 131.38(b)(1) with footnote "b." Where gaps exist in the State adoption and EPA approval of priority toxic pollutant objectives, the criteria in today's rule apply.

EPA is assigning "human health, water and organism consumption" criteria to waters with the States' municipal or "MUN" beneficial use designation in the Basin Plan. Also, some pollutants regulated through the Basin Plan have different averaging periods, *e.g.*, one hour as compared with the rule's "short-term." However, where classes of chemicals, such as polynuclear aromatic hydrocarbons, or PAHs, and phenols, are regulated through the Basin Plan, but not specific chemicals within the category, specific chemicals within the category are regulated by today's rule.

E. Rationale and Approach for Developing the Final Rule

This section explains EPA's legal basis for today's final rule, and discusses EPA's general approach for developing the specific requirements for the State of California.

1. Legal Basis

CWA section 303(c) specifies that adoption of water quality standards is primarily the responsibility of the States. However, CWA section 303(c) also describes a role for the Federal government to oversee State actions to ensure compliance with CWA requirements. If EPA's review of the States' standards finds flaws or omissions, then the CWA authorizes EPA to correct the deficiencies (see CWA section 303(c)(4)). This water quality standards promulgation authority has been used by EPA to issue final rules on several separate occasions, including the NTR, as amended, which promulgated criteria similar to those included here for a number of States. These actions have addressed both insufficiently protective State criteria and/or designated uses and failure to adopt needed criteria. Thus, today's action is not unique.

The CWA in section 303(c)(4) provides two bases for promulgation of Federal water quality standards. The first basis, in paragraph (A), applies when a State submits new or revised standards that EPA determines are not consistent with the applicable requirements of the CWA. If, after EPA's disapproval, the State does not amend its rules so as to be consistent with the CWA, EPA is to promptly propose appropriate Federal water quality standards for that State. The second basis for an EPA action is in paragraph (B), which provides that EPA shall promptly initiate promulgation "* * * in any case where the Administrator determines that a revised or new standard is necessary to meet the requirements of this Act." EPA is using section 303(c)(4)(B) as the legal basis for today's final rule.

As discussed in the preamble to the NTR, the Administrator's determination under CWA section 303(c)(4) that criteria are necessary to meet the requirements of the Act could be supported in several ways. Consistent with EPA's approach in the NTR, EPA interprets section 303(c)(2)(B) of the CWA to allow EPA to act where the State has not succeeded in establishing numeric water quality standards for toxic pollutants. This inaction can be the basis for the Administrator's determination under section 303(c)(4) that new or revised criteria are necessary to ensure designated uses are protected.

EPA does not believe that it is necessary to support the criteria in today's rule on a pollutant-specific, water body-by-water-body basis. For EPA to undertake an effort to conduct research and studies of each stream segment or water body across the State of California to demonstrate that for each toxic pollutant for which EPA has issued CWA section 304(a) criteria guidance there is a "discharge or presence" of that pollutant which could reasonably "be expected to interfere with" the designated use would impose an enormous administrative burden and would be contrary to the statutory directive for swift action manifested by the 1987 addition of section 303(c)(2)(B) to the CWA. Moreover, because these criteria are ambient criteria that define attainment of the designated uses, their application to all water bodies will result in additional controls on dischargers only where necessary to protect the designated uses.

EPA's interpretation of section 303(c)(2)(B) is supported by the language of the provision, the statutory framework and purpose of section 303, and the legislative history. In adding section 303(c)(2)(B) to the CWA, Congress understood the existing requirements in section 303(c)(1) for States to conduct triennial reviews of their water quality standards and submit the results of those reviews to EPA and in section 303(c)(4)(B) for promulgation. CWA section 303(c) includes numerous deadlines and section 303(c)(4) directs the Administrator to act "promptly" where the Administrator determines that a revised or new standard is necessary to meet the requirements of the Act. Congress, by linking section 303(c)(2)(B) to the section 303(c)(1) three-year review period, gave States a last chance to correct this deficiency on their own. The legislative history of the provision demonstrates that chief Senate sponsors, including Senators Stafford, Chaffee and others wanted the provision to eliminate State and EPA delays and force quick action. Thus, to interpret CWA section 303(c)(2)(B) and (c)(4) to require such a cumbersome pollutant specific effort on each stream segment would essentially render section 303(c)(2)(B) meaningless. The provision and its legislative background indicate that the Administrator's determination to invoke section 303(c)(4)(B) authority can be met by the Administrator making a generic finding of inaction by the State without the need to develop pollutant specific data for individual stream segments. Finally, the reference in section 303(c)(2)(B) to section 304(a) criteria suggests that section 304(a) criteria serve as default criteria; that once EPA has issued them, States were to adopt numeric criteria for those pollutants based on the 304(a) criteria, unless they had other scientifically defensible criteria. EPA also notes that this rule follows the approach EPA took nationally in promulgating the NTR for States that failed to comply with CWA section 303(c)(2)(B). 57 FR 60848, December 22, 1992. EPA incorporates the discussion in the NTR preamble as part of this rulemaking record.

This determination is supported by information in the rulemaking record showing the discharge or presence of priority toxic pollutants throughout the State. While this data is not necessarily complete, it constitutes a strong record supporting the need for numeric criteria for priority toxic pollutants with section 304(a) criteria guidance where the State does not have numeric criteria.

Today's final rule would not impose any undue or inappropriate burden on the State of California or its dischargers. It merely puts in place numeric criteria for toxic pollutants that are already used in other States in implementing CWA programs. Under this rulemaking, the State of California retains the ability to adopt alternative water quality criteria simply by completing its criteria adoption process. Upon EPA approval of those criteria, EPA will initiate action to stay the Federally-promulgated criteria and subsequently withdraw them.

2. Approach for Developing This Rule

In summary, EPA developed the criteria promulgated in today's final rule as follows. Where EPA promulgated criteria for California in the NTR, EPA has not acted to amend the criteria in the NTR. Where criteria for California were not included in the NTR, EPA used section 304(a) National criteria guidance documents as a starting point for the criteria promulgated in this rule. EPA then determined whether new information since the development of the national criteria guidance documents warranted any changes. New information came primarily from two sources. For human health criteria, new or revised risk reference doses and cancer potency factors on EPA's Integrated Risk Information System (IRIS) as of October 1996 form the basis for criteria values (see also 63 FR 68354). For aquatic life criteria, updated data sets resulting in revised criteria maximum concentrations (CMCs) and criteria continuous concentrations (CCCs) formed the basis for differences from the national criteria guidance documents. Both of these types of changes are discussed in more detail in the following sections. This revised information was used to develop the water quality criteria promulgated here for the State of California.

F. Derivation of Criteria

1. Section 304(a) Criteria Guidance Process

Under CWA section 304(a), EPA has developed methodologies and specific criteria guidance to protect aquatic life and human health. These methodologies are intended to provide protection for all surface waters on a national basis. The methodologies have been subject to public review, as have the individual criteria guidance documents. Additionally, the methodologies have been reviewed by EPA's Science Advisory Board (SAB) of external experts.

EPA has included in the record of this rule the aquatic life methodology as described in "Appendix B—Guidelines for Deriving Water Quality Criteria for the Protection of Aquatic Life and Its Uses" to the "Water Quality Criteria Documents; Availability" (45 FR 79341, November 28, 1980) as amended by the "Summary of Revisions to Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses" (50 FR 30792, July 29, 1985). (Note: Throughout the remainder of this preamble, this reference is described as the 1985 Guidelines. Any page number references are to the actual guidance document, not the notice of availability in the **Federal Register**. A copy of the 1985 Guidelines is available through the National Technical Information Service (PB85–227049), is in the administrative record for this rule, and is abstracted in Appendix A of *Quality Criteria for Water*, 1986.) EPA has also included in the administrative record of this rule the human health methodology as described in "Appendix C—Guidelines and Methodology Used in the Preparation of Health Effects Assessment Chapters of the Consent Decree Water Criteria Documents" (45 FR 79347, November 28, 1980). (Note: Throughout the remainder of this preamble, this reference is described as the Human Health Guidelines or the 1980 Guidelines.) EPA also recommends that the following be reviewed: "Appendix D—Response to Comments on Guidelines for Deriving Water Quality Criteria for the Protection of Aquatic Life and Its Uses," (45 FR 79357, November 28, 1980); "Appendix E—Responses to Public Comments on the Human Health Effects Methodology for Deriving Ambient Water Quality Criteria" (45 FR 79368, November 28, 1980); and "Appendix B—Response to Comments on Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses" (50 FR 30793, July 29, 1985). EPA placed into the administrative record for this rulemaking the most current individual criteria guidance for the priority toxic pollutants included in today's rule. (Note: All references to appendices are to the associated **Federal Register** publication.)

EPA received many comments related to the issue of what criteria should apply in the CTR if the CWA section 304(a) criteria guidance is undergoing re-evaluation, or if new data are developed that may affect a recommended criterion. As science is always evolving, EPA is faced with the challenge of promulgating criteria that reflect the best science and sound science. EPA addressed this challenge in some detail in its **Federal Register** notice that contained the Agency's current section 304(a) criteria guidance (63 FR 68335, December 10, 1998). There, EPA articulated its policy, reiterated here, that the existing criteria guidance represent the Agency's best assessment until such time as EPA's re-evaluation of a criteria guidance value for a particular chemical is complete. The reason for this is that both EPA's human health criteria guidance and aquatic life criteria guidance are developed taking into account numerous variables. For example, for human health criteria guidance, EPA evaluates many diverse toxicity studies, whose results feed into a reference dose or cancer potency estimate that, along with a number of exposure factors and determination of risk level, results in a guidance criterion. For aquatic life, EPA evaluates many diverse aquatic toxicity studies to determine chronic and acute toxicity taking into account how other factors (such as pH, temperature or hardness) affect toxicity. EPA also, to the extent possible, addresses bioaccumulation or bioconcentration. EPA then uses this toxicity information along with exposure information to determine the guidance criterion. Importantly, EPA subjects such evaluation to peer review and/or public comment.

For these reasons, EPA generally does not make a change to the 304(a) criteria guidance based on a partial picture of the evolving science. This makes sense, because to address one piece of new data without looking at all relevant data is less efficient and results in regulatory impacts that may go back and forth, when in the end, the criteria guidance value does not change that much. Certain new changes, however, do warrant change in criteria guidance, such as a change in a value in EPA's Integrated Risk Information System (IRIS) because it represents the Agency consensus about human health impacts. These changes are sufficiently examined across the Agency such that EPA believes they can be incorporated into EPA's water quality criteria guidance. EPA has followed this approach in the CTR. Included in the administrative record for today's rule is a document entitled "Status of Clean Water Act Section 304(a) Criteria" which further explains EPA's policy on managing change to criteria guidance.

2. Aquatic Life Criteria

Aquatic life criteria may be expressed in numeric or narrative form. EPA's 1985 Guidelines describe an objective, internally consistent and appropriate way of deriving chemical-specific, numeric water quality criteria for the protection of the presence of, as well as the uses of, both fresh and salt water aquatic organisms.

An aquatic life criterion derived using EPA's CWA section 304(a) method "might be thought of as an estimate of the highest concentration of a substance in water which does not present a significant risk to the aquatic organisms in the water and their uses." (45 FR 79341.) EPA's guidelines are designed to derive criteria that protect aquatic communities. EPA's 1985 Guidelines attempt to provide a reasonable and adequate amount of protection with only a small possibility of substantial overprotection or underprotection. As discussed in detail below, there are several individual factors which may make the criteria somewhat overprotective or underprotective. The approach EPA is using is believed to be as well balanced as possible, given the state of the science.

Numerical aquatic life criteria derived using EPA's 1985 Guidelines are expressed as short-term and long-term averages, rather than one number, in order that the criterion more accurately reflect toxicological and practical realities. The combination of a criterion maximum concentration (CMC), a short-term concentration limit, and a criterion continuous concentration (CCC), a four-day average concentration limit, are designed to provide protection of aquatic life and its uses from acute and chronic toxicity to animals and plants, without being as restrictive as a one-number criterion would have to be (1985 Guidelines, pages 4 & 5). The terms CMC and CCC are the formal names for the two (acute and chronic) values of a criterion for a pollutant; however, this document will also use the informal synonyms acute criterion and chronic criterion.

The two-number criteria are intended to identify average pollutant concentrations which will produce water quality generally suited to maintenance of aquatic life and designated uses while restricting the duration of excursions over the average so that total exposures will not cause unacceptable adverse effects. Merely specifying an average value over a time period may be insufficient unless the time period is short, because excursions higher than the average may kill or cause substantial damage in short periods.

A minimum data set of eight specified families is recommended for criteria development (details are given in the 1985 Guidelines, page 22). The eight specific families are intended to be representative of a wide spectrum of aquatic life. For this reason it is not necessary that the specific organisms tested be actually present in the water body. EPA's application of its guidelines to develop the criteria matrix in this rule is judged by the Agency to be appropriate for all waters of the United States (U.S.), and to all ecosystems (1985 Guidelines, page 4) including those waters of the U.S. and ecosystems in the State of California.

Fresh water and salt water (including both estuarine and marine waters) have different chemical compositions, and freshwater and saltwater species often do not inhabit the same water. To provide additional accuracy, criteria are developed for fresh water and for salt water.

For this rule, EPA updated freshwater aquatic life criteria contained in CWA section 304(a) criteria guidance first published in the early 1980's and later modified in the NTR, as amended, for the following ten pollutants: arsenic, cadmium, chromium (VI), copper, dieldrin, endrin, lindane (gamma BHC), nickel, pentachlorophenol, and zinc. The updates used as the basis for this rule are explained in a technical support document entitled, *1995 Updates: Water Quality Criteria Documents for the Protection of Aquatic Life in Ambient Water* (U.S. EPA–820–B–96–001, September 1996), available in the administrative record to this rulemaking; this document presents the derivation of each of the final CMCs and CCCs and the toxicity studies from which the updated freshwater criteria for the ten pollutants were derived.

The polychlorinated biphenyls (PCB) criteria in the criteria matrix for this rule differs from that in the NTR, as amended; for this rule, the criteria are expressed as the sum of seven aroclors, while for the NTR, as amended, the criteria are expressed for each of seven aroclors. The aquatic life criteria for PCBs in the CTR are based on the criteria contained in the 1980 criteria guidance document for PCBs which is included in the administrative record for this rule. This criteria document explains the derivation of aquatic life criteria based on total PCBs. For more information see the Response to Comments document for this rule. Today's chronic aquatic life criteria for PCBs are based on a final residue value (FRV). In EPA's guidelines for deriving aquatic life criteria, an FRV-based criterion is intended to prevent concentrations of pollutants in commercially or recreationally important aquatic species from affecting the marketability of those species or affecting the wildlife that consume aquatic life.

The proposed CTR included an updated freshwater and saltwater aquatic life criteria for mercury. In today's final rule, EPA has reserved the mercury criteria for freshwater and saltwater aquatic life, but is promulgating human health criteria for mercury for all surface waters in California. In some instances, the human health mercury criteria included in today's final rule may not protect some aquatic species or threatened or endangered species. In such instances, more stringent mercury limits may be determined and implemented through use of the State's narrative criterion. The reasons for reserving the mercury aquatic life numbers are explained in further detail in Section L, Endangered Species Act.

a. Freshwater Acute Selenium Criterion

EPA proposed a different freshwater acute aquatic life criterion for selenium for this rule than was promulgated in the NTR, as amended. EPA's proposed action was consistent with EPA's proposed selenium criterion maximum concentration for the Water Quality Guidance for the Great Lakes System (61 FR 58444, November 14, 1996). This proposal took into account data showing that selenium's two most prevalent oxidation states, selenite and selenate, present differing potentials for aquatic toxicity, as well as new data which indicated that various forms of selenium are additive. Additivity increases the toxicity of mixtures of different forms of the pollutant. The proposed approach produces a different selenium acute criterion concentration, or CMC, depending upon the relative proportions of selenite, selenate, and other forms of selenium that are present.

The preamble to the August 5, 1997, proposed rule provided a lengthy discussion of this proposed criterion for the State of California. See 62 FR 42160–42208. EPA incorporates that discussion here as part of this rulemaking record. In 1996, a similar discussion was included in the proposed rule for the Great Lakes System. Commenters questioned several aspects of the Great Lakes proposal. EPA is continuing to respond to those comments, and to follow up with additional literature review and toxicity testing. In addition, the U.S. FWS and U.S. NMFS (collectively, the Services) are concerned that EPA's proposed criterion may not be sufficiently protective of certain threatened and endangered species in California. Because the Services believe there is a lack of data to show for certain that the proposed criterion would not affect threatened and endangered species, the Services prefer that EPA further investigate the protectiveness of the criterion before finalizing the proposed criterion. Therefore, EPA is not promulgating a final acute freshwater selenium criterion at this time.

b. Dissolved Metals Criteria

In December of 1992, in the NTR, EPA promulgated water quality criteria for several States that had failed to meet the requirements of CWA section 303(c)(2)(B). Included among the water quality criteria promulgated were numeric criteria for the protection of aquatic life for 11 metals: arsenic, cadmium, chromium (III), chromium (VI), copper, lead, mercury, nickel, selenium, silver and zinc. Criteria for two metals applied to the State of California: chromium III and selenium.

The Agency received extensive public comment during the development of the NTR regarding the most appropriate approach for expressing the aquatic life metals criteria. The principal issue was the correlation between metals that are measured and metals that are bioavailable and toxic to aquatic life. It is now the Agency's policy that the use of dissolved metal to set and measure compliance with aquatic life water quality standards is the recommended approach, because dissolved metal more closely approximates the bioavailable fraction of the metal in the water column than does total recoverable metal.

Since EPA's previous aquatic life criteria guidance had been expressed as total recoverable metal, to express the criteria as dissolved, conversion factors were developed to account for the possible presence of particulate metal in the laboratory toxicity tests used to develop the total recoverable criteria. EPA included a set of recommended freshwater conversion factors with its Metals Policy (see Office of Water Policy and Technical Guidance on Interpretation and Implementation of Aquatic Life Metals Criteria, Martha G. Prothro, Acting Assistant Administrator for Water, October 1, 1993). Based on additional laboratory evaluations that simulated the original toxicity tests, EPA refined the procedures used to develop freshwater conversion factors for aquatic life criteria. These new conversion factors were made available for public review and comment in the amendments to the NTR on May 4, 1995, at 60 FR 22229. They are also contained in today's rule at 40 CFR 131.38(b)(2).

The preamble to the August 5, 1997, proposed rule provided a more detailed discussion of EPA's metals policy concerning the aquatic life water quality criteria for the State of California. See 62 FR 42160–42208. EPA incorporates that discussion here as part of this rulemaking record. Many commenters strongly supported the Agency's policy on dissolved metals aquatic life criteria. A few commenters expressed an opinion that the metals policy may not provide criteria that are adequately protective of aquatic or other species. Responses to those comments are contained in a memo to the CTR record entitled "Discussion of the Use of Dissolved Metals in the CTR" (February 1, 2000, Jeanette Wiltse) and EPA's response to comments document which are both contained in the administrative record for the final rule.

Calculation of Aquatic Life Dissolved Metals Criteria: Metals criteria values for aquatic life in today's rule in the matrix at 131.38(b)(1) are shown as dissolved metal. These criteria have been calculated in one of two ways. For freshwater metals criteria that are hardness-dependent, the metals criteria value is calculated separately for each hardness using the table at 40 CFR 131.38(b)(2). (The hardness-dependent freshwater values presented in the matrix at 40 CFR 131.38(b)(1) have been calculated using a hardness of 100 mg/l as CaCO3 for illustrative purposes only.) The hardness-dependent criteria are then multiplied by the appropriate conversion factors in the table at 40 CFR 131.38(b)(2). Saltwater and freshwater metals criteria that are not hardness-dependent are calculated by taking the total recoverable criteria values (from EPA's national section 304(a) criteria guidance, as updated and described in section F.2.a.) before rounding, and multiplying them by the appropriate conversion factors. The final dissolved metals criteria values, as they appear in the matrix at 40 CFR 131.38(b)(1), are rounded to two significant figures.

Translators for Dissolved to Total Recoverable Metals Limits: EPA's National Pollutant Discharge Elimination System (NPDES) regulations require that limits for metals in permits be stated as total recoverable in most cases (see 40 CFR 122.45(c)) except when an effluent guideline specifies the limitation in another form of the metal, the approved analytical methods measure only dissolved metal, or the permit writer expresses a metal's limit in another form (*e.g.*, dissolved, specific valence, or total) when required to carry out provisions of the CWA. This is because the chemical conditions in ambient waters frequently differ substantially from those in the effluent and these differences result in changes in the partitioning between dissolved and absorbed forms of the metal. This means that if effluent limits were expressed in the dissolved form, additional particulate metal could dissolve in the receiving water causing the criteria to be exceeded. Expressing criteria as dissolved metal requires translation between different metal forms in the calculation of the permit limit so that a total recoverable permit limit can be established that will achieve water quality standards. Thus, it is important that permitting authorities and other authorities have the ability to translate between dissolved metal in ambient waters and total recoverable metal in effluent.

EPA has completed guidance on the use of translators to convert from dissolved metals criteria to total recoverable permit limits. The document, *The Metals Translator: Guidance for Calculating a Total Recoverable Permit Limit From a Dissolved Criterion* (EPA 823–B–96–007, June 1996), is included in the administrative record for today's rule. This technical guidance examines how to develop a metals translator which is defined as the fraction of total recoverable metal in the downstream water that is dissolved, *i.e.*, the dissolved metal concentration divided by the total recoverable metal concentration. A translator may take one of three forms: (1) It may be assumed to be equivalent to the criteria guidance conversion factors; (2) it may be developed directly as the ratio of dissolved to total recoverable metal; and (3) it may be developed through the use of a partition coefficient that is functionally related to the number of metal binding sites on the adsorbent in the water column (*e.g.*, concentrations of total suspended solids or TSS). This guidance document discusses these three forms of translators, as well as field study designs, data generation and analysis, and site-specific study plans to generate site-specific translators.

California Regional Water Quality Control Boards may use any of these methods in developing water quality-based permit limits to meet water quality standards based on dissolved metals criteria. EPA encourages the State to adopt a statewide policy on the use of translators so that the most appropriate method or methods are used consistently within California.

c. Application of Metals Criteria

In selecting an approach for implementing the metals criteria, the principal issue is the correlation between metals that are measured and metals that are biologically available and toxic. In order to assure that the metals criteria are appropriate for the chemical conditions under which they are applied, EPA is providing for the adjustment of the criteria through application of the "water-effect ratio" procedure. EPA notes that performing the testing to use a site-specific water-effect ratio is optional on the part of the State.

In the NTR, as amended, EPA identified the water-effect ratio (WER) procedure as a method for optional site-specific criteria development for certain metals. The WER approach compares bioavailability and toxicity of a specific pollutant in receiving waters and in laboratory waters. A WER is an appropriate measure of the toxicity of a material obtained in a site water divided by the same measure of the toxicity of the same material obtained simultaneously in a laboratory dilution water.

On February 22, 1994, EPA issued *Interim Guidance on the Determination and Use of the Water-Effect Ratios for Metals* (EPA 823-B-94-001) now incorporated into the updated Second Edition of the Water Quality Standards Handbook, Appendix L. A copy of the Handbook is contained in the administrative record for today's rule. In accordance with the WER guidance and where application of the WER is deemed appropriate, EPA strongly encourages the application of the WER on a watershed or water body basis as part of a water quality criteria in California as opposed to the application on a discharger-by-discharger basis through individual NPDES permits. This approach is technically sound and an efficient use of resources. However, discharger specific WERs for individual NPDES permit limits are possible and potentially efficient where the NPDES discharger is the only point source discharger to a specific water body.

The rule requires a default WER value of 1.0 which will be assumed, if no site-specific WER is determined. To use a WER other than the default of 1.0, the rule requires that the WER must be determined as set forth in EPA's WER guidance or by another scientifically defensible method that has been adopted by the State as part of its water quality standards program and approved by EPA.

The WER is a more comprehensive mechanism for addressing bioavailability issues than simply expressing the criteria in terms of dissolved metal. Consequently, expressing the criteria in terms of dissolved metal, as done in today's rule for California, does not completely eliminate the utility of the WER. This is particularly true for copper, a metal that forms reduced-toxicity complexes with dissolved organic matter.

The *Interim Guidance on Determination and Use of Water-Effect Ratios for Metals* explains the relationship between WERs for dissolved criteria and WERs for total recoverable criteria. Dissolved measurements are to be used in the site-specific toxicity testing underlying the WERs for dissolved criteria. Because WERs for dissolved criteria generally are little affected by elevated particulate concentrations, EPA expects those WERs to be somewhat less than WERs for total recoverable criteria in such situations. Nevertheless, after the site-specific ratio of dissolved to total metal has been taken into account, EPA expects a permit limit derived using a WER for a dissolved criterion to be similar to the permit limit that would be derived from the WER for the corresponding total recoverable criterion.

d. Saltwater Copper Criteria

The saltwater copper criteria for aquatic life in today's rule are 4.8 µg/l (CMC) and 3.1 µg/l (CCC) in the dissolved form. These criteria reflect new data including data collected from studies for the New York/New Jersey Harbor and the San Francisco Bay indicating a need to revise the former copper 304(a) criteria guidance document to reflect a change in the saltwater CMC and CCC aquatic life values. These data also reflect a comprehensive literature search resulting in added toxicity test data for seven new species to the database for the saltwater copper criteria. EPA believes these new data have national implications and the national criteria guidance now contains a CMC of 4.8 µg/l dissolved and a CCC of 3.1 µg/l dissolved. In the amendments to the NTR, EPA noticed the availability of data to support these changes to the NTR, and solicited comments. The data can be found in the draft document entitled, *Ambient Water Quality Criteria—Copper, Addendum 1995*. This document is available from the Office of Water Resource Center and is available for review in the administrative record for today's rule.

e. Chronic Averaging Period

In establishing water quality criteria, EPA generally recommends an "averaging period" which reflects the duration of exposure required to elicit effects in individual organisms (TSD, Appendix D-2). The criteria continuous concentration, or CCC, is intended to be the highest concentration that could be maintained indefinitely in a water body without causing an unacceptable effect on the aquatic community or its uses (TSD, Appendix D-1). As aquatic organisms do not generally experience steady exposure, but rather fluctuating exposures to pollutants, and because aquatic organisms can generally tolerate higher concentrations of pollutants over a shorter periods of time, EPA expects that the concentration of a pollutant can exceed the CCC without causing an unacceptable effect if (a) the magnitude and duration of exceedences are appropriately limited and (b) there are compensating periods of time during which the concentration is below the CCC. This is done by specifying a duration of an "averaging period" over which the average concentration should not exceed the CCC more often than specified by the frequency (TSD, Appendix D-1).

EPA is promulgating a 4-day averaging period for chronic criteria, which means that measured or predicted ambient pollutant concentrations should be averaged over a 4-day period to determine attainment of chronic criteria. The State may apply to EPA for approval of an alternative averaging period. To do so, the State must submit to EPA the basis for such alternative averaging period.

The most important consideration for setting an appropriate averaging period is the length of time that sensitive organisms can tolerate exposure to a pollutant at levels exceeding a criterion without showing adverse effects on survival, growth, or reproduction. EPA believes that the chronic averaging period must be shorter than the duration of the chronic tests on which the CCC is based, since, in some cases, effects are elicited before exposure of the entire duration. Most of the toxicity tests used to establish the chronic criteria are conducted using steady exposure to toxicants for a least 28 days (TSD, page 35). Some chronic tests, however, are much shorter than this (TSD, Appendix D-2). EPA selected the 4-day averaging period based on the shortest duration in which chronic test effects are sometimes observed for certain species and toxicants. In addition, EPA believes that the results of some chronic tests are due to an acute effect on a sensitive life stage that occurs some time during the test, rather than being caused by long-term stress or long-term accumulation of the test material in the organisms.

Additional discussion of the rationale for the 4-day averaging period is contained in Appendix D of the TSD. Balancing all of the above factors and data, EPA believes that the 4-day averaging period falls within the scientifically reasonable range of values for choice of the averaging period, and is an appropriate length of time of pollutant exposure to ensure protection of sensitive organisms.

EPA established a 4-day averaging period in the NTR. In settlement of litigation on the NTR, EPA stated that it was "in the midst of conducting, sponsoring, or planning research related to the basis for and application of" water quality criteria and mentioned the issue of averaging period. See Partial Settlement Agreement in *American Forest and Paper Ass'n, Inc. et al.* v. *U.S. EPA* (Consolidated Case No. 93–0694 (RMU), D.D.C.). EPA is re-evaluating issues raised about averaging periods and will, if appropriate, revise the 1985 Guidelines.

EPA received public comment relevant to the averaging period during the comment period for the 1995 Amendments to the NTR (60 FR 22228, May 4, 1995), although these public comments did not address the chronic averaging period separately from the allowable excursion frequency and the design flow. Comments recommended that EPA use the 30Q5 design flow for chronic criteria.

While EPA is undertaking analysis of the chronic design conditions as part of the revisions to the 1985 Guidelines, EPA has not yet completed this work. Until this work is complete, for the reasons set forth in the TSD, EPA continues to believe that the 4-day chronic averaging period represents a reasonable, defensible value for this parameter.

EPA added language to the final rule which will enable the State to adopt alternative averaging periods and frequencies and associated design flows where appropriate. The State may apply to EPA for approval of alternative averaging periods and frequencies and related design flows; the State must submit the bases for any changes. Before approving any change, EPA will publish for public comment, a notice proposing the changes.

f. Hardness

Freshwater aquatic life criteria for certain metals are expressed as a function of hardness because hardness and/or water quality characteristics that are usually correlated with hardness can reduce or increase the toxicities of some metals. Hardness is used as a surrogate for a number of water quality characteristics which affect the toxicity of metals in a variety of ways. Increasing hardness has the effect of decreasing the toxicity of metals. Water quality criteria to protect aquatic life may be calculated at different concentrations of hardnesses measured in milligrams per liter (mg/l) as calcium carbonate ($CaCO_3$).

Section 131.38(b)(2) of the final rule presents the hardness-dependent equations for freshwater metals criteria. For example, using the equation for zinc, the total recoverable CMCs at a hardness of 10, 50, 100 or 200 mg/l as $CaCO_3$ are 17, 67, 120 and 220 micrograms per liter (μg/l), respectively. Thus, the specific value in the table in the regulatory text is for illustrative purposes only. Most of the data used to develop these hardness equations for deriving aquatic life criteria for metals were in the range of 25 mg/l to 400 mg/l as $CaCO_3$, and the formulas are therefore most accurate in this range. The majority of surface waters nationwide and in California have a hardness of less than 400 mg/l as $CaCO_3$.

In the past, EPA generally recommended that 25 mg/l as $CaCO_3$ be used as a default hardness value in deriving freshwater aquatic life criteria for metals when the ambient (or actual) hardness value is below 25 mg/l as $CaCO_3$. However, use of the approach results in criteria that may not be fully protective. Therefore, for waters with a hardness of less than 25 mg/l as $CaCO_3$, criteria should be calculated using the actual ambient hardness of the surface water.

In the past, EPA generally recommended that if the hardness was over 400 mg/l, two options were available: (1) Calculate the criterion using a default WER of 1.0 and using a hardness of 400 mg/l in the hardness equation; or (2) calculate the criterion using a WER and the actual ambient hardness of the surface water in the equation. Use of the second option is expected to result in the level of protection intended in the 1985 Guidelines whereas use of the first option is thought to result in an even more protective aquatic life criterion. At high hardness there is an indication that hardness and related inorganic water quality characteristics do not have as much of an effect on toxicity of metals as they do at lower hardnesses. Related water quality characteristics do not correlate as well at higher hardnesses as they do at lower hardnesses. Therefore, if hardness is over 400 mg/l as $CaCO_3$, a hardness of 400 mg/l as $CaCO_3$ should be used with a default WER of 1.0; alternatively, the WER and actual hardness of the surface water may be used.

EPA requested comments in the NTR amendments on the use of actual ambient hardness for calculating criteria when the hardness is below 25 mg/l as $CaCO_3$, and when hardness is greater than 400 mg/l as $CaCO_3$. Most of the comments received were in favor of using the actual hardness with the use of the water-effect ratio (1.0 unless otherwise specified by the permitting authority) when the hardness is greater than 400 mg/l as $CaCO_3$. A few commenters did not want the water-effect ratio to be mandatory in calculating hardness, and other commenters had concerns about being responsible for deriving an appropriate water-effect ratio. Overall, the commenters were in favor of using the actual hardness when calculating hardness-dependent freshwater metals criteria for hardness between 0–400 mg/l as $CaCO_3$. EPA took those comments into account in promulgating today's rule.

A hardness equation is most accurate when the relationships between hardness and the other important inorganic constituents, notably alkalinity and pH, are nearly identical in all of the dilution waters used in the toxicity tests and in the surface waters to which the equation is to be applied. If an effluent raises hardness but not alkalinity and/or pH, using the hardness of the downstream water might provide a lower level of protection than intended by the 1985 guidelines. If it appears that an effluent causes hardness to be inconsistent with alkalinity and/or pH, the intended level of protection will usually be maintained or exceeded if either (1) data are available to demonstrate that alkalinity and/or pH do not affect the toxicity of the metal, or (2) the hardness used in the hardness equation is the hardness of upstream water that does not contain the effluent. The level of protection intended by the 1985 guidelines can also be provided by using the WER procedure.

In some cases, capping hardness at 400 mg/l might result in a level of protection that is higher than that intended by the 1985 guidelines, but any such increase in the level of protection can be overcome by use of the WER procedure. For metals whose criteria are expressed as hardness equations, use of the WER procedure will generally be intended to account for effects of such water quality characteristics as total organic carbon on the toxicities of metals. The WER procedure is equally useful for accounting for any deviation from a hardness equation in a site water.

3. Human Health Criteria

EPA's CWA section 304(a) human health criteria guidance provides criteria recommendations to minimize adverse human effects due to substances in ambient water. EPA's CWA section 304(a) criteria guidance for human health are based on two types of toxicological endpoints: (1) carcinogenicity and (2) systemic toxicity (i.e., all other adverse effects other than cancer). Thus, there are two procedures for assessing these health effects: one for carcinogens and one for non-carcinogens.

If there are no data on how a chemical agent causes cancer, EPA's existing human health guidelines assume that carcinogenicity is a "non-threshold phenomenon," that is, there are no "safe" or "no-effect levels" because even extremely small doses are assumed to cause a finite increase in the incidence of the effect (i.e., cancer). Therefore, EPA's water quality criteria guidance for carcinogens are presented as pollutant concentrations corresponding to increases in the risk of developing cancer. See Human Health Guidelines at 45 FR 79347.

With existing criteria, pollutants that do not manifest any apparent carcinogenic effect in animal studies (i.e., systemic toxicants), EPA assumes that the pollutant has a threshold below which no effect will be observed. This assumption is based on the premise that a physiological mechanism exists within living organisms to avoid or overcome the adverse effect of the pollutant below the threshold concentration.

Note: Recent changes in the Agency's cancer guidelines addressing these assumptions are described in the Draft Water Quality Criteria Methodology: Human Health, 63 FR 43756, August 14, 1998.

The human health risks of a substance cannot be determined with any degree of confidence unless dose-response relationships are quantified. Therefore, a dose-response assessment is required before a criterion can be calculated. The dose-response assessment determines the quantitative relationships between the amount of exposure to a substance and the onset of toxic injury or disease. Data for determining dose-response relationships are typically derived from animal studies, or less frequently, from epidemiological studies in exposed populations.

The dose-response information needed for carcinogens is an estimate of the carcinogenic potency of the compound. Carcinogenic potency is defined here as a general term for a chemical's human cancer-causing potential. This term is often used loosely to refer to the more specific carcinogenic or cancer slope factor which is defined as an estimate of carcinogenic potency derived from animal studies or epidemiological data of human exposure. It is based on extrapolation from test exposures of high doses over relatively short periods of time to more realistic low doses over a lifetime exposure period by use of linear extrapolation models. The cancer slope factor, q1*, is EPA's estimate of carcinogenic potency and is intended to be a conservative upper bound estimate (e.g. 95% upper bound confidence limit).

For non-carcinogens, EPA uses the reference dose (RfD) as the dose-response parameter in calculating the criteria. For non-carcinogens, oral RfD assessments (hereinafter simply "RfDs") are developed based on pollutant concentrations that cause threshold effects. The RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without appreciable risk of deleterious effects during a lifetime. See Human Health Guidelines. The RfD was formerly referred to as an "Acceptable Daily Intake" or ADI. The RfD is useful as a reference point for gauging the potential effect of other doses. Doses that are less than the RfD are not likely to be associated with any health risks, and are therefore less likely to be of regulatory concern. As the frequency of exposures exceeding the RfD increases and as the size of the excess increases, the probability increases that adverse effect may be observed in a human population. Nonetheless, a clear conclusion cannot be categorically drawn that all doses below the RfD are "acceptable" and that all doses in excess of the RfD are "unacceptable." In extrapolating non-carcinogen animal test data to humans to derive an RfD, EPA divides either a No Observed-Adverse Effect Level (NOAEL), Lowest Observed Adverse Effect Level (LOAEL), or other benchmark dose observed in animal studies by an "uncertainty factor" which is based on professional judgment of toxicologists and typically ranges from 10 to 10,000.

For CWA section 304(a) human health criteria development, EPA typically considers only exposures to a pollutant that occur through the ingestion of water and contaminated fish and shellfish. Thus, the criteria are based on an assessment of risks related to the surface water exposure route only where designated uses are drinking water and fish and shellfish consumption.

The assumed exposure pathways in calculating the criteria are the consumption of 2 liters per day of water at the criteria concentration and the consumption of 6.5 grams per day of fish and shellfish contaminated at a level equal to the criteria concentration but multiplied by a "bioconcentration factor." The use of fish and shellfish consumption as an exposure factor requires the quantification of pollutant residues in the edible portions of the ingested species.

Bioconcentration factors (BCFs) are used to relate pollutant residues in aquatic organisms to the pollutant concentration in ambient waters. BCFs are quantified by various procedures depending on the lipid solubility of the pollutant. For lipid soluble pollutants, the average BCF is calculated from the weighted average percent lipids in the edible portions of fish and shellfish, which is about 3%; or it is calculated from theoretical considerations using the octanol/water partition coefficient. For non-lipid soluble compounds, the BCF is determined empirically. The assumed water consumption is taken from the National Academy of Sciences publication *Drinking Water and Health* (1977). (Referenced in the Human Health Guidelines.) This value is appropriate as it includes a margin of safety so that the general population is protected. See also EPA's discussion of the 2.0 liters/day assumption at 61 FR 65183 (Dec. 11, 1996). The 6.5 grams per day contaminated fish and shellfish consumption value was equivalent to the average per-capita consumption rate of all (contaminated and non-contaminated) freshwater and estuarine fish and shellfish for the U.S. population. See Human Health Guidelines.

EPA assumes in calculating water quality criteria that the exposed individual is an average adult with body weight of 70 kilograms. EPA assumes 6.5 grams per day of contaminated fish and shellfish consumption and 2.0 liters per day of contaminated drinking water consumption for a 70 kilogram person in calculating the criteria. Regarding issues concerning criteria development and differences in dose per kilogram of body weight, RfDs are always derived based on the most sensitive health effect endpoint. Therefore, when that basis is due to a chronic or lifetime health effect, the exposure parameters assume the exposed individual to be the average adult, as indicated above.

In the absence of this final rule, there may be particular risks to children. EPA believes that children are protected by the human health criteria contained in this final rule. Children are protected against other less sensitive adverse health endpoints due to the conservative way that the RfDs are derived. An RfD is a public health protective endpoint. It is an amount of a chemical that can be consumed on a daily basis for a lifetime without expecting an adverse effect. RfDs are based on sensitive health endpoints and are calculated to be protective for sensitive human sub-populations including children. If the basis of the RfD was due to an acute or shorter-term developmental effect, EPA uses exposure parameters other than those indicated above. Specifically, EPA uses parameters most representative of the population of concern (*e.g.*, the health criteria for nitrates based on infant exposure parameters). For carcinogens, the risk assessments are upper bound one in a million (10^{-6}) lifetime risk numbers. The risk to children is not likely to exceed these upper bounds estimates and may be zero at low doses. The exposure assumptions for drinking water and fish protect children because they are conservative for infants and children. EPA assumes 2 liters of untreated surface water and 6.5 grams of freshwater and estuarine fish are consumed each day. EPA believes the adult fish consumption assumption is conservative for children because children generally consume marine fish not freshwater and estuarine.

EPA has a process to develop a scientific consensus on oral reference dose assessments and carcinogenicity assessments (hereinafter simply cancer slope factors or slope factors or q1*s). Through this process, EPA develops a consensus of Agency opinion which is then used throughout EPA in risk management decision-making. EPA maintains an electronic data base which contains the official Agency consensus for oral RfD assessments and carcinogenicity assessments which is known as the Integrated Risk Information System (IRIS). It is available for use by the public on the National Institutes of Health's National Library of Medicine's TOXNET system, and through diskettes from the National Technical Information Service (NTIS). (NTIS access number is PB 90–591330.)

Section 304(a)(1) of the CWA requires EPA to periodically revise its criteria guidance to reflect the latest scientific knowledge: "(A) On the kind and extent of all identifiable effects on health and welfare * * *; (B) on the concentration and dispersal of pollutants, or their byproducts, through biological, physical, and chemical processes; and (C) on the effects of pollutants on the biological community diversity, productivity, and stability, including information on the factors affecting eutrophication rates of organic and inorganic sedimentation for varying types of receiving waters." In developing up-to-date water quality criteria for the protection of human health, EPA uses the most recent IRIS values (RfDs and q1*s) as the toxicological basis in the criterion calculation. IRIS reflects EPA's most current consensus on the toxicological assessment for a chemical. In developing the criteria in today's rule, the IRIS values as of October 1996 were used together with currently accepted exposure parameters for bioconcentration, fish and shellfish and water consumption, and body weight. The IRIS cover sheet for each pollutant criteria included in today's rule is contained in the administrative record.

For the human health criteria included in today's rule, EPA used the Human Health Guidelines on which criteria recommendations from the appropriate CWA section 304(a) criteria guidance document were based. (These documents are also placed in the administrative record for today's rule.) Where EPA has changed any parameters in IRIS used in criteria derivation since issuance of the criteria guidance document, EPA recalculated the criteria recommendation with the latest IRIS information. Thus, there are differences between the original 1980 criteria guidance document recommendations, and those in this rule, but this rule presents EPA's most current CWA section 304(a) criteria recommendation. The basis (q1* or RfD) and BCF for each pollutant criterion in today's rule is contained in the rule's Administrative Record Matrix which is included in the administrative record for the rule. In addition, all recalculated human health numbers are denoted by an "a" in the criteria matrix in 40 CFR 131.38(b)(1) of the rule. The pollutants for which a revised human health criterion has been calculated since the December 1992 NTR include:

mercury
dichlorobromomethane
1,2-dichloropropane
1,2-trans-dichloroethylene
2,4-dimethylphenol
acenaphthene
benzo(a)anthracene
benzo(a)pyrene
benzo(b)flouranthene
benzo(k)flouranthene
2-chloronaphthalene
chrysene
dibenzo(a,h)anthracene
indeno(1,2,3-cd)pyrene
N-nitrosodi-n-propylamine
alpha-endosulfan
beta-endosulfan
endosulfan sulfate
2-chlorophenol
butylbenzyl phthalate
polychlorinated biphenyls.

In November of 1991, the proposed NTR presented criteria for several pollutants in parentheses. These were pollutants for which, in 1980, insufficient information existed to develop human health water quality criteria, but for which, in 1991, sufficient information existed. Since these criteria did not undergo the public review and comment in a manner similar to the other water quality criteria presented in the NTR (for which sufficient information was available in 1980 to develop a criterion, as presented in the 1980 criteria guidance documents), they were not proposed for adoption into the water quality criteria, but were presented to serve as notice for inclusion in future State triennial reviews. Today's rule promulgates criteria for these nine pollutants:

copper
1, 2-dichloropropane
1,2-trans-dichloroethylene
2,4-dimethylphenol
acenaphthene
2-chloronaphthalene
N-nitrosodi-n-propylamine
2-chlorophenol
butylbenzene phthalate

All the criteria are based on IRIS values—either an RfD or q1*—which were listed on IRIS as of November 1991, the date of the proposed NTR. These values have not changed since the final NTR was published in December of 1992. The rule's Administrative Record Matrix in the administrative record of today's rule contains the specific RfDs, q1*s, and BCFs used in calculating these criteria.

Proposed Changes to the Human Health Criteria Methodology: EPA recently proposed revisions to the 1980 ambient water quality criteria derivation guidelines (the Human Health Guidelines). See *Draft Water Quality Criteria Methodology: Human Health*, 63 FR 43756, August 14, 1998; see also *Draft Water Quality Criteria Methodology: Human Health*, U.S. EPA Office of Water, EPA 822–Z–98–001. The EPA revisions consist of five documents: *Draft Water Quality Criteria Methodology: Human Health*, EPA 822–Z–98–001; *Ambient Water Quality Criteria Derivation Methodology Human Health, Technical Support Document, Final Draft*, EPA–822–B–98–005; and three Ambient Water Quality Criteria for the Protection of Human Health, Drafts—one each for Acrylonitrile, 1,3-Dichloropropene (1,3-DCP), and Hexachlorobutadiene (HCBD), respectively, EPA–822–R–98–006, –005, and –004. All five documents are contained in the administrative record for today's rule.

The proposed methodology revisions reflect significant scientific advances that have occurred during the past nineteen years in such key areas as cancer and noncancer risk assessments, exposure assessments and bioaccumulation. For specific details on these proposed changes and others, please refer to the Federal Register notice or the EPA document.

It should be noted that some of the proposed changes may result in significant numeric changes in the ambient water quality criteria. However, EPA will continue to rely on existing criteria as the basis for regulatory and non-regulatory decisions, until EPA revises and reissues a 304(a) criteria guidance using the revised final human health criteria methodology. The existing criteria are still viewed as scientifically acceptable by EPA. The intention of the proposed methodology revisions is to present the latest scientific advancements in the areas of risk and exposure assessment in order to incrementally improve the already sound toxicological and exposure bases for these criteria. As EPA's current human health criteria are the product of many years worth of development and peer review, it is reasonable to assume that revisiting all existing criteria, and incorporating peer review into such review, could require comparable amounts of time and resources. Given these circumstances, EPA proposed a process for revisiting these criteria as part of the overall revisions to the methodology for deriving human health criteria. This process is discussed in the Implementation Section of the Notice of *Draft Revisions to the Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health* (see 63 FR 43771–43776, August 14, 1998).

The State of California in its Ocean Plan, adopted in 1990 and approved by EPA in 1991, established numeric water quality criteria using an average fish and shellfish consumption rate of 23 grams per day. This value is based on an earlier California Department of Health Services estimate. The State is currently in the process of readopting its water quality control plans for inland surface waters, enclosed bays, and estuaries. The State intends to consider information on fish and shellfish consumption rates evaluated and summarized in a report prepared by the State's Pesticide and Environmental Toxicology Section of the Office of Environmental Health Hazard Assessment of the California Environmental Protection Agency. The report, entitled, *Chemicals in Fish Report No. 1: Consumption of Fish and Shellfish in California and the United States*, was published in final draft form in July of 1997, and released to the public on September 16, 1997. The report is currently undergoing final evaluation, and is expected to published in final form in the near future. This final draft report is contained in the administrative record for today's rule. Although EPA has not used this fish consumption value here because this information has not yet been finalized, the State may use any appropriate higher state-specific fish and shellfish consumption rates in its readoption of criteria in its statewide plans.

a. 2,3,7,8-TCDD (Dioxin) Criteria

In today's action, EPA is promulgating human health water quality criteria for 2,3,7,8-tetrachlorodibenzo-p-dioxin ("dioxin") at the same levels as promulgated in the NTR, as amended. These criteria are derived from EPA's 1984 CWA section 304(a) criteria guidance document for dioxin.

For National Pollutant Discharge Elimination System (NPDES) purposes, EPA supports the regulation of other dioxin and dioxin-like compounds through the use of toxicity equivalencies or TEQs in NPDES permits (see discussion below). For California waters, if the discharge of dioxin or dioxin-like compounds has reasonable potential to cause or contribute to a violation of a narrative criterion, numeric water quality-based effluent limits for dioxin or dioxin-like compounds should be included in NPDES permits and should be expressed using a TEQ scheme.

EPA has been evaluating the health threat posed by dioxin nearly continuously for over two decades. Following issuance of the 1984 criteria guidance document, evaluating the health effects of dioxin and recommending human health criteria for dioxin, EPA prepared draft reassessments reviewing new scientific information relating to dioxin in 1985 and 1988. EPA's Science Advisory Board (SAB), reviewing the 1988 draft reassessment, concluded that while the risk assessment approach used in 1984 criteria guidance document had inadequacies, a better alternative was unavailable (see SAB's *Dioxin Panel Review of Documents from the Office or Research and Development relating to the Risk and Exposure Assessment of 2,3,7,8-TCDD* (EPA–SAB–EC–90–003, November 28, 1989) included in the administrative record for today's rule). Between 1988 and 1990, EPA issued numerous reports and guidances relating to the control of dioxin discharges from pulp and paper mills. See e.g., EPA Memorandum, "Strategy for the Regulation of Discharges of PHDDs & PHDFs from Pulp and Paper Mills to the Waters of the United States," from Assistant Administrator for Water to Regional Water Management Division Directors and NPDES State Directors, dated May 21, 1990 (AR NL–16); EPA Memorandum, "State Policies, Water Quality Standards, and Permit Limitations Related to 2,3,7,8-TCDD in Surface Water," from the Assistant Administrator for Water to Regional Water Management Division Directors, dated January 5, 1990 (AR VA–66). These documents are available in the administrative record for today's rule.

In 1991, EPA's Administrator announced another scientific reassessment of the risks of exposure to dioxin (see Memorandum from Administrator William K. Reilly to Erich W. Bretthauer, Assistant Administrator for Research and Development and E. Donald Elliott, General Counsel, entitled *Dioxin: Follow-Up to Briefing on Scientific Developments*, April 8, 1991, included in the administrative record for today's rule). At that time, the Administrator made clear that while the reassessment was underway, EPA would continue to regulate dioxin in accordance with existing Agency policy. Thereafter, the Agency proceeded to regulate dioxin in a number of environmental programs, including standards under the Safe Drinking Water Act and the CWA.

The Administrator's promulgation of the dioxin human health criteria in the 1992 NTR affirmed the Agency's decision that the ongoing reassessment should not defer or delay regulating this potent contaminant, and further, that the risk assessment in the 1984 criteria guidance document for dioxin continued to be scientifically defensible. Until the reassessment process was completed, the Agency could not "say with any certainty what the degree or directions of any changes in the risk estimates might be" (57 FR 60863–64).

The basis for the dioxin criteria as well as the decision to include the dioxin criteria in the 1992 NTR pending the results of the reassessment were challenged. See *American Forest and Paper Ass'n, Inc. et al.* v. *U.S. EPA* (Consolidated Case No. 93–0694 (RMU) D.D.C.). By order dated September 4, 1996, the Court upheld EPA's decision. EPA's brief and the Court's decision are included in the administrative record for today's rule.

EPA has undertaken significant effort toward completion of the dioxin reassessment. On September 13, 1994, EPA released for public review and comment a draft reassessment of toxicity and exposure to dioxin. See *Health Assessment Document for 2,3,7,8-Tetrachlorobenzo-p-Dioxin (TCDD) and Related Compounds*, U.S. EPA, 1994. EPA is currently addressing comments made by the public and the SAB and anticipates that the final revised reassessment will go to the SAB in the near future. With today's rule, the Agency reaffirms that, notwithstanding the on-going risk reassessment, EPA intends to continue to regulate dioxin to avoid further harm to public health, and the basis for the dioxin criteria, both in terms of the cancer potency and the exposure estimates, remains scientifically defensible. The fact that EPA is reassessing the risk of dioxin, virtually a continuous process to evaluate new scientific information, does not mean that the current risk assessment is "wrong". It continues to be EPA's position that until the risk assessment for dioxin is revised, EPA supports and will continue to use the existing risk assessment for the regulation of dioxin in the environment. Accordingly, EPA today promulgates dioxin criteria based on the 1984 criteria guidance document for dioxin and promulgated in the NTR in 1992.

Toxicity Equivalency: The State of California, in its 1991 water quality control plans, adopted human health criteria for dioxin and dioxin-like compounds based on the concept of toxicity equivalency (TEQ) using toxicity equivalency factors (TEFs). EPA Region 9 reviewed and approved the State's use of the TEQ concept and TEFs in setting the State's human health water quality criteria for dioxin and dioxin-like compounds.

In 1987, EPA formally embraced the TEQ concept as an interim procedure to estimate the risks associated with exposures to 210 chlorinated dibenzo-p-dioxin and chlorinated dibenzofuran (CDD/CDF) congeners, including 2,3,7,8-TCDD. This procedure uses a set of derived TEFs to convert the concentration of any CDD/CDF congener into an equivalent concentration of 2,3,7,8-TCDD. In 1989, EPA updated its TEFs based on an examination of relevant scientific evidence and a recognition of the value of international consistency. This updated information can be found in EPA's 1989 *Update to the Interim Procedures for Estimating Risks Associated with Exposures to Mixtures of Chlorinated Dibenzo-p-dioxins and -dibenzofurans (CDDs and CDFs)* (EPA/625/3–89/016, March 1989). EPA had been active in an international effort aimed at adopting a common set of TEFs (International TEFs/89 or I–TEFs/89), to facilitate information exchange on environmental contamination of CDD/CDF. This document reflects EPA's support of an internationally consistent set of TEFs, the I–TEFs/89. EPA uses I–TEFs/89 in many of its regulatory programs.

In 1994, the World Health Organization (WHO) revised the TEF scheme for dioxins and furans to include toxicity from dioxin-like compounds (Ahlborg et al., 1994). However, no changes were made to the TEFs for dioxins and furans. In 1998, the WHO re-evaluated and revised the previously established TEFs for dioxins (Ds), furans (Fs) and dioxin-like compounds (Vanden Bers, 1998). The nomenclature for this TEF scheme is TEQDFP–WHO98, where TEQ represents the 2,3,7,8-TCDD Toxic Equivalence of the mixture, and the subscript DFP indicates that dioxins (Ds) furans (Fs) and dioxin-like compounds (P) are included in the TEF scheme. The subscript 98 following WHO displays the year changes were made to the TEF scheme.

EPA intends to use the 1998 WHO TEF scheme in the near future. At this point however, EPA will support the use of either the 1989 interim procedures or the 1998 WHO TEF scheme but encourages the use of the 1998 WHO TEF scheme in State programs. EPA expects California to use a TEF scheme in implementing the 2,3,7,8-TCDD water quality criteria contained in today's rule. The TEQ and TEF approach provide a methodology for setting NPDES water quality-based permit limits that are protective of human health for dioxin and dioxin-like compounds.

Several commenters requested EPA to promulgate criteria for other forms of dioxin, in addition to 2,3,7,8-TCDD. EPA's draft reassessment for dioxin examines toxicity based on the TEQ concept and I–TEFs/89. When EPA completes the dioxin reassessment, the Agency intends to adopt revised 304(a) water quality criteria guidance based on the reassessment for dioxin. If necessary, EPA will then act to amend the NTR and CTR to reflect the revised 304(a) water quality criteria guidance.

b. Arsenic Criteria

EPA is not promulgating human health criteria for arsenic in today's rule. EPA recognizes that it promulgated human health water quality criteria for arsenic for a number of States in 1992, in the NTR, based on EPA's 1980 section 304(a) criteria guidance for arsenic established, in part, from IRIS values current at that time. However, a number of issues and uncertainties existed at the time of the CTR proposal concerning the health effects of arsenic. These issues and uncertainties were summarized in "Issues Related to Health Risk of Arsenic" which is contained in the administrative record for today's rule. During the period of this rulemaking action, EPA commissioned a study of arsenic health effects by the National Research Council (NRC) arm of the National Academy of Sciences. EPA received the NRC report in March of 1999. EPA scientists reviewed the report, which recommended that EPA lower the Safe Drinking Water Act arsenic maximum contaminant level (MCL) as soon as possible (The arsenic MCL is currently 50 µg/l.) The bladder cancer analysis in the NRC report will provide part of the basis for the risk assessment of a proposed revised arsenic MCL in the near future. After promulgating a revised MCL for drinking water, the Agency plans to revise the CWA 304(a) human health criteria for arsenic in order to harmonize the two standards. Today's rule defers promulgating arsenic criteria based on the Agency's previous risk assessment of skin cancer. In the meantime, permitting authorities in California should rely on existing narrative water quality criteria to establish effluent limitations as necessary for arsenic. California has previously expressed its science and policy position by establishing a criterion level of 5 µg/l for arsenic. Permitting authorities may, among other considerations, consider that value when evaluating and interpreting narrative water quality criteria.

c. Mercury Criteria

The human health criteria promulgated here use the latest RfD in EPA's Integrated Risk Information System (IRIS) and the weighted average practical bioconcentration factor (PBCF) from the 1980 section 304(a) criteria guidance document for mercury. EPA considered the approach used in the Great Lakes Water Quality Guidance ("Guidance") incorporating Bioaccumulation Factors (BAFs), but rejected this approach for reasons outlined below. The equation used here to derive an ambient water quality criterion for mercury from exposure to organisms and water is:

$$HHC = \frac{RfD \times BW}{WC + (FC \times PBCF)}$$

Where:
RfD = Reference Dose
BW = Body Weight
WC = Water Consumption
FC = Total Fish and Shellfish Consumption per Day
PBCF = Practical Bioconcentration Factor (weighted average)

For mercury, the most current RfD from IRIS is 1×10^{-4} mg/kg/day. The RfD used a benchmark dose as an estimate of a No Observed Adverse Effect Level (NOAEL). The benchmark dose was calculated by applying a Weibel model for extra risk to all neurological effects observed in 81 Iraqi children exposed in utero as reported in Marsh, et. al. (1987). Maternal hair mercury was the measure of exposure. Extra risk refers to an adjustment for background incidence of a given health effect. Specifically, the extra risk is the added incidence of observing an effect above the background rate relative to the proportion of the population of interest that is not expected to exhibit such as effect. The resulting estimate was the lower 95% statistical bound on the 10% extra risk; this was 11 ppm mercury in maternal hair. This dose in hair was converted to an equivalent ingested amount by applying a model based on data from human studies; the resulting benchmark dose was 1 x 10^{-3} mg/kg body weight /day. The RfD was calculated by dividing the benchmark dose by a composite uncertainty factor of 10. The uncertainty factor was used to account for variability in the human population, in particular the wide variation in biological half-life of methylmercury and the variation that is observed in the ration of hair mercury to mercury in the blood. In addition the uncertainty factor accounts for lack of a two-generation reproductive study and the lack of data on long term effects of childhood mercury exposures. The RfD thus calculated is 1 x 10^{-4} mg/kg body weight/day or 0.1 µg/kg/day. The body weight used in the equation for the mercury criteria, as discussed in the Human Health Guidelines, is a mean adult human body weight of 70 kg. The drinking water consumption rate, as discussed in the Human Health Guidelines, is 2.0 liters per day.

The bioconcentration factor or BCF is defined as the ratio of chemical concentration in the organism to that in surrounding water. Bioconcentration occurs through uptake and retention of a substance from water only, through gill membranes or other external body surfaces. In the context of setting exposure criteria it is generally understood that the terms "BCF" and "steady-state BCF" are synonymous. A steady-state condition occurs when the organism is exposed for a sufficient length of time that the ratio does not change substantially.

The BCFs that were used herein are the "Practical Bioconcentration Factors (PBCFs)" that were derived in 1980: 5500 for fresh water, 3765 for estuarine coastal waters, and 9000 for open oceans. See pages C–100–1 of Ambient Water Quality Criteria for Mercury (EPA 440/5–80–058) for a complete discussion on the PBCF. Because of the way they were derived, these PBCFs take into account uptake from food as well as uptake from water. A weighted average PBCF was calculated to take into account the average consumption from the three waters using the following equation:

$$\text{Weighted Average Practical BCF} = \frac{\sum(FC \times PBCF)}{\sum(FC)} = \frac{(0.00172)(5500) + (0.00478)(3765) + (0.0122)(9000)}{0.00172 + 0.00478 + 0.0122} = \frac{137.3}{0.0187} = 7342.6$$

Given the large value for the weighted average PBCF, the contribution of drinking water to total daily intake is negligible so that assumptions concerning the chemical form of mercury in drinking water become less important. The human health mercury criteria promulgated for this rule are based on the latest RfD as listed in IRIS and a weighted PBCF from the 1980 § 304(a) criteria guidance document for mercury.

On March 23, 1995 (60 FR 15366), EPA promulgated the Great Lakes Water Quality Guidance ("Guidance"). The Guidance incorporated bioaccumulation factors (BAFs) in the derivation of criteria to protect human health because it is believed that BAFs are a better predictor than BCFs of the concentration of a chemical within fish tissue since BAFs include consideration of the uptake of contaminants from all routes of exposure. A bioaccumulation factor is defined as the ratio (in L/kg) of a substance's concentration in tissue to the concentration in the ambient water, in situations where both the organism and its food are exposed and the ratio does not change substantially over time. The final Great Lakes Guidance establishes a hierarchy of four methods for deriving BAFs for non-polar organic chemicals: (1) Field-measured BAFs; (2) predicted BAFs derived using a field-measured biota-sediment accumulation factor; (3) predicted BAFs derived by multiplying a laboratory-measured BCF by a food chain multiplier; and (4) predicted BAFs derived by multiplying a BCF calculated from the log Kow by a food-chain multiplier. The final Great Lakes Guidance developed BAFs for trophic levels three and four fish of the Great Lakes Basin. Respectively, the BAFs for mercury for trophic level 3 and 4 fish were: 27,900 and 140,000.

The BAF promulgated in the GLI was developed specifically for the Great Lakes System. It is uncertain whether the BAFs of 27,900 and 140,000 are appropriate for use in California at this time; therefore, today's final rule does not use the GLI BAF in establishing human health criteria for mercury in California. The magnitude of the BAF for mercury in a given system depends on how much of the total mercury is present in the methylated form. Methylation rates vary widely from one water body to another for reasons that are not fully understood. Lacking the data, it is difficult to determine if the BAF used in the GLI represents the true potential for mercury to bioaccumulate in California surface waters. The true, average BAF for California could be higher or lower. For more information see EPA's Response to Comments document in the administrative record for this rule (specifically comments CTR–002–007(b) and CTR–016–007).

EPA is developing a national BAF for mercury as part of revisions to its 304(a) criteria for human health; however, the BAF methodology that will be used is currently under evaluation as part of EPA's revisions to its National Human Health Methodology (see section F.3 above). EPA applied a similar methodology in its Mercury Study Report to Congress (MSRC) to derive a BAF for methylmercury. The MSRC is available through NTIS (EPA–452/R–97–003). Although a BAF was derived in the MSRC, EPA does not intend to use this BAF for National application. EPA is engaged in a separate effort to incorporate additional mercury bioaccumulation data that was not considered in the MSRC, and to assess uncertainties with using a National BAF approach for mercury. Once the proposed revised human health methodology, including the BAF component, is finalized, EPA will revise its 304(a) criteria for mercury to reflect changes in the underlying methodology, recommendations contained in the MSRC, and recommendations in a National Academy of Science report on human health assessment of methylmercury. When EPA changes its 304(a) criteria recommendation for mercury, States and Tribes will be expected to review their water quality standards for mercury and make any revisions necessary to ensure their standards are scientifically defensible.

New information may become available regarding the bioaccumulation of mercury in certain water bodies in California. EPA supports the use of this information to develop site-specific criteria for mercury. Further, if a California water body is impaired due to mercury fish tissue or sediment contamination, loadings of mercury could contribute to or exacerbate the impairment. Therefore, one option regulatory authorities should consider is to include water quality-based effluent limits (WQBELs) in permits based on mass for discharges to the impaired water body. Such WQBELs must be derived from and comply with applicable State water quality standards (including both numeric and narrative criteria) and assure that the discharge does not cause or contribute to a violation of water quality standards.

d. Polychlorinated Biphenyls (PCBs) Criteria

The NTR, as amended, calculated human health criteria for PCBs using a cancer potency factor of 7.7 per mg/kg-day from the Agency's IRIS. This cancer potency factor was derived from the Norback and Weltman (1985) study which looked at rats that were fed Aroclor 1260. The study used the linearized multistage model with a default cross-species scaling factor (body weight ratio to the ⅔ power). Although it is known that PCB mixtures vary greatly as to their potency in producing biological effects, for purposes of its carcinogenicity assessment, EPA considered Aroclor 1260 to be representative of all PCB mixtures. The Agency did not pool data from all available congener studies or generate a geometric mean from these studies, since the Norback and Weltman study was judged by EPA as acceptable, and not of marginal quality, in design or conduct as compared with other studies. Thereafter, the Institute for Evaluating Health Risks (IEHR, 1991) reviewed the pathological slides from the Norback and Weltman study, and concluded that some of the malignant liver tumors should have been interpreted as nonmalignant lesions, and that the cancer potency factor should be 5.1 per mg/kg-day as compared with EPA's 7.7 per mg/kg-day.

The Agency's peer-reviewed reassessment of the cancer potency of PCBs published in a final report, *PCBs: Cancer Dose-Response Assessment and Applications to Environmental Mixtures* (EPA/600/P–96/001F), adopts a different approach that distinguishes among PCB mixtures by using information on environmental processes. (The report is included in the administrative record of today's rule.) The report considers all cancer studies (which used commercial mixtures only) to develop a range of cancer potency factors, then uses information on environmental processes to provide guidance on choosing an appropriate potency factor for representative classes of environmental mixtures and different pathways. The reassessment provides that, depending on the specific application, either central estimates or upper bounds can be appropriate. Central estimates describe a typical individual's risk, while upper bounds provide assurance (*i.e.*, 95% confidence) that this risk is not likely to be underestimated if the underlying model is correct. Central estimates are used for comparing or ranking environmental hazards, while upper bounds provide information about the precision of the comparison or ranking. In the reassessment, the use of the upper bound values were found to increase cancer potency estimates by two or three-fold over those using central tendency. Upper bounds are useful for estimating risks or setting exposure-related standards to protect public health, and are used by EPA in quantitative cancer risk assessment. Thus, the cancer potency of PCB mixtures is determined using a tiered approach based on environmental exposure routes with upper-bound potency factors (using a body weight ratio to the ¾ power) ranging from 0.07 (lowest risk and persistence) to 2 (high risk and persistence) per mg/kg-day for average lifetime exposures to PCBs. It is noteworthy that bioaccumulated PCBs appear to be more toxic than commercial PCBs and appear to be more persistent in the body. For exposure through the food chain, risks can be higher than other exposures.

EPA issued the final reassessment report on September 27, 1996, and updated IRIS to include the reassessment on October 1, 1996. EPA updated the human health criteria for PCBs in the National Toxics Rule on September 27, 1999. For today's rule, EPA derived the human health criteria for PCBs using a cancer potency factor of 2 per mg/kg-day, an upper bound potency factor reflecting high risk and persistence. This decision is based on recent multimedia studies indicating that the major pathway of exposure to persistent toxic substances such as PCBs is via dietary exposure (*i.e.*, contaminated fish and shellfish consumption).

Following is the calculation of the human health criterion (HHC) for organism and water consumption:

$$HHC = \frac{RF \times BW \times (1{,}000\ \mu g/mg)}{q1^* \times [WC + (FC \times BCF)]}$$

Where:

RF = Risk Factor = 1×10^{-6}
BW = Body Weight = 70 kg
q1* = Cancer slope factor = 2 per mg/kg-day
WC = Water Consumption = 2 l/day
FC = Fish and Shellfish Consumption = 0.0065 kg/day
BCF = Bioconcentration Factor = 31,200

the HHC (µg/l) = 0.00017 µg/l (rounded to two significant digits).

Following is the calculation of the human health criterion for organism only consumption:

$$HHC = \frac{RF \times BW \times (1{,}000\ \mu g/mg)}{q1^* \times FC \times BCF}$$

Where:

RF = Risk Factor = 1×10^{-6}
BW = Body Weight = 70 kg
q1* = Cancer slope factor = 2 per mg/kg-day
FC = Total Fish and Shellfish Consumption per Day = 0.0065 kg/day
BCF = Bioconcentration Factor = 31,200

the HHC (µg/l) = 0.00017 µg/l (rounded to two significant digits).

The criteria are both equal to 0.00017 µg/l and apply to total PCBs. *See PCBs: Cancer Dose Response Assessment and Application to Environmental Mixtures* (EPA/600/9–96–001F). For a discussion of the body weight, water consumption, and fish and shellfish consumption factors, see the Human Health Guidelines. For a discussion of the BCF, see the 304(a) criteria guidance document for PCBs (included in the administrative record for today's rule).

e. Excluded Section 304(a) Human Health Criteria

As is the case in the NTR, as amended, today's rule does not promulgate criteria for certain priority pollutants for which CWA section 304(a) criteria guidance exists because those criteria were not based on toxicity to humans or aquatic organisms. The basis for those particular criteria is organoleptic effects (*e.g.*, taste and odor) which would make water and edible aquatic life unpalatable but not toxic. Because the basis for this rule is to protect the public health and aquatic life from toxicity consistent with the language and intent in CWA section 303(c)(2)(B), EPA is promulgating criteria only for those priority toxic pollutants whose criteria recommendations are based on toxicity. The CWA section 304(a) human health criteria based on organoleptic effects for zinc and 3-methyl-4-chlorophenol are excluded for this reason. See the 1992 NTR discussion at 57 FR 60864.

f. Cancer Risk Level

EPA's CWA section 304(a) criteria guidance documents for priority toxic pollutants that are based on carcinogenicity present concentrations for upper bound risk levels of 1 excess cancer case per 100,000 people (10^{-5}), per 1,000,000 people (10^{-6}), and per 10,000,000 people (10^{-7}). However, the criteria documents do not recommend a particular risk level as EPA policy.

As part of the proposed rule, EPA requested and received comment on the adoption of a 10^{-5} risk level for carcinogenic pollutants. The effect of a 10^{-5} risk level would have been to increase (*i.e.*, make less stringent) carcinogenic pollutant criteria values (noted in the matrix by footnote c) that are not already promulgated in the NTR, by one order of magnitude. For example, the organism-only criterion for gamma BHC (pollutant number 105 in the matrix) is 0.013 µg/l; the criterion based on a 10^{-5} risk level would have been 0.13 µg/l. EPA received several comments that indicated a preference for a higher (10^{-4} and 10^{-5}) risk level for effluent dependent waters or other types of special circumstances.

In today's rule, EPA is promulgating criteria that protect the general population at an incremental cancer risk level of one in a million (10^{-6}) for all priority toxic pollutants regulated as carcinogens, consistent with the criteria promulgated in the NTR for the State of California. Standards adopted by the State contained in the Enclosed Bays and Estuaries Plan (EBEP), and the Inland Surface Waters Plan (ISWP), partially approved by EPA on November 6, 1991, and the Ocean Plan approved by EPA on June 28, 1990, contained a risk level of 10^{-6} for most carcinogens. The State has historically protected at a 10^{-6} risk level for carcinogenic pollutants.

EPA, in its recent human health methodology revisions, proposed acceptable lifetime cancer risk for the general population in the range of 10^{-5} to 10^{-6}. EPA also proposed that States and Tribes ensure the most highly exposed populations do not exceed a 10^{-4} risk level. However, EPA's draft methodology revisions also stated that it will derive 304(a) criteria at a 10^{-6} risk level, which the Agency believes reflects the appropriate risk for the general population and which applies a risk management policy which ensures protection for all exposed population groups. (Draft Water Quality Criteria Methodology: Human Health, EPA 822–Z–98–001, August 1998, Appendix II, page 72).

Subpopulations within a State may exist, such as recreational and subsistence anglers, who as a result of greater exposure to a contaminant are at greater risk than the standard 70 kilogram person eating 6.5 grams per day of fish and shellfish and drinking 2.0 liters per day of drinking water with pollutant levels meeting the water quality criteria. EPA acknowledges that at any given risk level for the general population, those segments of the population that are more highly exposed face a higher relative risk. For example, if fish are contaminated at a level permitted by criteria derived on the basis of a risk level of 10^{-6}, individuals consuming up to 10 times the assumed fish consumption rate would still be protected at a 10^{-5} risk level. Similarly, individuals consuming 100 times the general population rate would be protected at a 10^{-4} risk level. EPA, therefore, believes that derivation of criteria at the 10^{-6} risk level is a reasonable risk management decision protective of designated uses under the CWA. While outside the scope of this rule, EPA notes that States and Tribes, however, have the discretion to adopt water quality criteria that result in a higher risk level (*e.g.*, 10^{-5}). EPA expects to approve such criteria if the State or Tribe has identified the most highly exposed subpopulation within the State or Tribe, demonstrates the chosen risk level is adequately protective of the most highly exposed subpopulation, and has completed all necessary public participation.

This demonstration has not happened in California. Further, the information that is available on highly exposed subpopulations in California supports the need to protect the general population at the 10^{-6} level. California has cited the Santa Monica Bay Seafood Consumption Study as providing the best available data set for estimating consumption of sport fish and shellfish in California for both marine or freshwater sources (Chemicals in Fish Report No. 1: Consumption of Fish and Shellfish in California and the United States, Final Draft Report, July 1997). Consumption rates of sport fish and shellfish of 21g/day, 50 g/day, 107 g/day, and 161 g/day for the median, mean, 90th, and 95th percentile rates, respectively, were determined from this study. Additional consumption of commercial species in the range of approximately 8 to 42 g/day would further increase these values. Clearly the consumption rates for the most highly exposed subpopulation within the State exceeds 10 times the 6.5 g/day rates used in the CTR. Therefore, use of a risk level of 10^{-5} for the general population would not be sufficient to protect the most highly exposed population in California at a 10^{-4} risk level. On the other hand, even the most highly exposed subpopulations cited in the California study do not have consumption rates approaching 100 times the 6.5 g/day rates used in the CTR. The use of the 10^{-6} risk level to protect average level consumers does not subject these subpopulations to risk levels as high as 10^{-4}.

EPA believes its decision to establish a 10^{-6} risk level for the CTR is also consistent with EPA's policy in the NTR to select the risk level that reflect the policies or preferences of CWA programs in the affected States. California adopted standards for priority toxic pollutants for its ocean waters in 1990 using a 10^{-6} risk level to protect human health (California Ocean Plan, 1990). In April 1991, and again in November 1992, California adopted standards for its inland surface waters and enclosed bays and estuaries in its Inland Surface Waters Plan (ISWP) and its Enclosed Bays and Estuaries Plan (EBEP) using a 10^{-6} risk level. To be consistent with the State's water quality standards, EPA used a 10^{-6} risk level for California in the NTR at 57 FR 60867. The State has continued using a 10^{-6} risk level to protect human health for its standards that were not withdrawn with the ISWP and EBEP. The most recent expression of risk level preference is contained in the Draft Functional Equivalent Document, Amendment of the Water Quality Control Plan for Ocean Waters of California, October 1998, where the State recommended maintaining a consistent risk level of 10^{-6} for the human health standards that it was proposing to revise.

EPA received several comments requesting a 10^{-5} risk level based on the risk level chosen for the Great Lakes Water Quality Guidance (the Guidance). There are several differences between the guidelines for the derivation of human health criteria contained in the Guidance and the California Toxics Rule (CTR) that make a 10^{-5} risk factor appropriate for the Guidance, but not for the CTR. These differences result in criteria developed using the 10^{-5} risk factor in the Guidance being at least as stringent as criteria derived under the CTR using a 10^{-6} risk factor. The relevant aspects of the Guidance include:

- Use of fish consumption rates that are considerably higher than fish consumption rates for the CTR.
- Use of bioaccumulation factors rather than bioconcentration factors in

estimating exposure, considerably increasing the dose of carcinogens to sensitive subgroups.

- Consideration of additivity of effects of mixtures for both carcinogenic and noncarcinogenic pollutants.

This combination of factors increase the calculated carcinogenic risk substantially under the Guidance (the combination would generally be more than one order of magnitude), making a lower overall risk factor acceptable. The Guidance risk factor provides, in fact, criteria with at least the same level of protection against carcinogens as criteria derived with a higher risk factor using the CTR. A lower risk factor for the CTR would not be appropriate absent concomitant changes in the derivation procedures that provide equivalent risk protection.

G. Description of Final Rule

1. Scope

Paragraph (a) in 40 CFR 131.38, entitled "Scope," states that this rule is a promulgation of criteria for priority toxic pollutants in the State of California for inland surface waters, enclosed bays, and estuaries. Paragraph (a) in 40 CFR 131.38 also states that this rule contains an authorizing compliance schedule provision.

2. EPA Criteria for Priority Toxic Pollutants

EPA's criteria for California are presented in tabular form at 40 CFR 131.38. For ease of presentation, the table that appears combines water quality criteria promulgated in the NTR, as amended, that are outside the scope of this rulemaking, with the criteria that are within the scope of today's rule. This is intended to help readers determine applicable water quality criteria for the State of California. The table contains footnotes for clarification.

Paragraph (b) in 40 CFR 131.38 presents a matrix of the applicable EPA aquatic life and/or human health criteria for priority toxic pollutants in California. Section 303(c)(2)(B) of the CWA addresses only pollutants listed as "toxic" pursuant to section 307(a) of the CWA for which EPA has developed section 304(a) criteria guidance. As discussed earlier in this preamble, the section 307(a) list of toxics contains 65 compounds and families of compounds, which potentially include thousands of specific compounds. Of these, the Agency identified a list of 126 "priority toxic pollutants" to implement the CWA (see 40 CFR 131.36(b)). Reference in this rule to priority toxic pollutants, toxic pollutants, or toxics refers to the 126 priority toxic pollutants.

EPA has not developed both aquatic life and human health CWA section 304(a) criterion guidance for all of the priority toxic pollutants. The matrix in 40 CFR 131.38(b) contains human health criteria in Column D for 92 priority toxic pollutants which are divided into Column 1: criteria for water consumption (i.e., 2.0 liters per day) and aquatic organism consumption (i.e., 6.5 grams per day of aquatic organisms); and Column 2: criteria for aquatic organism consumption only. The term aquatic organism includes fish and shellfish such as shrimp, clams, oysters and mussels. One reason the total number of priority toxic pollutants with criteria today differs from the total number of priority toxic pollutants contained in earlier published CWA section 304(a) criteria guidance is because EPA has developed and is promulgating chromium criteria for two valence states with respect to aquatic life criteria. Thus, although chromium is a single priority toxic pollutant, there are two criteria for chromium for aquatic life protection. See pollutant 5 in today's rule at 40 CFR 131.38(b). Another reason is that EPA is promulgating human health criteria for nine priority pollutants for which health-based national criteria have been calculated based on information obtained from EPA's IRIS database (EPA provided notice of these nine criteria in the NTR for inclusion in future State triennial reviews. See 57 FR 60848, 60890).

The matrix contains aquatic life criteria for 23 priority pollutants. These are divided into freshwater criteria (Column B) and saltwater criteria (Column C). These columns are further divided into acute and chronic criteria. The aquatic life criteria are considered by EPA to be protective when applied under the conditions described in the section 304(a) criteria documents and in the TSD. For example, water body uses should be protected if the criteria are not exceeded, on average, once every three year period. It should be noted that the criteria maximum concentrations (the acute criteria) are short-term concentrations and that the criteria continuous concentrations (the chronic criteria) are four-day averages. It should also be noted that for certain metals, the actual criteria are equations which are included as footnotes to the matrix. The toxicity of these metals is water hardness dependent and may be adjusted. The values shown in the table are illustrative only, based on a hardness expressed as calcium carbonate of 100 mg/l. Finally, the criterion for pentachlorophenol is pH dependent. The equation is the actual criterion and is included as a footnote. The value shown in the matrix is for a pH of 7.8. Several of the freshwater aquatic life criteria are incorporated into the matrix in the format used in the 1980 criteria methodology which uses a final acute value instead of a continuous maximum concentration. This distinction is noted in footnote g of the table.

The final rule at 40 CFR 131.38(c) establishes the applicability of the criteria to the State of California. 40 CFR 131.38(d) is described later in Section F, of this preamble. EPA has included in this rule provisions necessary to implement numeric criteria in a way that maintains the level of protection intended. These provisions are included in 40 CFR 131.38(c) of today's rule. For example, in order to do steady state waste load allocation analyses, most States have low flow values for streams and rivers which establish flow rates for various purposes. These low flow values become design flows for sizing treatment plants and developing water quality-based effluent limits and/or TMDLs. Historically, these design flows were selected for the purposes of waste load allocation analyses which focused on instream dissolved oxygen concentrations and protection of aquatic life. With the publication of the 1985 TSD, EPA introduced hydrologically and biologically based analyses for the protection of aquatic life and human health. (These concepts have been expanded subsequently in EPA's *Technical Guidance Manual for Performing Wasteload Allocations, Book 6, Design Conditions*, U.S. EPA, 1986. These analyses are included in Appendix D of the revised TSD. The discussion here is greatly simplified and is provided to support EPA's decision to promulgate design flows for instream flows and thereby maintain the adequacy of the criteria for priority toxic pollutants.) EPA recommended either of two methods for calculating acceptable low flows, the traditional hydrologic method developed by the U.S. Geological Survey or a biological based method developed by EPA. Other methods for evaluating the instream flow record may be available; use of these methods may result in TMDLs and/or water quality-based effluent limitations which adequately protect human health and/or aquatic life. The results of either of these two methods, or an equally protective alternative method, may be used.

The State of California may adopt specific design flows for streams and rivers to protect designated uses against the effects of toxics. EPA believes it is important to specify design flows in today's rule so that, in the absence of state design flows, the criteria promulgated today would be implemented appropriately. The TSD also recommends the use of three dynamic models to perform wasteload allocations. Dynamic wasteload models do not generally use specific steady state design flows but accomplish the same effect by factoring in the probability of occurrence of stream flows based on the historical flow record.

The low flows specified in the rule explicitly contain duration and frequency of occurrence which represent certain probabilities of occurrence. Likewise, the criteria for priority toxic pollutants are defined with duration and frequency components. Dynamic modeling techniques explicitly predict the effects of variability in receiving water, effluent flow, and pollution variation. Dynamic modeling techniques, as described in the TSD, allow for calculating wasteload allocations that meet the criteria for priority toxic pollutants without using a single, worst-case concentration based on a critical condition. Either dynamic modeling or steady state modeling can be used to implement the criteria promulgated today. For simplicity, only steady state conditions are discussed here. Clearly, if the criteria were implemented using design flows that are too high, the resulting toxic controls would not be adequate, because the resulting ambient concentrations would exceed EPA's criteria.

In the case of aquatic life, assuming exceedences occur more frequently than once in three years on the average, exceedences would result in diminished vitality of stream ecosystems characterized by the loss of desired species. Numeric water quality criteria should apply at all flows that are equal to or greater than flows specified below. The low flow values are:

Type of criteria	Design flow
Acute Aquatic Life (CMC).	1 Q 10 or 1 B 3
Chronic Aquatic Life (CCC).	7 Q 10 or 4 B 3
Human Health	harmonic mean flow

Where:

1 Q 10 is the lowest one day flow with an average recurrence frequency of once in 10 years determined hydrologically;

1 B 3 is biologically based and indicates an allowable exceedence of once every 3 years. It is determined by EPA's computerized method (DFLOW model);

7 Q 10 is the lowest average 7 consecutive day low flow with an average recurrence frequency of once in 10 years determined hydrologically;

4 B 3 is biologically based and indicates an allowable exceedences for 4 consecutive days once every 3 years. It is determined by EPA's computerized method (DFLOW model);

EPA is requiring that the harmonic mean flow be applied with human health criteria. The harmonic mean is a standard calculated statistical value. EPA's model for human health effects assumes that such effects occur because of a long-term exposure to low concentration of a toxic pollutant, for example, two liters of water per day for seventy years. To estimate the concentrations of the toxic pollutant in those two liters per day by withdrawal from streams with a high daily variation in flow, EPA believes the harmonic mean flow is the correct statistic to use in computing such design flows rather than other averaging techniques. (For a description of harmonic means see "Design Stream Flows Based on Harmonic Means," Lewis A. Rossman, Jr. of Hydraulics Engineering, Vol. 116, No. 7, July, 1990.)

All waters (including lakes, estuaries, and marine waters), whether or not suitable for such hydrologic calculations, are subject to the criteria promulgated today. Such criteria will need to be attained at the end of the discharge pipe, unless the State authorizes a mixing zone. Where the State plans to authorize a mixing zone, the criteria would apply at the locations allowed by the mixing zone. For example, the chronic criteria (CCC) would apply at the defined boundary of the chronic mixing zone. Discussion of and guidance on these factors are included in the revised TSD in Chapter 4.

EPA is aware that the criteria promulgated today for some of the priority toxic pollutants are at concentrations less than EPA's current analytical detection limits. Analytical detection limits have never been an acceptable basis for setting water quality criteria since they are not related to actual environmental impacts. The environmental impact of a pollutant is based on a scientific determination, not a measuring technique which is subject to change. Setting the criteria at levels that reflect adequate protection tends to be a forcing mechanism to improve analytical detection methods. See 1985 Guidelines, page 21. As the methods improve, limits based on the actual criteria necessary to protect aquatic life and human health become measurable. The Agency does not believe it is appropriate to promulgate criteria that are not sufficiently protective. EPA discusses this issue further in its Response to Comment Document for today's final rule.

EPA does believe, however, that the use of analytical detection limits are appropriate for assessing *compliance* with National Pollutant Discharge Elimination System (NPDES) permit limits. This view of the role of detection limits was first articulated in guidance for translating dioxin criteria into NPDES permit limits. See "Strategy for the Regulation of Discharges of PHDDs and PHDFs from Pulp and Paper Mills to Waters of the U.S." Memorandum from the Assistant Administrator for Water to the Regional Water Management Division Directors, May 21, 1990. This guidance presented a model for addressing toxic pollutants which have criteria less than current detection limits. EPA, in more recent guidance, recommends the use of the "minimum level" or ML for reporting sample results to assess compliance with WQBELs (TSD page 111). The ML, also called the "quantification level," is the level at which the entire analytical system gives recognizable mass spectra and acceptable calibration points, i.e., the point at which the method can reliably quantify the amount of pollutant in the sample. States can use their own procedures to average and otherwise account for monitoring data, *e.g.*, quantifying results below the ML. These results can then be used to assess compliance with WQBELs. (See 40 CFR part 132, Appendix F, Procedure 8.B.) This approach is applicable to priority toxic pollutants with criteria less than current detection limits. EPA's guidance explains that standard analytical methods may be used for purposes of assessing compliance with permit limits, but not for purposes of establishing water quality criteria or permit limits. Under the CWA, analytical methods are appropriately used in connection with NPDES permit limit compliance assessments. Because of the function of water quality criteria, EPA has not considered the sensitivity of analytical methods in deriving the criteria promulgated today.

EPA has promulgated 40 CFR 131.38(c)(3) to determine when freshwater or saltwater aquatic life criteria apply. This provision incorporates a time parameter to better define the critical condition. The structure of the paragraph is to establish applicable rules and to allow for site-specific exceptions where the rules are not consistent with actual field conditions. Because a distinct separation generally does not exist between freshwater and saltwater aquatic communities, EPA is establishing the following: (1) The freshwater criteria apply at salinities of 1 part per thousand and below at locations where this occurs 95% or more of the time; (2) saltwater criteria apply at salinities of 10 parts per thousand and above at locations where this occurs 95% more of the time; and (3) at salinities between 1 and 10 parts per thousand the more stringent of the two apply unless EPA approves the application of the freshwater or saltwater criteria based on an appropriate biological assessment. The percentiles included here were selected to minimize the chance of overlap, that is, one site meeting both criteria. Determination of these percentiles can be done by any reasonable means such as interpolation between points with measured data or by the application of calibrated and verified mathematical models (or hydraulic models). It is not EPA's intent to require actual data collection at particular locations.

In the brackish water transition zones of estuaries with varying salinities, there generally will be a mix of freshwater and saltwater species. Generally, therefore, it is reasonable for the more stringent of the freshwater or saltwater criteria to apply. In evaluating appropriate data supporting the alternative set of criteria, EPA will focus on the species composition as its preferred method. This assignment of criteria for fresh, brackish and salt waters was developed in consultation with EPA's research laboratories at Duluth, Minnesota and Narragansett, Rhode Island. The Agency believes such an approach is consistent with field experience.

Paragraph (d) in 40 CFR 131.38 lists the designated water and use classifications for which the criteria apply. The criteria are applied to the beneficial use designations adopted by the State of California; EPA has not promulgated any new use classifications in this rule.

Exceedences Frequency: In a water quality criterion for aquatic life, EPA recommends an allowable frequency for excursions of the criteria. See 1985 Guidelines, pages 11–13. This allowable frequency provides an appropriate period of time during which the aquatic community can recover from the effect of an excursion and then function normally for a period of time before the next excursion. An excursion is defined as an occurrence of when the average concentration over the duration of the averaging period is above the CCC or the CMC. As ecological communities are naturally subjected to a series of stresses, the allowable frequency of pollutant stress may be set at a value that does not significantly increase the frequency or severity of all stresses combined. See also TSD, Appendix D. In addition, providing an allowable frequency for exceeding the criterion recognizes that it is not generally possible to assure that criteria are never exceeded. (TSD, page 36.)

Based on the available data, today's rule requires that the acute criterion for a pollutant be exceeded no more than once in three years on the average. EPA is also requiring that the chronic criterion for a pollutant be exceeded no more than once in three years on the average. EPA acknowledges that States may develop allowable frequencies that differ from these allowable frequencies, so long as they are scientifically supportable, but believes that these allowable frequencies are protective of the designated uses where EPA is promulgating criteria.

The use of aquatic life criteria for developing water quality-based effluent limits in permits requires the permitting official to use an appropriate wasteload allocation model. (TSD, Appendix D–6.) As discussed above, there are generally two methods for determining design flows, the hydrologically-based method and the biologically-based method.

The biologically-based method directly uses the averaging periods and frequencies specified in the aquatic life criteria for determining design flows. (TSD, Appendix. D–8.) Because the biologically-based method calculates the design flow directly from the duration and allowable frequency, it most accurately provides the allowed number of excursions. The hydrologically based method applies the CMC at a design flow equal to or equivalent to the 1Q10 design flow (i.e., the lowest one-day flow with an average recurrence frequency of once in ten years), and applies the CCC at the 7Q10 design flow (i.e., the lowest average seven consecutive day flow with a recurrence frequency of once in ten years).

EPA established a three year allowable frequency in the NTR. In settlement of the litigation on the NTR, EPA stated that it was in the midst of conducting, sponsoring, or planning research aimed at addressing scientific issues related to the basis for and application of water quality criteria and mentioned the issue of allowable frequency. See Partial Settlement Agreement in *American Forest and Paper Ass'n, Inc. et al.* v. *U.S. EPA* (Consolidated Case No. 93–0694 (RMU) D.D.C. To that end, EPA is reevaluating issues raised about allowable frequency as part of its work in revising the 1985 Guidelines.

EPA recognizes that additional data concerning (a) the probable frequency of lethal events for an assemblage of taxa covering a range of sensitivities to pollutants, (b) the probable frequency of sublethal effects for such taxa, (c) the differing effects of lethal and sublethal events in reducing populations of such taxa, and (d) the time needed to replace organisms lost as a result of toxicity, may lead to further refinement of the allowable frequency value. EPA has not yet completed this work. Until this work is complete, EPA believes that where EPA promulgates criteria, the three year allowable frequency represents a value in the reasonable range for this parameter.

3. Implementation

Once the applicable designated uses and water quality criteria for a water body are determined, under the National Pollutant Discharge Elimination System (NPDES) program discharges to the water body must be characterized and the permitting authority must determine the need for permit limits. If a discharge causes, has the reasonable potential to cause, or contributes to an excursion of a numeric or narrative water quality criteria, the permitting authority must develop permit limits as necessary to meet water quality standards. These permit limits are water quality-based effluent limitations or WQBELs. The terms "cause," "reasonable potential to cause," and "contribute to" are the terms in the NPDES regulations for conditions under which water quality-based permit limits are required. See 40 CFR 122.44(d)(1).

Since the publication of the proposed CTR, the State of California adopted procedures which detail how water quality criteria will be implemented through NPDES permits, waste discharge requirements, and other regulatory approaches. These procedures entitled, *Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California* were adopted on March 2, 2000. Once these procedures are submitted for review under CWA section 303(c), EPA will review them as they relate to water quality standards, and approve or disapprove them.

Several commenters understood the language in the preamble to the proposed rule regarding implementation to mean that site-specific criteria, variances, and other actions would be prohibited or severely limited by the CTR. Site-specific criteria, variances and other actions modifying criteria are neither prohibited nor limited by the CTR. The State, if it so chooses, still can make these changes to its water quality standards, subject to EPA approval. However, with this Federal rule in effect, the State cannot implement any modifications that are less stringent than the CTR without an amendment to the CTR to reflect these modifications. EPA will make every effort to expeditiously accommodate Federal rulemaking of appropriate modifications to California's water quality standards. In the preamble to the proposed CTR, and here today, EPA is emphasizing that these efforts to amend the CTR on a case-by-case basis will generally increase the time before a modification can be implemented.

4. Wet Weather Flows

EPA has for a longtime maintained that CWA section 301(b)(1)(C) applies to NPDES permits for discharges from municipal separate storm sewer systems. Recently, the U.S. Court of Appeals for the Ninth Circuit upheld NPDES permits issued by EPA for five Arizona municipal separate storm sewer systems and addressed this issue specifically: *Defenders of Wildlife, et al.* v. *Browner*, No. 98–71080 (9th Cir., October 1999). The Court held that the CWA does not require "strict compliance" with State water quality standards for municipal storm sewer permits under section 301(b)(1)(C), but that at the same time, the CWA does give EPA discretion to incorporate appropriate water quality-based effluent limitations under another provision, CWA section 402(p)(3)(B)(iii).

The Court based its decision on the structure of section 402(p)(3), which contains distinct language for discharges of industrial storm water and municipal storm water. In section 402(p)(3)(A), Congress requires that "dischargers associated with industrial activity shall meet all applicable provisions of [section 402] and section [301]." 33 U.S.C. section 1342(p)(3)(A). The Court noted, therefore, that by incorporation, industrial storm water discharges need to achieve "any more stringent limitation, including those necessary to meet water quality standards * * *" The Court explained that industrial storm water discharges "must comply strictly with State water quality standards" but that Congress chose not to include a similar provision for municipal storm sewer discharges, including instead a requirement for controls to reduce pollutants to the maximum extent practicable or MEP standard in section 402(p)(3)(B). Reading the two related sections together, the Court concluded that section 402(p)(3)(B)(iii) does not require "strict compliance" by municipal storm sewer discharges according to section 301(b)(1)(C). At the same time, however, the Court found that the language in CWA section 402(p)(3)(B)(iii) which states that permits for discharges from municipal storm sewers shall require "such other provisions as the Administrator of the state determines appropriate for the control of such pollutants" provides EPA with discretion to incorporate provisions lending to ultimate compliance with water quality standards.

EPA believes that compliance with water quality standards through the use of Best Management Practices (BMPs) is appropriate. EPA articulated its position on the use of BMPs in storm water permits in the policy memorandum entitled, "Interim Permitting Approach for Water Quality-Based Effluent Limitations In Storm Water Permits" which was signed by the Assistant Administrator for Water, Robert Perciasepe on August 1, 1996 (61 FR 43761, August 9, 1996). A copy of this memorandum is contained in the administrative record for today's rule. The policy affirms the use of BMPs as a means to attain water quality standards in municipal storm water permits, and embraces BMPs as an interim permitting approach.

The interim permitting approach uses BMPs in first-round storm water permits, and expanded or better-tailored BMPs in subsequent permits, where necessary, to provide for the attainment of water quality standards. In cases where adequate information exists to develop more specific conditions or limitations to meet water quality standards, these conditions or limitations are to be incorporated into storm water permits, as necessary and appropriate.

This interim permitting approach, however, only applies to EPA. EPA encourages the State to adopt a similar policy for municipal storm water permits. This interim permitting approach provides time, where necessary, to more fully assess the range of issues and possible options for the control of storm water discharges for the protection of water quality. More information on this issue is included in the response to comment document in response to specific storm water issues raised by commenters.

5. Schedules of Compliance

A compliance schedule refers to an enforceable sequence of interim requirements in a permit leading to ultimate compliance with water quality-based effluent limitations or WQBELs in accordance with the CWA. The authorizing compliance schedule provision authorizes, but does not require, the permit issuing authority in the State of California to include such compliance schedules in permits under appropriate circumstances. The State of California is authorized to administer the National Pollutant Discharge Elimination System (NPDES) program and may exercise its discretion when deciding if a compliance schedule is justified because of the technical or financial (or other) infeasibility of immediate compliance. An authorizing compliance schedule provision is included in today's rule because of the potential for existing dischargers to have new or more stringent effluent limitations for which immediate compliance would not be possible or practicable.

New and Existing Dischargers: The provision allows compliance schedules only for an "existing discharger" which is defined as any discharger which is not a "new California discharger." A "new California discharger" includes "any building, structure, facility, or installation from which there is, or may be, a 'discharge of pollutants', the construction of which commences after the effective date of this regulation." These definitions are modeled after the existing 40 CFR 122.2 definitions for parallel terms, but with a cut-off date modified to reflect this rule. Only "new California dischargers" are required to comply immediately upon commencement of discharge with effluent limitations derived from the criteria in this rule. For "existing dischargers" whose permits are reissued or modified to contain new or more stringent limitations based upon certain water quality requirements, the permit could allow up to five years, or up to the length of a permit, to comply with such limitations. The provision applies to new or more stringent effluent limitations based on the criteria in this EPA rule.

EPA has included "increasing dischargers" within the category of "existing dischargers" since "increasing dischargers" are existing facilities with a change—an increase—in their discharge. Such facilities may include those with seasonal variations. "Increasing dischargers" will already have treatment systems in place for their current discharge, thus, they have less opportunity than a new discharger does to design and build a new treatment system which will meet new water quality-based requirements for their changed discharge. Allowing existing facilities with an increasing discharge a compliance schedule will avoid placing the discharger at a competitive disadvantage vis-a-vis other existing dischargers who are eligible for compliance schedules.

Today's rule does not prohibit the use of a short-term "shake down period" for new California dischargers as is provided for new sources or new dischargers in 40 CFR 122.29(d)(4). These regulations require that the owner or operator of (1) a new source; (2) a new discharger (as defined in 40 CFR 122.2) which commenced discharge after August 13, 1979; or (3) a recommencing discharger shall install and implement all pollution control equipment to meet the conditions of the permit before discharging. The facility must also meet all permit conditions in the shortest feasible time (not to exceed 90 days). This shake-down period is not a compliance schedule. This approach may be used to address violations which may occur during a new facility's start-up, especially where permit limits are water quality-based and biological treatment is involved.

The burden of proof to show the necessity of a compliance schedule is on the discharger, and the discharger must request approval from the permit issuing authority for a schedule of compliance. The discharger should submit a description of the minimum required actions or evaluations that must be undertaken in order to comply with the new or more restrictive discharge limits. Dates of completion for the required actions or evaluations should be included, and the proposed schedule should reflect the shortest practicable time to complete all minimum required actions.

Duration of Compliance Schedules: Today's rule provides that compliance schedules may provide for up to five years to meet new or more stringent effluent limitations in those limited circumstances where the permittee can demonstrate to the permit authority that an extended schedule is warranted. EPA's regulations at 122.47 require compliance with standards as soon as possible. This means that permit authorities should not allow compliance schedules where the permittee fails to demonstrate their necessity. This provision should not be considered a default compliance schedule duration for existing facilities.

In instances where dischargers wish to conduct toxicological studies, analyze results, and adopt and implement new or revised water quality-based effluent limitations, EPA believes that five years is sufficient time within which to complete this process. See the preamble to the proposed rule.

Under this rule, where a schedule of compliance exceeds one year, interim requirements are to be specified and interim progress reports are to be submitted at least annually to the permit issuing authority, in at least one-year time intervals.

The rule allows all compliance schedules to extend up to a maximum duration of five years, which is the maximum term of any NPDES permit. See 40 CFR 122.46. The discharger's opportunity to obtain a compliance schedule occurs when the existing permit for that discharge is issued, reissued or modified to contain more stringent limits based on the water quality criteria in today's rule. Such compliance schedules, however, cannot be extended to any indefinite point of time in the future because the compliance schedule provision in this rule will sunset on May 18, 2005. The sunset applies to the authorizing provision in today's rule (40 CFR 131.38(e)), not to individual schedules of compliance included in specific NPDES permits. Delays in reissuing expired permits (including those which continue in effect under applicable NPDES regulations) cannot indefinitely extend the period of time during which a compliance schedule is in effect. This would occur where the permit authority includes the single maximum five-year compliance schedule in a permit that is reissued just before the compliance schedule provision sunsets (having been previously issued without WQBELS using the rule's criteria on the eve of the effective date of this rule). Instead, the effect of the sunset provision is to limit the longest time period for compliance to ten years after the effective date of this rule.

EPA recognizes that where a permit is modified during the permit term, and the permittee needs the full five years to comply, the five-year schedule may extend beyond the term of the modified permit. In such cases, the rule allows for the modified permit to contain a compliance schedule with an interim limit by the end of the permit term. When the permit is reissued, the permit authority may extend the compliance schedule in the next permit, provided that, taking into account the amount of time allowed under the previous permit, the entire compliance schedule contained in the permit shall not exceed five years. Final permit limits and compliance dates will be included in the record for the permit. Final compliance dates must occur within five years from the date of permit issuance, reissuance, or modification, unless additional or less time is provided for by law.

EPA would prefer that the State adopt an authorizing compliance schedule provision but recognizes that the State may not be able to complete this action for some time after promulgation of the CTR. Thus, EPA has chosen to promulgate the rule with a sunset provision which states that the authorizing compliance schedule provision will cease or sunset on May 18, 2005. However, if the State Board adopts, and EPA approves, a statewide authorizing compliance schedule provision significantly prior to May 18, 2005, EPA will act to stay the authorizing compliance schedule provision in today's rule. Additionally, if a Regional Board adopts, and the State Board adopts and EPA approves, a Regional Board authorizing compliance schedule provision, EPA will act to stay today's provision for the appropriate or corresponding geographic region in California. At that time, the State Board's or Regional Board's authorizing compliance schedule provision will govern the ability of the State regulatory entity to allow a discharger to include a compliance schedule in a discharger's NPDES permit.

Antibacksliding: EPA wishes to address the potential concern over antibacksliding where revised permit limits based on new information are the result of the completion of additional studies. The Agency's interpretation of the CWA is that the antibacksliding requirements of section 402(o) of the CWA do not apply to revisions to effluent limitations made before the scheduled date of compliance for those limitations.

State Compliance Schedule Provisions: EPA supports the State in adopting a statewide provision independent of or as part of the effort to readopt statewide water quality control plans, or in adopting individual basin-wide compliance schedule provisions through its nine Regional Water Quality Control Boards (RWQCBs). The State and RWQCBs have broad discretion to adopt a provision, including discretion on reasonable lengths of time for final compliance with WQBELs. EPA recognizes that practical time frames within which to set interim goals may be necessary to achieve meaningful, long-term improvements in water quality in California.

At this time, two RWQCBs have adopted an authorizing compliance schedule provision as an amendment to their respective Basin Plans during the Boards' last triennial review process. The Basin Plans have been adopted by the State and have come to EPA for approval. Thus, the Basin Plans' provisions are effective for the respective Basins. If and when EPA approves of either Regional Basin Plan, EPA will expeditiously act to amend the CTR, staying its compliance schedule provision, for the appropriate geographic region.

6. Changes From Proposed Rule

A few changes were made in the final rule from the proposal both as a result of the Agency's consideration of issues raised in public comments and Endangered Species Act consultation with the U.S. Fish and Wildlife Service (FWS) and U.S. National Marine Fisheries Service (NMFS). The important changes include: reserving the mercury aquatic life criteria; reserving the selenium freshwater acute aquatic life criterion; reserving the chloroform human health criteria; and adding a sunset provision to the authorizing compliance schedule provision. EPA also clarified that the CTR will not replace priority toxic pollutant criteria which were adopted by the San Francisco Regional Water Quality Control Board in its 1986 Basin Plan, adopted by the State Board, and approved by EPA; specifying the harmonic mean for human health criteria for non-carcinogens and adding a provision which explicitly allows the State to adopt and implement an alternative averaging period, frequency, and design flow for a criterion after opportunity for public comment.

The first two changes, the reservation of mercury criteria and selenium criterion, are discussed in more detail below in Section L., The Endangered Species Act (ESA). The selenium criterion is also discussed in more detail above in Section E., Derivation of Criteria, in subsection 2.b., Freshwater Acute Selenium Criterion. EPA has also decided to reserve a decision on numeric criteria for chloroform and therefore not promulgate chloroform criteria in the final rule. As part of a large-scale regulation promulgated in December 1998 under the Safe Drinking Water Act, EPA published a health-based goal for chloroform (the maximum contaminant level goal or MCLG) of zero, see 63 FR 69390, Dec. 16, 1998. EPA provided new data and analyses concerning chloroform for public review and comment, including a different, mode of action approach for estimating the cancer risk, 63 FR 15674, March 31, 1998, but did not reach a conclusion on how to use that new information in establishing the final MCLG, pending further review by the Science Advisory Board. EPA has now concluded that any further actions on water quality criteria should take into account the new data and analysis as reviewed by the SAB. This decision is consistent with a recent federal court decision vacating the MCLG for chloroform (*Chlorine Chemistry Council* v. *EPA*, No. 98–1627 (DC Cir., Mar. 31,2000)). EPA intends to reassess the human health 304(a) criteria recommendation for chloroform. For these reasons, EPA has decided to reserve a decision on numeric criteria for chloroform in the CTR and not promulgate water quality criteria as proposed. Permitting authorities in California should continue to rely on existing narrative criteria to establish effluent limitations as necessary for chloroform.

The sunset provision for the authorizing compliance schedule provision has been added to ease the transition from a Federal provision to the State's provision that was adopted in March 2000 as part of its' new statewide implementation plan. The sunset provision is discussed in more detail in Section G.5 of today's preamble. The CTR matrix at 40 CFR 131.38(b)(1) makes it explicit that the rule does not supplant priority toxic pollutant criteria which were adopted by the San Francisco Regional Water Quality Control Board in its 1986 Basin Plan, adopted by the State Board, and approved by EPA. This change is discussed more fully in Section D.4. of today's preamble. EPA modified the design flow for implementing human health criteria for non-carcinogens from a 30Q5 to a harmonic mean. Human health criteria for non-carcinogens are based on an RfD, which is an acceptable daily exposure over a lifetime. EPA matched the criteria for protection over a human lifetime with the longest stream flow averaging period, i.e., the harmonic mean. Lastly, the CTR now contains language which is intended to make it easier for the State to adopt and implement an alternative averaging period, frequency and related design flow, for situations where the default parameters are inappropriate. This language is found at 40 CFR 131.38(c)(2)(iv).

H. Economic Analysis

This final rule establishes ambient water quality criteria which, by themselves, do not directly impose economic impacts (see section K). These criteria combined with the State-adopted designated uses for inland surface waters, enclosed bays and estuaries, and implementation policies, will establish water quality standards. Until the State implements these water quality standards, there will be no effect of this rule on any entity. The State will implement these criteria by ensuring that NPDES permits result in discharges that will meet these criteria. In so doing, the State will have considerable discretion.

EPA has analyzed the indirect potential costs and benefits of this rule. In order to estimate the indirect costs and benefits of the rule, an appropriate baseline must be established. The baseline is the starting point for measuring incremental costs and benefits of a regulation. The baseline is established by assessing what would occur in the absence of the regulation. At present, State Basin Plans contain a narrative water quality criterion stating that all waters shall be maintained free of toxic substances in concentrations that produce detrimental physiological responses in human, plant, animal, or aquatic life. EPA's regulation at 40 CFR 122.44(d)(1)(vi) requires that where a discharge causes or has the reasonable potential to cause an excursion above a narrative criterion within a State water quality standard, the permitting authority must establish effluent limits but may determine limits using a number of options. These options include establishing "effluent limits on a case-by-case basis, using EPA's water quality criteria published under section 304(a) of the CWA, supplemented where necessary by other relevant information" (40 CFR 122.44(d)(1)(vi)(B)). Thus, to the extent that the State is implementing its narrative criteria by applying the CWA section 304(a) criteria, this rule does not impose any incremental costs because the criteria in this rule are identical to the CWA section 304(a) criteria. Alternatively, to the extent that the State is implementing its narrative criteria on a "case-by-case basis" using "other relevant information" in its permits this rule may impose incremental indirect costs because the criteria in these permits may not be based on CWA 304(a) criteria. Both of these approaches to establishing effluent limits are in full compliance with the CWA.

Because a specific basis for effluent limits in all existing permits in California is not known, it is not possible to determine a precise estimate of the indirect costs of this rule. The incremental costs of the rule may be as low as zero, or as high as $61 million. The high estimate of costs is based on the possibility that most of the effluent limits now in effect are not based on 304(a) criteria. EPA evaluated these indirect costs using two different approaches. The first approach uses existing discharge data and makes assumptions about future State NPDES permit limits. Actual discharge levels are usually lower than the level set by current NPDES permit limits. This approach, representing the low-end scenario, also assumes that some of the discretionary mechanisms that would enhance flexibility (*e.g.*, site specific criteria, mixing zones) would be granted by the State. The second approach uses a sample of existing permit limits and assumes that dischargers are actually discharging at the levels contained in their permits and makes assumptions about limits statewide that would be required under the rule. This approach, representing the high-end scenario, also assumes that none of the discretionary mechanisms that would enhance flexibility (*e.g.*, site specific criteria, mixing zones) would be granted by the State. These two approaches recognize that the State has significant flexibility and discretion in how it chooses to implement standards within the NPDES permit program, the EA by necessity includes many assumptions about how the State will implement the water quality standards. These assumptions are based on a combination of EPA guidance and current permit conditions for the facilities examined in this analysis. To account for the uncertainty of EPA's implementation assumptions, this analysis estimates a wide range of costs and benefits. By completing the EA, EPA intends to inform the public about how entities might be potentially affected by State implementation of water quality standards in the NPDES permit program. The costs and benefits sections that follow summarize the methodology and results of the analysis.

1. Costs

EPA assessed the potential compliance costs that facilities may incur to meet permit limits based on the criteria in today's rule. The analysis focused on direct compliance costs such as capital costs and operation and maintenance costs (O&M) for end-of-pipe pollution control, indirect source controls, pollution prevention, monitoring, and costs of pursuing alternative methods of compliance.

The population of facilities with NPDES permits that discharge into California's enclosed bays, estuaries and inland surface waters includes 184 major dischargers and 1,057 minor dischargers. Of the 184 major facilities, 128 are publicly owned treatment works (POTWs) and 56 are industrial facilities. Approximately 2,144 indirect dischargers designated as significant industrial users discharge wastewater to those POTWs. In the EA for the proposed CTR, EPA used a three-phased process to select a sample of facilities to represent California dischargers potentially affected by the State's implementation of permit limits based on the criteria contained in this rule.

The first phase consisted of choosing three case study areas for which data was thought to exist. The three case studies with a total of 5 facilities included: the South San Francisco Bay (the San Jose/Santa Clara Water Pollution Control Plant and Sunnyvale Water Pollution Control Plant); the Sacramento River (the Sacramento Regional Wastewater Treatment Plant); and the Santa Ana River (the City of Riverside Water Quality Control Plant and the City of Colton Municipal Wastewater Treatment Facility). The second phase consisted of selecting five additional major industrial dischargers to complement the case-study POTWs.

The third phase involved selecting 10 additional facilities to improve the basis for extrapolating the costs of the selected sample facilities to the entire population of potentially affected dischargers. The additional 10 facilities were selected such that the group examined: (1) Was divided between major POTWs and major industrial discharger categories in proportion to the numbers of facilities in the State; (2) gave greater proportionate representation to major facilities than minor facilities based on a presumption that the majority of compliance costs would be incurred by major facilities; (3) gave a proportionate representation to each of four principal conventional treatment processes typically used by facilities in specified industries in California; and (4) was representative of the proportionate facilities located within the different California Regional Water Quality Control Boards. Within these constraints, facilities were selected at random to complete the sample.

In the EA for today's final rule, EPA primarily used the same sample as the EA for the proposed rule with some modifications. EPA increased the number of minor POTWs and minor industrial facilities in the sample. EPA randomly selected four new minor POTW facilities and five new minor industrial facilities to add to the sample. The number of sample facilities selected in each area under the jurisdiction of a Regional Water Quality Control Board was roughly proportional to the universe of facilities in each area.

For those facilities that were projected to exceed permit limits based on the criteria, EPA estimated the incremental costs of compliance. Using a decision matrix or flow chart, costs were developed for two different scenarios—a "low-end" cost scenario and a "high-end" cost scenario—to account for a range of regulatory flexibility available to the State when implementing permit limits based on the water quality criteria. The assumptions for baseline loadings also vary over the two scenarios. The low-end scenario generally assumed that facilities were discharging at the maximum effluent concentrations taken from actual monitoring data, while the high-end scenario generally assumed that facilities were discharging at their current effluent limits. The decision matrix specified assumptions used for selection of control options, such as optimization of existing treatment processes and operations, in-plant pollutant minimization and prevention, and end-of-pipe treatment.

The annualized potential costs that direct and indirect dischargers may incur as a result of State implementation of permit limits based on water quality standards using today's criteria are estimated to be between $33.5 million and $61 million. EPA believes that the costs incurred as a result of State implementation of these permit limits will approach the low-end of the cost range. Costs are unlikely to reach the high-end of the range because State authorities are likely to choose implementation options that provide some degree of flexibility or relief to point source dischargers. Furthermore, cost estimates for both scenarios, but especially for the high-end scenario, may be overstated because the analysis tended to use conservative assumptions in calculating these permit limits and in establishing baseline loadings. The baseline loadings for the high-end were based on current effluent limits rather than actual pollutant discharge data. Most facilities discharge pollutants in concentrations well below current effluent limits. In addition, both the high-end and low-end cost estimates in the EA may be slightly overstated since potential costs incurred to reduce chloroform discharges were included in these estimates. EPA made a decision to reserve the chloroform human health criteria after the EA was completed.

Under the low-end cost scenario, major industrial facilities and POTWs would incur about 27 percent of the potential costs, indirect dischargers would incur about 70 percent of the potential costs, while minor dischargers would incur about 3 percent. Of the major direct dischargers, POTWs would incur the largest share of projected costs (87 percent). However, distributed

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among 128 major POTWs in the State, the average cost per plant would be $61,000 per year. Chemical and petroleum industries would incur the highest cost of the industrial categories (5.6 percent of the annual costs, with an annual average of $25,200 per plant). About 57 percent of the low-end costs would be associated with pollution prevention activities, while nearly 38 percent would be associated with pursuing alternative methods of compliance under the regulations.

Under the high-end cost scenario, major industrial facilities and POTWs would incur about 94 percent of the potential costs, indirect dischargers would incur about 17 percent of the potential costs, while minor dischargers would incur about 5 percent. Among the major, direct dischargers, two categories would incur the majority of potential costs—major POTWs (82 percent), Chemical/Petroleum Products (9 percent). The average annual per plant cost for different industry categories would ranges from zero to $324,000. The two highest average cost categories would be major POTWs ($324,000 per year) and Chemical/Petroleum Products ($221,264 per year). The shift in proportion of potential costs between direct and indirect dischargers is due to the assumption that more direct dischargers would use end-of-pipe treatment under the high-end scenario. Thus, a smaller proportion of indirect dischargers would be impacted under the high-end scenario, since some municipalities are projected to add end-of-pipe treatment which would reduce the need for controls from indirect discharges. Over 91 percent of the annual costs are for waste minimization and treatment optimization costs. Waste minimization would represent nearly 84% of the total annual costs. Capital and operation and maintenance costs would make up less than 9 percent of annual costs.

Cost-Effectiveness: Cost-effectiveness is estimated in terms of the cost of reducing the loadings of toxic pollutants from point sources. The cost-effectiveness is derived by dividing the projected annual costs of implementing permit limits based on water quality standards using today's criteria by the toxicity-weighted pounds (pound-equivalents) of pollutants removed. Pound-equivalents are calculated by multiplying pounds of each pollutant removed by the toxic weight (based on the toxicity of copper) for that pollutant.

Based on this analysis, State implementation of permit limits based on today's criteria would be responsible for the reduction of about 1.1 million to 2.7 million toxic pound-equivalents per year, or 15 to 50 percent of the toxic-weighted baseline loadings for the high- and low-end scenarios, respectively. The cost-effectiveness of the scenarios would range from $22 (high-end scenario) to $31 (low-end scenario) per pound-equivalent.

2. Benefits

The benefits analysis is intended to provide insight into both the types and potential magnitude of the economic benefits expected as a result of implementation of water quality standards based on today's criteria. To the extent feasible, empirical estimates of the potential magnitude of the benefits were developed and then compared to the estimated costs of implementing water quality standards based on today's criteria.

To perform a benefits analysis, the types or categories of benefits that apply need to be defined. EPA relied on a set of benefits categories that typically apply to changes in the water resource environment. Benefits were categorized as either use benefits or passive (nonuse) benefits depending on whether or not they involve direct use of, or contact with, the resource. The most prominent use benefit categories are those related to recreational fishing, boating, and swimming. Another use benefit category of significance is human health risk reduction. Human health risk reductions can be realized through actions that reduce human exposure to contaminants such as exposure through the consumption of fish containing elevated levels of pollutants. Passive use benefits are those improvements in environmental quality that are valued by individuals apart from any use of the resource in question.

Benefits estimates were derived in this study using an approach in which benefits of discrete large-scale changes in water quality beyond present day conditions were estimated wherever feasible. A share of those benefits was then apportioned to implementation of water quality standards based on today's criteria. The apportionment estimate was based on a three-stage process:

First, EPA assessed current total loadings from all sources that are contributing to the toxics-related water quality problems observed in the State. This defines the overall magnitude of loadings. Second, the share of total loadings that are attributable to sources that would be controlled through implementation of water quality standards based on today's criteria was estimated. Since this analysis was designed to focus only on those controls imposed on point sources, this stage of the process entailed estimating the portion of total loadings originating from point sources. Third, the percentage reduction in loadings expected due to implementation of today's criteria was estimated and then multiplied by the share of point source loadings to calculate the portion of benefits that could be attributed to implementation of water quality standards based on today's criteria.

Total monetized annual benefits were estimated in the range of $6.9 to $74.7 million. By category, annual benefits would be $1.3 to $4.6 million for avoided cancer risk, $2.2 to $15.2 million for recreational angling, and $3.4 to $54.9 million for passive use benefits.

There are numerous categories of potential or likely benefits that have been omitted from the quantified and monetized benefit estimates. In terms of potential magnitudes of benefit, the following are likely to be significant contributors to the underestimation of the monetized values presented above:

• Improvements in water-related (in-stream and near stream) recreation apart from fishing. The omission of potential motorized and nonmotorized boating, swimming, picnicking, and related in-stream and stream-side recreational activities from the benefits estimates could contribute to an appreciable underestimation of total benefits. Such recreational activities have been shown in empirical research to be highly valued, and even modest changes in participation and or user values could lead to sizable benefits statewide. Some of these activities can be closely associated with water quality attributes (notably, swimming). Other recreational activities may be less directly related to the water quality improvements, but might nonetheless increase due to their association with fishing, swimming, or other activities in which the participants might engage.

• Improvements in consumptive and nonconsumptive land-based recreation, such as hunting and wildlife observation. Improvements in aquatic habitats may lead (via food chain and related ecologic benefit mechanisms) to healthier, larger, and more diverse populations of avian and terrestrial species, such as waterfowl, eagles, and otters. Improvements in the populations for these species could manifest as improved hunting and wildlife viewing opportunities, which might in turn increase participation and user day values for such activities. Although the scope of the benefits analysis has not allowed a quantitative assessment of these values at either pre- or post-rule conditions, it is conceivable that these benefits could be appreciable.

• Improvements in human health resulting from reduction of non-cancer risk. EPA estimated that implementation of water quality standards based on the criteria would result in a reduction of mercury concentrations in fish tissue and, thus, a reduction in the hazard from consumption of mercury contaminated fish. However, EPA was unable to monetize benefits due to reduced non-cancer health effects.

• Human health benefits for saltwater anglers outside of San Francisco Bay were not estimated. The number of saltwater anglers outside of San Francisco Bay is estimated to be 673,000 (based on Huppert, 1989, and U.S. FWS, 1993). The omission of other saltwater anglers may cause human health benefits to be underestimated. In addition, benefit estimates in the EA may be slightly overstated since potential benefits from reductions in chloroform discharges were included in these estimates. EPA made a decision to reserve the chloroform human health criteria after the EA was completed.

EPA received a number of comments which requested the Agency use the cost-benefit analysis in the EA as a factor in setting water quality criteria. EPA does not use the EA as a basis in determining protective water quality criteria. EPA's current regulations at 40 CFR 131.11 state that the criteria must be based on sound scientific rationale and must protect the designated use. From the outset of the water quality standards program, EPA has explained that while economic factors may be considered in designating uses, they may not be used to justify criteria that are not protective of those uses. 44 FR 25223–226, April 30, 1979. See e.g. *Mississippi Commission on Natural Resources* v. *Costle,* 625 F. 2d 1269, 1277 (5th Cir. 1980). EPA reiterated this interpretation of the CWA and its implementing regulations in discussing section 304(a) recommended criteria guidance stating that "they are based solely on data and scientific judgments on the relationship between pollutant concentrations and environmental and human health effects and do not reflect consideration of economic impacts or the technological feasibility of meeting the chemical concentrations in ambient water." 63 FR 36742 and 36762, July 7, 1998.

I. Executive Order 12866, Regulatory Planning and Review

Under Executive Order 12866 (58 FR 51735, October 4, 1993), the Agency must determine whether the regulatory action is "significant" and therefore subject to Office of Management and Budget (OMB) review and the requirements of the Executive Order. The Order defines "significant regulatory action" as one that is likely to result in a rule that may:

(1) Have an annual effect on the economy of $100 million or more or adversely affect in a material way the economy, a sector of the economy, productivity, competition, jobs, the environment, public health or safety, or State, local, or tribal governments or communities;

(2) Create a serious inconsistency or otherwise interfere with an action taken or planned by another Agency;

(3) Materially alter the budgetary impact of entitlements, grants, user fees, or loan programs or the rights and obligations of recipients thereof; or

(4) Raise novel legal or policy issues arising out of legal mandates, the President's priorities, or the principles set forth in the Executive Order.

It has been determined that this rule is not a "significant regulatory action" under the terms of Executive Order 12866 and is therefore not subject to OMB review.

J. Unfunded Mandates Reform Act of 1995

Title II of the Unfunded Mandates Reform Act of 1995 (UMRA), Public Law 104–4, establishes requirements for Federal agencies to assess the effects of their regulatory actions on State, local, and tribal governments and the private sector. Under section 202 of the UMRA, EPA generally must prepare a written statement, including a cost-benefit analysis, for proposed and final rules with "Federal mandates" that may result in expenditures to State, local, and tribal governments, in the aggregate, or to the private sector, of $100 million or more in any one year. Before promulgating any regulation for which a written statement is needed, section 205 of the UMRA generally requires EPA to identify and consider a reasonable number of regulatory alternatives and adopt the least costly, most cost-effective or least burdensome alternative that achieves the objectives of the rule. The provisions of section 205 do not apply when they are inconsistent with applicable law. Moreover, section 205 allows an Agency to adopt an alternative other than the least costly, most cost-effective or least burdensome alternative if the Administrator publishes with the final rule an explanation why that alternative was not adopted. Before EPA establishes any regulatory requirements that may significantly or uniquely affect small governments, including tribal governments, it must have developed under section 203 of the UMRA a small government Agency plan. The plan must provide for notifying potentially affected small governments, enabling officials of the affected small governments to have meaningful and timely input in the development of regulatory proposals with significant Federal intergovernmental mandates, and EPA informing, educating, and advising small governments on compliance with the regulatory requirements.

Today's rule contains no Federal mandates (under the regulatory provisions of Title II of the Unfunded Mandates Reform Act (UMRA)) for State, local, or tribal governments or the private sector. Today's rule imposes no enforceable duty on any State, local or Tribal governments or the private sector; rather, the CTR promulgates ambient water quality criteria which, when combined with State-adopted uses, will create water quality standards for those water bodies with adopted uses. The State will then use these resulting water quality standards in implementing its existing water quality control programs. Thus, today's rule is not subject to the requirements of sections 202 and 205 of the UMRA.

EPA has determined that this rule contains no regulatory requirements that might significantly or uniquely affect small governments. This rule establishes ambient water quality criteria which, by themselves do not directly impact any entity. The State will implement these criteria by ensuring that NPDES permits result in discharges that will meet these criteria. In so doing, the State will have considerable discretion. Until the State implements these water quality standards, there will be no effect of this rule on any entity. Thus, today's rule is not subject to the requirements of section 203 of UMRA.

K. Regulatory Flexibility Act

The Regulatory Flexibility Act generally requires Federal agencies to prepare a regulatory flexibility analysis of any rule subject to notice and comment rulemaking requirements under the Administrative Procedure Act or any other statute unless the Agency certifies that the rule will not have a significant economic impact of a substantial number of small entities. Small entities include small businesses, small organizations, and small governmental jurisdictions. For purposes of assessing the impacts of today's rule on small entities, small entity is defined as: (1) A small business according to RFA default definitions for small businesses (based on SBA size standards); (2) a small governmental jurisdiction that is a government of a city, county, town, school district or special district with a population of less than 50,000; and (3) a small organization that is any not-for-profit enterprise which is independently owned and operated and is not dominant in its field.

After considering the economic impacts of today's final rule on small entities, I certify that this action will not have a significant economic impact on a substantial number of small entities. This final rule will not impose any requirements on small entities.

Under the CWA water quality standards program, States must adopt water quality standards for their waters that must be submitted to EPA for approval. If the Agency disapproves a State standard and the State does not adopt appropriate revisions to address EPA's disapproval, EPA must promulgate standards consistent with the statutory requirements. EPA has authority to promulgate criteria or standards in any case where the Administrator determines that a revised or new standard is necessary to meet the requirements of the Act. These State standards (or EPA-promulgated standards) are implemented through various water quality control programs including the National Pollutant Discharge Elimination System (NPDES) program that limits discharges to navigable waters except in compliance with an EPA permit or permit issued under an approved State NPDES program. The CWA requires that all NPDES permits must include any limits on discharges that are necessary to meet State water quality standards.

Thus, under the CWA, EPA's promulgation of water quality criteria or standards establishes standards that the State, in turn, implements through the NPDES permit process. The State has considerable discretion in deciding how to meet the water quality standards and in developing discharge limits as needed to meet the standards. In circumstances where there is more than one discharger to a water body that is subject to water quality standards or criteria, a State also has discretion in deciding on the appropriate limits for the different dischargers. While the State's implementation of federally-promulgated water quality criteria or standards may result indirectly in new or revised discharge limits for small entities, the criteria or standards themselves do not apply to any discharger, including small entities.

Today's rule, as explained above, does not itself establish any requirements that are applicable to small entities. As a result of EPA's action here, the State of California will need to ensure that permits it issues include limits as necessary to meet the water quality standards established by the criteria in today's rule. In so doing, the State will have a number of discretionary choices associated with permit writing. While California's implementation of today's rule may ultimately result in some new or revised permit conditions for some dischargers, including small entities, EPA's action today does not impose any of these as yet unknown requirements on small entities.

The RFA requires analysis of the economic impact of a rule only on the small entities subject to the rule's requirements. Courts have consistently held that the RFA imposes no obligation on an Agency to prepare a small entity analysis of the effect of a rule on entities not regulated by the rule. *Motor & Equip. Mfrs. Ass'n* v. *Nichols*, 142 F.3d 449, 467 & n.18 (D.C. Cir. 1998)(quoting *United States Distribution Companies* v. *FERC*, 88 F.3d 1105, 1170 (D.C. Cir. 1996); see also *American Trucking Association, Inc.* v. *EPA*, 175 F.3d 1027 (D.C. Cir. 1999). This final rule will have a direct effect only on the State of California which is not a small entity under the RFA. Thus, individual dischargers, including small entities, are not directly subject to the requirements of the rule. Moreover, because of California's discretion in implementing these standards, EPA cannot assess the extent to which the promulgation of this rule may subsequently affect any dischargers, including small entities. Consequently, certification under section 605(b) is appropriate. *State of Michigan, et al.* v. *U.S. Environmental Protection Agency*, No. 98–1497 (D.C. Cir. Mar. 3, 2000), slip op. at 41–42.

L. Paperwork Reduction Act

This action requires no new or additional information collection, reporting, or record keeping subject to the Paperwork Reduction Act, 44 U.S.C. 3501 *et seq.*

M. Endangered Species Act

Pursuant to section 7(a) of the Endangered Species Act (ESA), EPA has consulted with the U.S. Fish and Wildlife Service and the U.S. National Marine Fisheries Service (collectively, the Services) concerning EPA's rulemaking action for the State of California. EPA initiated informal consultation in early 1994, and completed formal consultation in April 2000. As a result of the consultation, EPA modified some of the provisions in the final rule.

As part of the consultation process, EPA submitted to the Services a Biological Evaluation for their review in October of 1997. This evaluation found that the proposed CTR was not likely to jeopardize the continued existence of any Federally listed species or result in the destruction or adverse modification of designated critical habitat. In April of 1998, the Services sent EPA a draft Biological Opinion which tentatively found that EPA's proposed rule would jeopardize the continued existence of several Federally listed species and result in the destruction or have adverse effect on designated critical habitat. After lengthy discussions with the Services, EPA agreed to several changes in the final rule and the Services in turn issued a final Biological Opinion finding that EPA's action would not likely jeopardize the continued existence of any Federally listed species or result in the destruction or adverse modification of designated critical habitat. EPA's Biological Evaluation and the Services' final Biological Opinion are contained in the administrative record for today's rule.

In order to ensure the continued protection of Federally listed threatened and endangered species and to protect their critical habitat, EPA agreed to reserve the aquatic life criteria for mercury and the acute freshwater aquatic life criterion for selenium. The Services believe that EPA's proposed criteria are not sufficiently protective of Federally listed species and should not be promulgated. EPA agreed that it would reevaluate these criteria in light of the Services concerns before promulgating them for the State of California. Other commitments made by EPA are described in a letter to the Services dated December 16, 1999; this letter is contained in the administrative record for today's rule.

N. Congressional Review Act

The Congressional Review Act, 5 U.S.C. 801 *et seq.*, as added by the Small Business Regulatory Enforcement Fairness Act of 1996, generally provides that before a rule may take effect, the Agency promulgating the rule must submit a rule report, which includes a copy of the rule, to each House of the Congress and to the Comptroller General of the United States. EPA will submit a report containing this rule and other required information to the U.S. Senate, the U.S. House of Representatives, and the Comptroller General of the United States prior to publication of the rule in the **Federal Register**. A major rule cannot take effect until 60 days after it is published in the **Federal Register**. This rule is not a major rule as defined by 5 U.S.C. 804(2). This rule will be effective May 18, 2000.

O. Executive Order 13084, Consultation and Coordination With Indian Tribal Governments

Under Executive Order 13084, EPA may not issue a regulation that is not required by statute, that significantly or uniquely affects the communities of Indian tribal governments, and that imposes substantial direct compliance costs on those communities, unless the Federal government provides the funds necessary to pay the direct compliance costs incurred by the tribal governments, or EPA consults with those governments. If EPA complies by consulting, Executive Order 13084 requires EPA to provide to the Office of Management and Budget, in a separately identified section of the preamble to the rule, a description of the extent of EPA's prior consultation with representatives of affected tribal governments, a summary of the nature of their concerns, and a statement supporting the need to issue the regulation. In addition, Executive Order 13084 requires EPA to develop an effective process permitting elected officials and other representatives of Indian tribal governments "to provide meaningful and timely input in the development of regulatory policies on matters that significantly or uniquely affect their communities."

Today's rule does not significantly or uniquely affect the communities of Indian tribal governments nor does it impose substantial direct compliance cots on them. Today's rule will only address priority toxic pollutant water quality criteria for the State of California and does not apply to waters in Indian country. Accordingly, the requirements of section 3(b) of Executive Order 13084 do not apply to this rule.

P. National Technology Transfer and Advancement Act

Section 12(d) of the National Technology Transfer and Advancement Act of 1995 ("NTTAA"), Public Law No. 104–113, section 12(d) (15 U.S.C. 272 note) directs EPA to use voluntary consensus standards in its regulatory activities unless to do so would be inconsistent with applicable law or otherwise impractical. Voluntary consensus standards are technical standards (e.g., materials specifications, test methods, sampling procedures, and business practices) that are developed or adopted by voluntary consensus standards bodies. The NTTAA directs EPA to provide Congress, through OMB, explanations when the Agency decides not to use available and applicable voluntary consensus standards.

This final rule does not involve technical standards. Therefore, EPA did not consider the use of any voluntary consensus standards.

Q. Executive Order 13132 on Federalism

Executive Order 13132, entitled "Federalism" (64 FR 43255, August 10, 1999), requires EPA to develop an accountable process to ensure "meaningful and timely input by State and local officials in the development of regulatory policies that have federalism implications." "Policies that have federalism implications" is defined in the Executive Order to include regulations that have "substantial direct effects on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government."

Under section 6 of Executive Order 13132, EPA may not issue a regulation that has federalism implications, that imposes substantial direct compliance costs, and that is not required by statute, unless the Federal government provides the funds necessary to pay the direct compliance costs incurred by State and local governments, or EPA consults with State and local officials early in the process of developing the proposed regulation. EPA also may not issue a regulation that has federalism implications and that preempts State law, unless the Agency consults with State and local officials early in the process of developing the proposed regulation.

This final rule does not have federalism implications. It will not have substantial direct effects on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government, as specified in Executive Order 13132. The rule does not affect the nature of the relationship between EPA and States generally, for the rule only applies to water bodies in California. Further, the rule will not substantially affect the relationship of EPA and the State of California, or the distribution of power or responsibilities between EPA and the State. The rule does not alter the State's authority to issue NPDES permits or the State's considerable discretion in implementing these criteria. The rule simply implements Clean Water Act section 303(c)(2)(B) requiring numeric ambient water quality criteria for which EPA has issued section 304(a) recommended criteria in a manner that is consistent with previous regulatory guidance that the Agency has issued to implement CWA section 303(c)(2)(B). Further, this rule does not preclude the State from adopting water quality standards that meet the requirements of the CWA. Thus, the requirements of section 6 of the Executive Order do not apply to this rule.

Although section 6 of Executive Order 13132 does not apply to this rule, EPA did consult with State and local government representatives in developing this rule. EPA and the State reached an agreement that to best utilize its respective resources, EPA would promulgate water quality criteria and the State would concurrently work on a plan to implement the criteria. Since the proposal of this rule, EPA has kept State officials fully informed of changes to the proposal. EPA has continued to invite comment from the State on these changes. EPA believes that the final CTR incorporates comments from State officials and staff.

R. Executive Order 13045 on Protection of Children From Environmental Health Risks and Safety Risks

Executive Order 13045: "Protection of Children from Environmental Health Risks and Safety Risks" (62 FR 19885, April 23, 1997) applies to any rule that: (1) Is determined to be "economically significant" as defined under Executive Order 12866, and (2) concerns an environmental health or safety risk that EPA has reason to believe may have a disproportionate effect on children. If the regulatory action meets both criteria, the Agency must evaluate the environmental health or safety effects of the planned rule on children, and explain why the planned regulation is preferable to other potentially effective and reasonably feasible alternatives considered by the Agency.

While this final rule is not subject to the Executive Order because it is not economically significant as defined in Executive Order 12866, we nonetheless have reason to believe that the environmental health or safety risk addressed by this action may have a disproportionate effect on children. As a matter of EPA policy, we therefore have assessed the environmental health or safety effects of ambient water quality criteria on children. The results of this assessment are contained in section F.3., Human Health Criteria.

List of Subjects in 40 CFR Part 131

Environmental protection, Indians—lands, Intergovernmental relations, Reporting and recordkeeping requirements, Water pollution control.

Dated: April 27, 2000.

Carol Browner,

Administrator.

For the reasons set out in the preamble, part 131 of chapter I of title 40 of the Code of Federal Regulations is amended as follows:

PART 131—WATER QUALITY STANDARDS

1. The authority citation for part 131 continues to read as follows:

Authority: 33 U.S.C. 1251 *et seq.*

Subpart D—[Amended]

2. Section 131.38 is added to subpart D to read as follows:

§ 131.38 Establishment of Numeric Criteria for Priority Toxic Pollutants for the State of California.

(a) *Scope.* This section promulgates criteria for priority toxic pollutants in the State of California for inland surface waters and enclosed bays and estuaries. This section also contains a compliance schedule provision.

(b)(1) Criteria for Priority Toxic Pollutants in the State of California as described in the following table:

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A		B Freshwater		C Saltwater		D Human Health (10^{-6} risk for carcinogens) For consumption of:	
# Compound	CAS Number	Criterion Maximum Conc. [d] B1	Criterion Continuous Conc. [d] B2	Criterion Maximum Conc. [d] C1	Criterion Continuous Conc. [d] C2	Water & Organisms (µg/L) D1	Organisms Only (µg/L) D2
1. Antimony	7440360					14 a,s	4300 a,t
2. Arsenic [b]	7440382	340 i,m,w	150 i,m,w	69 i,m	36 i,m		
3. Beryllium	7440417					n	n
4. Cadmium [b]	7440439	4.3 e,i,m,w,x	2.2 e,i,m,w	42 i,m	9.3 i,m	n	n
5a. Chromium (III)	16065831	550 e,i,m,o	180 e,i,m,o			n	n
5b. Chromium (VI) [b]	18540299	16 i,m,w	11 i,m,w	1100 i,m	50 i,m	n	n
6. Copper [b]	7440508	13 e,i,m,w,x	9.0 e,i,m,w	4.8 i,m	3.1 i,m	1300	
7. Lead [b]	7439921	65 e,i,m	2.5 e,i,m	210 i,m	8.1 i,m	n	n
8. Mercury [b]	7439976	[Reserved]	[Reserved]	[Reserved]	[Reserved]	0.050 a	0.051 a
9. Nickel [b]	7440020	470 e,i,m,w	52 e,i,m,w	74 i,m	8.2 i,m	610 a	4600 a
10. Selenium [b]	7782492	[Reserved] p	5.0 q	290 i,m	71 i,m	n	n
11. Silver [b]	7440224	3.4 e,i,m		1.9 i,m			
12. Thallium	7440280					1.7 a,s	6.3 a,t
13. Zinc [b]	7440666	120 e,i,m,w,x	120 e,i,m,w	90 i,m	81 i,m		
14. Cyanide [b]	57125	22 o	5.2 o	1 r	1 r	700 a	220,000 a,j
15. Asbestos	1332214					7,000,000 fibers/L k,s	
16. 2,3,7,8-TCDD (Dioxin)	1746016					0.000000013 c	0.000000014 c
17. Acrolein	107028					320 s	780 t
18. Acrylonitrile	107131					0.059 a,c,s	0.66 a,c,t
19. Benzene	71432					1.2 a,c	71 a,c
20. Bromoform	75252					4.3 a,c	360 a,c
21. Carbon Tetrachloride	56235					0.25 a,c,s	4.4 a,c,t
22. Chlorobenzene	108907					680 a,s	21,000 a,j,t
23. Chlorodibromomethane	124481					0.401 a,c	34 a,c
24. Chloroethane	75003						
25. 2-Chloroethylvinyl Ether	110758						

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26. Chloroform	67663					[Reserved]	[Reserved]
27. Dichlorobromomethane	75274					0.56 a,c	46 a,c
28. 1,1-Dichloroethane	75343						
29. 1,2-Dichloroethane	107062					0.38 a,c,s	99 a,c,t
30. 1,1-Dichloroethylene	75354					0.057 a,c,s	3.2 a,c,t
31. 1,2-Dichloropropane	78875					0.52 a	39 a
32. 1,3-Dichloropropylene	542756					10 a,s	1,700 a,t
33. Ethylbenzene	100414					3,100 a,s	29,000 a,t
34. Methyl Bromide	74839					48 a	4,000 a
35. Methyl Chloride	74873					n	n
36. Methylene Chloride	75092					4.7 a,c	1,600 a,c
37. 1,1,2,2-Tetrachloroethane	79345					0.17 a,c,s	11 a,c,t
38. Tetrachloroethylene	127184					0.8 c,s	8.85 c,t
39. Toluene	108883					6,800 a	200,000 a
40. 1,2-Trans-Dichloroethylene	156605					700 a	140,000 a
41. 1,1,1-Trichloroethane	71556					n	n
42. 1,1,2-Trichloroethane	79005					0.60 a,c,s	42 a,c,t
43. Trichloroethylene	79016					2.7 c,s	81 c,t
44. Vinyl Chloride	75014					2 c,s	525 c,t
45. 2-Chlorophenol	95578					120 a	400 a
46. 2,4-Dichlorophenol	120832					93 a,s	790 a,t
47. 2,4-Dimethylphenol	105679					540 a	2,300 a
48. 2-Methyl-4,6-Dinitrophenol	534521					13.4 s	765 t
49. 2,4-Dinitrophenol	51285					70 a,s	14,000 a,t
50. 2-Nitrophenol	88755						
51. 4-Nitrophenol	100027						
52. 3-Methyl-4-Chlorophenol	59507						
53. Pentachlorophenol	87865	19 f,w	15 f,w	13	7.9	0.28 a,c	8.2 a,c,j
54. Phenol	108952					21,000 a	4,600,000 a,j,t
55. 2,4,6-Trichlorophenol	88062					2.1 a,c	6.5 a,c
56. Acenaphthene	83329					1,200 a	2,700 a
57. Acenaphthylene	208968						
58. Anthracene	120127					9,600 a	110,000 a

59. Benzidine	92875					0.00012 a,c,s	0.00054 a,c,t
60. Benzo(a)Anthracene	56553					0.0044 a,c	0.049 a,c
61. Benzo(a)Pyrene	50328					0.0044 a,c	0.049 a,c
62. Benzo(b)Fluoranthene	205992					0.0044 a,c	0.049 a,c
63. Benzo(ghi)Perylene	191242						
64. Benzo(k)Fluoranthene	207089					0.0044 a,c	0.049 a,c
65. Bis(2-Chloroethoxy)Methane	111911						
66. Bis(2-Chloroethyl)Ether	111444					0.031 a,c,s	1.4 a,c,t
67. Bis(2-Chloroisopropyl)Ether	39638329					1,400 a	170,000 a,t
68. Bis(2-Ethylhexyl)Phthalate	117817					1.8 a,c,s	5.9 a,c,t
69. 4-Bromophenyl Phenyl Ether	101553						
70. Butylbenzyl Phthalate	85687					3,000 a	5,200 a
71. 2-Chloronaphthalene	91587					1,700 a	4,300 a
72. 4-Chlorophenyl Phenyl Ether	7005723						
73. Chrysene	218019					0.0044 a,c	0.049 a,c
74. Dibenzo(a,h)Anthracene	53703					0.0044 a,c	0.049 a,c
75. 1,2 Dichlorobenzene	95501					2,700 a	17,000 a
76. 1,3 Dichlorobenzene	541731					400	2,600
77. 1,4 Dichlorobenzene	106467					400	2,600
78. 3,3'-Dichlorobenzidine	91941					0.04 a,c,s	0.077 a,c,t
79. Diethyl Phthalate	84662					23,000 a,s	120,000 a,t
80. Dimethyl Phthalate	131113					313,000 s	2,900,000 t
81. Di-n-Butyl Phthalate	84742					2,700 a,s	12,000 a,t
82. 2,4-Dinitrotoluene	121142					0.11 c,s	9.1 c,t
83. 2,6-Dinitrotoluene	606202						
84 Di-n-Octyl Phthalate	117840						
85. 1,2-Diphenylhydrazine	122667					0.040 a,c,s	0.54 a,c,t
86. Fluoranthene	206440					300 a	370 a
87. Fluorene	86737					1,300 a	14,000 a
88. Hexachlorobenzene	118741					0.00075 a,c	0.00077 a,c
89. Hexachlorobutadiene	87683					0.44 a,c,s	50 a,c,t
90. Hexachlorocyclopentadiene	77474					240 a,s	17,000 a,j,t
91. Hexachloroethane	67721					1.9 a,c,s	8.9 a,c,t

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92. Indeno(1,2,3-cd) Pyrene	193395					0.0044 a,c	0.049 a,c
93. Isophorone	78591					8.4 c,s	600 c,t
94. Naphthalene	91203						
95. Nitrobenzene	98953					17 a,s	1,900 a,j,t
96. N-Nitrosodimethylamine	62759					0.00069 a,c,s	8.1 a,c,t
97. N-Nitrosodi-n-Propylamine	621647					0.005 a	1.4 a
98. N-Nitrosodiphenylamine	86306					5.0 a,c,s	16 a,c,t
99. Phenanthrene	85018						
100. Pyrene	129000					960 a	11,000 a
101. 1,2,4-Trichlorobenzene	120821						
102. Aldrin	309002	3 g		1.3 g		0.00013 a,c	0.00014 a,c
103. alpha-BHC	319846					0.0039 a,c	0.013 a,c
104. beta-BHC	319857					0.014 a,c	0.046 a,c
105. gamma-BHC	58899	0.95 w		0.16 g		0.019 c	0.063 c
106. delta-BHC	319868						
107. Chlordane	57749	2.4 g	0.0043 g	0.09 g	0.004 g	0.00057 a,c	0.00059 a,c
108. 4,4'-DDT	50293	1.1 g	0.001 g	0.13 g	0.001 g	0.00059 a,c	0.00059 a,c
109. 4,4'-DDE	72559					0.00059 a,c	0.00059 a,c
110. 4,4'-DDD	72548					0.00083 a,c	0.00084 a,c
111. Dieldrin	60571	0.24 w	0.056 w	0.71 g	0.0019 g	0.00014 a,c	0.00014 a,c
112. alpha-Endosulfan	959988	0.22 g	0.056 g	0.034 g	0.0087 g	110 a	240 a
113. beta-Endosulfan	33213659	0.22 g	0.056 g	0.034 g	0.0087 g	110 a	240 a
114. Endosulfan Sulfate	1031078					110 a	240 a
115. Endrin	72208	0.086 w	0.036 w	0.037 g	0.0023 g	0.76 a	0.81 a,j
116. Endrin Aldehyde	7421934					0.76 a	0.81 a,j
117. Heptachlor	76448	0.52 g	0.0038 g	0.053 g	0.0036 g	0.00021 a,c	0.00021 a,c
118. Heptachlor Epoxide	1024573	0.52 g	0.0038 g	0.053 g	0.0036 g	0.00010 a,c	0.00011 a,c
119-125. Polychlorinated biphenyls (PCBs)			0.014 u		0.03 u	0.00017 c,v	0.00017 c,v
126. Toxaphene	8001352	0.73	0.0002	0.21	0.0002	0.00073 a,c	0.00075 a,c
Total Number of Criteria [h]		22	21	22	20	92	90

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Footnotes to Table in Parargraph (b)(1):

a. Criteria revised to reflect the Agency q1* or RfD, as contained in the Integrated Risk Information System (IRIS) as of October 1, 1996. The fish tissue bioconcentration factor (BCF) from the 1980 documents was retained in each case.

b. Criteria apply to California waters except for those waters subject to objectives in Tables III–2A and III–2B of the San Francisco Regional Water Quality Control Board's (SFRWQCB) 1986 Basin Plan, that were adopted by the SFRWQCB and the State Water Resources Control Board, approved by EPA, and which continue to apply.

c. Criteria are based on carcinogenicity of 10 (-6) risk.

d. Criteria Maximum Concentration (CMC) equals the highest concentration of a pollutant to which aquatic life can be exposed for a short period of time without deleterious effects. Criteria Continuous Concentration (CCC) equals the highest concentration of a pollutant to which aquatic life can be exposed for an extended period of time (4 days) without deleterious effects. ug/L equals micrograms per liter.

e. Freshwater aquatic life criteria for metals are expressed as a function of total hardness (mg/L) in the water body. The equations are provided in matrix at paragraph (b)(2) of this section. Values displayed above in the matrix correspond to a total hardness of 100 mg/l.

f. Freshwater aquatic life criteria for pentachlorophenol are expressed as a function of pH, and are calculated as follows: Values displayed above in the matrix correspond to a pH of 7.8. CMC = exp(1.005(pH) − 4.869). CCC = exp(1.005(pH) − 5.134).

g. This criterion is based on 304(a) aquatic life criterion issued in 1980, and was issued in one of the following documents: Aldrin/Dieldrin (EPA 440/5–80–019), Chlordane (EPA 440/5–80–027), DDT (EPA 440/5–80–038), Endosulfan (EPA 440/5–80–046), Endrin (EPA 440/5–80–047), Heptachlor (440/5–80–052), Hexachlorocyclohexane (EPA 440/5–80–054), Silver (EPA 440/5–80–071). The Minimum Data Requirements and derivation procedures were different in the 1980 Guidelines than in the 1985 Guidelines. For example, a "CMC" derived using the 1980 Guidelines was derived to be used as an instantaneous maximum. If assessment is to be done using an averaging period, the values given should be divided by 2 to obtain a value that is more comparable to a CMC derived using the 1985 Guidelines.

h. These totals simply sum the criteria in each column. For aquatic life, there are 23 priority toxic pollutants with some type of freshwater or saltwater, acute or chronic criteria. For human health, there are 92 priority toxic pollutants with either "water + organism" or "organism only" criteria. Note that these totals count chromium as one pollutant even though EPA has developed criteria based on two valence states. In the matrix, EPA has assigned numbers 5a and 5b to the criteria for chromium to reflect the fact that the list of 126 priority pollutants includes only a single listing for chromium.

i. Criteria for these metals are expressed as a function of the water-effect ratio, WER, as defined in paragraph (c) of this section. CMC = column B1 or C1 value x WER; CCC = column B2 or C2 value x WER.

j. No criterion for protection of human health from consumption of aquatic organisms (excluding water) was presented in the 1980 criteria document or in the 1986 Quality Criteria for Water. Nevertheless, sufficient information was presented in the 1980 document to allow a calculation of a criterion, even though the results of such a calculation were not shown in the document.

k. The CWA 304(a) criterion for asbestos is the MCL.

l. [Reserved]

m. These freshwater and saltwater criteria for metals are expressed in terms of the dissolved fraction of the metal in the water column. Criterion values were calculated by using EPA's Clean Water Act 304(a) guidance values (described in the total recoverable fraction) and then applying the conversion factors in § 131.36(b)(1) and (2).

n. EPA is not promulgating human health criteria for these contaminants. However, permit authorities should address these contaminants in NPDES permit actions using the State's existing narrative criteria for toxics.

o. These criteria were promulgated for specific waters in California in the National Toxics Rule ("NTR"), at § 131.36. The specific waters to which the NTR criteria apply include: Waters of the State defined as bays or estuaries and waters of the State defined as inland, i.e., all surface waters of the State not ocean waters. These waters specifically include the San Francisco Bay upstream to and including Suisun Bay and the Sacramento-San Joaquin Delta. This section does not apply instead of the NTR for this criterion.

p. A criterion of 20 ug/l was promulgated for specific waters in California in the NTR and was promulgated in the total recoverable form. The specific waters to which the NTR criterion applies include: Waters of the San Francisco Bay upstream to and including Suisun Bay and the Sacramento-San Joaquin Delta; and waters of Salt Slough, Mud Slough (north) and the San Joaquin River, Sack Dam to the mouth of the Merced River. This section does not apply instead of the NTR for this criterion. The State of California adopted and EPA approved a site specific criterion for the San Joaquin River, mouth of Merced to Vernalis; therefore, this section does not apply to these waters.

q. This criterion is expressed in the total recoverable form. This criterion was promulgated for specific waters in California in the NTR and was promulgated in the total recoverable form. The specific waters to which the NTR criterion applies include: Waters of the San Francisco Bay upstream to and including Suisun Bay and the Sacramento-San Joaquin Delta; and waters of Salt Slough, Mud Slough (north) and the San Joaquin River, Sack Dam to Vernalis. This criterion does not apply instead of the NTR for these waters. This criterion applies to additional waters of the United States in the State of California pursuant to 40 CFR 131.38(c). The State of California adopted and EPA approved a site-specific criterion for the Grassland Water District, San Luis National Wildlife Refuge, and the Los Banos State Wildlife Refuge; therefore, this criterion does not apply to these waters.

r. These criteria were promulgated for specific waters in California in the NTR. The specific waters to which the NTR criteria apply include: Waters of the State defined as bays or estuaries including the San Francisco Bay upstream to and including Suisun Bay and the Sacramento-San Joaquin Delta. This section does not apply instead of the NTR for these criteria.

s. These criteria were promulgated for specific waters in California in the NTR. The specific waters to which the NTR criteria apply include: Waters of the Sacramento-San Joaquin Delta and waters of the State defined as inland (*i.e.*, all surface waters of the State not bays or estuaries or ocean) that include a MUN use designation. This section does not apply instead of the NTR for these criteria.

t. These criteria were promulgated for specific waters in California in the NTR. The specific waters to which the NTR criteria apply include: Waters of the State defined as bays and estuaries including San Francisco Bay upstream to and including Suisun Bay and the Sacramento-San Joaquin Delta; and waters of the State defined as inland (i.e., all surface waters of the State not bays or estuaries or ocean) without a MUN use designation. This section does not apply instead of the NTR for these criteria.

u. PCBs are a class of chemicals which include aroclors 1242, 1254, 1221, 1232, 1248, 1260, and 1016, CAS numbers 53469219, 11097691, 11104282, 11141165, 12672296, 11096825, and 12674112, respectively. The aquatic life criteria apply to the sum of this set of seven aroclors.

v. This criterion applies to total PCBs, e.g., the sum of all congener or isomer or homolog or aroclor analyses.

w. This criterion has been recalculated pursuant to the 1995 Updates: Water Quality Criteria Documents for the Protection of Aquatic Life in Ambient Water, Office of Water, EPA–820–B–96–001, September 1996. See also Great Lakes Water Quality Initiative Criteria Documents for the Protection of Aquatic Life in Ambient Water, Office of Water, EPA–80–B–95–004, March 1995.

x. The State of California has adopted and EPA has approved site specific criteria for the Sacramento River (and tributaries) above Hamilton City; therefore, these criteria do not apply to these waters.

General Notes to Table in Paragraph (b)(1)

1. The table in this paragraph (b)(1) lists all of EPA's priority toxic pollutants whether or not criteria guidance are available. Blank spaces indicate the absence of national section 304(a) criteria guidance. Because of variations in chemical nomenclature systems, this listing of toxic pollutants does not duplicate the listing in Appendix A to 40 CFR Part 423–126 Priority Pollutants. EPA has added the Chemical Abstracts Service (CAS) registry numbers, which provide a unique identification for each chemical.

2. The following chemicals have organoleptic-based criteria recommendations that are not included on this chart: zinc, 3-methyl-4-chlorophenol.

3. Freshwater and saltwater aquatic life criteria apply as specified in paragraph (c)(3) of this section.

(2) Factors for Calculating Metals Criteria. Final CMC and CCC values should be rounded to two significant figures.

(i) CMC = WER × (*Acute Conversion Factor*) × (exp{m_A[ln (*hardness*)]+b_A})

(ii) CCC = WER × (*Acute Conversion Factor*) × (exp{m_C[ln (*hardness*)]+b_C})

(iii) Table 1 to paragraph (b)(2) of this section:

Metal	m_A	b_A	m_C	b_C
Cadmium	1.128	−3.6867	0.7852	−2.715
Copper	0.9422	−1.700	0.8545	−1.702
Chromium (III)	0.8190	3.688	0.8190	1.561
Lead	1.273	−1.460	1.273	−4.705
Nickel	0.8460	2.255	0.8460	0.0584
Silver	1.72	−6.52		
Zinc	0.8473	0.884	0.8473	0.884

Note to Table 1: The term "exp" represents the base e exponential function.

(iv) Table 2 to paragraph (b)(2) of this section:

Metal	Conversion factor (CF) for freshwater acute criteria	CF for freshwater chronic criteria	CF for saltwater acute criteria	CF[a] for saltwater chronic criteria
Antimony	(d)	(d)	(d)	(d)
Arsenic	1.000	1.000	1.000	1.000
Beryllium	(d)	(d)	(d)	(d)
Cadmium	[b] 0.944	[b] 0.909	0.994	0.994
Chromium (III)	0.316	0.860	(d)	(d)
Chromium (VI)	0.982	0.962	0.993	0.993
Copper	0.960	0.960	0.83	0.83
Lead	[b] 0.791	[b] 0.791	0.951	0.951
Mercury				
Nickel	0.998	0.997	0.990	0.990
Selenium		(c)	0.998	0.998
Silver	0.85	(d)	0.85	(d)
Thallium	(d)	(d)	(d)	(d)
Zinc	0.978	0.986	0.946	0.946

Footnotes to Table 2 of Paragraph (b)(2):

[a] Conversion Factors for chronic marine criteria are not currently available. Conversion Factors for acute marine criteria have been used for both acute and chronic marine criteria.

[b] Conversion Factors for these pollutants in freshwater are hardness dependent. CFs are based on a hardness of 100 mg/l as calcium carbonate ($CaCO_3$). Other hardness can be used; CFs should be recalculated using the equations in table 3 to paragraph (b)(2) of this section.

[c] Bioaccumulative compound and inappropriate to adjust to percent dissolved.

[d] EPA has not published an aquatic life criterion value.

Note to Table 2 of Paragraph (b)(2): The term "Conversion Factor" represents the recommended conversion factor for converting a metal criterion expressed as the total recoverable fraction in the water column to a criterion expressed as the dissolved fraction in the water column. See "Office of Water Policy and Technical Guidance on Interpretation and Implementation of Aquatic Life Metals Criteria", October 1, 1993, by Martha G. Prothro, Acting Assistant Administrator for Water available from Water Resource Center, USEPA, Mailcode RC4100, M Street SW, Washington, DC, 20460 and the note to § 131.36(b)(1).

(v) Table 3 to paragraph (b)(2) of this section:

	Acute	Chronic
Cadmium	CF=1.136672—[(ln {hardness}) (0.041838)]	CF = 1.101672—[(ln {hardness})(0.041838)]
Lead	CF=1.46203—[(ln {hardness})(0.145712)]	CF = 1.46203—[(ln {hardness})(0.145712)]

(c) *Applicability.* (1) The criteria in paragraph (b) of this section apply to the State's designated uses cited in paragraph (d) of this section and apply concurrently with any criteria adopted by the State, except when State regulations contain criteria which are more stringent for a particular parameter and use, or except as provided in footnotes p, q, and x to the table in paragraph (b)(1) of this section.

(2) The criteria established in this section are subject to the State's general rules of applicability in the same way and to the same extent as are other Federally-adopted and State-adopted numeric toxics criteria when applied to the same use classifications including mixing zones, and low flow values below which numeric standards can be exceeded in flowing fresh waters.

(i) For all waters with mixing zone regulations or implementation procedures, the criteria apply at the appropriate locations within or at the boundary of the mixing zones; otherwise the criteria apply throughout the water body including at the point of discharge into the water body.

(ii) The State shall not use a low flow value below which numeric standards can be exceeded that is less stringent than the flows in Table 4 to paragraph (c)(2) of this section for streams and rivers.

(iii) Table 4 to paragraph (c)(2) of this section:

A012332

Criteria	Design flow
Aquatic Life Acute Criteria (CMC).	1 Q 10 or 1 B 3
Aquatic Life Chronic Criteria (CCC).	7 Q 10 or 4 B 3
Human Health Criteria.	Harmonic Mean Flow

Note to Table 4 of Paragraph (c)(2): 1. CMC (Criteria Maximum Concentration) is the water quality criteria to protect against acute effects in aquatic life and is the highest instream concentration of a priority toxic pollutant consisting of a short-term average not to be exceeded more than once every three years on the average.

2. CCC (Continuous Criteria Concentration) is the water quality criteria to protect against chronic effects in aquatic life and is the highest in stream concentration of a priority toxic pollutant consisting of a 4-day average not to be exceeded more than once every three years on the average.

3. 1 Q 10 is the lowest one day flow with an average recurrence frequency of once in 10 years determined hydrologically.

4. 1 B 3 is biologically based and indicates an allowable exceedence of once every 3 years. It is determined by EPA's computerized method (DFLOW model).

5. 7 Q 10 is the lowest average 7 consecutive day low flow with an average recurrence frequency of once in 10 years determined hydrologically.

6. 4 B 3 is biologically based and indicates an allowable exceedence for 4 consecutive days once every 3 years. It is determined by EPA's computerized method (DFLOW model).

(iv) If the State does not have such a low flow value below which numeric standards do not apply, then the criteria included in paragraph (d) of this section apply at all flows.

(v) If the CMC short-term averaging period, the CCC four-day averaging period, or once in three-year frequency is inappropriate for a criterion or the site to which a criterion applies, the State may apply to EPA for approval of an alternative averaging period, frequency, and related design flow. The State must submit to EPA the bases for any alternative averaging period, frequency, and related design flow. Before approving any change, EPA will publish for public comment, a document proposing the change.

(3) The freshwater and saltwater aquatic life criteria in the matrix in paragraph (b)(1) of this section apply as follows:

(i) For waters in which the salinity is equal to or less than 1 part per thousand 95% or more of the time, the applicable criteria are the freshwater criteria in Column B;

(ii) For waters in which the salinity is equal to or greater than 10 parts per thousand 95% or more of the time, the applicable criteria are the saltwater criteria in Column C except for selenium in the San Francisco Bay estuary where the applicable criteria are the freshwater criteria in Column B (refer to footnotes p and q to the table in paragraph (b)(1) of this section); and

(iii) For waters in which the salinity is between 1 and 10 parts per thousand as defined in paragraphs (c)(3)(i) and (ii) of this section, the applicable criteria are the more stringent of the freshwater or saltwater criteria. However, the Regional Administrator may approve the use of the alternative freshwater or saltwater criteria if scientifically defensible information and data demonstrate that on a site-specific basis the biology of the water body is dominated by freshwater aquatic life and that freshwater criteria are more appropriate; or conversely, the biology of the water body is dominated by saltwater aquatic life and that saltwater criteria are more appropriate. Before approving any change, EPA will publish for public comment a document proposing the change.

(4) *Application of metals criteria.* (i) For purposes of calculating freshwater aquatic life criteria for metals from the equations in paragraph (b)(2) of this section, for waters with a hardness of 400 mg/l or less as calcium carbonate, the actual ambient hardness of the surface water shall be used in those equations. For waters with a hardness of over 400 mg/l as calcium carbonate, a hardness of 400 mg/l as calcium carbonate shall be used with a default Water-Effect Ratio (WER) of 1, or the actual hardness of the ambient surface water shall be used with a WER. The same provisions apply for calculating the metals criteria for the comparisons provided for in paragraph (c)(3)(iii) of this section.

(ii) The hardness values used shall be consistent with the design discharge conditions established in paragraph (c)(2) of this section for design flows and mixing zones.

(iii) The criteria for metals (compounds #1—#13 in the table in paragraph (b)(1) of this section) are expressed as dissolved except where otherwise noted. For purposes of calculating aquatic life criteria for metals from the equations in footnote i to the table in paragraph (b)(1) of this section and the equations in paragraph (b)(2) of this section, the water effect ratio is generally computed as a specific pollutant's acute or chronic toxicity value measured in water from the site covered by the standard, divided by the respective acute or chronic toxicity value in laboratory dilution water. To use a water effect ratio other than the default of 1, the WER must be determined as set forth in Interim Guidance on Determination and Use of Water Effect Ratios, U.S. EPA Office of Water, EPA–823–B–94–001, February 1994, or alternatively, other scientifically defensible methods adopted by the State as part of its water quality standards program and approved by EPA. For calculation of criteria using site-specific values for both the hardness and the water effect ratio, the hardness used in the equations in paragraph (b)(2) of this section must be determined as required in paragraph (c)(4)(ii) of this section. Water hardness must be calculated from the measured calcium and magnesium ions present, and the ratio of calcium to magnesium should be approximately the same in standard laboratory toxicity testing water as in the site water.

(d)(1) Except as specified in paragraph (d)(3) of this section, all waters assigned any aquatic life or human health use classifications in the Water Quality Control Plans for the various Basins of the State ("Basin Plans") adopted by the California State Water Resources Control Board ("SWRCB"), except for ocean waters covered by the Water Quality Control Plan for Ocean Waters of California ("Ocean Plan") adopted by the SWRCB with resolution Number 90–27 on March 22, 1990, are subject to the criteria in paragraph (d)(2) of this section, without exception. These criteria apply to waters identified in the Basin Plans. More particularly, these criteria apply to waters identified in the Basin Plan chapters designating beneficial uses for waters within the region. Although the State has adopted several use designations for each of these waters, for purposes of this action, the specific standards to be applied in paragraph (d)(2) of this section are based on the presence in all waters of some aquatic life designation and the presence or absence of the MUN use designation (municipal and domestic supply). (See Basin Plans for more detailed use definitions.)

(2) The criteria from the table in paragraph (b)(1) of this section apply to the water and use classifications defined in paragraph (d)(1) of this section as follows:

Water and use classification	Applicable criteria
(i) All inland waters of the United States or enclosed bays and estuaries that are waters of the United States that include a MUN use designation.	(A) Columns B1 and B2—all pollutants (B) Columns C1 and C2—all pollutants (C) Column D1—all pollutants
(ii) All inland waters of the United States or enclosed bays and estuaries that are waters of the United States that do not include a MUN use designation.	(A) Columns B1 and B2—all pollutants (B) Columns C1 and C2—all pollutants (C) Column D2—all pollutants

(3) Nothing in this section is intended to apply instead of specific criteria, including specific criteria for the San Francisco Bay estuary, promulgated for California in the National Toxics Rule at § 131.36.

(4) The human health criteria shall be applied at the State-adopted 10 (−6) risk level.

(5) Nothing in this section applies to waters located in Indian Country.

(e) *Schedules of compliance.* (1) It is presumed that new and existing point source dischargers will promptly comply with any new or more restrictive water quality-based effluent limitations ("WQBELs") based on the water quality criteria set forth in this section.

(2) When a permit issued on or after May 18, 2000 to a new discharger contains a WQBEL based on water quality criteria set forth in paragraph (b) of this section, the permittee shall comply with such WQBEL upon the commencement of the discharge. A new discharger is defined as any building, structure, facility, or installation from which there is or may be a "discharge of pollutants" (as defined in 40 CFR 122.2) to the State of California's inland surface waters or enclosed bays and estuaries, the construction of which commences after May 18, 2000.

(3) Where an existing discharger reasonably believes that it will be infeasible to promptly comply with a new or more restrictive WQBEL based on the water quality criteria set forth in this section, the discharger may request approval from the permit issuing authority for a schedule of compliance.

(4) A compliance schedule shall require compliance with WQBELs based on water quality criteria set forth in paragraph (b) of this section as soon as possible, taking into account the dischargers' technical ability to achieve compliance with such WQBEL.

(5) If the schedule of compliance exceeds one year from the date of permit issuance, reissuance or modification, the schedule shall set forth interim requirements and dates for their achievement. The dates of completion between each requirement may not exceed one year. If the time necessary for completion of any requirement is more than one year and is not readily divisible into stages for completion, the permit shall require, at a minimum, specified dates for annual submission of progress reports on the status of interim requirements.

(6) In no event shall the permit issuing authority approve a schedule of compliance for a point source discharge which exceeds five years from the date of permit issuance, reissuance, or modification, whichever is sooner. Where shorter schedules of compliance are prescribed or schedules of compliance are prohibited by law, those provisions shall govern.

(7) If a schedule of compliance exceeds the term of a permit, interim permit limits effective during the permit shall be included in the permit and addressed in the permit's fact sheet or statement of basis. The administrative record for the permit shall reflect final permit limits and final compliance dates. Final compliance dates for final permit limits, which do not occur during the term of the permit, must occur within five years from the date of issuance, reissuance or modification of the permit which initiates the compliance schedule. Where shorter schedules of compliance are prescribed or schedules of compliance are prohibited by law, those provisions shall govern.

(8) The provisions in this paragraph (e), Schedules of compliance, shall expire on May 18, 2005.

[FR Doc. 00–11106 Filed 5–17–00; 8:45 am]
BILLING CODE 6560–50–P

State of California
CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD, LOS ANGELES REGION

Resolution No. R-00-02

APPROVING THE
STANDARD URBAN STORM WATER MITIGATION PLAN
FOR
MUNICIPAL STORM WATER AND URBAN RUNOFF MANAGEMENT PROGRAMS
IN LOS ANGELES COUNTY

WHEREAS, THE CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD, LOS ANGELES REGION FINDS:

1. On July 15, 1996, a municipal separate storm sewer system permit (Los Angeles County MS4 Permit) was issued to the County of Los Angeles and 85 incorporated cities to control and minimize the discharge of pollutants associated with storm water and urban runoff. This permit became Regional Board Order No. 96-054, Waste Discharge Requirements for Municipal Storm Water and Urban Runoff Discharges within the County of Los Angeles.

2. On June 30, 1999, a municipal storm water permit was issued to the City of Long Beach (City of Long Beach MS4 Permit) which removed the City of Long Beach from Board Order No. 96-054, giving the City of Long Beach its own distinct Municipal Storm Water and Urban Runoff NPDES permit, Regional Board Order No. 99-060, "Waste Discharge Requirements for Municipal Storm Water and Urban Runoff Discharges within the City of Long Beach".

3. On August 19, 1999, a statewide general storm water permit for construction activity (Statewide Construction Storm Water Permit) was adopted by the State Water Resources Control Board (State Board). This permit became State Board Order No. 99-08-DWQ, and applies to construction projects that disturbs five acres or more or is part of a larger common plan of sale in the Los Angeles region.

4. Many of the rivers and streams in Los Angeles County are formally designated as impaired, pursuant to Section 303 (d) of the federal Water Pollution Control Act, for specific pollutants that are commonly found in storm water and urban runoff.

5. Storm water runoff carries with it many pollutants in varying concentrations that are suspended in, and or dissolved, in the runoff. The sources of these pollutants include nearly all properties that have been developed since the pollutants originate through the many diverse activities of habitation and land use. Pollutants generated from individual property developments vary greatly in the concentration or loading of each pollutant. Generally, the relative contribution of the pollutant from runoff from any individual property development will represent only a small portion of the entire loading of a water body given the many square miles of land upon which storm water runoff is generated. When the individual contributions from tens of thousands of discrete property units are aggregated, the pollutant loading becomes significant. The resultant pollutant loads results in the impairment of that water body and the conveyance of pollutants, including sediments, metals, complex organic compounds, oil and grease, nutrients, and pesticides to the ocean and harbors within Los Angeles County. The loading of pollutants generated in the Los Angeles area are being measured through the monitoring program being conducted by the Los Angeles County Department of Public Works in conformance with its obligations as the Principal Permittee under the Los Angeles CountyMS4 Permit.

6. The nature of property use is related to the types and quantities of pollutants that are transported from that property during a rainfall event.

7. As property is developed or redeveloped, the utilization of Best Management Practices provide an opportunity to reduce the loading of pollutants to water bodies. This is accomplished by various techniques and can be passive (source reduction) or active (treatment). As property is developed from undisturbed lands, the project can be designed to incorporate Structural or Treatment Control (Best Management Practices (BMPs) that would normally not be available or practical to use on property that has been in urban use.

8. BMPs are effective means of reducing pollutants and Structural or Treatment Control BMPs can be "designed-into" a project in a cost effective way and in a manner that is either transparent to or which enhances the use to which the property has been placed. Some BMPs encourage the setting aside of areas as a greenbelt to allow storm water runoff to flow over areas which are permeable, thereby allowing all or a portion of the runoff to infiltrate. Other BMPs can be designed and built into structures such as catch basins that incorporate replaceable filters to absorb oily wastes or by installing screens to prevent litter from passing through the system and into the water body.

9. Arrays of Structural or Treatment control BMPs are available to developers of both new and redevelopment properties. The use of BMPs is already required by the terms of the Los Angeles County and Long Beach Municipal Storm Water and Urban Runoff NPDES permits.

10. The ability of any BMP to be effective is limited by the volume of water that the BMP is exposed to in any discrete period of time. A BMP that can only be effective for a small volume of storm water runoff is inherently less effective than one sized to accommodate a larger volume of water.

11. Storm water runoff will normally convey a disproportionate loading of pollutants in the initial period runoff is generated during a storm event. Storm events generating up to 0.75 inches of precipitation, measured over a 24-hour period, constitute 85 percent of the total amount of runoff that can be expected during an average wet season. Designing a BMP to be able to accommodate this amount of runoff will result in the application of a BMP intervention to all but 15% of the total runoff during a year, and usually all of the critical runoff that occurs in the early phase of the precipitation event, commonly referred to as the "first Flush."

12. Both the Los Angeles County MS4 Permit (Part III.A.1.c) and the City of Long Beach MS4 Permits contain provisions related to the adoption of Standard Urban Storm Water Mitigation Plans (SUSMPs) requiring their development and implementation.

13. Standard Urban Storm Water Mitigation Plans are required for a specified set of enumerated projects and the permit specifically identifies seven distinct categories for which SUSMPs are required to be prepared. The permit specifically states that the seven categories of projects are the minimum categories requiring SUSMPs.

14. Standard Urban Storm Water Mitigation Plans are also required for development or redevelopment of Parking Lots 5,000 square feet or greater and Locations in Environmentally Sensitive Areas. These categories have been added to advance efforts to control storm water pollution beyond the minimum in Los Angeles County.

15. Standard Urban Storm Water Mitigation Plans are required to be approved by the Regional Board Executive Officer following which they are to be implemented by the Permittees and used by the Permittees as the minimum criteria for the approval of project specific Urban Storm Water Mitigation Plans and the issuance of grading or building permits to project applicants.

16. The Statewide Construction Storm Water Permit requires that Storm Water Pollution Prevention Plans (State SWPPPs) contain post-construction BMPs that will be implemented after construction is complete.

17. Section 402 (p) of the Clean Water Act requires the Administrator of the United States Environmental Protection Agency or her designated agent, in this instance, the Regional Board, to require as part of the storm water program "controls to reduce the discharge of pollutants to the maximum extent practicable, including management practices, control techniques and system, design and engineering methods, and such other provisions as the Administrator or the State determines appropriate for the control of such pollutants." [USC Section 1342 (p)(3)(B)].

18. A recent decision of the United States 9th Circuit Court of Appeals, *Defenders of Wildlife v. Browner* (1999) Case No. 98-71080, provides additional support and clarification of the authority of the Administrator and the Regional Board to impose additional controls on storm water pollution. The Court in *Defenders of Wildlife v. Browner* said that the USEPA and the States have discretion under the law to determine what pollution controls are appropriate to achieve compliance.

19. Pursuant to the requirements of Regional Board Order No. 96-054, Waste Discharge Requirements for Municipal Storm Water and Urban Runoff Discharges within the County of Los Angeles, the Regional Board Executive Officer received a proposal for Standard Urban Storm Water Mitigation Plans submitted by the Principal Permittee.

20. Upon the review of the Regional Board Executive Officer, the Standard Urban Storm Water Mitigation Plan submitted for the seven applicable categories was deemed inadequate. A revised SUSMP proposal was developed subsequent to a discussion of the proposal's conceptual foundation at a public workshop held on August 10, 1999. This workshop was well attended with over 80 municipal representatives and interested parties participating.

21. On August 16, 1999, a public notice was issued indicating that the Standard Urban Storm Water Mitigation Plans proposed by the Principal Permittee would be augmented by the addition of criteria related to specifying numerical design criteria for BMP construction. The matter was noticed for the Regional Board's September meeting to allow the issue to be discussed before the Board although no formal action of the Regional Board itself is required for SUSMP approval.

22. On September 16, 1999, the Regional Board conducted a public hearing on the Standard Urban Storm Water Mitigation Plan proposal as amended by the Executive Officer. At that hearing, the Regional Board Executive Officer suggested additional time would be necessary to develop a more comprehensive proposal incorporating the comments received at the public hearing.

23. Between September 16, 1999 and January 25, 2000, the Regional Board Executive Officer met with interested parties to discuss comments and concerns from interested parties.

24. The Southern California Council of Governments (SCAG) has indicated its interest in obtaining funding to prepare a regional plan(s) to address storm water pollution and identify regional treatment solutions for implementation.

25. On December 7, 1999, the Regional Board Executive Officer released a revised Standard Urban Storm Water Mitigation Plan document to interested parties.

THEREFORE BE IT RESOLVED THAT:

1. The Regional Board endorses the Standard Urban Storm Water Mitigation Plan prepared by the Regional Board Executive Officer and noticed to the public on December 7, 1999 and the concepts therein relating to numerical storm water mitigation standards for Best Management Practices; and

2. The Regional Board directs the Regional Board Executive Officer to approve the Standard Urban Storm Water Mitigation Plan at the earliest opportunity incorporating changes made and formally approved by the Regional Board at the January 26, 1999 Board Hearing;

3. The Regional Board adopts the approved requirements as provisions applicable to the SUSMP requirements for the City of Long Beach.

4. The Regional Board adopts the numerical mitigation standards for storm water, endorsed herein, as the minimum design criteria for review of post-construction BMPs in the Los Angeles Region for construction projects subject to coverage under the Statewide Construction Storm Water Permit.

5. The Regional Board encourages the Permittees and all interested parties to work together in a spirit of cooperation to effect the implementation of the Standard Urban Storm Water Mitigation Plan at the earliest possible date, and

6. The Regional Board encourages the efforts by the Southern California Council of Governments and area Council of Governments (COGs) to develop regional plans and identify regional solutions to address storm water pollution from new development and redevelopment.

I, Dennis Dickerson, Executive Officer, do hereby certify that the foregoing is a full, true and correct copy of a Resolution adopted by the California Regional Water Quality Control Board, Los Angeles Region, on January 26, 2000.

ORIGINAL SIGNED BY

DENNIS A. DICKERSON
Executive Officer

Winston H. Hickox
Secretary for Environmental Protection

State Water Resources Control Board

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Gray Davis
Governor

December 26, 2000

TO: RWQCB Executive Officers

FROM: /s/
Craig M. Wilson
Chief Counsel
OFFICE OF CHIEF COUNSEL

DATE:

SUBJECT: STATE WATER BOARD ORDER WQ 2000-11: SUSMP

On October 5, 2000, the State Water Resources Control Board (State Water Board) adopted a precedential decision concerning the use of Standard Urban Storm Water Mitigation Plans (SUSMPs) in municipal storm water permits. (Order WQ 2000-11; hereafter referred to as "the Order.") The Order arose from the municipal storm water permit in the Los Angeles region. As a precedential decision, the State Water Board has recognized that the decision includes significant legal or policy determinations that are likely to recur. (Gov. Code §11425.60.) The Regional Water Quality Control Board (Regional Water Board) orders must be consistent with applicable portions of the State Water Board's precedential decisions.

In the Order, the State Water Board considered SUSMPs related to new development and redevelopment. The SUSMPs include a list of best management practices (BMPs) for specific development categories, and a numeric design standard for structural or treatment control BMPs. The numeric design standard created objective and measurable criteria for the amount of runoff that must be treated or infiltrated by BMPs. The purpose of the SUSMPs is to control runoff both during and after construction.

Several of the conclusions reached in the Order are likely to recur, and future municipal storm water permits must be consistent with the principles set forth therein.[1] Pursuant to the Clean Water Act, municipal storm water permits must require controls to reduce the discharge of pollutants to the maximum extent practicable (MEP). The Order finds that the provisions in the SUSMPs, as revised in the Order, constitute MEP. The Order also discusses areas where the Regional Water Boards may exercise more discretion.

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[1] The Order considered a Phase I storm water permit, applicable to urban areas with populations of 100,000 and greater. The State Water Board will soon embark on Phase II, which will include municipal permits for smaller municipalities. The Order did not address Phase II requirements, which may be different than Phase I requirements.

1. The Order finds that the design standard in the SUSMPs, which essentially requires that 85 percent of the runoff from specified categories of development be infiltrated or treated, reflects MEP. It is conceivable that the specific design standard could vary depending on such factors as rainfall and soil characteristics.

2. The Order determined that SUSMPs appropriately applied to the following categories of development: single-family hillside residences, 100,000 square foot commercial developments, automotive repair shops, restaurants, home subdivisions with 10 to 99 housing units, home subdivisions with 100 or more housing units, and parking lots with 5,000 square feet or more or with 25 or more parking spaces and potentially exposed to storm water runoff. Redevelopment projects that are within one of these categories are included if the redevelopment adds or creates at least 5,000 square feet of impervious surface to the original developments; if the addition constitutes less than 50 percent of the original development, the design standard only applies to the addition. The Order approved a waiver from compliance with the design standard where there is a risk of groundwater contamination because a known unconfined aquifer lies beneath the land surface or an existing or potential underground source of drinking water is less than 10 feet from the soil surface.

3. The Order allows broader discretion by the Regional Water Boards to decide whether to include additional types of development in future SUSMPs. These areas for potential future inclusion in SUSMPs include retail gasoline outlets, ministerial projects (only discretionary projects are included in the approved SUSMPs), and projects in environmentally sensitive areas. If Boards include these types of developments in future permits, the Order explains the types of evidence and findings that are necessary.

4. The Order encourages regional solutions. The Order endorses establishment of a mitigation fund or "bank" that could be funded by developers who obtain waivers from the design standards. The Order explains that such a funding mechanism must be developed after consultation with appropriate local agencies.

The SUSMPs as developed by the Los Angeles Regional Water Board resulted from a requirement in a municipal storm water permit to draft and submit a proposal. The Regional Water Board then made revisions to the SUSMPs, and the State Water Board made further revisions prior to approving the SUSMPs. In light of the specificity and detail in the Order, Regional Water Boards should simply incorporate SUSMP requirements for new development and redevelopment into new municipal permits, rather than adopting a process of submittal, review and revision of proposals. In adopting SUSMPs in permits, the requirements should be substantially similar to the SUSMPs approved in the Order. If, for example, the Regional Water Board determines that a different design standard than 85 percent of the runoff is appropriate, the permit findings should explain how the alternative design standard is generally equivalent to the standards approved in the Order, and why the alternative standard is appropriate to the area. The general principles of the Order—that design standards for BMPs for new development and redevelopment are required—must be implemented.

cc: Edward C. Anton
Acting Executive Director

STATE WATER BOARD
RESOLUTION NO. 2005-0013

ADOPTION OF THE PROPOSED AMENDMENT TO THE
CALIFORNIA OCEAN PLAN (OCEAN PLAN)

WHEREAS:

1. The Ocean Plan was adopted by the State Water Board in 1972 and amended in 1978, 1983, 1988, 1990, 1997, and 2001.

2. The State Water Board is responsible for reviewing Ocean Plan water quality standards and for modifying and adopting standards in accordance with Section 303(c)(1) of the federal Clean Water Act and Section 13170.2 of the California Water Code (CWC).

3. The State Water Board held scoping meetings regarding four potential Ocean Plan amendments on January 23, 2004 and February 3, 2004.

4. The State Water Board held a public hearing for the Triennial Review of the Ocean Plan on May 24, 2004 to receive additional public comment for potential revisions of the Ocean Plan.

5. State Water Board staff is proposing an amendment to the Ocean Plan regarding water contact bacterial standards as the first issue to be considered for this Triennial Review.

6. The State Water Board prepared and circulated a draft Functional Equivalent Document (FED) in accordance with the provisions of the California Environmental Quality Act and Title 14, California Code of Regulations 15251(g).

7. The State Water Board held a public hearing in Sacramento on October 6, 2004. The State Water Board determined that the bacterial issue needed more consideration and deferred a decision until the January 2005 workshop.

8. On December 16, 2004, the U.S. Environmental Protection Agency (USEPA) adopted the Water Quality Standards for Coastal and Great Lakes Recreation Waters; Final Rule. This rule establishes enterococcus criteria for California's coastal waters, including bays and estuaries.

9. The State Water Board staff has prepared a draft Final FED, an Attachment to this resolution, which includes the specific proposed amendment to the Ocean Plan and responses to the comments received at the hearing. The proposed amendments are identical to USEPA's geometric mean and single sample maximum criteria.

10. Amendments to the Ocean Plan do not become effective until approved by the Office of Administrative Law (OAL) and USEPA.

THEREFORE BE IT RESOLVED THAT THE STATE WATER BOARD:

1. Revises the bacterial water quality objectives for ocean waters in Chapter II, Section B of the Ocean Plan as shown in the Attachment (Final FED Amendment of the Water Quality Control Plan Ocean Waters of California).

2. Approves the draft Final FED as part of the Attachment to the resolution.

3. Authorizes the State Water Board's Executive Director to sign the Certificate of Fee Exemption.

4. Authorizes the State Water Board staff to submit the amended Ocean Plan to OAL and USEPA for final approval.

CERTIFICATION

The undersigned, Clerk to the Board, does hereby certify that the foregoing is a full, true, and correct copy of a resolution duly and regularly adopted at a meeting of the State Water Board held on January 20, 2005.

Debbie Irvin
Clerk to the Board

STATE WATER RESOURCES CONTROL BOARD: CALIFORNIA OCEAN PLAN

SUMMARY

Section 13170.2 of the California Water Code directs the State Water Resources Control Board (State Water Board) to formulate and adopt a water quality control plan for ocean waters of California. The State Water Board first adopted this plan, known as the *California Ocean Plan*, in 1972. The California Water Code also requires a review of the California Ocean Plan at least every three years to guarantee that current standards are adequate and are not allowing degradation to indigenous marine species or posing a threat to human health. The amendments to the California Ocean Plan are reviewed and approved by the US Environmental Protection Agency under the Clean Water Act.

The current 2001 California Ocean Plan is available from the State Water Board web page at http://www.swrcb.ca.gov/plnspols/oplans/index.html. The State Water Board recently amended the plan in January 2005, and will be considering further amendments in April 2005. The 2005 California Ocean Plan will be posted on the web page in the near future.

The California Ocean Plan establishes water quality objectives for California's ocean waters and provides the basis for regulation of wastes discharged into the State's coastal waters. The plan applies to point and nonpoint source discharges. Both the State Water Board and the six coastal Regional Water Quality Control Boards (Regional Water Boards) implement and interpret the California Ocean Plan.

The California Ocean Plan identifies the applicable beneficial uses of marine waters. These beneficial uses include preservation and enhancement of designated Areas of Special Biological Significance (ASBS), rare and endangered species, marine habitat, fish migration, fish spawning, shellfish harvesting, recreation, commercial and sport fishing, mariculture, industrial water supply, aesthetic enjoyment, and navigation.

The California Ocean Plan establishes a set of narrative and numerical water quality objectives to protect beneficial uses. These objectives are based on bacterial, physical, chemical, and biological characteristics as well as radioactivity. The water quality objectives in Table B of the California Ocean Plan apply to all receiving waters under the jurisdiction of the plan and are established for the protection of aquatic life and for the protection of human health from both carcinogens and noncarcinogens. Within Table B there are 21 objectives for protecting aquatic life, 20 for protecting human health from noncarcinogens, and 42 for protecting human health from exposure to carcinogens.

The Ocean Plan also includes an implementation program for achieving water quality objectives. Effluent limitations are established for the protection of marine waters.

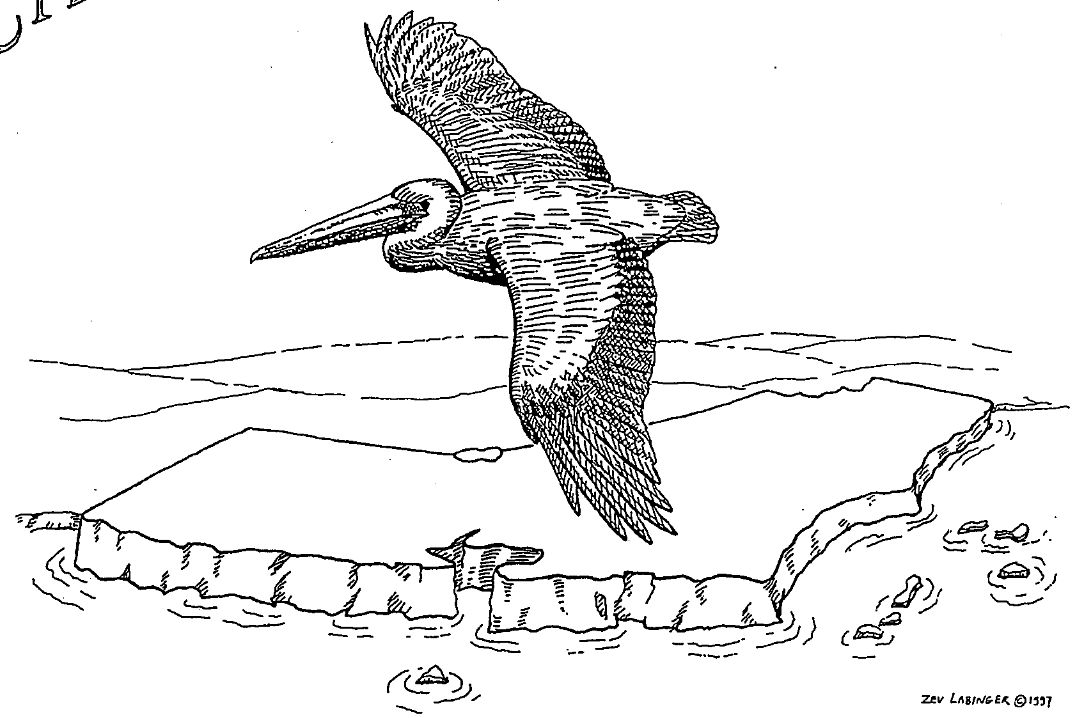
When a discharge permit is written, the water quality objectives for the receiving water are converted into effluent limitations that apply to discharges into State ocean waters. These effluent limitations are established on a discharge-specific basis depending on the initial dilution calculated for each outfall and the Table B objectives.

Implementation provisions are also established for bacterial assessment and remedial action requirements. These provisions provide a basis for determining the occurrence and extent of any impairment of beneficial uses due to bacterial contamination and for providing remedial actions necessary to minimize or eliminate any impairment of a beneficial use.

The California Ocean Plan clearly states that waste shall not be discharged to ASBS and that such discharges shall be located a sufficient distance from ASBS to assure maintenance of natural water quality conditions in these areas. It also provides that Regional Water Boards may approve waste discharge requirements or recommend certification for limited-term (*i.e.*, weeks or months) activities in ASBS.

WATER QUALITY CONTROL PLAN
OCEAN WATERS OF CALIFORNIA

CALIFORNIA OCEAN PLAN



2001

STATE WATER RESOURCES CONTROL BOARD
CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY

State of California
Gray Davis, Governor

California Environmental Protection Agency
Winston H. Hickox, Secretary

State Water Resources Control Board
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State of California

STATE WATER RESOURCES CONTROL BOARD

2001

CALIFORNIA OCEAN PLAN

WATER QUALITY CONTROL PLAN

OCEAN WATERS OF CALIFORNIA

Effective December 3, 2001

Adopted by the State Water Resources Control Board on November 16, 2000.
Approved by the U. S. Environmental Protection Agency on December 3, 2001.

The energy challenge facing California is real. Every Californian needs to take immediate action to reduce energy consumption. For a list of simple ways you can reduce demand and cut your energy costs, see our Web-site at http://www.swrcb.ca.gov .

STATE WATER RESOURCES CONTROL BOARD
RESOLUTION NO. 2000-108

ADOPTION OF THE PROPOSED AMENDMENTS TO
THE CALIFORNIA OCEAN PLAN
(OCEAN PLAN)

WHEREAS:

1. The Ocean Plan was adopted by the State Water Resources Control Board (SWRCB) in 1972 and amended in 1978, 1983, 1988, 1990, and 1997.

2. The SWRCB is responsible for reviewing Ocean Plan water quality standards and for modifying and adopting standards in accordance with Section 303(c)(1) of the federal Clean Water Act and Section 13170.2 of the California Water Code (CWC).

3. The SWRCB initiated a public review of the Ocean Plan in 1991, including a public hearing, and adopted a workplan in 1992 for considering issues identified by the comments received.

4. The SWRCB reviewed these issues and amended the Ocean Plan in 1997.

5. The SWRCB staff reviewed the high priority issues remaining from the 1992 Workplan, selected five issues for further analyses, and based upon this analysis proposed five additional amendments to the Ocean Plan.

6. The SWRCB staff has also identified a sixth issue consisting of minor administrative changes to the Ocean Plan to update terminology and references.

7. The proposed amendments are the following:

   Issue 1: Replacement of the acute toxicity effluent limitation in Table "A" with an acute toxicity water quality objective.

   Issue 2: Revision of chemical water quality objectives for protection of human health.

   Issue 3: Addition of provisions for compliance determination for chemical water quality objectives.

   Issue 4: Revisions of the format and organization of the Ocean Plan.

Issue 5: Development of special protection for water quality and designated uses specifying procedures for nomination and designation of special category waters.

Issue 6: Administrative changes to the Ocean Plan that include:

a. Defining governmental agencies referenced in the Ocean Plan,
b. Defining dredged materials,
c. Describing the relationship of the Ocean Plan to other State plans and policies,
d. Updating the reference for the radioactivity water quality objective,
e. Changing the test method references for total and fecal bacteria and for acute toxicity,
f. Changing a subtitle in Appendix II, and
g. Changing the Ocean Plan's effective date.

8. The SWRCB prepared and circulated a draft Functional Equivalent Document (FED) in accordance with the provisions of the California Environmental Quality Act and Title 14, California Code of Regulations 15251(g).

9. The SWRCB held three public hearings in Sacramento, Irvine, and Monterey in November and December of 1998. The SWRCB has carefully considered all testimony and comments received on this matter and has determined that the adoption of the proposed Ocean Plan amendments will not have a significant adverse effect on the environment.

10. The SWRCB staff has prepared a draft Final FED, Attachment A to this resolution, which includes the specific proposed amendments to the Ocean Plan and responses to the comments received at the hearings.

11. The SWRCB has considered relevant management agency agreements in accordance with CWC Section 13179.1.

12. Amendments to the Ocean Plan do not become effective until approved by the Office of Administrative Law and the U.S. Environmental Protection Agency.

THEREFORE BE IT RESOLVED THAT:

The SWRCB:

1. Approves the draft Final FED identified as Attachment A to the resolution, as revised at the November 16, 2000 Board Meeting.

2. Approves the proposed amendments to the Ocean Plan, as revised at the November 16, 2000 Board Meeting.

3. Agrees to reassess and modify as appropriate the Minimum Level values in Appendix II of the Ocean Plan during the triennial reviews to consider and reflect the availability and use of more sensitive analytical methods. Prior to adoption of new Minimum Levels, the SWRCB will consider environmental and economic effects.

4. Authorizes the SWRCB Executive Director to sign the Certificate of Fee Exemption identified as Attachment B to the resolution.

5. Authorizes the SWRCB staff to submit the amended Ocean Plan to the Office of Administrative Law and the U.S. Environmental Protection Agency for final approval.

CERTIFICATION

The undersigned, Administrative Assistant to the Board, does hereby certify that the foregoing is a full, true, and correct copy of a resolution duly and regularly adopted at a meeting of the State Water Resources Control Board held on November 16, 2000.

Maureen Marché

Maureen Marché
Administrative Assistant to the Board

CALIFORNIA OCEAN PLAN

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CALIFORNIA OCEAN PLAN

WATER QUALITY CONTROL PLAN FOR OCEAN WATERS OF CALIFORNIA

INTRODUCTION

A. Purpose and Authority

1. In furtherance of legislative policy set forth in Section 13000 of Division 7 of the California Water Code (CWC) (Stats. 1969, Chap. 482) pursuant to the authority contained in Section 13170 and 13170.2 (Stats. 1971, Chap. 1288) the State Water Resources Control Board hereby finds and declares that protection of the quality of the ocean* waters for use and enjoyment by the people of the State requires control of the discharge of waste* to ocean* waters in accordance with the provisions contained herein. The Board finds further that this plan shall be reviewed at least every three years to guarantee that the current standards are adequate and are not allowing degradation* to marine species or posing a threat to public health.

B. Principles

1. Harmony Among Water Quality Control Plans and Policies.

   a. In the adoption and amendment of water quality control plans, it is the intent of this Board that each plan will provide for the attainment and maintenance of the water quality standards of downstream waters.

   b. To the extent there is a conflict between a provision of this plan and a provision of another statewide plan or policy, or a regional water quality control plan (basin plan), the more stringent provision shall apply except where pursuant to Chap. III.I of this Plan, the SWRCB has approved an exception to the Plan requirements.

C. Applicability

1. This plan is applicable, in its entirety, to point source discharges to the ocean*. Nonpoint sources of waste* discharges to the ocean* are subject to Chapter I Beneficial Uses, Chapter II - WATER QUALITY OBJECTIVES (wherein compliance with water quality objectives shall, in all cases, be determined by direct measurements in the receiving waters) and Chapter III - PROGRAM OF IMPLEMENTATION Parts A.2, D, E, and H.

2. This plan is not applicable to discharges to enclosed* bays and estuaries* or inland waters, nor is it applicable to vessel wastes, or the control of dredged* material.

3. Provisions regulating the thermal aspects of waste* discharged to the ocean* are set forth in the Water Quality Control Plan for the Control of Temperature in the Coastal and Interstate Waters and Enclosed* Bays and Estuaries* of California.

4. Within this Plan, references to the State Board or SWRCB shall mean the State Water Resources Control Board. References to a Regional Board or RWQCB shall mean a California Regional Water Quality Control Board. References to the Environmental Protection Agency, US EPA, or EPA shall mean the federal Environmental Protection Agency.

* See Appendix I for definition of terms.

I. BENEFICIAL USES

A. The beneficial uses of the ocean* waters of the State that shall be protected include industrial water supply; water contact and non-contact recreation, including aesthetic enjoyment; navigation; commercial and sport fishing; mariculture*; preservation and enhancement of designated Areas* of Special Biological Significance (ASBS); rare and endangered species; marine habitat; fish migration; fish spawning and shellfish* harvesting.

* See Appendix I for definition of terms.

II. WATER QUALITY OBJECTIVES

A. General Provisions

1. This chapter sets forth limits or levels of water quality characteristics for ocean* waters to ensure the reasonable protection of beneficial uses and the prevention of nuisance. The discharge of waste* shall not cause violation of these objectives.

2. The Water Quality Objectives and Effluent Limitations are defined by a statistical distribution when appropriate. This method recognizes the normally occurring variations in treatment efficiency and sampling and analytical techniques and does not condone poor operating practices.

3. Compliance with the water quality objectives of this chapter shall be determined from samples collected at stations representative of the area within the waste field where initial* dilution is completed.

B. Bacterial Characteristics

1. Water-Contact Standards

   a. Within a zone bounded by the shoreline and a distance of 1,000 feet from the shoreline or the 30-foot depth contour, whichever is further from the shoreline, and in areas outside this zone used for water contact sports, as determined by the Regional Board, but including all kelp* beds, the following bacterial objectives shall be maintained throughout the water column:

      (1) Samples of water from each sampling station shall have a density of total coliform organisms less than 1,000 per 100 ml (10 per ml); provided that not more than 20 percent of the samples at any sampling station, in any 30-day period, may exceed 1,000 per 100 ml (10 per ml), and provided further that no single sample when verified by a repeat sample taken within 48 hours shall exceed 10,000 per 100 ml (100 per ml).

      (2) The fecal coliform density based on a minimum of not less than five samples for any 30-day period, shall not exceed a geometric mean of 200 per 100 ml nor shall more than 10 percent of the total samples during any 60-day period exceed 400 per 100 ml.

   b. The "Initial* Dilution Zone" of wastewater outfalls shall be excluded from designation as "kelp* beds" for purposes of bacterial standards, and Regional Boards should recommend extension of such exclusion zone where warranted to the SWRCB (for consideration under Chapter III.H.). Adventitious assemblages of kelp plants on waste discharge structures (e.g., outfall pipes and diffusers) do not constitute kelp* beds for purposes of bacterial standards.

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* See Appendix I for definition of terms.

2. Shellfish* Harvesting Standards

   a. At all areas where shellfish* may be harvested for human consumption, as determined by the Regional Board, the following bacterial objectives shall be maintained throughout the water column:

      (1) The median total coliform density shall not exceed 70 per 100 ml, and not more than 10 percent of the samples shall exceed 230 per 100 ml.

C. Physical Characteristics

1. Floating particulates and grease and oil shall not be visible.

2. The discharge of waste* shall not cause aesthetically undesirable discoloration of the ocean* surface.

3. Natural* light shall not be significantly* reduced at any point outside the initial* dilution zone as the result of the discharge of waste*.

4. The rate of deposition of inert solids and the characteristics of inert solids in ocean* sediments shall not be changed such that benthic communities are degraded*.

D. Chemical Characteristics

1. The dissolved oxygen concentration shall not at any time be depressed more than 10 percent from that which occurs naturally, as the result of the discharge of oxygen demanding waste* materials.
2. The pH shall not be changed at any time more than 0.2 units from that which occurs naturally.
3. The dissolved sulfide concentration of waters in and near sediments shall not be significantly* increased above that present under natural conditions.
4. The concentration of substances set forth in Chapter II, Table B, in marine sediments shall not be increased to levels which would degrade* indigenous biota.
5. The concentration of organic materials in marine sediments shall not be increased to levels that would degrade* marine life.
6. Nutrient materials shall not cause objectionable aquatic growths or degrade* indigenous biota.
7. Numerical Water Quality Objectives
   a. Table B water quality objectives apply to all discharges within the jurisdiction of this Plan.
   b. Table B Water Quality Objectives

* See Appendix I for definition of terms.

TABLE B
WATER QUALITY OBJECTIVES

	Units of Measurement	Limiting Concentrations: 6-Month Median	Daily Maximum	Instantaneous Maximum
OBJECTIVES FOR PROTECTION OF MARINE AQUATIC LIFE				
Arsenic	ug/l	8.	32.	80.
Cadmium	ug/l	1.	4.	10.
Chromium (Hexavalent) (see below, a)	ug/l	2.	8.	20.
Copper	ug/l	3.	12.	30.
Lead	ug/l	2.	8.	20.
Mercury	ug/l	0.04	0.16	0.4
Nickel	ug/l	5.	20.	50.
Selenium	ug/l	15.	60.	150.
Silver	ug/l	0.7	2.8	7.
Zinc	ug/l	20.	80.	200.
Cyanide (see below, b)	ug/l	1.	4.	10.
Total Chlorine Residual (For intermittent chlorine sources see below, c)	ug/l	2.	8.	60.
Ammonia (expressed as nitrogen)	ug/l	600.	2400.	6000.
Acute* Toxicity	TUa	N/A	0.3	N/A
Chronic* Toxicity	TUc	N/A	1.	N/A
Phenolic Compounds (non-chlorinated)	ug/l	30.	120.	300.
Chlorinated Phenolics	ug/l	1.	4.	10.
Endosulfan	ug/l	0.009	0.018	0.027
Endrin	ug/l	0.002	0.004	0.006
HCH*	ug/l	0.004	0.008	0.012
Radioactivity	Not to exceed limits specified in Title 17, Division 1, Chapter 5, Subchapter 4, Group 3, Article 3, Section 30253 of the California Code of Regulations. Reference to Section 30253 is prospective, including future changes to any incorporated provisions of federal law, as the changes take effect.			

* See Appendix I for definition of terms.

Table B Continued

Chemical	30-day Average (ug/l) Decimal Notation	Scientific Notation
OBJECTIVES FOR PROTECTION OF HUMAN HEALTH – NONCARCINOGENS		
acrolein	220.	2.2×10^{2}
antimony	1,200.	1.2×10^{3}
bis(2-chloroethoxy) methane	4.4	4.4×10^{0}
bis(2-chloroisopropyl) ether	1,200.	1.2×10^{3}
chlorobenzene	570.	5.7×10^{2}
chromium (III)	190,000.	1.9×10^{5}
di-n-butyl phthalate	3,500.	3.5×10^{3}
dichlorobenzenes*	5,100.	5.1×10^{3}
diethyl phthalate	33,000.	3.3×10^{4}
dimethyl phthalate	820,000.	8.2×10^{5}
4,6-dinitro-2-methylphenol	220.	2.2×10^{2}
2,4-dinitrophenol	4.0	4.0×10^{0}
ethylbenzene	4,100.	4.1×10^{3}
fluoranthene	15.	1.5×10^{1}
hexachlorocyclopentadiene	58.	5.8×10^{1}
nitrobenzene	4.9	4.9×10^{0}
thallium	2.	$2. \times 10^{0}$
toluene	85,000.	8.5×10^{4}
tributyltin	0.0014	1.4×10^{-3}
1,1,1-trichloroethane	540,000.	5.4×10^{5}
OBJECTIVES FOR PROTECTION OF HUMAN HEALTH – CARCINOGENS		
acrylonitrile	0.10	1.0×10^{-1}
aldrin	0.000022	2.2×10^{-5}
benzene	5.9	5.9×10^{0}
benzidine	0.000069	6.9×10^{-5}
beryllium	0.033	3.3×10^{-2}
bis(2-chloroethyl) ether	0.045	4.5×10^{-2}
bis(2-ethylhexyl) phthalate	3.5	3.5×10^{0}
carbon tetrachloride	0.90	9.0×10^{-1}
chlordane*	0.000023	2.3×10^{-5}
chlorodibromomethane	8.6	8.6×10^{0}

* See Appendix I for definition of terms.

Table B Continued

Chemical	30-day Average (ug/l) Decimal Notation	Scientific Notation
OBJECTIVES FOR PROTECTION OF HUMAN HEALTH – CARCINOGENS		
chloroform	130.	1.3×10^{2}
DDT*	0.00017	1.7×10^{-4}
1,4-dichlorobenzene	18.	1.8×10^{1}
3,3'-dichlorobenzidine	0.0081	8.1×10^{-3}
1,2-dichloroethane	28.	2.8×10^{1}
1,1-dichloroethylene	0.9	9×10^{-1}
dichlorobromomethane	6.2	6.2×10^{0}
dichloromethane	450.	4.5×10^{2}
1,3-dichloropropene	8.9	8.9×10^{0}
dieldrin	0.00004	4.0×10^{-5}
2,4-dinitrotoluene	2.6	2.6×10^{0}
1,2-diphenylhydrazine	0.16	1.6×10^{-1}
halomethanes*	130.	1.3×10^{2}
heptachlor	0.00005	5×10^{-5}
heptachlor epoxide	0.00002	2×10^{-5}
hexachlorobenzene	0.00021	2.1×10^{-4}
hexachlorobutadiene	14.	1.4×10^{1}
hexachloroethane	2.5	2.5×10^{0}
isophorone	730.	7.3×10^{2}
N-nitrosodimethylamine	7.3	7.3×10^{0}
N-nitrosodi-N-propylamine	0.38	3.8×10^{-1}
N-nitrosodiphenylamine	2.5	2.5×10^{0}
PAHs*	0.0088	8.8×10^{-3}
PCBs*	0.000019	1.9×10^{-5}
TCDD equivalents*	0.0000000039	3.9×10^{-9}
1,1,2,2-tetrachloroethane	2.3	2.3×10^{0}
tetrachloroethylene	2.0	2.0×10^{0}
toxaphene	0.00021	2.1×10^{-4}
trichloroethylene	27.	2.7×10^{1}
1,1,2-trichloroethane	9.4	9.4×10^{0}
2,4,6-trichlorophenol	0.29	2.9×10^{-1}
vinyl chloride	36.	3.6×10^{1}

* See Appendix I for definition of terms.

Table B Notes:

a) Dischargers may at their option meet this objective as a total chromium objective.

b) If a discharger can demonstrate to the satisfaction of the Regional Board (subject to EPA approval) that an analytical method is available to reliably distinguish between strongly and weakly complexed cyanide, effluent limitations for cyanide may be met by the combined measurement of free cyanide, simple alkali metal cyanides, and weakly complexed organometallic cyanide complexes. In order for the analytical method to be acceptable, the recovery of free cyanide from metal complexes must be comparable to that achieved by the approved method in 40 CFR PART 136, as revised May 14, 1999.

c) Water quality objectives for total chlorine residual applying to intermittent discharges not exceeding two hours, shall be determined through the use of the following equation:

$$\log y = -0.43 (\log x) + 1.8$$

where: y = the water quality objective (in ug/l) to apply when chlorine is being discharged;
x = the duration of uninterrupted chlorine discharge in minutes.

E. Biological Characteristics

1. Marine communities, including vertebrate, invertebrate, and plant species, shall not be degraded*.

2. The natural taste, odor, and color of fish, shellfish*, or other marine resources used for human consumption shall not be altered.

3. The concentration of organic materials in fish, shellfish* or other marine resources used for human consumption shall not bioaccumulate to levels that are harmful to human health.

F. Radioactivity

1. Discharge of radioactive waste* shall not degrade* marine life.

* See Appendix I for definition of terms.

III. PROGRAM OF IMPLEMENTATION

A. General Provisions

1. Effective Date

a. The *Water Quality Control Plan, Ocean Waters of California, California Ocean Plan* was adopted and has been effective since 1972. There have been multiple amendments of the Ocean Plan since its adoption.

This document includes the most recent amendments of the Ocean Plan as approved by the SWRCB on November 16, 2000. However, amendments in this version of the Ocean Plan do not become effective until approved by the US EPA. Persons using the Ocean Plan prior to US EPA approval of this version should reference the 1997 Ocean Plan. Once approved by the US EPA, this document (the 2001 Ocean Plan) will supercede the 1997 Ocean Plan.

2. General Requirements For Management Of Waste Discharge To The Ocean*

a. Waste* management systems that discharge to the ocean* must be designed and operated in a manner that will maintain the indigenous marine life and a healthy and diverse marine community.

b. Waste discharged* to the ocean* must be essentially free of:

(1) Material that is floatable or will become floatable upon discharge.

(2) Settleable material or substances that may form sediments which will degrade* benthic communities or other aquatic life.

(3) Substances which will accumulate to toxic levels in marine waters, sediments or biota.

(4) Substances that significantly* decrease the natural* light to benthic communities and other marine life.

(5) Materials that result in aesthetically undesirable discoloration of the ocean* surface.

c. Waste* effluents shall be discharged in a manner which provides sufficient initial* dilution to minimize the concentrations of substances not removed in the treatment.

d. Location of waste* discharges must be determined after a detailed assessment of the oceanographic characteristics and current patterns to assure that:

(1) Pathogenic organisms and viruses are not present in areas where shellfish* are harvested for human consumption or in areas used for swimming or other body-contact sports.

(2) Natural water quality conditions are not altered in areas designated as being of special biological significance or areas that existing marine laboratories use as a source of seawater.

(3) Maximum protection is provided to the marine environment.

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* See Appendix I for definition of terms.

e. Waste* that contains pathogenic organisms or viruses should be discharged a sufficient distance from shellfishing* and water-contact sports areas to maintain applicable bacterial standards without disinfection. Where conditions are such that an adequate distance cannot be attained, reliable disinfection in conjunction with a reasonable separation of the discharge point from the area of use must be provided. Disinfection procedures that do not increase effluent toxicity and that constitute the least environmental and human hazard should be used.

3. Areas of Special Biological Significance

a. ASBS* shall be designated by the SWRCB following the procedures provided in Appendix IV. A list of ASBS* is available in Appendix V.

4. Combined Sewer Overflow: Not withstanding any other provisions in this plan, discharges from the City of San Francisco's combined sewer system are subject to the US EPA's Combined Sewer Overflow Policy.

B. Table A Effluent Limitations

TABLE A
EFFLUENT LIMITATIONS

	Unit of Measurement	Limiting Concentrations: Monthly (30-day Average)	Weekly (7-day Average)	Maximum at any time
Grease and Oil	mg/l	25.	40.	75.
Suspended Solids			See below +	
Settleable Solids	Ml/l	1.0	1.5	3.0
Turbidity	NTU	75.	100.	225.
PH	Units		Within limit of 6.0 to 9.0 at all times	

Table A Notes:

\+ Suspended Solids: Dischargers shall, as a 30-day average, remove 75% of suspended solids from the influent stream before discharging wastewaters to the ocean*, except that the effluent limitation to be met shall not be lower than 60 mg/l. Regional Boards may recommend that the SWRCB (Chapter IIIJ), with the concurrence of the Environmental Protection Agency, adjust the lower effluent concentration limit (the 60 mg/l above) to suit the environmental and effluent characteristics of the discharge. As a further consideration in making such recommendation for adjustment, Regional Boards should evaluate effects on existing and potential water* reclamation projects.

If the lower effluent concentration limit is adjusted, the discharger shall remove 75% of suspended solids from the influent stream at any time the influent concentration exceeds four times such adjusted effluent limit.

1. Table A effluent limitations apply only to publicly owned treatment works and industrial discharges for which Effluent Limitations Guidelines have not been established pursuant to Sections 301, 302, 304, or 306 of the Federal Clean Water Act.

* See Appendix I for definition of terms.

2. Table A effluent limitations shall apply to a discharger's total effluent, of whatever origin (i.e., gross, not net, discharge), except where otherwise specified in this Plan.

3. The SWRCB is authorized to administer and enforce effluent limitations established pursuant to the Federal Clean Water Act. Effluent limitations established under Sections 301, 302, 306, 307, 316, 403, and 405 of the aforementioned Federal Act and administrative procedures pertaining thereto are included in this plan by reference. Compliance with Table A effluent limitations, or Environmental Protection Agency Effluent Limitations Guidelines for industrial discharges, based on Best Practicable Control Technology, shall be the minimum level of treatment acceptable under this plan, and shall define reasonable treatment and waste control technology.

C. Implementation Provisions for Table B

1. Effluent concentrations calculated from Table B water quality objectives shall apply to a discharger's total effluent, of whatever origin (i.e., gross, not net, discharge), except where otherwise specified in this Plan.

2. Effluent limitations shall be imposed in a manner prescribed by the SWRCB such that the concentrations set forth below as water quality objectives shall not be exceeded in the receiving water upon completion of initial* dilution, except that objectives indicated for radioactivity shall apply directly to the undiluted waste* effluent.

3. Calculation of Effluent Limitations

a. Effluent limitations for water quality objectives listed in Table B, with the exception of acute* toxicity and radioactivity, shall be determined through the use of the following equation:

Equation 1: $Ce = Co + Dm (Co - Cs)$

where:

Ce = the effluent concentration limit, ug/l

Co = the concentration (water quality objective) to be met at the completion of initial* dilution, ug/l

Cs = background seawater concentration (see Table C below), ug/l

Dm = minimum probable initial* dilution expressed as parts seawater per part wastewater.

TABLE C
BACKGROUND SEAWATER CONCENTRATIONS (Cs)

Waste Constituent	Cs (ug/l)
Arsenic	3.
Copper	2.
Mercury	0.0005
Silver	0.16
Zinc	8.

For all other Table B parameters, Cs = 0.

* See Appendix I for definition of terms.

b. Determining a Mixing Zone for the Acute* Toxicity Objective

The mixing zone for the acute* toxicity objective shall be ten percent (10%) of the distance from the edge of the outfall structure to the edge of the chronic mixing zone (zone of initial dilution). There is no vertical limitation on this zone. The effluent limitation for the acute* toxicity objective listed in Table B shall be determined through the use of the following equation:

Equation 2: Ce = Ca + (0.1) Dm (Ca)

where:

Ca = the concentration (water quality objective) to be met at the edge of the acute mixing zone.

Dm = minimum probable initial* dilution expressed as parts seawater per part wastewater (This equation applies only when Dm > 24).

c. Toxicity Testing Requirements based on the Minimum Initial* Dilution Factor for Ocean Waste Discharges

(1) Dischargers shall conduct acute* toxicity testing if the minimum initial* dilution of the effluent is greater than 1,000:1 at the edge of the mixing zone.

(2) Dischargers shall conduct either acute* or chronic* toxicity testing if the minimum initial* dilution ranges from 350:1 to 1,000:1 depending on the specific discharge conditions. The RWQCB shall make this determination.

(3) Dischargers shall conduct chronic* toxicity testing for ocean waste discharges with minimum initial* dilution factors ranging from 100:1 to 350:1. The RWQCBs may require that acute toxicity testing be conducted in addition to chronic as necessary for the protection of beneficial uses of ocean waters.

(4) Dischargers shall conduct chronic toxicity testing if the minimum initial* dilution of the effluent falls below 100:1 at the edge of the mixing zone.

d. For the purpose of this Plan, minimum initial* dilution is the lowest average initial* dilution within any single month of the year. Dilution estimates shall be based on observed waste flow characteristics, observed receiving water density structure, and the assumption that no currents, of sufficient strength to influence the initial* dilution process, flow across the discharge structure.

e. The Executive Director of the SWRCB shall identify standard dilution models for use in determining Dm, and shall assist the Regional Board in evaluating Dm for specific waste discharges. Dischargers may propose alternative methods of calculating Dm, and the Regional Board may accept such methods upon verification of its accuracy and applicability.

* See Appendix I for definition of terms.

f. The six-month median shall apply as a moving median of daily values for any 180-day period in which daily values represent flow weighted average concentrations within a 24-hour period. For intermittent discharges, the daily value shall be considered to equal zero for days on which no discharge occurred.

g. The daily maximum shall apply to flow weighted 24 hour composite samples.

h. The instantaneous maximum shall apply to grab sample determinations.

i. If only one sample is collected during the time period associated with the water quality objective (e.g., 30-day average or 6-month median), the single measurement shall be used to determine compliance with the effluent limitation for the entire time period.

j. Discharge requirements shall also specify effluent limitations in terms of mass emission rate limits utilizing the general formula:

Equation 3: lbs/day = 0.00834 x Ce x Q

where:

Ce = the effluent concentration limit, ug/l

Q = flow rate, million gallons per day (MGD)

k. The six-month median limit on daily mass emissions shall be determined using the six-month median effluent concentration as Ce and the observed flow rate Q in millions of gallons per day. The daily maximum mass emission shall be determined using the daily maximum effluent concentration limit as Ce and the observed flow rate Q in millions of gallons per day.

l. Any significant change in waste* flow shall be cause for reevaluating effluent limitations.

4. Minimum* Levels

For each numeric effluent limitation, the Regional Board must select one or more Minimum* Levels (and their associated analytical methods) for inclusion in the permit. The "reported" Minimum* Level is the Minimum* Level (and its associated analytical method) chosen by the discharger for reporting and compliance determination from the Minimum* Levels included in their permit.

a. Selection of Minimum* Levels from Appendix II

The Regional Board must select all Minimum* Levels from Appendix II that are below the effluent limitation. If the effluent limitation is lower than all the Minimum* Levels in Appendix II, the Regional Board must select the lowest Minimum* Level from Appendix II.

* See Appendix I for definition of terms.

b. Deviations from Minimum* Levels in Appendix II

The Regional Board, in consultation with the State Water Board's Quality Assurance Program, must establish a Minimum* Level to be included in the permit in any of the following situations:

1. A pollutant is not listed in Appendix II.
2. The discharger agrees to use a test method that is more sensitive than those described in 40 CFR 136 (revised May 14, 1999).
3. The discharger agrees to use a Minimum* Level lower than those listed in Appendix II.
4. The discharger demonstrates that their calibration standard matrix is sufficiently different from that used to establish the Minimum* Level in Appendix II and proposes an appropriate Minimum* Level for their matrix.
5. A discharger uses an analytical method having a quantification practice that is not consistent with the definition of Minimum* Level (e.g., US EPA methods 1613, 1624, 1625).

5. Use of Minimum* Levels

a. Minimum* Levels in Appendix II represent the lowest quantifiable concentration in a sample based on the proper application of method-specific analytical procedures and the absence of matrix interferences. Minimum* Levels also represent the lowest standard concentration in the calibration curve for a specific analytical technique after the application of appropriate method-specific factors.

Common analytical practices may require different treatment of the sample relative to the calibration standard. Some examples are given below:

Substance or Grouping	Method-Specific Treatment	Most Common Factor
Volatile Organics	No differential treatment	1
Semi-Volatile Organics	Samples concentrated by extraction	1000
Metals	Samples diluted or concentrated	½ , 2 , and 4
Pesticides	Samples concentrated by extraction	100

b. Other factors may be applied to the Minimum* Level depending on the specific sample preparation steps employed. For example, the treatment typically applied when there are matrix effects is to dilute the sample or sample aliquot by a factor of ten. In such cases, this additional factor must be applied during the computation of the reporting limit. Application of such factors will alter the reported Minimum* Level.

c. Dischargers are to instruct their laboratories to establish calibration standards so that the Minimum* Level (or its equivalent if there is differential treatment of samples relative to calibration standards) is the lowest calibration standard. At no time is the discharger to use analytical data derived from *extrapolation* beyond the lowest point of the calibration curve. In accordance with Section 4b, above, the discharger's laboratory may employ a calibration standard lower than the Minimum* Level in Appendix II.

* See Appendix I for definition of terms.

6. Sample Reporting Protocols

   a. Dischargers must report with each sample result the reported Minimum* Level (selected in accordance with Section 4, above) and the laboratory's current MDL*.

   b. Dischargers must also report the results of analytical determinations for the presence of chemical constituents in a sample using the following reporting protocols:

      (1) Sample results greater than or equal to the reported Minimum* Level must be reported "as measured" by the laboratory (i.e., the measured chemical concentration in the sample).

      (2) Sample results less than the reported Minimum* Level, but greater than or equal to the laboratory's MDL*, must be reported as "Detected, but Not Quantified", or DNQ. The laboratory must write the estimated chemical concentration of the sample next to DNQ as well as the words "Estimated Concentration" (may be shortened to "Est. Conc.").

      (3) Sample results less than the laboratory's MDL* must be reported as "Not Detected", or ND.

7. Compliance Determination

   Sufficient sampling and analysis shall be required to determine compliance with the effluent limitation.

   a. Compliance with Single-Constituent Effluent Limitations

      Dischargers are out of compliance with the effluent limitation if the concentration of the pollutant (see Section 7c, below) in the monitoring sample is greater than the effluent limitation and greater than or equal to the reported Minimum* Level.

   b. Compliance with Effluent Limitations expressed as a Sum of Several Constituents

      Dischargers are out of compliance with an effluent limitation which applies to the sum of a group of chemicals (e.g., PCB's) if the sum of the individual pollutant concentrations is greater than the effluent limitation. Individual pollutants of the group will be considered to have a concentration of zero if the constituent is reported as ND or DNQ.

   c. Multiple Sample Data Reduction

      The concentration of the pollutant in the effluent may be estimated from the result of a single sample analysis or by a measure of central tendency (arithmetic mean, geometric mean, median, etc.) of multiple sample analyses when all sample results are quantifiable (i.e., greater than or equal to the reported Minimum* Level). When one or more sample results are reported as ND or DNQ, the central tendency concentration of the pollutant shall be the median (middle) value of the multiple samples. If, in an even number of samples, one or both of the middle values is ND or DNQ, the median will be the lower of the two middle values.

* See Appendix I for definition of terms.

d. Powerplants and Heat Exchange Dischargers

Due to the large total volume of powerplant and other heat exchange discharges, special procedures must be applied for determining compliance with Table B objectives on a routine basis. Effluent concentration values (Ce) shall be determined through the use of equation 1 considering the minimal probable initial* dilution of the combined effluent (in-plant waste streams plus cooling water flow). These concentration values shall then be converted to mass emission limitations as indicated in equation 3. The mass emission limits will then serve as requirements applied to all inplant waste* streams taken together which discharge into the cooling water flow, except that limits for total chlorine residual, acute* (if applicable per Section (3)(c)) and chronic* toxicity and instantaneous maximum concentrations in Table B shall apply to, and be measured in, the combined final effluent, as adjusted for dilution with ocean water. The Table B objective for radioactivity shall apply to the undiluted combined final effluent.

8. Pollutant Minimization Program

a. Pollutant Minimization Program Goal

The goal of the Pollutant Minimization Program is to reduce all potential sources of a pollutant through pollutant minimization (control) strategies, including pollution prevention measures, in order to maintain the effluent concentration at or below the effluent limitation.

Pollution prevention measures may be particularly appropriate for persistent bioaccumulative priority pollutants where there is evidence that beneficial uses are being impacted. The completion and implementation of a Pollution Prevention Plan, required in accordance with CA Water Code Section 13263.3 (d) will fulfill the Pollution Minimization Program requirements in this section.

b. Determining the need for a Pollutant Minimization Program

1. The discharger must develop and conduct a Pollutant Minimization Program if all of the following conditions are true:

   (a) The calculated effluent limitation is less than the reported Minimum* Level

   (b) The concentration of the pollutant is reported as DNQ

   (c) There is evidence showing that the pollutant is present in the effluent above the calculated effluent limitation.

2. Alternatively, the discharger must develop and conduct a Pollutant Minimization Program if all of the following conditions are true:

   (a) The calculated effluent limitation is less than the Method Detection Limit*.

   (b) The concentration of the pollutant is reported as ND.

   (c) There is evidence showing that the pollutant is present in the effluent above the calculated effluent limitation.

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* See Appendix I for definition of terms.

c. Regional Boards may include special provisions in the discharge requirements to require the gathering of evidence to determine whether the pollutant is present in the effluent at levels above the calculated effluent limitation. Examples of evidence may include:

1. health advisories for fish consumption,
2. presence of whole effluent toxicity,
3. results of benthic or aquatic organism tissue sampling,
4. sample results from analytical methods more sensitive than methods included in the permit (in accordance with Section 4b, above).
5. the concentration of the pollutant is reported as DNQ and the effluent limitation is less than the MDL

d. Elements of a Pollutant Minimization Program

The Regional Board may consider cost-effectiveness when establishing the requirements of a Pollutant Minimization Program. The program shall include actions and submittals acceptable to the Regional Board including, but not limited to, the following:

1. An annual review and semi-annual monitoring of potential sources of the reportable pollutant, which may include fish tissue monitoring and other bio-uptake sampling;
2. Quarterly monitoring for the reportable pollutant in the influent to the wastewater treatment system;
3. Submittal of a control strategy designed to proceed toward the goal of maintaining concentrations of the reportable pollutant in the effluent at or below the calculated effluent limitation;
4. Implementation of appropriate cost-effective control measures for the pollutant, consistent with the control strategy; and,
5. An annual status report that shall be sent to the Regional Board including:
   (a) All Pollutant Minimization Program monitoring results for the previous year;
   (b) A list of potential sources of the reportable pollutant;
   (c) A summary of all action taken in accordance with the control strategy; and,
   (d) A description of actions to be taken in the following year.

9. Toxicity Reduction Requirements

a. If a discharge consistently exceeds an effluent limitation based on a toxicity objective in Table B, a toxicity reduction evaluation (TRE) is required. The TRE shall include all reasonable steps to identify the source of toxicity. Once the source(s) of toxicity is identified, the discharger shall take all reasonable steps necessary to reduce toxicity to the required level.

* See Appendix I for definition of terms.

b. The following shall be incorporated into waste discharge requirements: (1) a requirement to conduct a TRE if the discharge consistently exceeds its toxicity effluent limitation, and (2) a provision requiring a discharger to take all reasonable steps to reduce toxicity once the source of toxicity is identified.

D. Implementation Provisions for Bacterial Assessment and Remedial Action Requirements

1. The requirements listed below shall be used to determine the occurrence and extent of any impairment of a beneficial use due to bacterial contamination, generate information which can be used in the development of an enterococcus standard, and provide the basis for remedial actions necessary to minimize or eliminate any impairment of a beneficial use.

   a. Measurement of enterococcus density shall be conducted at all stations where measurement of total and fecal coliforms are required. In addition to the requirements of Chapter II.B.I, if a shore station consistently exceeds a coliform objective or exceeds a geometric mean enterococcus density of 24 organisms per 100 ml for a 30-day period or 12 organisms per 100 ml for a six-month period, the Regional Board shall require the appropriate agency to conduct a survey to determine if that agency's discharge is the source of the contamination. The geometric mean shall be a moving average based on no less than five samples per month, spaced evenly over the time interval. When a sanitary survey identifies a controllable source of indicator organisms associated with a discharge of sewage, the Regional Board shall take action to control the source.

   b. Waste discharge requirements shall require the discharger to conduct sanitary surveys when so directed by the Regional Board. Waste discharge requirements shall contain provisions requiring the discharger to control any controllable discharges identified in a sanitary survey.

E. Implementation Provisions For Areas* of Special Biological Significance (ASBS)

1. Waste* shall not be discharged to areas designated as being of special biological significance. Discharges shall be located a sufficient distance from such designated areas to assure maintenance of natural water quality conditions in these areas.

2. Regional Boards may approve waste discharge requirements or recommend certification for limited-term (i.e. weeks or months) activities in ASBS*. Limited-term activities include, but are not limited to, activities such as maintenance/repair of existing boat facilities, restoration of sea walls, repair of existing storm water pipes, and replacement/repair of existing bridges. Limited-term activities may result in temporary and short-term changes in existing water quality. Water quality degradation shall be limited to the shortest possible time. The activities must not permanently degrade water quality or result in water quality lower than that necessary to protect existing uses, and all practical means of minimizing such degradation shall be implemented.

* See Appendix I for definition of terms.

F. Revision of Waste* Discharge Requirements

1. The Regional Board shall revise the waste* discharge requirements for existing* discharges as necessary to achieve compliance with this Plan and shall also establish a time schedule for such compliance.

2. The Regional Boards may establish more restrictive water quality objectives and effluent limitations than those set forth in this Plan as necessary for the protection of beneficial uses of ocean* waters.

3. Regional Boards may impose alternative less restrictive provisions than those contained within Table B of the Plan, provided an applicant can demonstrate that:

   a. Reasonable control technologies (including source control, material substitution, treatment and dispersion) will not provide for complete compliance; or

   b. Any less stringent provisions would encourage water* reclamation;

4. Provided further that:

   a. Any alternative water quality objectives shall be below the conservative estimate of chronic* toxicity, as given in Table D, and such alternative will provide for adequate protection of the marine environment;

   b. A receiving water quality toxicity objective of 1 TUc is not exceeded; and

   c. The State Board grants an exception (Chapter III. I.) to the Table B limits as established in the Regional Board findings and alternative limits.

TABLE D
CONSERVATIVE ESTIMATES OF CHRONIC TOXICITY

Constituent	**Estimate of Chronic Toxicity (ug/l)**
Arsenic	19.
Cadmium	8.
Hexavalent Chromium	18.
Copper	5.
Lead	22.
Mercury	0.4
Nickel	48.
Silver	3.
Zinc	51.
Cyanide	10.
Total Chlorine Residual	10.0
Ammonia	4000.0
Phenolic Compounds (non-chlorinated)	a) (see below)
Chlorinated Phenolics	a)
Chlorinated Pesticides and PCB's	b)

* See Appendix I for definition of terms.

Table D Notes:

a) There are insufficient data for phenolics to estimate chronic toxicity levels. Requests for modification of water quality objectives for these waste* constituents must be supported by chronic toxicity data for representative sensitive species. In such cases, applicants seeking modification of water quality objectives should consult the Regional Water Quality Control Board to determine the species and test conditions necessary to evaluate chronic effects.

b) Limitations on chlorinated pesticides and PCB's shall not be modified so that the total of these compounds is increased above the objectives in Table B.

G. Monitoring Program

1. The Regional Boards shall require dischargers to conduct self-monitoring programs and submit reports necessary to determine compliance with the waste* discharge requirements, and may require dischargers to contract with agencies or persons acceptable to the Regional Board to provide monitoring reports. Monitoring provisions contained in waste discharge requirements shall be in accordance with the Monitoring Procedures provided in Appendix III.

2. Where the Regional Board is satisfied that any substance(s) of Table B will not significantly occur in a discharger's effluent, the Regional Board may elect not to require monitoring for such substance(s), provided the discharger submits periodic certification that such substance(s) is not added to the waste* stream, and that no change has occurred in activities that could cause such substance(s) to be present in the waste* stream. Such election does not relieve the discharger from the requirement to meet the objectives of Table B.

3. The Regional Board may require monitoring of bioaccumulation of toxicants in the discharge zone. Organisms and techniques for such monitoring shall be chosen by the Regional Board on the basis of demonstrated value in waste* discharge monitoring.

H. Discharge Prohibitions

1. Hazardous Substances

   a. The discharge of any radiological, chemical, or biological warfare agent or high-level radioactive waste* into the ocean* is prohibited.

2. Areas Designated for Special Water Quality Protection

   a. Waste* shall not be discharged to designated Areas* of Special Biological Significance except as provided in Chapter III E. Implementation Provisions For Areas of Special Biological Significance..

3. Sludge

   a. Pipeline discharge of sludge to the ocean* is prohibited by federal law; the discharge of municipal and industrial waste* sludge directly to the ocean*, or into

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* See Appendix I for definition of terms.

a waste* stream that discharges to the ocean*, is prohibited by this Plan. The discharge of sludge digester supernatant directly to the ocean*, or to a waste* stream that discharges to the ocean* without further treatment, is prohibited.

b. It is the policy of the SWRCB that the treatment, use and disposal of sewage sludge shall be carried out in the manner found to have the least adverse impact on the total natural and human environment. Therefore, if federal law is amended to permit such discharge, which could affect California waters, the SWRCB may consider requests for exceptions to this section under Chapter III, H. of this Plan, provided further that an Environmental Impact Report on the proposed project shows clearly that any available alternative disposal method will have a greater adverse environmental impact than the proposed project.

4. By-Passing

a. The by-passing of untreated wastes* containing concentrations of pollutants in excess of those of Table A or Table B to the ocean* is prohibited.

I. State Board Exceptions to Plan Requirements

1. The State Board may, in compliance with the California Environmental Quality Act, subsequent to a public hearing, and with the concurrence of the Environmental Protection Agency, grant exceptions where the Board determines:

a. The exception will not compromise protection of ocean* waters for beneficial uses, and,

b. The public interest will be served.

* See Appendix I for definition of terms.

APPENDIX I

DEFINITION OF TERMS

ACUTE TOXICITY

a. Acute Toxicity (TUa)

Expressed in Toxic Units Acute (TUa)

$$TUa = \frac{100}{\text{96-hr LC 50\%}}$$

b. Lethal Concentration 50% (LC 50)

LC 50 (percent waste giving 50% survival of test organisms) shall be determined by static or continuous flow bioassay techniques using standard marine test species as specified in Appendix III, Chapter II. If specific identifiable substances in wastewater can be demonstrated by the discharger as being rapidly rendered harmless upon discharge to the marine environment, but not as a result of dilution, the LC 50 may be determined after the test samples are adjusted to remove the influence of those substances.

When it is not possible to measure the 96-hour LC 50 due to greater than 50 percent survival of the test species in 100 percent waste, the toxicity concentration shall be calculated by the expression:

$$TUa = \frac{\log(100 - S)}{1.7}$$

where:

S = percentage survival in 100% waste. If S > 99, TUa shall be reported as zero.

AREAS OF SPECIAL BIOLOGICAL SIGNIFICANCE (ASBS) are those areas designated by the SWRCB as requiring protection of species or biological communities to the extent that alteration of natural water quality is undesirable.

CHLORDANE shall mean the sum of chlordane-alpha, chlordane-gamma, chlordene-alpha, chlordene-gamma, nonachlor-alpha, nonachlor-gamma, and oxychlordane.

CHRONIC TOXICITY: This parameter shall be used to measure the acceptability of waters for supporting a healthy marine biota until improved methods are developed to evaluate biological response.

a. Chronic Toxicity (TUc)

Expressed as Toxic Units Chronic (TUc)

$$TUc = \frac{100}{NOEL}$$

b. No Observed Effect Level (NOEL)

The NOEL is expressed as the maximum percent effluent or receiving water that causes no observable effect on a test organism, as determined by the result of a critical life stage toxicity test listed in Appendix II.

DDT shall mean the sum of 4,4'DDT, 2,4'DDT, 4,4'DDE, 2,4'DDE, 4,4'DDD, and 2,4'DDD.

DEGRADE: Degradation shall be determined by comparison of the waste field and reference site(s) for characteristic species diversity, population density, contamination, growth anomalies, debility, or supplanting of normal species by undesirable plant and animal species. Degradation occurs if there are significant differences in any of three major biotic groups, namely, demersal fish, benthic invertebrates, or attached algae. Other groups may be evaluated where benthic species are not affected, or are not the only ones affected.

DICHLOROBENZENES shall mean the sum of 1,2- and 1,3-dichlorobenzene.

DOWNSTREAM OCEAN WATERS shall mean waters downstream with respect to ocean currents.

DREDGED MATERIAL: Any material excavated or dredged from the navigable waters of the United States, including material otherwise referred to as "spoil".

ENCLOSED BAYS are indentations along the coast which enclose an area of oceanic water within distinct headlands or harbor works. Enclosed bays include all bays where the narrowest distance between headlands or outermost harbor works is less than 75 percent of the greatest dimension of the enclosed portion of the bay. This definition includes but is not limited to: Humboldt Bay, Bodega Harbor, Tomales Bay, Drakes Estero, San Francisco Bay, Morro Bay, Los Angeles Harbor, Upper and Lower Newport Bay, Mission Bay, and San Diego Bay.

ENDOSULFAN shall mean the sum of endosulfan-alpha and -beta and endosulfan sulfate.

ESTUARIES AND COASTAL LAGOONS are waters at the mouths of streams that serve as mixing zones for fresh and ocean waters during a major portion of the year. Mouths of streams that are temporarily separated from the ocean by sandbars shall be considered as estuaries. Estuarine waters will generally be considered to extend from a bay or the open ocean to the upstream limit of tidal action but may be considered to extend seaward if significant mixing of fresh and salt water occurs in the open coastal waters. The waters described by this definition include but are not limited to the Sacramento-San Joaquin Delta as defined by Section 12220 of the California Water Code, Suisun Bay, Carquinez Strait downstream to Carquinez Bridge, and appropriate areas of the Smith, Klamath, Mad, Eel, Noyo, and Russian Rivers.

HALOMETHANES shall mean the sum of bromoform, bromomethane (methyl bromide) and chloromethane (methyl chloride).

HCH shall mean the sum of the alpha, beta, gamma (lindane) and delta isomers of hexachlorocyclohexane.

INITIAL DILUTION is the process which results in the rapid and irreversible turbulent mixing of wastewater with ocean water around the point of discharge.

For a submerged buoyant discharge, characteristic of most municipal and industrial wastes that are released from the submarine outfalls, the momentum of the discharge and its initial buoyancy act together to produce turbulent mixing. Initial dilution in this case is completed when the diluting wastewater ceases to rise in the water column and first begins to spread horizontally.

For shallow water submerged discharges, surface discharges, and nonbuoyant discharges, characteristic of cooling water wastes and some individual discharges, turbulent mixing results primarily from the momentum of discharge. Initial dilution, in these cases, is considered to be completed when the momentum induced velocity of the discharge ceases to produce significant mixing of the waste, or the diluting plume reaches a fixed distance from the discharge to be specified by the Regional Board, whichever results in the lower estimate for initial dilution.

KELP BEDS, for purposes of the bacteriological standards of this plan, are significant aggregations of marine algae of the genera Macrocystis and Nereocystis. Kelp beds include the total foliage canopy of Macrocystis and Nereocystis plants throughout the water column.

MARICULTURE is the culture of plants and animals in marine waters independent of any pollution source.

MATERIAL: (a) In common usage: (1) the substance or substances of which a thing is made or composed (2) substantial; (b) For purposes of this Ocean Plan relating to waste disposal, dredging and the disposal of dredged material and fill, MATERIAL means matter of any kind or description which is subject to regulation as waste, or any material dredged from the navigable waters of the United States. See also, DREDGED MATERIAL.

MDL (Method Detection Limit) is the minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero, as defined in 40 CFR PART 136 Appendix B.

MINIMUM LEVEL (ML) is the concentrations at which the entire analytical system must give a recognizable signal and acceptable calibration point. The ML is the concentration in a sample that is equivalent to the concentration of the lowest calibration standard analyzed by a specific analytical procedure, assuming that all the method-specified sample weights, volumes and processing steps have been followed.

NATURAL LIGHT: Reduction of natural light may be determined by the Regional Board by measurement of light transmissivity or total irradiance, or both, according to the monitoring needs of the Regional Board.

OCEAN WATERS are the territorial marine waters of the State as defined by California law to the extent these waters are outside of enclosed bays, estuaries, and coastal lagoons. If a discharge outside the territorial waters of the State could affect the quality of the waters of the State, the discharge may be regulated to assure no violation of the Ocean Plan will occur in ocean waters.

<u>PAHs</u> (polynuclear aromatic hydrocarbons) shall mean the sum of acenaphthylene, anthracene, 1,2-benzanthracene, 3,4-benzofluoranthene, benzo[k]fluoranthene, 1,12-benzoperylene, benzo[a]pyrene, chrysene, dibenzo[ah]anthracene, fluorene, indeno[1,2,3-cd]pyrene, phenanthrene and pyrene.

<u>PCBs</u> (polychlorinated biphenyls) shall mean the sum of chlorinated biphenyls whose analytical characteristics resemble those of Aroclor-1016, Aroclor-1221, Aroclor-1232, Aroclor-1242, Aroclor-1248, Aroclor-1254 and Aroclor-1260.

<u>SHELLFISH</u> are organisms identified by the California Department of Health Services as shellfish for public health purposes (i.e., mussels, clams and oysters).

<u>SIGNIFICANT</u> difference is defined as a statistically significant difference in the means of two distributions of sampling results at the 95 percent confidence level.

<u>TCDD EQUIVALENTS</u> shall mean the sum of the concentrations of chlorinated dibenzodioxins (2,3,7,8-CDDs) and chlorinated dibenzofurans (2,3,7,8-CDFs) multiplied by their respective toxicity factors, as shown in the table below.

Isomer Group	Toxicity Equivalence Factor
2,3,7,8-tetra CDD	1.0
2,3,7,8-penta CDD	0.5
2,3,7,8-hexa CDDs	0.1
2,3,7,8-hepta CDD	0.01
octa CDD	0.001
2,3,7,8 tetra CDF	0.1
1,2,3,7,8 penta CDF	0.05
2,3,4,7,8 penta CDF	0.5
2,3,7,8 hexa CDFs	0.1
2,3,7,8 hepta CDFs	0.01
octa CDF	0.001

<u>WASTE</u>: As used in this Plan, waste includes a discharger's total discharge, of whatever origin, <u>i.e.</u>, gross, not net, discharge.

<u>WATER RECLAMATION</u>: The treatment of wastewater to render it suitable for reuse, the transportation of treated wastewater to the place of use, and the actual use of treated wastewater for a direct beneficial use or controlled use that would not otherwise occur.

APPENDIX II
MINIMUM* LEVELS

The Minimum* Levels identified in this appendix represent the lowest concentration of a pollutant that can be quantitatively measured in a sample given the current state of performance in analytical chemistry methods in California. These Minimum* Levels were derived from data provided by state-certified analytical laboratories in 1997 and 1998 for pollutants regulated by the California Ocean Plan and shall be used until new values are adopted by the SWRCB. There are four major chemical groupings: volatile chemicals, semi-volatile chemicals, inorganics, pesticides & PCB's. "No Data" is indicated by "--".

TABLE II-1
MINIMUM* LEVELS – VOLATILE CHEMICALS

		Minimum* Level (ug/L)	
Volatile Chemicals	**CAS Number**	**GC Method [a]**	**GCMS Method [b]**
Acrolein	107028	2.	5
Acrylonitrile	107131	2.	2
Benzene	71432	0.5	2
Bromoform	75252	0.5	2
Carbon Tetrachloride	56235	0.5	2
Chlorobenzene	108907	0.5	2
Chlorodibromomethane	124481	0.5	2
Chloroform	67663	0.5	2
1,2-Dichlorobenzene (volatile)	95501	0.5	2
1,3-Dichlorobenzene (volatile)	541731	0.5	2
1,4-Dichlorobenzene (volatile)	106467	0.5	2
Dichlorobromomethane	75274	0.5	2
1,1-Dichloroethane	75343	0.5	1
1,2-Dichloroethane	107062	0.5	2
1,1-Dichloroethylene	75354	0.5	2
Dichloromethane	75092	0.5	2
1,3-Dichloropropene (volatile)	542756	0.5	2
Ethyl benzene	100414	0.5	2
Methyl Bromide	74839	1.	2
Methyl Chloride	74873	0.5	2
1,1,2,2-Tetrachloroethane	79345	0.5	2
Tetrachloroethylene	127184	0.5	2
Toluene	108883	0.5	2
1,1,1-Trichloroethane	71556	0.5	2
1,1,2-Trichloroethane	79005	0.5	2
Trichloroethylene	79016	0.5	2
Vinyl Chloride	75014	0.5	2

Table II-1 Notes

a) GC Method = Gas Chromatography
b) GCMS Method = Gas Chromatography / Mass Spectrometry
* To determine the lowest standard concentration in an instrument calibration curve for these techniques, use the given ML (see Chapter III, "Use of Minimum* Levels").

TABLE II-2
MINIMUM* LEVELS – SEMI VOLATILE CHEMICALS

Semi-Volatile Chemicals	CAS Number	Minimum* Level (ug/L) GC Method [a,*]	GCMS Method [b,*]	HPLC Method [c,*]	COLOR Method [d]
Acenapthylene	208968	--	10	0.2	--
Anthracene	120127	--	10	2	--
Benzidine	92875	--	5	--	--
Benzo(a)anthracene	56553	--	10	2	--
Benzo(a)pyrene	50328	--	10	2	--
Benzo(b)fluoranthene	205992	--	10	10	--
Benzo(g,h,i)perylene	191242	--	5	0.1	--
Benzo(k)floranthene	207089	--	10	2	--
Bis 2-(1-Chloroethoxy) methane	111911	--	5	--	--
Bis(2-Chloroethyl)ether	111444	10	1	--	--
Bis(2-Chloroisopropyl)ether	39638329	10	2	--	--
Bis(2-Ethylhexyl) phthalate	117817	10	5	--	--
2-Chlorophenol	95578	2	5	--	--
Chrysene	218019	--	10	5	--
Di-n-butyl phthalate	84742	--	10	--	--
Dibenzo(a,h)anthracene	53703	--	10	0.1	--
1,2-Dichlorobenzene (semivolatile)	95504	2	2	--	--
1,3-Dichlorobenzene (semivolatile)	541731	2	1	--	--
1,4-Dichlorobenzene (semivolatile)	106467	2	1	--	--
3,3-Dichlorobenzidine	91941	--	5	--	--
2,4-Dichlorophenol	120832	1	5	--	--
1,3-Dichloropropene	542756	--	5	--	
Diethyl phthalate	84662	10	2	--	--
Dimethyl phthalate	131113	10	2	--	--
2,4-Dimethylphenol	105679	1	2	--	--
2,4-Dinitrophenol	51285	5	5	--	--
2,4-Dinitrotoluene	121142	10	5	--	--
1,2-Diphenylhydrazine	122667	--	1	--	--
Fluoranthene	206440	10	1	0.05	--
Fluorene	86737	--	10	0.1	--
Hexachlorobenzene	118741	5	1	--	--
Hexachlorobutadiene	87683	5	1	--	--
Hexachlorocyclopentadiene	77474	5	5	--	--

Table II-2 continued on next page...

Table II-2 (Continued)
Minimum* Levels – Semi Volatile Chemicals

Semi-Volatile Chemicals	CAS Number	Minimum* Level (ug/L) GC Method [a,*]	GCMS Method [b,*]	HPLC Method [c,*]	COLOR Method [d]
Hexachloroethane	67721	5	1	--	--
Indeno(1,2,3-cd)pyrene	193395	--	10	0.05	--
Isophorone	78591	10	1	--	--
2-methyl-4,6-dinitrophenol	534521	10	5	--	--
3-methyl-4-chlorophenol	59507	5	1	--	--
N-nitrosodi-n-propylamine	621647	10	5	--	--
N-nitrosodimethylamine	62759	10	5	--	--
N-nitrosodiphenylamine	86306	10	1	--	--
Nitrobenzene	98953	10	1	--	--
2-Nitrophenol	88755	--	10	--	--
4-Nitrophenol	100027	5	10	--	--
Pentachlorophenol	87865	1	5	--	--
Phenanthrene	85018	--	5	0.05	--
Phenol	108952	1	1	--	50
Pyrene	129000	--	10	0.05	--
2,4,6-Trichlorophenol	88062	10	10	--	--

Table II-2 Notes:

a) GC Method = Gas Chromatography
b) GCMS Method = Gas Chromatography / Mass Spectrometry
c) HPLC Method = High Pressure Liquid Chromatography
d) COLOR Method = Colorimetric

* To determine the lowest standard concentration in an instrument calibration curve for this technique, multiply the given ML by 1000 (see Chapter III, "Use of Minimum* Levels").

TABLE II-3
MINIMUM* LEVELS - INORGANICS

Inorganic Substances	CAS Number	Minimum* Level (ug/L)								
		COLOR Method[a]	DCP Method[b]	FAA Method[c]	GFAA Method[d]	HYDRIDE Method[e]	ICP Method[f]	ICPMS Method[g]	SPGFAA Method[h]	CVAA Method[i]
Antimony	7440360	--	1000.	10.	5.	0.5	50.	0.5	5.	--
Arsenic	7440382	20.	1000.	--	2.	1.	10.	2.	2.	--
Beryllium	7440417	--	1000.	20.	0.5	--	2.	0.5	1.	--
Cadmium	7440439	--	1000.	10.	0.5	--	10.	0.2	0.5	--
Chromium (total)	--	--	1000.	50.	2.	--	10.	0.5	1.	--
Chromium (VI)	18540299	10.	--	5.	--	--	--	--	--	--
Copper	7440508	--	1000.	20.	5.	--	10.	0.5	2.	--
Cyanide	57125	5.	--	--	--	--	--	--	--	--
Lead	7439921	--	10000.	20.	5.	--	5.	0.5	2.	--
Mercury	7439976	--	--	--	--	--	--	0.5	--	0.2
Nickel	7440020	--	1000.	50.	5.	--	20.	1.	5.	--
Selenium	7782492	--	1000.	--	5.	1.	10.	2.	5.	--
Silver	7440224	--	1000.	10.	1.	--	10.	0.2	2.	--
Thallium	7440280	--	1000.	10.	2.	--	10.	1.	5.	--
Zinc	7440666	--	1000.	20.	--	--	20.	1.	10.	--

Table II-3 Notes

a) COLOR Method = Colorimetric
b) DCP Method = Direct Current Plasma
c) FAA Method = Flame Atomic Absorption
d) GFAA Method = Graphite Furnace Atomic Absorption
e) HYDRIDE Method = Gaseous Hydride Atomic Absorption
f) ICP Method = Inductively Coupled Plasma
g) ICPMS Method = Inductively Coupled Plasma / Mass Spectrometry
h) SPGFAA Method = Stabilized Platform Graphite Furnace Atomic Absorption (i.e., US EPA 200.9)
i) CVAA Method = Cold Vapor Atomic Absorption

* To determine the lowest standard concentration in an instrument calibration curve for these techniques, use the given ML (see Chapter III, "Use of Minimum* Levels").

TABLE II-4
MINIMUM* LEVELS – PESTICIDES AND PCBs

Pesticides – PCB's	CAS Number	Minimum* Level (ug/L) GC Method[a],*
Aldrin	309002	0.005
Chlordane	57749	0.1
4,4'-DDD	72548	0.05
4,4'-DDE	72559	0.05
4,4'-DDT	50293	0.01
Dieldrin	60571	0.01
a-Endosulfan	959988	0.02
b-Endosulfan	33213659	0.01
Endosulfan Sulfate	1031078	0.05
Endrin	72208	0.01
Heptachlor	76448	0.01
Heptachlor Epoxide	1024573	0.01
a-Hexachlorocyclohexane	319846	0.01
b-Hexachlorocyclohexane	319857	0.005
d-Hexachlorocyclohexane	319868	0.005
g-Hexachlorocyclohexane (Lindane)	58899	0.02
PCB 1016	--	0.5
PCB 1221	--	0.5
PCB 1232	--	0.5
PCB 1242	--	0.5
PCB 1248	--	0.5
PCB 1254	--	0.5
PCB 1260	--	0.5
Toxaphene	8001352	0.5

Table II-4 Notes

a) GC Method = Gas Chromatography

* To determine the lowest standard concentration in an instrument calibration curve for this technique, multiply the given ML by 100 (see Chapter III, "Use of Minimum* Levels").

APPENDIX III

STANDARD MONITORING PROCEDURES

The purpose of this appendix is to provide direction to the Regional Boards on the implementation of the California Ocean Plan and to ensure the reporting of useful information. It is not feasible to cover all circumstances and conditions that could be encountered by all dischargers. Therefore, this appendix should be considered as the basic component of any discharger monitoring program. Regional Boards can deviate from the procedures required in the appendix only with the approval of the State Water Resources Control Board unless the Ocean Plan allows for the selection of alternate protocols by the Regional Boards. If no direction is given in this appendix for a specific provision of the Ocean Plan, it is within the discretion of the Regional Board to establish the monitoring requirements for the provision.

The following text is referenced by applicable chapter in the Ocean Plan. All references to 40 CFR PART 136 are to the revised edition of May 14, 1999.

Ocean Plan Chapter II. B. Bacterial Standards:

For all bacterial analyses, sample dilutions should be performed so the range of values extends from 2 to 16,000. The detection methods used for each analysis shall be reported with the results of the analysis.

Detection methods used for coliforms (total and fecal) shall be those presented in Table 1A of 40 CFR PART 136, unless alternate methods have been approved in advance by US EPA pursuant to 40 CFR PART 136.

Detection methods used for enterococcus shall be those presented in EPA publication EPA 600/4-85/076, Test Methods for *Escherichia coli* and Enterococci in Water By Membrane Filter Procedure or any improved method determined by the Regional Board to be appropriate.

Ocean Plan Chapter II. H Table B. Compliance with Table B Objectives:

Procedures, calibration techniques, and instrument/reagent specifications used to determine compliance with Table B shall conform to the requirements of federal regulations (40 CFR PART 136). All methods shall be specified in the monitoring requirement section of waste discharge requirements.

Where methods are not available in 40 CFR PART 136, the Regional Boards shall specify suitable analytical methods in waste discharge requirements. Acceptance of data should be predicated on demonstrated laboratory performance.

Laboratories analyzing monitoring data shall be certified by the Department of Health Services, in accordance with the provisions of Section 13176 CWC, and must include quality assurance quality control data with their reports.

The State or Regional Board may, subject to EPA approval, specify test methods which are more sensitive than those specified in 40 CFR PART 136. Total chlorine residual is likely to be a method detection limit effluent limitation in many cases. The limit of detection of total chlorine residual in standard test methods is less than or equal to 20 ug/l.

Monitoring for the substances in Table B shall be required periodically. For discharges less than 1 MGD (million gallons per day), the monitoring of all the Table B parameters should consist of at least one complete scan of the Table B constituents one time in the life of the waste discharge requirements. For discharges between 1 and 10 MGD, the monitoring frequency shall be at least one complete scan of the Table B substances annually. Discharges greater than 10 MGD shall be required to monitor at least semiannually.

Compliance monitoring for the acute toxicity objective (TUa) in Table B shall be determined using an US EPA approved protocol as provided in 40 CFR PART 136. Acute toxicity monitoring requirements in permits prepared by the Regional Boards shall use marine test species instead of freshwater species when measuring compliance.

The Regional Board shall require the use of critical life stage toxicity tests specified in this Appendix to measure TUc. Other species or protocols will be added to the list after SWRCB review and approval. A minimum of three test species with approved test protocols shall be used to measure compliance with the toxicity objective. If possible, the test species shall include a fish, an invertebrate, and an aquatic plant. After a screening period, monitoring can be reduced to the most sensitive species. Dilution and control water should be obtained from an unaffected area of the receiving waters. The sensitivity of the test organisms to a reference toxicant shall be determined concurrently with each bioassay test and reported with the test results.

Use of critical life stage bioassay testing shall be included in waste discharge requirements as a monitoring requirement for all discharges greater than 100 MGD by January 1, 1991 at the latest. For other major dischargers, critical life stage bioassay testing shall be included as a monitoring requirement one year before the waste discharge requirement is scheduled for renewal.

The tests presented in Table III-1 shall be used to measure TUc. Other tests may be added to the list when approved by the State Board.

TABLE III-1
APPROVED TESTS – CHRONIC TOXICITY (TUc)

Species	Effect	Tier	Reference
giant kelp, *Macrocystis pyrifera*	percent germination; germ tube length	1	1,3
red abalone, *Haliotis rufescens*	Abnormal shell development	1	1,3
oyster, *Crassostrea gigas*; mussels, *Mytilus spp.*	Abnormal shell development; percent survival	1	1,3
urchin, *Strongylocentrotus purpuratus*; sand dollar, *Dendraster excentricus*	Percent normal development	1	1,3
urchin, *Strongylocentrotus purpuratus*; sand dollar, *Dendraster excentricus*	Percent fertilization	1	1,3
shrimp, *Holmesimysis costata*	Percent survival; growth	1	1,3
shrimp, *Mysidopsis bahia*	Percent survival; growth; fecundity	2	2,4
topsmelt, *Atherinops affinis*	Larval growth rate; percent survival	1	1,3
Silversides, *Menidia beryllina*	Larval growth rate; percent survival	2	2,4

Table III-1 Notes

The first tier test methods are the preferred toxicity tests for compliance monitoring. A Regional Board can approve the use of a second tier test method for waste discharges if first tier organisms are not available.

Protocol References

1. Chapman, G.A., D.L. Denton, and J.M. Lazorchak. 1995. Short-term methods for estimating the chronic toxicity of effluents and receiving waters to west coast marine and estuarine organisms. U.S. EPA Report No. EPA/600/R-95/136.

2. Klemm, D.J., G.E. Morrison, T.J. Norberg-King, W.J. Peltier, and M.A. Heber. 1994. Short-term methods for estimating the chronic toxicity of effluents and receiving water to marine and estuarine organisms. U.S. EPA Report No. EPA-600-4-91-003.

3. SWRCB 1996. Procedures Manual for Conducting Toxicity Tests Developed by the Marine Bioassay Project. 96-1WQ.

4. Weber, C.I., W.B. Horning, I.I., D.J. Klemm, T.W. Nieheisel, P.A. Lewis, E.L. Robinson, J. Menkedick and F. Kessler (eds). 1988. Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Marine and Estuarine Organisms. EPA/600/4-87/028. National Information Service, Springfield, VA.

APPENDIX IV

PROCEDURES FOR THE NOMINATION AND DESIGNATION OF AREAS* OF SPECIAL BIOLOGICAL SIGNIFICANCE (ASBS).

1. Any person may nominate areas of ocean waters for designation as ASBS by the SWRCB. Nominations shall be made to the appropriate RWQCB and shall include:

   (a) Information such as maps, reports, data, statements, and photographs to show that:

      (1) Candidate areas are located in ocean waters as defined in the "Ocean Plan".

      (2) Candidate areas are intrinsically valuable or have recognized value to man for scientific study, commercial use, recreational use, or esthetic reasons.

      (3) Candidate areas need protection beyond that offered by waste discharge restrictions or other administrative and statutory mechanisms.

   (b) Data and information to indicate whether the proposed designation may have a significant effect on the environment.

      (1) If the data or information indicate that the proposed designation will have a significant effect on the environment, the nominee must submit sufficient information and data to identify feasible changes in the designation that will mitigate or avoid the significant environmental effects.

2. The SWRCB or a RWQCB may also nominate areas for designation as ASBS on their own motion.

3. A RWQCB may decide to (a) consider individual ASBS nominations upon receipt, (b) consider several nominations in a consolidated proceeding, or (c) consider nominations in the triennial review of its water quality control plan (basin plan). A nomination that meets the requirements of 1. above may be considered at any time but not later than the next scheduled triennial review of the appropriate basin plan or Ocean Plan.

4. After determining that a nomination meets the requirements of paragraph 1. above, the Executive Officer of the affected RWQCB shall prepare a Draft Nomination Report containing the following:

   (a) The area or areas nominated for designation as ASBS.

   (b) A description of each area including a map delineating the boundaries of each proposed area.

   (c) A recommendation for action on the nomination(s) and the rationale for the recommendation. If the Draft Nomination Report recommends approval of the proposed designation, the Draft Nomination Report shall comply with the CEQA documentation requirements for a water quality control plan amendment in Section 3777, Title 23, California Code of Regulations.

5. The Executive Officer shall, at a minimum, seek informal comment on the Draft Nomination Report from the SWRCB, Department of Fish and Game, other interested state and federal agencies, conservation groups, affected waste dischargers, and other interested parties. Upon incorporation of responses from the consulted agencies, the Draft Nomination Report shall become the Final Nomination Report.

6. (a) If the Final Nomination Report recommends approval of the proposed designation, the Executive Officer shall ensure that processing of the nomination complies with the CEQA consultation requirements in Section 3778, Title 23, California Code of Regulations and proceed to step 7 below.

   (b) If the Final Nomination Report recommends against approval of the proposed designation, the Executive Officer shall notify interested parties of the decision. No further action need be taken. The nominating party may seek reconsideration of the decision by the RWQCB itself.

7. The RWQCB shall conduct a public hearing to receive testimony on the proposed designation. Notice of the hearing shall be published three times in a newspaper of general circulation in the vicinity of the proposed area or areas and shall be distributed to all known interested parties 45 days in advance of the hearing. The notice shall describe the location, boundaries, and extent of the area or areas under consideration, as well as proposed restrictions on waste discharges within the area.

8. The RWQCB shall respond to comments as required in Section 3779, Title 23, California Code of Regulations, and 40 C.F.R. Part 25 (July 1, 1999).

9. The RWQCB shall consider the nomination after completing the required public review processes required by CEQA.

   (a) If the RWQCB supports the recommendation for designation, the board shall forward to the SWRCB its recommendation for approving designation of the proposed area or areas and the supporting rationale. The RWQCB submittal shall include a copy of the staff report, hearing transcript, comments, and responses to comments.

   (b) If the RWQCB does not support the recommendation for designation, the Executive Officer shall notify interested parties of the decision, and no further action need be taken.

10. After considering the RWQCB recommendation and hearing record, the SWRCB may approve or deny the recommendation, refer the matter to the RWQCB for appropriate action, or conduct further hearing itself. If the SWRCB acts to approve a recommended designation, the SWRCB shall amend Appendix V, Table V-1, of this Plan. The amendment will go into effect after approval by the Office of Administrative Law and US EPA. In addition, after the effective date of a designation, the affected RWQCB shall revise its water quality control plan in the next triennial review to include the designation.

11. The SWRCB Executive Director shall advise other agencies to whom the list of designated areas is to be provided that the basis for an ASBS designation is limited to protection of marine life from waste discharges.

APPENDIX V

AREAS* OF SPECIAL BIOLOGICAL SIGNIFICANCE

TABLE V-1
AREAS OF SPECIAL BIOLOGICAL SIGNIFICANCE
(DESIGNATED OR APPROVED BY THE STATE WATER RESOURCES CONTROL BOARD)

No.	ASBS Name	Date Designated	SWRCB Resolution No.	Region No.
1.	Pygmy Forest Ecological Staircase	March 21, 1974,	74-28	1
2.	Del Mar Landing Ecological Reserve	March 21, 1974,	74-28	1
3.	Gerstle Cove	March 21, 1974,	74-28	1
4.	Bodega Marine Life Refuge	March 21, 1974,	74-28	1
5.	Kelp Beds at Saunders Reef	March 21, 1974,	74-28	1
6.	Kelp Beds at Trinidad Head	March 21, 1974,	74-28	1
7.	Kings Range National Conservation Area	March 21, 1974,	74-28	1
8.	Redwoods National Park	March 21, 1974,	74-28	1
9.	James V. Fitzgerald Marine Reserve	March 21, 1974,	74-28	2
10.	Farallon Island	March 21, 1974,	74-28	2
11.	Duxbury Reef Reserve and Extension	March 21, 1974,	74-28	2
12.	Point Reyes Headland Reserve and Extension	March 21, 1974,	74-28	2
13.	Double Point	March 21, 1974,	74-28	2
14.	Bird Rock	March 21, 1974,	74-28	2
15.	Ano Nuevo Point and Island	March 21, 1974,	74-28	3
16.	Point Lobos Ecological Reserve	March 21, 1974,	74-28	3
17.	San Miguel, Santa Rosa, and Santa Cruz Islands	March 21, 1974,	74-28	4
18.	Julia Pfeiffer Burns Underwater Park	March 21, 1974,	74-28	3
19.	Pacific Grove Marine Gardens Fish Refuge and Hopkins Marine Life Refuge	March 21, 1974,	74-28	3
20.	Ocean Area Surrounding the Mouth of Salmon Creek	March 21, 1974,	74-28	3
21.	San Nicolas Island and Begg Rock	March 21, 1974,	74-28	4
22.	Santa Barbara Island, Santa Barbara County and Anacapa Island	March 21, 1974,	74-28	4
23.	San Clemente Island	March 21, 1974,	74-28	4

Table V-1 Continued on next page...

Table V-1 (Continued)

Areas of Special Biological Significance
(Designated or Approved by the State Water Resources Control Board)

No.	ASBS Name	Date Designated	SWRCB Resolution No.	Region No.
24.	Mugu Lagoon to Latigo Point	March 21, 1974,	74-28	4
25.	Santa Catalina Island – Subarea One, Isthmus Cove to Catalina Head	March 21, 1974,	74-28	4
26.	Santa Catalina Island - Subarea Two, North End of Little Harbor to Ben Weston Point	March 21, 1974,	74-28	4
27.	Santa Catalina Island - Subarea Three, Farnsworth Bank Ecological Reserve	March 21, 1974,	74-28	4
28.	Santa Catalina Island - Subarea Four, Binnacle Rock to Jewfish Point	March 21, 1974,	74-28	4
29.	San Diego-La Jolla Ecological Reserve	March 21, 1974,	74-28	9
30.	Heisler Park Ecological Reserve	March 21, 1974,	74-28	9
31.	San Diego Marine Life Refuge	March 21, 1974,	74-28	9
32.	Newport Beach Marine Life Refuge	April 18, 1974	74-32	8
33.	Irvine Coast Marine Life Refuge	April 18, 1974	74-32	8
34.	Carmel Bay	June 19, 1975	75-61	3

REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	TMDL PRIORITY	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION
3	R	Tembladero Slough	30911010					
				Fecal Coliform		Low	5 Miles	
					Agriculture Pasture Grazing-Riparian and/or Upland Urban Runoff/Storm Sewers Natural Sources			
				Nutrients		Low	5 Miles	
					Agriculture Irrigated Crop Production Agriculture-storm runoff Agriculture-irrigation tailwater Agricultural Return Flows Nonpoint Source			
				Pesticides		Medium	5 Miles	
					Agriculture Irrigated Crop Production Agriculture-storm runoff Agricultural Return Flows Nonpoint Source			
3	R	Watsonville Slough	30510030					
				Pathogens		Medium	6.2 Miles	
					Urban Runoff/Storm Sewers Source Unknown Nonpoint Source			
				Pesticides		Low	6.2 Miles	
					Agriculture Irrigated Crop Production Agriculture-storm runoff Agriculture-irrigation tailwater Nonpoint Source			
				Sedimentation/Siltation		Medium	6.2 Miles	
					Agriculture Irrigated Crop Production Agriculture-storm runoff Nonpoint Source			
4	C	Abalone Cove Beach	40511000					
				Beach Closures		High	1.1 Miles	2002
					Nonpoint Source			
				DDT (sediment)		Low	1.1 Miles	
					Nonpoint Source			

2002 CWA SECTION 303(d) LIST OF ... ER QUALITY LIMITED SEGMENTS

(For Irrigated Agricultural Sources)

REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	TMDL PRIORITY	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION
				PCBs *Fish Consumption Advisory for PCBs.*	Nonpoint Source	Low	1.1 Miles	
4	R	Aliso Canyon Wash	40521000					
				Selenium	Nonpoint Source	High	10 Miles	2003
4	C	Amarillo Beach	40431000					
				DDT *Fish Consumption Advisory for DDT.*	Nonpoint Source	Low	0.64 Miles	
				PCBs *Fish Consumption Advisory for PCBs.*	Nonpoint Source	Low	0.64 Miles	
4	R	Arroyo Seco Reach 1 (LA River to West Holly Ave.)	40515010					
				Algae	Nonpoint Source	High	5.2 Miles	2002
				High Coliform Count	Nonpoint Source	High	5.2 Miles	2002
				Trash	Nonpoint Source	Low	5.2 Miles	
4	R	Arroyo Seco Reach 2 (Figueroa St. to Riverside Dr.)	40515010					
				Algae	Nonpoint Source	High	4.4 Miles	2002
				High Coliform Count	Nonpoint Source	High	4.4 Miles	2002
				Trash	Nonpoint Source	Low	4.4 Miles	
4	C	Avalon Beach	40511000					
				Bacteria Indicators *Area affected is between Pier and BB restaurant (2/3), between Pier and BB restaurant (1/3), between storm drain and Pier (1/3). and between BB restaurant and the Tuna Club.*	Nonpoint/Point Source	Low	0.67 Miles	
4	R	Ballona Creek	40513000					
				Cadmium (sediment)	Nonpoint/Point Source	High	6.5 Miles	2004
				ChemA (tissue)	Source Unknown	High	6.5 Miles	2004

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REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	TMDL PRIORITY	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION
				Chlordane (tissue)	Nonpoint/Point Source	High	6.5 Miles	2004
				Copper, Dissolved	Nonpoint Source	High	6.5 Miles	2004
				DDT (tissue)	Nonpoint/Point Source	High	6.5 Miles	2004
				Dieldrin (tissue)	Nonpoint/Point Source	High	6.5 Miles	2004
				Enteric Viruses	Nonpoint/Point Source	High	6.5 Miles	2003
				High Coliform Count	Nonpoint/Point Source	High	6.5 Miles	2003
				Lead, Dissolved	Nonpoint Source	High	6.5 Miles	2004
				PCBs (tissue)	Nonpoint/Point Source	High	6.5 Miles	2004
				pH	Urban Runoff/Storm Sewers Nonpoint Source	Low	6.5 Miles	
				Sediment Toxicity	Nonpoint/Point Source	High	6.5 Miles	2004
				Selenium, Total	Urban Runoff/Storm Sewers Nonpoint Source	Low	6.5 Miles	
				Silver (sediment)	Nonpoint Source	Low	6.5 Miles	
				Toxicity	Nonpoint/Point Source	High	6.5 Miles	2004
				Zinc, Dissolved	Urban Runoff/Storm Sewers Nonpoint Source	Low	6.5 Miles	
4	R	Ballona Creek Estuary	40513000					
				Chlordane (tissue & sediment)	Nonpoint/Point Source	High	2.3 Miles	2004
				DDT (sediment)	Nonpoint/Point Source	High	2.3 Miles	2004
				High Coliform Count	Nonpoint/Point Source	High	2.3 Miles	2003

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(For Irrigated Agricultural Sources)

REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	TMDL PRIORITY	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION
				Lead (sediment)	Nonpoint/Point Source	High	2.3 Miles	2004
				PAHs (sediment)	Nonpoint/Point Source	Low	2.3 Miles	
				PCBs (tissue & sediment)	Nonpoint/Point Source	High	2.3 Miles	2004
				Sediment Toxicity	Nonpoint/Point Source	High	2.3 Miles	2004
				Shellfish Harvesting Advisory	Nonpoint/Point Source	High	2.3 Miles	2003
				Zinc (sediment)	Nonpoint/Point Source	High	2.3 Miles	2003
4	T	Ballona Creek Wetlands	40517000					
				Exotic Vegetation	Nonpoint Source	Low	289 Acres	
				Habitat alterations	Nonpoint Source	Low	289 Acres	
				Hydromodification	Nonpoint Source	Low	289 Acres	
				Reduced Tidal Flushing	Nonpoint Source	Low	289 Acres	
				Trash	Nonpoint Source	Low	289 Acres	
4	C	Big Rock Beach	40431000					
				Beach Closures	Nonpoint Source	High	0.74 Miles	2002
				DDT *Fish consumption advisory for DDT.*	Nonpoint Source	Low	0.74 Miles	
				High Coliform Count	Nonpoint Source	High	0.74 Miles	2002
				PCBs *Fish Consumption Advisory for PCBs.*	Nonpoint Source	Low	0.74 Miles	
4	C	Bluff Cove Beach	40511000					
				Beach Closures	Nonpoint Source	High	0.55 Miles	2002

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REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	TMDL PRIORITY	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION
				DDT *Fish Consumption Advisory for DDT.*	Nonpoint Source	Low	0.55 Miles	
				PCBs *Fish Consumption Advisory for PCBs.*	Nonpoint Source	Low	0.55 Miles	
4	C	Cabrillo Beach (Inner) LA Harbor Area	40512000					
				Beach Closures (Coliform)	Nonpoint Source	High	0.56 Miles	2004
				DDT *Fish consumption advisory for DDT.*	Nonpoint Source	Medium	0.56 Miles	
				PCBs *Fish consumption advisory for PCBs.*	Nonpoint Source	Medium	0.56 Miles	
4	C	Cabrillo Beach (Outer)	40512000					
				Beach Closures	Nonpoint Source	High	0.58 Miles	2002
				DDT *Fish consumption advisory for DDT.*	Nonpoint Source	Low	0.58 Miles	
				High Coliform Count	Nonpoint Source	High	0.58 Miles	2002
				PCBs *Fish consumption advisory for PCBs.*	Nonpoint Source	Low	0.58 Miles	
4	E	Calleguas Creek Reach 1 (was Mugu Lagoon on 1998 303(d) list)	40311000					
				Chlordane (tissue)	Nonpoint Source	Medium	344 Acres	
				Copper	Nonpoint/Point Source	Medium	344 Acres	
				DDT (tissue & sediment)	Nonpoint Source	Medium	344 Acres	
				Endosulfan (tissue)	Nonpoint Source	Medium	344 Acres	
				Mercury	Nonpoint/Point Source	Medium	344 Acres	
				Nickel	Nonpoint/Point Source	Medium	344 Acres	

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REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	TMDL PRIORITY	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION
				Nitrogen	Nonpoint/Point Source	High	344 Acres	2002
				PCBs (tissue)	Nonpoint/Point Source	Medium	344 Acres	
				Sediment Toxicity	Nonpoint/Point Source	Medium	344 Acres	
				Sedimentation/Siltation	Agriculture Natural Sources	Medium	344 Acres	
				Zinc	Nonpoint/Point Source	Medium	344 Acres	
4	R	Calleguas Creek Reach 2 (estuary to Potrero Rd- was Calleguas Creek Reaches 1 and 2 on 1998 303d list)	40312000					
				Ammonia	Nonpoint/Point Source	High	4.3 Miles	2002
				ChemA (tissue) *Historical use of pesticides and lubricants.*	Nonpoint Source	Medium	4.3 Miles	
				Chlordane (tissue)	Nonpoint Source	Medium	4.3 Miles	
				Copper, Dissolved	Nonpoint Source	Low	4.3 Miles	
				DDT	Nonpoint Source	Low	4.3 Miles	
				DDT (tissue & sediment)	Nonpoint Source	Medium	4.3 Miles	
				Endosulfan (tissue)	Nonpoint Source	Medium	4.3 Miles	
				Fecal Coliform *Area affected is at the mouth of the creek.*	Nonpoint/Point Source	Low	4.3 Miles	
				Nitrogen	Nonpoint/Point Source	High	4.3 Miles	2002
				PCBs (tissue)	Nonpoint/Point Source	Medium	4.3 Miles	
				Sediment Toxicity	Nonpoint/Point Source	Medium	4.3 Miles	

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REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	TMDL PRIORITY	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION
				Sedimentation/Siltation	Agriculture Natural Sources	Low	4.3 Miles	
				Toxaphene (tissue & sediment)	Nonpoint Source	Low	4.3 Miles	
4	R	Calleguas Creek Reach 3 (Potrero Road upstream to confluence with Conejo Creek on 1998 303d list)	40312000					
				Chloride	Nonpoint/Point Source	Medium	3.5 Miles	
				Nitrate and Nitrite	Nonpoint/Point Source	High	3.5 Miles	2002
				Sedimentation/Siltation	Agriculture Natural Sources	Low	3.5 Miles	
				Total Dissolved Solids	Nonpoint/Point Source	High	3.5 Miles	2003
4	R	Calleguas Creek Reach 4 (was Revolon Slough Main Branch: Mugu Lagoon to Central Avenue on 1998 303d list)	40311000					
				Algae	Nonpoint Source	High	7.2 Miles	2002
				Boron *This listing was made by USEPA.*	Nonpoint Source	Medium	7.2 Miles	
				ChemA (tissue) *Historical use of pesticides and lubricants.*	Nonpoint Source	Medium	7.2 Miles	
				Chlordane (tissue & sediment)	Nonpoint Source	Medium	7.2 Miles	
				Chlorpyrifos (tissue)	Nonpoint Source	Medium	7.2 Miles	
				DDT (tissue & sediment)	Nonpoint Source	Medium	7.2 Miles	
				Dieldrin (tissue)	Nonpoint Source	Medium	7.2 Miles	
				Endosulfan (tissue & sediment)	Nonpoint Source	Medium	7.2 Miles	
				Fecal Coliform	Nonpoint/Point Source	Low	7.2 Miles	

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REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	TMDL PRIORITY	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION
				Nitrate as Nitrate (NO3)	Nonpoint/Point Source	Low	7.2 Miles	
				Nitrogen	Nonpoint Source	High	7.2 Miles	2002
				PCBs (tissue)	Nonpoint Source	Medium	7.2 Miles	
				Sedimentation/Siltation	Agriculture Natural Sources	Low	7.2 Miles	
				Selenium	Nonpoint Source	Medium	7.2 Miles	
				Sulfates *This listing was made by USEPA.*	Nonpoint Source	Medium	7.2 Miles	
				Total Dissolved Solids *This listing was made by USEPA.*	Nonpoint Source	Medium	7.2 Miles	
				Toxaphene (tissue & sediment)	Nonpoint Source	Medium	7.2 Miles	
				Toxicity	Nonpoint Source	High	7.2 Miles	2004
				Trash	Nonpoint Source	Low	7.2 Miles	
4	R	Calleguas Creek Reach 5 (was Beardsley Channel on 1998 303d list)	40311000					
				Algae	Nonpoint Source	High	4.3 Miles	2002
				ChemA (tissue)	Nonpoint Source	Medium	4.3 Miles	
				Chlordane (tissue & sediment)	Nonpoint Source	Medium	4.3 Miles	
				Chlorpyrifos (tissue)	Nonpoint Source	High	4.3 Miles	2003
				Dacthal (sediment)	Nonpoint Source	Medium	4.3 Miles	
				DDT (tissue & sediment)	Nonpoint Source	Medium	4.3 Miles	
				Dieldrin (tissue)	Nonpoint Source	Medium	4.3 Miles	

REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	TMDL PRIORITY	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION
				Endosulfan (tissue & sediment)	Nonpoint Source	Medium	4.3 Miles	
				Nitrogen	Nonpoint Source	High	4.3 Miles	2002
				PCBs (tissue)	Nonpoint Source	Medium	4.3 Miles	
				Sedimentation/Siltation	Agriculture Natural Sources	Low	4.3 Miles	
				Toxaphene (tissue & sediment)	Nonpoint Source	Medium	4.3 Miles	
				Toxicity	Nonpoint Source	High	4.3 Miles	2004
				Trash	Nonpoint Source	Low	4.3 Miles	
4	R	Calleguas Creek Reach 6 (was Arroyo Las Posas Reaches 1 and 2 on 1998 303d list)	40362000					
				Ammonia	Nonpoint/Point Source	High	15 Miles	2002
				Chloride	Nonpoint/Point Source	Medium	15 Miles	
				DDT (sediment)	Nonpoint Source	Medium	15 Miles	
				Fecal Coliform	Nonpoint/Point Source	Low	15 Miles	
				Nitrate and Nitrite	Nonpoint/Point Source	High	15 Miles	2002
				Nitrate as Nitrate (NO3)	Nonpoint/Point Source	High	15 Miles	2002
				Sedimentation/Siltation	Agriculture Natural Sources	Low	15 Miles	
				Sulfates	Nonpoint/Point Source	High	15 Miles	2003
				Total Dissolved Solids	Nonpoint/Point Source	High	15 Miles	2003

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REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	TMDL PRIORITY	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION
4	R	Calleguas Creek Reach 7 (was Arroyo Simi Reaches 1 and 2 on 1998 303d list)	40367000					
				Ammonia	Nonpoint/Point Source	High	14 Miles	2002
				Boron	Nonpoint Source	High	14 Miles	2003
				Chloride	Nonpoint Source	Medium	14 Miles	
				Fecal Coliform	Nonpoint Source	Low	14 Miles	
				Organophosphorus Pesticides	Municipal Point Sources Agriculture	Low	14 Miles	
				Sedimentation/Siltation	Agriculture Natural Sources	Low	14 Miles	
				Sulfates	Nonpoint Source	High	14 Miles	2003
				Total Dissolved Solids	Nonpoint Source	High	14 Miles	2003
4	R	Calleguas Creek Reach 8 (was Tapo Canyon Reach 1)	40366000					
				Boron	Nonpoint/Point Source	High	7.2 Miles	2003
				Chloride	Nonpoint/Point Source	High	7.2 Miles	2002
				Sedimentation/Siltation	Nonpoint Source	Low	7.2 Miles	
				Sulfates	Nonpoint/Point Source	High	7.2 Miles	2003
				Total Dissolved Solids	Nonpoint/Point Source	High	7.2 Miles	2003
4	R	Calleguas Creek Reach 9A (was lower part of Conejo Creek Reach 1 on 1998 303d list)	40312000					
				Algae	Nonpoint/Point Source	High	1.7 Miles	2002
				ChemA (tissue)	Nonpoint Source	Low	1.7 Miles	

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REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	TMDL PRIORITY	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION
				Chlordane (tissue) *Historical use of pesticides and lubricants.*	Nonpoint Source	Low	1.7 Miles	
				DDT (tissue)	Nonpoint Source	Low	1.7 Miles	
				Dieldrin (tissue) *Historical use of pesticides and lubricants.*	Nonpoint Source	Low	1.7 Miles	
				Endosulfan (tissue)	Nonpoint Source	Low	1.7 Miles	
				Fecal Coliform	Nonpoint/Point Source	Low	1.7 Miles	
				Hexachlorocyclohexane/HCH (tissue) *Historical use of pesticides and lubricants.*	Nonpoint Source	Low	1.7 Miles	
				Nitrate as Nitrate (NO3)	Nonpoint/Point Source	Low	1.7 Miles	
				Nitrate as Nitrogen	Nonpoint/Point Source	Low	1.7 Miles	
				Nitrite as Nitrogen	Nonpoint/Point Source	Low	1.7 Miles	
				PCBs (tissue) *Historical use of pesticides and lubricants.*	Nonpoint Source	Low	1.7 Miles	
				Sulfates	Nonpoint/Point Source	High	1.7 Miles	2003
				Total Dissolved Solids	Nonpoint/Point Source	High	1.7 Miles	2003
				Toxaphene (tissue & sediment)	Nonpoint Source	Medium	1.7 Miles	
4	R	Calleguas Creek Reach 9B (was part of Conejo Creek Reaches 1 and 2 on 1998 303d list)	40363000					
				Algae	Nonpoint/Point Source	High	6.2 Miles	2002
				Ammonia	Nonpoint/Point Source	High	6.2 Miles	2002
				ChemA (tissue)	Nonpoint Source	Low	6.2 Miles	

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REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	TMDL PRIORITY	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION
				Chloride	Nonpoint/Point Source	Medium	6.2 Miles	
				DDT (tissue)	Nonpoint Source	Low	6.2 Miles	
				Endosulfan (tissue)	Nonpoint Source	Low	6.2 Miles	
				Fecal Coliform	Nonpoint/Point Source	Low	6.2 Miles	
				Sulfates	Nonpoint/Point Source	High	6.2 Miles	2003
				Total Dissolved Solids	Nonpoint/Point Source	High	6.2 Miles	2003
				Toxaphene (tissue & sediment)	Nonpoint Source	Medium	6.2 Miles	
				Toxicity	Nonpoint/Point Source	High	6.2 Miles	2004
4	R	Calleguas Creek Reach 10 (Conejo Creek (Hill Canyon)-was part of Conejo Crk Reaches 2 & 3, and lower Conejo Crk/Arroyo Conejo N Fk on 1998 303d list)	40364000					
				Algae	Nonpoint/Point Source	High	3 Miles	2002
				Ammonia	Nonpoint/Point Source	High	3 Miles	2002
				ChemA (tissue)	Nonpoint Source	Medium	3 Miles	
				Chloride	Nonpoint/Point Source	Medium	3 Miles	
				DDT (tissue)	Nonpoint Source	Medium	3 Miles	
				Endosulfan (tissue)	Nonpoint Source	Medium	3 Miles	
				Fecal Coliform	Nonpoint Source	Low	3 Miles	
				Nitrite as Nitrogen	Nonpoint/Point Source	Low	3 Miles	
				Sulfates	Nonpoint Source	High	3 Miles	2003

REGION	TYPE	NAME	CAL WATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	TMDL PRIORITY	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION
				Total Dissolved Solids	Nonpoint/Point Source	High	3 Miles	2003
				Toxaphene (tissue & sediment)	Nonpoint Source	Medium	3 Miles	
				Toxicity	Nonpoint/Point Source	High	3 Miles	2004
4	R	Calleguas Creek Reach 11 (Arroyo Santa Rosa, was part of Conejo Creek Reach 3 on 1998 303d list)	40365000					
				Algae	Nonpoint/Point Source	High	8.7 Miles	2002
				Ammonia	Nonpoint/Point Source	High	8.7 Miles	2002
				ChemA (tissue)	Nonpoint Source	Medium	8.7 Miles	
				DDT (tissue)	Nonpoint Source	Medium	8.7 Miles	
				Endosulfan (tissue)	Nonpoint Source	Medium	8.7 Miles	
				Fecal Coliform	Nonpoint/Point Source	Low	8.7 Miles	
				Sedimentation/Siltation	Agriculture Natural Sources	Low	8.7 Miles	
				Sulfates	Nonpoint/Point Source	High	8.7 Miles	2003
				Total Dissolved Solids	Nonpoint/Point Source	High	8.7 Miles	2003
				Toxaphene (tissue & sediment)	Nonpoint/Point Source	Medium	8.7 Miles	
				Toxicity	Nonpoint/Point Source	High	8.7 Miles	2004
4	R	Calleguas Creek Reach 12 (was Conejo Creek/Arroyo Conejo North Fork on 1998 303d list)	40364000					
				Ammonia	Nonpoint/Point Source	High	5.5 Miles	2002
				Chlordane (tissue)	Nonpoint Source	Medium	5.5 Miles	

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REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	TMDL PRIORITY	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION
				DDT (tissue)	Nonpoint Source	Medium	5.5 Miles	
				Sulfates	Nonpoint/Point Source	High	5.5 Miles	2003
				Total Dissolved Solids	Nonpoint/Point Source	High	5.5 Miles	2003
4	R	Calleguas Creek Reach 13 (Conejo Creek South Fork, was Conejo Cr Reach 4 and part of Reach 3 on 1998 303d list)	40368000					
				Algae	Nonpoint/Point Source	High	17 Miles	2002
				Ammonia	Nonpoint/Point Source	High	17 Miles	2002
				ChemA (tissue)	Nonpoint Source	Medium	17 Miles	
				Chloride	Nonpoint/Point Source	Medium	17 Miles	
				DDT (tissue)	Nonpoint Source	Medium	17 Miles	
				Endosulfan (tissue)	Nonpoint Source	Medium	17 Miles	
				Sulfates	Nonpoint/Point Source	High	17 Miles	2003
				Total Dissolved Solids	Nonpoint/Point Source	High	17 Miles	2003
				Toxaphene (tissue & sediment)	Nonpoint Source	Medium	17 Miles	
				Toxicity	Nonpoint/Point Source	High	17 Miles	2004
4	R	Canada Larga (Ventura River Watershed)	40210010					
				Fecal Coliform *Horse stables, land use, cattle, and wildlife may be sources.*	Nonpoint Source	Low	8 Miles	
				Low Dissolved Oxygen	Nonpoint Source	Low	8 Miles	
4	C	Carbon Beach	40416000					
				Beach Closures	Nonpoint Source	High	1.5 Miles	2002

REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	TMDL PRIORITY	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION
				DDT *Fish consumption advisory for DDT.*	Nonpoint Source	Low	1.5 Miles	
				PCBs *Fish consumption advisory for PCBs.*	Nonpoint Source	Low	1.5 Miles	
4	C	Castlerock Beach	40513000					
				Bacteria Indicators	Nonpoint/Point Source	Low	0.21 Miles	
				Beach Closures	Nonpoint Source	High	0.21 Miles	2002
				DDT *Fish Consumption Advisory for DDT.*	Nonpoint Source	Low	0.21 Miles	
				PCBs *Fish Consumption Advisory for PCBs.*	Nonpoint Source	Low	0.21 Miles	
4	T	Colorado Lagoon	40512000					
				Chlordane (tissue & sediment)	Nonpoint Source	Medium	13 Acres	
				DDT (tissue)	Nonpoint Source	Medium	13 Acres	
				Dieldrin (tissue)	Nonpoint Source	Medium	13 Acres	
				Lead (sediment)	Nonpoint Source	Medium	13 Acres	
				PAHs (sediment)	Nonpoint Source	Medium	13 Acres	
				PCBs (tissue)	Nonpoint Source	Medium	13 Acres	
				Sediment Toxicity	Nonpoint Source	Medium	13 Acres	
				Zinc (sediment)	Nonpoint Source	Medium	13 Acres	
4	R	Compton Creek	40515010					
				Copper	Nonpoint/Point Source	High	8.5 Miles	2003
				High Coliform Count	Nonpoint/Point Source	High	8.5 Miles	2002

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REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	TMDL PRIORITY	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION
				Lead	Nonpoint/Point Source	High	8.5 Miles	2003
				pH	Nonpoint/Point Source	High	8.5 Miles	2002
4	R	Coyote Creek	40515010					
				Abnormal Fish Histology	Nonpoint/Point Source	Medium	13 Miles	
				Algae	Nonpoint/Point Source	High	13 Miles	2003
				Copper, Dissolved	Nonpoint Source	Low	13 Miles	
				High Coliform Count	Nonpoint/Point Source	High	13 Miles	2003
				Lead, Dissolved	Nonpoint Source	Low	13 Miles	
				Selenium, Total	Nonpoint Source	Low	13 Miles	
				Toxicity *This listing was made by USEPA.*	Point Source	Medium	13 Miles	
				Zinc, Dissolved	Nonpoint Source	Low	13 Miles	
4	R	Dominguez Channel (above Vermont)	40512000					
				Aldrin (tissue)	Nonpoint/Point Source	Medium	6.7 Miles	
				Ammonia	Nonpoint/Point Source	Medium	6.7 Miles	
				ChemA (tissue)	Nonpoint/Point Source	Medium	6.7 Miles	
				Chlordane (tissue)	Nonpoint/Point Source	Medium	6.7 Miles	
				Chromium (sediment)	Nonpoint/Point Source	Medium	6.7 Miles	
				Copper	Nonpoint/Point Source	Medium	6.7 Miles	
				DDT (tissue & sediment)	Nonpoint/Point Source	Medium	6.7 Miles	

REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	TMDL PRIORITY	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION
				Dieldrin (tissue)	Nonpoint/Point Source	Medium	6.7 Miles	
				High Coliform Count	Nonpoint/Point Source	High	6.7 Miles	2003
				Lead (tissue)	Nonpoint/Point Source	Medium	6.7 Miles	
				PAHs (sediment)	Nonpoint/Point Source	Medium	6.7 Miles	
				PCBs (tissue)	Nonpoint/Point Source	Medium	6.7 Miles	
				Zinc (sediment)	Nonpoint/Point Source	Low	6.7 Miles	
4	R	Dominguez Channel (Estuary to Vermont)	40512000					
				Aldrin (tissue)	Nonpoint/Point Source	Medium	8.3 Miles	
				Ammonia	Nonpoint/Point Source	Medium	8.3 Miles	
				Benthic Community Effects	Nonpoint/Point Source	Medium	8.3 Miles	
				ChemA (tissue)	Nonpoint/Point Source	Medium	8.3 Miles	
				Chlordane (tissue)	Nonpoint/Point Source	Medium	8.3 Miles	
				Chromium (sediment)	Nonpoint/Point Source	Medium	8.3 Miles	
				DDT (tissue & sediment)	Nonpoint/Point Source	Medium	8.3 Miles	
				Dieldrin (tissue)	Nonpoint/Point Source	Medium	8.3 Miles	
				High Coliform Count	Nonpoint/Point Source	High	8.3 Miles	2003
				Lead (tissue)	Nonpoint/Point Source	Medium	8.3 Miles	
				PAHs (sediment)	Nonpoint/Point Source	Medium	8.3 Miles	
				Zinc (sediment)	Nonpoint/Point Source	Medium	8.3 Miles	

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REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	TMDL PRIORITY	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION
4	R	Dry Canyon Creek	40521000					
				Fecal Coliform	Urban Runoff/Storm Sewers Natural Sources	Low	3.9 Miles	
				Selenium, Total	Nonpoint Source	Low	3.9 Miles	
4	R	Duck Pond Agricultural Drains/Mugu Drain/Oxnard Drain No 2	40311000					
				ChemA (tissue)	Nonpoint Source	Medium	12 Miles	
				Chlordane (tissue)	Nonpoint Source	Medium	12 Miles	
				DDT (tissue & sediment)	Nonpoint Source	Medium	12 Miles	
				Nitrogen	Nonpoint Source	High	12 Miles	2002
				Sediment Toxicity	Nonpoint Source	Medium	12 Miles	
				Toxaphene (tissue)	Nonpoint Source	Medium	12 Miles	
				Toxicity	Nonpoint Source	High	12 Miles	2004
4	L	El Dorado Lakes	40515010					
				Algae	Nonpoint Source	Medium	35 Acres	
				Ammonia	Nonpoint Source	Medium	35 Acres	
				Copper	Nonpoint Source	Medium	35 Acres	
				Eutrophic	Nonpoint Source	Medium	35 Acres	
				Lead	Nonpoint Source	Medium	35 Acres	
				Mercury (tissue)	Nonpoint Source	Medium	35 Acres	
				pH	Nonpoint Source	Medium	35 Acres	

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REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	TMDL PRIORITY	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION
4	L	Elizabeth Lake	40351000					
				Eutrophic		Medium	123 Acres	
					Nonpoint Source			
				Organic Enrichment/Low Dissolved Oxygen		Medium	123 Acres	
					Nonpoint Source			
				pH		Medium	123 Acres	
					Nonpoint Source			
				Trash		Medium	123 Acres	
					Nonpoint Source			
4	C	Escondido Beach	40434000					
				Beach Closures		High	1.2 Miles	2002
					Nonpoint Source			
				DDT *Fish consumption advisory for DDT.*		Low	1.2 Miles	
					Nonpoint Source			
				PCBs *Fish consumption advisory for PCBs.*		Low	1.2 Miles	
					Nonpoint Source			
4	C	Flat Rock Point Beach Area	40511000					
				Beach Closures		High	0.11 Miles	2002
					Nonpoint Source			
				DDT *Fish Consumption Advisory for DDT.*		Low	0.11 Miles	
					Nonpoint Source			
				PCBs *Fish Consumption Advisory for PCBs.*		Low	0.11 Miles	
					Nonpoint Source			
4	R	Fox Barranca (tributary to Calleguas Creek Reach 6)	40362000					
				Boron		High	6.7 Miles	2003
					Nonpoint Source			
				Nitrate and Nitrite		High	6.7 Miles	2002
					Nonpoint Source			
				Sulfates		High	6.7 Miles	2003
					Nonpoint Source			
				Total Dissolved Solids		High	6.7 Miles	2003
					Nonpoint Source			

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(For Irrigated Agricultural Sources)

REGION	TYPE	NAME	CAL WATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	TMDL PRIORITY	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION
4	C	Inspiration Point Beach	40511000					
				Beach Closures		High	0.14 Miles	2002
					Nonpoint Source			
				DDT *Fish Consumption Advisory for DDT.*		Low	0.14 Miles	
					Nonpoint Source			
				PCBs *Fish Consumption Advisroy for PCBs.*		Low	0.14 Miles	
					Nonpoint Source			
4	C	La Costa Beach	40416000					
				Beach Closures		High	0.74 Miles	2002
					Nonpoint Source			
				DDT *Fish Consumption Advisory for DDT.*		Low	0.74 Miles	
					Nonpoint Source			
				PCBs *Fish Consumption Advisory for PCBs.*		Low	0.74 Miles	
					Nonpoint Source			
4	L	Lake Hughes	40351000					
				Algae		Medium	21 Acres	
					Nonpoint Source			
				Eutrophic		Medium	21 Acres	
					Nonpoint Source			
				Fish Kills		Medium	21 Acres	
					Nonpoint Source			
				Odors		Medium	21 Acres	
					Nonpoint Source			
				Trash		Medium	21 Acres	
					Nonpoint Source			
4	L	Lake Sherwood	40426000					
				Algae		High	135 Acres	2003
					Nonpoint Source			
				Ammonia		High	135 Acres	2002
					Nonpoint Source			
				Eutrophic		High	135 Acres	2002
					Nonpoint Source			
				Mercury (tissue)		High	135 Acres	2004
					Nonpoint Source			

REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	TMDL PRIORITY	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION
				Organic Enrichment/Low Dissolved Oxygen		High	135 Acres	2002
					Nonpoint Source			
4	C	Las Flores Beach	40415000					
				DDT *Fish Consumption Advisory for DDT.*		Low	1.1 Miles	
					Nonpoint Source			
				High Coliform Count		High	1.1 Miles	2002
					Nonpoint Source			
				PCBs *Fish Consumption Advisory for PCBs.*		Low	1.1 Miles	
					Nonpoint Source			
4	C	Las Tunas Beach	40412000					
				Beach Closures		High	1.2 Miles	2002
					Nonpoint Source			
				DDT *Fish Consumption Advisory for DDT.*		Low	1.2 Miles	
					Nonpoint Source			
				PCBs *Fish Consumption Advisory for PCBs.*		Low	1.2 Miles	
					Nonpoint Source			
4	R	Las Virgenes Creek	40422010					
				High Coliform Count		High	12 Miles	2003
					Nonpoint Source			
				Nutrients (Algae)		High	12 Miles	2003
					Nonpoint Source			
				Organic Enrichment/Low Dissolved Oxygen		High	12 Miles	2002
					Nonpoint Source			
				Scum/Foam-unnatural		High	12 Miles	2002
					Nonpoint Source			
				Sedimentation/Siltation		Low	12 Miles	
					Source Unknown			
				Selenium		High	12 Miles	2004
					Nonpoint Source			
				Trash		Medium	12 Miles	
					Nonpoint Source			
4	C	Leo Carillo Beach (South of County Line)	40444000					
				Beach Closures		High	1.8 Miles	2002
					Nonpoint Source			

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(For Irrigated Agricultural Sources)

REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	TMDL PRIORITY	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION
				High Coliform Count		High	1.8 Miles	2002
					Nonpoint Source			
4	R	Lindero Creek Reach 1	40423000					
				Algae		High	3 Miles	2003
					Nonpoint Source			
				High Coliform Count		High	3 Miles	2003
					Nonpoint Source			
				Scum/Foam-unnatural		High	3 Miles	2002
					Nonpoint Source			
				Selenium		High	3 Miles	2004
					Nonpoint Source			
				Trash		Medium	3 Miles	
					Nonpoint Source			
4	R	Lindero Creek Reach 2 (Above Lake)	40425000					
				Algae		High	4.5 Miles	2003
					Nonpoint Source			
				High Coliform Count		High	4.5 Miles	2003
					Nonpoint Source			
				Scum/Foam-unnatural		High	4.5 Miles	2002
					Nonpoint Source			
				Selenium		High	4.5 Miles	2004
					Nonpoint Source			
				Trash		Medium	4.5 Miles	
					Nonpoint Source			
4	B	Long Beach Harbor Main Channel, SE, W Basin, Pier J, Breakwater	40518000					
				Benthic Community Effects		Medium	1076 Acres	
					Nonpoint Source			
				DDT (tissue) *Fish Consumption Advisory.*		Medium	1076 Acres	
					Nonpoint Source			
				PAHs (sediment)		Medium	1076 Acres	
					Nonpoint Source			
				PCBs (tissue) *Fish Consumption Advisory.*		Medium	1076 Acres	
					Nonpoint Source			
				Sediment Toxicity		Medium	1076 Acres	
					Nonpoint Source			

REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	TMDL PRIORITY	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION
4	C	Long Point Beach	40511000					
				DDT		Low	0.7 Miles	
				Fish Consumption Advisory for DDT.				
					Nonpoint Source			
				High Coliform Count		High	0.7 Miles	2002
					Nonpoint Source			
				PCBs		Low	0.7 Miles	
				Fish Consumption Advisory for PCBs.				
					Nonpoint Source			
4	B	Los Angeles Fish Harbor	40518000					
				DDT		Medium	34 Acres	
					Nonpoint Source			
				PAHs		Medium	34 Acres	
					Nonpoint Source			
				PCBs		Medium	34 Acres	
					Nonpoint Source			
4	B	Los Angeles Harbor Consolidated Slip	40512000					
				Benthic Community Effects		Medium	36 Acres	
					Nonpoint Source			
				Cadmium (sediment)		Low	36 Acres	
				Historical use of pesticides and lubricants, stormwater runoff, aerial deposition, and historical discharges for metals.				
					Nonpoint Source			
				Chlordane (tissue & sediment)		Medium	36 Acres	
					Nonpoint Source			
				Chromium (sediment)		Medium	36 Acres	
					Nonpoint Source			
				Copper (sediment)		Low	36 Acres	
					Nonpoint Source			
				DDT (tissue & sediment)		Medium	36 Acres	
				Fish Consumption Advisory for DDT.				
					Nonpoint Source			
				Dieldrin (tissue)		Low	36 Acres	
				Historical use of pesticides and lubricants, stormwater runoff, aerial deposition, and historical discharges for metals.				
					Nonpoint Source			
				Lead (sediment)		Medium	36 Acres	
					Nonpoint Source			
				Mercury (sediment)		Low	36 Acres	
				Historical use of pesticides and lubricants, stormwater runoff, aerial deposition, and historical discharges for metals.				
					Nonpoint Source			

(For Irrigated Agricultural Sources)

REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	TMDL PRIORITY	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION
				Nickel (sediment)	Nonpoint Source	Low	36 Acres	
				PAHs (sediment)	Nonpoint Source	Medium	36 Acres	
				PCBs (tissue & sediment) *Fish Consumption Advisory for PCBs.*	Nonpoint Source	Medium	36 Acres	
				Sediment Toxicity	Nonpoint Source	Medium	36 Acres	
				Toxaphene (tissue)	Nonpoint Source	Low	36 Acres	
				Zinc (sediment) *Historical use of pesticides and lubricants, stormwater runoff, aerial deposition, and historical discharges for metals.*	Nonpoint Source	Low	36 Acres	
4	B	Los Angeles Harbor Inner Breakwater	40512000					
				DDT	Nonpoint Source	Medium	74 Acres	
				PAHs	Nonpoint Source	Medium	74 Acres	
				PCBs	Nonpoint Source	Medium	74 Acres	
4	B	Los Angeles Harbor Main Channel	40518000					
				Beach Closures	Nonpoint/Point Source	High	279 Acres	2004
				Copper (tissue & sediment)	Nonpoint/Point Source	Medium	279 Acres	
				DDT (tissue & sediment) *Fish Consumption Advisory for DDT.*	Nonpoint/Point Source	Medium	279 Acres	
				PAHs (tissue & sediment)	Nonpoint/Point Source	Medium	279 Acres	
				PCBs (tissue & sediment) *Fish Consumption Advisory for PCBs.*	Nonpoint/Point Source	Medium	279 Acres	
				Sediment Toxicity	Nonpoint/Point Source	Medium	279 Acres	
				Zinc (tissue & sediment)	Nonpoint/Point Source	Medium	279 Acres	

(For Irrigated Agricultural Sources)

REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	TMDL PRIORITY	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION
4	B	Los Angeles Harbor Southwest Slip	40512000					
				DDT *Fish Consumption Advisory for DDT.*	Nonpoint Source	Medium	63 Acres	
				PCBs *Fish Consumption Advisory for PCBs.*	Nonpoint Source	Medium	63 Acres	
				Sediment Toxicity	Nonpoint Source	Medium	63 Acres	
4	E	Los Angeles River Estuary (Queensway Bay)	40512000					
				Chlordane (sediment) *Historical use of pesticides and lubricants.*	Nonpoint Source	Low	261 Acres	
				DDT (sediment) *Historical use of pesticides and lubricants.*	Nonpoint Source	Low	261 Acres	
				Lead (sediment) *Historical use of pesticides and lubricants.*	Nonpoint Source	Low	261 Acres	
				PCBs (sediment) *Historical use of pesticides and lubricants.*	Nonpoint Source	Low	261 Acres	
				Zinc (sediment) *Historical use of pesticides and lubricants.*	Nonpoint Source	Low	261 Acres	
4	R	Los Angeles River Reach 3 (Figueroa St. to Riverside Dr.)	40521000					
				Ammonia	Nonpoint/Point Source	High	7.9 Miles	2003
				Nutrients (Algae)	Nonpoint/Point Source	High	7.9 Miles	2003
				Odors	Nonpoint/Point Source	High	7.9 Miles	2003
				Scum/Foam-unnatural	Nonpoint/Point Source	High	7.9 Miles	2003
4	R	Los Angeles River Reach 4 (Sepulveda Dr. to Sepulveda Dam)	40521000					
				Ammonia	Nonpoint/Point Source	High	11 Miles	2003

(For Irrigated Agricultural Sources)

REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	TMDL PRIORITY	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION
				High Coliform Count	Nonpoint/Point Source	High	11 Miles	2003
				Lead	Nonpoint/Point Source	High	11 Miles	2003
				Nutrients (Algae)	Nonpoint/Point Source	High	11 Miles	2003
				Odors	Nonpoint/Point Source	High	11 Miles	2003
				Scum/Foam-unnatural	Nonpoint/Point Source	High	11 Miles	2003
4	R	Los Angeles River Reach 5 (within Sepulveda Basin)	40521000					
				Ammonia	Nonpoint/Point Source	High	5.4 Miles	2003
				Nutrients (Algae)	Nonpoint/Point Source	High	5.4 Miles	2003
				Odors	Nonpoint/Point Source	High	5.4 Miles	2003
				Oil	Nonpoint/Point Source	Low	5.4 Miles	
				Scum/Foam-unnatural	Nonpoint/Point Source	High	5.4 Miles	2003
4	T	Los Cerritos Channel	40515010					
				Ammonia	Nonpoint Source	Medium	31 Acres	
				Chlordane (sediment)	Source Unknown	Low	31 Acres	
				Copper	Nonpoint Source	Medium	31 Acres	
				High Coliform Count	Nonpoint Source	Medium	31 Acres	
				Lead	Nonpoint Source	Medium	31 Acres	
				Zinc	Nonpoint Source	Medium	31 Acres	
4	L	Machado Lake (Harbor Park Lake)	40512000					
				Algae	Nonpoint Source	Low	45 Acres	

REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	TMDL PRIORITY	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION
				Ammonia	Nonpoint Source	Low	45 Acres	
				ChemA (tissue) *Historical use of pesticides and lubricants.*	Nonpoint Source	Medium	45 Acres	
				Chlordane (tissue) *Fish Consumption Advisory.*	Nonpoint Source	Low	45 Acres	
				DDT (tissue) *Fish Consumption Advisory.*	Nonpoint Source	Low	45 Acres	
				Dieldrin (tissue)	Nonpoint Source	Low	45 Acres	
				Eutrophic	Nonpoint Source	Low	45 Acres	
				Odors	Nonpoint Source	Low	45 Acres	
				PCBs (tissue)	Nonpoint Source	Low	45 Acres	
				Trash	Nonpoint Source	Medium	45 Acres	
4	C	Malaga Cove Beach	40511000					
				Beach Closures	Nonpoint Source	High	0.39 Miles	2002
				DDT *Fish Consumption Advisory for DDT.*	Nonpoint Source	Low	0.39 Miles	
				PCBs *Fish Consumption Advisory for PCBs.*	Nonpoint Source	Low	0.39 Miles	
4	L	Malibou Lake	40424000					
				Algae	Nonpoint Source	High	40 Acres	2002
				Eutrophic	Nonpoint Source	High	40 Acres	2002
				Organic Enrichment/Low Dissolved Oxygen	Nonpoint Source	High	40 Acres	2002

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REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	TMDL PRIORITY	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION
4	C	Malibu Beach	40421000					
				Beach Closures		High	0.77 Miles	2002
					Nonpoint Source			
				DDT		Low	0.77 Miles	
				Fish Consumption Advisory for DDT.				
					Nonpoint Source			
4	R	Malibu Creek	40421000					
				Fish barriers		Low	11 Miles	
					Dam Construction			
				High Coliform Count		High	11 Miles	2003
					Nonpoint/Point Source			
				Nutrients (Algae)		High	11 Miles	2003
					Nonpoint/Point Source			
				Scum/Foam-unnatural		High	11 Miles	2003
					Nonpoint/Point Source			
				Sedimentation/Siltation		Low	11 Miles	
					Source Unknown			
				Trash		Medium	11 Miles	
					Nonpoint Source			
4	E	Malibu Lagoon	40421000					
				Benthic Community Effects		Low	15 Acres	
					Nonpoint/Point Source			
				Enteric Viruses		High	15 Acres	2002
					Nonpoint/Point Source			
				Eutrophic		High	15 Acres	2002
					Nonpoint/Point Source			
				High Coliform Count		High	15 Acres	2003
					Nonpoint/Point Source			
				pH		Low	15 Acres	
				Possible sources might be septic systems, storm drains, and birds.				
					Source Unknown			
				Shellfish Harvesting Advisory		High	15 Acres	2002
					Nonpoint/Point Source			
				Swimming Restrictions		High	15 Acres	2002
					Nonpoint/Point Source			
4	C	Malibu Lagoon Beach (Surfrider)	40421000					
				Beach Closures		High	1 Miles	2002
					Nonpoint Source			

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REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	TMDL PRIORITY	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION
				DDT *Fish Consumption Advisory for DDT.*	Nonpoint Source	Low	1 Miles	
				High Coliform Count	Nonpoint Source	High	1 Miles	2002
				PCBs *Fish Consumption Advisory for PCBs.*	Nonpoint Source	Low	1 Miles	
4	B	Marina del Rey Harbor - Back Basins	40517000					
				Chlordane (tissue & sediment)	Nonpoint Source	Medium	391 Acres	
				Copper (sediment)	Nonpoint Source	Low	391 Acres	
				DDT (tissue)	Nonpoint Source	Medium	391 Acres	
				Dieldrin (tissue)	Nonpoint Source	Medium	391 Acres	
				Fish Consumption Advisory	Nonpoint Source	Medium	391 Acres	
				High Coliform Count	Nonpoint Source	High	391 Acres	2003
				Lead (sediment)	Nonpoint Source	Medium	391 Acres	
				PCBs (tissue & sediment) *Historical use of pesticides, storm water runoff/aerial deposition from urban areas. Shellfish harvesting advisory for PCBs in tissue.*	Nonpoint Source	Medium	391 Acres	
				Sediment Toxicity	Nonpoint Source	Medium	391 Acres	
				Zinc (sediment)	Nonpoint Source	Medium	391 Acres	
4	R	McCoy Canyon Creek	40521000					
				Fecal Coliform	Nonpoint Source	Low	4 Miles	
				Nitrate	Nonpoint Source	Low	4 Miles	
				Nitrate as Nitrogen	Urban Runoff/Storm Sewers Natural Sources	Low	4 Miles	

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REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	TMDL PRIORITY	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION
				Selenium, Total		Low	4 Miles	
					Urban Runoff/Storm Sewers Natural Sources			
4	C	McGrath Beach	40311000					
				High Coliform Count		High	1.5 Miles	2003
					Nonpoint Source			
4	L	McGrath Lake	40311000					
				Chlordane (sediment)		Medium	20 Acres	
					Nonpoint Source			
				DDT (sediment)		Medium	20 Acres	
					Nonpoint Source			
				Dieldrin (sediment) *Historical use of pesticides and lubricants, storm water runoff/aerial deposition from agricultural fields.*		Low	20 Acres	
					Nonpoint Source			
				Fecal Coliform		Low	20 Acres	
					Agriculture Landfills Natural Sources			
				PCBs (sediment) *Historical use of pesticides and lubricants, storm water runoff/aerial deposition from agricultural fields.*		Low	20 Acres	
					Nonpoint Source			
				Sediment Toxicity		Medium	20 Acres	
					Nonpoint Source			
4	R	Medea Creek Reach 1 (Lake to Confl. with Lindero)	40424000					
				Algae		High	2.6 Miles	2003
					Nonpoint Source			
				High Coliform Count		High	2.6 Miles	2003
					Nonpoint Source			
				Sedimentation/Siltation		Low	2.6 Miles	
					Source Unknown			
				Selenium		High	2.6 Miles	2004
					Nonpoint Source			
				Trash		Medium	2.6 Miles	
					Nonpoint Source			
4	R	Medea Creek Reach 2 (Abv Confl. with Lindero)	40423000					
				Algae		High	5.4 Miles	2003
					Nonpoint Source			

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REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	TMDL PRIORITY	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION
				High Coliform Count	Nonpoint Source	High	5.4 Miles	2003
				Sedimentation/Siltation	Source Unknown	Low	5.4 Miles	
				Selenium	Nonpoint Source	High	5.4 Miles	2004
				Trash	Nonpoint Source	Medium	5.4 Miles	
4	L	Munz Lake	40351000					
				Eutrophic	Nonpoint Source	Medium	6.6 Acres	
				Trash	Nonpoint Source	Medium	6.6 Acres	
4	C	Nicholas Canyon Beach	40444000					
				Beach Closures	Nonpoint Source	High	1.7 Miles	2002
				DDT *Fish Consumption Advisory for DDT.*	Nonpoint Source	Low	1.7 Miles	
				PCBs *Fish Consumption Advisory for PCBs.*	Nonpoint Source	Low	1.7 Miles	
4	R	Palo Comado Creek	40423000					
				High Coliform Count	Nonpoint Source	High	6.8 Miles	2003
4	C	Paradise Cove Beach	40435000					
				Beach Closures	Nonpoint Source	High	1.7 Miles	2002
				DDT *Fish consumption advisory for DDT.*	Nonpoint Source	Low	1.7 Miles	
				High Coliform Count	Nonpoint Source	High	1.7 Miles	2002
				PCBs *Fish consumption advisory for PCBs.*	Nonpoint Source	Low	1.7 Miles	

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REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	TMDL PRIORITY	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION
4	L	Peck Road Park Lake	40531000					
				Chlordane (tissue)		Low	103 Acres	
					Nonpoint Source			
				DDT (tissue)		Low	103 Acres	
					Nonpoint Source			
				Lead		Low	103 Acres	
					Nonpoint Source			
				Odors		Low	103 Acres	
					Nonpoint Source			
				Organic Enrichment/Low Dissolved Oxygen		Low	103 Acres	
					Nonpoint Source			
4	C	Point Dume Beach	40435000					
				Beach Closures		High	2.5 Miles	2002
					Nonpoint Source			
				DDT *Fish consumption advisory for DDT.*		Low	2.5 Miles	
					Nonpoint Source			
				PCBs *Fish consumtiion advisory for PCBs.*		Low	2.5 Miles	
					Nonpoint Source			
4	C	Point Fermin Park Beach	40512000					
				Beach Closures		High	1.6 Miles	2002
					Nonpoint Source			
				DDT *Fish consumption advisory for DDT.*		Low	1.6 Miles	
					Nonpoint Source			
				PCBs *Fish consumption advisory for PCBs.*		Low	1.6 Miles	
					Nonpoint Source			
4	R	Pole Creek (trib to Santa Clara River Reach 3)	40331000					
				Sulfates		Low	9 Miles	
					Nonpoint Source			
				Total Dissolved Solids		Low	9 Miles	
					Nonpoint Source			
4	B	Port Hueneme Harbor (Back Basins)	40311000					
				DDT (tissue)		Medium	65 Acres	
					Nonpoint Source			

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REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	TMDL PRIORITY	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION
				PCBs (tissue)	Nonpoint Source	Medium	65 Acres	
4	C	Portugese Bend Beach	40511000					
				Beach Closures	Nonpoint Source	High	1.4 Miles	2002
				DDT *Fish Consumption Advisory for DDT.*	Nonpoint Source	Low	1.4 Miles	
				PCBs *Fish Consumption Advisory for PCB.*	Nonpoint Source	Low	1.4 Miles	
4	C	Promenade Park Beach	40210000					
				Bacteria Indicators *Area affected is at Oak Street, Redwood Apartments, and south of drain at California Street.*	Nonpoint/Point Source	Low	0.37 Miles	
4	L	Puddingstone Reservoir	40552000					
				Chlordane (tissue)	Nonpoint Source	Medium	243 Acres	
				DDT (tissue)	Nonpoint Source	Medium	243 Acres	
				Mercury (tissue)	Nonpoint Source	Medium	243 Acres	
				Organic Enrichment/Low Dissolved Oxygen	Nonpoint Source	Low	243 Acres	
				PCBs (tissue)	Nonpoint Source	Low	243 Acres	
4	C	Puerco Beach	40431000					
				Beach Closures	Nonpoint Source	High	0.5 Miles	2002
				DDT *Fish Consumption Advisory for DDT.*	Nonpoint Source	Low	0.5 Miles	
				PCBs *Fish Consumption Advisory for PCBs.*	Nonpoint Source	Low	0.5 Miles	
4	C	Redondo Beach	40512000					
				Beach Closures	Nonpoint Source	High	1.5 Miles	2002

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REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	TMDL PRIORITY	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION
				DDT *Fish Consumption Advisory for DDT.*	Nonpoint Source	Low	1.5 Miles	
				High Coliform Count	Nonpoint Source	High	1.5 Miles	2002
				PCBs *Fish Consumption Advisory for PCBs.*	Nonpoint Source	Low	1.5 Miles	
4	C	Rincon Beach	40100010					
				Bacteria Indicators *Area affected is 50 and 150 yards south of mouth of Rincon Creek, and at the end of the footpath.*	Nonpoint/Point Source	Low	0.09 Miles	
4	R	Rio De Santa Clara/Oxnard Drain No. 3	40311000					
				ChemA (tissue)	Nonpoint Source	Medium	1.9 Miles	
				Chlordane (tissue)	Nonpoint Source	Medium	1.9 Miles	
				DDT (tissue)	Nonpoint Source	Medium	1.9 Miles	
				Nitrogen	Nonpoint Source	High	1.9 Miles	2002
				PCBs (tissue)	Nonpoint Source	Medium	1.9 Miles	
				Sediment Toxicity	Nonpoint Source	Medium	1.9 Miles	
				Toxaphene (tissue)	Nonpoint Source	Medium	1.9 Miles	
4	R	Rio Hondo Reach 1 (Confl. LA River to Snt Ana Fwy)	40515010					
				Copper	Nonpoint/Point Source	High	4.6 Miles	2003
				High Coliform Count	Nonpoint/Point Source	High	4.6 Miles	2002
				Lead	Nonpoint/Point Source	High	4.6 Miles	2003
				pH	Nonpoint/Point Source	High	4.6 Miles	2002
				Trash	Nonpoint/Point Source	Low	4.6 Miles	

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REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	TMDL PRIORITY	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION
				Zinc		High	4.6 Miles	2003
					Nonpoint/Point Source			
4	R	Rio Hondo Reach 2 (At Spreading Grounds)	40515010					
				High Coliform Count		High	4.9 Miles	2002
					Nonpoint/Point Source			
4	C	Robert H. Meyer Memorial Beach	40441000					
				Beach Closures		High	1.2 Miles	2002
					Nonpoint Source			
				DDT *Fish Consumption Advisory for DDT.*		Low	1.2 Miles	
					Nonpoint Source			
				PCBs *Fish Consumption Advisory for PCBs.*		Low	1.2 Miles	
					Nonpoint Source			
4	C	Royal Palms Beach	40511000					
				Beach Closures		High	1.1 Miles	2002
					Nonpoint Source			
				DDT *Fish consumption advisory for DDT.*		Low	1.1 Miles	
					Nonpoint Source			
				PCBs *Fish consumption advisory for PCBs.*		Low	1.1 Miles	
					Nonpoint Source			
4	R	San Antonio Creek (Tributary to Ventura River Reach 4)	40220023					
				Nitrogen		Low	9.8 Miles	
					Nonpoint Source			
4	C	San Buenaventure Beach	40210000					
				Bacteria Indicators *Area affected is south of drain at Kalorama Street and south of drain at San Jon Road.*		Low	0.3 Miles	
					Nonpoint/Point Source			
4	R	San Gabriel River Estuary	40516000					
				Abnormal Fish Histology		Medium	3.4 Miles	
					Nonpoint/Point Source			
4	R	San Gabriel River Reach 1 (Estuary to Firestone)	40515010					
				Abnormal Fish Histology		Medium	6.4 Miles	
					Nonpoint/Point Source			

2002 CWA SECTION 303(d) LIST OF WATER QUALITY LIMITED SEGMENTS

Approved by USEPA: July 2003

(For Irrigated Agricultural Sources)

REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	TMDL PRIORITY	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION
				Algae	Nonpoint/Point Source	High	6.4 Miles	2003
				High Coliform Count	Nonpoint/Point Source	High	6.4 Miles	2003
				Toxicity *This listing was made by USEPA.*	Point Source	Medium	6.4 Miles	
4	R	San Gabriel River Reach 2 (Firestone to Whittier Narrows Dam	40515010					
				Copper, Dissolved	Nonpoint Source	Low	12 Miles	
				High Coliform Count	Nonpoint/Point Source	High	12 Miles	2003
				Lead	Nonpoint/Point Source	Medium	12 Miles	
				Zinc, Dissolved	Nonpoint Source	Low	12 Miles	
4	R	San Gabriel River Reach 3 (Whittier Narrows to Ramona)	40531000					
				Toxicity *This listing was made by USEPA.*	Point Source	Medium	7.2 Miles	
4	R	San Jose Creek Reach 1 (SG Confluence to Temple St.)	40531000					
				Algae	Nonpoint/Point Source	Low	2.7 Miles	
				High Coliform Count	Nonpoint/Point Source	Low	2.7 Miles	
4	R	San Jose Creek Reach 2 (Temple to I-10 at White Ave.)	40531000					
				Algae	Nonpoint/Point Source	High	17 Miles	2003
				High Coliform Count	Nonpoint/Point Source	High	17 Miles	2003
4	B	San Pedro Bay Near/Off Shore Zones	40512000					
				Chromium (sediment)	Nonpoint/Point Source	Low	5758 Acres	
				Copper (sediment)	Nonpoint/Point Source	Low	5758 Acres	

2002 CWA SECTION 303(d) LIST O… …ER QUALITY LIMITED SEGMENTS

(For Irrigated Agricultural Sources)

REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	TMDL PRIORITY	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION
				DDT (tissue & sediment) *Fish Consumption Advisory for DDT.*	Nonpoint/Point Source	Medium	5758 Acres	
				PAHs (sediment)	Nonpoint/Point Source	Medium	5758 Acres	
				PCBs *Fish consumption advisory for PCBs.*	Nonpoint/Point Source	Medium	5758 Acres	
				Sediment Toxicity	Nonpoint/Point Source	Medium	5758 Acres	
				Zinc (sediment)	Nonpoint/Point Source	Low	5758 Acres	
4	E	Santa Clara River Estuary	40311000					
				ChemA	Source Unknown	Medium	49 Acres	
				High Coliform Count	Nonpoint Source	Medium	49 Acres	
				Toxaphene	Nonpoint Source	Medium	49 Acres	
4	R	Santa Clara River Reach 3 (Freeman Diversion to A Street)	40321000					
				Ammonia	Nonpoint/Point Source	High	31 Miles	2003
				Chloride	Nonpoint/Point Source	High	31 Miles	2002
				Total Dissolved Solids	Nonpoint/Point Source	Low	31 Miles	
4	R	Santa Clara River Reach 7 (Blue Cut to West Pier Hwy 99 Bridge)	40351000					
				Chloride *Chloride was relisted by USEPA.*	Nonpoint/Point Source	High	9.4 Miles	2002
				High Coliform Count	Nonpoint/Point Source	Medium	9.4 Miles	
				Nitrate and Nitrite	Nonpoint/Point Source	Low	9.4 Miles	

2002 CWA SECTION 303(d) LIST OF WATER QUALITY LIMITED SEGMENTS

Approved by USEPA: July 2003

(For Irrigated Agricultural Sources)

REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	TMDL PRIORITY	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION
4	R	Santa Clara River Reach 8 (W Pier Hwy 99 to Bouquet Cyn Rd.)	40351000					
				Chloride *Chloride was relisted by USEPA.*	Nonpoint/Point Source	High	5.2 Miles	2002
				High Coliform Count	Nonpoint/Point Source	Medium	5.2 Miles	
4	R	Santa Clara River Reach 9 (Bouquet Canyon Rd to above Lang Gaging Station)	40351000					
				High Coliform Count	Nonpoint/Point Source	Medium	21 Miles	
4	B	Santa Monica Bay Offshore/Nearshore	40513000					
				Chlordane (sediment)	Nonpoint/Point Source	Medium	146645 Acres	
				DDT (tissue & sediment) *Centered on Palos Verdes Shelf.*	Nonpoint/Point Source	Low	146645 Acres	
				Debris	Nonpoint/Point Source	Low	146645 Acres	
				Fish Consumption Advisory	Nonpoint/Point Source	Low	146645 Acres	
				PAHs (sediment)	Nonpoint/Point Source	Low	146645 Acres	
				PCBs (tissue & sediment)	Nonpoint/Point Source	Low	146645 Acres	
				Sediment Toxicity	Nonpoint/Point Source	Low	146645 Acres	
4	R	Santa Monica Canyon	40513000					
				High Coliform Count	Nonpoint Source	High	2.7 Miles	2002
				Lead	Nonpoint Source	Medium	2.7 Miles	
4	C	Sea Level Beach	40441000					
				Beach Closures	Nonpoint Source	High	0.21 Miles	2002
				DDT *Fish Consumption Advisory for DDT.*	Nonpoint Source	Low	0.21 Miles	

(For Irrigated Agricultural Sources)

REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	TMDL PRIORITY	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION
				PCBs *Fish Consumption Advisory for PCBs.*		Low	0.21 Miles	
					Nonpoint Source			
4	R	Sespe Creek (tributary to Santa Clara River Reach 3)	40332020					
				Chloride		Low	63 Miles	
					Nonpoint Source			
				pH		Low	63 Miles	
					Nonpoint Source			
4	R	Stokes Creek	40422020					
				High Coliform Count		High	4.7 Miles	2002
					Nonpoint Source			
4	C	Topanga Beach	40413000					
				Beach Closures		High	2.5 Miles	2002
					Nonpoint Source			
				DDT *Fish Consumption Advisory for DDT.*		Low	2.5 Miles	
					Nonpoint Source			
				High Coliform Count		High	2.5 Miles	2002
					Nonpoint Source			
				PCBs *Fish Consumption Advisory for PCBs.*		Low	2.5 Miles	
					Nonpoint Source			
4	R	Torrey Canyon Creek	40341000					
				Nitrate and Nitrite		High	1.7 Miles	2003
					Nonpoint Source			
4	C	Trancas Beach (Broad Beach)	40437000					
				Beach Closures		High	1.7 Miles	2002
					Nonpoint Source			
				DDT *Fish Consumption Advisory for DDT.*		Low	1.7 Miles	
					Nonpoint Source			
				High Coliform Count		High	1.7 Miles	2002
					Nonpoint Source			
				PCBs *Fish Consumption Advisory for PCBs.*		Low	1.7 Miles	
					Nonpoint Source			

2002 CWA SECTION 303(d) LIST OF WATER QUALITY LIMITED SEGMENTS

(For Irrigated Agricultural Sources)

REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	TMDL PRIORITY	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION
4	R	Triunfo Canyon Creek Reach 1	40424000					
				Lead	Nonpoint Source	High	2.5 Miles	2004
				Mercury	Nonpoint Source	High	2.5 Miles	2004
				Sedimentation/Siltation	Source Unknown	Low	2.5 Miles	
4	R	Triunfo Canyon Creek Reach 2	40424000					
				Lead	Nonpoint Source	High	3.3 Miles	2004
				Mercury	Nonpoint Source	High	3.3 Miles	2004
				Sedimentation/Siltation	Source Unknown	Low	3.3 Miles	
4	R	Tujunga Wash (LA River to Hansen Dam)	40521000					
				Ammonia	Nonpoint Source	High	9.7 Miles	2002
				Copper	Nonpoint Source	High	9.7 Miles	2003
				High Coliform Count	Nonpoint Source	High	9.7 Miles	2002
				Odors	Nonpoint Source	High	9.7 Miles	2002
				Scum/Foam-unnatural	Nonpoint Source	High	9.7 Miles	2002
				Trash	Nonpoint Source	Low	9.7 Miles	
4	R	Ventura River Estuary	40210011					
				Algae	Nonpoint/Point Source	Medium	0.2 Miles	
				Eutrophic	Nonpoint/Point Source	Medium	0.2 Miles	
				Fecal Coliform *Stables and horse property may be the sources.*	Nonpoint Source	Low	0.2 Miles	
				Total Coliform *Stables and horse property may be the sources.*	Nonpoint Source	Low	0.2 Miles	

2002 CWA SECTION 303(d) LIST OF WATER QUALITY LIMITED SEGMENTS

(For Irrigated Agricultural Sources)

REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	TMDL PRIORITY	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION
				Trash		Medium	0.2 Miles	
					Nonpoint/Point Source			
4	R	Ventura River Reach 1 and 2 (Estuary to Weldon Canyon)	40210011					
				Algae		Medium	4.5 Miles	
					Nonpoint/Point Source			
4	R	Ventura River Reach 3 (Weldon Canyon to Confl. w/ Coyote Cr)	40210011					
				Pumping		Medium	2.8 Miles	
					Nonpoint Source			
				Water Diversion		Medium	2.8 Miles	
					Nonpoint Source			
4	R	Ventura River Reach 4 (Coyote Creek to Camino Cielo Rd)	40220021					
				Pumping		Medium	19 Miles	
					Nonpoint Source			
				Water Diversion		Medium	19 Miles	
					Nonpoint Source			
4	R	Verdugo Wash Reach 1 (LA River to Verdugo Rd.)	40521000					
				Algae		High	2 Miles	2002
					Nonpoint Source			
				High Coliform Count		High	2 Miles	2002
					Nonpoint Source			
				Trash		Low	2 Miles	
					Nonpoint Source			
4	R	Verdugo Wash Reach 2 (Above Verdugo Road)	40524000					
				Algae		High	7.6 Miles	2002
					Nonpoint Source			
				High Coliform Count		High	7.6 Miles	2002
					Nonpoint Source			
				Trash		Low	7.6 Miles	
					Nonpoint Source			
4	L	Westlake Lake	40425000					
				Algae		High	119 Acres	2003
					Nonpoint Source			

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(For Irrigated Agricultural Sources)

REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	TMDL PRIORITY	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION
				Ammonia	Nonpoint Source	High	119 Acres	2002
				Eutrophic	Nonpoint Source	High	119 Acres	2002
				Lead	Nonpoint Source	High	119 Acres	2004
				Organic Enrichment/Low Dissolved Oxygen	Nonpoint Source	High	119 Acres	2002
4	R	Wheeler Canyon/Todd Barranca	40321000					
				Nitrate and Nitrite	Nonpoint Source	High	10 Miles	2003
				Sulfates	Nonpoint Source	Low	10 Miles	
				Total Dissolved Solids	Nonpoint Source	Low	10 Miles	
4	C	Whites Point Beach	40511000					
				Beach Closures	Nonpoint Source	High	1.1 Miles	2002
				DDT *Fish Consumption Advisory for DDT.*	Nonpoint Source	Low	1.1 Miles	
				PCBs *Fish Consumption Advisory for PCBs.*	Nonpoint Source	Low	1.1 Miles	
4	C	Zuma Beach (Westward Beach)	40436000					
				Beach Closures	Nonpoint Source	High	1.6 Miles	2002
				DDT *Fish Consumption Advisory for DDT.*	Nonpoint Source	Low	1.6 Miles	
				PCBs *Fish Consumption Advisory for PCBs.*	Nonpoint Source	Low	1.6 Miles	
5	R	Arcade Creek	51921000					
				Chlorpyrifos	Urban Runoff/Storm Sewers	High	9.9 Miles	2003
				Copper	Urban Runoff/Storm Sewers	Low	9.9 Miles	

REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	TMDL PRIORITY	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION

ABBREVIATIONS

REGIONAL WATER QUALITY CONTROL BOARDS

1 North Coast
2 San Francisco Bay
3 Central Coast
4 Los Angeles
5 Central Valley
6 Lahontan
7 Colorado River Basin
8 Santa Ana
9 San Diego

WATER BODY TYPE

B = Bays and Harbors
C = Coastal Shorelines/Beaches
E = Estuaries
L = Lakes/Reserviors
R = Rivers and Streams
S = Saline Lakes
T = Wetlands, Tidal
W = Wetlands, Freshwater

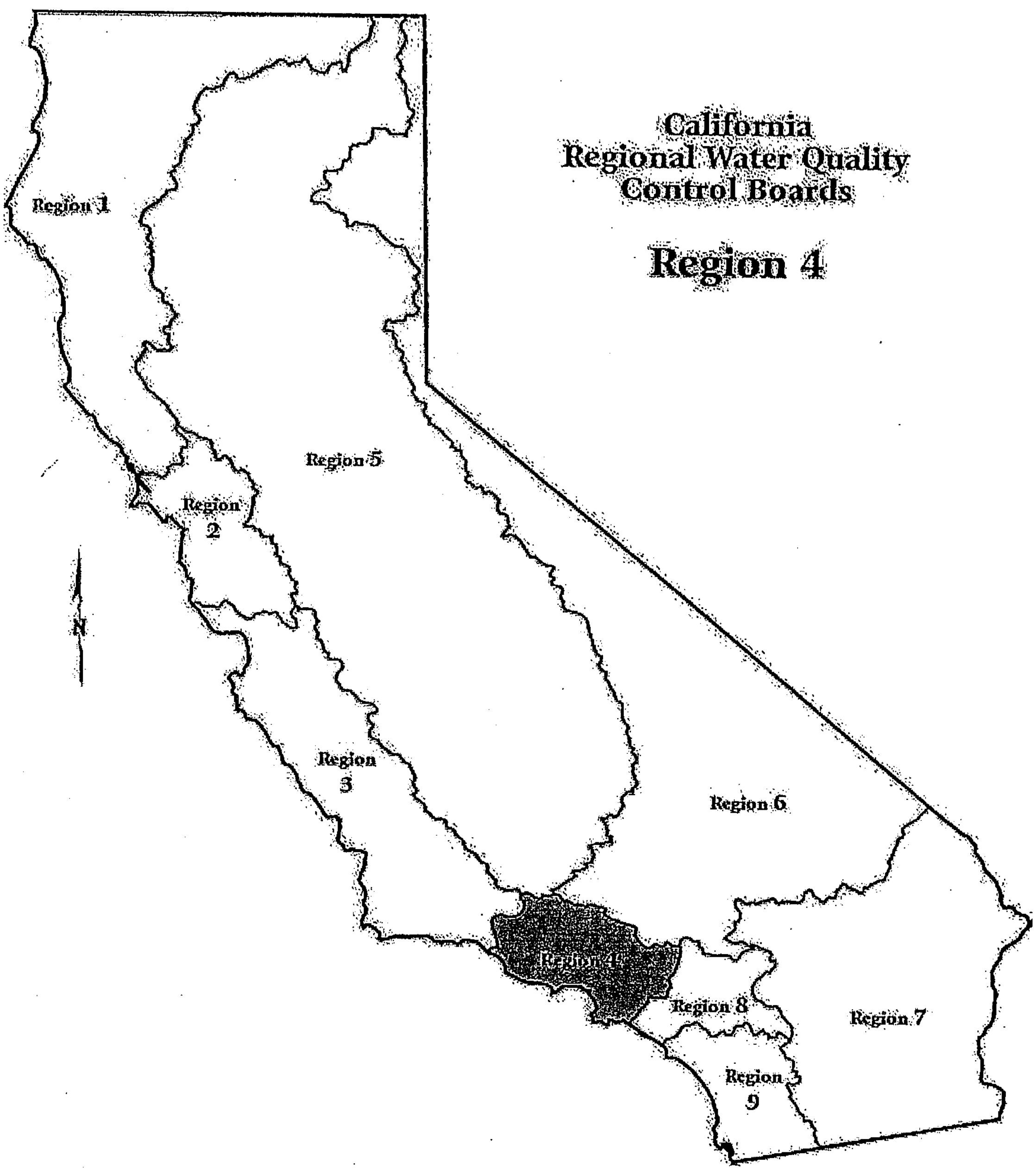
CALWATER WATERSHED

"Calwater Watershed" is the State Water Resources Control Board hydrological subunit area or an even smaller area delineation.

GROUP A PESTICIDES OR CHEM A

aldrin, dieldrin, chlordane, endrin, heptachlor, heptachlor epoxide, hexachlorocyclohexane (including lindane), endosulfan, and toxaphene

Fact Sheets Supporting "Do Not Delist" Recommendations



September 2005

A012436

Water Segment:	Ashland Avenue Drain
Pollutant:	Coliform Bacteria
Decision:	Do Not Delist
Weight of Evidence:	This pollutant is being considered for listing under section 2.2 of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status. One line of evidence is available in the administrative record to assess this pollutant. Based on the applicable factor, a TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard. This water segment-pollutant combination was moved off the section 303(d) list during the 2002 listing cycle. Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.
SWRCB Staff Recommendation:	After review of the available data and information for this recommendation, SWRCB staff conclude that the water body should be placed in the Water Quality Limited Segments Being Addressed category of the section 303(d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.
Lines of Evidence:	

Line of Evidence	Remedial Program in Place
Beneficial Use	R1 - Water Contact Recreation
Information Used to Assess Water Quality:	A TMDL and implementation plan has been approved for this water segment-pollutant combination. The Santa Monica Bay Bacteria Dry Weather TMDL was approved by RWQCB on January 24, 2002 and subsequently approved by USEPA. The Santa Monica Bay Bacteria Wet Weather TMDL was approved by RWQCB on December 12, 2004 and approved by USEPA on June 19, 2003.

Water Segment: Avalon Beach

Pollutant: Bacteria Indicators

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 4.1 of the Listing Policy. Under section 4.1 a single line of evidence is necessary to assess delisting status.

Five lines of evidence are available in the administrative record from three sampling stations to assess this pollutant. A large number of samples exceed the bacteriological standards for waters adjacent to public beaches and public water-contact sports areas.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of not removing this water segment-pollutant combination from the section 303(d) list.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3. Sixty-five out of 215 samples exceeded the bacteriological standards for waters adjacent to public beaches and public water-contact sports areas and this exceeds the allowable frequency of the Listing Policy.
4. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because applicable water quality standards for the pollutant are exceeded.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Water

Beneficial Use: R1 - Water Contact Recreation

Matrix: Water

Water Quality Objective/ Water Quality Criterion: 17 CCR 7958 (in part): The minimum protective bacteriological standards for waters adjacent to public beaches and public water-contact sports areas shall be as follows:
(1) Based on a single sample, the density of bacteria in water from each sampling station at a public beach or public water contact sports area shall not exceed:
(A) 1,000 total coliform bacteria per 100 milliliters, if the ratio of fecal/total coliform bacteria exceeds 0.1; or
(B) 10,000 total coliform bacteria per 100 milliliters; or
(C) 400 fecal coliform bacteria per 100 milliliters; or

(D) 104 enterococcus bacteria per 100 milliliters.

Data Used to Assess Water Quality:	Forty-two samples, 7 exceeding (SWRCB, 2003).
Spatial Representation:	Data collected between BB restaurant and Tuna Club. 1 station: DHS (120) which is the same as DHS (126)99. This station represents the beach 50 yards on either side of the sampling point.
Temporal Representation:	Data collected in 1999, 2000, and 2001.
Data Quality Assessment:	County Health Department.

Numeric Line of Evidence	Pollutant-Water
Beneficial Use:	R1 - Water Contact Recreation
Matrix:	Water
Water Quality Objective/ Water Quality Criterion:	17 CCR 7958 (in part): The minimum protective bacteriological standards for waters adjacent to public beaches and public water-contact sports areas shall be as follows: (1) Based on a single sample, the density of bacteria in water from each sampling station at a public beach or public water contact sports area shall not exceed: (A) 1,000 total coliform bacteria per 100 milliliters, if the ratio of fecal/total coliform bacteria exceeds 0.1; or (B) 10,000 total coliform bacteria per 100 milliliters; or (C) 400 fecal coliform bacteria per 100 milliliters; or (D) 104 enterococcus bacteria per 100 milliliters.
Data Used to Assess Water Quality:	Forty-three samples, 14 exceeding (SWRCB, 2003).
Spatial Representation:	Data collected between Pier and BB restaurant (1/3). 1 station: DHS118. This station represents the beach 50 yards on either side of the sampling point.
Temporal Representation:	Data collected in 1999, 2000, and 2001.
Data Quality Assessment:	County Health Department.

Numeric Line of Evidence	Pollutant-Water
Beneficial Use:	R1 - Water Contact Recreation
Matrix:	Water
Water Quality Objective/ Water Quality Criterion:	17 CCR 7958 (in part): The minimum protective bacteriological standards for waters adjacent to public beaches and public water-contact sports areas shall be as follows: (1) Based on a single sample, the density of bacteria in water from each sampling station at a public beach or public water contact sports area shall not exceed: (A) 1,000 total coliform bacteria per 100 milliliters, if the ratio of fecal/total coliform bacteria exceeds 0.1; or (B) 10,000 total coliform bacteria per 100 milliliters; or (C) 400 fecal coliform bacteria per 100 milliliters; or (D) 104 enterococcus bacteria per 100 milliliters.

Data Used to Assess Water Quality:	Forty-three samples, 10 exceeding (SWRCB, 2003).
Spatial Representation:	Data collected between Pier and BB restaurant (2/3). 1 station: DHS(119). this station represents the beach 50 yards on either side of the sampling point.
Temporal Representation:	Data collected in 1999, 2000, and 2001.
Data Quality Assessment:	County health Department.

Numeric Line of Evidence	Pollutant-Water
Beneficial Use:	R1 - Water Contact Recreation
Matrix:	Water
Water Quality Objective/ Water Quality Criterion:	17 CCR 7958 (in part): The minimum protective bacteriological standards for waters adjacent to public beaches and public water-contact sports areas shall be as follows: (1) Based on a single sample, the density of bacteria in water from each sampling station at a public beach or public water contact sports area shall not exceed: (A) 1,000 total coliform bacteria per 100 milliliters, if the ratio of fecal/total coliform bacteria exceeds 0.1; or (B) 10,000 total coliform bacteria per 100 milliliters; or (C) 400 fecal coliform bacteria per 100 milliliters; or (D) 104 enterococcus bacteria per 100 milliliters.
Data Used to Assess Water Quality:	Seventeen samples exceeding standards out of 44 samples (SWRCB, 2003).
Spatial Representation:	Data collected between storm drain and Pier (1/3). 1 station. This station represents the beach 50 yards on either side of the sampling point.
Temporal Representation:	Data collected in 1999, 2000, and 2001.
Data Quality Assessment:	County Health Department.

Numeric Line of Evidence	Pollutant-Water
Beneficial Use:	R1 - Water Contact Recreation
Matrix:	Water
Water Quality Objective/ Water Quality Criterion:	17 CCR 7958 (in part): The minimum protective bacteriological standards for waters adjacent to public beaches and public water-contact sports areas shall be as follows: (1) Based on a single sample, the density of bacteria in water from each sampling station at a public beach or public water contact sports area shall not exceed: (A) 1,000 total coliform bacteria per 100 milliliters, if the ratio of fecal/total coliform bacteria exceeds 0.1; or (B) 10,000 total coliform bacteria per 100 milliliters; or (C) 400 fecal coliform bacteria per 100 milliliters; or (D) 104 enterococcus bacteria per 100 milliliters.
Data Used to Assess Water Quality:	Forty-three samples, 17 samples exceeding (SWRCB, 2003).

Spatial Representation:	Data collected between storm drain and Pier (2/3). 1 station: DHS(116). This station represents the beach 50 yards on either side of the sampling point.
Temporal Representation:	Data collected in 1999, 2000, and 2001.
Data Quality Assessment:	County health Department.

Water Segment: Ballona Creek

Pollutant: Copper

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 4.1 of the Listing Policy. Four lines of evidence are available in the record to access this pollutant. The total number of sample exceedances from the combined four dissolved copper lines of evidence when compared with CTR dissolved copper criteria exceed the frequency allowed by the Listing Policy.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification against removing this water segment-pollutant combination from the section 303(d) list.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3. 30 of 138 samples exceeded the dissolved copper CTR-CCC guidelines for copper and this exceeds the allowable frequency listed in Table 4.1 of the Listing Policy.
4. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from on the section 303(d) list because applicable water quality standards are exceeded and a pollutant contributes to or causes the problem.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Water

Beneficial Use: WA - Warm Freshwater Habitat

Matrix: Water

Water Quality Objective/ Water Quality Criterion: CTR Copper Criterion for continuous concentration in water for the protection of aquatic life is expressed as a function of the total harness of the water body. At a total hardness of 100 mg/l the continuous concentration for Copper is 9.0 ug/l. The aquatic life criteria will vary depending of total hardness reported. The criterion is linked and applicable for the protection of aquatic life Beneficial Uses.

Data Used to Assess Water Quality: Numeric data generated from 22 samples taken from 10/12/00 to 4/30/03 at one to two-week sampling interval. Six (6) samples exceeded the Copper Continuous Criterion Concentration, which equals the highest concentration of a pollutant to which aquatic life can be exposed for an extended period of time (4days) without deleterious effects (LACDPW, 2003-2003).

Spatial Representation:	One sample site sampled during the dry and wet season beginning from 10/12/00 through 4/30/03 at approximately one to two week intervals.
Temporal Representation:	Twenty-two (22) samples where taken during the wet and dry season from 10/12/00 to 4/30/03 at approximately one to two week intervals as part of the Los Angeles County Storm water monitoring program prepared by the Los Angeles County Department of Public Works.
Environmental Conditions:	The Ballona Creek monitoring station is located at the existing stream gage station (Stream Gage No. F38C-R) between Sawtelle Boulevard and Sepulveda Boulevard in the City of Los Angeles. At this location, which was chosen to avoid tidal influences, the upstream tributary watershed of Ballona Creek is 88.8 square miles. The entire Ballona Creek Watershed is 127.1 square miles. At the gauging station, Ballona Creek is a concrete lined trapezoidal channel.
Data Quality Assessment:	Evaluation of Analytes and QA/QC Specifications for Monitoring Program (Woodward-Clyde, 1996) Los Angeles County Department of Public Works.

Numeric Line of Evidence	Pollutant-Water
Beneficial Use:	WA - Warm Freshwater Habitat
Matrix:	Water
Water Quality Objective/ Water Quality Criterion:	California Toxics Rule. Acute criterion.
Data Used to Assess Water Quality:	Thirty-eight water samples, 17 samples exceeding acute criterion (LACDPW, 2003-2003).
Spatial Representation:	Samples were collected spatially along creek.
Temporal Representation:	Fall, spring, winter, summer in different years.
Environmental Conditions:	Data 1-5 years old, data measured in water body, environmental conditions (winter, spring in different years).
Data Quality Assessment:	Los Angeles County Department of Public Works.

Numeric Line of Evidence	Pollutant-Water
Beneficial Use:	WA - Warm Freshwater Habitat
Matrix:	Water
Water Quality Objective/ Water Quality Criterion:	CTR Copper Criterion for continuous concentration in water for the protection of aquatic life is expressed as a function of the total harness of the water body. At a total hardness of 100 mg/l the continuous concentration for Copper is 9.0 ug/l. The aquatic life criteria will vary depending of total hardness reported. The criterion is linked and applicable for the protection of aquatic life Beneficial Uses.
Data Used to Assess Water Quality:	None of 30 samples exceeded the CTR criterion. Detection limit was 10 ug/L (SCCWRP, 2004).
Spatial Representation:	The metals data from SCCWRP were from a characterization study of Ballona Creek and Estuary to identify relative metals contributions of runoff discharges during dry conditions. Twelve in-stream sites, including nine from Ballona Creek and three of the in-stream sites in the estuary. One of the storm drains was

A012444

	Sepulveda Canyon Channel and this data was used to assess conditions for that listed reach.
Temporal Representation:	Sampling was conducted on May 17, July 16, and September 24, 2003.
Environmental Conditions:	These samples represent dry-weather conditions.
Data Quality Assessment:	Southern California Coastal Water Research Project.

Numeric Line of Evidence	Pollutant-Water
Beneficial Use:	WA - Warm Freshwater Habitat
Matrix:	Water
Water Quality Objective/ Water Quality Criterion:	CTR Criterion
Data Used to Assess Water Quality:	Seven of 48 samples exceeded the CTR criterion. The detection limit is 10 ug/L (LACDPW, 2003-2003).
Spatial Representation:	The metals data from the City of Los Angeles were from four locations along Ballona Creek at National Boulevard, Overland Avenue, Centinela Boulevard, and Pacific Avenue. The data from National and Overland Boulevards are representative of Ballona Creek Reaches 1 and 2, respectively.
Temporal Representation:	Sampled on a monthly basis between January 2002 through May 2003.
Environmental Conditions:	Samples are representative of dry-weather conditions. A hardness value of 300 mg/L was used to calculate the water quality criterion.
Data Quality Assessment:	City of Los Angeles.

Water Segment: Ballona Creek Estuary

Pollutant: Chlordane

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under sections 4.5 and 4.6 of the Listing Policy. Under section 4.5 a single line of evidence is necessary to assess delisting status while under section 4.6, a minimum of two lines of evidence are needed to assess listing status.

Three lines of evidence are available in the administrative record to assess this pollutant. Based on section 4.5, the site shows that this pollutant probably has not accumulated in fish and shellfish to levels that are of concern. The assessments are over 10 years old and may not be representative of current conditions and a newer tissue guideline was used. The sediments in this water have been found to be toxic and concentrations of the pollutant in the water body an vicinity of the water body exceed the sediment guideline.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification against removing this water segment-pollutant combination from the section 303(d) list in the Water Quality Limited Segments category for bioaccumulation but the water should be removed from the list for sediment-related impacts.

This conclusion is based on the staff findings that:
1. The sediment quality guideline used complies with the requirements of section 6.1.3 of the Policy.
2. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
3. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
4. Eighteen of 20 samples exceeded the sediment guideline and 4 of 4 samples exhibit toxicity. A minimum of 212 samples would be needed in order for 18 exceedances to result in a delisting.
5. None of 4 measurements exceed the applicable tissue guideline.
6. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from on the section 303(d) list because applicable water quality standards are exceeded and a pollutant contributes to or causes the problem.

Lines of Evidence:

Numeric Line of Evidence Toxicity

Beneficial Use: MA - Marine Habitat

Matrix: -N/A

Water Quality Objective/ Water Quality Criterion:	Basin Plan: All waters shall be maintained free of toxic substances in concentrations that are toxic to, or that produce detrimental physiological responses in human, plant, animal, or aquatic life.
Evaluation Guideline:	Significant toxicity as compared to control.
Data Used to Assess Water Quality:	Four samples with 4 measurements of significant amphipod toxicity (Anderson et al., 1998).
Spatial Representation:	One station at the mouth of the estuary (BPTCP 44024.0).
Temporal Representation:	Samples collected January 1993 and February 1994.
Data Quality Assessment:	Bay Protection and Toxic Cleanup Program.

Numeric Line of Evidence	Pollutant-Tissue
Beneficial Use:	CM - Commercial and Sport Fishing (CA), MA - Marine Habitat
Matrix:	Tissue
Water Quality Objective/ Water Quality Criterion:	Basin Plan: Toxic pollutants shall not be present at levels that will bioaccumulate in aquatic life to levels which are harmful to aquatic life or human health.
Evaluation Guideline:	OEHHA Screening Value: 30 ug/kg (Brodberg and Pollock, 1999).
Data Used to Assess Water Quality:	Four samples with no measurements exceeding the screening value (SWAMP, 2004).
Spatial Representation:	One station.
Temporal Representation:	State Mussel Watch Data: Composite mussel sample of three individuals collected in 1985, 1986, and 1988. Toxic Substances Monitoring Program: One fish sample collected in 1993.
Data Quality Assessment:	State Mussel Watch an Toxic Substances Monitoring Program. Data that are older than ten years are not used by OEHHA in developing health assessments because data do not represent current conditions (Brodberg, personal communication).

Numeric Line of Evidence	Pollutant-Sediment
Beneficial Use:	CM - Commercial and Sport Fishing (CA), MA - Marine Habitat
Matrix:	Sediment
Water Quality Objective/ Water Quality Criterion:	Basin Plan: Surface waters shall not contain concentrations of chemical constituents in amounts that adversely affect any designated beneficial use.
Evaluation Guideline:	An Effects Range-Median value of 6 ug/g was used (Long and Morgan, 1990).
Data Used to Assess Water Quality:	Twenty samples with 18 exceeding the sediment quality guideline (Anderson, et al,1998).
Spatial Representation:	The sediment listings were based primarily on data collected as part of the BPTCP, which collected samples from a single station (Station 44024.0) at the mouth of the estuary. The CSTF database also contains sediment data from two

studies in the bay near the mouth of the Ballona Creek Estuary. In one study, the US Army Corps of Engineers (USACE) analyzed chemical concentrations in sediments at six stations. The other study performed by the LACDPW provides information on long-term trends in sediment contaminant concentrations at two locations.

Temporal Representation:	BPTCP: January 1993 and February 1994. USACE: in March 1998. LACDPW: 1990 -1999.
Data Quality Assessment:	Description of QA information in the Contaminated Sediments Task Force Database.

Region 4

Water Segment: Ballona Creek Estuary

Pollutant: DDT

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for delisting under sections 4.5 and 4.6 of the Listing Policy. Under section 4.5 a single line of evidence is necessary to assess listing status while under section 4.6, a minimum of two lines of evidence are needed to assess listing status.

Three lines of evidence are available in the administrative record to assess this pollutant. Based on section 4.6, the site has significant sediment toxicity but it is unknown if the pollutant is likely to cause or contribute to any toxic effect because there is no guideline to interpret the data. In addition, there is one exceedance for the pollutant in tissue.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of removing this water segment-pollutant combination for sediment from the section 303(d) list in the Water Quality Limited Segments category.

This conclusion is based on the staff findings that:
1. No sediment quality guideline is available that complies with the requirements of section 6.1.3 of the Policy.
2. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
3. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
4. One of 4 samples exceeded the tissue guideline and this is not enough information to consider removal of the pollutant from the list using the Policy's delisting factors.
5. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because, applicable water quality standards are exceeded for tissue measurements and a pollutant contributes to or causes the problem. The sediment listing for this pollutant, however, should be removed.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Tissue

Beneficial Use: CM - Commercial and Sport Fishing (CA), MA - Marine Habitat

Matrix: Tissue

Water Quality Objective/ Water Quality Criterion: Basin Plan: Toxic pollutants shall not be present at levels that will bioaccumulate in aquatic life to levels which are harmful to aquatic life or human health.

Evaluation Guideline:	OEHHA Screening Value: 100 ug/kg (Brodberg and Pollock, 1999).
Data Used to Assess Water Quality:	Four samples with 1 measurement exceeding the screening value (TSMP, 2002).
Spatial Representation:	One station.
Temporal Representation:	State Mussel Watch Data: Composite mussel sample of three individuals collected in 1985, 1986, and 1988. Toxic Substances Monitoring Program: One fish sample collected in 1993.
Data Quality Assessment:	State Mussel Watch an Toxic Substances Monitoring Program. Data that are older than ten years are not used by OEHHA in developing health assessments because data do not represent current conditions (Brodberg, personal communication).

Numeric Line of Evidence	Pollutant-Sediment
Beneficial Use:	CM - Commercial and Sport Fishing (CA), MA - Marine Habitat
Matrix:	Sediment
Water Quality Objective/ Water Quality Criterion:	Basin Plan: Surface waters shall not contain concentrations of chemical constituents in amounts that adversely affect any designated beneficial use.
Evaluation Guideline:	No sediment quality guideline is available that satisfies the conditions of section 6.1.3 of the Listing Policy.
Data Used to Assess Water Quality:	Twenty-eight samples are available (Anderson et al., 1998).
Spatial Representation:	Eight stations.
Temporal Representation:	The sediment listings were based primarily on data collected as part of the BPTCP, which collected samples from a single station (Station 44024.0) at the mouth of the estuary. The CSTF database also contains sediment data from two studies in the bay near the mouth of the Ballona Creek Estuary. In one study, the US Army Corps of Engineers (USACE) analyzed chemical concentrations in sediments at six stations. The other study performed by the LACDPW provides information on long-term trends in sediment contaminant concentrations at two locations.
Environmental Conditions:	BPTCP: January 1993 and February 1994. USACE: in March 1998. LACDPW: 1990 -1999.
Data Quality Assessment:	Description of QA information in the Contaminated Sediments Task Force Database.

Numeric Line of Evidence	Toxicity
Beneficial Use:	MA - Marine Habitat
Matrix:	-N/A
Water Quality Objective/ Water Quality Criterion:	Basin Plan: All waters shall be maintained free of toxic substances in concentrations that are toxic to, or that produce detrimental physiological

	responses in human, plant, animal, or aquatic life.
Evaluation Guideline:	Significant toxicity as compared to control.
Data Used to Assess Water Quality:	Four samples with 4 measurements of significant amphipod toxicity (Anderson et al., 1998).
Spatial Representation:	One station at the mouth of the estuary (BPTCP 44024.0).
Temporal Representation:	Samples collected January 1993 and February 1994.
Data Quality Assessment:	Bay Protection and Toxic Cleanup Program.

Water Segment: Ballona Creek Estuary

Pollutant: Lead

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under sections 4.6 of the Listing Policy. Under section 4.6, a minimum of two lines of evidence are needed to assess listing status.

Two lines of evidence are available in the administrative record to assess this pollutant. The sediments in this water segment have been found to be toxic and concentrations of the pollutant in the water body exceed the guidelines.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification against removing this water segment-pollutant combination from the section 303(d) list in the Water Quality Limited Segments category.

This conclusion is based on the staff findings that:
1. The sediment quality guideline used complies with the requirements of section 6.1.3 of the Policy.
2. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
3. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
4. Twelve of 28 samples exceeded the sediment guideline, and 4 of 4 samples exhibit toxicity. The allowable frequency for this pollutant exceeds the allowable frequency listed in Table 4.1 of the Listing Policy.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from on the section 303(d) list because applicable water quality standards are exceeded and a pollutant contributes to or causes the problem.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Sediment

Beneficial Use: MA - Marine Habitat

Matrix: Sediment

Water Quality Objective/ Water Quality Criterion: Basin Plan: Surface waters shall not contain concentrations of chemical constituents in amounts that adversely affect any designated beneficial use.

Evaluation Guideline: A Probable Effects Level of 112.18 ug/g was used (MacDonald et al., 1996).

Data Used to Assess Water Quality: Twenty eight samples with 12 exceeding the sediment quality guideline (Anderson et al., 1998).

Spatial Representation: The sediment listings were based primarily on data collected as part of the BPTCP, which collected samples from a single station (Station 44024.0) at the mouth of the estuary. The CSTF database also contains sediment data from two studies in the bay near the mouth of the Ballona Creek Estuary. In one study, the US Army Corps of Engineers (USACE) analyzed chemical concentrations in sediments at six stations. The other study performed by the LACDPW provides information on long-term trends in sediment contaminant concentrations at two locations.

Temporal Representation:	BPTCP: January 1993 and February 1994. USACE: in March 1998. LACDPW: 1990 -1999.
Data Quality Assessment:	Description of QA information in the Contaminated Sediments Task Force Database.

Numeric Line of Evidence	Toxicity
Beneficial Use:	MA - Marine Habitat
Matrix:	-N/A
Water Quality Objective/ Water Quality Criterion:	Basin Plan: All waters shall be maintained free of toxic substances in concentrations that are toxic to, or that produce detrimental physiological responses in human, plant, animal, or aquatic life.
Evaluation Guideline:	Significant toxicity as compared to control.
Data Used to Assess Water Quality:	Four samples with 4 measurements of significant amphipod toxicity (Anderson et al., 1998).
Spatial Representation:	One station at the mouth of the estuary (BPTCP 44024.0).
Temporal Representation:	Samples collected January 1993 and February 1994.
Data Quality Assessment:	Bay Protection and Toxic Cleanup Program.

Water Segment: Ballona Creek Estuary

Pollutant: PCBs (dioxin-like)

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under sections 4.5 and 4.6 of the Listing Policy. Under section 4.5 a single line of evidence is necessary to assess delisting status while under section 4.6, a minimum of two lines of evidence are needed to assess listing status.

Three lines of evidence are available in the administrative record to assess this pollutant. Based on section 4.5, the site shows that this pollutant has accumulated in fish and shellfish to levels that are of concern. The sediments in this water have been found to be toxic but concentrations of the pollutant in the water body an vicinity of the sediment do not exceed sediment guidelines.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification against removing this water segment-pollutant combination from the section 303(d) list in the Water Quality Limited Segments category.

This conclusion is based on the staff findings that:
1. The tissue and sediment quality guideline used complies with the requirements of section 6.1.3 of the Policy.
2. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
3. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
4. Four of 4 measurements exceed the applicable tissue guideline. Four of 4 samples exhibit toxicity and 1of 28 samples exceeded the sediment guideline. At least 28 samples are needed before a pollutant can be considered for removal from the list using the frequencies presented in Table 4.1 of the Listing Policy.
5. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from on the section 303(d) list because although sediment guidelines are not exceeded, there is still evidence of sediment toxicity and pollutant accumulation in tissue in this water body.

Lines of Evidence:

Numeric Line of Evidence Toxicity

Beneficial Use: MA - Marine Habitat

Matrix: -N/A

Water Quality Objective/ Water Quality Criterion: Basin Plan: All waters shall be maintained free of toxic substances in concentrations that are toxic to, or that produce detrimental physiological

	responses in human, plant, animal, or aquatic life.
Evaluation Guideline:	Significant toxicity as compared to control.
Data Used to Assess Water Quality:	Four samples with 4 measurements of significant amphipod toxicity (Anderson et al., 1998).
Spatial Representation:	One station at the mouth of the estuary (BPTCP 44024.0).
Temporal Representation:	Samples collected January 1993 and February 1994.
Data Quality Assessment:	Bay Protection and Toxic Cleanup Program.

Numeric Line of Evidence	Pollutant-Tissue
Beneficial Use:	CM - Commercial and Sport Fishing (CA), MA - Marine Habitat
Matrix:	Tissue
Water Quality Objective/ Water Quality Criterion:	Basin Plan: Toxic pollutants shall not be present at levels that will bioaccumulate in aquatic life to levels which are harmful to aquatic life or human health.
Evaluation Guideline:	OEHHA Screening Value: 20 ug/kg (Brodberg and Pollock, 1999).
Data Used to Assess Water Quality:	Four samples with 4 measurements exceeding the screening value (TSMP, 2002).
Spatial Representation:	One station.
Temporal Representation:	State Mussel Watch Data: Composite mussel sample of three individuals collected in 1985, 1986, and 1988. Toxic Substances Monitoring Program: One fish sample collected in 1993.
Data Quality Assessment:	State Mussel Watch an Toxic Substances Monitoring Program. Data that are older than ten years are no used by OEHHA in developing health assessments because data do not represent current conditions (Brodberg, personal communication).

Numeric Line of Evidence	Pollutant-Sediment
Beneficial Use:	CM - Commercial and Sport Fishing (CA), MA - Marine Habitat
Matrix:	Sediment
Water Quality Objective/ Water Quality Criterion:	Basin Plan: Surface waters shall not contain concentrations of chemical constituents in amounts that adversely affect any designated beneficial use.
Evaluation Guideline:	A sediment quality guideline of 400 ng/g was used to evaluate the data (McDonald et al., 2000).
Data Used to Assess Water Quality:	Twenty-eight samples with 1 exceeding the sediment quality guideline (Anderson et al.,1998).
Spatial Representation:	Eight stations.
Temporal Representation:	The sediment listings were based primarily on data collected as part of the BPTCP, which collected samples from a single station (Station 44024.0) at the

mouth of the estuary. The CSTF database also contains sediment data from two studies in the bay near the mouth of the Ballona Creek Estuary. In one study, the US Army Corps of Engineers (USACE) analyzed chemical concentrations in sediments at six stations. The other study performed by the LACDPW provides information on long-term trends in sediment contaminant concentrations at two locations.

Environmental Conditions: BPTCP: January 1993 and February 1994.
USACE: in March 1998.
LACDPW: 1990 -1999.

Data Quality Assessment: Description of QA information in the Contaminated Sediments Task Force Database.

Water Segment: Ballona Creek Estuary

Pollutant: Zinc

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under sections 4.6 of the Listing Policy. Under section 4.6 a single line of evidence is necessary to assess delisting status.

Two lines of evidence are available in the administrative record to assess this pollutant. Based on section 4.6, the site has significant sediment toxicity and the pollutant concentration still exceeds the sediment guideline.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification against removing this water segment-pollutant combination from the section 303(d) list in the Water Quality Limited Segments category.

This conclusion is based on the staff findings that:
1. The sediment quality guideline used complies with the requirements of section 6.1.3 of the Policy.
2. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
3. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
4. Three of 28 samples exceeded the sediment guideline, 4 of 4 samples exhibit toxicity, and these exceed the allowable frequency listed in Table 4.1 of the Listing Policy.
5. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from on the section 303(d) list because applicable water quality standards are exceeded and a pollutant contributes to or causes the problem.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Sediment

Beneficial Use: MA - Marine Habitat

Matrix: -N/A

Water Quality Objective/ Water Quality Criterion: Basin Plan: Surface waters shall not contain concentrations of chemical constituents in amounts that adversely affect any designated beneficial use.

Evaluation Guideline: An Effects Range-Median of 410 ug/g was used (Long et al., 1995).

Data Used to Assess Water Quality: Twenty-eight samples with 3 measurements exceeding the sediment quality guideline (Anderson et al., 1998).

Spatial Representation:	The sediment listings were based primarily on data collected as part of the BPTCP, which collected samples from a single station (Station 44024.0) at the mouth of the estuary. The CSTF database also contains sediment data from two studies in the bay near the mouth of the Ballona Creek Estuary. In one study, the US Army Corps of Engineers (USACE) analyzed chemical concentrations in sediments at six stations. The other study performed by the LACDPW provides information on long-term trends in sediment contaminant concentrations at two locations.
Temporal Representation:	BPTCP: January 1993 and February 1994. USACE: in March 1998. LACDPW: 1990 -1999.
Data Quality Assessment:	Description of QA information in the Contaminated Sediments Task Force Database.

Numeric Line of Evidence	Toxicity
Beneficial Use:	MA - Marine Habitat
Matrix:	-N/A
Water Quality Objective/ Water Quality Criterion:	Basin Plan: All waters shall be maintained free of toxic substances in concentrations that are toxic to, or that produce detrimental physiological responses in human, plant, animal, or aquatic life.
Evaluation Guideline:	Significant toxicity as compared to control.
Data Used to Assess Water Quality:	Four samples with 4 measurements of significant amphipod toxicity (Anderson et al., 1998).
Spatial Representation:	One station at the mouth of the estuary (BPTCP 44024.0).
Temporal Representation:	Samples collected January 1993 and February 1994.
Data Quality Assessment:	Bay Protection and Toxic Cleanup Program.

Region 4

Water Segment: Big Rock Beach

Pollutant: Coliform Bacteria

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for listing under section 2.2 of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status.

Two lines of evidence are available in the administrative record to assess this pollutant. Based on the applicable factor, a TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard. The beach closure information is backed by coliform data. Beach closure information should not be placed on the section 303(d) list because it is not a pollutant or toxicity (section 2 of the Listing Policy).

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.

SWRCB Staff Recommendation: After review of the available data and information for this recommendation, SWRCB staff conclude that the water body and pollutant (coliform) should be placed in the Water Quality Limited Segments Being Addressed category of the section 303(d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.

Lines of Evidence:

Line of Evidence	Remedial Program in Place
Beneficial Use	R1 - Water Contact Recreation
Information Used to Assess Water Quality:	A TMDL and implementation plan has been approved for this water segment-pollutant combination. The Santa Monica Bay Bacteria Dry Weather TMDL was approved by RWQCB on January 24, 2002 and subsequently approved by USEPA. The Santa Monica Bay Bacteria Wet Weather TMDL was approved by RWQCB on December 12, 2004 and approved by USEPA on June 19, 2003.

Water Segment: Brown Barranca/Long Canyon

Pollutant: Nitrate and Nitrite

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for listing under section 2.2 of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status.

One line of evidence is available in the administrative record to assess this pollutant. Based on the applicable factor, a TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard. This water segment-pollutant combination was moved off the section 303(d) list during the 2002 listing cycle.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.

SWRCB Staff Recommendation: After review of the available data and information for this recommendation, SWRCB staff conclude that the water body should be placed in the Water Quality Limited Segments Being Addressed category of the section 303(d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.

Lines of Evidence:

Line of Evidence Remedial Program in Place

Beneficial Use MU - Municipal & Domestic

Information Used to Assess Water Quality: A TMDL and implementation plan has been approved for this water segment-pollutant combination. The Santa Clara Rive Nitrogen TMDL was approved by RWQCB on August 7, 2003 and subsequently approved by USEPA on March 18, 2004.

Region 4

Water Segment: Cabrillo Beach (Outer)

Pollutant: Coliform Bacteria

Decision: Do Not Delist

Weight of Evidence: Two lines of evidence are available in the administrative record to assess this pollutant. Based on the applicable factor, a TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard. The beach closure information is backed by coliform data. Beach closure information should not be placed on the section 303(d) list because it is not a pollutant or toxicity (section 2 of the Listing Policy).

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.

SWRCB Staff Recommendation: After review of the available data and information for this recommendation, SWRCB staff conclude that the water body and pollutant (coliform) should be placed in the Water Quality Limited Segments Being Addressed category of the section 303(d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.

Lines of Evidence:

Line of Evidence Remedial Program in Place

Beneficial Use R1 - Water Contact Recreation

Information Used to Assess Water Quality: A TMDL and implementation plan has been approved for this water segment-pollutant combination. The Santa Monica Bay Bacteria Dry Weather TMDL was approved by RWQCB on January 24, 2002 and subsequently approved by USEPA. The Santa Monica Bay Bacteria Wet Weather TMDL was approved by RWQCB on December 12, 2004 and approved by USEPA on June 19, 2003.

Water Segment: Calleguas Creek Reach 1 (was Mugu Lagoon on 1998 303(d) list)

Pollutant: DDT

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 3.5 of the Listing Policy. One line of evidence is available in the administrative record to assess this pollutant.

Based on the readily available data and information, the weight of evidence indicates that there is insufficient justification in favor of removing this water segment-pollutant combination from the section 303(d) list in the Water Quality Limited Segments category.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3. Two of the 4 samples exceeded the OEHHA Screening Value but the number of samples is insufficient to determine with the confidence and power required by the Listing Policy.
4. Pursuant to section 3.11 of the Listing Policy, no additional data and information are available indicating that standards are not met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because it cannot be determined if applicable water quality standards are attained.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Tissue

Beneficial Use: CM - Commercial and Sport Fishing (CA)

Matrix: Tissue

Water Quality Objective/ Water Quality Criterion: Los Angeles RWQCB Basin Plan: Toxic pollutants shall not be present at levels that will bioaccumulate in aquatic life to levels which are harmful to aquatic life or human health.

Evaluation Guideline: 100 ng/g (OEHHA Screening Value).

Data Used to Assess Water Quality: Two out of 4 samples exceeded. Representation: A total of 4 filet composite samples of gray smoothhound shark were collected. Shark were collected in 1992-94 and 1997. The guideline was exceeded in samples collected in 1992 and 1993 (TSMP, 2002).

Spatial Representation: One station located at Laguna Road Bridge.

Temporal Representation: Samples were collected annually 1992-94, 1997.

Data Quality Assessment:	Toxic Substances Monitoring Program 1992-93 and 1994-95 Data Reports. Environmental Chemistry Quality Assurance and Data Report for the Toxic Substances Monitoring Program,1996-2000. Department of Fish and Game

Water Segment: Calleguas Creek Reach 1 (was Mugu Lagoon on 1998 303(d) list)

Pollutant: Mercury

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 3.5 of the Listing Policy. One line of evidence is available in the administrative record to assess this pollutant.

Based on the readily available data and information, the weight of evidence indicates that there is insufficient justification in favor of removing this water segment-pollutant combination from the section 303(d) list in the Water Quality Limited Segments category.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3. Two of the 4 samples exceeded the OEHHA Screening Value but the number of samples is insufficient to determine with the confidence and power required by the Listing Policy.
4. Pursuant to section 3.11 of the Listing Policy, no additional data and information are available indicating that standards are not met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because it cannot be determined if applicable water quality standards are attained.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Tissue

Beneficial Use: CM - Commercial and Sport Fishing (CA)

Matrix: Tissue

Water Quality Objective/ Water Quality Criterion: Los Angeles RWQCB Basin Plan: Toxic pollutants shall not be present at levels that will bioaccumulate in aquatic life to levels which are harmful to aquatic life or human health.

Evaluation Guideline: 0.3 ug/g (OEHHA Screening Value)

Data Used to Assess Water Quality: Two out of 4 samples exceeded. A total of 4 filet composite samples of gray smoothhound shark were collected. Shark were collected in 1992-94 and 1997. The guideline was exceeded in samples collected 1992-94. The 1997 sample did not exceed the guideline (TSMP, 2002).

Spatial Representation: One station located at Laguna Road Bridge.

Temporal Representation: Samples were collected annually 1992-94, 1997.

Data Quality Assessment: Toxic Substances Monitoring Program 1992-93 and 1994-95 Data Reports. Environmental Chemistry Quality Assurance and Data Report for the Toxic Substances Monitoring Program,1996-2000. Department of Fish and Game

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Water Segment: Calleguas Creek Reach 1 (was Mugu Lagoon on 1998 303(d) list)

Pollutant: Nitrogen

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for listing under section 2.2 of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status.

One line of evidence is available in the administrative record to assess this pollutant. A TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.

After review of the available data and information for this recommendation, SWRCB staff concludes that the water body should be placed in the Water Quality Limited Segments Being Addressed category of the section 303 (d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.

SWRCB Staff Recommendation: After review of the available data and information for this recommendation, SWRCB staff conclude that the water body and pollutant combination should be placed in the Water Quality Limited Segments Being Addressed category of the section 303(d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.

Lines of Evidence:

Line of Evidence Remedial Program in Place

Beneficial Use ES - Estuarine Habitat

Information Used to Assess Water Quality: A TMDL for this water segment-pollutant combination was approved by the RWQCB in October 2002. The TMDL has an approved implementation plan. USEPA approved the TMDL on June 20, 2003.

Water Segment: Calleguas Creek Reach 2 (estuary to Potrero Rd- was Calleguas Creek Reaches 1 and 2 on 1998 303d list)

Pollutant: Ammonia

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for listing under section 2.2 of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status.

One line of evidence is available in the administrative record to assess this pollutant. A TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.

After review of the available data and information for this recommendation, SWRCB staff concludes that the water body should be placed in the Water Quality Limited Segments Being Addressed category of the section 303(d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.

SWRCB Staff Recommendation: After review of the available data and information for this recommendation, SWRCB staff conclude that the water body and pollutant combination should be placed in the Water Quality Limited Segments Being Addressed category of the section 303(d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.

Lines of Evidence:

Line of Evidence — Remedial Program in Place

Beneficial Use — ES - Estuarine Habitat

Information Used to Assess Water Quality: — A TMDL for this water segment-pollutant combination was approved by the RWQCB in October 2002. The TMDL has an approved implementation plan. USEPA approved the TMDL on June 20, 2003.

Water Segment: Calleguas Creek Reach 2 (estuary to Potrero Rd- was Calleguas Creek Reaches 1 and 2 on 1998 303d list)

Pollutant: Copper

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 4.1 of the Listing Policy. Under section 4.1 a single line of evidence is necessary to assess delisting status. One line of evidence is available in the administrative record to assess this pollutant. Seven samples exceed the CTR dissolved copper continuous concentration in water for the protection of aquatic life.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification against removing this water segment-pollutant combination from the section 303(d) list.

This conclusion is based on the staff findings that:
1. It is unknown whether the data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3. Seven of 11 samples exceeded the CTR dissolved copper continuous concentration in water for the protection of aquatic life but the number of samples is insufficient to determine with the confidence and power required by the Listing Policy.
4. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because it cannot be determined if applicable water quality standards are attained.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Water

Beneficial Use: WA - Warm Freshwater Habitat

Matrix: Water

Water Quality Objective/ Water Quality Criterion: CTR Copper Criterion for continuous concentration in water for the protection of aquatic life is expressed as a function of the total hardness of the water body. At a total hardness of 100mg/l the continuous concentration for Copper is 9.0 ug/l.

Data Used to Assess Water Eleven water samples, 7 samples exceeding for chronic standard (SWRCB,

Quality:	2003).
Spatial Representation:	Three sites.
Temporal Representation:	Summer, fall, winter of 1998 and 1999.
Data Quality Assessment:	Calleguas Creek Characterization Study.

Water Segment: Calleguas Creek Reach 2 (estuary to Potrero Rd- was Calleguas Creek Reaches 1 and 2 on 1998 303d list)

Pollutant: DDT

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 4.1 of the Listing Policy. Under section 4.1 a single line of evidence is necessary to assess delisting status. One line of evidence is available in the administrative record to assess this pollutant. Seven samples exceed the CTR Criteria Continuous Concentration for DDT in saltwater because this segment is influenced by tides.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification against removing this water segment-pollutant combination from the section 303(d) list.

This conclusion is based on the staff findings that:
1.It is unknown whether the data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2.The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3.Seven of 11 samples exceeded the CTR criteria and there is not enough samples to support delisting the water segment as specified in Table 4.1 of the Listing Policy.
4.Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from on the section 303(d) list because applicable water quality standards are exceeded and the pollutant contributes to or causes the problem. in addition, there are not enough total samples taken to support removal from the 303(d) list.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Water

Beneficial Use: WA - Warm Freshwater Habitat

Matrix: Water

Water Quality Objective/ Water Quality Criterion: California Toxics Rule: 0.001 ug/L.

Data Used to Assess Water Eleven water samples, 7 samples exceeding (SWRCB, 2003).

Quality:	
Spatial Representation:	Three sites.
Temporal Representation:	Summer, fall, winter, spring in 1998 and 1999.
Data Quality Assessment:	Calleguas Creek Characterization Study

Water Segment: Calleguas Creek Reach 2 (estuary to Potrero Rd- was Calleguas Creek Reaches 1 and 2 on 1998 303d list)

Pollutant: Fecal Coliform

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 4.3 of the Listing Policy. Under section 4.3 a single line of evidence is necessary to assess delisting status. One line of evidence is available in the administrative record to assess this pollutant. A large number of samples exceed the water quality objective.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification against removing this water segment-pollutant combination from the section 303(d) list.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
2. Twenty-four of 34 samples exceeded the Fecal Coliform water quality objective and this exceeds the allowable frequency listed in Table 4.2 of the Listing Policy.
3. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from on the section 303(d) list because applicable water quality standards are exceeded and a pollutant contributes to or causes the problem.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Water

Beneficial Use: R1 - Water Contact Recreation

Matrix: Water

Water Quality Objective/ Water Quality Criterion: Basin Plan: In waters designated for water contact recreation (REC-1), the fecal coliform concentration shall not exceed a log mean of 200/100 ml (based on a minimum of not less than four samples for any 30-day period), nor shall more than 10 percent of total samples during any 30-day period exceed 400/100 ml.

Data Used to Assess Water Quality: Thirty-four bacteria samples, Geomean of 934 exceeds standard, 24 samples exceeding at 400/100ml standard (SWRCB, 2003).

Spatial Representation: Three sites.

Temporal Representation:	Summer, fall, winter, spring.
Data Quality Assessment:	Calleguas Creek Characterization Study.

Water Segment: Calleguas Creek Reach 2 (estuary to Potrero Rd- was Calleguas Creek Reaches 1 and 2 on 1998 303d list)

Pollutant: Nitrogen

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for listing under section 2.2 of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status.

One line of evidence is available in the administrative record to assess this pollutant. A TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.

After review of the available data and information for this recommendation, SWRCB staff concludes that the water body should be placed in the Water Quality Limited Segments Being Addressed category of the section 303(d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.

SWRCB Staff Recommendation: After review of the available data and information for this recommendation, SWRCB staff conclude that the water body and pollutant combination should be placed in the Water Quality Limited Segments Being Addressed category of the section 303(d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.

Lines of Evidence:

Line of Evidence Remedial Program in Place

Beneficial Use MU - Municipal & Domestic

Information Used to Assess Water Quality: A TMDL for this water segment-pollutant combination was approved by the RWQCB in October 2002. The TMDL has an approved implementation plan. USEPA approved the TMDL on June 20, 2003.

Region 4

Water Segment: Calleguas Creek Reach 3 (Potrero Road upstream to confluence with Conejo Creek on 1998 303d list)

Pollutant: Nitrate and Nitrite

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for listing under section 2.2 of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status.

One line of evidence is available in the administrative record to assess this pollutant. A TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.

After review of the available data and information for this recommendation, SWRCB staff concludes that the water body should be placed in the Water Quality Limited Segments Being Addressed category of the section 303(d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.

SWRCB Staff Recommendation: After review of the available data and information for this recommendation, SWRCB staff conclude that the water body and pollutant combination should be placed in the Water Quality Limited Segments Being Addressed category of the section 303(d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.

Lines of Evidence:

Line of Evidence Remedial Program in Place

Beneficial Use MU - Municipal & Domestic

Information Used to Assess Water Quality: A TMDL for this water segment-pollutant combination was approved by the RWQCB in October 2002. The TMDL has an approved implementation plan. USEPA approved the TMDL on June 20, 2003.

Water Segment: Calleguas Creek Reach 4 (was Revolon Slough Main Branch: Mugu Lagoon to Central Avenue on 1998 303d list)

Pollutant: Chlordane

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 3.5 of the Listing Policy. One line of evidence is available in the administrative record to assess this pollutant.

Based on the readily available data and information, the weight of evidence indicates that there is insufficient justification in favor of removing this water segment-pollutant combination from the section 303(d) list in the Water Quality Limited Segments category.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3. Three of the 3 samples exceeded the OEHHA Screening Value but the number of samples is insufficient to determine with the confidence and power required by the Listing Policy.
4. Pursuant to section 3.11 of the Listing Policy, no additional data and information are available indicating that standards are not met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because it cannot be determined if applicable water quality standards are attained.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Tissue

Beneficial Use: CM - Commercial and Sport Fishing (CA)

Matrix: Tissue

Water Quality Objective/ Water Quality Criterion: Los Angeles RWQCB Basin Plan: Toxic pollutants shall not be present at levels that will bioaccumulate in aquatic life to levels which are harmful to aquatic life or human health.

Evaluation Guideline: 100 ng/g NAS Guideline (whole fish)

Data Used to Assess Water Quality: Three out of 3 samples exceeded. A total of 3 whole fish composite samples of fathead minnows were collected in 1993-94 and 1997. The guideline was exceeded in all samples (TSMP, 2002).

Spatial Representation: One station located below concrete apron just downstream of Woods Road.

Temporal Representation: Samples were collected annually 1993-94 and 1997.

Data Quality Assessment: Toxic Substances Monitoring Program 1992-93 and 1994-95 Data Reports. Environmental Chemistry Quality Assurance and Data Report for the Toxic Substances Monitoring Program,1996-2000. Department of Fish and Game

Water Segment: Calleguas Creek Reach 4 (was Revolon Slough Main Branch: Mugu Lagoon to Central Avenue on 1998 303d list)

Pollutant: DDT

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 3.5 of the Listing Policy. One line of evidence is available in the administrative record to assess this pollutant.

Based on the readily available data and information, the weight of evidence indicates that there is insufficient justification in favor of removing this water segment-pollutant combination from the section 303(d) list in the Water Quality Limited Segments category.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3. Three of the 3 samples exceeded the OEHHA Screening Value but the number of samples is insufficient to determine with the confidence and power required by the Listing Policy.
4. Pursuant to section 3.11 of the Listing Policy, no additional data and information are available indicating that standards are not met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because it cannot be determined if applicable water quality standards are attained.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Tissue

Beneficial Use: CM - Commercial and Sport Fishing (CA)

Matrix: Tissue

Water Quality Objective/ Water Quality Criterion: Los Angeles RWQCB Basin Plan: Toxic pollutants shall not be present at levels that will bioaccumulate in aquatic life to levels which are harmful to aquatic life or human health.

Evaluation Guideline: 1000 ng/g NAS Guideline (whole fish)

Data Used to Assess Water Quality: Three out of 3 samples exceeded (note: Fillet sample of goldfish exceeded OEHHA screening value in 1992). A total of 3 whole fish composite samples of flathead minnow were collected. Flathead minnow samples were collected in 1993-94 and 1997. The guideline was exceeded in all samples (TSMP, 2002).

Spatial Representation: One station located below concrete apron just downstream of Woods Road.

Temporal Representation: Samples were collected annually from 1993-94 and 1997.

Data Quality Assessment: Toxic Substances Monitoring Program 1992-93 and 1994-95 Data Reports. Environmental Chemistry Quality Assurance and Data Report for the Toxic Substances Monitoring Program,1996-2000. Department of Fish and Game

Water Segment: Calleguas Creek Reach 4 (was Revolon Slough Main Branch: Mugu Lagoon to Central Avenue on 1998 303d list)

Pollutant: Fecal Coliform

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 4.3 of the Listing Policy. Under section 4.3 a single line of evidence is necessary to assess delisting status. One line of evidence is available in the administrative record to assess this pollutant. Six samples exceed the Fecal coliform water quality objective.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification against removing this water segment-pollutant combination from the section 303(d) list.

This conclusion is based on the staff findings that:
1.It is unknown whether the data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2.The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3.Six of 12 samples exceeded the Fecal Coliform water quality objective but the number of samples is insufficient to determine with the confidence and power required by the Listing Policy.
4. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because it cannot be determined if applicable water quality standards are attained.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Water

Beneficial Use: R1 - Water Contact Recreation

Matrix: Water

Water Quality Objective/ Water Quality Criterion: Basin Plan: In waters designated for water contact recreation (REC-1), the fecal coliform concentration shall not exceed a log mean of 200/100 ml (based on a minimum of not less than four samples for any 30-day period), nor shall more than 10 percent of total samples during any 30-day period exceed 400/100 ml.

Data Used to Assess Water Twelve bacteria samples, 6 exceeding 400/100 ml standard (SWRCB, 2003).

Quality:	
Spatial Representation:	One site.
Temporal Representation:	Summer, fall, winter, spring.
Data Quality Assessment:	Calleguas Creek Characterization Study

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Water Segment: Calleguas Creek Reach 4 (was Revolon Slough Main Branch: Mugu Lagoon to Central Avenue on 1998 303d list)

Pollutant: Nitrate as Nitrate (NO3)

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 4.1 of the Listing Policy. Under section 4.1 a single line of evidence is necessary to assess delisting status. One line of evidence is available in the administrative record to assess this pollutant. A large number of samples exceed the water quality objective. A TMDL has been developed and approved by USEPA and an approved implementation plan is expected to address the nitrogen related impacts in this water body. The Nitrate as Nitrate listing should be placed on the water quality limited segments being addressed category of the section 303(d) list.

Based on the readily available data and information, the weight of evidence indicates that there is insufficient justification for removing this water segment-pollutant combination from the section 303(d) list.

This conclusion is based on the staff findings that:
1.The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2.The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3.Thirty-eight of 43 samples exceeded the Nitrate as Nitrate water quality objective. This exceeds the allowable frequency listed in Table 4.1 of the Listing Policy.
4.Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from on the section 303(d) list because applicable water quality standards are exceeded and an approved TMDL currently in place is expected to result in attainment of nitrogen standards in this water body.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Water

Beneficial Use: GW - Groundwater Recharge

Matrix: Water

Water Quality Objective/ Water Quality Criterion: Basin Plan: Waters shall not exceed 10 mg/L nitrogen as nitrate-nitrogen plus nitrite-nitrogen (NO2-N), 45 mg/L as nitrate (NO3), 10 mg/L as nitrate-nitrogen (NO3-N) or as otherwise designated in another part of the Basin Plan.

Data Used to Assess Water Quality: Forty-three water samples, 38 exceeding (SWRCB,2003).

Spatial Representation: Three sites.

Temporal Representation:	Summer, fall, winter, spring.
Data Quality Assessment:	Calleguas Creek Characterization Study

Line of Evidence	Remedial Program in Place
Beneficial Use	MU - Municipal & Domestic
Information Used to Assess Water Quality:	A TMDL for this water segment-pollutant combination was approved by the RWQCB in October 2002. The TMDL has an approved implementation plan. USEPA approved the TMDL on June 20, 2003.

Water Segment: Calleguas Creek Reach 4 (was Revolon Slough Main Branch: Mugu Lagoon to Central Avenue on 1998 303d list)

Pollutant: Nitrogen

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for listing under section 2.2 of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status.

Two lines of evidence are available in the administrative record to assess this pollutant. Based on the applicable factor, TMDLs have been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard. The excess algal growth information is backed by nutrient exceedances nitrate data. Excess algal growth should not be placed on the section 303(d) list because this reflects a condition caused by a pollutant or pollutants.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.

SWRCB Staff Recommendation: After review of the available data and information for this recommendation, SWRCB staff conclude that the water body and pollutant combination should be placed in the Water Quality Limited Segments Being Addressed category of the section 303(d) list because a TMDL has been approved by USEPA and an implementation plan has been approved. Furthermore, the qualitative line of evidence on excess algal growth merely reflects conditions caused by documented nutrient pollutants and therefore should be removed from the 303(d) list. Nutrient TMDLs development and implementation should result in attainment of standards and the subsequent elimination of excess algal growth conditions.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Water

Beneficial Use: GW - Groundwater Recharge

Matrix: Water

Water Quality Objective/ Water Quality Criterion: Basin Plan: Waters shall not exceed 10 mg/L nitrogen as nitrate-nitrogen plus nitrite-nitrogen (NO2-N), 45 mg/L as nitrate (NO3), 10 mg/L as nitrate-nitrogen (NO3-N) or as otherwise designated in another part of the Basin Plan.

Data Used to Assess Water Quality: Forty-three water samples, 38 exceeding (SWRCB,2003).

Spatial Representation: Three sites.

Temporal Representation:	Summer, fall, winter, spring.
Data Quality Assessment:	Calleguas Creek Characterization Study

Line of Evidence	Remedial Program in Place
Beneficial Use	GW - Groundwater Recharge
Information Used to Assess Water Quality:	A TMDL for this water segment-pollutant combination was approved by the RWQCB in October 2002. The TMDL has an approved implementation plan. USEPA approved the TMDL on June 20, 2003.

Water Segment: Calleguas Creek Reach 4 (was Revolon Slough Main Branch: Mugu Lagoon to Central Avenue on 1998 303d list)

Pollutant: Toxaphene

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 3.5 of the Listing Policy. One line of evidence is available in the administrative record to assess this pollutant.

Based on the readily available data and information, the weight of evidence indicates that there is insufficient justification in favor of removing this water segment-pollutant combination from the section 303(d) list in the Water Quality Limited Segments category.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3. Three of the 3 samples exceeded the OEHHA Screening Value but the number of samples is insufficient to determine with the confidence and power required by the Listing Policy.
4. Pursuant to section 3.11 of the Listing Policy, no additional data and information are available indicating that standards are not met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because it cannot be determined if applicable water quality standards are attained.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Tissue

Beneficial Use: CM - Commercial and Sport Fishing (CA)

Matrix: Tissue

Water Quality Objective/ Water Quality Criterion: Los Angeles RWQCB Basin Plan: Toxic pollutants shall not be present at levels that will bioaccumulate in aquatic life to levels which are harmful to aquatic life or human health.

Evaluation Guideline: 100 ng/g NAS Guideline (whole fish)

Data Used to Assess Water Quality: Three out of 3 samples exceeded (note: Fillet sample of goldfish exceeded OEHHA screening value in 1992). A total of 3 whole fish composite samples of fathead minnows were collected in 1993-94 and 1997. The guideline was exceeded in all samples (TSMP, 2002).

Spatial Representation: One station located below concrete apron just downstream of Woods Road.

Temporal Representation: Samples were collected annually 1993-94 and 1997.

Data Quality Assessment:	Toxic Substances Monitoring Program 1992-93 and 1994-95 Data Reports. Environmental Chemistry Quality Assurance and Data Report for the Toxic Substances Monitoring Program, 1996-2000. Department of Fish and Game

Water Segment: Calleguas Creek Reach 4 (was Revolon Slough Main Branch: Mugu Lagoon to Central Avenue on 1998 303d list)

Pollutant: Toxaphene

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 3.5 of the Listing Policy. One line of evidence is available in the administrative record to assess this pollutant.

Based on the readily available data and information, the weight of evidence indicates that there is insufficient justification in favor of removing this water segment-pollutant combination from the section 303(d) list in the Water Quality Limited Segments category.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3. Three of the 3 samples exceeded the OEHHA Screening Value but the number of samples is insufficient to determine with the confidence and power required by the Listing Policy.
4. Pursuant to section 3.11 of the Listing Policy, no additional data and information are available indicating that standards are not met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because it cannot be determined if applicable water quality standards are attained.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Tissue

Beneficial Use: CM - Commercial and Sport Fishing (CA)

Matrix: Tissue

Water Quality Objective/ Water Quality Criterion: Los Angeles RWQCB Basin Plan: Toxic pollutants shall not be present at levels that will bioaccumulate in aquatic life to levels which are harmful to aquatic life or human health.

Evaluation Guideline: 100 ng/g NAS Guideline (whole fish)

Data Used to Assess Water Quality: Three out of 3 samples exceeded (note: Fillet sample of goldfish exceeded OEHHA screening value in 1992). A total of 3 whole fish composite samples of fathead minnows were collected in 1993-94 and 1997. The guideline was exceeded in all samples (TSMP, 2002).

Spatial Representation: One station located below concrete apron just downstream of Woods Road.

Temporal Representation:	Samples were collected annually 1993-94 and 1997.
Data Quality Assessment:	Toxic Substances Monitoring Program 1992-93 and 1994-95 Data Reports. Environmental Chemistry Quality Assurance and Data Report for the Toxic Substances Monitoring Program,1996-2000. Department of Fish and Game

Water Segment: Calleguas Creek Reach 5 (was Beardsley Channel on 1998 303d list)

Pollutant: Nitrogen

Decision: Do Not Delist

Weight of Evidence: This water quality condition is being considered for listing under Water Quality limited segment being addressed (section 2.2) of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status.

One line of evidence is available in the administrative record to assess this water body condition. A TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard. Qualitative excess algal growth information is backed by nutrient data and is sufficient to support continued placement on the section 303(d) list (Listing Policy section 4.7).

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification for placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.

SWRCB Staff Recommendation: After review of the available data and information for this recommendation, SWRCB staff conclude that the water body and pollutant combination should be placed in the Water Quality Limited Segments Being Addressed category of the section 303(d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.

Lines of Evidence:

Line of Evidence Remedial Program in Place

Beneficial Use MU - Municipal & Domestic

Information Used to Assess Water Quality: A TMDL for this water segment-pollutant combination was approved by the RWQCB in October 2002. The TMDL has an approved implementation plan. USEPA approved the TMDL on June 20, 2003.

Water Segment:	Calleguas Creek Reach 6 (was Arroyo Las Posas Reaches 1 and 2 on 1998 303d list)
Pollutant:	Ammonia
Decision:	Do Not Delist
Weight of Evidence:	This pollutant is being considered for listing under section 2.2 of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status. One line of evidence is available in the administrative record to assess this pollutant. A TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard. Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.
SWRCB Staff Recommendation:	After review of the available data and information for this recommendation, SWRCB staff concludes that the water body should be placed in the Water Quality Limited Segments Being Addressed category of the section 303 (d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.
Lines of Evidence:	

Line of Evidence	Remedial Program in Place
Beneficial Use	MU - Municipal & Domestic
Information Used to Assess Water Quality:	A TMDL for this water segment-pollutant combination was approved by the RWQCB in October 2002. The TMDL has an approved implementation plan. USEPA approved the TMDL on June 20, 2003.

Water Segment: Calleguas Creek Reach 6 (was Arroyo Las Posas Reaches 1 and 2 on 1998 303d list)

Pollutant: Fecal Coliform

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 4.3 of the Listing Policy. Under section 4.3 a single line of evidence is necessary to assess delisting status. One line of evidence is available in the administrative record to assess this pollutant. Four samples exceed the Fecal Coliform water quality objective.

Based on the readily available data and information, the weight of evidence indicates there is sufficient justification against removing this water segment-pollutant combination from the section 303(d) list.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
2. Four of 12 samples exceeded the fecal coliform water quality objective but there is insufficient samples taken to determine whether the water body segment can be removed from the 303(d) list in accordance with the allowable frequency listed in Table 4.2 of the Listing Policy.
3. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because it cannot be determined if applicable water quality standards are attained.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Water

Beneficial Use: R1 - Water Contact Recreation

Matrix: Water

Water Quality Objective/ Water Quality Criterion: Basin Plan: In waters designated for water contact recreation (REC-1), the fecal coliform concentration shall not exceed a log mean of 200/100 ml (based on a minimum of not less than four samples for any 30-day period), nor shall more than 10 percent of total samples during any 30-day period exceed 400/100 ml.

Data Used to Assess Water Quality: Twelve bacteria samples, 4 samples exceeding. Geomean of 557 exceeds 200/100 ml standard (SWRCB, 2003).

Spatial Representation: One site.

Temporal Representation:	Summer, fall, winter, spring.
Data Quality Assessment:	Calleguas Creek Characterization Study

Water Segment:	Calleguas Creek Reach 6 (was Arroyo Las Posas Reaches 1 and 2 on 1998 303d list)
Pollutant:	Nitrate and Nitrite
Decision:	Do Not Delist
Weight of Evidence:	This pollutant is being considered for listing under section 2.2 of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status. One line of evidence is available in the administrative record to assess this pollutant. A TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard. Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.
SWRCB Staff Recommendation:	After review of the available data and information for this recommendation, SWRCB staff concludes that the water body should be placed in the Water Quality Limited Segments Being Addressed category of the section 303 (d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.
Lines of Evidence:	

Line of Evidence	Remedial Program in Place
Beneficial Use	MU - Municipal & Domestic
Information Used to Assess Water Quality:	A TMDL for this water segment-pollutant combination was approved by the RWQCB in October 2002. The TMDL has an approved implementation plan. USEPA approved the TMDL on June 20, 2003.

Water Segment: Calleguas Creek Reach 6 (was Arroyo Las Posas Reaches 1 and 2 on 1998 303d list)

Pollutant: Nitrate as Nitrate (NO3)

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for listing under section 2.2 of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status.

One line of evidence is available in the administrative record to assess this pollutant. A TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.

SWRCB Staff Recommendation: After review of the available data and information for this recommendation, SWRCB staff concludes that the water body should be placed in the Water Quality Limited Segments Being Addressed category of the section 303 (d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.

Lines of Evidence:

Line of Evidence	Remedial Program in Place
Beneficial Use	MU - Municipal & Domestic
Information Used to Assess Water Quality:	A TMDL for this water segment-pollutant combination was approved by the RWQCB in October 2002. The TMDL has an approved implementation plan. USEPA approved the TMDL on June 20, 2003.

Water Segment: Calleguas Creek Reach 6 (was Arroyo Las Posas Reaches 1 and 2 on 1998 303d list)

Pollutant: Nitrate as Nitrate (NO3)

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 4.1 of the Listing Policy. Under section 4.1 a single line of evidence is necessary to assess delisting status. One line of evidence is available in the administrative record to assess this pollutant. A large number of samples exceed the nitrate as nitrate water quality objective.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification against removing this water segment-pollutant combination from the section 303(d) list.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3. Eight of 12 samples exceeded the nitrate as nitrate water quality objective and there are insufficient number of total samples to support removing the water segment fro the 303(d) list in accordance with Table 4.1 of the Listing Policy.
4. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from on the section 303(d) list because applicable water quality standards are exceeded and a pollutant contributes to or causes the problem.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Water

Beneficial Use: GW - Groundwater Recharge

Matrix: Water

Water Quality Objective/ Water Quality Criterion: Basin Plan: Waters shall not exceed 10 mg/L nitrogen as nitrate-nitrogen plus nitrite-nitrogen (NO2-N), 45 mg/L as nitrate (NO3), 10 mg/L as nitrate-nitrogen (NO3-N) or as otherwise designated in another part of the Basin Plan.

Data Used to Assess Water Twelve water samples, 8 samples exceeding (SWRCB,2003).

Quality:	
Spatial Representation:	One site.
Temporal Representation:	Summer, fall, winter, spring.
Data Quality Assessment:	NPDES reports.

Region 4

Water Segment:	Calleguas Creek Reach 7 (was Arroyo Simi Reaches 1 and 2 on 1998 303d list)
Pollutant:	Ammonia
Decision:	Do Not Delist
Weight of Evidence:	This pollutant is being considered for listing under section 2.2 of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status. One line of evidence is available in the administrative record to assess this pollutant. A TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard. Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.
SWRCB Staff Recommendation:	After review of the available data and information for this recommendation, SWRCB staff concludes that the water body should be placed in the Water Quality Limited Segments Being Addressed category of the section 303 (d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.
Lines of Evidence:	

Line of Evidence	Remedial Program in Place
Beneficial Use	MU - Municipal & Domestic
Information Used to Assess Water Quality:	A TMDL for this water segment-pollutant combination was approved by the RWQCB in October 2002. The TMDL has an approved implementation plan. USEPA approved the TMDL on June 20, 2003.

Water Segment: Calleguas Creek Reach 7 (was Arroyo Simi Reaches 1 and 2 on 1998 303d list)

Pollutant: Fecal Coliform

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 4.3 of the Listing Policy. Under section 4.3 a single line of evidence is necessary to assess delisting status. One line of evidence is available in the administrative record to assess this pollutant.

Based on the readily available data and information, the weight of evidence indicates there is sufficient justification against removing this water segment-pollutant combination from the section 303(d) list.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
2. Seventeen of 24 samples exceeded the fecal coliform water quality objective and there is insufficient samples taken to determine whether the water body segment can be removed from the 303(d) list in accordance with the allowable frequency listed in Table 4.2 of the Listing Policy.
3. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because it cannot be determined if applicable water quality standards are attained.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Water

Beneficial Use: R1 - Water Contact Recreation

Matrix: Water

Water Quality Objective/ Water Quality Criterion: Basin Plan: In waters designated for water contact recreation (REC-1), the fecal coliform concentration shall not exceed a log mean of 200/100 ml (based on a minimum of not less than four samples for any 30-day period), nor shall more than 10 percent of total samples during any 30-day period exceed 400/100 ml.

Data Used to Assess Water Quality: Twenty-four bacteria samples, 17 samples exceeding. Geomean of 909 exceed 200/100 ml standard (SWRCB, 2003).

Spatial Representation: Two sites.

Temporal Representation: Summer, fall, winter, spring.

Data Quality Assessment: Calleguas Creek Characterization Study

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Water Segment: Calleguas Creek Reach 9A (was lower part of Conejo Creek Reach 1 on 1998 303d list)

Pollutant: Chlordane

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 4.1 of the Listing Policy. Under section 4.1 a single line of evidence is necessary to assess listing status. One line of evidence is available in the administrative record to assess this pollutant. Two samples exceed the OEHHA screening value but the number of samples is insufficient to determine with the confidence and power required by the Listing Policy.

Based on the readily available data and information, the weight of evidence indicates that there is insufficient justification in favor of removing this water segment-pollutant combination from the section 303(d) list.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3. Two of 2 samples exceeded the OEHHA screening value. At least 28 samples are needed before a pollutant can be considered for removal from the list using the frequencies presented in Table 4.1 of the Listing Policy.
4. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because it cannot be determined if applicable water quality standards are attained.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Tissue

Beneficial Use: CM - Commercial and Sport Fishing (CA)

Matrix: Tissue

Water Quality Objective/ Water Quality Criterion: Los Angeles RWQCB Basin Plan: No individual pesticide or combination of pesticides shall be present in concentrations that adversely affect beneficial uses.

Evaluation Guideline: OEHHA Screening Value: 30 ug/kg (Brodberg and Pollock, 1999). Section 6.1.3 of the Listing Policy does not allow the use of MTRLs to evaluate fish and shellfish tissue data.

Data Used to Assess Water Quality:	Two tissue samples, 2 samples exceeding (TSMP, 2002).
Spatial Representation:	Sample was collected spatially.
Temporal Representation:	One-time sample.
Data Quality Assessment:	TSMP

Water Segment: Calleguas Creek Reach 9A (was lower part of Conejo Creek Reach 1 on 1998 303d list)

Pollutant: DDT

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 4.5 of the Listing Policy. One line of evidence is available in the administrative record to assess this pollutant.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification against removing this water segment-pollutant combination from the section 303(d) list in the Water Quality Limited Segments category.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3. Four of the 4 samples exceeded the NAS Guideline (whole fish). A minimum of 48 samples would be needed in order for this water body to be delisted for this pollutant with 4 exceedances.
4. Pursuant to section 3.11 of the Listing Policy, no additional data and information are available indicating that standards are not met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from on the section 303(d) list because applicable water quality standards are exceeded and a pollutant contributes to or causes the problem.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Tissue

Beneficial Use: CM - Commercial and Sport Fishing (CA)

Matrix: Tissue

Water Quality Objective/ Water Quality Criterion: Los Angeles RWQCB Basin Plan: Toxic pollutants shall not be present at levels that will bioaccumulate in aquatic life to levels which are harmful to aquatic life or human health.

Evaluation Guideline: 1000 ng/g NAS Guideline (whole fish).

Data Used to Assess Water Quality: Four out of 4 samples exceeded. A total of 4 whole fish composite samples of fathead minnow and mosquitofish were collected. Two fathead minnow samples were collected in 1992. Two mosquitofish samples were collected in 1998. The guideline was exceeded in all samples (TSMP, 2002).

Spatial Representation: One station located at Rancho Road crossing south west of Camarillo.

Temporal Representation:	Samples were collected in 6/2/92 and 6/25/98.
Data Quality Assessment:	Toxic Substances Monitoring Program 1992-93 Data Report. Environmental Chemistry Quality Assurance and Data Report for the Toxic Substances Monitoring Program,1996-2000. Department of Fish and Game

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Water Segment: Calleguas Creek Reach 9A (was lower part of Conejo Creek Reach 1 on 1998 303d list)

Pollutant: Dieldrin

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 4.5 of the Listing Policy. Under section 4.5 a single line of evidence is necessary to assess listing status. One line of evidence is available in the administrative record to assess this pollutant. Two samples exceed the OEHHA Screening value but the number of samples is insufficient to determine with the confidence and power required by the Listing Policy.

Based on the readily available data and information, the weight of evidence indicates that there is insufficient justification in favor of removing this water segment-pollutant combination from the section 303(d) list.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3. Two of 2 samples exceeded the OEHHA screening values. At least 28 samples are needed before a pollutant can be considered for removal from the list using the frequencies presented in Table 4.1 of the Listing Policy.
4. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because it cannot be determined if applicable water quality standards are attained.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Tissue

Beneficial Use: CM - Commercial and Sport Fishing (CA)

Matrix: Tissue

Water Quality Objective/ Water Quality Criterion: Los Angeles RWQCB Basin Plan: No individual pesticide or combination of pesticides shall be present in concentrations that adversely affect beneficial uses.

Evaluation Guideline: OEHHA Screening Value: 2.0 ug/kg (Brodberg and Pollock, 1999). Section 6.1.3 of the Listing Policy does not allow the use of MTRLs to evaluate fish and shellfish tissue data.

Data Used to Assess Water Quality:	Two tissue samples, 2 samples exceeding (TSMP, 2002).
Spatial Representation:	Sample was collected spatially.
Temporal Representation:	One-time sample.
Data Quality Assessment:	TSMP QAPP.

Water Segment: Calleguas Creek Reach 9A (was lower part of Conejo Creek Reach 1 on 1998 303d list)

Pollutant: Fecal Coliform

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 4.3 of the Listing Policy. Under section 4.3 a single line of evidence is necessary to assess listing status. One line of evidence is available in the administrative record to assess this pollutant. Five samples exceed the water quality objective but the number of samples is insufficient to determine with the confidence and power required by the Listing Policy.

Based on the readily available data and information, the weight of evidence indicates that there is insufficient justification in favor of removing this water segment-pollutant combination from the section 303(d) list.

This conclusion is based on the staff findings that:
5.It is unknown whether the data used satisfies the data quality requirements of section 6.1.4 of the Policy.
6.The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
7.Five of 12 samples exceeded the fecal coliform water quality objective. At least 28 samples are needed before a pollutant can be considered for removal from the list using the frequencies presented in Table 4.1 of the Listing Policy.
8.Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because it cannot be determined if applicable water quality standards are attained.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Water

Beneficial Use: R1 - Water Contact Recreation

Matrix: Water

Water Quality Objective/ Water Quality Criterion: Basin Plan: In waters designated for water contact recreation (REC-1), the fecal coliform concentration shall not exceed a log mean of 200/100 ml (based on a minimum of not less than four samples for any 30-day period), nor shall more than 10 percent of total samples during any 30-day period exceed 400/100 ml.

Data Used to Assess Water Quality:	Twelve bacteria samples, 5 samples exceeding 400/100 ml standard. Geomean of 206 exceeds 200/100 ml standard (SWRCB, 2003).
Spatial Representation:	One site (small reach).
Temporal Representation:	Summer, fall, winter, spring.
Data Quality Assessment:	Calleguas Creek Characterization Study

Water Segment: Calleguas Creek Reach 9A (was lower part of Conejo Creek Reach 1 on 1998 303d list)

Pollutant: Lindane

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 4.1 of the Listing Policy. Under section 4.1 a single line of evidence is necessary to assess listing status. One line of evidence is available in the administrative record to assess this pollutant. None of the samples exceed the OEHHA screening value but the number of samples is insufficient to determine with the confidence and power required by the Listing Policy.

Based on the readily available data and information, the weight of evidence indicates that there is insufficient justification in favor of removing this water segment-pollutant combination from the section 303(d) list.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3. None of the 2 samples exceeded the OEHHA screening value. At least 28 samples are needed before a pollutant can be considered for removal from the list using the frequencies presented in Table 4.1 of the Listing Policy.
4. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because it cannot be determined if applicable water quality standards are attained.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Tissue

Beneficial Use: CM - Commercial and Sport Fishing (CA)

Matrix: Tissue

Water Quality Objective/ Water Quality Criterion: Los Angeles RWQCB Basin Plan: Toxic pollutants shall not be present at levels that will bioaccumulate in aquatic life to levels which are harmful to aquatic life or human health.

Evaluation Guideline: OEHHA Screening Value: 30 ug/kg for Lindane (gamma-HCH) (Brodberg and Pollock, 1999). Section 6.1.3 of the Listing Policy does not allow the use of

	MTRLs to evaluate fish and shellfish tissue data.
Data Used to Assess Water Quality:	Two tissue samples with no samples exceeding the screening value (TSMP, 2002).
Spatial Representation:	Sample was collected spatially.
Temporal Representation:	One-time sample.
Data Quality Assessment:	TSMP

Water Segment: Calleguas Creek Reach 9A (was lower part of Conejo Creek Reach 1 on 1998 303d list)

Pollutant: Nitrate as Nitrate (NO3)

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 4.1 of the Listing Policy. Under section 4.1 a single line of evidence is necessary to assess listing status. One line of evidence is available in the administrative record to assess this pollutant. Six samples exceed the water quality objective but the number of samples is insufficient to determine with the confidence and power required by the Listing Policy.

Based on the readily available data and information, the weight of evidence indicates that there is insufficient justification in favor of removing this water segment-pollutant combination from the section 303(d) list.

This conclusion is based on the staff findings that:
1. It is unknown whether the data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3. Six of 12 samples exceeded the nitrate as nitrate (NO3) water quality objective. At least 28 samples are needed before a pollutant can be considered for removal from the list using the frequencies presented in Table 4.1 of the Listing Policy.
4.Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because it cannot be determined if applicable water quality standards are attained.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Water

Beneficial Use: GW - Groundwater Recharge

Matrix: Water

Water Quality Objective/ Water Quality Criterion: Basin Plan: Waters shall not exceed 10 mg/L nitrogen as nitrate-nitrogen plus nitrite-nitrogen (NO2-N), 45 mg/L as nitrate (NO3), 10 mg/L as nitrate-nitrogen (NO3-N) or as otherwise designated in [another part of the Basin Plan].

Data Used to Assess Water Twelve water samples, 6 samples exceeding (SWRCB, 2002).

Quality:	
Spatial Representation:	One site only (Conejo Creek).
Temporal Representation:	Summer, fall, winter, spring.
Environmental Conditions:	Data 3-4 years old, data measured at site, during all seasons.
Data Quality Assessment:	Calleguas Creek Characterization Study

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Water Segment: Calleguas Creek Reach 9A (was lower part of Conejo Creek Reach 1 on 1998 303d list)

Pollutant: Nitrogen, Nitrate

Decision: Do Not Delist

Weight of Evidence: This water quality condition is being considered for listing under Water Quality limited segment being addressed (section 2.2) of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status.

Three lines of evidence are available in the administrative record to assess this water body condition. A TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard. Qualitative excess algal growth information is backed by nutrient data and is sufficient to support continued placement on the section 303(d) list (Listing Policy section 3.7).

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification for placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.

SWRCB Staff Recommendation: After review of the available data and information for this recommendation, SWRCB staff conclude that the water body and pollutant combination should be placed in the Water Quality Limited Segments Being Addressed category of the section 303(d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.

Lines of Evidence:

Line of Evidence Remedial Program in Place

Beneficial Use MU - Municipal & Domestic

Information Used to Assess Water Quality: A TMDL for this water segment-pollutant combination was approved by the RWQCB in October 2002. The TMDL has an approved implementation plan. USEPA approved the TMDL on June 20, 2003.

Region 4

Water Segment: Calleguas Creek Reach 9A (was lower part of Conejo Creek Reach 1 on 1998 303d list)

Pollutant: Nitrogen, Nitrite

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 4.1 of the Listing Policy. Under section 4.1 a single line of evidence is necessary to assess delisting status. One line of evidence is available in the administrative record to assess this pollutant. A large number of samples exceed the water quality objective.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification against removing this water segment-pollutant combination from the section 303(d) list.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3. Eighteen of 110 samples exceeded the nitrite-nitrogen water quality objective and this exceeds the allowable frequency listed in Table 4.1 of the Listing Policy.
4. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because applicable water quality standards are exceeded and a pollutant contributes to or causes the problem.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Water

Beneficial Use: GW - Groundwater Recharge

Matrix: Water

Water Quality Objective/ Water Quality Criterion: Basin Plan: Waters shall not exceed 10 mg/L nitrogen as nitrate-nitrogen plus nitrite-nitrogen (NO2-N), 45 mg/L as nitrate (NO3), 10 mg/L as nitrate-nitrogen (NO3-N) or as otherwise designated in another part of the Basin Plan.

Data Used to Assess Water Quality: One-hundred and ten water samples, 18 samples exceeding (SWRCB, 2003).

Spatial Representation:	One site only (Conejo Creek).
Temporal Representation:	Summer, fall, winter, spring.
Data Quality Assessment:	NPDES report.

Water Segment: Calleguas Creek Reach 9A (was lower part of Conejo Creek Reach 1 on 1998 303d list)

Pollutant: Nitrogen, Nitrite

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for listing under section 2.2 of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status.

One line of evidence is available in the administrative record to assess this pollutant. A TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.

SWRCB Staff Recommendation: After review of the available data and information for this recommendation, SWRCB staff concludes that the water body should be placed in the Water Quality Limited Segments Being Addressed category of the section 303 (d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.

Lines of Evidence:

Line of Evidence	Remedial Program in Place
Beneficial Use	MU - Municipal & Domestic
Information Used to Assess Water Quality:	A TMDL for this water segment-pollutant combination was approved by the RWQCB in October 2002. The TMDL has an approved implementation plan. USEPA approved the TMDL on June 20, 2003.

Region 4

Water Segment: Calleguas Creek Reach 9A (was lower part of Conejo Creek Reach 1 on 1998 303d list)

Pollutant: PCBs (dioxin-like)

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 4.1 of the Listing Policy. Under section 4.1 a single line of evidence is necessary to assess listing status. One line of evidence is available in the administrative record to assess this pollutant. Two samples exceed the USEPA screening value but the number of samples is insufficient to determine with the confidence and power required by the Listing Policy.

Based on the readily available data and information, the weight of evidence indicates that there is insufficient justification in favor of removing this water segment-pollutant combination from the section 303(d) list.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
6.The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
2. Two of 2 samples exceeded the USEPA Screening value. At least 28 samples are needed before a pollutant can be considered for removal from the list using the frequencies presented in Table 4.1 of the Listing Policy.
3. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because it cannot be determined if applicable water quality standards are attained.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Tissue

Beneficial Use: CM - Commercial and Sport Fishing (CA)

Matrix: Tissue

Water Quality Objective/ Water Quality Criterion: Los Angeles RWQCB Basin Plan: Toxic pollutants shall not be present at levels that will bioaccumulate in aquatic life to levels which are harmful to aquatic life or human health.

Evaluation Guideline: USEPA Screening Value: 5.47 ug/kg (USEPA, 2000). Section 6.1.3 of the Listing Policy does not allow the use of MTRLs to evaluate fish and shellfish tissue data.

Data Used to Assess Water Quality: Two composite tissue samples, 2 samples exceeding (TSMP, 2002).

Spatial Representation: Samples were collected spatially.

Temporal Representation:	One-time sample.
Data Quality Assessment:	TSMP

Water Segment: Calleguas Creek Reach 9A (was lower part of Conejo Creek Reach 1 on 1998 303d list)

Pollutant: Toxaphene

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 4.5 of the Listing Policy. One line of evidence is available in the administrative record to assess this pollutant.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification against removing this water segment-pollutant combination from the section 303(d) list in the Water Quality Limited Segments category.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3. Four of the 4 samples exceeded the NAS Guideline (whole fish). A minimum of 48 samples would be needed in order for this water body to be delisted for this pollutant with 4 exceedances.
4. Pursuant to section 3.11 of the Listing Policy, no additional data and information are available indicating that standards are not met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from on the section 303(d) list because applicable water quality standards are exceeded and a pollutant contributes to or causes the problem.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Tissue

Beneficial Use: CM - Commercial and Sport Fishing (CA)

Matrix: Tissue

Water Quality Objective/ Water Quality Criterion: Los Angeles RWQCB Basin Plan: Toxic pollutants shall not be present at levels that will bioaccumulate in aquatic life to levels which are harmful to aquatic life or human health.

Evaluation Guideline: 100 ng/g - NAS Guideline (Whole fish).

Data Used to Assess Water Quality: Four out of 4 samples exceeded. Two whole fish composite samples of fathead minnow and 2 whole fish composite samples of mosquitofish were collected. Fathead minnow were collected in 1992. Mosquitofish were collected in 1998. The guideline was exceeded in all samples (TSMP, 2002).

Spatial Representation: One station located at Rancho Road crossing south west of Camarillo.

Temporal Representation:	Samples were collected annually in 1992 and 1998.
Data Quality Assessment:	Toxic Substances Monitoring Program 1992-93 Data Report. Environmental Chemistry Quality Assurance and Data Report for the Toxic Substances Monitoring Program,1996-2000. Department of Fish and Game.

Water Segment: Calleguas Creek Reach 9B (was part of Conejo Creek Reaches 1 and 2 on 1998 303d list)

Pollutant: Ammonia

Decision: Do Not Delist

Weight of Evidence: This water quality condition is being considered for listing under Water Quality limited segment being addressed (section 2.2) of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status.

Two lines of evidence are available in the administrative record to assess this water body condition. A TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard. Qualitative excess algal growth information is backed by nutrient data and is sufficient to support continued placement on the section 303(d) list (Listing Policy section 3.7).

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification for placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.

SWRCB Staff Recommendation: After review of the available data and information for this recommendation, SWRCB staff conclude that the water body and pollutant combination should be placed in the Water Quality Limited Segments Being Addressed category of the section 303(d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.

Lines of Evidence:

Line of Evidence Remedial Program in Place

Beneficial Use CO - Cold Freshwater Habitat, MU - Municipal & Domestic

Information Used to Assess Water Quality: A TMDL for this water segment-pollutant combination was approved by the RWQCB in October 2002. The TMDL has an approved implementation plan. USEPA approved the TMDL on June 20, 2003.

Water Segment: Calleguas Creek Reach 9B (was part of Conejo Creek Reaches 1 and 2 on 1998 303d list)

Pollutant: Fecal Coliform

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 4.2 of the Listing Policy. Under section 4.2 a single line of evidence is necessary to assess listing status. One line of evidence is available in the administrative record to assess this pollutant. Three samples exceed the fecal coliform water quality objective but the number of samples is insufficient to determine with the confidence and power required by the Listing Policy.

Based on the readily available data and information, the weight of evidence indicates that there is insufficient justification in favor of removing this water segment-pollutant combination from the section 303(d) list.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
2. Three of 12 samples exceeded the fecal coliform water quality objective. At least 26 samples are needed before a pollutant can be considered for removal from the list using the frequencies presented in Table 4.2 of the Listing Policy.
3. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because it cannot be determined if applicable water quality standards are attained.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Water

Beneficial Use: R1 - Water Contact Recreation

Matrix: Water

Water Quality Objective/ Water Quality Criterion: Basin Plan: In waters designated for water contact recreation (REC-1), the fecal coliform concentration shall not exceed a log mean of 200/100 ml (based on a minimum of not less than four samples for any 30-day period), nor shall more than 10 percent of total samples during any 30-day period exceed 400/100 ml.

Data Used to Assess Water Quality: Twelve bacteria samples, 3 samples exceeding WQO. Geomean of 243 exceeds 200/100 ml (SWRCB, 2003).

Spatial Representation:	One site.
Temporal Representation:	All seasons during 1998-1999.
Data Quality Assessment:	Calleguas Creek Characterization Study

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Water Segment: Calleguas Creek Reach 10 (Conejo Creek (Hill Canyon)-was part of Conejo Crk Reaches 2 & 3, and lower Conejo Crk/Arroyo Conejo N Fk on 1998 303d list)

Pollutant: Fecal Coliform

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 4.2 of the Listing Policy. Under section 4.2 a single line of evidence is necessary to assess listing status. One line of evidence is available in the administrative record to assess this pollutant. Eleven samples exceed the water quality objective but the number of samples is insufficient to determine with the confidence and power required by the Listing Policy.

Based on the readily available data and information, the weight of evidence indicates that there is insufficient justification in favor of removing this water segment-pollutant combination from the section 303(d) list.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
2. Eleven of 24 samples exceeded the fecal coliform water quality objective. At least 26 samples are needed before a pollutant can be considered for removal from the list using the frequencies presented in Table 4.2 of the Listing Policy.
3. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because it cannot be determined if applicable water quality standards are attained.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Water

Beneficial Use: R1 - Water Contact Recreation

Matrix: Water

Water Quality Objective/ Water Quality Criterion: Basin Plan: In waters designated for water contact recreation (REC-1), the fecal coliform concentration shall not exceed a log mean of 200/100 ml (based on a minimum of not less than four samples for any 30-day period), nor shall more than 10 percent of total samples during any 30-day period exceed 400/100 ml.

Data Used to Assess Water Quality: Twenty-four bacteria samples, 11 samples exceeding the 400/100 ml standard. Geomean of 431 exceeds 200/100 ml standard (SWRCB, 2003).

Spatial Representation:	Two sites.
Temporal Representation:	Summer, fall, winter, spring.
Data Quality Assessment:	Calleguas Creek Characterization Study

Water Segment: Calleguas Creek Reach 10 (Conejo Creek (Hill Canyon)-was part of Conejo Crk Reaches 2 & 3, and lower Conejo Crk/Arroyo Conejo N Fk on 1998 303d list)

Pollutant: Nitrogen, Nitrite

Decision: Do Not Delist

Weight of Evidence: This water quality condition is being considered for listing under Water Quality limited segment being addressed (section 2.2) of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status.

Two lines of evidence are available in the administrative record to assess this water body condition. One line of evidence indicates that there is insufficient justification in favor of removing this water segment-pollutant combination from the section 303(d) list because 5 of 42 samples exceeded the water quality objective. In addition, a TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard. Qualitative excess algal growth information is backed by nutrient data and is sufficient to support continued placement on the section 303(d) list.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification for placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.

SWRCB Staff Recommendation: After review of the available data and information for this recommendation, SWRCB staff conclude that the water body and pollutant combination should be placed in the Water Quality Limited Segments Being Addressed category of the section 303(d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Water

Beneficial Use: GW - Groundwater Recharge

Matrix: Water

Water Quality Objective/ Water Quality Criterion: Basin Plan: Waters shall not exceed 10 mg/L nitrogen as nitrate-nitrogen plus nitrite-nitrogen (NO2-N), 45 mg/L as nitrate (NO3), 10 mg/L as nitrate-nitrogen (NO3-N), or 1 mg/L nitrite-nitrogen (NO2-N) or as otherwise designated in [another part of the Basin Plan].

Data Used to Assess Water Quality: Forty-two water samples, 5 samples exceeding (SWRCB, 2003).

Spatial Representation: One site.

Temporal Representation: Summer, fall, winter spring.

Environmental Conditions:	Data 2-5 years old, data measured at site, data measured during all seasons.
Data Quality Assessment:	NPDES Program and Calleguas Creek Ambient Water Quality Monitoring Program

Line of Evidence	Remedial Program in Place
Beneficial Use	CO - Cold Freshwater Habitat, MU - Municipal & Domestic
Information Used to Assess Water Quality:	A TMDL for this water segment-pollutant combination was approved by the RWQCB in October 2002. The TMDL has an approved implementation plan. USEPA approved the TMDL on June 20, 2003.

Water Segment: Calleguas Creek Reach 11 (Arroyo Santa Rosa, was part of Conejo Creek Reach 3 on 1998 303d list)

Pollutant: Ammonia

Decision: Do Not Delist

Weight of Evidence: This water quality condition is being considered for listing under Water Quality limited segment being addressed (section 2.2) of the Listing Policy. Under this section of the
Policy, a minimum of one line of evidence is needed to assess listing status.

Two lines of evidence are available in the administrative record to assess this water body condition. A TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard. Qualitative excess algal growth information is backed by nutrient data and is sufficient to support continued placement on the section 303(d) list (Listing Policy section 4.7).

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification for placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.

SWRCB Staff Recommendation: After review of the available data and information for this recommendation, SWRCB staff conclude that the water body and pollutant combination should be placed in the Water Quality Limited Segments Being Addressed category of the section 303(d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.

Lines of Evidence:

Line of Evidence	Remedial Program in Place
Beneficial Use	MU - Municipal & Domestic
Information Used to Assess Water Quality:	A TMDL for this water segment-pollutant combination was approved by the RWQCB in October 2002. The TMDL has an approved implementation plan. USEPA approved the TMDL on June 20, 2003.

Water Segment: Calleguas Creek Reach 11 (Arroyo Santa Rosa, was part of Conejo Creek Reach 3 on 1998 303d list)

Pollutant: Fecal Coliform

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 4.1 of the Listing Policy. Under section 4.1 a single line of evidence is necessary to assess listing status. One line of evidence is available in the administrative record to assess this pollutant. Six samples exceed the water quality objective but the number of samples is insufficient to determine with the confidence and power required by the Listing Policy.

Based on the readily available data and information, the weight of evidence indicates that there is insufficient justification in favor of removing this water segment-pollutant combination from the section 303(d) list.

This conclusion is based on the staff findings that:
1.It is unknown whether the data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2.The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3.Six of 12 samples exceeded the fecal coliform water quality objective. At least 28 samples are needed before a pollutant can be considered for removal from the list using the frequencies presented in Table 4.1 of the Listing Policy.
4.Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because it cannot be determined if applicable water quality standards are attained.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Water

Beneficial Use: R1 - Water Contact Recreation

Matrix: Water

Water Quality Objective/ Water Quality Criterion: Basin Plan: In waters designated for water contact recreation (REC-1), the fecal coliform concentration shall not exceed a log mean of 200/100 ml (based on a minimum of not less than four samples for any 30-day period), nor shall more than 10 percent of total samples during any 30-day period exceed 400/100 ml.

Data Used to Assess Water Quality:	Twelve water samples with 6 samples exceeding the 400/100 ml standard. Geomean of 393 exceeds 200/100 ml (SWRCB, 2003).
Spatial Representation:	One site.
Temporal Representation:	Summer, fall, winter, spring.
Data Quality Assessment:	Calleguas Creek Characterization Study

Water Segment: Calleguas Creek Reach 12 (was Conejo Creek/Arroyo Conejo North Fork on 1998 303d list)

Pollutant: Ammonia

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for listing under section 2.2 of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status.

One line of evidence is available in the administrative record to assess this pollutant. A TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.

SWRCB Staff Recommendation: After review of the available data and information for this recommendation, SWRCB staff concludes that the water body should be placed in the Water Quality Limited Segments Being Addressed category of the section 303 (d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.

Lines of Evidence:

Line of Evidence Remedial Program in Place

Beneficial Use MU - Municipal & Domestic

Information Used to Assess Water Quality: A TMDL for this water segment-pollutant combination was approved by the RWQCB in October 2002. The TMDL has an approved implementation plan. USEPA approved the TMDL on June 20, 2003.

Water Segment: Calleguas Creek Reach 13 (Conejo Creek South Fork, was Conejo Cr Reach 4 and part of Reach 3 on 1998 303d list)

Pollutant: Ammonia

Decision: Do Not Delist

Weight of Evidence: This water quality condition is being considered for listing under Water Quality limited segment being addressed (section 2.2) of the Listing Policy. Under this section of the
Policy, a minimum of one line of evidence is needed to assess listing status.

Two lines of evidence are available in the administrative record to assess this water body condition. A TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard. Qualitative excess algal growth information is backed by nutrient data and is sufficient to support continued placement on the section 303(d) list (Listing Policy section 4.7).

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification for placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.

SWRCB Staff Recommendation: After review of the available data and information for this recommendation, SWRCB staff conclude that the water body and pollutant combination should be placed in the Water Quality Limited Segments Being Addressed category of the section 303(d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.

Lines of Evidence:

Line of Evidence Remedial Program in Place

Beneficial Use CO - Cold Freshwater Habitat, MU - Municipal & Domestic

Information Used to Assess Water Quality: A TMDL for this water segment-pollutant combination was approved by the RWQCB in October 2002. The TMDL has an approved implementation plan. USEPA approved the TMDL on June 20, 2003.

Water Segment: Calleguas Creek Reach 13 (Conejo Creek South Fork, was Conejo Cr Reach 4 and part of Reach 3 on 1998 303d list)

Pollutant: Chloride

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 4.1 of the Listing Policy. Under section 4.1 a single line of evidence is necessary to assess listing status. One line of evidence is available in the administrative record to assess this pollutant. None of the samples exceed the water quality objective but the number of samples is insufficient to determine with the confidence and power required by the Listing Policy.

Based on the readily available data and information, the weight of evidence indicates that there is insufficient justification in favor of removing this water segment-pollutant combination from the section 303(d) list.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
2. Seventeen of 19 samples exceeded the water quality objective. At least 28 samples are needed before a pollutant can be considered for removal from the list using the frequencies presented in Table 4.1 of the Listing Policy.
3. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because it cannot be determined if applicable water quality standards are attained.

Lines of Evidence:

Numeric Line of Evidence	Pollutant-Water
Beneficial Use:	AG - Agricultural Supply
Matrix:	Water
Water Quality Objective/ Water Quality Criterion:	Basin Plan WQO: Chloride 1.5 mg/L.
Data Used to Assess Water Quality:	Nineteen water samples, 17 samples exceeding (SWRCB, 2003).
Spatial Representation:	Two sites.
Temporal Representation:	Summer, fall, winter, spring.
Data Quality Assessment:	NPDES reports.

Water Segment: Canada Larga (Ventura River Watershed)

Pollutant: Fecal Coliform

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 4.1 of the Listing Policy. Under section 4.1 a single line of evidence is necessary to assess listing status. One line of evidence is available in the administrative record to assess this pollutant. One sample exceed the water quality objective but the number of samples is insufficient to determine with the confidence and power required by the Listing Policy.

Based on the readily available data and information, the weight of evidence indicates that there is insufficient justification in favor of removing this water segment-pollutant combination from the section 303(d) list.

This conclusion is based on the staff findings that:
1.It is unknown whether the data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2.It is unknown whether the data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3.One of 9 samples exceeded the water quality objective. At least 28 samples are needed before a pollutant can be considered for removal from the list using the frequencies presented in Table 4.1 of the Listing Policy.
4.Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because it cannot be determined if applicable water quality standards are attained.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Water

Beneficial Use: R1 - Water Contact Recreation

Matrix: Water

Water Quality Objective/ Water Quality Criterion: Basin Plan: In waters designated for water contact recreation (REC-1), the fecal coliform concentration shall not exceed a log mean of 200/100 ml (based on a minimum of not less than four samples for any 30-day period), nor shall more than 10 percent of total samples during any 30-day period exceed 400/100 ml.

Data Used to Assess Water Quality:	One of 9 samples exceeded (SWRCB, 2003).
Spatial Representation:	Unknown.
Temporal Representation:	Different seasons and years.
Data Quality Assessment:	Unknown.

Water Segment: Castlerock Beach

Pollutant: Bacteria Indicators

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for listing under section 2.2 of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status.

Two lines of evidence are available in the administrative record to assess this pollutant. Based on the applicable factor, a TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard. The beach closure information is backed by coliform data. Beach closure information should not be placed on the section 303(d) list because it is not a pollutant or toxicity (section 2 of the Listing Policy).

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.

SWRCB Staff Recommendation: After review of the available data and information for this recommendation, SWRCB staff conclude that the water body and pollutant (coliform) should be placed in the Water Quality Limited Segments Being Addressed category of the section 303(d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.

Lines of Evidence:

Line of Evidence Remedial Program in Place

Beneficial Use R1 - Water Contact Recreation

Information Used to Assess Water Quality: A TMDL and implementation plan has been approved for this water segment-pollutant combination. The Santa Monica Bay Bacteria Dry Weather TMDL was approved by RWQCB on January 24, 2002 and subsequently approved by USEPA. The Santa Monica Bay Bacteria Wet Weather TMDL was approved by RWQCB on December 12, 2004 and approved by USEPA on June 19, 2003.

Water Segment: Compton Creek

Pollutant: pH

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for listing under section 2.2 of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status.

One line of evidence is available in the administrative record to assess this pollutant. Based on the applicable factor, a TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.

SWRCB Staff Recommendation: After review of the available data and information for this recommendation, SWRCB staff conclude that the water body should be placed in the Water Quality Limited Segments Being Addressed category of the section 303(d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.

Lines of Evidence:

Line of Evidence Remedial Program in Place

Beneficial Use R2 - Non-Contact Recreation

Information Used to Assess Water Quality: A TMDL and implementation plan has been approved for this water segment-pollutant combination. The Los Angeles River Nitrogen TMDL was approved by RWQCB on August 19, 2003 and subsequently approved by USEPA on March 18, 2004.

Region 4

Water Segment: Coyote Creek

Pollutant: Copper

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 4.1 of the Listing Policy. Under section 4.1 a single line of evidence is necessary to assess delisting status.

One line of applicable evidence is available in the administrative record to assess this pollutant. A sufficient number of samples exceeds the CTR dissolved copper criterion for continuous concentration (CCC) in water for the protection of aquatic life. Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification against removing this water segment-pollutant combination from the section 303(d) list.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3. Seventeen of 63 samples exceed the CTR Dissolved Copper Criterion for continuous concentration (CCC) in water for the protection of aquatic life and this exceeds the allowable frequency listed in Table 4.1 of the Listing Policy.
4. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from on the section 303(d) list because applicable water quality standards are exceeded and the pollutant contributes to or causes the problem.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Water

Beneficial Use: WA - Warm Freshwater Habitat

Matrix: Water

Water Quality Objective/ Water Quality Criterion: CTR Dissolved Copper Criterion for continuous concentration (CCC) in water for the protection of aquatic life is expressed as a function of the total harness of the water body. The aquatic life criteria will vary depending of total hardness reported at the sampling site. The CCC for dissolved copper is the highest concentration to which aquatic life can be exposed for an extended period of time (four days) without deleterious effects. This criterion is linked and applicable for the protection of aquatic life Beneficial Uses.

Data Used to Assess Water Quality: Numeric data generated from 63 samples taken from 11/10/97 to 1/13/04 at one to two-week sampling interval. 17 samples exceeded the dissolved copper continuous criterion concentration, which equals the highest concentration of a pollutant to which aquatic life can be exposed for an extended period of time (4days) without deleterious effects (LACSD, 2004) (LACDPW, 2004).

Spatial Representation:	One (1) sampling station sampled from 11/10/97 to 1/13/04. Los Angeles Department of Public Works mass emission station at Spring Street on Coyote Creek.
Temporal Representation:	Sixty-three samples taken during the wet season from 11/10/97 to 1/13/04 at approximately one to two week intervals.
Environmental Conditions:	Results are from samples taken from 1997 to 2004. Sampling was carried out at Spring Street on Coyote Creek during the wet season.
Data Quality Assessment:	Evaluation of Analytes and QA/QC Specifications for Monitoring Program (Woodward-Clyde, 1996) Los Angeles County Department of Public Works.

Numeric Line of Evidence	Pollutant-Water
Beneficial Use:	MU - Municipal & Domestic
Matrix:	Water
Water Quality Objective/ Water Quality Criterion:	There is no guideline applicable to determine exceedances due to total Copper.
Data Used to Assess Water Quality:	Numeric data generated from 21 samples taken from 10/30/00 to 4/30/03 at one to two-week sampling interval. It was not possible to determine any exceedances of total copper concentration in this water body because there is not guideline applicable to assess the effect of the total fraction of this pollutant available (LACDPW, 2004).
Spatial Representation:	One sample site sampled during the dry and wet season beginning from 10/12/00 through 4/30/03 at approximately one to two week intervals.
Temporal Representation:	Twenty-one samples where taken during the wet and dry season from 10/12/00 to 4/30/03 at approximately one to two week intervals as part of the Los Angeles County Storm water monitoring program prepared by the Los Angeles County Department of Public Works.
Environmental Conditions:	The Coyote Creek Monitoring Station (S13) is located at the existing ACOE stream gage station (Stream Gage No. F354-R) below Spring Street in the lower San Gabriel River watershed. The site assists in determining mass loading for the San Gabriel River watershed. At this location, the upstream tributary area is 150 square miles (extending into Orange County). The sampling site was chosen to avoid backwater effects from the San Gabriel River. Coyote Creek, at the gauging station, is a concrete lined trapezoidal channel. The Coyote Creek sampling location has been an active stream gauging station since 1963.
Data Quality Assessment:	Evaluation of Analytes and QA/QC Specifications for Monitoring Program (Woodward-Clyde, 1996) Los Angeles County Department of Public Works.

Water Segment: Coyote Creek

Pollutant: Lead

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 4.1 of the Listing Policy. Under section 4.1 a single line of evidence is necessary to assess listing status.

One applicable line of evidence is available in the administrative record to assess this pollutant. A sufficient number of samples exceed the CTR dissolved lead water quality criteria. Total lead was detected in ten (10) samples taken from 11/12/01 through 4/30/03, but data reported could not be compared against any established criteria or WQO for the protection of any beneficial use in fresh water.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification against removing this water segment-pollutant combination on the section 303(d) list.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3. Six of 64 samples exceeded the CTR criteria for the dissolved fraction of lead and this exceeds the allowable frequency listed in Table 4.1 of the Listing Policy.
4. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because applicable water quality standards for the pollutant are exceeded.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Water

Beneficial Use: MU - Municipal & Domestic, WA - Warm Freshwater Habitat

Matrix: Water

Water Quality Objective/ Water Quality Criterion: There is no fresh water WQO or criteria for Total Lead linked or applicable with protection of Warm Fresh Water Habitat or MUN BUs.

Data Used to Assess Water Quality: Numeric data generated from 21 samples taken from 10/30/00 to 4/30/03 at one to two-week sampling interval. Total lead was detected in ten (10) samples taken from 11/12/01 through 4/30/03. Data reported could not be compared against any established criteria or WQO established for total lead for the protection of any beneficial use in fresh water (LACSD, 2004); (LACDPW, 2004).

Spatial Representation: One sample site sampled during the dry and wet season beginning from 10/12/00

	through 4/30/03 at approximately one to two week intervals.
Temporal Representation:	Twenty-one (21) samples where taken during the wet and dry season from 10/12/00 to 4/30/03 at approximately one to two week intervals as part of the Los Angeles County Storm water monitoring program prepared by the Los Angeles County Department of Public Works.
Environmental Conditions:	The Coyote Creek Monitoring Station (S13) is located at the existing ACOE stream gage station (Stream Gage No. F354-R) below Spring Street in the lower San Gabriel River watershed. The site assists in determining mass loading for the San Gabriel River watershed. At this location, the upstream tributary area is 150 square miles (extending into Orange County). The sampling site was chosen to avoid backwater effects from the San Gabriel River. Coyote Creek, at the gauging station, is a concrete lined trapezoidal channel. The Coyote Creek sampling location has been an active stream gauging station since 1963.
Data Quality Assessment:	Evaluation of Analytes and QA/QC Specifications for Monitoring Program (Woodward-Clyde, 1996) Los Angeles County Department of Public Works.

Numeric Line of Evidence	Pollutant-Water
Beneficial Use:	WA - Warm Freshwater Habitat
Matrix:	Water
Water Quality Objective/ Water Quality Criterion:	CTR Dissolved Lead Criterion for continuous concentration (CCC) in water for the protection of aquatic life is expressed as a function of the total harness of the water body. The aquatic life criteria will vary depending of total hardness reported at the sampling site. The CCC for dissolved lead is the highest concentration to which aquatic life can be exposed for an extended period of time (four days) without deleterious effects. This criterion is linked and applicable for the protection of aquatic life Beneficial Uses.
Data Used to Assess Water Quality:	Numeric data generated from 64 samples taken from 11/10/97 to 1/13/04 at one to two-week sampling interval. Six samples exceeded the dissolved lead continuous criterion concentration, which equals the highest concentration of a pollutant to which aquatic life can be exposed for an extended period of time (4days) without deleterious effects (LACSD, 2004) (LACDPW 2004).
Spatial Representation:	One (1) sampling station sampled from 11/10/97 to 1/13/04. Los Angeles Department of Public Works mass emission station at Spring Street on Coyote Creek.
Temporal Representation:	Sixty-four (64) samples taken during the wet season from 11/10/97 to 1/13/04 at approximately one to two week intervals.
Environmental Conditions:	Results are from samples taken from 1997 to 2004. Sampling was carried out at Spring Street on Coyote Creek during the wet season.
Data Quality Assessment:	Evaluation of Analytes and QA/QC Specifications for Monitoring Program (Woodward-Clyde, 1996) Los Angeles County Department of Public Works.

Water Segment: Dan Blocker Memorial (Coral) Beach

Pollutant: Coliform Bacteria

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for listing under section 2.2 of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status.

One line of evidence is available in the administrative record to assess this pollutant. Based on the applicable factor, a TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard. This water segment-pollutant combination was moved off the section 303(d) list during the 2002 listing cycle.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.

SWRCB Staff Recommendation: After review of the available data and information for this recommendation, SWRCB staff conclude that the water body should be placed in the Water Quality Limited Segments Being Addressed category of the section 303(d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.

Lines of Evidence:

Line of Evidence Remedial Program in Place

Beneficial Use R1 - Water Contact Recreation

Information Used to Assess Water Quality: A TMDL and implementation plan has been approved for this water segment-pollutant combination. The Santa Monica Bay Bacteria Dry Weather TMDL was approved by RWQCB on January 24, 2002 and subsequently approved by USEPA. The Santa Monica Bay Bacteria Wet Weather TMDL was approved by RWQCB on December 12, 2004 and approved by USEPA on June 19, 2003.

Water Segment: Dockweiler Beach

Pollutant: Coliform Bacteria

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for listing under section 2.2 of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status.

One line of evidence is available in the administrative record to assess this pollutant. Based on the applicable factor, a TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.

SWRCB Staff Recommendation: After review of the available data and information for this recommendation, SWRCB staff conclude that the water body and pollutant (coliform) should be placed in the Water Quality Limited Segments Being Addressed category of the section 303(d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.

Lines of Evidence:

Line of Evidence Remedial Program in Place

Beneficial Use R1 - Water Contact Recreation

Information Used to Assess Water Quality: A TMDL and implementation plan has been approved for this water segment-pollutant combination. The Santa Monica Bay Bacteria Dry Weather TMDL was approved by RWQCB on January 24, 2002 and subsequently approved by USEPA. The Santa Monica Bay Bacteria Wet Weather TMDL was approved by RWQCB on December 12, 2004 and approved by USEPA on June 19, 2003.

Region 4

Water Segment: Dominguez Channel (lined portion above Vermont Ave)

Pollutant: Copper

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 4.1 of the Listing Policy. Under section 4.1 a single line of evidence is necessary to assess listing status. Three lines of evidence are available in the administrative record to assess this pollutant.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of not removing the S28 segment located at Dominguez Channel and Artesia Blvd in the City of Torrance on the section 303(d) list in the Water Quality Limited Segments category.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3. Sixteen of the 19 samples taken between 2000-2003 exceed the CTR Criteria for protection of aquatic life. Although 19 samples is not enough to determine with the confidence and power of the Listing Policy, a minimum of 188 samples would be needed in order for 16 exceedances to result in a delisting.
4.Pursuant to section 3.11 of the Listing Policy, no additional data and information are available indicating that standards are not met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from on the section 303(d) list because applicable water quality standards are exceeded and a pollutant contributes to or causes the problem.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Water

Beneficial Use: MU - Municipal & Domestic, R1 - Water Contact Recreation, R2 - Non-Contact Recreation, RA - Rare & Endangered Species, WA - Warm Freshwater Habitat, WI - Wildlife Habitat

Matrix: Water

Water Quality Objective/ Water Quality Criterion: CTR dissolved copper criteria for continuous concentration (CCC) and maximum concentration (CMC) in water for the protection of aquatic life are expressed as a function of the total hardness of the water body. The aquatic life criteria will vary depending of total hardness reported at the sampling site. The CCC for dissolved copper is the highest concentration to which aquatic life can be exposed for an extended period of time (e.g., four days) without deleterious effects. The CMC for dissolved copper is the highest concentration to which aquatic life can be exposed for a short period of time (e.g., one hour) without deleterious effects. These criteria are linked and applicable for the protection of aquatic life beneficial uses. Calculation of the criteria based on ambient hardness at the time of sampling resulted in copper CCCs ranging from 2.26 to 16.88 ug/l; and CMCs ranging from 2.95 to 27.04 ug/L.

Data Used to Assess Water Quality:	Twelve out of 12 samples exceed both the CCC and CMC (LACDWP, 2003a).
Spatial Representation:	Samples were taken at the Dominguez Channel Monitoring Station (S23) which is located within the Dominguez Channel/Los Angeles Harbor watershed in Lennox, near Los Angeles International Airport (LAX). The monitoring station is near the intersection of 116th Street and Isis Avenue. The overall watershed land use is predominantly transportation, and includes areas of LAX and Interstate 105.
Temporal Representation:	Samples were taken in October 2000, and in January through April 2001.
Environmental Conditions:	According to the County of Los Angeles, Department of Public Works, Stormwater Monitoring Reports, 2000-2001 Monitoring Report samples were taken during storm events, the amount of rainfall was not noted.
Data Quality Assessment:	Evaluation of Analytes and QA/QC Specifications for Monitoring Program (Woodward-Clyde, 1996) Los Angeles County Department of Public Works.

Numeric Line of Evidence	Pollutant-Water
Beneficial Use:	MU - Municipal & Domestic, R1 - Water Contact Recreation, R2 - Non-Contact Recreation, RA - Rare & Endangered Species, WA - Warm Freshwater Habitat, WI - Wildlife Habitat
Matrix:	Water
Water Quality Objective/ Water Quality Criterion:	CTR dissolved copper criteria for continuous concentration (CCC) and maximum concentration (CMC) in water for the protection of aquatic life are expressed as a function of the total hardness of the water body. The aquatic life criteria will vary depending of total hardness reported at the sampling site. The CCC for dissolved copper is the highest concentration to which aquatic life can be exposed for an extended period of time (e.g., four days) without deleterious effects. The CMC for dissolved copper is the highest concentration to which aquatic life can be exposed for a short period of time (e.g., one hour) without deleterious effects. These criteria are linked and applicable for the protection of aquatic life beneficial uses. Calculation of the criteria based on ambient hardness at the time of sampling resulted in copper CCCs ranging from 1.79 to 18.25 ug/l; and CMCs ranging from 2.28 to 29.46 ug/L.
Data Used to Assess Water Quality:	Four out of 6 samples exceeded both the CCC and CMC (LACDWP, 2003a).
Spatial Representation:	Samples were taken at the Dominguez Channel Monitoring Station (S28) which is located at Dominguez Channel and Artesia Boulevard in the City of Torrance. At this location, which was chosen to avoid tidal influence, the upstream tributary area is 33 square miles. The portion of the river where the monitoring site is located is a concrete-lined rectangular channel.
Temporal Representation:	Samples were taken October through December 2002, and February through April 2003. The positive quantification limit (PQL) of the sample taken on

	3/15/03 was higher than the CCC criteria, however sample concentration results was even greater.
Environmental Conditions:	According to the County of Los Angeles, Department of Public Works, Stormwater Monitoring Reports, 2002-2003 Monitoring Report samples were taken during storm events, the amount of rainfall was not noted.
Data Quality Assessment:	Evaluation of Analytes and QA/QC Specifications for Monitoring Program (Woodward-Clyde, 1996) Los Angeles County Department of Public Works.

Numeric Line of Evidence	Pollutant-Water
Beneficial Use:	MU - Municipal & Domestic, R1 - Water Contact Recreation, R2 - Non-Contact Recreation, RA - Rare & Endangered Species, WA - Warm Freshwater Habitat, WI - Wildlife Habitat
Matrix:	Water
Water Quality Objective/ Water Quality Criterion:	CTR dissolved copper criteria for continuous concentration (CCC) and maximum concentration (CMC) in water for the protection of aquatic life are expressed as a function of the total hardness of the water body. The aquatic life criteria will vary depending of total hardness reported at the sampling site. The CCC for dissolved copper is the highest concentration to which aquatic life can be exposed for an extended period of time (e.g., four days) without deleterious effects. The CMC for dissolved copper is the highest concentration to which aquatic life can be exposed for a short period of time (e.g., one hour) without deleterious effects. These criteria are linked and applicable for the protection of aquatic life beneficial uses. Calculation of the criteria based on ambient hardness at the time of sampling resulted in copper CCCs ranging from 1.79 to 18.25 ug/l; and CMCs ranging from 2.28 to 29.46 ug/L.
Data Used to Assess Water Quality:	The single sample taken exceeded both the CCC and CMC (LACDWP, 2003a).
Spatial Representation:	Samples were taken at the Dominguez Channel Monitoring Station (S28) which is located at Dominguez Channel and Artesia Boulevard in the City of Torrance. At this location, which was chosen to avoid tidal influence, the upstream tributary area is 33 square miles. The portion of the river where the monitoring site is located is a concrete-lined rectangular channel.
Temporal Representation:	The sample was taken in January 2002.
Environmental Conditions:	According to the County of Los Angeles, Department of Public Works, Stormwater Monitoring Reports, 2001-2002 Monitoring Report samples were taken during storm events, the amount of rainfall was not noted.
Data Quality Assessment:	Evaluation of Analytes and QA/QC Specifications for Monitoring Program (Woodward-Clyde, 1996) Los Angeles County Department of Public Works.

Water Segment: Dominguez Channel (lined portion above Vermont Ave)

Pollutant: Total Fecal Coliform

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 4.3 of the Listing Policy. Under section 4.2 a single line of evidence is necessary to assess delisting status.

Three lines of evidence from different sampling years are available in the administrative record to assess this pollutant. In all sample sets a number of samples exceeded bacterial water quality objective.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification against removing this water segment-pollutant combination from the section 303(d) list.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3. Eleven out of 12 samples exceeded the fecal coliform bacteria water quality objective. Although this is not enough samples to determine with the confidence and power of the Listing Policy, a minimum of 67 samples would be needed in order for eleven exceedances to result in a delisting.
4. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from on the section 303(d) list because applicable water quality standards are exceeded and a pollutant contributes to or causes the problem.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Water

Beneficial Use: MU - Municipal & Domestic, R1 - Water Contact Recreation, R2 - Non-Contact Recreation, RA - Rare & Endangered Species, WA - Warm Freshwater Habitat, WI - Wildlife Habitat

Matrix: Water

Water Quality Objective/ Water Quality Criterion: Basin Plan single sample water quality objective for fecal coliform in fresh waters designated REC-1 is fecal coliform density shall not exceed 400/100ml MPN.

Data Used to Assess Water Quality: Four out of 4 samples exceeded the 400 MPN limit, sample results ranged from 900 to 17,000 MPN

Spatial Representation:	Samples were taken at the Dominguez Channel Monitoring Station (S23) which is located within the Dominguez Channel/Los Angeles Harbor watershed in Lennox, near Los Angeles International Airport (LAX). The monitoring station is near the intersection of 116th Street and Isis Avenue. The overall watershed land use is predominantly transportation, and includes areas of LAX and Interstate 105.
Temporal Representation:	Samples were taken 1/30/01, 2/15/01, 2/28/01, and 3/7/01.
Environmental Conditions:	According to the County of Los Angeles, Department of Public Works, Stormwater Monitoring Reports, 2000-2001 Monitoring Report samples were taken during storm events, the amount of rainfall was not noted.
Data Quality Assessment:	Evaluation of Analytes and QA/QC Specifications for Monitoring Program (Woodward-Clyde, 1996) Los Angeles County Department of Public Works.

Numeric Line of Evidence	Pollutant-Water
Beneficial Use:	MU - Municipal & Domestic, R1 - Water Contact Recreation, R2 - Non-Contact Recreation, RA - Rare & Endangered Species, WA - Warm Freshwater Habitat, WI - Wildlife Habitat
Matrix:	Water
Water Quality Objective/ Water Quality Criterion:	Basin Plan single sample water quality objective for fecal coliform in fresh waters designated REC-1 is fecal coliform density shall not exceed 400/100ml MPN.
Data Used to Assess Water Quality:	Two of 2 samples exceeded the 400 MPN objective. One sample was 5,000, the other 6,000 MPN.
Spatial Representation:	Samples were taken at the Dominguez Channel Monitoring Station (S28) which is located at Dominguez Channel and Artesia Boulevard in the City of Torrance. At this location, which was chosen to avoid tidal influence, the upstream tributary area is 33 square miles. The portion of the river where the monitoring site is located is a concrete-lined rectangular channel.
Temporal Representation:	Samples were taken on 1/28/02 and 3/19/02.
Environmental Conditions:	According to the County of Los Angeles, Department of Public Works, Stormwater Monitoring Reports, 2001-2002 Monitoring Report samples were taken during storm events, the amount of rainfall was not noted.
Data Quality Assessment:	Evaluation of Analytes and QA/QC Specifications for Monitoring Program (Woodward-Clyde, 1996) Los Angeles County Department of Public Works.

Numeric Line of Evidence	Pollutant-Water
Beneficial Use:	MU - Municipal & Domestic, R1 - Water Contact Recreation, R2 - Non-Contact Recreation, RA - Rare & Endangered Species, WA - Warm Freshwater Habitat, WI - Wildlife Habitat
Matrix:	Water
Water Quality Objective/ Water Quality Criterion:	Basin Plan single sample water quality objective for fecal coliform in fresh waters designated REC-1 is fecal coliform density shall not exceed 400/100ml MPN.

Data Used to Assess Water Quality:	Five out of six samples exceeded the 400 MPN objective. Samples exceeding the objective ranged from 2,300 to 240,000 MPN.
Spatial Representation:	Samples were taken at the Dominguez Channel Monitoring Station (S28) which is located at Dominguez Channel and Artesia Boulevard in the City of Torrance. At this location, which was chosen to avoid tidal influence, the upstream tributary area is 33 square miles. The portion of the river where the monitoring site is located is a concrete-lined rectangular channel.
Temporal Representation:	Samples taken on 10/10/02, 11/8/02, 12/16/02, 2/11/03, and 3/15/03 exceeded the objective. A sample taken on 4/30/03 did not exceed the objective.
Environmental Conditions:	According to the County of Los Angeles, Department of Public Works, Stormwater Monitoring Reports, 2002-2003 Monitoring Report samples were taken during storm events, the amount of rainfall was not noted.
Data Quality Assessment:	Evaluation of Analytes and QA/QC Specifications for Monitoring Program (Woodward-Clyde, 1996) Los Angeles County Department of Public Works.

Region 4

Water Segment: Dominguez Channel Estuary (unlined portion below Vermont Ave)

Pollutant: Lead

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 4 of the Listing Policy. The Policy calls for the delisting of waters if the decision is found to be faulty. Three different lines of evidence are available in the administrative record to assess this pollutant.

Lead in tissue was used in 2002 to list this segment. The listing was based on EDLs or MTRL and these guidelines do not meet the requirements of the Listing Policy. In addition only one tissue sample was taken in 1992 at a one site and this is not representative of the water segment.

Sediment samples were exceeded between 1994 and 2004 and this exceeds the allowable frequency listed in Table 3.1, The Listing Policy also requires that the pollutant be linked with observed toxicity or benthic community impacts in order for the segment to be listed. Only one toxicity sample and one benthic community sample was collected in 1996 and although the total number of samples is not sufficient to establish the linkage required by the Listing Policy the benthic community sample was of sufficient magnitude to indicate a linkage between pollutant and benthic community impacts.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification for replacing the lead in tissue listing with lead in sediment for this water segment-pollutant combination.

This conclusion is based on the staff findings that there is insufficient data available to assess the status of this water body for lead in tissue because there are no applicable tissue guidelines for this pollutant. However 29 of 93 core grab sediment samples exceeded the Probable Effects Level of 112.18 ug/l for lead and benthic community impacts were recorded. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the lead in tissue should be replaced with lead in sediment water body-pollutant combination in the 303(d) list. The tissue listing was based on faulty evaluation guidelines but lead in the sediment was found to exceed applicable sediment quality guidelines and the benthic community impacts documented may be caused or contribute to by this pollutant.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Tissue

Beneficial Use: CM - Commercial and Sport Fishing (CA)

Matrix:	Tissue
Water Quality Objective/ Water Quality Criterion:	Basin Plan: Toxic pollutants shall not be present at levels that will bioaccumulate in aquatic life to levels which are harmful to aquatic life or human health.
Evaluation Guideline:	There is no tissue guideline available for this pollutant that meets the requirements of section 6.1.3 of the Listing Policy. The original listing was based on an EDL and MTRL. The Listing Policy does not allow the use of EDLs or MTRLs in listing or delisting decisions.
Data Used to Assess Water Quality:	One tissue sample is available. Mussel watch monitoring data is not available in the water segment (TSMP, 2002).
Spatial Representation:	One station.
Temporal Representation:	The sample was collected in 1992.
Data Quality Assessment:	Toxic Substances Monitoring Program.

Numeric Line of Evidence	Pollutant-Sediment
Beneficial Use:	CM - Commercial and Sport Fishing (CA)
Matrix:	Sediment
Water Quality Objective/ Water Quality Criterion:	Basin Plan: Surface waters shall not contain concentrations of chemical constituents in amounts that adversely affect any designated beneficial use.
Evaluation Guideline:	A Probable Effect Level of 112.18 ug/g was used (MacDonald et al., 1996).
Data Used to Assess Water Quality:	Of the 93 core and grab sediment samples, 29 exceeded the sediment quality guideline (Anderson et al., 1998).
Spatial Representation:	The ninety-three samples were spread throughout the water body.
Temporal Representation:	The samples were collected between 1994 and 2002.
Data Quality Assessment:	Bay Protection and Toxic Cleanup Program Other quality assurance described in the Contaminated Sediments Task Force Database.

Numeric Line of Evidence	Toxicity
Beneficial Use:	ES - Estuarine Habitat, MA - Marine Habitat
Matrix:	Sediment
Water Quality Objective/ Water Quality Criterion:	Basin Plan: Surface waters shall not contain concentrations of chemical constituents in amounts that adversely affect any designated beneficial use.
Evaluation Guideline:	The data were analyzed using the BPTCP reference envelope approach.
Data Used to Assess Water Quality:	One toxicity sample that showed 61 percent survival (Anderson et al., 1998).
Spatial Representation:	One station at H. Ford Bridge (BPTCP station 47010.0).
Temporal Representation:	The sample was collected in 1996.
Data Quality Assessment:	Bay Protection and Toxic Cleanup Program.

Numeric Line of Evidence	Population/Community Degradation
Beneficial Use:	ES - Estuarine Habitat, MA - Marine Habitat
Matrix:	Sediment
Water Quality Objective/ Water Quality Criterion:	Basin Plan: Surface waters shall not contain concentrations of chemical constituents in amounts that adversely affect any designated beneficial use.
Evaluation Guideline:	Evaluation of the benthic data were completed using the approaches developed by scientists associated with the BPTCP. The relative benthic index used is a calculated value considering the total fauna, total mollusk species, crustacean species and indicator species at a site. The index ranges from 0 to 1.0. An index value of less than or equal to 0.3 is an indication that pollutants or other factors are negatively impacting the benthic community (Anderson et al., 1998).
Data Used to Assess Water Quality:	One benthic community sample with a benthic index of 0.21 (Anderson et al., 1998).
Spatial Representation:	One station at H. Ford Bridge (BPTCP station 47010.0).
Temporal Representation:	The sample was collected in 1996.
Environmental Conditions:	Adjacent waters (Consolidated Slip) also has degraded benthic communities.
Data Quality Assessment:	Bay Protection and Toxic Cleanup Program (Stephenson et al., 1994).

Water Segment: Duck Pond Agricultural Drains/Mugu Drain/Oxnard Drain No 2

Pollutant: Nitrogen

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for listing under section 2.2 of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status.

One line of evidence is available in the administrative record to assess this pollutant. A TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.

SWRCB Staff Recommendation: After review of the available data and information for this recommendation, SWRCB staff concludes that the water body should be placed in the Water Quality Limited Segments Being Addressed category of the section 303(d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.

Lines of Evidence:

Line of Evidence Remedial Program in Place

Beneficial Use MU - Municipal & Domestic

Information Used to Assess Water Quality: A TMDL for this water segment-pollutant combination was approved by the RWQCB in October 2002. The TMDL has an approved implementation plan. USEPA approved the TMDL on June 20, 2003.

Water Segment: El Dorado Lakes

Pollutant: Mercury

Decision: Do Not Delist

Weight of Evidence: Based on the readily available data and information, the weight of evidence indicates that there is insufficient justification in favor of removing this water segment-pollutant combination from the section 303(d) list in the Water Quality Limited Segments category.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3. Two of the 2 samples exceeded the water quality objectives but the number of samples is insufficient to determine with the confidence and power required by the Listing Policy.
4. Pursuant to section 3.11 of the Listing Policy, no additional data and information are available indicating that standards are not met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because it cannot be determined if applicable water quality standards are attained.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Tissue

Beneficial Use: CM - Commercial and Sport Fishing (CA)

Matrix: Tissue

Water Quality Objective/ Water Quality Criterion: Los Angeles RWQCB Basin Plan: Toxic pollutants shall not be present at levels that will bioaccumulate in aquatic life to levels which are harmful to aquatic life or human health.

Evaluation Guideline: 0.3 ug/g (OEHHA Screening Value).

Data Used to Assess Water Quality: Two out of 2 samples exceeded. Two filet composite samples of largemouth bass were collected. Bass were collected in 1992 and 1998. Both samples exceeded the guideline (TSMP, 2002).

Spatial Representation: One station located in northern most lake in El Dorado Park.

Temporal Representation: Samples were collected in 1992 and 1998.

Data Quality Assessment: Toxic Substances Monitoring Program 1992-93 Data Report. Environmental Chemistry Quality Assurance and Data Report for the Toxic Substances Monitoring Program,1996-2000. Department of Fish and Game

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Water Segment:	Fox Barranca (tributary to Calleguas Creek Reach 6)
Pollutant:	Nitrate and Nitrite
Decision:	Do Not Delist
Weight of Evidence:	This pollutant is being considered for listing under section 2.2 of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status. One line of evidence is available in the administrative record to assess this pollutant. A TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard. Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.
SWRCB Staff Recommendation:	After review of the available data and information for this recommendation, SWRCB staff concludes that the water body should be placed in the Water Quality Limited Segments Being Addressed category of the section 303 (d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.
Lines of Evidence:	

Line of Evidence	Remedial Program in Place
Beneficial Use	MU - Municipal & Domestic
Information Used to Assess Water Quality:	A TMDL for this water segment-pollutant combination was approved by the RWQCB in October 2002. The TMDL has an approved implementation plan. USEPA approved the TMDL on June 20, 2003.

Water Segment: Hobie Beach (Channel Islands Harbor)

Pollutant: Bacteria Indicators

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 4.3 of the Listing Policy. Under section 4.2 a single line of evidence is necessary to assess delisting status.

One line of evidence from data collected in 1999, 2000, and 2001 is available in the administrative record to assess this pollutant. This data set was probably used to place the water body segment on the 2002 303(d) list originally. A large number of samples exceed the water quality objective.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification against removing this water segment-pollutant combination from the section 303(d) list.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3. Forty-nine of 97 samples exceeded the 17 CCR bacteriological standard for water adjacent to public beaches and public water-contact sports areas and this exceeds the allowable frequency listed in Table 4.2 of the Listing Policy.
4. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from on the section 303(d) list because applicable water quality standards are exceeded and a pollutant contributes to or causes the problem.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Water

Beneficial Use: R1 - Water Contact Recreation

Matrix: Water

Water Quality Objective/ Water Quality Criterion: 17 CCR 7958 (in part): The minimum protective bacteriological standards for waters adjacent to public beaches and public water-contact sports areas shall be as follows:
(1) Based on a single sample, the density of bacteria in water from each sampling station at a public beach or public water contact sports area shall not exceed:
(A) 1,000 total coliform bacteria per 100 milliliters, if the ratio of fecal/total coliform bacteria exceeds 0.1; or

(B) 10,000 total coliform bacteria per 100 milliliters; or
(C) 400 fecal coliform bacteria per 100 milliliters; or
(D) 104 enterococcus bacteria per 100 milliliters.

Data Used to Assess Water Quality:	Forty-nine samples exceeding standards out of 97 samples (SWRCB, 2003).
Spatial Representation:	One station: V(36000). This station represents the beach 50 yards on either side of the sampling point.
Temporal Representation:	Data collected in 1999, 2000, and 2001.
Data Quality Assessment:	County Health Department

Water Segment: Hopper Creek

Pollutant: Sulfates

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 4.1 of the Listing Policy. Under section 4.1 a single line of evidence is necessary to assess delisting status.

One line of evidence is available in the administrative record to assess this pollutant. This data set was probably used to place this water body-combination on the 2002 303(d) list originally. A large number of samples exceed the water quality objective.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification against removing this water segment-pollutant combination from the section 303(d) list.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3. Eleven of 12 samples exceeded the sulfate 600 mg/l water quality objective but the number of samples is insufficient to determine with the confidence and power required by the Listing Policy.
4. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because it cannot be determined if applicable water quality standards are attained.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Water

Beneficial Use: AG - Agricultural Supply

Matrix: Water

Water Quality Objective/ Water Quality Criterion: Basin Plan WQO: 600 mg/L.

Data Used to Assess Water Twelve water samples, 11 samples exceeding (SWRCB, 2003).

Quality:	
Spatial Representation:	At Hwy 126
Temporal Representation:	Quarterly sampling events, 2002-2003.
Data Quality Assessment:	United Water Conservation District

Region 4

Water Segment: Hopper Creek

Pollutant: Total Dissolved Solids

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 4.2 of the Listing Policy. Under section 4.2 a single line of evidence is necessary to assess delisting status.

One line of evidence is available in the administrative record to assess this pollutant. This data set was probably used to place this water body - pollutant combination on the 2002 303(d) list originally. A large number of samples exceed the water quality objective.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification against removing this water segment-pollutant combination from the section 303(d) list.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3. Ten of 11 samples exceeded the total dissolved solids of 1,300 mg/l basin plan water quality objective but the number of samples is insufficient to determine with the confidence and power required by the Listing Policy.
4. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because it cannot be determined if applicable water quality standards are attained.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Water

Beneficial Use: AG - Agricultural Supply

Matrix: Water

Water Quality Objective/ Water Quality Criterion: Basin Plan WQO: 1,300 mg/L.

Data Used to Assess Water Quality: Eleven water samples, 10 samples exceeding (SWRCB, 2003).

Spatial Representation:	Collected at Hwy. 126.
Temporal Representation:	Quarterly sampling events, 2002-2003.
Data Quality Assessment:	United Water Conservation District

Water Segment: Las Flores Beach

Pollutant: Coliform Bacteria

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for listing under section 2.2 of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status.

Two lines of evidence are available in the administrative record to assess this pollutant. Based on the applicable factor, a TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard. The beach closure information is backed by coliform data. Beach closure information should not be placed on the section 303(d) list because it is not a pollutant or toxicity (section 2 of the Listing Policy).

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.

SWRCB Staff Recommendation: After review of the available data and information for this recommendation, SWRCB staff conclude that the water body should be placed in the Water Quality Limited Segments Being Addressed category of the section 303(d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.

Lines of Evidence:

Line of Evidence	Remedial Program in Place
Beneficial Use	R1 - Water Contact Recreation
Information Used to Assess Water Quality:	A TMDL and implementation plan has been approved for this water segment-pollutant combination. The Santa Monica Bay Bacteria Dry Weather TMDL was approved by RWQCB on January 24, 2002 and subsequently approved by USEPA. The Santa Monica Bay Bacteria Wet Weather TMDL was approved by RWQCB on December 12, 2004 and approved by USEPA on June 19, 2003.

Water Segment: Latigo Canyon Creek

Pollutant: Sulfates

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for placement on the section 303(d) list under section 3.2 of the Listing Policy. Under section 3.2 a single line of evidence is necessary to assess listing status.

One line of evidence is available in the administrative record to assess this pollutant. An insufficient total number of samples were taken and an insufficient number of samples exceed the MCL guideline for Sulfate.

Based on the readily available data and information, the weight of evidence indicates that there is insufficient justification in favor of placing this water segment-pollutant combination on the section 303(d) list in the Water Quality Limited Segments category.

This conclusion is based on the staff findings that:
1.The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2.The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3.Two of two samples exceeded the MCL guideline. More data is needed to determine if the water quality standard is exceeded.
4.Pursuant to section 3.11 of the Listing Policy, no additional data and information are available indicating that standards are not met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be placed on the section 303(d) list because it cannot be determined if applicable water quality standards are exceeded.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Water

Beneficial Use: MU - Municipal & Domestic, R1 - Water Contact Recreation, R2 - Non-Contact Recreation, WA - Warm Freshwater Habitat, WI - Wildlife Habitat

Matrix: Water

Water Quality Objective/ Water Quality Criterion: CCR- Title 22 Table 64449-B Secondary Maximum Contaminant Levels of 250 mg/l for Sulfate.

Data Used to Assess Water Quality: Two samples with two exceeding (SWAMP, 2004).

Spatial Representation: One station at Latigo Canyon Creek Upper: 34.03758 -118.76575.

Temporal Representation: Samples were collected March 2003 through March 2004.

Environmental Conditions:	Los Angeles County Coastal Streams: 404.33.
Data Quality Assessment:	SWAMP Quality Assurance Plan.

Water Segment: Long Point Beach

Pollutant: Coliform Bacteria

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for listing under section 2.2 of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status.

One line of evidence is available in the administrative record to assess this pollutant. Based on the applicable factor, a TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard. This water segment-pollutant combination was moved off the section 303(d) list during the 2002 listing cycle.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.

SWRCB Staff Recommendation: After review of the available data and information for this recommendation, SWRCB staff conclude that the water body and pollutant (coliform) should be placed in the Water Quality Limited Segments Being Addressed category of the section 303(d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.

Lines of Evidence:

Line of Evidence Remedial Program in Place

Beneficial Use R1 - Water Contact Recreation

Information Used to Assess Water Quality: A TMDL and implementation plan has been approved for this water segment-pollutant combination. The Santa Monica Bay Bacteria Dry Weather TMDL was approved by RWQCB on January 24, 2002 and subsequently approved by USEPA. The Santa Monica Bay Bacteria Wet Weather TMDL was approved by RWQCB on December 12, 2004 and approved by USEPA on June 19, 2003.

Region 4

Water Segment: Los Angeles Harbor - Consolidated Slip

Pollutant: Cadmium

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under sections 4.6 and 4.9 of the Listing Policy. Under section 4.6 a single line of evidence is necessary to assess delisting status while under section 4.9, a minimum of two lines of evidence are needed to assess listing status.

Four lines of evidence are available in the administrative record to assess this pollutant. Based on section 4.6, the site has significant sediment toxicity and the pollutant concentration exceeds the sediment guideline. The benthic community is impacted.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification against removing this water segment-pollutant combination from the section 303(d) list in the Water Quality Limited Segments category.

This conclusion is based on the staff findings that:
1. The sediment quality guideline used complies with the requirements of section 6.1.3 of the Policy.
2. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
3. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
4. Six of 20 samples exceeded the 4.21 ug/g PEL cadmium sediment guideline, 8 samples exhibit toxicity, and 4 sediment stations had a degraded benthic community. The four lines of evidence show that the water body segment exceeds the allowable frequency listed in Table 4.1 of the Listing Policy. The benthic community in this water body is impacted and this pollutant is associated with this impact.
5. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because applicable water quality standards are exceeded and a pollutant contributes to or causes the problem.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Sediment

Beneficial Use: MA - Marine Habitat

Matrix: Sediment

Water Quality Objective/ Water Quality Criterion: Basin Plan: Existing habitats and associated populations of wetlands fauna and flora shall be maintained by:

-Maintaining substrate characteristics necessary to support flora and fauna which would be present naturally,
-Protecting food supplies for fish and wildlife,
-Protecting reproductive and nursery areas, and
-Protecting wildlife corridors.

Basin Plan: Surface waters shall not contain concentrations of chemical constituents in amounts that adversely affect any designated beneficial use (LARWQCB, 1995)

Evaluation Guideline:	PEL: 4.21 ug/g (MacDonald et al., 1996).
Data Used to Assess Water Quality:	Of the 41 sediment core and grab samples, 15 exceed the sediment quality guideline (LARWQCB and CCC, 2004).
Spatial Representation:	Samples were collected throughout the water body.
Temporal Representation:	Samples collected between 1992 and 1997.
Data Quality Assessment:	BPTCP Quality Assurance Project Plan (Stephenson et al., 1994) Contaminated Sediments Task Force Database.

Numeric Line of Evidence	Toxicity
Beneficial Use:	MA - Marine Habitat
Matrix:	Sediment
Water Quality Objective/ Water Quality Criterion:	Basin Plan: Existing habitats and associated populations of wetlands fauna and flora shall be maintained by: -Maintaining substrate characteristics necessary to support flora and fauna which would be present naturally, -Protecting food supplies for fish and wildlife, -Protecting reproductive and nursery areas, and -Protecting wildlife corridors. (LARWQCB, 1995).
Evaluation Guideline:	Significant toxicity as compared to control conditions.
Data Used to Assess Water Quality:	Thirteen of 17 samples were significantly toxic (Anderson et al., 1998).
Spatial Representation:	Samples were collected throughout the estuary.
Temporal Representation:	Samples were collected in 1994 and 1996.
Data Quality Assessment:	BPTCP Quality Assurance Project Plan (Stephenson et al., 1994).

Numeric Line of Evidence	Population/Community Degradation
Beneficial Use:	MA - Marine Habitat
Matrix:	Sediment
Water Quality Objective/ Water Quality Criterion:	Basin Plan: Existing habitats and associated populations of wetlands fauna and flora shall be maintained by:

	-Maintaining substrate characteristics necessary to support flora and fauna which would be present naturally, -Protecting food supplies for fish and wildlife, -Protecting reproductive and nursery areas, and -Protecting wildlife corridors. Basin Plan: Surface waters shall not contain concentrations of chemical constituents in amounts that adversely affect any designated beneficial use (LARWQCB, 1995)
Evaluation Guideline:	Evaluation of the benthic data were completed using the approaches developed by scientists associated with the BPTCP. The relative benthic index used is a calculated value considering the total fauna, total mollusk species, crustacean species and indicator species at a site. The index ranges from 0 to 1.0. An index value of less than or equal to 0.3 is an indication that pollutants or other factors are negatively impacting the benthic community (Anderson et al., 1998).
Data Used to Assess Water Quality:	Eleven samples are available with 5 exhibiting degraded conditions and 6 with transitional community characteristics (Anderson et al., 1998).
Spatial Representation:	The samples were collected throughout the water body.
Temporal Representation:	Samples were collected in 1992 and 1996.
Data Quality Assessment:	BPTCP Quality Assurance Project Plan (Stephenson et al., 1994)

Line of Evidence	Remedial Program in Place
Beneficial Use	MA - Marine Habitat
Information Used to Assess Water Quality:	The Consolidated Toxic Hot Spots Cleanup Plan describes how the Los Angeles Contaminated Task Force will develop a plan for the cleanup of this site. While the planning has progressed, no remediation of the site has occurred. No responsible parties have been identified.

Water Segment: Los Angeles Harbor - Consolidated Slip

Pollutant: Chlordane

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for delisting under sections 4.6 of the Listing Policy. Under section 4.6 two lines of evidence are necessary to assess listing status.

Four lines of evidence are available in the administrative record to assess this pollutant. Based on section 4.6, there is known significant toxicity and benthic impacts associated with this pollutant and the number of pollutant exceedances exceed the frequency allowed by the Listing Policy.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of not removing this water segment-pollutant combination from the section 303(d) list in the Water Quality Limited Segments category.

This conclusion is based on the staff findings that:
1. The sediment quality guideline used complies, with the requirements of section 6.1.3 of the Policy.
2. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
3. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
4. Thirty of 39 samples taken between 1993 and 1997 exceeded the 6ng/g Effects Range Medium sediment guideline, There is known significant sediment toxicity data and benthic community impacts associated with the water body segment, and pollutant concentrations exceed the allowable frequency listed in Table 4.1 of the Listing Policy.
5. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because applicable water quality standards are exceeded and a pollutant contributes to or causes the problem.

Lines of Evidence:

Numeric Line of Evidence Toxicity

Beneficial Use: MA - Marine Habitat

Matrix: Sediment

Water Quality Objective/ Water Quality Criterion: Basin Plan: Existing habitats and associated populations of wetlands fauna and flora shall be maintained by:

-Maintaining substrate characteristics necessary to support flora and fauna which

	would be present naturally, -Protecting food supplies for fish and wildlife, -Protecting reproductive and nursery areas, and -Protecting wildlife corridors. (LARWQCB, 1995).
Evaluation Guideline:	Significant toxicity as compared to control conditions.
Data Used to Assess Water Quality:	Thirteen of 17 samples were significantly toxic (Anderson et al., 1998).
Spatial Representation:	Samples were collected throughout the estuary.
Temporal Representation:	Samples were collected in 1994 and 1996.
Data Quality Assessment:	BPTCP Quality Assurance Project Plan (Stephenson et al., 1994).

Numeric Line of Evidence	Population/Community Degradation
Beneficial Use:	MA - Marine Habitat
Matrix:	Sediment
Water Quality Objective/ Water Quality Criterion:	Basin Plan: Existing habitats and associated populations of wetlands fauna and flora shall be maintained by: -Maintaining substrate characteristics necessary to support flora and fauna which would be present naturally, -Protecting food supplies for fish and wildlife, -Protecting reproductive and nursery areas, and -Protecting wildlife corridors. Basin Plan: Surface waters shall not contain concentrations of chemical constituents in amounts that adversely affect any designated beneficial use (LARWQCB, 1995)
Evaluation Guideline:	Evaluation of the benthic data were completed using the approaches developed by scientists associated with the BPTCP. The relative benthic index used is a calculated value considering the total fauna, total mollusk species, crustacean species and indicator species at a site. The index ranges from 0 to 1.0. An index value of less than or equal to 0.3 is an indication that pollutants or other factors are negatively impacting the benthic community (Anderson et al., 1998).
Data Used to Assess Water Quality:	Eleven samples are available with 5 exhibiting degraded conditions and 6 with transitional community characteristics (Anderson et al., 1998).
Spatial Representation:	The samples were collected throughout the water body.
Temporal Representation:	Samples were collected in 1992 and 1996.
Data Quality Assessment:	BPTCP Quality Assurance Project Plan (Stephenson et al., 1994)

Numeric Line of Evidence	Pollutant-Sediment
Beneficial Use:	MA - Marine Habitat
Matrix:	Sediment
Water Quality Objective/	Basin Plan: Surface waters shall not contain concentrations of chemical

Water Quality Criterion:	constituents in amounts that adversely affect any designated beneficial use (LARWQCB, 1995)
Evaluation Guideline:	An Effect Range Median of 6 ng/g was used (Long and Morgan, 1990).
Data Used to Assess Water Quality:	Of the 39 core and grab samples, 30 exceed the sediment quality guideline (LARWQCB and CCC, 2004).
Spatial Representation:	The samples are spread throughout the water body.
Temporal Representation:	Samples were collected between 1993 and 1997.
Data Quality Assessment:	Bay Protection and Toxic Cleanup Program (Stephenson et al., 1994) Contaminated Sediments Task Force Database.

Numeric Line of Evidence	Pollutant-Tissue
Beneficial Use:	MA - Marine Habitat
Matrix:	Tissue
Water Quality Objective/ Water Quality Criterion:	Basin Plan: Toxic pollutants shall not be present at levels that will bioaccumulate in aquatic life to levels which are harmful to aquatic life or human health (LARWQCB, 1995)
Evaluation Guideline:	OEHHA Screening Value: 2.0 ug/kg (Brodberg and Pollock, 1999).
Data Used to Assess Water Quality:	The guideline is not exceeded in any of the 12 measurements. The original listing was based on exceeding background levels rather than valid assessment guidelines (TSMP, 2002).
Spatial Representation:	One station.
Temporal Representation:	Data collected in most years from 1992 through 2003.
Data Quality Assessment:	State Mussel Watch Program.

Water Segment: Los Angeles Harbor - Consolidated Slip

Pollutant: Chromium (total)

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for delisting under sections 4.6 of the Listing Policy. Under section 4.6 two lines of evidence are necessary to assess listing status.

Three lines of evidence are available in the administrative record to assess this pollutant. Based on section 4.6, there is known significant toxicity and bioassessment data associated with this pollutant and the number of pollutant exceedances exceed the frequency allowed by the Listing Policy.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of not removing this water segment-pollutant combination from the section 303(d) list in the Water Quality Limited Segments category.

This conclusion is based on the staff findings that:
1. The sediment quality guideline used complies, with the requirements of section 6.1.3 of the Policy.
2. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
3. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
4. Twelve of 41 samples taken between 1992 and 1997 exceeded the 370 ug/g Effects Range Medium sediment guideline, There is known significant toxicity data and benthic community impacts associated with the water body segment, and pollutant concentrations exceed the allowable frequency listed in Table 4.1 of the Listing Policy.
5. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because applicable water quality standards are exceeded and a pollutant contributes to or causes the problem.

Lines of Evidence:

Numeric Line of Evidence Toxicity

Beneficial Use: MA - Marine Habitat

Matrix: Sediment

Water Quality Objective/ Water Quality Criterion: Basin Plan: Existing habitats and associated populations of wetlands fauna and flora shall be maintained by:

-Maintaining substrate characteristics necessary to support flora and fauna which

	would be present naturally, -Protecting food supplies for fish and wildlife, -Protecting reproductive and nursery areas, and -Protecting wildlife corridors. (LARWQCB, 1995).
Evaluation Guideline:	Significant toxicity as compared to control conditions.
Data Used to Assess Water Quality:	Thirteen of 17 samples were significantly toxic (Anderson et al., 1998).
Spatial Representation:	Samples were collected throughout the estuary.
Temporal Representation:	Samples were collected in 1994 and 1996.
Data Quality Assessment:	BPTCP Quality Assurance Project Plan (Stephenson et al., 1994).

Numeric Line of Evidence	Population/Community Degradation
Beneficial Use:	MA - Marine Habitat
Matrix:	Sediment
Water Quality Objective/ Water Quality Criterion:	Basin Plan: Existing habitats and associated populations of wetlands fauna and flora shall be maintained by: -Maintaining substrate characteristics necessary to support flora and fauna which would be present naturally, -Protecting food supplies for fish and wildlife, -Protecting reproductive and nursery areas, and -Protecting wildlife corridors. Basin Plan: Surface waters shall not contain concentrations of chemical constituents in amounts that adversely affect any designated beneficial use (LARWQCB, 1995)
Evaluation Guideline:	Evaluation of the benthic data were completed using the approaches developed by scientists associated with the BPTCP. The relative benthic index used is a calculated value considering the total fauna, total mollusk species, crustacean species and indicator species at a site. The index ranges from 0 to 1.0. An index value of less than or equal to 0.3 is an indication that pollutants or other factors are negatively impacting the benthic community (Anderson et al., 1998).
Data Used to Assess Water Quality:	Eleven samples are available with 5 exhibiting degraded conditions and 6 with transitional community characteristics (Anderson et al., 1998).
Spatial Representation:	The samples were collected throughout the water body.
Temporal Representation:	Samples were collected in 1992 and 1996.
Data Quality Assessment:	BPTCP Quality Assurance Project Plan (Stephenson et al., 1994)

Numeric Line of Evidence	Pollutant-Sediment
Beneficial Use:	MA - Marine Habitat
Matrix:	Sediment
Water Quality Objective/	Basin Plan: Surface waters shall not contain concentrations of chemical

Water Quality Criterion:	constituents in amounts that adversely affect any designated beneficial use (LARWQCB, 1995)
Evaluation Guideline:	An Effects Range-Median of 370 ug/g was used (Long et al., 1995).
Data Used to Assess Water Quality:	Of the 41 core and grab samples, 12 exceeded the sediment guideline (LARWQCB and CCC, 2004).
Spatial Representation:	The samples are spread throughout the water body.
Temporal Representation:	Samples collected between 1992 and 1997.
Data Quality Assessment:	Bay Protection and Toxic Cleanup Program (Stephenson et al., 1994) Contaminated Sediments Task Force Database.

Water Segment: Los Angeles Harbor - Consolidated Slip

Pollutant: Copper

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under sections 4.6 and 4.9 of the Listing Policy. Under section 4.6 a single line of evidence is necessary to assess delisting status while under section 4.9, a minimum of two lines of evidence are needed to assess listing status.

Four lines of evidence are available in the administrative record to assess this pollutant. Based on section 4.6, the site has significant sediment toxicity and the pollutant concentration exceeds the sediment guideline. The benthic community is impacted.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification against removing this water segment-pollutant combination from the section 303(d) list in the Water Quality Limited Segments category.

This conclusion is based on the staff findings that:
1.The sediment quality guideline used complies with the requirements of section 6.1.3 of the Policy.
2.The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
3.The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
4.Two of 20 samples exceeded the 270 ug/g cadmium sediment guideline, 8 samples exhibit toxicity, and 4 sediment stations had a degraded benthic community. The four lines of evidence show that the water body segment exceeds the allowable frequency listed in Table 4.1 of the Listing Policy. The benthic community in this water body is impacted and this pollutant is associated with this impact.
5.Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because applicable water quality standards are exceeded and a pollutant contributes to or causes the problem.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Sediment

Beneficial Use: MA - Marine Habitat

Matrix: Sediment

Water Quality Objective/ Water Quality Criterion: Basin Plan: Existing habitats and associated populations of wetlands fauna and flora shall be maintained by:

-Maintaining substrate characteristics necessary to support flora and fauna which would be present naturally,
-Protecting food supplies for fish and wildlife,
-Protecting reproductive and nursery areas, and
-Protecting wildlife corridors.

Basin Plan: Surface waters shall not contain concentrations of chemical constituents in amounts that adversely affect any designated beneficial use (LARWQCB, 1995)

Evaluation Guideline:	ERM of 270 ug/g (Long et al., 1995).
Data Used to Assess Water Quality:	Data set from 2002 has 122 core samples; 1992-1997 data set has 41 samples. Of the 163 measurements, 103 exceed the sediment quality guideline (LARWQCB and CCC, 2004).
Spatial Representation:	Samples were collected throughout the water body.
Temporal Representation:	Samples collected from 1992 through 1997 and in 2002.
Data Quality Assessment:	BPTCP Quality Assurance Project Plan (Stephenson et al., 1994) Contaminated Sediments Task Force Database.

Numeric Line of Evidence	Toxicity
Beneficial Use:	MA - Marine Habitat
Matrix:	Sediment
Water Quality Objective/ Water Quality Criterion:	Basin Plan: Existing habitats and associated populations of wetlands fauna and flora shall be maintained by: -Maintaining substrate characteristics necessary to support flora and fauna which would be present naturally, -Protecting food supplies for fish and wildlife, -Protecting reproductive and nursery areas, and -Protecting wildlife corridors. (LARWQCB, 1995).
Evaluation Guideline:	Significant toxicity as compared to control conditions.
Data Used to Assess Water Quality:	Thirteen of 17 samples were significantly toxic (Anderson et al., 1998).
Spatial Representation:	Samples were collected throughout the estuary.
Temporal Representation:	Samples were collected in 1994 and 1996.
Data Quality Assessment:	BPTCP Quality Assurance Project Plan (Stephenson et al., 1994).

Numeric Line of Evidence	Population/Community Degradation
Beneficial Use:	MA - Marine Habitat
Matrix:	Sediment
Water Quality Objective/ Water Quality Criterion:	Basin Plan: Existing habitats and associated populations of wetlands fauna and flora shall be maintained by:

	-Maintaining substrate characteristics necessary to support flora and fauna which would be present naturally, -Protecting food supplies for fish and wildlife, -Protecting reproductive and nursery areas, and -Protecting wildlife corridors. Basin Plan: Surface waters shall not contain concentrations of chemical constituents in amounts that adversely affect any designated beneficial use (LARWQCB, 1995)
Evaluation Guideline:	Evaluation of the benthic data were completed using the approaches developed by scientists associated with the BPTCP. The relative benthic index used is a calculated value considering the total fauna, total mollusk species, crustacean species and indicator species at a site. The index ranges from 0 to 1.0. An index value of less than or equal to 0.3 is an indication that pollutants or other factors are negatively impacting the benthic community (Anderson et al., 1998).
Data Used to Assess Water Quality:	Eleven samples are available with 5 exhibiting degraded conditions and 6 with transitional community characteristics (Anderson et.al., 1998).
Spatial Representation:	The samples were collected throughout the water body.
Temporal Representation:	Samples were collected in 1992 and 1996.
Data Quality Assessment:	BPTCP Quality Assurance Project Plan (Stephenson et al., 1994)

Line of Evidence	Remedial Program in Place
Beneficial Use	MA - Marine Habitat
Information Used to Assess Water Quality:	The Consolidated Toxic Hot Spots Cleanup Plan describes how the Los Angeles Contaminated Task Force will develop a plan for the cleanup of this site. While the planning has progressed, no remediation of the site has occurred. No responsible parties have been identified.

Water Segment: Los Angeles Harbor - Consolidated Slip

Pollutant: DDT

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 4.4 of the Listing Policy. Under section 4.4 a single line of evidence is necessary to assess delisting status.

Three lines of evidence are available in the administrative record to assess this pollutant. Tissue data was used to place this water body pollutant on the 2002 list. There is also an OEHHA fish consumption advisory established in this water body segment. Under section 4.4 of the Listing Policy any water body segment where a health advisory against consumption of edible resident organisms has been removed and the chemical or biological contaminant specific evaluation guideline for tissue is no longer exceeded shall be removed from the section 303(d) list.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of not removing this water segment-pollutant combination on the section 303(d) list in the Water Quality Limited Segments category.

This conclusion is based on the staff findings that an OEHHA fish consumption advisory has been established for this pollutant and the water segment specific data indicates that the 100 ug/kg evaluation guideline for tissue was exceeded once. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because applicable water quality standards are exceeded and a pollutant contributes to or causes the problem.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Sediment

Beneficial Use: MA - Marine Habitat

Matrix: Sediment

Water Quality Objective/ Water Quality Criterion: Basin Plan: Surface waters shall not contain concentrations of chemical constituents in amounts that adversely affect any designated beneficial use (LARWQCB, 1995)

Evaluation Guideline: No sediment quality guideline is available for this pollutant that satisfies the requirements of section 6.1.3 of the Listing Policy (LARWQCB and CCC, 2004).

Data Used to Assess Water Quality:	One-hundred and sixty-two samples are available.
Spatial Representation:	The samples are spread throughout the water body.
Temporal Representation:	The samples were collected between 1992 and 1997.
Data Quality Assessment:	Bay Protection and Toxic Cleanup Program (Stephenson et al., 1994) Contaminated Sediments Task Force Database.

Numeric Line of Evidence	Pollutant-Tissue
Beneficial Use:	MA - Marine Habitat
Matrix:	Tissue
Water Quality Objective/ Water Quality Criterion:	Basin Plan: Toxic pollutants shall not be present at levels that will bioaccumulate in aquatic life to levels which are harmful to aquatic life or human health (LARWQCB, 1995)
Evaluation Guideline:	An OEHHA screening value of 100 ug/kg was used.
Data Used to Assess Water Quality:	The guideline is exceeded in one of the 12 measurements. The original listing was based on exceeding background levels rather than valid assessment guidelines (SMWP, 2004).
Spatial Representation:	One station.
Temporal Representation:	Samples were collected from 1992 through 2003.
Data Quality Assessment:	State Mussel Watch Program.

Line of Evidence	Health Advisories
Beneficial Use	MA - Marine Habitat
Information Used to Assess Water Quality:	A fish consumption advisory has been established for the DDT in the Los Angeles/Long Beach Harbor area. The advisory was established by the Office of Environmental Health Hazard Assessment.

Region 4

Water Segment: Los Angeles Harbor - Consolidated Slip

Pollutant: Lead

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for delisting under sections 4.6 of the Listing Policy. Under section 4.6 two lines of evidence are necessary to assess listing status.

Three lines of evidence are available in the administrative record to assess this pollutant. Based on section 4.6, there is known significant toxicity and bioassessment data associated with this pollutant and the number of pollutant exceedances exceed the frequency allowed by the Listing Policy.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of not removing this water segment-pollutant combination from the section 303(d) list in the Water Quality Limited Segments category.

This conclusion is based on the staff findings that:
1. The sediment quality guideline used complies, with the requirements of section 6.1.3 of the Policy.
2. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
3. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
4. Twenty-two of 41 samples taken between 1992 and 1997 and 77 of 122 samples taken in 2002 exceeded the 112.18 ug/g Effects Range Medium sediment guideline, There is known significant toxicity data and benthic community impacts associated with the water body segment, and pollutant concentrations exceed the allowable frequency listed in Table 4.1 of the Listing Policy.
5. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because applicable water quality standards are exceeded and a pollutant contributes to or causes the problem.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Sediment

Beneficial Use: MA - Marine Habitat

Matrix: Sediment

Water Quality Objective/ Water Quality Criterion: Basin Plan: Surface waters shall not contain concentrations of chemical constituents in amounts that adversely affect any designated beneficial use (LARWQCB, 1995)

Evaluation Guideline: A probable Effects Level of 112.18 ug/g was used (MacDonald et al., 1996).

Data Used to Assess Water Quality:	Data set from 2002: 77 of 122 core and grab samples exceed the sediment guideline . Data from 1992-1997: 22 of 41 core and grab samples exceed the sediment guideline (LARWQCB and CCC, 2004).
Spatial Representation:	The 163 samples are spread throughout the water body.
Temporal Representation:	Samples were collected from 1992 to 1997 and in 2002.
Data Quality Assessment:	Bay Protection and Toxic Cleanup Program (Stephenson et al. 1994) Contaminated Sediments Task Force Database.

Numeric Line of Evidence	Toxicity
Beneficial Use:	MA - Marine Habitat
Matrix:	Sediment
Water Quality Objective/ Water Quality Criterion:	Basin Plan: Existing habitats and associated populations of wetlands fauna and flora shall be maintained by: -Maintaining substrate characteristics necessary to support flora and fauna which would be present naturally, -Protecting food supplies for fish and wildlife, -Protecting reproductive and nursery areas, and -Protecting wildlife corridors. (LARWQCB, 1995).
Evaluation Guideline:	Significant toxicity as compared to control conditions.
Data Used to Assess Water Quality:	Thirteen of 17 samples were significantly toxic (Anderson et al., 1998).
Spatial Representation:	Samples were collected throughout the estuary.
Temporal Representation:	Samples were collected in 1994 and 1996.
Data Quality Assessment:	BPTCP Quality Assurance Project Plan (Stephenson et al., 1994).

Numeric Line of Evidence	Population/Community Degradation
Beneficial Use:	MA - Marine Habitat
Matrix:	Sediment
Water Quality Objective/ Water Quality Criterion:	Basin Plan: Existing habitats and associated populations of wetlands fauna and flora shall be maintained by: -Maintaining substrate characteristics necessary to support flora and fauna which would be present naturally, -Protecting food supplies for fish and wildlife, -Protecting reproductive and nursery areas, and -Protecting wildlife corridors. Basin Plan: Surface waters shall not contain concentrations of chemical constituents in amounts that adversely affect any designated beneficial use (LARWQCB, 1995)
Evaluation Guideline:	Evaluation of the benthic data were completed using the approaches developed

by scientists associated with the BPTCP. The relative benthic index used is a calculated value considering the total fauna, total mollusk species, crustacean species and indicator species at a site. The index ranges from 0 to 1.0. An index value of less than or equal to 0.3 is an indication that pollutants or other factors are negatively impacting the benthic community (Anderson et al., 1998).

Data Used to Assess Water Quality:	Eleven samples are available with 5 exhibiting degraded conditions and 6 with transitional community characteristics (Anderson et al., 1998).
Spatial Representation:	The samples were collected throughout the water body.
Temporal Representation:	Samples were collected in 1992 and 1996.
Data Quality Assessment:	BPTCP Quality Assurance Project Plan (Stephenson et al., 1994)

Water Segment: Los Angeles Harbor - Consolidated Slip

Pollutant: Mercury

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under sections 4.6 and 4.9 of the Listing Policy. Under section 4.6 a single line of evidence is necessary to assess delisting status while under section 4.9, a minimum of two lines of evidence are needed to assess listing status.

Four lines of evidence are available in the administrative record to assess this pollutant. Based on section 4.6, the site has significant sediment toxicity and the pollutant concentration exceeds the sediment guideline. The benthic community is impacted.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification against removing this water segment-pollutant combination from the section 303(d) list in the Water Quality Limited Segments category.

This conclusion is based on the staff findings that:
1. The sediment quality guideline used complies with the requirements of section 6.1.3 of the Policy.
2. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
3. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
4. Two of 20 samples exceeded the 2.1 ug/g mercury sediment guideline, 8 samples exhibit toxicity, and 4 sediment stations had a degraded benthic community. The four lines of evidence show that the water body segment exceeds the allowable frequency listed in Table 4.1 of the Listing Policy. The benthic community in this water body is impacted and this pollutant is associated with this impact.
5. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because applicable water quality standards are exceeded and a pollutant contributes to or causes the problem.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Sediment

Beneficial Use: MA - Marine Habitat

Matrix: Sediment

Water Quality Objective/ Water Quality Criterion: Basin Plan: Surface waters shall not contain concentrations of chemical constituents in amounts that adversely affect any designated beneficial use

	(LARWQCB, 1995)
Evaluation Guideline:	Sediment Quality Guideline: 2.1 ug/g (PTI Environmental Services, 1991).
Data Used to Assess Water Quality:	Data set from 2002 has 122 samples and the data from 1992 through 1997 has 33 samples (cores and grabs). Twenty-three measures exceed the sediment guideline in 155 samples (LARWQCB and CCC, 2004).
Spatial Representation:	Samples were collected throughout the water body.
Temporal Representation:	Samples were collected between 1992 and 2002.
Data Quality Assessment:	BPTCP Quality Assurance Project Plan (Stephenson et al., 1994) Contaminated Sediments Task Force Database.

Numeric Line of Evidence	Toxicity
Beneficial Use:	MA - Marine Habitat
Matrix:	Sediment
Water Quality Objective/ Water Quality Criterion:	Basin Plan: Existing habitats and associated populations of wetlands fauna and flora shall be maintained by: -Maintaining substrate characteristics necessary to support flora and fauna which would be present naturally, -Protecting food supplies for fish and wildlife, -Protecting reproductive and nursery areas, and -Protecting wildlife corridors. (LARWQCB, 1995).
Evaluation Guideline:	Significant toxicity as compared to control conditions.
Data Used to Assess Water Quality:	Thirteen of 17 samples were significantly toxic (Anderson et al., 1998).
Spatial Representation:	Samples were collected throughout the estuary.
Temporal Representation:	Samples were collected in 1994 and 1996.
Data Quality Assessment:	BPTCP Quality Assurance Project Plan (Stephenson et al., 1994).

Numeric Line of Evidence	Population/Community Degradation
Beneficial Use:	MA - Marine Habitat
Matrix:	Sediment
Water Quality Objective/ Water Quality Criterion:	Basin Plan: Existing habitats and associated populations of wetlands fauna and flora shall be maintained by: -Maintaining substrate characteristics necessary to support flora and fauna which would be present naturally, -Protecting food supplies for fish and wildlife, -Protecting reproductive and nursery areas, and -Protecting wildlife corridors. Basin Plan: Surface waters shall not contain concentrations of chemical constituents in amounts that adversely affect any designated beneficial use

	(LARWQCB, 1995)
Evaluation Guideline:	Evaluation of the benthic data were completed using the approaches developed by scientists associated with the BPTCP. The relative benthic index used is a calculated value considering the total fauna, total mollusk species, crustacean species and indicator species at a site. The index ranges from 0 to 1.0. An index value of less than or equal to 0.3 is an indication that pollutants or other factors are negatively impacting the benthic community (Anderson et al., 1998).
Data Used to Assess Water Quality:	Eleven samples are available with 5 exhibiting degraded conditions and 6 with transitional community characteristics (Anderson et al., 1998).
Spatial Representation:	The samples were collected throughout the water body.
Temporal Representation:	Samples were collected in 1992 and 1996.
Data Quality Assessment:	BPTCP Quality Assurance Project Plan (Stephenson et al., 1994)

Line of Evidence	Remedial Program in Place
Beneficial Use	MA - Marine Habitat
Information Used to Assess Water Quality:	The Consolidated Toxic Hot Spots Cleanup Plan describes how the Los Angeles Contaminated Sediment Task Force will develop a plan for the cleanup of this site. While the planning has progressed, no remediation of the site has occurred. No responsible parties have been identified.

Region 4

Water Segment: Los Angeles Harbor - Consolidated Slip

Pollutant: Polychlorinated biphenyls

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under sections 4.4, 4.5, and 4.6 of the Listing Policy. Under section 4.4 and 4.5 a single line of evidence is necessary to assess delisting status while under section 4.6, a minimum of two lines of evidence are needed to assess listing status.

Five lines of evidence are available in the administrative record to assess this pollutant. There is a PCB fish consumption health advisory established for the Los Angeles/ Long Beach harbor area. Tissue data shows exceedances of the OEHHA tissue guidelines, sediment core samples taken between 1992 and 2002 exceed PCBs sediment guidelines and significant sediment toxicity has been documented in the segment. In addition, the benthic community is impacted as well.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification against removing this water segment-pollutant combination from the section 303(d) list in the Water Quality Limited Segments category.

This conclusion is based on the staff findings that:
1. The tissue and sediment quality guidelines used comply with the requirements of section 6.1.3 of the Policy.
2. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
3. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
4. Eighty-eight of 161 samples exceeded the 400 ng/g sediment guideline, 13 of 17 samples exhibit toxicity. Twelve of 12 tissue samples exceeded the 20 ug/kg OEHHA tissue guidelines. All of these exceedances surpass the allowable frequency listed in Table 4.1 of the Listing Policy. There is a PCB fish consumption health advisory established for the Los Angeles/ Long Beach harbor area and the benthic community in this water body is impacted.
5.Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because applicable water quality standards are exceeded and a pollutant contributes to or causes the problem.

Lines of Evidence:

Numeric Line of Evidence Toxicity

Beneficial Use: MA - Marine Habitat

Matrix: Sediment

Water Quality Objective/ Water Quality Criterion:	Basin Plan: Existing habitats and associated populations of wetlands fauna and flora shall be maintained by: -Maintaining substrate characteristics necessary to support flora and fauna which would be present naturally, -Protecting food supplies for fish and wildlife, -Protecting reproductive and nursery areas, and -Protecting wildlife corridors. (LARWQCB, 1995).
Evaluation Guideline:	Significant toxicity as compared to control conditions.
Data Used to Assess Water Quality:	Thirteen of 17 samples were significantly toxic (Anderson et al., 1998).
Spatial Representation:	Samples were collected throughout the estuary.
Temporal Representation:	Samples were collected in 1994 and 1996.
Data Quality Assessment:	BPTCP Quality Assurance Project Plan (Stephenson et al., 1994).

Numeric Line of Evidence	Population/Community Degradation
Beneficial Use:	MA - Marine Habitat
Matrix:	Sediment
Water Quality Objective/ Water Quality Criterion:	Basin Plan: Existing habitats and associated populations of wetlands fauna and flora shall be maintained by: -Maintaining substrate characteristics necessary to support flora and fauna which would be present naturally, -Protecting food supplies for fish and wildlife, -Protecting reproductive and nursery areas, and -Protecting wildlife corridors. Basin Plan: Surface waters shall not contain concentrations of chemical constituents in amounts that adversely affect any designated beneficial use (LARWQCB, 1995)
Evaluation Guideline:	Evaluation of the benthic data were completed using the approaches developed by scientists associated with the BPTCP. The relative benthic index used is a calculated value considering the total fauna, total mollusk species, crustacean species and indicator species at a site. The index ranges from 0 to 1.0. An index value of less than or equal to 0.3 is an indication that pollutants or other factors are negatively impacting the benthic community (Anderson et al., 1998).
Data Used to Assess Water Quality:	Eleven samples are available with 5 exhibiting degraded conditions and 6 with transitional community characteristics (Anderson et al., 1998).
Spatial Representation:	The samples were collected throughout the water body.
Temporal Representation:	Samples were collected in 1992 and 1996.
Data Quality Assessment:	BPTCP Quality Assurance Project Plan (Stephenson et al., 1994)

Numeric Line of Evidence	Pollutant-Tissue

Beneficial Use:	CM - Commercial and Sport Fishing (CA), MA - Marine Habitat
Matrix:	Tissue
Water Quality Objective/ Water Quality Criterion:	Basin Plan: Toxic pollutants shall not be present at levels that will bioaccumulate in aquatic life to levels which are harmful to aquatic life or human health (LARWQCB, 1995)
Evaluation Guideline:	An OEHHA tissue guideline of 20 ug/kg was used (Brodberg & Pollack, 1999)
Data Used to Assess Water Quality:	The tissue guideline is exceeded in 12 of 12 measurements (SMWP, 2004).
Spatial Representation:	One station.
Temporal Representation:	Samples were collected between 1992 and 2003.
Data Quality Assessment:	State Mussel Watch Program.

Numeric Line of Evidence	Pollutant-Sediment
Beneficial Use:	CM - Commercial and Sport Fishing (CA), MA - Marine Habitat
Matrix:	Sediment
Water Quality Objective/ Water Quality Criterion:	Basin Plan: Surface waters shall not contain concentrations of chemical constituents in amounts that adversely affect any designated beneficial use (LARWQCB, 1995)
Evaluation Guideline:	A sediment quality guideline of 400 ng/g was used (MacDonald et al., 2000).
Data Used to Assess Water Quality:	Of the 161 core and grab samples, 88 exceed the guideline (LARWQCB and CCC, 2004).
Spatial Representation:	The samples are spread throughout the water body.
Temporal Representation:	Samples were collected between 1992 and 2002.
Data Quality Assessment:	Bay Protection and Toxic Cleanup Program (Stephenson et al., 1994) Contaminated Sediments Task Force Database.

Line of Evidence	Health Advisories
Beneficial Use	CM - Commercial and Sport Fishing (CA), MA - Marine Habitat
Information Used to Assess Water Quality:	A fish consumption advisory has been established for PCBs in the Los Angeles/Long Beach Harbor area. The advisory was established by the Office of Environmental Health Hazard Assessment.

Water Segment: Los Angeles Harbor - Consolidated Slip

Pollutant: Toxaphene

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 4.5 of the Listing Policy. Under section 4.5 a single line of evidence is necessary to assess delisting status.

One line of evidence is available in the administrative record to assess this pollutant.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification against removing this water segment-pollutant combination from the section 303(d) list.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3. Five of 12 samples exceeded the 30 ug/kg OEHHA tissue guideline but the number of samples is insufficient to determine with the confidence and power required by the Listing Policy.
4. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because it cannot be determined if applicable water quality standards are attained.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Tissue

Beneficial Use: MA - Marine Habitat

Matrix: Tissue

Water Quality Objective/ Water Quality Criterion: Basin Plan: Toxic pollutants shall not be present at levels that will bioaccumulate in aquatic life to levels which are harmful to aquatic life or human health (LARWQCB, 1995)

Evaluation Guideline: An OEHHA tissue guideline of 30 ug/kg was used (Brodberg and Pollock, 1999).

Data Used to Assess Water Quality: Five measurements of 12 total measurements exceed the tissue guideline (SMWP, 2004).

Spatial Representation:	One station.
Temporal Representation:	One sample per year from 1992 through 2003.
Data Quality Assessment:	State Mussel Watch Program.

Water Segment: Los Angeles Harbor - Consolidated Slip

Pollutant: Zinc

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for delisting under sections 4.6 of the Listing Policy. Under section 4.6 two lines of evidence are necessary to assess listing status.

Three lines of evidence are available in the administrative record to assess this pollutant. Based on section 4.6, there is known significant toxicity and bioassessment data associated with this pollutant and the number of pollutant exceedances exceed the frequency allowed by the Listing Policy.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification against removing this water segment-pollutant combination from the section 303(d) list in the Water Quality Limited Segments category.

This conclusion is based on the staff findings that:
1. The sediment quality guideline used complies, with the requirements of section 6.1.3 of the Policy.
2. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
3. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
4. Thirty of 41 samples taken between 1992 and 1997 and 76 of 122 samples taken in 2002 exceeded the 410 ug/g Effects Range Medium sediment guideline. There is known significant toxicity data and benthic community impacts associated with the water body segment, and pollutant concentrations exceed the allowable frequency listed in Table 4.1 of the Listing Policy.
5. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because applicable water quality standards are exceeded and a pollutant contributes to or causes the problem.

Lines of Evidence:

Numeric Line of Evidence Toxicity

Beneficial Use: MA - Marine Habitat

Matrix: Sediment

Water Quality Objective/ Water Quality Criterion: Basin Plan: Existing habitats and associated populations of wetlands fauna and flora shall be maintained by:

-Maintaining substrate characteristics necessary to support flora and fauna which

	would be present naturally, -Protecting food supplies for fish and wildlife, -Protecting reproductive and nursery areas, and -Protecting wildlife corridors. (LARWQCB, 1995).
Evaluation Guideline:	Significant toxicity as compared to control conditions.
Data Used to Assess Water Quality:	Thirteen of 17 samples were significantly toxic (Anderson et al., 1998).
Spatial Representation:	Samples were collected throughout the estuary.
Temporal Representation:	Samples were collected in 1994 and 1996.
Data Quality Assessment:	BPTCP Quality Assurance Project Plan (Stephenson et al., 1994).

Numeric Line of Evidence	Population/Community Degradation
Beneficial Use:	MA - Marine Habitat
Matrix:	Sediment
Water Quality Objective/ Water Quality Criterion:	Basin Plan: Existing habitats and associated populations of wetlands fauna and flora shall be maintained by: -Maintaining substrate characteristics necessary to support flora and fauna which would be present naturally, -Protecting food supplies for fish and wildlife, -Protecting reproductive and nursery areas, and -Protecting wildlife corridors. Basin Plan: Surface waters shall not contain concentrations of chemical constituents in amounts that adversely affect any designated beneficial use (LARWQCB, 1995)
Evaluation Guideline:	Evaluation of the benthic data were completed using the approaches developed by scientists associated with the BPTCP. The relative benthic index used is a calculated value considering the total fauna, total mollusk species, crustacean species and indicator species at a site. The index ranges from 0 to 1.0. An index value of less than or equal to 0.3 is an indication that pollutants or other factors are negatively impacting the benthic community (Anderson et al., 1998).
Data Used to Assess Water Quality:	Eleven samples are available with 5 exhibiting degraded conditions and 6 with transitional community characteristics (Anderson et al., 1998).
Spatial Representation:	The samples were collected throughout the water body.
Temporal Representation:	Samples were collected in 1992 and 1996.
Data Quality Assessment:	BPTCP Quality Assurance Project Plan (Stephenson et al., 1994)

Numeric Line of Evidence	Pollutant-Sediment
Beneficial Use:	MA - Marine Habitat
Matrix:	Sediment
Water Quality Objective/	Basin Plan: Surface waters shall not contain concentrations of chemical

Water Quality Criterion:	constituents in amounts that adversely affect any designated beneficial use (LARWQCB, 1995)
Evaluation Guideline:	An Effects Range-Median of 410 ug/g was used (Long et al., 1995).
Data Used to Assess Water Quality:	From the 2002 data set, 76 of 122 core and grab samples exceed the sediment guideline. For the 1992-1997 data set, 30 of 41 core and grab samples exceed the sediment guideline (LARWQCB and CCC, 2004).
Spatial Representation:	The 163 samples are spread throughout the water body.
Temporal Representation:	Samples were collected between 1992 and 1997 and in 2002.
Data Quality Assessment:	Bay Protection and Toxic Cleanup Program. Contaminated Sediments Task Force Database.

Region 4

Water Segment: Los Angeles Harbor - Fish Harbor

Pollutant: DDT

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 4.4 of the Listing Policy. Under section 4.4 a single line of evidence is necessary to assess delisting status.

Two lines of evidence are available in the administrative record to assess this pollutant. There is an OEHHA fish consumption advisory in place for the Los Angeles/Long Beach Harbor area. There is no new information indicating that this health advisory has been removed or not applicable to this specific water segment. There is also no sediment quality guideline available to assess exceedances of DDT in sediment that complies with the requirements of section 6.1.3 of the Listing Policy. Under section 4.4 of the Listing Policy any water body segment where a health advisory against consumption of edible resident organisms has been removed or the chemical or biological contaminant-specific evaluation guideline for tissue is no longer exceeded shall be removed from the section 303(d) list. In this case, there are no current tissue data available for evaluation, it is unknown whether pollutant concentrations exceed sediment quality guidelines, and in the absence of more current information, a health advisory remains place and is applicable to this water body segment.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of not removing this water segment-pollutant combination on the section 303(d) list in the Water Quality Limited Segments category.

This conclusion is based on the staff findings that although there are no current tissue data available for evaluation, and it is not possible to determine any exceedances of sediment quality guideline, an OEHHA fish consumption advisory remains is in place for this pollutant. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because it cannot be determined if applicable water quality standards are attained.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Sediment

Beneficial Use: CM - Commercial and Sport Fishing (CA), MA - Marine Habitat

Matrix: Sediment

Water Quality Objective/ Basin Plan: Surface waters shall not contain concentrations of chemical

Water Quality Criterion:	constituents in amounts that adversely affect any designated beneficial use.
Evaluation Guideline:	No sediment quality guideline is available that complies with the requirements of section 6.1.3 of the Listing Policy.
Data Used to Assess Water Quality:	Twelve core and grab samples are available (LARWQCB and CCC, 2004).
Spatial Representation:	The samples are spread throughout the water body.
Temporal Representation:	The samples were collected in 1992 and 1999.
Data Quality Assessment:	Bay Protection and Toxic Cleanup Program QAPP. Quality assurance for other samples presented in the Contaminated Sediments Task Force Database.

Line of Evidence	Health Advisories
Beneficial Use	CM - Commercial and Sport Fishing (CA), MA - Marine Habitat
Information Used to Assess Water Quality:	A fish consumption advisory has been established for the DDT in the Los Angeles/Long Beach Harbor area. The advisory was established by the Office of Environmental Health Hazard Assessment.

Region 4

Water Segment: Los Angeles Harbor - Fish Harbor

Pollutant: Polychlorinated biphenyls

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 4.4 of the Listing Policy. Under section 4.4 a single line of evidence is necessary to assess delisting status.

Two lines of evidence are available in the administrative record to assess this pollutant. There is an OEHHA fish consumption advisory in place for the Los Angeles/Long Beach Harbor area. There is no new information indicating that this health advisory has been removed or not applicable to this specific water segment. Although there are no current tissue data for evaluation, a sufficient number of samples exceeded sediment quality guidelines. Under section 4.4 of the Listing Policy any water body segment where a health advisory against consumption of edible resident organisms has been removed or the chemical or biological contaminant-specific evaluation guideline for tissue is no longer exceeded shall be removed from the section 303(d) list. In this case, there are no current tissue data available for evaluation, but pollutant concentrations exceed sediment quality guidelines and in the absence of more current information, a health advisory remains in place that is applicable to this water body segment.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of not removing this water segment-pollutant combination on the section 303(d) list in the Water Quality Limited Segments category.

This conclusion is based on the staff findings that an OEHHA fish consumption advisory is in place for this pollutant and six of 13 sediment samples exceeded the 400 ug/l PCB sediment quality evaluation guideline. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because it cannot be determined if applicable water quality standards are attained.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Sediment

Beneficial Use: CM - Commercial and Sport Fishing (CA), MA - Marine Habitat

Matrix: Sediment

Water Quality Objective/ Basin Plan: Surface waters shall not contain concentrations of chemical

Water Quality Criterion:	constituents in amounts that adversely affect any designated beneficial use.
Evaluation Guideline:	A sediment quality guideline of 400 ng/g was used (MacDonald et al., 2000).
Data Used to Assess Water Quality:	Of the 13 samples available, 6 measurements exceeded the sediment quality guideline (LARWQCB and CCC, 2004).
Spatial Representation:	The samples are spread throughout the water body.
Temporal Representation:	The samples were collected in 1992, 1995, and 1999. All of the exceedances occurred in 1999.
Data Quality Assessment:	Bay Protection and Toxic Cleanup Program QAPP. Quality assurance for other samples presented in the Contaminated Sediments Task Force Database.

Line of Evidence	Health Advisories
Beneficial Use	CM - Commercial and Sport Fishing (CA), MA - Marine Habitat
Information Used to Assess Water Quality:	A fish consumption advisory has been established for the PCB in the Los Angeles/Long Beach Harbor area. The advisory was established by the Office of Environmental Health Hazard Assessment.

Region 4

Water Segment: Los Angeles Harbor - Fish Harbor

Pollutant: Polycyclic Aromatic Hydrocarbons (PAHs) (Aquatic Ecosystems)

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for delisting under sections 4.6 of the Listing Policy. Under section 4.6 two lines of evidence are necessary to assess listing status.

Two lines of evidence are available in the administrative record to assess this pollutant. Based on section 4.6, a sufficient number of samples exceed the 1,442 ng/l low molecular and the 9,600 ng/l high molecular weight PAH sediment quality guidelines. The numbers of pollutant exceedances exceed the frequency allowed by the Listing Policy. However, water body segment exhibited non-significant sediment toxicity and it cannot be determined whether any toxic effects are associated with these pollutant concentrations

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of not removing this water segment-pollutant combination from the section 303(d) list in the Water Quality Limited Segments category.

This conclusion is based on the staff findings that:
1.The sediment quality guideline used complies, with the requirements of section 6.1.3 of the Policy.
2.The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
3.The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
4.Five of 12 samples exceeded the 1,442 ng/l low molecular weight and 6 of 12 exceeded 9,600 ng/l high molecular weight PAH sediment quality guideline. The pollutant concentrations exceed the allowable frequency listed in Table 4.1 of the Listing Policy. Recorded toxicity for this water body segment is not significant
5.Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because it cannot be determined if applicable water quality standards are attained.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Sediment

Beneficial Use: MA - Marine Habitat

Matrix: Sediment

Water Quality Objective/ Water Quality Criterion: Basin Plan: Surface waters shall not contain concentrations of chemical constituents in amounts that adversely affect any designated beneficial use.

Evaluation Guideline: Sediment quality guidelines were used as follows: 1,800 ug/g for total PAHs

	(Fairey et al., 2001), 1,442 ng/g for low molecular weight PAHs (MacDonald et al., 1996), and 9,600 ng/g for high molecular weight PAHs (Long et al., 1995).
Data Used to Assess Water Quality:	Of the 12 sediment core and grab samples: none exceeded the total PAH sediment quality guideline, 5 measurements exceeded the low molecular weight PAH guideline, and 6 measurements exceeded the high molecular weight PAH guideline (LARWQCB and CCC, 2004).
Spatial Representation:	The samples were spread throughout the water body.
Temporal Representation:	Samples were collected in 1992 and 1999.
Data Quality Assessment:	Bay Protection and Toxic Cleanup Program QAPP. Quality assurance for other samples presented in the Contaminated Sediments Task Force Database.

Numeric Line of Evidence	Toxicity
Beneficial Use:	MA - Marine Habitat
Matrix:	Sediment
Water Quality Objective/ Water Quality Criterion:	Basin Plan: Surface waters shall not contain concentrations of chemical constituents in amounts that adversely affect any designated beneficial use.
Evaluation Guideline:	Samples were considered toxic if (1) there was a significant difference in mean organism response between the sample and the control, and (2) the mean organism response in the test, as a percent of the control, was less than the threshold based on the 90th percentile minimum significant difference value.
Data Used to Assess Water Quality:	Of the 6 samples collected, one sample was considered toxic to amphipods (Anderson, et al., 1998).
Spatial Representation:	Three samples were collected at the entrance to Fish Harbor.
Temporal Representation:	The samples were collected in 1992.
Data Quality Assessment:	Bay Protection and Toxic Cleanup Program QAPP.

Region 4

Water Segment: Los Angeles River Estuary (Queensway Bay)

Pollutant: Chlordane

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for delisting under sections 4.6 of the Listing Policy. Under section 4.6 two lines of evidence are necessary to assess listing status.

Three lines of evidence are available in the administrative record to assess this pollutant. Based on section 4.6, there is known significant toxicity and bioassessment data associated with this water body segment and pollutant sediment concentrations exceed sediment guidelines.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of not removing this water segment-pollutant combination from the section 303(d) list in the Water Quality Limited Segments category.

This conclusion is based on the staff findings that:
1. The sediment quality guideline used complies, with the requirements of section 6.1.3 of the Policy.
2. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
3. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
4. There is significant toxicity and bioassessment data are associated with this water body segment, and nine of 9 sediment samples taken exceeded the sediment guidelines. There is an insufficient total number of samples to allow removal of this water body pollutant combination from the list using the frequencies presented in Table 4.1 of the Listing Policy.
5. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because applicable water quality standards are exceeded and a pollutant contributes to or causes the problem.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Sediment

Beneficial Use: ES - Estuarine Habitat

Matrix: Sediment

Water Quality Objective/ Water Quality Criterion: Basin Plan: Existing habitats and associated populations of wetlands fauna and flora shall be maintained by:

-Maintaining substrate characteristics necessary to support flora and fauna which

would be present naturally,
-Protecting food supplies for fish and wildlife,
-Protecting reproductive and nursery areas, and
-Protecting wildlife corridors.

Basin Plan: Surface waters shall not contain concentrations of chemical constituents in amounts that adversely affect any designated beneficial use.

Evaluation Guideline: ERM: 6 ng/g (Long and Morgan, 1990)

Data Used to Assess Water Quality: Nine samples, 9 samples exceeding (Anderson et al., 1998).

Spatial Representation: Samples were collected synoptically with toxicity samples.

Temporal Representation: Samples taken in 2 different years.

Data Quality Assessment: BPTCP Quality Assurance Project Plan.

Numeric Line of Evidence Toxicity

Beneficial Use: ES - Estuarine Habitat

Matrix: Sediment

Water Quality Objective/ Water Quality Criterion: Basin Plan: Existing habitats and associated populations of wetlands fauna and flora shall be maintained by:

-Maintaining substrate characteristics necessary to support flora and fauna which would be present naturally,
-Protecting food supplies for fish and wildlife,
-Protecting reproductive and nursery areas, and
-Protecting wildlife corridors.

Basin Plan: Surface waters shall not contain concentrations of chemical constituents in amounts that adversely affect any designated beneficial use.

Evaluation Guideline: BPTCP reference envelope approach used.

Data Used to Assess Water Quality: Four of six sediment samples were found to be significantly toxic to amphipods (Anderson et al., 1998).

Spatial Representation: Samples were collected synoptically with sediment samples.

Temporal Representation: Samples taken in 2 different years.

Data Quality Assessment: BPTCP Quality Assurance Project Plan.

Numeric Line of Evidence Population/Community Degradation

Beneficial Use: ES - Estuarine Habitat

Matrix: Sediment

Water Quality Objective/ Water Quality Criterion: Basin Plan: Existing habitats and associated populations of wetlands fauna and flora shall be maintained by:

-Maintaining substrate characteristics necessary to support flora and fauna which would be present naturally,

	-Protecting food supplies for fish and wildlife, -Protecting reproductive and nursery areas, and -Protecting wildlife corridors. Basin Plan: Surface waters shall not contain concentrations of chemical constituents in amounts that adversely affect any designated beneficial use.
Evaluation Guideline:	Evaluation of the benthic data were completed using the approaches developed by scientists associated with the BPTCP. The relative benthic index used is a calculated value considering the total fauna, total mollusk species, crustacean species and indicator species at a site. The index ranges from 0 to 1.0. An index value of less than or equal to 0.3 is an indication that pollutants or other factors are negatively impacting the benthic community.
Data Used to Assess Water Quality:	The benthic community was classified as transitional (Anderson et al., 1998).
Spatial Representation:	Samples were collected synoptically with sediment and toxicity data.
Temporal Representation:	Samples taken in 2 different years.
Data Quality Assessment:	BPTCP

Water Segment: Los Angeles River Estuary (Queensway Bay)

Pollutant: Lead

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for delisting under sections 4.6 of the Listing Policy. Under section 4.6 two lines of evidence are necessary to assess listing status.

Three lines of evidence are available in the administrative record to assess this pollutant. Based on section 4.6, there is known significant toxicity and bioassessment data associated with this water body segment and pollutant sediment concentrations exceed sediment guidelines.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification against removing this water segment-pollutant combination from the section 303(d) list in the Water Quality Limited Segments category.

This conclusion is based on the staff findings that:
1. The sediment quality guideline used complies, with the requirements of section 6.1.3 of the Policy.
2. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
3. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
4. There is significant toxicity and bioassessment data are associated with this water body segment, and five of 27 sediment samples taken exceeded the sediment guidelines. There are insufficient total numbers of samples to allow removal of this water body pollutant combination from the list using the frequencies presented in Table 4.1 of the Listing Policy.
5. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because applicable water quality standards are exceeded and a pollutant contributes to or causes the problem.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Sediment

Beneficial Use: ES - Estuarine Habitat

Matrix: Sediment

Water Quality Objective/ Water Quality Criterion: Basin Plan: Existing habitats and associated populations of wetlands fauna and flora shall be maintained by:

-Maintaining substrate characteristics necessary to support flora and fauna which

would be present naturally,
-Protecting food supplies for fish and wildlife,
-Protecting reproductive and nursery areas, and
-Protecting wildlife corridors.

Basin Plan: Surface waters shall not contain concentrations of chemical constituents in amounts that adversely affect any designated beneficial use.

Evaluation Guideline: PEL: 112.18 ug/g (McDonald et al., 1996).

Data Used to Assess Water Quality: Twenty-seven samples, 5 samples exceeding (Anderson et al., 1998).

Spatial Representation: Samples were collected synoptically with toxicity samples.

Temporal Representation: Samples taken in three different years.

Data Quality Assessment: BPTCP Quality Assurance Project Plan.

Numeric Line of Evidence Toxicity

Beneficial Use: ES - Estuarine Habitat

Matrix: Sediment

Water Quality Objective/ Water Quality Criterion: Basin Plan: Existing habitats and associated populations of wetlands fauna and flora shall be maintained by:

-Maintaining substrate characteristics necessary to support flora and fauna which would be present naturally,
-Protecting food supplies for fish and wildlife,
-Protecting reproductive and nursery areas, and
-Protecting wildlife corridors.

Basin Plan: Surface waters shall not contain concentrations of chemical constituents in amounts that adversely affect any designated beneficial use (LARWQCB, 1995)

Evaluation Guideline: BPTCP reference envelope approach used (SWRCB, 1997)

Data Used to Assess Water Quality: Four of six sediment samples were found to be significantly toxic to amphipods (Anderson et al., 1998).

Spatial Representation: Samples were collected synoptically with sediment samples.

Temporal Representation: Samples taken in 2 different years.

Data Quality Assessment: BPTCP Quality Assurance Project Plan (Stephenson et al., 1994)

Numeric Line of Evidence Population/Community Degradation

Beneficial Use: ES - Estuarine Habitat

Matrix: Sediment

Water Quality Objective/ Water Quality Criterion: Basin Plan: Existing habitats and associated populations of wetlands fauna and flora shall be maintained by:

-Maintaining substrate characteristics necessary to support flora and fauna which

would be present naturally,
-Protecting food supplies for fish and wildlife,
-Protecting reproductive and nursery areas, and
-Protecting wildlife corridors.

Basin Plan: Surface waters shall not contain concentrations of chemical constituents in amounts that adversely affect any designated beneficial use (LARWQCB, 1995)

Evaluation Guideline:	Evaluation of the benthic data were completed using the approaches developed by scientists associated with the BPTCP. The relative benthic index used is a calculated value considering the total fauna, total mollusk species, crustacean species and indicator species at a site. The index ranges from 0 to 1.0. An index value of less than or equal to 0.3 is an indication that pollutants or other factors are negatively impacting the benthic community.
Data Used to Assess Water Quality:	The benthic community was classified as transitional (Anderson et al., 1998).
Spatial Representation:	Samples were collected synoptically with sediment and toxicity samples.
Temporal Representation:	Samples taken in 2 different years.
Data Quality Assessment:	BPTCP Quality Assurance Project Plan (Stephenson et al., 1994)

Water Segment: Los Angeles River Estuary (Queensway Bay)

Pollutant: Polychlorinated biphenyls

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for delisting under sections 4.6 of the Listing Policy. Under section 4.6 two lines of evidence are necessary to assess listing status.

Three lines of evidence are available in the administrative record to assess this pollutant. Based on section 4.6, there is known significant toxicity and bioassessment data associated with this water body segment but the number of pollutant sediment exceedances does not exceed the frequency allowed by the Listing Policy.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification against of removing this water segment-pollutant combination from the section 303(d) list in the Water Quality Limited Segments category.

This conclusion is based on the staff findings that:
1. The sediment quality guideline used complies, with the requirements of section 6.1.3 of the Policy.
2. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
3. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
4. There is significant toxicity data and bioassessment data are associated with this water body segment. None of the 18 sediment samples taken exceeded the sediment guidelines but the number of samples is insufficient to delist pursuant to the Listing Policy.
5. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because it cannot be determined if applicable water quality standards for the pollutant are exceeded.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Sediment

Beneficial Use: ES - Estuarine Habitat

Matrix: Sediment

Water Quality Objective/ Water Quality Criterion: Basin Plan: Existing habitats and associated populations of wetlands fauna and flora shall be maintained by:

-Maintaining substrate characteristics necessary to support flora and fauna which

would be present naturally,
-Protecting food supplies for fish and wildlife,
-Protecting reproductive and nursery areas, and
-Protecting wildlife corridors.

Basin Plan: Surface waters shall not contain concentrations of chemical constituents in amounts that adversely affect any designated beneficial use (LARWQCB, 1995)

Evaluation Guideline:	Sediment guideline of 400 ng/g used (MacDonald et al., 2000).
Data Used to Assess Water Quality:	Eighteen samples with no samples exceeding (Anderson et al., 1998).
Spatial Representation:	Samples were collected synoptically with toxicity samples.
Temporal Representation:	Samples taken in 2 different years.
Data Quality Assessment:	BPTCP Quality Assurance Project Plan (Stephenson et al., 1994)

Numeric Line of Evidence	Toxicity
Beneficial Use:	ES - Estuarine Habitat
Matrix:	Sediment
Water Quality Objective/ Water Quality Criterion:	Basin Plan: Existing habitats and associated populations of wetlands fauna and flora shall be maintained by: -Maintaining substrate characteristics necessary to support flora and fauna which would be present naturally, -Protecting food supplies for fish and wildlife, -Protecting reproductive and nursery areas, and -Protecting wildlife corridors. Basin Plan: Surface waters shall not contain concentrations of chemical constituents in amounts that adversely affect any designated beneficial use.
Evaluation Guideline:	BPTCP reference envelope approach used (Anderson et al., 1998)
Data Used to Assess Water Quality:	Four out of six sediment samples were found to be significantly toxic to amphipods (Anderson, et al., 1998).
Spatial Representation:	Samples were collected synoptically with sediment samples.
Temporal Representation:	Samples taken in 2 different years.
Data Quality Assessment:	BPTCP Quality Assurance Project Plan (Stephenson et al., 1994).

Numeric Line of Evidence	Population/Community Degradation
Beneficial Use:	ES - Estuarine Habitat
Matrix:	Sediment
Water Quality Objective/ Water Quality Criterion:	Basin Plan: Existing habitats and associated populations of wetlands fauna and flora shall be maintained by: -Maintaining substrate characteristics necessary to support flora and fauna which

would be present naturally,
-Protecting food supplies for fish and wildlife,
-Protecting reproductive and nursery areas, and
-Protecting wildlife corridors.

Basin Plan: Surface waters shall not contain concentrations of chemical constituents in amounts that adversely affect any designated beneficial use.

Evaluation Guideline:	Evaluation of the benthic data were completed using the approaches developed by scientists associated with the BPTCP. The relative benthic index used is a calculated value considering the total fauna, total mollusk species, crustacean species and indicator species at a site. The index ranges from 0 to 1.0. An index value of less than or equal to 0.3 is an indication that pollutants or other factors are negatively impacting the benthic community (Anderson et al., 1998).
Data Used to Assess Water Quality:	The benthic community was classified as transitional (Anderson et al., 1998).
Spatial Representation:	Samples were collected synoptically with sediment and toxicity samples.
Temporal Representation:	Samples taken in 2 different years.
Data Quality Assessment:	BPTCP Quality Assurance Project Plan (Stephenson et al., 1994)

Region 4

Water Segment: Los Angeles River Reach 1 (Estuary to Carson Street)

Pollutant: Ammonia

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for listing under section 2.2 of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status.

Two lines of evidence are available in the administrative record to assess this pollutant. Based on the applicable factor, a TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.

SWRCB Staff Recommendation: After review of the available data and information for this recommendation, SWRCB staff conclude that the water body should be placed in the Water Quality Limited Segments Being Addressed category of the section 303(d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.

Lines of Evidence:

Line of Evidence Remedial Program in Place

Beneficial Use WA - Warm Freshwater Habitat

Information Used to Assess Water Quality: A TMDL and implementation plan has been approved for this water segment-pollutant combination. The Los Angeles River Nitrogen TMDL was approved by RWQCB on August 19, 2003 and subsequently approved by USEPA on March 18, 2004.

Region 4

Water Segment: Los Angeles River Reach 1 (Estuary to Carson Street)

Pollutant: Copper

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 4.1 of the Listing Policy. Under section 4.1 a single line of evidence is necessary to assess delisting status.

One line of evidence is available in the administrative record to assess this pollutant. This data set was probably used to place the water body - pollutant combination on the 2002 303(d) list originally. A sufficient number of samples exceed the acute and chronic CTR Criteria for the protection of aquatic life.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification against removing this water segment-pollutant combination from the section 303(d) list.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3. Eleven of 18 samples exceeded the CTR - CMC acute criterion, and 13 of 18 samples exceeded the CTR- CCC chronic criterion and this exceeds the allowable frequency listed in Table 4.1 of the Listing Policy.
4. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from on the section 303(d) list because applicable water quality standards are exceeded and a pollutant contributes to or causes the problem.

Lines of Evidence:

Numeric Line of Evidence	Pollutant-Water
Beneficial Use:	WA - Warm Freshwater Habitat, WI - Wildlife Habitat
Matrix:	Water
Water Quality Objective/ Water Quality Criterion:	CTRs are applicable to Aquatic Life.
Data Used to Assess Water Quality:	Eighteen water samples, 11 samples exceeding (acute), 13 samples exceeding (chronic) (LACDWP, 2004c).
Spatial Representation:	Samples were collected mostly in main stem of Los Angeles River.
Temporal Representation:	Fall, winter, spring (1997-1999).

Environmental Conditions:	Data 2-5 years old, data measured in water body, sample taken different seasons and years.
QA/QC Equivalent:	Los Angeles County Stormwater Program

Region 4

Water Segment: Los Angeles River Reach 1 (Estuary to Carson Street)

Pollutant: Zinc

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 4.1 of the Listing Policy. Under section 4.1 a single line of evidence is necessary to assess delisting status.

One line of evidence is available in the administrative record to assess this pollutant. This data set was probably used to place the water body - pollutant combination on the 2002 303(d) list originally. A sufficient number of samples exceed the acute and chronic CTR Criteria for the protection of aquatic life.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification against removing this water segment-pollutant combination from the section 303(d) list.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3. Seven of 18 samples exceeded the CTR - CMC acute criterion, and 7 of 18 samples exceeded the CTR- CCC chronic criterion and this exceeds the allowable frequency listed in Table 4.1 of the Listing Policy.
4. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from on the section 303(d) list because applicable water quality standards are exceeded and a pollutant contributes to or causes the problem.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Water

Beneficial Use: ES - Estuarine Habitat, MA - Marine Habitat, MI - Fish Migration, MU - Municipal & Domestic, RA - Rare & Endangered Species, SA - Saline Water Habitat, SP - Fish Spawning, WA - Warm Freshwater Habitat, WI - Wildlife Habitat

Matrix: Water

Water Quality Objective/ Water Quality Criterion: CTRs are applicable to Aquatic Life.

Data Used to Assess Water Quality: Eighteen water samples, 7 samples exceeding (acute and chronic criteria) (LACDPW, 2003).

Spatial Representation:	Samples were collected mainly in the main stem of the LA River.
Temporal Representation:	Fall, winter in different years.
Environmental Conditions:	Data 2-5 years old, data measured in water body, sample taken different seasons and years.
QA/QC Equivalent:	Los Angeles County Stormwater Program

Water Segment: Los Angeles River Reach 1 (Estuary to Carson Street)

Pollutant: pH

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for listing under section 2.2 of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status.

One line of evidence is available in the administrative record to assess this pollutant. Based on the applicable factor, a TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard. It is unknown if the nutrients (algae), foam, and odor information backed by pollutant data. The nutrients (algae), and odor information should not be placed on the section 303(d) list because is not a pollutant or toxicity (section 2 of the Listing Policy).

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.

SWRCB Staff Recommendation: After review of the available data and information for this recommendation, SWRCB staff conclude that the water body and pollutant (pH) should be placed in the Water Quality Limited Segments Being Addressed category of the section 303(d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.

Lines of Evidence:

Line of Evidence	Remedial Program in Place
Beneficial Use	WA - Warm Freshwater Habitat
Information Used to Assess Water Quality:	A TMDL and implementation plan has been approved for this water segment-pollutant combination. The Los Angeles River Nitrogen TMDL was approved by RWQCB on August 19, 2003 and subsequently approved by USEPA on March 18, 2004.

Water Segment:	Los Angeles River Reach 2 (Carson to Figueroa Street)
Pollutant:	Ammonia
Decision:	Do Not Delist
Weight of Evidence:	This pollutant is being considered for listing under section 2.2 of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status. One line of evidence is available in the administrative record to assess this pollutant. Based on the applicable factor, a TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard. Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.
SWRCB Staff Recommendation:	After review of the available data and information for this recommendation, SWRCB staff conclude that the water body should be placed in the Water Quality Limited Segments Being Addressed category of the section 303(d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.
Lines of Evidence:	

Line of Evidence	Remedial Program in Place
Beneficial Use	WA - Warm Freshwater Habitat
Information Used to Assess Water Quality:	A TMDL and implementation plan has been approved for this water segment-pollutant combination. The Los Angeles River Nitrogen TMDL was approved by RWQCB on August 19, 2003 and subsequently approved by USEPA on March 18, 2004.

Region 4

Water Segment: Los Angeles River Reach 4 (Sepulveda Dr. to Sepulveda Dam)

Pollutant: Ammonia

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for listing under section 2.2 of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status.

Four lines of evidence are available in the administrative record to assess this pollutant. A TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard. The nutrient(algae), foam, and odor listings are backed by ammonia data. Nutrient(algae), foam, and odor information should not be placed on the section 303(d) list because they are not pollutants or toxicity (section 2 of the Listing Policy).

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.

SWRCB Staff Recommendation: After review of the available data and information for this recommendation, SWRCB staff conclude that the water body and pollutant (ammonia) should be placed in the Water Quality Limited Segments Being Addressed category of the section 303(d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.

Lines of Evidence:

Line of Evidence	Remedial Program in Place
Beneficial Use	R2 - Non-Contact Recreation
Information Used to Assess Water Quality:	A TMDL and implementation plan has been approved for this water segment-pollutant combination. The Los Angeles River Nitrogen TMDL was approved by RWQCB on August 19, 2003 and subsequently approved by USEPA on March 18, 2004.

Water Segment: Los Angeles River Reach 5 (within Sepulveda Basin)

Pollutant: Ammonia

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for listing under section 2.2 of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status.

Four lines of evidence are available in the administrative record to assess this pollutant. A TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard. The nutrient(algae), foam, and odor listings are backed by ammonia data. Nutrient(algae), foam, and odor information should not be placed on the section 303(d) list because they are not pollutants or toxicity (section 2 of the Listing Policy).

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.

SWRCB Staff Recommendation: After review of the available data and information for this recommendation, SWRCB staff conclude that the water body and pollutant (ammonia) should be placed in the Water Quality Limited Segments Being Addressed category of the section 303(d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.

Lines of Evidence:

Line of Evidence Remedial Program in Place

Beneficial Use WA - Warm Freshwater Habitat

Information Used to Assess Water Quality: A TMDL and implementation plan has been approved for this water segment-pollutant combination. The Los Angeles River Nitrogen TMDL was approved by RWQCB on August 19, 2003 and subsequently approved by USEPA on March 18, 2004.

Water Segment: Los Cerritos Channel

Pollutant: Chlordane

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 4.1 of the Listing Policy. Under section 4.1 a single line of evidence is necessary to assess listing status.

One line of evidence is available in the administrative record to assess this pollutant. This line of evidence was probably used to place this water body pollutant combination on the 303(d) list originally. One of the samples exceed the ERM sediment quality guidance and the number of samples is insufficient to make a delisting determination with the confidence and power required by the Listing Policy.

Based on the readily available data and information, the weight of evidence indicates that there is insufficient justification in favor of removing this water segment-pollutant combination from the section 303(d) list.

This conclusion is based on the staff findings that:
1.The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2.The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3.One of four samples exceeded the ERM sediment guideline. At least 28 samples are needed before a pollutant can be considered for removal from the list using the frequencies presented in Table 4.1 of the Listing Policy.
4.Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because it cannot be determined if applicable water quality standards are attained.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Sediment

Beneficial Use: ES - Estuarine Habitat, MA - Marine Habitat, MI - Fish Migration, RA - Rare & Endangered Species, SP - Fish Spawning, WI - Wildlife Habitat

Matrix: Sediment

Water Quality Objective/ Water Quality Criterion: Basin Plan: Existing habitats and associated populations of wetlands fauna and flora shall be maintained by:

-Maintaining substrate characteristics necessary to support flora and fauna which would be present naturally,
-Protecting food supplies for fish and wildlife,
-Protecting reproductive and nursery areas, and

-Protecting wildlife corridors.
(LARWQCB, 1995)

	Basin Plan: Surface waters shall not contain concentrations of chemical constituents in amounts that adversely affect any designated beneficial use.
Evaluation Guideline:	ERM: 6 ng/g (Long and Morgan, 1990).
Data Used to Assess Water Quality:	Four sediment samples with one sample exceeding the ERM (Anderson, et al., 1998).
Spatial Representation:	Data was collected spatially.
Temporal Representation:	Winter 1993 and 1994.
Data Quality Assessment:	BPTCP QAPP.

Water Segment: Machado Lake (Harbor Park Lake)

Pollutant: Chlordane

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for placement on the section 303(d) list under section 3.5 of the Listing Policy. One line of evidence is available in the administrative record to assess this pollutant.

Based on the readily available data and information, the weight of evidence indicates that there is insufficient justification in favor of removing this water segment-pollutant combination from the section 303(d) list in the Water Quality Limited Segments category.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3. Four of the 9 samples exceeded the OEHHA Screening Value but the number of samples is insufficient to determine with the confidence and power required by the Listing Policy.
4. Pursuant to section 3.11 of the Listing Policy, no additional data and information are available indicating that standards are not met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because it cannot be determined if applicable water quality standards are attained.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Tissue

Beneficial Use: CM - Commercial and Sport Fishing (CA)

Matrix: Tissue

Water Quality Objective/ Water Quality Criterion: Los Angeles RWQCB Basin Plan: Toxic pollutants shall not be present at levels that will bioaccumulate in aquatic life to levels which are harmful to aquatic life or human health

Evaluation Guideline: 30 ng/g (OEHHA Screening Value)

Data Used to Assess Water Quality: Four out of 9 samples exceeded. A total of 9 filet composite samples of carp and largemouth bass were collected. Carp were collected in 1993-94, 1997, and 2002. Largemouth bass were collected in 1992, 1994, 1997, and 2002. The guideline was exceeded in 1993, 1994, 1997, and 2002 samples of carp. Largemouth bass did not exceed the guideline (TSMP, 2002).

Spatial Representation: One station in the entire lake.

Temporal Representation: Samples were collected annually 1992-94, 1997, and 2002.

Data Quality Assessment: Toxic Substances Monitoring Program 1992-93 and 1994-95 Data Reports. Environmental Chemistry Quality Assurance and Data Report for the Toxic Substances Monitoring Program,1996-2000. Department of Fish and Game Environmental Chemistry Quality Assurance and Data Report for the Toxic Substances Monitoring Program, 2001-2002. Department of Fish and Game.

Water Segment: Machado Lake (Harbor Park Lake)

Pollutant: DDT

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 3.5 of the Listing Policy. One line of evidence is available in the administrative record to assess this pollutant.

Based on the readily available data and information, the weight of evidence indicates that there is insufficient justification in favor of removing this water segment-pollutant combination from the section 303(d) list in the Water Quality Limited Segments category.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3. Four of the 9 samples exceeded the OEHHA Screening Value but the number of samples is insufficient to determine with the confidence and power required by the Listing Policy.
4. Pursuant to section 3.11 of the Listing Policy, no additional data and information are available indicating that standards are not met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because it cannot be determined if applicable water quality standards are attained.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Tissue

Beneficial Use: CM - Commercial and Sport Fishing (CA)

Matrix: Tissue

Water Quality Objective/ Water Quality Criterion: Los Angeles RWQCB Basin Plan: Toxic pollutants shall not be present at levels that will bioaccumulate in aquatic life to levels which are harmful to aquatic life or human health.

Evaluation Guideline: 100 ng/g (OEHHA Screening Value)

Data Used to Assess Water Quality: Four out of 9 samples exceeded. A total of 5 filet composite samples of largemouth bass and 4 composite filet samples of carp were collected. Largemouth bass were collected in 1992, 1994, 1997, and 2002. Carp were collected in 1993-94, 1997, and 2002. The guideline was exceeded in all carp samples. Largemouth bass did not exceed the guideline (TSMP, 2002).

Spatial Representation: One station in the entire lake.

Temporal Representation: Samples were collected annually 1992-94, 1997, and 2002.

Data Quality Assessment:	Toxic Substances Monitoring Program 1992-93 and 1994-95 Data Reports. Environmental Chemistry Quality Assurance and Data Report for the Toxic Substances Monitoring Program, 1996-2000. Department of Fish and Game Environmental Chemistry Quality Assurance and Data Report for the Toxic Substances Monitoring Program, 2001-2002. Department of Fish and Game.

Water Segment:	Machado Lake (Harbor Park Lake)
Pollutant:	Dieldrin
Decision:	Do Not Delist

Weight of Evidence:

This pollutant is being considered for removal from the section 303(d) list under section 3.5 of the Listing Policy. One line of evidence is available in the administrative record to assess this pollutant.

Based on the readily available data and information, the weight of evidence indicates that there is insufficient justification in favor of removing this water segment-pollutant combination from the section 303(d) list in the Water Quality Limited Segments category.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3. Four of the 9 samples exceeded the OEHHA Screening Value but the number of samples is insufficient to determine with the confidence and power required by the Listing Policy.
4. Pursuant to section 3.11 of the Listing Policy, no additional data and information are available indicating that standards are not met.

SWRCB Staff Recommendation:

After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because it cannot be determined if applicable water quality standards are attained.

Lines of Evidence:

Numeric Line of Evidence	Pollutant-Tissue
Beneficial Use:	CM - Commercial and Sport Fishing (CA)
Matrix:	Tissue
Water Quality Objective/ Water Quality Criterion:	Los Angeles RWQCB Basin Plan: Toxic pollutants shall not be present at levels that will bioaccumulate in aquatic life to levels which are harmful to aquatic life or human health.
Evaluation Guideline:	2 ng/g (OEHHA Screening Value)
Data Used to Assess Water Quality:	Four out of 9 samples exceeded. A total of 5 filet composite samples of largemouth bass and 4 composite filet samples of carp were collected. Largemouth bass were collected in 1992, 1994, 1997, and 2002. Carp were collected in 1993-94, 1997, and 2002. The guideline was exceeded in all carp samples. Largemouth bass did not exceed the guideline (TSMP, 2002).
Spatial Representation:	One station in the entire lake.

Temporal Representation:	Samples were collected annually 1992-94, 1997, and 2002.
Data Quality Assessment:	Toxic Substances Monitoring Program 1992-93 and 1994-95 Data Reports. Environmental Chemistry Quality Assurance and Data Report for the Toxic Substances Monitoring Program,1996-2000. Department of Fish and Game Environmental Chemistry Quality Assurance and Data Report for the Toxic Substances Monitoring Program, 2001-2002. Department of Fish and Game.

Region 4

Water Segment: Machado Lake (Harbor Park Lake)

Pollutant: Polychlorinated biphenyls

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 3.5 of the Listing Policy. One line of evidence is available in the administrative record to assess this pollutant.

Based on the readily available data and information, the weight of evidence indicates that there is insufficient justification in favor of removing this water segment-pollutant combination from the section 303(d) list in the Water Quality Limited Segments category.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3. Four of the 9 samples exceeded the OEHHA Screening Value but the number of samples is insufficient to determine with the confidence and power required by the Listing Policy.
4. Pursuant to section 3.11 of the Listing Policy, no additional data and information are available indicating that standards are not met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because it cannot be determined if applicable water quality standards are attained.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Tissue

Beneficial Use: CM - Commercial and Sport Fishing (CA)

Matrix: Tissue

Water Quality Objective/ Water Quality Criterion: Los Angeles RWQCB Basin Plan: Toxic pollutants shall not be present at levels that will bioaccumulate in aquatic life to levels which are harmful to aquatic life or human health.

Evaluation Guideline: 20 ng/g (OEHHA Screening Value)

Data Used to Assess Water Quality: Four out of 9 samples exceeded. A total of 5 filet composite samples of largemouth bass and 4 filet composite samples of carp were collected. Carp were collected in 1993-94, 1997, and 2002. Largemouth bass were collected in 1992, 1994, 1997, and 2002. The guideline was exceeded in 1993, 1994, 1997, and 2002 samples of carp. Largemouth bass did not exceed the guideline (TSMP, 2002).

Spatial Representation: One station in the entire lake.

Temporal Representation:	Samples were collected annually 1992-94, 1997, and 2002.
Data Quality Assessment:	Toxic Substances Monitoring Program 1992-93 and 1994-95 Data Reports. Environmental Chemistry Quality Assurance and Data Report for the Toxic Substances Monitoring Program,1996-2000. Department of Fish and Game Environmental Chemistry Quality Assurance and Data Report for the Toxic Substances Monitoring Program, 2001-2002. Department of Fish and Game.

Region 4

Water Segment: Malibu Lagoon

Pollutant: pH

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 4.2 of the Listing Policy. Under section 4.2 a single line of evidence is necessary to assess listing status.

One line of evidence is available in the administrative record to assess this pollutant. This line of evidence was probably used to place the water body pollutant combination on the 2002 303(d) list originally. Thirty-three samples exceeded the water quality objective when the water body was listed. However, twenty-two exceedances or less would be required in order to delist the water body pollutant combination to provide the adequate confidence and power that standards are being met in accordance with the Listing Policy.

Based on the readily available data and information, the weight of evidence indicates that there is insufficient justification in favor of removing this water segment-pollutant combination from the section 303(d) list.

This conclusion is based on the staff findings that:
1.The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2.The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3.Thirty-three of 138 samples exceeded the pH water quality objective. At least 22 samples or less are needed before a pollutant can be considered for removal from the list using the frequencies presented in Table 4.2 of the Listing Policy.
4.Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because applicable water quality standards are exceeded and a pollutant contributes to or causes the problem.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Water

Beneficial Use: ES - Estuarine Habitat, MA - Marine Habitat, MI - Fish Migration, RA - Rare & Endangered Species, SP - Fish Spawning, WE - Wetland Habitat, WI - Wildlife Habitat

Matrix: Water

Water Quality Objective/ Water Quality Criterion: Basin Plan: The pH of bays and estuaries shall not be depressed below 6.5 or raised above 8.5 as a result of waste discharges. Ambient pH levels shall not be changed more than 0.2 units from natural conditions as a result of waste

	discharge.
Data Used to Assess Water Quality:	There were 138 water samples, with 33 samples exceeding the water quality objective (SWRCB, 2003).
Spatial Representation:	pH data was collected a various monitoring stations within the lagoon.
Temporal Representation:	Winter 1997, Summer-Winter 1998, Winter- Fall 1999.
Data Quality Assessment:	Las Virgenas NPDES Municipal Water District.

Region 4

Water Segment:	Malibu Lagoon Beach (Surfrider)
Pollutant:	Coliform Bacteria
Decision:	Do Not Delist
Weight of Evidence:	This pollutant is being considered for listing under section 2.2 of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status. Two lines of evidence are available in the administrative record to assess this pollutant. Based on the applicable factor, a TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard. The beach closure information is backed by coliform data. Beach closure information should not be placed on the section 303(d) list because it is not a pollutant or toxicity (section 2 of the Listing Policy). Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.
SWRCB Staff Recommendation:	After review of the available data and information for this recommendation, SWRCB staff conclude that the water body and pollutant (coliform) should be placed in the Water Quality Limited Segments Being Addressed category of the section 303(d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.
Lines of Evidence:	

Line of Evidence	Remedial Program in Place
Beneficial Use	R1 - Water Contact Recreation
Information Used to Assess Water Quality:	A TMDL and implementation plan has been approved for this water segment-pollutant combination. The Santa Monica Bay Bacteria Dry Weather TMDL was approved by RWQCB on January 24, 2002 and subsequently approved by USEPA. The Santa Monica Bay Bacteria Wet Weather TMDL was approved by RWQCB on December 12, 2004 and approved by USEPA on June 19, 2003.

Water Segment: Marina del Rey Harbor - Back Basins

Pollutant: Coliform Bacteria

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for listing under section 2.2 of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status.

One line of evidence is available in the administrative record to assess this pollutant. Based on the applicable factor, a TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.

SWRCB Staff Recommendation: After review of the available data and information for this recommendation, SWRCB staff conclude that the water body should be placed in the Water Quality Limited Segments Being Addressed category of the section 303(d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.

Lines of Evidence:

Line of Evidence	Remedial Program in Place
Beneficial Use	R1 - Water Contact Recreation
Information Used to Assess Water Quality:	A TMDL and implementation plan has been approved for this water segment-pollutant combination. The Marina del Rey Pathogens TMDL was approved by RWQCB on August 7, 2003 and subsequently approved by USEPA on March 23, 2004.

Water Segment: Marina del Rey Harbor - Back Basins

Pollutant: DDT

Decision: Do Not Delist

Weight of Evidence: Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification against removing this water segment-pollutant combination from the section 303(d) list in the Water Quality Limited Segments category.

This conclusion is based on the staff findings that:
1. The sediment quality guideline used complies with the requirements of section 6.1.3 of the Policy.
2. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
3. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
4. Two out of 4 samples exceeded the OEHHA Screening Value for fish tissue. A minimum of 28 samples would be needed in order for this water body to be delisted for this pollutant with 2 exceedances.
5. Pursuant to section 3.11 of the Listing Policy, no additional data and information are available indicating that standards are not met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from on the section 303(d) list because applicable water quality standards are exceeded and a pollutant contributes to or causes the problem.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Sediment

Beneficial Use: MA - Marine Habitat, WI - Wildlife Habitat

Matrix: Sediment

Water Quality Objective/ Water Quality Criterion: Basin Plan: Existing habitats and associated populations of wetlands fauna and flora shall be maintained by:

-Maintaining substrate characteristics necessary to support flora and fauna which would be present naturally,
-Protecting food supplies for fish and wildlife,
-Protecting reproductive and nursery areas, and
-Protecting wildlife corridors.

Basin Plan: Surface waters shall not contain concentrations of chemical constituents in amounts that adversely affect any designated beneficial use.

Evaluation Guideline: A sediment quality guideline is not available that satisfies the conditions established in section 6.1.3 of the Listing Policy.

Data Used to Assess Water Quality:	Ten samples ranging in concentration from 33.96 ppb to 97 ppb (Anderson, et al., 1998).
Spatial Representation:	Samples were collected synoptically with toxicity samples.
Temporal Representation:	Summer-winter 1993, summer 1996, fall-winter 1997.
Data Quality Assessment:	BPTCP QAPP.

Numeric Line of Evidence	Pollutant-Tissue
Beneficial Use:	MA - Marine Habitat, WI - Wildlife Habitat
Matrix:	Tissue
Water Quality Objective/ Water Quality Criterion:	Los Angeles RWQCB Basin Plan: Toxic pollutants shall not be present at levels that will bioaccumulate in aquatic life to levels which are harmful to aquatic life or human health.
Evaluation Guideline:	100 ng/g - OEHHA Screening Value.
Data Used to Assess Water Quality:	Two out of 4 samples exceeded. A total of 3 filet composite samples of white croaker, yellowfin croaker, and round stingray along with an individual sample of sargo were collected. White croaker was collected in 1993. All others were collected in 1995. The guideline was exceeded in white croaker and sargo. Yellowfin croaker and round stingray did not exceed the guideline (TSMP, 2002).
Spatial Representation:	One station located about midway between the boat ramp and the entrance to the ocean.
Temporal Representation:	Samples were collected on 6/22/93 and 6/28/95.
Data Quality Assessment:	Toxic Substances Monitoring Program 1992-93 and 1994-95 Data Reports.

Numeric Line of Evidence	Toxicity
Beneficial Use:	MA - Marine Habitat, WI - Wildlife Habitat
Matrix:	Sediment
Water Quality Objective/ Water Quality Criterion:	Basin Plan: Existing habitats and associated populations of wetlands fauna and flora shall be maintained by: -Maintaining substrate characteristics necessary to support flora and fauna which would be present naturally, -Protecting food supplies for fish and wildlife, -Protecting reproductive and nursery areas, and -Protecting wildlife corridors. Basin Plan: Surface waters shall not contain concentrations of chemical constituents in amounts that adversely affect any designated beneficial use.
Evaluation Guideline:	BPTCP reference envelope approach used.
Data Used to Assess Water Quality:	Seven samples, 6 samples considered toxic (Anderson et al., 1998).
Spatial Representation:	Samples were collected synoptically with sediment samples.

Temporal Representation:	Summer-winter 1993, summer 1996, fall-winter 1997.
Data Quality Assessment:	BPTCP QAPP.

Water Segment: Marina del Rey Harbor - Back Basins

Pollutant: Dieldrin

Decision: Do Not Delist

Weight of Evidence: Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification against removing this water segment-pollutant combination from the section 303(d) list in the Water Quality Limited Segments category.

This conclusion is based on the staff findings that:
1. The sediment quality guideline used complies with the requirements of section 6.1.3 of the Policy.
2. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
3. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
4. Two out of 4 samples exceeded the OEHHA Screening Value for fish tissue. A minimum of 28 samples would be needed in order for this water body to be delisted for this pollutant with 2 exceedances.
5. Pursuant to section 3.11 of the Listing Policy, no additional data and information are available indicating that standards are not met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from on the section 303(d) list because applicable water quality standards are exceeded and a pollutant contributes to or causes the problem.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Tissue

Beneficial Use: CM - Commercial and Sport Fishing (CA)

Matrix: Tissue

Water Quality Objective/ Water Quality Criterion: Los Angeles RWQCB Basin Plan: Toxic pollutants shall not be present at levels that will bioaccumulate in aquatic life to levels which are harmful to aquatic life or human health.

Evaluation Guideline: 2 ng/g - OEHHA Screening Value.

Data Used to Assess Water Quality: Two out of 4 samples exceeded. A total of 3 filet composite samples of white croaker, yellowfin croaker, and round stingray along with an individual sample of sargo were collected. White croaker was collected in 1993. All others were collected in 1995. The guideline was exceeded in white croaker and sargo. Yellowfin croaker and round stingray did not exceed the guideline (TSMP, 2002).

Spatial Representation: One station located about midway between the boat ramp and the entrance to the ocean.

Temporal Representation: Samples were collected on 6/22/93 and 6/28/95.

Data Quality Assessment: Toxic Substances Monitoring Program 1992-93 and 1994-95 Data Reports.

Water Segment: Marina del Rey Harbor - Back Basins

Pollutant: Polychlorinated biphenyls

Decision: Do Not Delist

Weight of Evidence: Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification against removing this water segment-pollutant combination from the section 303(d) list in the Water Quality Limited Segments category.

This conclusion is based on the staff findings that:
1. The sediment quality guideline used complies with the requirements of section 6.1.3 of the Policy.
2. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
3. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
4. Three out of 4 samples exceeded the OEHHA Screening Value for fish tissue and, although none of the 18 sediment samples exceeded the criteria for PCBs, 6 samples were found to be toxic.
5. Pursuant to section 3.11 of the Listing Policy, no additional data and information are available indicating that standards are not met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from on the section 303(d) list because applicable water quality standards are exceeded and a pollutant contributes to or causes the problem.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Tissue

Beneficial Use: AG - Agricultural Supply, CM - Commercial and Sport Fishing (CA)

Matrix: Tissue

Water Quality Objective/ Water Quality Criterion: Los Angeles RWQCB Basin Plan: Toxic pollutants shall not be present at levels that will bioaccumulate in aquatic life to levels which are harmful to aquatic life or human health.

Evaluation Guideline: 20 ng/g - OEHHA Screening Value.

Data Used to Assess Water Quality: Three out of 4 samples exceeded. A total of 3 filet composite samples of white croaker, yellowfin croaker, and round stingray along with an individual sample of sargo were collected. White croaker was collected in 1993. All others were

	collected in 1995. The guideline was exceeded in white croaker, sargo, and yellowfin croaker. Round stingray did not exceed the guideline (TSMP, 2002).
Spatial Representation:	One station located about midway between the boat ramp and the entrance to the ocean.
Temporal Representation:	Samples were collected on 6/22/93 and 6/28/95.
Data Quality Assessment:	Toxic Substances Monitoring Program 1992-93 and 1994-95 Data Reports.

Numeric Line of Evidence	Pollutant-Sediment
Beneficial Use:	MA - Marine Habitat, WI - Wildlife Habitat
Matrix:	Sediment
Water Quality Objective/ Water Quality Criterion:	Basin Plan: Existing habitats and associated populations of wetlands fauna and flora shall be maintained by: -Maintaining substrate characteristics necessary to support flora and fauna which would be present naturally, -Protecting food supplies for fish and wildlife, -Protecting reproductive and nursery areas, and -Protecting wildlife corridors. Basin Plan: Surface waters shall not contain concentrations of chemical constituents in amounts that adversely affect any designated beneficial use.
Evaluation Guideline:	Sediment Quality Guideline: 400 ug/g (McDonald et al., 2000).
Data Used to Assess Water Quality:	18 sediment samples with none exceeding the sediment quality guideline.
Spatial Representation:	Samples were collected synoptically with toxicity samples.
Temporal Representation:	Summer-winter 1993, summer 1996, fall-winter 1997.
Data Quality Assessment:	BPTCP and TSMP QAPPs.

Numeric Line of Evidence	Toxicity
Beneficial Use:	MA - Marine Habitat, WI - Wildlife Habitat
Matrix:	Sediment
Water Quality Objective/ Water Quality Criterion:	Basin Plan: Existing habitats and associated populations of wetlands fauna and flora shall be maintained by: -Maintaining substrate characteristics necessary to support flora and fauna which would be present naturally, -Protecting food supplies for fish and wildlife, -Protecting reproductive and nursery areas, and -Protecting wildlife corridors. Basin Plan: Surface waters shall not contain concentrations of chemical constituents in amounts that adversely affect any designated beneficial use.
Evaluation Guideline:	BPTCP reference envelope approach used.

Data Used to Assess Water Quality:	Seven samples, 6 samples considered toxic (Anderson et al., 1998).
Spatial Representation:	Samples were collected synoptically with sediment samples.
Temporal Representation:	Summer-winter 1993, summer 1996, fall-winter 1997.
Data Quality Assessment:	BPTCP QAPP.

Region 4

Water Segment: Marina del Rey Harbor Beach

Pollutant: Coliform Bacteria

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for listing under section 2.2 of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status.

Two lines of evidence are available in the administrative record to assess this pollutant. Based on the applicable factor, a TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard. The beach closure information is backed by coliform data. Beach closure information should not be placed on the section 303(d) list because it is not a pollutant or toxicity (section 2 of the Listing Policy).

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.

SWRCB Staff Recommendation: After review of the available data and information for this recommendation, SWRCB staff conclude that the water body should be placed in the Water Quality Limited Segments Being Addressed category of the section 303(d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.

Lines of Evidence:

Line of Evidence Remedial Program in Place

Beneficial Use R1 - Water Contact Recreation

Information Used to Assess Water Quality: A TMDL and implementation plan has been approved for this water segment-pollutant combination. The Marina del Rey Pathogens TMDL was approved by RWQCB on August 7, 2003 and subsequently approved by USEPA on March 23, 2004.

Line of Evidence Remedial Program in Place

Beneficial Use R1 - Water Contact Recreation

Information Used to Assess Water Quality: A TMDL and implementation plan has been approved for this water segment-pollutant combination. The Marina del Rey Pathogens TMDL was approved by RWQCB on August 7, 2003 and subsequently approved by USEPA on March 23, 2004.

Water Segment: McCoy Canyon Creek

Pollutant: Fecal Coliform

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 4.3 of the Listing Policy. Under section 4.2 a single line of evidence is necessary to assess delisting status.

One line of evidence is available in the administrative record to assess this pollutant. This Line of evidence was probably used to place this water body pollutant combination on the 303(d) list originally. A sufficient number of samples exceed the water quality objective.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification against removing this water segment-pollutant combination from the section 303(d) list.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3. Thirty-eight of 56 samples originally exceeded the water quality objective and this exceeds the allowable frequency listed in Table 4.1 of the Listing Policy.
4. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from on the section 303(d) list because applicable water quality standards are exceeded and a pollutant contributes to or causes the problem.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Water

Beneficial Use: R1 - Water Contact Recreation

Matrix: Water

Water Quality Objective/ Water Quality Criterion: Basin Plan: In waters designated for water contact recreation (REC-1), the fecal coliform concentration shall not exceed a log mean of 200/100 ml (based on a minimum of not less than four samples for any 30-day period), nor shall more than 10 percent of total samples during any 30-day period exceed 400/100 ml.

Data Used to Assess Water Quality:	Fifty-six bacterial samples, 38 samples exceeding (SWRCB, 2003).
Spatial Representation:	Samples were collected along the creek.
Temporal Representation:	Spring, summer, fall, winter.
Data Quality Assessment:	City of Calabasas NPDES Monitoring.

Water Segment: McCoy Canyon Creek

Pollutant: Nitrogen, Nitrate

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 4.1 of the Listing Policy. Under section 4.1 a single line of evidence is necessary to assess delisting status.

One line of evidence is available in the administrative record to assess this pollutant. This Line of evidence was probably used to place this water body pollutant combination on the 303(d) list originally A sufficient number of samples exceed the water quality objective.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification against removing this water segment-pollutant combination from the section 303(d) list.

This conclusion is based on the staff findings that:
1.The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2.The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3. 19 of 51 samples originally exceeded the water quality objective and this exceeds the allowable frequency listed in Table 4.1 of the Listing Policy.
4. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from on the section 303(d) list because applicable water quality standards are exceeded and a pollutant contributes to or causes the problem.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Water

Beneficial Use: GW - Groundwater Recharge

Matrix: Water

Water Quality Objective/ Water Quality Criterion: Basin Plan: Waters shall not exceed 10 mg/L nitrogen as nitrate-nitrogen plus nitrite-nitrogen (NO2-N), 45 mg/L as nitrate (NO3), 10 mg/L as nitrate-nitrogen (NO3-N), or 1 mg/L nitrite-nitrogen (NO2-N) or as otherwise designated in [another part of the Basin Plan].

Data Used to Assess Water Quality:	Fifty-one water samples, 19 samples exceeding (SWRCB, 2003).
Spatial Representation:	Samples were collected along the creek.
Temporal Representation:	Spring-Summer-Fall 2000 and Winter-Spring 2001.
Data Quality Assessment:	City of Calabasas NPDES Monitoring.

Water Segment:	McGrath Beach
Pollutant:	Coliform Bacteria
Decision:	Do Not Delist

Weight of Evidence:

This pollutant is being considered for listing under section 2.2 of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status.

One line of evidence is available in the administrative record to assess this pollutant. Based on the applicable factor, a TMDL has been developed and approved by USEPA. the TMDL is being implemented through a Cleanup and abatement Order and is expected to result in attainment of the standard by 2006.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.

SWRCB Staff Recommendation:

After review of the available data and information for this recommendation, SWRCB staff conclude that the water body should be placed in the Water Quality Limited Segments Being Addressed category of the section 303(d) list because a TMDL has been approved by USEPA and a Cleanup and Abatement Order has been approved implementing the TMDL.

Lines of Evidence:

Line of Evidence	Remedial Program in Place
Beneficial Use	R1 - Water Contact Recreation
Information Used to Assess Water Quality:	A TMDL was approved by USEPA on November 20, 2003. The RWQCB is implementing the TMDL through a Cleanup and Abatement Order.

Water Segment: McGrath Lake

Pollutant: Dieldrin

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under sections 4.1 of the Listing Policy. Under section 4.1 a single line of evidence is necessary to assess listing status

Two lines of evidence are available in the administrative record to assess this pollutant. Based on section 4.6 the site has sediment toxicity and the pollutant is likely to be causing or contributing to the toxic effect, but the number of samples is insufficient to determine with the confidence and power required by the Listing Policy.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification against removing this water segment-pollutant combination on the section 303(d) list in the Water Quality Limited Segments category.

This conclusion is based on the staff findings that:
1. The sediment quality guideline used complies with the requirements of section 6.1.3 of the Policy.
2. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
3. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
4. Two of two samples exceeded the sediment quality guideline for the pollutant, and two of five samples exhibit toxicity, but the number of samples is insufficient to determine with the confidence and power required by the Listing Policy.
5. Pursuant to section 3.11 of the Listing Policy, no additional data and information are available indicating that standards are not met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because it cannot be determined if applicable water quality standards are attained.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Sediment

Beneficial Use: ES - Estuarine Habitat, RA - Rare & Endangered Species, WE - Wetland Habitat, WI - Wildlife Habitat

Matrix: Sediment

Water Quality Objective/ Water Quality Criterion:	Basin Plan: Existing habitats and associated populations of wetlands fauna and flora shall be maintained by: -Maintaining substrate characteristics necessary to support flora and fauna which would be present naturally, -Protecting food supplies for fish and wildlife, -Protecting reproductive and nursery areas, and -Protecting wildlife corridors. Basin Plan: Surface waters shall not contain concentrations of chemical constituents in amounts that adversely affect any designated beneficial use (LARWQCB, 1995)
Evaluation Guideline:	ERM of 8 ng/g used (Long et al., 1995).
Data Used to Assess Water Quality:	Two samples and both measurements exceed the sediment guideline (Anderson et al., 1998).
Spatial Representation:	Samples were collected concurrently with toxicity measurements.
Temporal Representation:	Four different events in 4 different years.
Data Quality Assessment:	BPTCP QAPP (Stephenson et al., 1994)

Numeric Line of Evidence	Toxicity
Beneficial Use:	ES - Estuarine Habitat, RA - Rare & Endangered Species, WE - Wetland Habitat, WI - Wildlife Habitat
Matrix:	Sediment
Water Quality Objective/ Water Quality Criterion:	Basin Plan: Existing habitats and associated populations of wetlands fauna and flora shall be maintained by: -Maintaining substrate characteristics necessary to support flora and fauna which would be present naturally, -Protecting food supplies for fish and wildlife, -Protecting reproductive and nursery areas, and -Protecting wildlife corridors.
Evaluation Guideline:	BPTCP reference envelope approach used.
Data Used to Assess Water Quality:	Five amphipod toxicity tests with 2 measurements showing significant toxicity. One mussel development test with the measurement showing significant toxicity (Anderson et al., 1998).
Spatial Representation:	Samples were collected concurrently with chemical measurements.
Temporal Representation:	Four different events in 4 different years.
Data Quality Assessment:	BPTCP and DFG QAPP (Stephenson et al., 1994)

Line of Evidence	Remedial Program in Place
Beneficial Use	ES - Estuarine Habitat, RA - Rare & Endangered Species, WE - Wetland Habitat, WI - Wildlife Habitat
Information Used to Assess	The Consolidated Toxic Hot Spots Cleanup Plan describes how the

Water Quality: RWQCB will work with the McGrath State Beach Area Trustee Council to address cleanup of this site. While the planning has progressed, no remediation of the site has occurred. No responsible parties have been identified.

Water Segment: McGrath Lake

Pollutant: Fecal Coliform

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 4.3 of the Listing Policy. Under section 4.2 a single line of evidence is necessary to assess delisting status.

One line of evidence is available in the administrative record to assess this pollutant. This Line of evidence was probably used to place this water body pollutant combination on the 303(d) list originally. A sufficient number of samples exceed the water quality objective.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification against removing this water segment-pollutant combination from the section 303(d) list.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3. Six of 29 samples originally exceeded the water quality objective and this exceeds the allowable frequency listed in Table 4.2 of the Listing Policy.
4. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from on the section 303(d) list because applicable water quality standards are exceeded and a pollutant contributes to or causes the problem.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Water

Beneficial Use: R1 - Water Contact Recreation

Matrix: Water

Water Quality Objective/ Water Quality Criterion: Basin Plan: In waters designated for water contact recreation (REC-1), the fecal coliform concentration shall not exceed a log mean of 200/100 ml (based on a minimum of not less than four samples for any 30-day period), nor shall more than 10 percent of total samples during any 30-day period exceed 400/100 ml.

Data Used to Assess Water Quality: 29 bacteria samples, 6 sample exceeding the geometric mean of 200/100 mL
Included in the 29 bacterial samples, 16 sample in the Spring of 2002.
5 of the 16 samples exceeded the 400/100 mL objective.

Spatial Representation: 5 sites.

Temporal Representation: Spring, Summer, and Fall 1999-2000.

Data Quality Assessment: Ventura Division of Environmental Health Services collected the data.

Water Segment: McGrath Lake

Pollutant: Polychlorinated biphenyls

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 4.6 of the Listing Policy. Under section 4.6, one or more lines of evidence is necessary to assess listing status.

Two lines of evidence are available in the administrative record to assess this pollutant. The site has significant sediment toxicity. None of the samples exceed the sediment guideline but the number of samples is insufficient to determine with the confidence and power required by the Listing Policy.

Based on the readily available data and information, the weight of evidence indicates that there is insufficient justification in favor of removing this water segment-pollutant combination from the section 303(d) list.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3. None of 5 samples exceeded the total PCB guideline. At least 28 samples are needed before a pollutant can be considered for removal from the list using the frequencies presented in Table 4.1 of the Listing Policy.
4. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because it cannot be determined if applicable water quality standards are attained.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Sediment

Beneficial Use: ES - Estuarine Habitat, RA - Rare & Endangered Species, WE - Wetland Habitat, WI - Wildlife Habitat

Matrix: Sediment

Water Quality Objective/ Water Quality Criterion: Basin Plan: Existing habitats and associated populations of wetlands fauna and flora shall be maintained by:

-Maintaining substrate characteristics necessary to support flora and fauna which would be present naturally,
-Protecting food supplies for fish and wildlife,
-Protecting reproductive and nursery areas, and
-Protecting wildlife corridors.

	Basin Plan: Surface waters shall not contain concentrations of chemical constituents in amounts that adversely affect any designated beneficial use.
Evaluation Guideline:	Sediment guideline of 400 ng/g used (MacDonald et al., 2000).
Data Used to Assess Water Quality:	Five sediment samples, none of the samples exceed the sediment guideline (Anderson et al., 1998).
Spatial Representation:	Samples were collected concurrently with toxicity measurements.
Temporal Representation:	4 different events in 4 different years.
Data Quality Assessment:	BPTCP and DFG QAPP (Stephenson et al., 1994)

Numeric Line of Evidence	Toxicity
Beneficial Use:	ES - Estuarine Habitat, RA - Rare & Endangered Species, WE - Wetland Habitat, WI - Wildlife Habitat
Matrix:	Sediment
Water Quality Objective/ Water Quality Criterion:	Basin Plan: Existing habitats and associated populations of wetlands fauna and flora shall be maintained by: -Maintaining substrate characteristics necessary to support flora and fauna which would be present naturally, -Protecting food supplies for fish and wildlife, -Protecting reproductive and nursery areas, and -Protecting wildlife corridors.
Evaluation Guideline:	BPTCP reference envelope approach used.
Data Used to Assess Water Quality:	Five amphipod toxicity tests with 2 measurements showing significant toxicity. One mussel development test with the measurement showing significant toxicity (Anderson et al., 1998).
Spatial Representation:	Samples were collected concurrently with chemical measurements.
Temporal Representation:	Four different events in 4 different years.
Data Quality Assessment:	BPTCP and DFG QAPP (Stephenson et al., 1994)

Line of Evidence	Remedial Program in Place
Beneficial Use	ES - Estuarine Habitat, RA - Rare & Endangered Species, WE - Wetland Habitat, WI - Wildlife Habitat
Information Used to Assess Water Quality:	The Consolidated Toxic Hot Spots Cleanup Plan describes how the RWQCB will work with the McGrath State Beach Area Trustee Council to address cleanup of this site. While the planning has progressed, no remediation of the site has occurred. No responsible parties have been identified.

Water Segment: McGrath Lake

Pollutant: Sediment Bioassays for Estuarine and Marine Water

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 4.6 of the Listing Policy. Under section 4.1 a single line of evidence is necessary to assess delisting status. One line of evidence is available in the administrative record to assess this pollutant.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification against removing this water segment-pollutant combination from the section 303(d) list.

This conclusion is based on the staff findings that:
1.The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2.The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3. Two of five samples originally exhibited toxicity but the number of samples is insufficient to determine with the confidence and power required by the Listing Policy.
4. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because it cannot be determined if applicable water quality standards are attained.

Lines of Evidence:

Numeric Line of Evidence Toxicity

Beneficial Use: ES - Estuarine Habitat, RA - Rare & Endangered Species, WE - Wetland Habitat, WI - Wildlife Habitat

Matrix: Sediment

Water Quality Objective/ Water Quality Criterion: Basin Plan: Existing habitats and associated populations of wetlands fauna and flora shall be maintained by:

-Maintaining substrate characteristics necessary to support flora and fauna which would be present naturally,
-Protecting food supplies for fish and wildlife,
-Protecting reproductive and nursery areas, and
-Protecting wildlife corridors.

Evaluation Guideline: BPTCP reference envelope approach used.

Data Used to Assess Water Quality: Five amphipod toxicity tests with 2 measurements showing significant toxicity. One mussel development test with the measurement showing significant toxicity

	(Anderson et al., 1998).
Spatial Representation:	Samples were collected concurrently with chemical measurements.
Temporal Representation:	Four different events in 4 different years.
Data Quality Assessment:	BPTCP and DFG QAPP (Stephenson et al., 1994)

Water Segment:	Mint Canyon Creek Reach 1 (Confl to Rowler Cyn)
Pollutant:	Nitrate and Nitrite
Decision:	Do Not Delist
Weight of Evidence:	This pollutant is being considered for listing under section 2.2 of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status. One line of evidence is available in the administrative record to assess this pollutant. Based on the applicable factor, a TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard. This water segment-pollutant combination was moved off the section 303(d) list during the 2002 listing cycle. Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.
SWRCB Staff Recommendation:	After review of the available data and information for this recommendation, SWRCB staff conclude that the water body should be placed in the Water Quality Limited Segments Being Addressed category of the section 303(d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.
Lines of Evidence:	

Line of Evidence	Remedial Program in Place
Beneficial Use	MU - Municipal & Domestic
Information Used to Assess Water Quality:	A TMDL and implementation plan has been approved for this water segment-pollutant combination. The Santa Clara River Nitrogen TMDL was approved by RWQCB on August 7, 2003 and subsequently approved by USEPA on March 18, 2004.

Water Segment: Palo Verde Shoreline Park Beach

Pollutant: Pathogens

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for listing under section 2.2 of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status.

One line of evidence is available in the administrative record to assess this pollutant. Based on the applicable factor, a TMDL has been developed by RWQCB but it has not been approved by USEPA.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.

SWRCB Staff Recommendation: After review of the available data and information for this recommendation, SWRCB staff conclude that the water body should be placed in the Water Quality Limited Segments Being Addressed category of the section 303(d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.

Lines of Evidence:

Line of Evidence Remedial Program in Place

Beneficial Use R1 - Water Contact Recreation

Information Used to Assess Water Quality: A TMDL and implementation plan has been approved for this water segment-pollutant combination. The Santa Monica Bay Bacteria Dry Weather TMDL was approved by RWQCB on January 24, 2002 and subsequently approved by USEPA. The Santa Monica Bay Bacteria Wet Weather TMDL was approved by RWQCB on December 12, 2004 and approved by USEPA on June 19, 2003.

Water Segment: Paradise Cove Beach

Pollutant: Fecal Coliform

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for listing under section 2.2 of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status.

Two lines of evidence are available in the administrative record to assess this pollutant. Based on the applicable factor, a TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard. The beach closure information is backed by coliform data. Beach closure information should not be placed on the section 303(d) list because it is not a pollutant or toxicity (section 2 of the Listing Policy).

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.

SWRCB Staff Recommendation: After review of the available data and information for this recommendation, SWRCB staff conclude that the water body and pollutant (coliform) should be placed in the Water Quality Limited Segments Being Addressed category of the section 303(d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.

Lines of Evidence:

Line of Evidence Remedial Program in Place

Beneficial Use R1 - Water Contact Recreation

Information Used to Assess Water Quality: A TMDL and implementation plan has been approved for this water segment-pollutant combination. The Santa Monica Bay Bacteria Dry Weather TMDL was approved by RWQCB on January 24, 2002 and subsequently approved by USEPA. The Santa Monica Bay Bacteria Wet Weather TMDL was approved by RWQCB on December 12, 2004 and approved by USEPA on June 19, 2003.

Region 4

Water Segment: Peninsula Beach

Pollutant: Bacteria Indicators

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for listing under section 2.2 of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status.

Two lines of evidence are available in the administrative record to assess this pollutant. Based on the applicable factor, a TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard. Data is the record shows that this site does not meet water quality standards.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3. Nineteen of 102 samples exceeded the bacteria water quality standards and this exceeds the allowable frequency listed in Table 4.2 of the Listing Policy.
4. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information for this recommendation, SWRCB staff conclude that the water body should be placed in the Water Quality Limited Segments Being Addressed category of the section 303(d) list because a TMDL has been approved by USEPA an implementation plan has been approved, and standards are not met.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Water

Beneficial Use: R1 - Water Contact Recreation

Matrix: Water

Water Quality Objective/ Water Quality Criterion: 17 CCR 7958 (in part): The minimum protective bacteriological standards for waters adjacent to public beaches and public water-contact sports areas shall be as follows:
(1) Based on a single sample, the density of bacteria in water from each sampling station at a public beach or public water contact sports area shall not exceed:

(A) 1,000 total coliform bacteria per 100 milliliters, if the ratio of fecal/total coliform bacteria exceeds 0.1; or
(B) 10,000 total coliform bacteria per 100 milliliters; or
(C) 400 fecal coliform bacteria per 100 milliliters; or.
(D) 104 enterococcus bacteria per 100 milliliters.

Data Used to Assess Water Quality:	One hundred two samples, 19 samples exceeding.
Spatial Representation:	1 station: VC(23000). This station represents the beach 50 yards on either side of the sampling point. Samples were collected in the beach area within two rock jetties.
Temporal Representation:	Data collected in 1999, 2000, and 2001.
Data Quality Assessment:	County Health Department.

Line of Evidence	Remedial Program in Place
Beneficial Use	R1 - Water Contact Recreation
Information Used to Assess Water Quality:	A TMDL and implementation plan has been approved for this water segment-pollutant combination. The Santa Monica Bay Bacteria Dry Weather TMDL was approved by RWQCB on January 24, 2002 and subsequently approved by USEPA. The Santa Monica Bay Bacteria Wet Weather TMDL was approved by RWQCB on December 12, 2004 and approved by USEPA on June 19, 2003.

Region 4

Water Segment: Pico Kenter Drain

Pollutant: Coliform Bacteria

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for listing under section 2.2 of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status.

Two lines of evidence are available in the administrative record to assess this pollutant. Based on the applicable factor, a TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard. This water segment-pollutant combination was moved off the section 303(d) list during the 2002 listing cycle.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.

SWRCB Staff Recommendation: After review of the available data and information for this recommendation, SWRCB staff conclude that the water body should be placed in the Water Quality Limited Segments Being Addressed category of the section 303(d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.

Lines of Evidence:

Line of Evidence Remedial Program in Place

Beneficial Use R1 - Water Contact Recreation

Information Used to Assess Water Quality: A TMDL and implementation plan has been approved for this water segment-pollutant combination. The Santa Monica Bay Bacteria Dry Weather TMDL was approved by RWQCB on January 24, 2002 and subsequently approved by USEPA. The Santa Monica Bay Bacteria Wet Weather TMDL was approved by RWQCB on December 12, 2004 and approved by USEPA on June 19, 2003.

Water Segment: Piru Creek (from gaging station below Santa Felicia Dam to headwaters)

Pollutant: pH

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 4.2 of the Listing Policy. Under section 4.2 a single line of evidence is necessary to assess listing status.

One line of evidence is available in the administrative record to assess this pollutant. Four of 24 samples exceeded the pH water quality objective.

Based on the readily available data and information, the weight of evidence indicates that there is insufficient justification in favor of removing this water segment-pollutant combination from the section 303(d) list.

This conclusion is based on the staff findings that:
1.The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2.The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3.Four of 24 samples exceeded the pH water quality objective. At least 26 samples are needed before a pollutant can be considered for removal from the list using the frequencies presented in Table 4.2 of the Listing Policy.
4.Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because it cannot be determined if applicable water quality standards are attained.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Water

Beneficial Use: CO - Cold Freshwater Habitat, RA - Rare & Endangered Species, SP - Fish Spawning, WA - Warm Freshwater Habitat, WE - Wetland Habitat, WI - Wildlife Habitat

Matrix: Water

Water Quality Objective/ Water Quality Criterion: Basin Plan: The pH of inland surface waters shall not be depressed below 6.5 or raised above 8.5 as a result of waste discharges. Ambient pH levels shall not be changed more than 0.5 units from natural conditions as a result of waste discharge.

Data Used to Assess Water Quality: Twenty-four water samples, 4 samples exceeding (SWRCB, 2003).

Spatial Representation: Samples representative of the Reach.

Temporal Representation: Quarterly sampling events.

Environmental Conditions: Data 2-5 years old, samples collected at site.

Data Quality Assessment: United Water Conservation District.

Water Segment: Pole Creek (trib to Santa Clara River Reach 3)

Pollutant: Sulfates

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 4.1 of the Listing Policy. Under section 4.1 a single line of evidence is necessary to assess listing status.

One line of evidence is available in the administrative record to assess this pollutant. This line of evidence was probably used to place this water body pollutant combination on the 303(d) list originally. Eleven of the samples exceeded the sulfate water quality objective in this line of evidence but the number of samples is insufficient to make a delisting determination with the confidence and power required by the Listing Policy.

Based on the readily available data and information, the weight of evidence indicates that there is insufficient justification in favor of removing this water segment-pollutant combination from the section 303(d) list.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3. Eleven of 12 samples exceeded the sulfate water quality objective but the number of samples is insufficient to determine with the confidence and power required by the Listing Policy.
4. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because it cannot be determined if applicable water quality standards are attained.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Water

Beneficial Use: AG - Agricultural Supply

Matrix: Water

Water Quality Objective/ Water Quality Criterion: Basin Plan: 650 mg/L.

Data Used to Assess Water Quality: Twelve water samples, 11 samples exceeding (SWRCB, 2003).

Spatial Representation: Along creek.

Temporal Representation: Less than quarterly sampling.

Environmental Conditions:	Data 2-5 years old, samples collected at site.
Data Quality Assessment:	United Water Conservation District.

Water Segment: Pole Creek (trib to Santa Clara River Reach 3)

Pollutant: Total Dissolved Solids

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 4.2 of the Listing Policy. Under section 4.2 a single line of evidence is necessary to assess listing status.

One line of evidence is available in the administrative record to assess this pollutant. This line of evidence was probably used to place this water body pollutant combination on the 303(d) list originally. Eleven of the samples exceeded the TDS water quality objective in this line of evidence but the number of samples is insufficient to make a delisting determination with the confidence and power required by the Listing Policy.

Based on the readily available data and information, the weight of evidence indicates that there is insufficient justification in favor of removing this water segment-pollutant combination from the section 303(d) list.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3. Eleven of 12 samples exceeded the sulfate water quality objective but the number of samples is insufficient to determine with the confidence and power required by the Listing Policy.
4. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because it cannot be determined if applicable water quality standards are attained.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Water

Beneficial Use: AG - Agricultural Supply

Matrix: Water

Water Quality Objective/ Water Quality Criterion: Basin Plan: 1,300 mg/L.

Data Used to Assess Water Quality:	Twelve water samples, 11 samples exceeding (SWRCB, 2003).
Spatial Representation:	Along creek.
Temporal Representation:	Less than quarterly sampling.
Data Quality Assessment:	United Water Conservation District.

Water Segment: Promenade Park Beach

Pollutant: Bacteria Indicators

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for listing under section 2.2 of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status.

Two lines of evidence are available in the administrative record to assess this pollutant. Based on the applicable factor, a TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard. This water segment-pollutant combination was moved off the section 303(d) list during the 2002 listing cycle. Data also indicate that water quality standards are not met.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3. Eleven of 97 samples exceeded the water quality standard and this exceeds the allowable frequency listed in Table 4.2 of the Listing Policy.
4. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are not met.

SWRCB Staff Recommendation: After review of the available data and information for this recommendation, SWRCB staff conclude that the water body should be placed in the Water Quality Limited Segments Being Addressed category of the section 303(d) list because a TMDL has been approved by USEPA, an implementation plan has been approved, and water quality standards are not met.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Water

Beneficial Use: R1 - Water Contact Recreation

Matrix: Water

Water Quality Objective/ Water Quality Criterion: 17 CCR 7958 (in part): The minimum protective bacteriological standards for waters adjacent to public beaches and public water-contact sports areas shall be as follows:
(1) Based on a single sample, the density of bacteria in water from each sampling station at a public beach or public water contact sports area shall not

exceed:
(A) 1,000 total coliform bacteria per 100 milliliters, if the ratio of fecal/total coliform bacteria exceeds 0.1; or
(B) 10,000 total coliform bacteria per 100 milliliters; or
(C) 400 fecal coliform bacteria per 100 milliliters; or
(D) 104 enterococcus bacteria per 100 milliliters.

Data Used to Assess Water Quality: 97 samples, 11 sample exceeding (SWRCB, 2003).

Spatial Representation: 1 station: VC(14000). This station represents the beach 50 yards on either side of the sampling point. Data collected at Figueroa Street.

Temporal Representation: Data collected in 1999, 2000, and 2001.

Data Quality Assessment: County Health Department.

Numeric Line of Evidence Pollutant-Water

Beneficial Use: R1 - Water Contact Recreation

Matrix: Water

Water Quality Objective/ Water Quality Criterion: 17 CCR 7958 (in part): The minimum protective bacteriological standards for waters adjacent to public beaches and public water-contact sports areas shall be as follows:
(1) Based on a single sample, the density of bacteria in water from each sampling station at a public beach or public water contact sports area shall not exceed:
(A) 1,000 total coliform bacteria per 100 milliliters, if the ratio of fecal/total coliform bacteria exceeds 0.1; or
(B) 10,000 total coliform bacteria per 100 milliliters; or
(C) 400 fecal coliform bacteria per 100 milliliters; or
(D) 104 enterococcus bacteria per 100 milliliters.

Data Used to Assess Water Quality: 94 samples, 14 samples exceeding (SWRCB, 2003).

Spatial Representation: 1 station: VC(15000). This station represents the beach 50 yards on either side of the sampling point. Data collected at Redwood Apartments.

Temporal Representation: Data collected in 1999, 2000, and 2001.

Data Quality Assessment: County Health Department.

Numeric Line of Evidence Pollutant-Water

Beneficial Use: R1 - Water Contact Recreation

Matrix: Water

Water Quality Objective/ Water Quality Criterion: 17 CCR 7958 (in part): The minimum protective bacteriological standards for waters adjacent to public beaches and public water-contact sports areas shall be as follows:
(1) Based on a single sample, the density of bacteria in water from each sampling station at a public beach or public water contact sports area shall not exceed:
(A) 1,000 total coliform bacteria per 100 milliliters, if the ratio of fecal/total

	coliform bacteria exceeds 0.1; or (B) 10,000 total coliform bacteria per 100 milliliters; or (C) 400 fecal coliform bacteria per 100 milliliters; or (D) 104 enterococcus bacteria per 100 milliliters.
Data Used to Assess Water Quality:	99 samples, 14 samples exceeding (SWRCB, 2003).
Spatial Representation:	1 station: VC(16000). This station represents the beach 50 yards on either side of the sampling point. Data collected at Oak Street.
Temporal Representation:	Data collected in 1999, 2000, and 2001.
Data Quality Assessment:	County Health Department.
QA/QC Equivalent:	County Health Department.

Numeric Line of Evidence	Pollutant-Water
Beneficial Use:	R1 - Water Contact Recreation
Matrix:	Water
Water Quality Objective/ Water Quality Criterion:	17 CCR 7958 (in part): The minimum protective bacteriological standards for waters adjacent to public beaches and public water-contact sports areas shall be as follows: (1) Based on a single sample, the density of bacteria in water from each sampling station at a public beach or public water contact sports area shall not exceed: (A) 1,000 total coliform bacteria per 100 milliliters, if the ratio of fecal/total coliform bacteria exceeds 0.1; or (B) 10,000 total coliform bacteria per 100 milliliters; or (C) 400 fecal coliform bacteria per 100 milliliters; or (D) 104 enterococcus bacteria per 100 milliliters.
Data Used to Assess Water Quality:	105 samples, 19 samples exceeding (SWRCB, 2003).
Spatial Representation:	1 station: VC(17000). This station represents the beach 50 yards on either side of the sampling point. Data collect Holiday Inn (south of drain at California Street).
Temporal Representation:	Data collected in 1999, 2000, and 2001.
Data Quality Assessment:	County Health Department.

Line of Evidence	Remedial Program in Place
Beneficial Use	R1 - Water Contact Recreation
Information Used to Assess Water Quality:	A TMDL and implementation plan has been approved for this water segment-pollutant combination. The Santa Monica Bay Bacteria Dry Weather TMDL was approved by RWQCB on January 24, 2002 and subsequently approved by USEPA. The Santa Monica Bay Bacteria Wet Weather TMDL was approved by RWQCB on December 12, 2004 and approved by USEPA on June 19, 2003.

Water Segment: Puddingstone Reservoir

Pollutant: Mercury

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 3.5 of the Listing Policy. One line of evidence is available in the administrative record to assess this pollutant.

Based on the readily available data and information, the weight of evidence indicates that there is insufficient justification in favor of removing this water segment-pollutant combination from the section 303(d) list in the Water Quality Limited Segments category.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3. Two of the 2 samples exceeded the OEHHA Screening Value but the number of samples is insufficient to determine with the confidence and power required by the Listing Policy.
4. Pursuant to section 3.11 of the Listing Policy, no additional data and information are available indicating that standards are not met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because it cannot be determined if applicable water quality standards are attained.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Tissue

Beneficial Use: CM - Commercial and Sport Fishing (CA)

Matrix: Tissue

Water Quality Objective/ Water Quality Criterion: Los Angeles RWQCB Basin Plan: Toxic pollutants shall not be present at levels that will bioaccumulate in aquatic life to levels which are harmful to aquatic life or human health.

Evaluation Guideline: 0.3 ug/g (OEHHA Screening Value)

Data Used to Assess Water Quality: Two out of 2 samples exceeded. Two filet composite samples of largemouth bass were collected in 1992 and 1999. Both samples exceeded the guideline (TSMP, 2002).

Spatial Representation: One station located from the middle cove on the west shore and from the inlet cove on the northeast shore.

Temporal Representation: Samples were collected in 1992 and 1999.

Data Quality Assessment: Toxic Substances Monitoring Program 1992-93 Data Report. Environmental Chemistry Quality Assurance and Data Report for the Toxic Substances Monitoring Program,1996-2000. Department of Fish and Game

Water Segment: Redondo Beach

Pollutant: Coliform Bacteria

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for listing under section 2.2 of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status.

Two lines of evidence are available in the administrative record to assess this pollutant. Based on the applicable factor, a TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard. The beach closure information is backed by coliform data. Beach closure information should not be placed on the section 303(d) list because it is not a pollutant or toxicity (section 2 of the Listing Policy).

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.

SWRCB Staff Recommendation: After review of the available data and information for this recommendation, SWRCB staff conclude that the water body and pollutant (coliform) should be placed in the Water Quality Limited Segments Being Addressed category of the section 303(d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.

Lines of Evidence:

Line of Evidence Remedial Program in Place

Beneficial Use R1 - Water Contact Recreation

Information Used to Assess Water Quality: A TMDL and implementation plan has been approved for this water segment-pollutant combination. The Santa Monica Bay Bacteria Dry Weather TMDL was approved by RWQCB on January 24, 2002 and subsequently approved by USEPA. The Santa Monica Bay Bacteria Wet Weather TMDL was approved by RWQCB on December 12, 2004 and approved by USEPA on June 19, 2003.

Water Segment: Rincon Beach

Pollutant: Bacteria Indicators

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for listing under section 2.2 of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status.

Two lines of evidence are available in the administrative record to assess this pollutant. Based on the applicable factor, a TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard. Water quality indicate that the bacteria water quality standard is not met.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3. Twenty-six of 107 samples exceeded the bacteria water quality standards and this exceeds the allowable frequency listed in Table 4.2 of the Listing Policy.
4. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are not met.

SWRCB Staff Recommendation: After review of the available data and information for this recommendation, SWRCB staff conclude that the water body should be placed in the Water Quality Limited Segments Being Addressed category of the section 303(d) list because a TMDL has been approved by USEPA, an implementation plan has been approved, and water quality standards are not attained.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Water

Beneficial Use: R1 - Water Contact Recreation

Matrix: Water

Water Quality Objective/ Water Quality Criterion: 17 CCR 7958 (in part): The minimum protective bacteriological standards for waters adjacent to public beaches and public water-contact sports areas shall be as follows:
(1) Based on a single sample, the density of bacteria in water from each sampling station at a public beach or public water contact sports area shall not exceed:
(A) 1,000 total coliform bacteria per 100 milliliters, if the ratio of fecal/total

	coliform bacteria exceeds 0.1; or (B) 10,000 total coliform bacteria per 100 milliliters; or (C) 400 fecal coliform bacteria per 100 milliliters; or (D) 104 enterococcus bacteria per 100 milliliters.
Data Used to Assess Water Quality:	107 samples, 26 samples exceeding (SWRCB, 2003).
Spatial Representation:	1 station: VC(1000). This station represents the beach 50 yards on either side of the sampling point. Sample were collected 50 yards from the mouth of the creek.
Temporal Representation:	Data collected in 1999, 2000, and 2001.
Data Quality Assessment:	County Health Department.

Numeric Line of Evidence	Pollutant-Water
Beneficial Use:	R1 - Water Contact Recreation
Matrix:	Water
Water Quality Objective/ Water Quality Criterion:	17 CCR 7958 (in part): The minimum protective bacteriological standards for waters adjacent to public beaches and public water-contact sports areas shall be as follows: (1) Based on a single sample, the density of bacteria in water from each sampling station at a public beach or public water contact sports area shall not exceed: (A) 1,000 total coliform bacteria per 100 milliliters, if the ratio of fecal/total coliform bacteria exceeds 0.1; or (B) 10,000 total coliform bacteria per 100 milliliters; or (C) 400 fecal coliform bacteria per 100 milliliters; or (D) 104 enterococcus bacteria per 100 milliliters.
Data Used to Assess Water Quality:	Data used to assess water quality 101 samples, 15 samples exceeding (SWRCB, 2003).
Spatial Representation:	1 station: VC(1100). This station represents the beach 50 yards on either side of the sampling point. Samples collected at the end of the footpath.
Temporal Representation:	Data collected in 1999, 2000, and 2001.
Data Quality Assessment:	County Health Department.

Numeric Line of Evidence	Pollutant-Water
Beneficial Use:	R1 - Water Contact Recreation
Matrix:	Water
Water Quality Objective/ Water Quality Criterion:	17 CCR 7958 (in part): The minimum protective bacteriological standards for waters adjacent to public beaches and public water-contact sports areas shall be as follows: (1) Based on a single sample, the density of bacteria in water from each sampling station at a public beach or public water contact sports area shall not exceed: (A) 1,000 total coliform bacteria per 100 milliliters, if the ratio of fecal/total coliform bacteria exceeds 0.1; or

(B) 10,000 total coliform bacteria per 100 milliliters; or
(C) 400 fecal coliform bacteria per 100 milliliters; or
(D) 104 enterococcus bacteria per 100 milliliters.

Data Used to Assess Water Quality:	104 samples, 23 samples exceeding (SWRCB, 2003).
Spatial Representation:	1 station: VC(1050). This station represents the beach 50 yards on either side of the sampling point. Sampled collected 150 yards south of the creek's mouth.
Temporal Representation:	Data collected in 1999, 2000, and 2001.
Data Quality Assessment:	County Health Department.

Line of Evidence	Remedial Program in Place
Beneficial Use	R1 - Water Contact Recreation
Information Used to Assess Water Quality:	A TMDL and implementation plan has been approved for this water segment-pollutant combination. The Santa Monica Bay Bacteria Dry Weather TMDL was approved by RWQCB on January 24, 2002 and subsequently approved by USEPA. The Santa Monica Bay Bacteria Wet Weather TMDL was approved by RWQCB on December 12, 2004 and approved by USEPA on June 19, 2003.

Water Segment: Rio De Santa Clara/Oxnard Drain No. 3

Pollutant: Chlordane

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 3.5 of the Listing Policy. One line of evidence is available in the administrative record to assess this pollutant.

Based on the readily available data and information, the weight of evidence indicates that there is insufficient justification in favor of removing this water segment-pollutant combination from the section 303(d) list in the Water Quality Limited Segments category.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3. Two of the 2 samples exceeded the OEHHA Screening Value but the number of samples is insufficient to determine with the confidence and power required by the Listing Policy.
4. Pursuant to section 3.11 of the Listing Policy, no additional data and information are available indicating that standards are not met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because it cannot be determined if applicable water quality standards are attained.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Tissue

Beneficial Use: CM - Commercial and Sport Fishing (CA)

Matrix: Tissue

Water Quality Objective/ Water Quality Criterion: Los Angeles RWQCB Basin Plan: Toxic pollutants shall not be present at levels that will bioaccumulate in aquatic life to levels which are harmful to aquatic life or human health.

Evaluation Guideline: 100 ng/g NAS Guideline (whole fish)

Data Used to Assess Water Quality: Two out of 2 samples exceeded. A total of 2 whole fish composite samples of mosquitofish were collected. Both samples were collected in 1997 (TSMP, 2002).

Spatial Representation: One station near Oxnard Drain located downstream of the bridge at Arnold Road.

Temporal Representation: The samples were collected only in 1997.

Region 4

Water Segment: Rio De Santa Clara/Oxnard Drain No. 3

Pollutant: DDT

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 3.5 of the Listing Policy. One line of evidence is available in the administrative record to assess this pollutant.

Based on the readily available data and information, the weight of evidence indicates that there is insufficient justification in favor of removing this water segment-pollutant combination from the section 303(d) list in the Water Quality Limited Segments category.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3. Two of the 2 samples exceeded the OEHHA Screening Value but the number of samples is insufficient to determine with the confidence and power required by the Listing Policy.
4. Pursuant to section 3.11 of the Listing Policy, no additional data and information are available indicating that standards are not met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because it cannot be determined if applicable water quality standards are attained.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Tissue

Beneficial Use: CM - Commercial and Sport Fishing (CA)

Matrix: Tissue

Water Quality Objective/ Water Quality Criterion: Los Angeles RWQCB Basin Plan: Toxic pollutants shall not be present at levels that will bioaccumulate in aquatic life to levels which are harmful to aquatic life or human health.

Evaluation Guideline: 1000 ng/g NAS Guideline (whole fish)

Data Used to Assess Water Quality: Two out of 2 samples exceeded. A total of 2 whole fish composite samples of mosquitofish were collected. Mosquitofish samples were collected in 1997. The guideline was exceeded in both mosquitofish samples (TSMP, 2002).

Spatial Representation: One station near Oxnard Drain located downstream of the bridge at Arnold Road.

Temporal Representation: Samples were collected in 1997.

Water Segment: Rio De Santa Clara/Oxnard Drain No. 3

Pollutant: Toxaphene

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 3.5 of the Listing Policy. One line of evidence is available in the administrative record to assess this pollutant.

Based on the readily available data and information, the weight of evidence indicates that there is insufficient justification in favor of removing this water segment-pollutant combination from the section 303(d) list in the Water Quality Limited Segments category.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3. Two of the 2 samples exceeded the OEHHA Screening Value but the number of samples is insufficient to determine with the confidence and power required by the Listing Policy.
4. Pursuant to section 3.11 of the Listing Policy, no additional data and information are available indicating that standards are not met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because it cannot be determined if applicable water quality standards are attained.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Tissue

Beneficial Use: CM - Commercial and Sport Fishing (CA)

Matrix: Tissue

Water Quality Objective/ Water Quality Criterion: Los Angeles RWQCB Basin Plan: Toxic pollutants shall not be present at levels that will bioaccumulate in aquatic life to levels which are harmful to aquatic life or human health.

Evaluation Guideline: 100 ng/g NAS Guideline (whole fish)

Data Used to Assess Water Quality: Two out of 2 samples exceeded. A total of 2 whole fish composite samples of mosquitofish were collected. Mosquitofish samples were collected in 1997. The guideline was exceeded in both mosquitofish samples (TSMP, 2002).

Spatial Representation: One station near Oxnard Drain located downstream of the bridge at Arnold Road.

Temporal Representation: Samples were collected in 1997.

Region 4

Water Segment: Rio Hondo Reach 1 (Confl. LA River to Snt Ana Fwy)

Pollutant: Ammonia

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for listing under section 2.2 of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status.

One line of evidence is available in the administrative record to assess this pollutant. Based on the applicable factor, a TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.

SWRCB Staff Recommendation: After review of the available data and information for this recommendation, SWRCB staff conclude that the water body should be placed in the Water Quality Limited Segments Being Addressed category of the section 303(d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.

Lines of Evidence:

Line of Evidence Remedial Program in Place

Beneficial Use CO - Cold Freshwater Habitat, RA - Rare & Endangered Species, SP - Fish Spawning, WA - Warm Freshwater Habitat, WE - Wetland Habitat, WI - Wildlife Habitat

Information Used to Assess Water Quality: An alternative enforceable program is in place that will address ammonia water quality standards exceedances for this reach (SWRCB, 2003).

In June 1995, the seven water reclamation plants discharging in the San Gabriel River and Santa Clara River watersheds received NPDES permits containing requirements regarding compliance with the Basin Plan water quality objectives for ammonia. In accordance with these permits, the Los Angeles County Sanitation Districts have been pursuing the addition of nitrification and denitrification facilities at each of these plants to comply with the ammonia objectives. By June 2003, it is expected that these new facilities will be operational and ammonia will be drastically reduced. Research facility operation shows that the monthly average ammonia concentration will fully comply with the chronic ammonia objective. Objective is
expected to be applicable in June 2003. It is probable that the majority of ammonia discharged to this water body was contributed by POTWs. Information

in the record indicates that the majority (over 95%) of the ammonia in the Los Angeles River was contributed by POTWs. Also, it is probable that the contribution in the San Gabriel River watershed is dominated by contributions from POTWs as well. Generally, concentrations of ammonia upstream of the treatment
plants are much lower than downstream concentrations (up to an order of magnitude difference).

Region 4

Water Segment: Rio Hondo Reach 1 (Confl. LA River to Snt Ana Fwy)

Pollutant: pH

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for listing under section 2.2 of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status.

One line of evidence is available in the administrative record to assess this pollutant. Based on the applicable factor, a TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.

SWRCB Staff Recommendation: After review of the available data and information for this recommendation, SWRCB staff conclude that the water body should be placed in the Water Quality Limited Segments Being Addressed category of the section 303(d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.

Lines of Evidence:

Line of Evidence Remedial Program in Place

Beneficial Use R2 - Non-Contact Recreation

Information Used to Assess Water Quality: A TMDL and implementation plan has been approved for this water segment-pollutant combination. The Los Angeles River Nitrogen TMDL was approved by RWQCB on August 19, 2003 and subsequently approved by USEPA on March 18, 2004.

Water Segment: San Antonio Creek (Tributary to Ventura River Reach 4)

Pollutant: Nitrogen

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 4.1 of the Listing Policy. Under section 4.1 a single line of evidence is necessary to assess listing status.

One line of evidence is available in the administrative record to assess this pollutant. This line of evidence was used to place this water body pollutant combination on the 303(d) list originally. Four of the samples exceeded the nitrogen site specific water quality objective in this line of evidence but the number of samples is insufficient to make a delisting determination with the confidence and power required by the Listing Policy.

Based on the readily available data and information, the weight of evidence indicates that there is insufficient justification in favor of removing this water segment-pollutant combination from the section 303(d) list.

This conclusion is based on the staff findings that:
1.The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
1.The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3.Four of 23 samples exceeded the nitrogen site specific water quality objective, but the number of samples is insufficient to determine with the confidence and power required by the Listing Policy.
4.Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be placed on the section 303(d) list because it cannot be determined if applicable water quality standards are exceeded.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Water

Beneficial Use: CO - Cold Freshwater Habitat, SP - Fish Spawning, WA - Warm Freshwater Habitat, WI - Wildlife Habitat

Matrix: Water

Water Quality Objective/ Water Quality Criterion: Basin Plan: 5 mg/L (as NO3-N and NO2-N). Table 3-8 of the Basin Plan.

Data Used to Assess Water Quality: Twenty-three water samples, 4 samples exceeding (SWRCB, 2003).

Spatial Representation: Two sample sites.

Temporal Representation:	Winter 1998 - Summer 2000.
Data Quality Assessment:	Ojai Valley Wastewater Treatment Plant.

Water Segment: San Gabriel River Reach 2 (Firestone to Whittier Narrows Dam

Pollutant: Copper

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 4.1 of the Listing Policy. Under section 4.1 a single line of evidence is necessary to assess delisting status.

Two lines of evidence are available in the administrative record to assess this pollutant. The combined lines of evidence result in a total of 11 samples exceeding the CTR criteria continuous concentration.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification against removing this water segment-pollutant combination from the section 303(d) list.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3. Eleven of 88 samples exceeded the CTR criteria and this exceeds the allowable frequency listed in Table 4.1 of the Listing Policy.
4.Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from on the section 303(d) list because applicable water quality standards are exceeded and a pollutant contributes to or causes the problem.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Water

Beneficial Use: RA - Rare & Endangered Species, WA - Warm Freshwater Habitat, WE - Wetland Habitat, WI - Wildlife Habitat

Matrix: Water

Water Quality Objective/ Water Quality Criterion: California Toxics Rule: The Criteria Continuous Concentration for dissolved copper is dependent on the water hardness. After considering the event specific hardness values, the range of acceptable concentrations is 0.17 ug/L to 28 ug/L.

Data Used to Assess Water Quality: Twenty-six water samples, 7 samples exceeding (LACDPW, 2004c).

Spatial Representation: One site (S 14).

Temporal Representation: Fall, winter, spring (1997-2000).

Data Quality Assessment:	Stormwater Monitoring Program

Numeric Line of Evidence	Pollutant-Water
Beneficial Use:	RA - Rare & Endangered Species, WA - Warm Freshwater Habitat, WE - Wetland Habitat, WI - Wildlife Habitat
Matrix:	Water
Water Quality Objective/ Water Quality Criterion:	CTR Dissolved Copper Criterion for continuous concentration (CCC) in water for the protection of aquatic life is expressed as a function of the total harness of the water body. The aquatic life criteria will vary depending of total hardness reported at the sampling site. The CCC for dissolved copper is the highest concentration to which aquatic life can be exposed for an extended period of time (four days) without deleterious effects. This criterion is linked and applicable for the protection of aquatic life Beneficial Uses.
Data Used to Assess Water Quality:	Numeric data generated from 62 samples taken from 10/14/97 to 1/13/04 at one to two-week sampling interval. Four samples exceeded the dissolved Copper Continuous Criterion Concentration, which equals the highest concentration of a pollutant to which aquatic life can be exposed for an extended period of time (4days) without deleterious effects (LACDPW, 2004c).
Spatial Representation:	One (1) sampling station sampled from 10/14/97 to 1/13/04.
Temporal Representation:	Sixty-two samples taken during the wet and dry season from 10/14/97 to 1/13/04 at approximately one to two week intervals.
Environmental Conditions:	Results are from samples taken from 1997 to 2004. The dissolved copper criterion was exceeded in 4 out of 62 measurements. The 4 exceedances occurred during the El Niño rain season in the winter of 1997 - 1998.
Data Quality Assessment:	Evaluation of Analytes and QA/QC Specifications for Monitoring Program (Woodward-Clyde, 1996) Los Angeles County Department of Public Works.

Region 4

Water Segment: San Gabriel River Reach 2 (Firestone to Whittier Narrows Dam

Pollutant: Fecal Coliform

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 4.2 of the Listing Policy. Under section 4.2 a single line of evidence is necessary to assess listing status.

One line of evidence is available in the administrative record to assess this pollutant. Sixteen samples exceeded the fecal coliform water quality objective but the total number of samples taken is insufficient to determine whether the water body pollutant combination can be delisted with the confidence and power required by the Listing Policy.

Based on the readily available data and information, the weight of evidence indicates that there is insufficient justification in favor of removing this water segment-pollutant combination from the section 303(d) list.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3. Sixteen of 16 samples exceeded the fecal coliform water quality objective. At least 26 samples are needed before a pollutant can be considered for removal from the list using the frequencies presented in Table 4.2 of the Listing Policy.
4.Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because it cannot be determined if applicable water quality standards are attained.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Water

Beneficial Use: MU - Municipal & Domestic, R1 - Water Contact Recreation

Matrix: Water

Water Quality Objective/ Water Quality Criterion: "In waters designated for contact recreation (REC-1), the fecal coliform concentration shall not exceed a log mean of 200/100 ml"
From the LA Regional Water Quality Control Board's Basin Plan

Data Used to Assess Water Quality: Sixteen out of 16 samples at this location exceeded the objective for fecal coliform (LACDPW, 2004c).

Summary of Results for the 2000-2001 Routine Monitoring at the San Gabriel River (Table B-5)

Spatial Representation:	The San Gabriel River Monitoring Station is located at an historic stream gage station (Stream Gage No. F263C-R), below San Gabriel River Parkway in Pico Rivera. At this location the upstream tributary area is 450 square miles. The San Gabriel River, at the gauging station, is a grouted rock-concrete stabilizer along the western levee and a natural section on the eastern side. Flow measurement and water sampling are conducted in the grouted rock area along the western levee of the river. The length of the concrete stabilizer is nearly 70 feet. The San Gabriel River sampling location has been an active stream gauging station since 1968.
Temporal Representation:	Samples taken between 10/28/2000 and 4/30/2003
Environmental Conditions:	Samples taken on 10/10/2002 and 4/30/2003 were 'DRY' samples. All others were 'WET'.
Data Quality Assessment:	Detailed QA/QC contained in this report.

Water Segment: San Gabriel River Reach 3 (Whittier Narrows to Ramona)

Pollutant: Toxicity

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for delisting under sections 4.6 of the Listing Policy. Under section 4.6 a single line of evidence is necessary to assess listing status.

Two lines of evidence are available in the administrative record to assess this pollutant. Based on section 4.6. One Sample exceeded the NOEC but the number of samples is insufficient to determine with the confidence and power required by the Listing Policy if standards are met.

Based on the readily available data and information, the weight of evidence indicates that there is insufficient justification in favor of removing this water segment-pollutant combination from the section 303(d) list.

This conclusion is based on the staff findings that:
1.The sediment quality guideline used complies, with the requirements of section 6.1.3 of the Policy.
2.The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
3.The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
4.One of the 15 samples exceeded the NOEC. At least 28 samples are needed before a pollutant can be considered for removal from the list using the frequencies presented in Table 4.1 of the Listing Policy.
5.Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because it cannot be determined if applicable water quality standards are attained.

Lines of Evidence:

Numeric Line of Evidence Toxicity

Beneficial Use: WA - Warm Freshwater Habitat

Matrix: Water

Water Quality Objective/ Water Quality Criterion: Narrative Toxicity Basin Plan WQO is applicable to the protection of aquatic life BUs.

Evaluation Guideline: No observed effect concentration (NOEC) is the highest tested concentration of toxicant to which organisms are exposed in a full life-cycle or partial life-cycle (shot-term) test that causes no observable adverse effect on the test organisms. The guideline is used and recommended to determine the highest concentration of toxicant at which the values of the observed responses are not statistically significantly different from the control.

Data Used to Assess Water Quality:	Numeric data generated from a total of 9 samples from Reach 3 stations R-11 and RA, taken on a quarterly basis from 7/2003 to 6/2004. Significant toxicity was recorded in one sample from the first quarter of 2004 in the chronic bioassay test with P. promelas (fathead minnow).
Spatial Representation:	Two sample sites sampled from 7/2003 through 6/2004 on a quarterly basis. Stations R11 and RA located upstream and down stream in Reach 3 of the San Gabriel River.
Temporal Representation:	Nine samples where taken on a quarterly basis from 7/2003 to 6/2004.
Environmental Conditions:	The submitted toxicity results are from 2003-04. In June 2003, the LA County Sanitation Districts completed conversion of water reclamation plants in the San Gabriel River watershed to nitrification/denitrification (NDN) mode.
Data Quality Assessment:	Evaluation of Analytes and QA/QC Specifications for Monitoring Program (Woodward-Clyde, 1996) Los Angeles County Department of Public Works.

Numeric Line of Evidence	Toxicity
Beneficial Use:	WA - Warm Freshwater Habitat
Matrix:	Water
Water Quality Objective/ Water Quality Criterion:	Narrative Toxicity Basin Plan WQO is applicable to the protection of aquatic life BUs.
Evaluation Guideline:	No observed effect concentration (NOEC) is the highest tested concentration of toxicant to which organisms are exposed in a full life-cycle or partial life-cycle (shot-term) test that causes no observable adverse effect on the test organisms. The guideline is used and recommended to determine the highest concentration of toxicant at which the values of the observed responses are not statistically significantly different from the control.
Data Used to Assess Water Quality:	Numeric toxicity results generated from a total of six samples none of which were found to be toxic. This was a collaborative toxicity study conducted by the U.S. EPA and the Districts in August through October 2003. The study generated a total of 6 samples taken for Reach 3. Two (2) samples were analyzed from the August 2003 sampling, two samples were analyzed from the September 2003 sampling, and 2 samples were analyzed from the October 2003 sampling from receiving water station R-11.
Spatial Representation:	Two sample sites sampled from 7/2003 through 6/2004 at a quarterly basis. Stations R11 in Reach 3 of the San Gabriel River.
Temporal Representation:	Six samples taken during the three (3) sampling events of the collaborative monitoring program from 7/2003 to 6/2004.
Environmental Conditions:	The collaborative study generated a total of 6 samples taken for Reach 3. Two samples were analyzed from the August 2003 sampling, two samples were analyzed from the September 2003 sampling, and 2 samples were analyzed from the October 2003 sampling from receiving water station R-11.
Data Quality Assessment:	Evaluation of Analytes and QA/QC Specifications for Monitoring Program (Woodward-Clyde, 1996) Los Angeles County Department of Public Works.

Water Segment: San Pedro Bay Near/Off Shore Zones

Pollutant: DDT

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 3.5 of the Listing Policy. One line of evidence is available in the administrative record to assess this pollutant.

Based on the readily available data and information, the weight of evidence indicates that there is insufficient justification in favor of removing this water segment-pollutant combination from the section 303(d) list in the Water Quality Limited Segments category..

This conclusion is based on the staff findings that:
1. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3. Three of the 4 samples exceeded the OEHHA Screening Value but the number of samples is insufficient to determine with the confidence and power required by the Listing Policy.
4. Pursuant to section 3.11 of the Listing Policy, no additional data and information are available indicating that standards are not met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because it cannot be determined if applicable water quality standards are attained.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Tissue

Beneficial Use: CM - Commercial and Sport Fishing (CA), IN - Industrial Service Supply

Matrix: Tissue

Water Quality Objective/ Water Quality Criterion: Los Angeles RWQCB Basin Plan: Toxic pollutants shall not be present at levels that will bioaccumulate in aquatic life to levels which are harmful to aquatic life or human health.

Evaluation Guideline: 100 ng/g (OEHHA Screening Value)

Data Used to Assess Water Quality: Three out of 4 samples exceeded. All 4 samples were filet composites representing the following species: queenfish, spotted turbot, and white croaker. All but one white croaker sample exceeded guideline. This white croaker and 99.89 ng/g DDT just below the guideline (TSMP, 2002).

Spatial Representation: One station was sampled: Belmont Pier.

Temporal Representation: Samples were collected in July and October 1999.

Data Quality Assessment:	CFCP 1998 Year I QA Summary Pesticides and PCBs. California Department of Fish and Game. CDFG Fish and Wildlife Water Pollution Control Laboratory Data Quality Assurance Report. 1999 Coastal Fish Contamination Program

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Water Segment: San Pedro Bay Near/Off Shore Zones

Pollutant: Polychlorinated biphenyls

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 3.5 of the Listing Policy. One line of evidence is available in the administrative record to assess this pollutant.

Based on the readily available data and information, the weight of evidence indicates that there is insufficient justification in favor of removing this water segment-pollutant combination from the section 303(d) list in the Water Quality Limited Segments category.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3. Four of the 4 samples exceeded the OEHHA Screening Value but the number of samples is insufficient to determine with the confidence and power required by the Listing Policy.
4. Pursuant to section 3.11 of the Listing Policy, no additional data and information are available indicating that standards are not met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because it cannot be determined if applicable water quality standards are attained.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Tissue

Beneficial Use: CM - Commercial and Sport Fishing (CA), IN - Industrial Service Supply

Matrix: Tissue

Water Quality Objective/ Water Quality Criterion: Los Angeles RWQCB Basin Plan: Toxic pollutants shall not be present at levels that will bioaccumulate in aquatic life to levels which are harmful to aquatic life or human health.

Evaluation Guideline: 20 ng/g (OEHHA Screening Value for Belmont Pier Health Advisory for DDT & PCB)

Data Used to Assess Water Quality: Four out of 4 samples exceeded. All 4 samples were filet composites representing the following species: queenfish, spotted turbot, and white croaker. All samples exceeded guideline.

Spatial Representation: One station was sampled: Belmont Pier.

Temporal Representation: Samples were collected in July and October 1999.

Data Quality Assessment:	CFCP 1998 Year 1 QA Summary Pesticides and PCBs. California Department of Fish and Game. CDFG Fish and Wildlife Water Pollution Control Laboratory Data Quality Assurance Report. 1999 Coastal Fish Contamination Program (CFCP Year 2). California Department of

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Water Segment: Santa Clara River Reach 3 (Freeman Diversion to A Street)

Pollutant: Ammonia

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for listing under section 2.2 of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status.

One line of evidence is available in the administrative record to assess this pollutant. Based on the applicable factor, a TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard. This water segment-pollutant combination was moved off the section 303(d) list during the 2002 listing cycle.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.

SWRCB Staff Recommendation: After review of the available data and information for this recommendation, SWRCB staff conclude that the water body should be placed in the Water Quality Limited Segments Being Addressed category of the section 303(d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.

Lines of Evidence:

Line of Evidence	Remedial Program in Place
Beneficial Use	MU - Municipal & Domestic
Information Used to Assess Water Quality:	A TMDL and implementation plan has been approved for this water segment-pollutant combination. The Santa Clara Rive Nitrogen TMDL was approved by RWQCB on August 7, 2003 and subsequently approved by USEPA on March 18, 2004.

Water Segment: Santa Clara River Reach 3 (Freeman Diversion to A Street)

Pollutant: Total Dissolved Solids

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 4.2 of the Listing Policy. Under section 4.2 a single line of evidence is necessary to assess delisting status.

One line of evidence is available in the administrative record to assess this pollutant. A sufficient number of samples exceed the water quality objective.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification against removing this water segment-pollutant combination from the section 303(d) list.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3. Thirty-eight of 189 samples exceeded the TDS water quality objective and this exceeds the allowable frequency listed in Table 4.2 of the Listing Policy.
4.Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from on the section 303(d) list because applicable water quality standards are exceeded and a pollutant contributes to or causes the problem.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Water

Beneficial Use: AG - Agricultural Supply, GW - Groundwater Recharge

Matrix: Water

Water Quality Objective/ Water Quality Criterion: Basin Plan: 1,300 mg/L.

Data Used to Assess Water Quality: One-hundred and eighty-nine samples, 38 samples exceeding.

Spatial Representation: Samples representative of Reach.

Temporal Representation:	Quarterly sampling events.
Data Quality Assessment:	POTW, United Water Conservation District, Department of Water Resources.

Water Segment: Santa Clara River Reach 5 (Blue Cut gaging station to West Pier Hwy 99 Bridge) (was named Santa Clara River Reach 7 on 2002 303(d) lists)

Pollutant: Nitrate and Nitrite

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for listing under section 2.2 of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status.

Three lines of evidence are available in the administrative record to assess this pollutant. Based on the applicable factor, a TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard. This water segment-pollutant combination was moved off the section 303(d) list during the 2002 listing cycle.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.

SWRCB Staff Recommendation: After review of the available data and information for this recommendation, SWRCB staff conclude that the water body should be placed in the Water Quality Limited Segments Being Addressed category of the section 303(d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Water

Beneficial Use: MU - Municipal & Domestic

Matrix: Water

Water Quality Objective/ Water Quality Criterion: The Basin Plan Site Specific Water Quality Objective for the sum of Nitrate-Nitrogen and Nitrite-Nitrogen of 5 mg/l is linked and applicable for the protection of drinking water supplies.

Data Used to Assess Water Quality: Numeric data generated from a total of 29 samples taken in four sampling stations (seven samples from station RC, seven from station RD, seven from RE and eight from RB-01 from 9/10/03 to 5/12/04 at approximately monthly sampling intervals. Two samples taken in station RD in 9/10/03 and 1/14/04 exceeded the Nitrate and Nitrite 5mg/l Site-specific WQO to protect MUN BUs (LACSD, 2004b).

Spatial Representation: Samples were taken at four samples stations (RC ,RD, RE, and RB01) from 9/10/03 to 5/12/04 at approximately monthly sampling intervals.

Temporal Representation: Twenty-nine samples where taken from 9/10/03 to 5/12/04 at approximately monthly sampling intervals at four sampling stations within Reach 7 of the Santa

	Clara River.
Environmental Conditions:	The Districts' Valencia Water Reclamation Plant, which is located in Reach 7, was partially converted to NDN mode starting May 12, 2003, and was fully converted t o NDN mode on June 18, 2003. The implementation of NDN at these WRP's represents a significant change in water quality nitrogen conditions in Reach 7 o f the Santa Clara River.
Data Quality Assessment:	Quality Assurance Document Of The County Sanitation Districts Of Los Angeles County. July 2003.

Numeric Line of Evidence	Pollutant-Water
Beneficial Use:	MU - Municipal & Domestic
Matrix:	Water
Water Quality Objective/ Water Quality Criterion:	The Basin Plan Site Specific Water Quality Objective for Santa Clara River, Reach 7, shall not exceed the sum of Nitrate-Nitrogen plus Nitrite-Nitrogen concentrations of 5 mg/l for the protection of drinking water supplies. In addition, Los Angeles regional waters shall not exceed concentrations of 10 mg/l as Nitrate- Nitrogen or 1 mg/l as Nitrite-Nitrogen.
Data Used to Assess Water Quality:	Numeric data generated from a total of eight (8) samples taken from 9/10/03 to 4/27/04 at approximately monthly sampling intervals. None of the samples exceeded the site specific WQO for Santa Clara River, Reach 7 for the sum of Nitrate-Nitrogen plus Nitrite-Nitrogen or the WQOs for Nitrate- Nitrogen, or Nitrite-Nitrogen individually (LACSD, 2004b).
Spatial Representation:	One sample site sampled from 9/10/03 to 4/27/04 at approximately monthly sampling intervals.
Temporal Representation:	Eight (8) samples taken at monthly intervals from 9/10/03 to 4/27/04.
Environmental Conditions:	Data age is 1 year to 8 months old obtained from the United Water Conservation District (UWCD) for their receiving water sampling station located near the Los Angeles/ Ventura County Line at the end of Reach 7 of the Santa Clara River.
Data Quality Assessment:	Fruit Growers Laboratory Quality Manual.

Line of Evidence	Remedial Program in Place
Beneficial Use	MU - Municipal & Domestic
Information Used to Assess Water Quality:	A TMDL and implementation plan has been approved for this water segment-pollutant combination. The Santa Clara River Nitrogen TMDL was approved by RWQCB on August 7, 2003 and subsequently approved by USEPA on March 18, 2004.

Water Segment: Santa Monica Bay Offshore/Nearshore

Pollutant: Chlordane

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for delisting under sections 4.6 of the Listing Policy. Under section 4.6 a single line of evidence is necessary to assess listing status.

Two lines of evidence are available in the administrative record to assess this pollutant. Based on section 4.6, the site does have significant sediment toxicity but chlordane is not likely to cause or contribute to any toxic effect. The benthic community is impacted.

Based on the readily available data and information, the weight of evidence indicates that there is insufficient justification in favor of removing this water segment-pollutant combination from the section 303(d) list in the Water Quality Limited Segments category.

This conclusion is based on the staff findings that:
1. The sediment quality guideline used complies, with the requirements of section 6.1.3 of the Policy.
2. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
3. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
4. None of the 23 chlordane samples exceeded the sediment guideline, and five of the 23 samples exhibit toxicity, although toxicity is documented, the pollutant does not exceed the allowable frequency listed in Table 4.1 of the Listing Policy However, at least 28 samples are needed before a pollutant can be considered for removal from the list using the frequencies presented in Table 4.1 of the Listing Policy.
5. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because it cannot be determined if applicable water quality standards are attained.

Lines of Evidence:

Numeric Line of Evidence Population/Community Degradation

Beneficial Use: MA - Marine Habitat

Matrix: Sediment

Water Quality Objective/ Water Quality Criterion: Narrative Toxicity Basin Plan WQO is applicable to the protection of aquatic life BUs.

Evaluation Guideline: Benthic Response Index (BRI) is a guidance developed by SCCWRP based on changes in biodiversity along a pollutant gradient that is defined by the index values. The index points define specific percentages where the biodiversity of

	the reference pool is lost. The BRI defines the abundance weighted pollution tolerance of the species present at a site and ranges from Response level RL 1 through 4. RL1 indicates marginal deviations from reference conditions (REF), while RL 2 through 4 are considered evidence of disturbed benthic conditions.
Data Used to Assess Water Quality:	Data generated from 23 samples within different stations in Santa Monica Bay using the BRI to assess benthic conditions indicate that 5 samples marginally deviate from reference conditions (LACSD, 2004b).
Spatial Representation:	Twenty-three sample sites within Santa Monica Bay at different dates in 1998.
Temporal Representation:	Twenty-three samples taken during 1998 at 23 different sampling stations.
Data Quality Assessment:	Southern California Bight 1998 Regional Marine Monitoring Survey (Bight 98) Quality Assurance Manual (CSCCWRP Bight 98 Steering Committee. July 1998)

Numeric Line of Evidence	Pollutant-Sediment
Beneficial Use:	MA - Marine Habitat
Matrix:	Sediment
Water Quality Objective/ Water Quality Criterion:	Narrative Basin Plan WQO for pesticide is applicable to the protection of aquatic life BUs.
Evaluation Guideline:	Sediment Quality Guidelines (SQGs) are used to determine the toxic effects of a sample , concurrently collected measurements of chemical concentrations can be used to associate toxic effects with toxicity or other biological effects. The predictability of toxicity, using the SQGs values reported (Long et al., 1998) is reasonably good and is most useful if accompanied by data from biological analyses, toxicological analyses, and other interpretative tools.
Data Used to Assess Water Quality:	Data generated from 23 samples different stations in Santa Monica Bay using SQGs to assess toxic effects due total chlordane. No sample exceeded the total chlordane SQG (LACSD, 2004).
Spatial Representation:	Twenty-three sample sites were sampled within Santa Monica Bay at different dates during 1998.
Temporal Representation:	Twenty three samples were taken from twenty three different sampling stations within the Santa Monica Bay during 1998.
Data Quality Assessment:	Quality Assurance Document Of The County Sanitation Districts Of Los Angeles County. July 2003.

Water Segment: Santa Monica Bay Offshore/Nearshore

Pollutant: Polychlorinated biphenyls

Decision: Do Not Delist

Weight of Evidence: Based on the readily available data and information, the weight of evidence indicates that there is insufficient justification in favor of removing this water segment-pollutant combination from the section 303(d) list in the Water Quality Limited Segments category.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3. Six of the 7 samples exceeded the water quality objectives but the number of samples is insufficient to determine with the confidence and power required by the Listing Policy.
4. Pursuant to section 3.11 of the Listing Policy, no additional data and information are available indicating that standards are not met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because it cannot be determined if applicable water quality standards are attained.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Tissue

Beneficial Use: CM - Commercial and Sport Fishing (CA)

Matrix: Tissue

Water Quality Objective/ Water Quality Criterion: Los Angeles RWQCB Basin Plan: Toxic pollutants shall not be present at levels that will bioaccumulate in aquatic life to levels which are harmful to aquatic life or human health.

Evaluation Guideline: 20 ng/g (OEHHA Screening Value).

Data Used to Assess Water Quality: Six out of 7 samples exceeded. All 7 samples were filet composites representing the following species: barred surfperch, California corbina, queenfish, walleye surfperch, and white croaker. All but one of two California corbina exceeded guideline (TSMP, 2002).

Spatial Representation: Two stations were sampled: Santa Monica Pier and Venice Pier.

Temporal Representation: Samples were collected in July and November 1999.

Data Quality Assessment:	CFCP 1998 Year 1 QA Summary Pesticides and PCBs. California Department of Fish and Game. CDFG Fish and Wildlife Water Pollution Control Laboratory Data Quality Assurance Report. 1999 Coastal Fish Contamination Program (CFCP Year 2). California Department of Fish and Game.

Water Segment: Santa Monica Bay Offshore/Nearshore

Pollutant: Polycyclic Aromatic Hydrocarbons (PAHs) (Aquatic Ecosystems)

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for delisting under sections 4.6 of the Listing Policy. Under section 4.6 a single line of evidence is necessary to assess listing status.

Two lines of evidence are available in the administrative record to assess this pollutant. Based on section 4.6, the site does have significant sediment toxicity but this PAHs are is not likely to cause or contribute to any toxic effect. The benthic community is impacted.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of removing this water segment-pollutant combination from the section 303(d) list in the Water Quality Limited Segments category.

This conclusion is based on the staff findings that:
1. The sediment quality guideline used complies, with the requirements of section 6.1.3 of the Policy.
2. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
3. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
4. None of the 23 samples exceeded the PAHs sediment guideline, but five of the 23 samples exhibit toxicity. Although toxicity is documented, the number of samples is insufficient to determine with the confidence and power required by the Listing Policy.
5. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because it cannot be determined if applicable water quality standards are attained.

Lines of Evidence:

Numeric Line of Evidence Population/Community Degradation

Beneficial Use: MA - Marine Habitat

Matrix: Sediment

Water Quality Objective/ Water Quality Criterion: Narrative Toxicity Basin Plan WQO is applicable to the protection of aquatic life BUs.

Evaluation Guideline: Benthic Response Index (BRI) is a guidance developed by SCCWRP based on changes in biodiversity along a pollutant gradient that is defined by the index values. The index points define specific percentages where the biodiversity of

	the reference pool is lost. The BRI defines the abundance weighted pollution tolerance of the species present at a site and ranges from Response level RL 1 through 4. RL1 indicates marginal deviations from reference conditions (REF), while RL 2 through 4 are considered evidence of disturbed benthic conditions.
Data Used to Assess Water Quality:	Data generated from 23 samples within different stations in Santa Monica Bay using the BRI to assess benthic conditions indicate that 5 samples marginally deviate from reference conditions (LACSD, 2004b).
Spatial Representation:	Twenty-three sample sites within Santa Monica Bay at different dates in 1998.
Temporal Representation:	Twenty-three samples taken during 1998 at 23 different sampling stations.
Data Quality Assessment:	Southern California Bight 1998 Regional Marine Monitoring Survey (Bight 98) Quality Assurance Manual (CSCCWRP Bight 98 Steering Committee. July 1998)

Numeric Line of Evidence	Pollutant-Sediment
Beneficial Use:	MA - Marine Habitat
Matrix:	Sediment
Water Quality Objective/ Water Quality Criterion:	Narrative Ocean Plan WQO regarding biological characteristics specifies that marine communities, including vertebrate, invertebrate, and plant species , shall not be degraded.
Evaluation Guideline:	Sediment Quality Guidelines (SQGs) are used to determine the toxic effects of a sample, concurrently collected measurements of chemical concentrations can be used to associate toxic effects with toxicity or other biological effects. The predictability of toxicity, using the SQGs values reported (Fairey et al., 2001) is reasonably good and is most useful if accompanied by data from biological analyses, toxicological analyses, and other interpretative tools.
Data Used to Assess Water Quality:	Data generated from 23 samples at different stations in Santa Monica Bay using SQGs to assess toxic effects due total PAHs. No sample exceeded the total PAHs SQG for the protection of marine aquatic life (LACSD, 2004b).
Spatial Representation:	Twenty-three sample sites were sampled within Santa Monica Bay at different dates during 1998.
Temporal Representation:	Twenty-seven samples where taken from 5/7/02 through 5/4/04 at quarterly intervals from three sampling stations (R1, R2, and R5).
Data Quality Assessment:	Quality Assurance Document Of The County Sanitation Districts Of Los Angeles County. July 2003.

Region 4

Water Segment: Santa Monica Beach

Pollutant: Coliform Bacteria

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for listing under section 2.2 of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status.

Two lines of evidence are available in the administrative record to assess this pollutant. Based on the applicable factor, a TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard. The beach closure information is backed by coliform data. Beach closure information should not be placed on the section 303(d) list because it is not a pollutant or toxicity (section 2 of the Listing Policy).

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.

SWRCB Staff Recommendation: After review of the available data and information for this recommendation, SWRCB staff conclude that the water body and pollutant (coliform) should be placed in the Water Quality Limited Segments Being Addressed category of the section 303(d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.

Lines of Evidence:

Line of Evidence Remedial Program in Place

Beneficial Use R1 - Water Contact Recreation

Information Used to Assess Water Quality: A TMDL and implementation plan has been approved for this water segment-pollutant combination. The Santa Monica Bay Bacteria Dry Weather TMDL was approved by RWQCB on January 24, 2002 and subsequently approved by USEPA. The Santa Monica Bay Bacteria Wet Weather TMDL was approved by RWQCB on December 12, 2004 and approved by USEPA on June 19, 2003.

Water Segment: Santa Monica Canyon

Pollutant: Coliform Bacteria

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for listing under section 2.2 of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status.

One line of evidence is available in the administrative record to assess this pollutant. Based on the applicable factor, a TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard. This water segment-pollutant combination was moved off the section 303(d) list during the 2002 listing cycle.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.

SWRCB Staff Recommendation: After review of the available data and information for this recommendation, SWRCB staff conclude that the water body should be placed in the Water Quality Limited Segments Being Addressed category of the section 303(d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.

Lines of Evidence:

Line of Evidence Remedial Program in Place

Beneficial Use R1 - Water Contact Recreation

Information Used to Assess Water Quality: A TMDL and implementation plan has been approved for this water segment-pollutant combination. The Santa Monica Bay Bacteria Dry Weather TMDL was approved by RWQCB on January 24, 2002 and subsequently approved by USEPA. The Santa Monica Bay Bacteria Wet Weather TMDL was approved by RWQCB on December 12, 2004 and approved by USEPA on June 19, 2003.

Region 4

Water Segment: Sepulveda Canyon

Pollutant: Coliform Bacteria

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for listing under section 2.2 of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status.

One line of evidence is available in the administrative record to assess this pollutant. Based on the applicable factor, a TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard. This water segment-pollutant combination was moved off the section 303(d) list during the 2002 listing cycle.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.

SWRCB Staff Recommendation: After review of the available data and information for this recommendation, SWRCB staff conclude that the water body should be placed in the Water Quality Limited Segments Being Addressed category of the section 303(d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.

Lines of Evidence:

Line of Evidence Remedial Program in Place

Beneficial Use R1 - Water Contact Recreation

Information Used to Assess Water Quality: A TMDL and implementation plan has been approved for this water segment-pollutant combination. The Santa Monica Bay Bacteria Dry Weather TMDL was approved by RWQCB on January 24, 2002 and subsequently approved by USEPA. The Santa Monica Bay Bacteria Wet Weather TMDL was approved by RWQCB on December 12, 2004 and approved by USEPA on June 19, 2003.

Water Segment: Sespe Creek (from 500 ft below confluence with Little Sespe Cr to headwaters)

Pollutant: Chloride

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 4.1 of the Listing Policy. Under section 4.1 a single line of evidence is necessary to assess listing status.

One line of evidence is available in the administrative record to assess this pollutant. Six samples exceeded the water quality objective but the total number of samples taken is insufficient to determine if standards are met with the sufficient confidence and power required by the Listing Policy.

Based on the readily available data and information, the weight of evidence indicates that there is insufficient justification in favor of removing this water segment-pollutant combination from the section 303(d) list.

This conclusion is based on the staff findings that:
1.The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2.The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3.Six of 16 samples exceeded the water quality objective. At least 28 samples are needed before a pollutant can be considered for removal from the list using the frequencies presented in Table 4.1 of the Listing Policy.
4.Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because it cannot be determined if applicable water quality standards are attained.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Water

Beneficial Use: AG - Agricultural Supply, BI - Preserva.of Bio.Hab.of Spec.Signif., CO - Cold Freshwater Habitat, MI - Fish Migration, RA - Rare & Endangered Species, SP - Fish Spawning, WA - Warm Freshwater Habitat, WE - Wetland Habitat, WI - Wildlife Habitat

Matrix: Water

Water Quality Objective/ Water Quality Criterion: Basin Plan: 60 mg/L.

Data Used to Assess Water Quality: There were sixteen total water samples, with 6 samples exceeding the objective (SWRCB, 2003).

Spatial Representation: Samples are representative of the Reach.

Temporal Representation:	Quarterly sampling events.
Data Quality Assessment:	United Water Conservation District methods.

Water Segment: Surfers Point at Seaside

Pollutant: Bacteria Indicators

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for listing under section 2.2 of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status.

One line of evidence is available in the administrative record to assess this pollutant. Based on the applicable factor, a TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard. This water segment-pollutant combination was moved off the section 303(d) list during the 2002 listing cycle.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.

SWRCB Staff Recommendation: After review of the available data and information for this recommendation, SWRCB staff conclude that the water body should be placed in the Water Quality Limited Segments Being Addressed category of the section 303(d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.

Lines of Evidence:

Line of Evidence Remedial Program in Place

Beneficial Use R1 - Water Contact Recreation

Information Used to Assess Water Quality: A TMDL and implementation plan has been approved for this water segment-pollutant combination. The Santa Monica Bay Bacteria Dry Weather TMDL was approved by RWQCB on January 24, 2002 and subsequently approved by USEPA. The Santa Monica Bay Bacteria Wet Weather TMDL was approved by RWQCB on December 12, 2004 and approved by USEPA on June 19, 2003.

Water Segment: Topanga Beach

Pollutant: Coliform Bacteria

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for listing under section 2.2 of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status.

One line of evidence is available in the administrative record to assess this pollutant. Based on the applicable factor, a TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.

SWRCB Staff Recommendation: After review of the available data and information for this recommendation, SWRCB staff conclude that the water body and pollutant (coliform) should be placed in the Water Quality Limited Segments Being Addressed category of the section 303(d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.

Lines of Evidence:

Line of Evidence Remedial Program in Place

Beneficial Use R1 - Water Contact Recreation

Information Used to Assess Water Quality: A TMDL and implementation plan has been approved for this water segment-pollutant combination. The Santa Monica Bay Bacteria Dry Weather TMDL was approved by RWQCB on January 24, 2002 and subsequently approved by USEPA. The Santa Monica Bay Bacteria Wet Weather TMDL was approved by RWQCB on December 12, 2004 and approved by USEPA on June 19, 2003.

Water Segment: Torrance Beach

Pollutant: Coliform Bacteria

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for listing under section 2.2 of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status.

One line of evidence is available in the administrative record to assess this pollutant. Based on the applicable factor, a TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.

SWRCB Staff Recommendation: After review of the available data and information for this recommendation, SWRCB staff conclude that the water body and pollutant (coliform) should be placed in the Water Quality Limited Segments Being Addressed category of the section 303(d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.

Lines of Evidence:

Line of Evidence Remedial Program in Place

Beneficial Use R1 - Water Contact Recreation

Information Used to Assess Water Quality: A TMDL and implementation plan has been approved for this water segment-pollutant combination. The Santa Monica Bay Bacteria Dry Weather TMDL was approved by RWQCB on January 24, 2002 and subsequently approved by USEPA. The Santa Monica Bay Bacteria Wet Weather TMDL was approved by RWQCB on December 12, 2004 and approved by USEPA on June 19, 2003.

Water Segment: Torrey Canyon Creek

Pollutant: Nitrate and Nitrite

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for listing under section 2.2 of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status.

One line of evidence is available in the administrative record to assess this pollutant. Based on the applicable factor, a TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should be placed in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list because a TMDL and implementation plan have been approved.

Lines of Evidence:

Line of Evidence Remedial Program in Place

Beneficial Use MU - Municipal & Domestic

Information Used to Assess Water Quality: A TMDL and implementation plan has been approved for this water segment-pollutant combination. The Santa Clara Rive Nitrogen TMDL was approved by RWQCB on August 7, 2003 and subsequently approved by USEPA on March 18, 2004.

Water Segment: Trancas Beach (Broad Beach)

Pollutant: Fecal Coliform

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for listing under section 2.2 of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status.

One line of evidence is available in the administrative record to assess this pollutant. Based on the applicable factor, a TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.

SWRCB Staff Recommendation: After review of the available data and information for this recommendation, SWRCB staff conclude that the water body and pollutant (coliform) should be placed in the Water Quality Limited Segments Being Addressed category of the section 303(d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.

Lines of Evidence:

Line of Evidence Remedial Program in Place

Beneficial Use R1 - Water Contact Recreation

Information Used to Assess Water Quality: A TMDL and implementation plan has been approved for this water segment-pollutant combination. The Santa Monica Bay Bacteria Dry Weather TMDL was approved by RWQCB on January 24, 2002 and subsequently approved by USEPA. The Santa Monica Bay Bacteria Wet Weather TMDL was approved by RWQCB on December 12, 2004 and approved by USEPA on June 19, 2003.

Region 4

Water Segment: Tujunga Wash (LA River to Hansen Dam)

Pollutant: Ammonia

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for listing under section 2.2 of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status.

Three lines of evidence are available in the administrative record to assess this pollutant. A TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.

SWRCB Staff Recommendation: After review of the available data and information for this recommendation, SWRCB staff conclude that the water body and pollutant (ammonia) should be placed in the Water Quality Limited Segments Being Addressed category of the section 303(d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.

Lines of Evidence:

Line of Evidence Remedial Program in Place

Beneficial Use WA - Warm Freshwater Habitat

Information Used to Assess Water Quality: A TMDL and implementation plan has been approved for this water segment-pollutant combination. The Los Angeles River Nitrogen TMDL was approved by RWQCB on August 19, 2003 and subsequently approved by USEPA on March 18, 2004.

Water Segment: Venice Beach

Pollutant: Coliform Bacteria

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for listing under section 2.2 of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status.

One line of evidence is available in the administrative record to assess this pollutant. Based on the applicable factor, a TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.

SWRCB Staff Recommendation: After review of the available data and information for this recommendation, SWRCB staff conclude that the water body and pollutant (coliform) should be placed in the Water Quality Limited Segments Being Addressed category of the section 303(d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.

Lines of Evidence:

Line of Evidence Remedial Program in Place

Beneficial Use R1 - Water Contact Recreation

Information Used to Assess Water Quality: A TMDL and implementation plan has been approved for this water segment-pollutant combination. The Santa Monica Bay Bacteria Dry Weather TMDL was approved by RWQCB on January 24, 2002 and subsequently approved by USEPA. The Santa Monica Bay Bacteria Wet Weather TMDL was approved by RWQCB on December 12, 2004 and approved by USEPA on June 19, 2003.

Water Segment: Ventura River Estuary

Pollutant: Total Coliform

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 4.3 of the Listing Policy. Under section 4.3 a single line of evidence is necessary to assess delisting status.

One line of evidence is available in the administrative record to assess this pollutant. A large number of samples exceed Basin Plan and Ocean Plan total coliform water quality objectives.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification against removing this water segment-pollutant combination from the section 303(d) list.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3. Twenty-four of 37 samples exceeded the Basin Plan 1,000/100ml geometric mean limit water quality objective, and 32 of 37 and 37 of 37 samples exceed the median density limit and the 10 percent limit Ocean Plan shellfish harvesting standards respectively, and these exceed the allowable frequency listed in Table 4.2 of the Listing Policy.
4. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because applicable water quality standards are exceeded and a pollutant contributes to or causes the problem.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Water

Beneficial Use: R1 - Water Contact Recreation, SH - Shellfish Harvesting

Matrix: Water

Water Quality Objective/ Water Quality Criterion: Basin Plan: In waters designated for marine water contact recreation (REC-1), the total coliform density shall not exceed the geometric mean limit of 1,000/100 ml.

Ocean Plan: In all waters where shellfish can be harvested for human consumption (SHELL), the median total coliform concentration throughout the water column shall not exceed 70/100 ml, nor shall more than ten percent of the

	samples collected exceed 230/100 ml.
Data Used to Assess Water Quality:	Numeric data generated from 37 bacteria samples out of which 24 exceeded the Basin Plan marine waters 1000/100ml geometric mean limit, 32 exceeded the Ocean Plan's shellfish harvesting median density standard of 70/100ml and the 37 exceeded 10 percent limit of 230/100ml (SWRCB, 2003).
Spatial Representation:	One sampling site.
Temporal Representation:	Collected during different seasons and years.
Data Quality Assessment:	Ojai Valley River Volunteer Monitoring Program.

Region 4

Water Segment: Wheeler Canyon/Todd Barranca

Pollutant: Nitrate and Nitrite

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for listing under section 2.2 of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status.

One line of evidence is available in the administrative record to assess this pollutant. Based on the applicable factor, a TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard. This water segment-pollutant combination was moved off the section 303(d) list during the 2002 listing cycle.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.

SWRCB Staff Recommendation: After review of the available data and information for this recommendation, SWRCB staff conclude that the water body should be placed in the Water Quality Limited Segments Being Addressed category of the section 303(d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.

Lines of Evidence:

Line of Evidence Remedial Program in Place

Beneficial Use MU - Municipal & Domestic

Information Used to Assess Water Quality: A TMDL and implementation plan has been approved for this water segment-pollutant combination. The Santa Clara Rive Nitrogen TMDL was approved by RWQCB on August 7, 2003 and subsequently approved by USEPA on March 18, 2004.

Water Segment: Wheeler Canyon/Todd Barranca

Pollutant: Sulfates

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 4.2 of the Listing Policy. Under section 4.2 a single line of evidence is necessary to assess delisting status.

One line of evidence is available in the administrative record to assess this pollutant. A large number of samples exceed the site specific sulfate water quality objective.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification against removing this water segment-pollutant combination from the section 303(d) list.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3. Eleven of 12 samples exceeded the sulfate site specific water quality objective. At least 28 samples are needed before a pollutant can be considered for removal from the list using the frequencies presented in Table 4.2 of the Listing Policy.
4. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from the section 303(d) list because applicable water quality standards are exceeded and it cannot be determined if applicable water quality standards are attained because there are an insufficient number of total samples.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Water

Beneficial Use: AG - Agricultural Supply

Matrix: Water

Water Quality Objective/ Water Quality Criterion: Basin Plan: 650 mg/L (Table 3-8, water body tributary to Santa Clara River Reach 3 between Freeman Diversion and Fillmore Street A).

Data Used to Assess Water Quality: There were twelve water samples, with 11 samples exceeding the objective (SWRCB, 2003).

Spatial Representation:	Represents creek.
Temporal Representation:	Quarterly sampling events.
Data Quality Assessment:	United Water Conservation District data quality assessment.

Water Segment: Wheeler Canyon/Todd Barranca

Pollutant: Total Dissolved Solids

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for removal from the section 303(d) list under section 4.2 of the Listing Policy. Under section 4.2 a single line of evidence is necessary to assess delisting status.

One line of evidence is available in the administrative record to assess this pollutant. A large number of samples exceed the site specific TDS water quality objective.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification against removing this water segment-pollutant combination from the section 303(d) list.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3. Twelve of 12 samples exceeded the site specific TDS water quality objective. At least 26 samples are needed before a pollutant can be considered for removal from the list using the frequencies presented in Table 4.2 of the Listing Policy.
4. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, SWRCB staff concludes that the water body-pollutant combination should not be removed from on the section 303(d) list because applicable water quality standards are exceeded and it cannot be determined if applicable water quality standards are attained because there are insufficient numbers of samples.

Lines of Evidence:

Numeric Line of Evidence Pollutant-Water

Beneficial Use: AG - Agricultural Supply

Matrix: -N/A

Water Quality Objective/ Water Quality Criterion: Basin Plan: 1,300 mg/L (Table 3-8, water body tributary to Santa Clara River Reach 3 between Freeman Diversion and Fillmore Street A).

Data Used to Assess Water Quality: There were twelve water samples, with all 12 samples exceeding the objective (SWRCB, 2003).

Spatial Representation:	Represents creek.
Temporal Representation:	Quarterly sampling events.
Data Quality Assessment:	United Water Conservation District
QA/QC Equivalent:	United Water Conservation District methods used.

Region 4

Water Segment: Will Rogers Beach

Pollutant: Coliform Bacteria

Decision: Do Not Delist

Weight of Evidence: This pollutant is being considered for listing under section 2.2 of the Listing Policy. Under this section of the Policy, a minimum of one line of evidence is needed to assess listing status.

One line of evidence is available in the administrative record to assess this pollutant. Based on the applicable factor, a TMDL has been developed and approved by USEPA and an approved implementation plan is expected to result in attainment of the standard.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination in the Water Quality Limited Segments Being Addressed portion of the section 303(d) list.

SWRCB Staff Recommendation: After review of the available data and information for this recommendation, SWRCB staff conclude that the water body and pollutant (coliform) should be placed in the Water Quality Limited Segments Being Addressed category of the section 303(d) list because a TMDL has been approved by USEPA and an implementation plan has been approved.

Lines of Evidence:

Line of Evidence Remedial Program in Place

Beneficial Use R1 - Water Contact Recreation

Information Used to Assess Water Quality: A TMDL and implementation plan has been approved for this water segment-pollutant combination. The Santa Monica Bay Bacteria Dry Weather TMDL was approved by RWQCB on January 24, 2002 and subsequently approved by USEPA. The Santa Monica Bay Bacteria Wet Weather TMDL was approved by RWQCB on December 12, 2004 and approved by USEPA on June 19, 2003.

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Please Note:

The electronic docket system that supports the proposed NPDES Stormwater Multi-Sector General Permit for Industrial Activities (MSGP-2006) has been moved to a new site. The old site edocket.gov has been moved to www.regulations.gov

Unfortunately the new website, www.regulations.gov is experiencing technical difficulties. In order to find the docket for the MSGP-2006, please follow these steps:

- Go to www.regulations.gov
- Click on "Advanced Search" at the top of the page
- Click on "Docket Search" from the drop down menu
- Select "Environmental Protection Agency" from the Agency drop down menu
- Then enter the docket ID "OW-2005-0007"

Please scroll down to see the federal register notice below of Air Quality Planning and Standards (Mail Code C 439–04), 109 T.W. Alexander Drive, Research Triangle Park, NC 27711, or e-mail at: *whitlow.jeff@epa.gov*. Additional Information about the CAAAC and its subcommittees can be found on the CAAAC Web site: *http://www.epa.gov/air/caaac.*

Providing Written Comments at This Meeting: It is the policy of the subcommittee to accept written public comments of any length, and to accommodate oral public comments whenever possible. Due to the brief nature of this meeting, the subcommittee will only accept written comments. The subcommittee expects that statements submitted for this meeting will not be repetitive of previously-submitted oral or written statements. Although the subcommittee accepts written comments until the date of the meeting (unless otherwise stated), written comments should be received by Mr. Whitlow no later than noon Eastern Time five business days prior to the meeting so that the comments may be made available to the subcommittee members for their consideration. Comments should be supplied to Mr. Whitlow (preferably via e-mail) at the address/contact information noted above, as follows: one hard copy with original signature or one electronic copy via e-mail (acceptable file format: Adobe Acrobat PDF, WordPerfect, MS Word, MS PowerPoint, or Rich Text files).

Dated: November 22, 2005.

Gregory A. Green,

Deputy Director, Office of Air Quality Planning and Standards.

[FR Doc. E5–6723 Filed 11–30–05; 8:45 am]

BILLING CODE 6560–50–P

ENVIRONMENTAL PROTECTION AGENCY

[FRL—8004–6]

Science Advisory Board Staff Office Cancellation of Public Teleconference of the Science Advisory Board Arsenic Review Panel

AGENCY: Environmental Protection Agency (EPA).

ACTION: Notice.

SUMMARY: The Environmental Protection Agency (EPA), Science Advisory Board (SAB) Staff Office is canceling a public teleconference meeting of the SAB's Arsenic Review Panel announced earlier (70 FR 69340, November 15, 2005).

DATES: December 5, 2005. The public conference call from 2 p.m. to 4:30 p.m. Eastern Time has been cancelled. A future notice in the **Federal Register** will announce the new date and time for the Arsenic Review Panel's next meeting.

Dated: November 29, 2005.

Anthony F. Maciorowski,

Associate Director for Science, EPA Science Advisory Board Staff Office.

[FR Doc. 05–23558 Filed 11–30–05; 8:45 am]

BILLING CODE 6560–50–P

ENVIRONMENTAL PROTECTION AGENCY

[FRL–8004–2]

Calhoun Park Area Superfund Site; Charleston, Charleston County, SC; Notice of Proposed Settlement

AGENCY: Environmental Protection Agency.

ACTION: Notice of proposed settlement.

SUMMARY: Under Section 122(h)(1) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the Environmental Protection Agency (EPA) has proposed to settle claims for payment of all past cost, as well as future costs related to the Calhoun Park Area Site ("Site") located in Charleston County, Charleston, South Carolina. EPA will consider public comments on the proposed settlement until January 3, 2006. EPA may withdraw from or modify the proposed settlement should such comments disclose facts or considerations which indicate the proposed settlement is inappropriate, improper, or inadequate.

Copies of the proposed settlement are available from: Ms. Paula V. Batchelor, U.S. Environmental Protection Agency, Region 4, Superfund Enforcement and Information Management Branch, Waste Management Division, 61 Forsyth Street, SW., Atlanta, Georgia 30303. 404/562–8887. *Batchelor.Paula@EPA.Gov.*

Written or e-mail comments may be submitted to Ms. Batchelor at the above address within thirty days of the date of publication.

Dated: November 10, 2005.

Rosalind H. Brown,

Chief, Superfund Enforcement and Information Management Branch, Waste Management Division.

[FR Doc. E5–6722 Filed 11–30–05; 8:45 am]

BILLING CODE 6560–50–P

ENVIRONMENTAL PROTECTION AGENCY

[FRL–8004–5]

Proposed National Pollutant Discharge Elimination System (NPDES) General Permit for Stormwater Discharges From Industrial Activities

AGENCY: Environmental Protection Agency (EPA).

ACTION: Notice of availability for comment.

SUMMARY: EPA Regions 1, 2, 3, 5, 6, 9, and 10 today are proposing EPA's NPDES general permit for stormwater discharges from industrial activity, also referred to as the Multi-Sector General Permit (MSGP). Today's proposed permit will replace the existing permit covering industrial sites in EPA Regions 1, 2, 3, 5, 6, 8, 9 and 10 that expired on October 30, 2005. Today's proposed permit is similar to the existing permit and will authorize the discharge of stormwater associated with industrial activities in accordance with the terms and conditions described therein. EPA seeks comment on the proposed permit and on the accompanying fact sheet.

DATES: Comments on the proposed general permit must be postmarked by January 16, 2006.

ADDRESSES: Comments may be submitted electronically, by mail, or through hand delivery/courier. Send written comments to: Follow the detailed instructions as provided in Section I.B.

FOR FURTHER INFORMATION CONTACT: For further information on the proposed NPDES general permit, contact the appropriate EPA Regional Office listed in Section I.F, or contact Jenny Molloy, EPA Headquarters, Office of Water, Office of Wastewater Management at tel.: 202–564–1939 or e-mail: *molloy.jennifer@epa.gov.*

SUPPLEMENTARY INFORMATION:

I. General Information

A. How Can I Get Copies of This Document and Other Related Information?

1. *Docket.* EPA has established an official public docket for this action under Docket ID No. OW–2005–0007. The official public docket is the collection of materials that is available for public viewing at the Water Docket in the EPA Docket Center, (EPA/DC) EPA West, Room B102, 1301 Constitution Ave., NW., Washington, DC. Although all documents in the docket are listed in an index, some information is not publicly available,

i.e, CBI or other information whose disclosure is restricted by statute. Publicly available docket materials are available in hard copy at the EPA Docket Center Public Reading Room, open from 8:30 a.m. to 4:30 p.m., Monday through Friday, excluding legal holidays. The telephone number for the Public Reading Room is (202) 566–1744, and the telephone number for the Water Docket is (202) 566–2426.

2. *Electronic Access.* You may access this ≤Federal Register document electronically through the EPA Internet under the "Federal Register" listings at *http://www.epa.gov/fedrgstr/.*

Electronic versions of the proposed permit and fact sheet are available at EPA's stormwater Web site *http://www.epa.gov/npdes/stormwater.*

An electronic version of the public docket is available through EPA's electronic public docket and comment system, EPA Dockets. You may use EPA Dockets at *http://www.epa.gov/edocket/* to submit or view public comments, access the index listing of the contents of the official public docket, and to access those documents in the public docket that are available electronically. Once in the system, select "search", then key in the appropriate docket identification number.

Certain types of information will not be placed in the EPA Dockets. Information claimed as CBI and other information whose disclosure is restricted by statute, which is not included in the official public docket, will not be available for public viewing in EPA's electronic public docket. EPA policy is that copyrighted material will not be placed in EPA's electronic public docket but will be available only in printed, paper form in the official public docket. Although not all docket materials may be available electronically, you may still access any of the publicly available docket materials through the docket facility identified in Section I.A.1.

Submitting CBI. Do not submit this information to EPA through regulations.gov or e-mail. Clearly mark all of the information that you claim to be CBI. For CBI information on computer discs mailed to EPA, mark the surface of the disc as CBI. Also identify electronically the specific information contained in the disc or that you claim is CBI. In addition to one complete version of the specific information claimed as CBI, you must submit a copy that does not contain the information claimed as CBI for inclusion in the public document. Information so marked will not be disclosed except in accordance with procedures set forth in 40 CFR Part 2.

For public commenters, it is important to note that EPA's policy is that public comments, whether submitted electronically or in paper, will be made available for public viewing in EPA's electronic public docket as EPA receives them and without change, unless the comment contains copyrighted material, CBI, or other information whose disclosure is restricted by statute. When EPA identifies a comment containing copyrighted material, EPA will provide a reference to that material in the version of the comment that is placed in EPA's electronic public docket. The entire printed comment, including the copyrighted material, will be available in the public docket.

Public comments submitted on computer disks that are mailed or delivered to the docket will be transferred to EPA's electronic public docket. Public comments that are mailed or delivered to the Docket will be scanned and placed in EPA's electronic public docket. Where practical, physical objects will be photographed, and the photograph will be placed in EPA's electronic public docket along with a brief description written by the docket staff.

B. How and to Whom Do I Submit Comments?

You may submit comments electronically, by mail, or through hand delivery/courier. To ensure proper receipt by EPA, identify the appropriate docket identification number in the subject line on the first page of your comment. To ensure that EPA can read, understand and therefore properly respond to comments, the Agency would prefer that commenters cite, where possible, the paragraph(s) or sections in the fact sheet or permit to which each comment refers. Please ensure that your comments are submitted within the specified comment period. Comments received after the close of the comment period will be marked "late". EPA is not required to consider these late comments.

EPA seeks comment on the proposed permit and on the accompanying fact sheet.

1. *Electronically.* If you submit an electronic comment as prescribed below, EPA recommends that you include your name, mailing address, and an e-mail address or other contact information in the body of your comment. Also include this contact information on the outside of any disk or CD–ROM you submit, and in any cover letter accompanying the disk or CD–ROM. This ensures that you can be identified as the submitter of the comment and allows EPA to contact you in case EPA cannot read your comment due to technical difficulties or needs further information on the substance of your comment. EPA's policy is that EPA will not edit your comment, and any identifying or contact information provided in the body of a comment will be included as part of the comment that is placed in the official public docket, and made available in EPA's electronic public docket. If EPA cannot read your comment due to technical difficulties and cannot contact you for clarification, EPA may not be able to consider your comment.

i. *EPA Dockets.* Your use of EPA's electronic public docket to submit comments to EPA electronically is EPA's preferred method for receiving comments. Go directly to EPA Dockets at *http://www.epa.gov/edocket,* and follow the online instructions for submitting comments. Once in the system, select "search", and then key in Docket ID No. OW–2005–0007. The system is an "anonymous access" system, which means EPA will not know your identity, e-mail address, or other contact information unless you provide it in the body of your comment.

ii. *E-mail.* Comments may be sent by electronic mail (e-mail) to *ow-docket@epa.gov,* Attention Docket ID No. OW–2005–0007. In contrast to EPA's electronic public docket, EPA's e-mail system is not an "anonymous access" system. If you send an e-mail comment directly to the Docket without going through EPA's electronic public docket, EPA's e-mail system automatically captures your e-mail address. E-mail addresses that are automatically captured by EPA's e-mail system are included as part of the comment that is placed in the official public docket, and made available in EPA's electronic public docket.

iii. *Disk or CD–ROM.* You may submit comments on a disk or CD–ROM that you mail to the mailing address identified in Section I.B.2. These electronic submissions will be accepted in Microsoft Word or ASCII file format. Avoid the use of special characters and any form of encryption.

2. *By Mail.* Send the original and three copies of your comments to: Water Docket, Environmental Protection Agency, Mailcode: 4101T, 1200 Pennsylvania Ave., NW., Washington, DC 20460, Attention Docket ID No. OW–2005–0007.

3. *By Hand Delivery or Courier.* Deliver your comments to: Public Reading Room, Room B102, EPA West Building, 1301 Constitution Avenue, NW., Washington, DC 20004, Attention Docket ID No. OW–2005–0007. Such

deliveries are only accepted during the Docket's normal hours of operation as identified in Section I.A.1.

C. Public Hearings

EPA has not scheduled any public hearings to receive public comment concerning the proposed permit. All persons will continue to have the right to provide written comments at any time during the public comment period. However, interested persons may request a public hearing pursuant to 40 CFR 124.12 concerning the proposed permit. Requests for a public hearing must be sent or delivered in writing to the same address as provided above for public comments prior to the close of the comment period. Requests for a public hearing must state the nature of the issues proposed to be raised in the hearing. Pursuant to 40 CFR 124.12, EPA shall hold a public hearing if it finds, on the basis of requests, a significant degree of public interest in a public hearing on the proposed permit. If EPA decides to hold a public hearing, a public notice of the date, time and place of the hearing will be made at least 30 days prior to the hearing. Any person may provide written or oral statements and data pertaining to the proposed permit at the public hearing.

D. Public Meetings

EPA will hold an informal public meeting at EPA headquarters in Washington, DC, December 20, 2005. The public meeting will include a presentation on the draft permit and a question and answer session. In addition, some EPA Regional offices may schedule public meetings in their areas. Due to an informal public meeting's ability to accommodate group discussion and question and answer sessions, public meetings have been used for many stormwater general permits and appear to be more valuable than formalized public hearings in helping the public understand a draft stormwater permit and identify the issues of concern. Written, but not oral, comments for the official permit record will be accepted at the public meetings. Comments generated from what was learned at a public meeting (or discussion with someone who did attend) can be submitted any time up to the end of the comment period. More information on these meetings will be available on the Internet at *http://www.epa.gov/npdes/stormwater* and on the various EPA Regional Web sites including any additional dates and locations if scheduled.

Due to limited seating, those wishing to attend EPA's public meeting are asked to please send an e-mail message containing their name, telephone number and organization to Lance Wills at *wills.lance@epa.gov*. An e-mail message is not required, however. Anyone wishing to may attend. Directions to the meeting site will be provided upon receipt of your e-mail.

E. Finalizing the Permit

After the close of the public comment period, EPA will issue a final permit decision. This decision will not be made until after all public comments have been considered and appropriate changes made to the permit. Responses to Comments will be included as part of the final permit decision.

Since this permit was not reissued or replaced prior to expiration of the MSGP 2000, MSGP is administratively continued in accordance with the Administrative Procedure Act, and remains in force and effect. Any facility with permit coverage prior to the October 30, 2005 expiration date, automatically remains covered by this permit until the earliest of:

• Reissuance or replacement of the permit, at which time the facility must submit an NOI requesting authorization to discharge under the new permit and comply with the requirements of the new permit to maintain authorization to discharge, or:

• The facility submits a Notice of Termination, or;

• Issuance or denial of an individual permit for the facility discharges, or;

• A formal permit decision by EPA not to reissue this general permit, at which time the facility must seek coverage under an alternative general permit or an individual permit.

F. Who Are the EPA Regional Contacts for This Proposed Permit?

For EPA Region 1, contact Thelma Murphy at tel.: (617) 918–1615 or e-mail at *murphy.thelma@epa.gov*.

For EPA Region 2, contact Stephen Venezia at tel.: (212) 637–3856 or e-mail at *venezia.stephen@epa.gov* or for Puerto Rico, Sergio Bosques at tel.: (787) 977–5838 or e-mail at *bosques.sergio@epa.gov*.

For EPA Region 3, contact Paula Estornell at tel.: (215) 814–5632 or e-mail at *estornell.paula@epa.gov*.

For EPA Region 5, contact Brian Bell at tel.: (312) 886–0981 or e-mail at *bell.brianc@epa.gov*.

For EPA Region 6, contact Brent Larsen at tel.: (214) 665–7523 or e-mail at: *larsen.brent@epa.gov*.

For EPA Region 9, contact Eugene Bromley at tel.: (415) 972–3510 or e-mail at *bromley.eugene@epa.gov*.

For EPA Region 10, contact Misha Vakoc at tel.: (206) 553–6650 or e-mail at *vakoc.misha@epa.gov*.

II. Background

A. Statutory and Regulatory History

Section 405 of the Water Quality Act of 1987 (WQA) added section 402(p) of the Clean Water Act (CWA), which directed the Environmental Protection Agency (EPA) to develop a phased approach to regulate stormwater discharges under the National Pollutant Discharge Elimination System (NPDES) program. EPA published a final regulation on the first phase on this program on November 16, 1990, establishing permit application requirements for "stormwater discharges associated with industrial activity". See 55 FR 48063. EPA defined the term "stormwater discharge associated with industrial activity" in a comprehensive manner to cover a wide variety of facilities. See 40 CFR 122.26(b)(14).

III. Scope and Applicability of the 2006 Multi-Sector General Permit

The 2000 Multi-Sector General Permit expired at midnight, October 30, 2005.

A. Geographic Coverage

EPA can only provide permit coverage for classes of discharges that are outside the scope of a state's NPDES program authorization. EPA notes that unlike the 2000 MSGP, facilities located in Regions 4 and 8 will not be covered by this permit. The geographic coverage of today's proposed permit is listed in Appendix C of the proposed 2006 MSGP.

B. Categories of Facilities Covered

Today's proposed MSGP regulates stormwater discharges from industrial facilities in 29 categories, shown in Table III–1, in the five states and other areas where EPA remains the permitting authority. See Appendix D of the proposed MSGP 2006 and the MSGP fact sheet for more complete information.

Sector A—Timber Products
Sector B—Paper and Allied Products Manufacturing
Sector C—Chemical and Allied Products Manufacturing
Sector D—Asphalt Paving and Roofing Materials Manufactures and Lubricant Manufacturers
Sector E—Glass, Clay, Cement, Concrete, and Gypsum Product Manufacturing
Sector F—Primary Metals
Sector G—Metal Mining (Ore Mining and Dressing)
Sector H—Coal Mines and Coal Mining-Related Facilities
Sector I—Oil and Gas Extraction and Refining

Sector J—Mineral Mining and Dressing
Sector K—Hazardous Waste Treatment Storage or Disposal
Sector L—Landfills and Land Application Sites
Sector M—Automobile Salvage Yards
Sector N—Scrap Recycling Facilities
Sector O—Steam Electric Generating Facilities
Sector P—Land Transportation
Sector Q—Water Transportation
Sector R—Ship and Boat Building or Repairing Yards
Sector S—Air Transportation Facilities
Sector T—Treatment Works
Sector U—Food and Kindred Products
Sector V—Textile Mills, Apparel, and other Fabric Products Manufacturing
Sector W—Furniture and Fixtures
Sector X—Printing and Publishing
Sector Y—Rubber, Miscellaneous Plastic Products, and Miscellaneous Manufacturing Industries
Sector Z—Leather Tanning and Finishing
Sector AA—Fabricated Metal Products
Sector AB—Transportation Equipment, Industrial or Commercial Machinery
Sector AC—Electronic, Electrical, Photographic and Optical Goods
Sector AD—Reserved for Facilities Not Covered Under Other Sectors and Designated by the Director

B. Summary of Significant Changes From 2000 Multi-Sector General Permit

This permit replaces the previous Multi-Sector General Permit that was issued for a five-year term on October 30, 2000 (65 FR 64746). The MSGP 2000 was subsequently corrected on January 9, 2001 (66 FR 1675–1678) and March 23, 2001 (66 FR 16233–16237). On April 16, 2001 (66 FR 19483–19485) EPA re-issued the permit, as corrected, for facilities in certain areas of Regions 8 and 10.

The proposed permit is structured in five sections: general requirements that apply to all facilities (e.g., eligibility of discharges, storm water pollution prevention plan (SWPPP) requirements, and monitoring requirements), industry sector-specific conditions, and specific requirements applicable to individual States or Tribes. Additionally, the appendices provide information on Endangered Species Act and National Historic Properties Act procedures, the Notice of Intent (NOI), the Notice of Termination (NOT), and the Conditional No Exposure Exclusion.

The organization and numbering of today's draft MSGP has been revised from the 2000 MSGP to more clearly present permittee responsibilities. EPA made changes to the discharge authorization time frame, training, monitoring, reporting, recordkeeping, inspections, and some sector-specific provisions to ensure that receiving waters will be adequately protected. The significant changes are summarized below. These changes are discussed in more detail in the MSGP fact sheet.

Discharge Authorization Time Frame

EPA has instituted a 30-day public comment period for facilities that have correctly completed NOI applications. The period begins after EPA posts the facility's NOI on the eNOI Web site. Authorization to discharge is granted at the end of the 30 day period unless EPA has substantive reason to delay or deny authorization.

Monitoring and Reporting

Several changes to MSGP-reporting and monitoring requirements are listed below.

- Inactive and unstaffed sites may exercise a Benchmark Monitoring waiver as long as there are no industrial materials or activities exposed.
- A facility covered under MSGP 2006 must monitor quarterly during year 1 for benchmarks. Facilities with an average of 4 monitoring events that do not exceed the benchmark qualify for a waiver from additional benchmark monitoring for the remainder of the permit term.
- Follow-up monitoring requirements have been added when results indicate a facility's discharge exceeds a numeric effluent limitation, or causes and contributes to an exceedance of a water quality standard, to verify that BMPs have been modified to protect water quality. Facilities with follow-up monitoring exceedances are required to report those to EPA within 30 days of receiving the analytical data.
- Benchmark Monitoring Requirements for Total Suspended Solids (TSS) were added for each sector where they were not otherwise included in the MSGP 2000.
- Total Recoverable Chromium and Phenols were added as Benchmark Monitoring Parameters for the Wood Preserving (SIC 2491) Subsector of Sector A—Timber Products.
- Total Recoverable Manganese was removed as a Benchmark Monitoring Parameter for Waste Rock and Overburden Piles from Active Ore Mining or Dressing Facilities under Sector G—Metal Mining (Ore Mining and Dressing).
- Total Recoverable Lead, Total Recoverable Nickel, Total Recoverable Zinc, Ammonia Nitrogen, and Nitrate + Nitrite Nitrogen were added as Benchmark Monitoring Parameters for the Oil Refining (SIC 2911) Subsector of Sector I—Oil and Gas Extraction and Refining.
- Total Recoverable Lead was added as a Benchmark Monitoring Parameter for the Tires and Inner Tubes; Rubber Footwear; Gaskets, Packing and Sealing Devices; Rubber Hose and Belting; and Fabricated Rubber Products, Not Elsewhere Classified (SIC 3011–3069, rubber manufacturing only) Subsector of Sector Y—Rubber, Miscellaneous Plastic Products, and Miscellaneous Manufacturing Industries.
- Total Recoverable Lead and Total Recoverable Copper were added as a Benchmark Monitoring Parameter for the Electronic and Electrical Equipment and Components Except Computers (SIC 3612–3699) Subsector of Sector AC—Electronic, Electrical, Photographic, and Optical Goods Sector.
- Electronic monitoring data reporting options will be available for filing all monitoring data, including follow-up monitoring data. In addition, it will be possible to file reports of unauthorized discharges electronically. All electronic reporting will be through the eNOI Center system.

Industry Sector-specific Requirements

- The organization of Sector G—Metal Mining requirements has been revised. Additional information has been added regarding contaminated seeps and springs discharging from waste rock dumps; final stabilization; management, inspection, maintenance, and cessation of clearing, grading, and excavation activities; site map requirements; and monitoring frequency.
- Management, inspection, maintenance, and cessation requirements for clearing, grading, and excavation activities have been added to Sector J—Mineral Mining and Dressing.
- Additional information has been added to Sector M—Automobile Savage Yards to include the inspection of areas where hazardous materials are stored and the proper handling of mercury-containing automotive switches.
- Added information on mercury spill kits to Sector N—Scrap Recycling and Waste Recycling Facilities.
- Added text to include illicit plumbing connections and a SWPPP requirement to include specific good housekeeping control measures used in each of the facility areas in Sector P—Land Transportation and Warehousing.
- Requirements have been added to Sector S—Air Transportation for emphasizing BMPs, facility inspections, specific good housekeeping control measures requirements, vehicle and equipment washwater requirements, and monitoring during the deicing

season and for describing controls used for collecting or containing contaminated melt water from collection areas used for disposal of contaminated snow.

- Added electrical and electronic equipment and components to Sector AC—Electronic and Electrical Equipment and Components, Photographic and Optical Goods.

C. Permit Appeal Procedures

Within 120 days following notice of EPA's final decision for the general permit under 40 CFR 124.15, any interested person may appeal the permit in the Federal Court of Appeals in accordance with Section 509(b)(1) of the CWA. Persons affected by a general permit may not challenge the conditions of a general permit as a right in further Agency proceedings. They may instead either challenge the general permit in court, or apply for an individual permit as specified at 40 CFR 122.21 (and authorized at 40 CFR 122.28), and then petition the Environmental Appeals Board to review any conditions of the individual permit (40 CFR 124.19 as modified on May 15, 2000, 65 FR 30886).

III. Executive Order 12866

Under Executive Order 12866 (58 FR 51735 (October 4, 1993)) the Agency must determine whether the regulatory action is "significant" and therefore subject to OMB review and the requirements of the Executive Order. The Order defines "significant regulatory action" as one that is likely to result in a rule that may: (1) Have an annual effect on the economy of $100 million or more or adversely affect in a material way the economy, a sector of the economy, productivity, competition, jobs, the environment, public health or safety, or State, local, or Tribal governments or communities; (2) create a serious inconsistency or otherwise interfere with an action taken or planned by another agency; (3) materially alter the budgetary impact of entitlements, grants, user fees, or loan programs or the rights and obligations of recipients thereof; or (4) raise novel legal or policy issues arising out of legal mandates, the President's priorities, or the principles set forth in the Executive Order. OMB has exempted review of NPDES general permits under the terms of Executive Order 12866.

IV. Regulatory Flexibility Act

The Regulatory Flexibility Act (RFA) generally requires an agency to prepare a regulatory flexibility analysis of any rule subject to notice and comment rule-making requirements under the Administrative Procedures Act or any other statute unless the agency certifies that the rule will not have a significant economic impact on a substantial number of small entities. Small entities include small businesses, small organizations, and small governmental jurisdictions.

Issuance of an NPDES general permit is not subject to rulemaking requirements, including the requirement for a general notice of proposed rulemaking, under APA section 553 or any other law, and is thus not subject to the RFA requirements.

The APA defines two broad, mutually exclusive categories of agency action—"rules" and "orders". Its definition of "rule" encompasses "an agency statement of general or particular applicability and future effect designed to implement, interpret, or prescribe law or policy or describing the organization, procedure, or practice requirements of an agency * * *" APA section 551(4). Its definition of "order" is residual: "a final disposition * * * of an agency in a matter other than rule making but including licensing." APA section 551(6) (emphasis added). The APA defines "license" to "include * * * an agency permit * * *" APA section 551(8). The APA thus categorizes a permit as an order, which by the APA's definition is not a rule. Section 553 of the APA establishes "rule making" requirements. The APA defines "rule making" as "the agency process for formulating, amending, or repealing a rule." APA section 551(5). By its terms, then, section 553 applies only to "rules" and not also to "orders," which include permits.

V. Unfunded Mandates Reform Act

Title II of the Unfunded Mandates Reform Act of 1995 (UMRA), Public Law 104–4, establishes requirements for Federal agencies to assess the effects of their "regulatory actions" on State, local, and tribal governments and the private sector. UMRA uses the term "regulatory actions" to refer to regulations. (See, *e.g.*, UMRA section 201, "Each agency shall * * * assess the effects of Federal regulatory actions * * * (other than to the extent that such regulations incorporate requirements specifically set forth in law)" (emphasis added)). UMRA section 102 defines "regulation" by reference to 2 U.S.C. 658 which in turn defines "regulation" and "rule" by reference to section 601(2) of the Regulatory Flexibility Act (RFA). That section of the RFA defines "rule" as "any rule for which the agency publishes a notice of proposed rulemaking pursuant to section 553(b) of [the Administrative Procedure Act (APA)], or any other law. * * *"

As discussed in the RFA section of this notice, NPDES general permits are not "rules" under the APA and thus not subject to the APA requirement to publish a notice of proposed rulemaking. NPDES general permits are also not subject to such a requirement under the CWA. While EPA publishes a notice to solicit public comment on draft general permits, it does so pursuant to the CWA section 402(a) requirement to provide "an opportunity for a hearing." Thus, NPDES general permits are not "rules" for RFA or UMRA purposes.

VI. Paperwork Reduction Act

EPA has reviewed the requirements imposed on regulated facilities resulting from the proposed Multi-Sector General Permit under the Paperwork Reduction Act of 1980, 44 U.S.C. 3501 *et seq.* The information collection requirements of the Multi-Sector General Permit have already been approved by the Office of Management and Budget (OMB) (OMB Control No. 2040–0188) in previous submissions made for the NPDES permit program under the provisions of the Clean Water Act.

Authority: Clean Water Act, 33 U.S.C. 1251 *et seq.*

Dated: November 16, 2005.

Linda M. Murphy,

Director, Office of Ecosystem Protection, EPA Region 1.

Dated: November 16, 2005.

Carl-Axel P. Soderberg,

Division Director, Caribbean Environmental Protection Division, EPA Region 2.

Dated: November 15, 2005.

Jon M. Capacasa,

Director, Water Protection Division, EPA Region 3.

Dated: November 21, 2005.

Jo Lynn Traub,

Director, Water Division, EPA Region 5.

Dated: November 15, 2005.

Miguel I. Flores,

Director, Water Quality Protection Division, EPA Region 6.

Dated: November 4, 2005.

Alexis Strauss,

Director, Water Division, EPA Region 9.

Dated: November 17, 2005.

Robert R. Robichaud,

Associate Director, Office of Water and Watersheds, EPA Region 10.

[FR Doc. E5–6721 Filed 11–30–05; 8:45 am]

BILLING CODE 6560–50–P

U.S. Environmental Protection Agency
2006 Proposed Reissuance of

National Pollutant Discharge Elimination System (NPDES) Stormwater Multi-Sector General Permit for Industrial Activities Fact Sheet

AGENCY: Environmental Protection Agency (EPA)
ACTION: Notice of Proposed NPDES general permit

A012734

Summary

The Regional Administrators of EPA Regions 1, 2, 3, 5, 6, 9, and 10 are today proposing a reissuance of EPA's NPDES Stormwater Multi-Sector General Permit (MSGP). This general permit, MSGP 2006, when finalized, will replace the MSGP 2000, which was issued on October 30, 2000 (65 FR 64746), and expired on October 30, 2005.

Public Comment

EPA is soliciting comment on the proposed MSGP 2006. Comments on any provision of the permit, or comments on the fact sheet discussion are welcome. The comment period is open for 45 days from publication of this Notice in the Federal Register. Comments may be submitted to EPA in the following ways:

- EPA Dockets. Your use of EPA's electronic public docket to submit comments to EPA electronically is EPA's preferred method for receiving comments. Go directly to EPA Dockets at http://www.epa.gov/edocket, and follow the online instructions for submitting comments. Once in the system, select "search", and then key in Docket ID No. OW-2005-0007. The system is an "anonymous access" system, which means EPA will not know your identity, e-mail address, or other contact information unless you provide it in the body of your comment.
- E-mail. Comments may be sent by electronic mail (e-mail) to ow-docket@epa.gov, Attention Docket ID No. OW-2005-0007. In contrast to EPA's electronic public docket, EPA's e-mail system is not an "anonymous access" system. If you send an e-mail comment directly to the Docket without going through EPA's electronic public docket, EPA's e-mail system automatically captures your e-mail address. E-mail addresses that are automatically captured by EPA's e-mail system are included as part of the comment that is placed in the official public docket, and made available in EPA's electronic public docket.
- Disk or CD-ROM. You may submit comments on a disk or CD-ROM that you mail to the mailing address identified in Section I.B.2. These electronic submissions will be accepted in Microsoft Word or ASCII file format. Avoid the use of special characters and any form of encryption.
- By Mail. Send the original and three copies of your comments to: Water Docket, Environmental Protection Agency, Mailcode: 4101T, 1200 Pennsylvania Ave., NW., Washington, DC, 20460, Attention Docket ID No. OW-2005-0007.
- By Hand Delivery or Courier. Deliver your comments to: Public Reading Room, Room B102, EPA West Building, 1301 Constitution Avenue NW., Washington, DC 20004, Attention Docket ID No. OW-2005-0007. Such deliveries are only accepted during the Docket's normal hours of operation as identified on the next page under "Addresses."

Addresses

The index to the administrative record for the proposed reissued MSGP is available at the appropriate Regional Office or from the EPA Water Docket Office in Washington, DC. The administrative record, including documents immediately referenced in this proposed reissuance and applicable documents used to support the MSGP 2006 and the prior issuances of the MSGP in 1995 and 2000, is stored at the EPA Water Docket Office at the following address: U.S. Environmental Protection Agency, EPA Docket Center (EPA/DC), Water Docket, MC4101T, 1200 Pennsylvania Avenue NW, Washington, DC 20460. The records are available for inspection from 9 a.m. to 4 p.m., Monday through Friday, excluding legal holidays. For appointments to examine any portion of the administrative record, please call the Water Docket Office at 202-566-2426. A reasonable fee may be charged for copying. Specific record information can also be made available at the appropriate Regional Office upon request.

For Further Information

For further information on the proposed MSGP, contact the appropriate EPA Regional Office. Contact information is available through the Internet on EPA's Office of Wastewater Management website at http://www.epa.gov/npdes/stormwatercontacts.

Supplemental Information

This fact sheet explains and provides additional details on the topics covered in the MSGP. The actual language of the proposed MSGP 2006 appears after this fact sheet. Many provisions of the proposed MSGP 2006 originated with previous permits. Therefore, additional discussion on many MSGP requirements can be found in fact sheets for the 1995 and 2000 MSGPs.

Contents

1. Background

Section 405 of the Water Quality Act of 1987 (WQA) added section 402(p) of the Clean Water Act (CWA), which directed the Environmental Protection Agency (EPA) to develop a phased approach to regulate stormwater discharges under the National Pollutant Discharge Elimination System (NPDES) program. EPA published a final regulation on the first phase on this program on November 16, 1990, establishing permit application requirements for "stormwater discharges associated with industrial activity." EPA defined the term "stormwater discharge associated with industrial activity" in a comprehensive manner to cover a wide variety of facilities.

The Regional Administrators of EPA Regions 1, 2, 3, 5, 6, 9 and 10 are today proposing to reissue EPA's NPDES Stormwater Multi-Sector General Permit (MSGP). The MSGP currently authorizes stormwater discharges associated with industrial activity for most areas of the United States that are not authorized to administer the NPDES permit program. The initial MSGP was issued on September 29, 1995 (60 FR 50804), and amended on February 9, 1996 (61 FR 5248), February 20, 1996 (61 FR 6412), September 24, 1996 (61 FR 50020), August 7, 1998 (63 FR 42534), and September 30, 1998 (63 FR 52430). The current MSGP was issued on October 30, 2000 (65 FR 64746), after being proposed on March 30, 2000 (65 FR 17010). MSGP 2000 was subsequently corrected on January 9, 2001 (66 FR 1675-1678) and March 23, 2001 (66 FR 16233-16237). On April 16, 2001 (66 FR 19483-19485) EPA re-issued the permit, as corrected, for facilities in certain areas of Regions 8 and 10.

2. Changes from MSGP 2000

The organization of today's proposed MSGP has been changed substantially from the MSGP 2000. Parts 1, 2 and 3 of today's proposed MSGP 2006 contain provisions common to all discharges. Part 4 details the industrial sector-specific requirements, and Part 5 details the State- and Tribe-specific requirements. The permit also includes appendices for: definitions and acronyms (Appendix A); standard permit conditions (Appendix B); areas covered (Appendix C); activities covered (Appendix D); Endangered Species Act procedures (Appendix E); National Historical Places Act procedures (Appendix F); Notice of Intent requirements and form (Appendix G); and Notice of Termination (NOT) (Appendix H). These appendices were extracted from the general permit body as one-time per permit term references for permitted facilities, unless substantial changes in industrial activities are undertaken during the active permit term. The intent of the reorganization was to simplify the process of determining requirements for the permitted facilities by placing the core requirements into the main permit body.

A detailed list of proposed changes from MSGP 2000 is included below. A discussion of notable differences is provided in Chapter 3 of this Fact Sheet.

2.1 MSGP 2006 Part 1

1. Simplified co-located activity discussion (Part 1.2.1)
2. Makes a clearer distinction between eligibility requirements (Part 1.2) and permit compliance (Part 1.3).
3. Added description that generic pH range limits not included to address a known exceedance covered under an individual permit or alternative general permit could be covered under the MSGP (Part 1.2.4.3 [MSGP 2000 Parts 1.2.3.3.2 and 1.2.3.3.2.1])
4. Added description that discharges previously covered by an individual permit or alternative general permit where the permittee fails to implement BMPs that provide equal or better pollution prevention or pollutant removal required by the previous permit are not authorized (Part 1.2.4.3 [MSGP 2000 Parts 1.2.3.3.2 and 1.2.3.3.2.2])
5. Clarified that facility discharges are not authorized when a Total Maximum Daily Load (TMDL) specifically articulates a Wasteload Allocation (WLA) requiring more stringent controls than can be achieved under MSGP 2006, or when a TMDL applies a WLA of zero (0) to the facility's discharge (Part 1.2.4.4)
6. Added specific eligibility provisions in lieu of an ambiguous eligibility requirement for new discharges to impaired waters without TMDLs (Part 1.2.4.9)
7. Deleted information on initiating a new source review and on NEPA requirements after state assumption of the MSGP ([MSGP 2000 Parts 1.2.4.2, 1.2.4.3]

8. Revised and clarified water quality provisions and discharge standards: Numeric Effluent Limitations (Part 1.4.1), Benchmarks (Part 1.4.2), and Water Quality Standards (Part 1.4.3)
9. Clarified what a facility must do when there is a determination that a facility's discharge does not comply with applicable water quality standards (Part 1.4.3)
10. Added information on coverage under the MSGP for discharges of pollutants of concern to waters for which there is a Total Maximum Daily Load (TMDL); emphasized verification of compliance with a wasteload allocation (WLA) through monitoring (Part 1.4.4.1)
11. Added information on coverage under the MSGP for discharges to an impaired water without an established TMDL (Part 1.4.4.2)
12. Clarified that NOIs must be submitted in accordance with the deadlines specified in Table 1-2 of the permit (Part 1.5.1) and added Table 1-2
13. Changed authorization to discharge from 2 days to 30 days after EPA posts a facility's complete NOI on the e-NOI website (Part 1.5.2)
14. Described the exact time of termination and requirement for still complying with the conditions of the permit until an NOT is submitted (Part 1.6.1)

2.2 MSGP 2006 Part 2

1. Added SWPPP site description requirements of impervious surface estimate and precipitation information (Part 2.1.2)
2. Added description of the locations of surface water bodies requirements to be included in the site description (Part 2.1.3 [MSGP 2000 Part 4.2.2.3.3])
3. Included a requirement to determine relevant water quality standards, TMDLs and impaired water status for receiving waters (Parts 2.1.3.1 and 2.1.3.2)
4. Emphasized that facilities are responsible to include a description of location and source of run-on from adjacent property, and to evaluate how those sources impact the quality of discharges from the facility (Part 2.1.2 [MSGP 2000 Part 4.2.2.3.10])
5. Added requirement that if a facility discharges through a municipal separate storm sewer system (MS4), the facility must identify the operator of that MS4 and the receiving water body (Part 2.1.3 [MSGP 2000 Part 4.2.3])
6. Changed notification deadline from 180 days to 14 days when a facility is unable to provide the certification required for the elimination of unauthorized discharges (Part 2.1.4.4 [MSGP 2000 Part 4.4.1.3])
7. Added salt storage as a category under potential pollutant sources (Part 2.1.4.6)
8. Updated information to consider when selecting BMPs (Part 2.1.5 [MSGP 2000 Parts 4.2.7.1.1 through 4.2.7.1.2])

9. Added a reference to the *Guidance Manual for Conditional Exclusion from Stormwater Permitting Based on "No Exposure" of Industrial Activities to Stormwater* (Part 2.1.5.2 [MSGP 2000 Part 4.2.7.2.1.2])

10. Clarified that regular preventive maintenance measures are distinct from specific BMP improvement needs discovered during inspections or as a result of monitoring (Part 2.1.5.3 [MSGP 2000 Part 4.2.7.2.1.3])

11. Added examples of preventive measures for spills (Part 2.1.5.4)

12. Clarified spill response procedures and added new requirement that employees who may cause, detect or respond to a spill or leak must be trained in these procedures and have necessary spill response equipment available. Also, if possible, one of these individuals should be a member of the facility's Pollution Prevention Team. Added requirement for including in the SWPPP contact information for individuals and agencies that must be notified in the event of a spill (Part 2.1.5.4 [MSGP 2000 Part 4.2.7.2.1.4])

13. Added requirement for documenting in the SWPPP all training sessions and the employees who received the training (Part 2.1.5.6 [MSGP 2000 Part 4.2.7.2.1.6])

14. Deleted outdated reference to the User's Guide to the MSGP-2000 (MSGP 2000 Part 4.2.7.2.2.2)

15. Added that if repairs to existing BMPs that are not operating effectively cannot be performed prior to the next anticipated rainfall, that back-up measures must be in place, and justification for the extended repair schedule be included in the SWPPP (Part 2.2 [MSGP 2000 Part 4.3])

16. Changed deadline for completion of BMP modification or addition to be within 60 days instead of 12 weeks after discovery of any deficiency or discharge standard exceedance. Added an opportunity to have EPA approve an extended deadline when appropriate. (Parts 2.3 [MSGP 2000 Part 4.9.3])

17. Deleted requirement of including a copy of the permit in the facility's SWPPP (MSGP 2000 Part 4.7)

18. Clarified SWPPP availability requirements (Part 2.4 [MSGP 2000 Part 8.2])

2.3 MSGP 2006 Part 3

1. Defined "qualified personnel" (Part 3.1.2 [MSGP 2000 Part 4.2.7.2.1.5])

2. Clarified, as part of the comprehensive site compliance evaluation, that outfall or discharge location inspections include looking for evidence of pollutants discharging to surface waters at facility outfall(s) and the condition of and around the outfall, including flow dissipation measures to prevent scouring (Part 3.1.3 [MSGP 2000 Part 4.9.2])

3. Added modifications to quarterly benchmark monitoring scheduling, based on precipitation patterns (Part 3.2.2.1)

4. Moved initiation of quarterly benchmark monitoring from the 2nd year of permit coverage to the 1st year of permit coverage (Part 3.2.2.1 [MSGP 2000 5.1.2.1])

5. Modified the benchmark monitoring requirements such that no additional benchmark monitoring is required (for a given pollutant) when, following 4 quarters of monitoring, the average of the 4 quarterly samples does not exceed the benchmark (Part 3.2.2.3 [MSGP 2000 5.1.2.2])

6. In MSGP 2000 an additional 4 quarters of benchmark monitoring was required in year 4 when the average of the year 2 monitoring exceeded the benchmark. In the proposed MSGP 2006 an additional 4 quarters of monitoring commences in the 2nd year of permit coverage if the average of the 1st year monitoring exceeds the benchmark, if the operator determines that modifications to the SWPPP are necessary, and once corrective actions have been implemented (Part 3.2.2.4 [MSGP 2000 5.1.2.1])

7. Clarified the provision to review the SWPPP after the average of the 4 monitoring values exceeds the benchmark, and determine if improvements to the SWPPP and BMPs are needed. Added a provision to make a determination that modifications are not needed, in which case the justification must be included in the SWPPP, and monitoring may be reduced to once per year. When modifications are needed, corrective actions must be taken and an additional 4 quarter of monitoring undertaken (Part 3.2.2.4)

8. Extended the benchmark monitoring waiver to any inactive and unstaffed site, not just those remote facilities where monitoring is not feasible, but added the prerequisite that no industrial materials or activities be exposed to stormwater (Part 3.2.2.5 [MSGP 2000 Part 5.1.2.3])

9. Added a requirement for monitoring applicable pollutants of concern in discharges to impaired waters (Part 3.2.5)

10. Updated requirement of storm event total volume data to be reported in liters instead of gallons (Part 3.2.6.2 [MSGP Part 5.2.3])

11. Added a specific section to clarify the requirement to take immediate corrective action when there is an exceedance of an effluent limitation, a water quality standard, or other limitation stipulated in Part 5; when inspections or evaluations identify inadequacies in stormwater controls, or; when the SWPPP review following a benchmark exceedance (average of 4 monitoring events) reveals inadequacies (Part 3.3)

12. Deleted additional reporting for dischargers to a large or medium municipal separate storm sewer system (MSGP 2000 Part 7.2)

13. Added follow-up monitoring requirements for pollutants with effluent limitation guidelines, coalpile runoff and wasteload allocations (pollutants for which only annual monitoring is otherwise required) when results indicate discharge exceeds the numeric effluent limitation, or when the discharge has been found to cause or contribute to a water quality standard exceedance, to verify that BMPs have been adequately modified to protect water quality (Part 3.4)

14. Added requirements for reporting results of follow-up monitoring exceedances (Part 3.4)

15. Added requirement for facilities' administrative records to accurately reflect a traceable historical record of BMP installation, maintenance, monitoring results, and revision of practices and data collected to support continued maintenance of those practices or their

abandonment in lieu of more effective control mechanisms (Part 3.6 [MSGP 2000 Part 8.1])

16. Updated information for Region 4 indicating that coverage is not available under this permit (Part 3.7.4 [MSGP 2000 Part 8.3.4])
17. Updated information for Region 5 indicating that coverage will be available under this permit (Part 3.7.5 [MSGP 2000 Part 8.3.5])
18. Updated information for Region 6 indicating that coverage is not available under this permit for Arkansas (Part 3.7.6 [MSGP 2000 Part 8.3.6])
19. Updated information for Region 8 indicating that coverage is not available under this permit (Part 3.7.8 [MSGP 2000 Part 8.3.4])
20. Updated Region 10 states to include Alaska (Part 3.7.10 [MSGP 2000 Part 8.3.10])

2.4 MSGP 2006 Part 4 (Specific Requirements for Industrial Activity [MSGP 2000 Section 6, Sector-Specific Requirements for Industrial Activity])

All information previously included in Section 6, "Sector-Specific Requirements for Industrial Activity," is now in Part 4, "Specific Requirements for Industrial Activity." The content of this section has also been updated, as detailed below.

1. The Benchmark Monitoring Requirement for Total Suspended Solids (TSS) was added to each Sector where it was not otherwise included in the MSGP 2000. It should be noted that monitoring for this parameter is required for the sectors and subsectors that did not have any benchmark monitoring requirements in the MSGP 2000 in addition to those sectors and subsectors that did have benchmark monitoring requirements in the MSGP 2000. These sectors and subsectors that previously did not have benchmark monitoring requirements are listed below.

   I. Oil and Gas Extraction and Refining

   P. Land Transportation and Warehousing

   R. Ship and Boat Building and Repairing Yards

   T. Treatment Works

   V. Textile Mills, Apparel, and Other Fabric Product Manufacturing; Leather and Leather Products

   W. Furniture and Fixtures

   X. Printing and Publishing

   Y. Rubber, Miscellaneous Plastic Products, and Miscellaneous Manufacturing Industries

Z. Leather Tanning and Finishing

AB. Transportation Equipment, Industrial or Commercial Machinery

AC. Electronic, Electrical, Photographic, and Optical Goods

AD. Non-classified Facilities

2. New benchmarks for chromium and phenols were added to the wood preserving (SIC 2491) subsector of sector A, timber products.

3. New benchmarks for ammonia, lead, nickel, zinc and nitrate-nitrite nitrogen were added to sector I, oil and gas extraction and refining.

4. A new benchmark for lead was added to the rubber manufacturing subsectors of sector Y, rubber, miscellaneous plastic products, and miscellaneous manufacturing industries: Tires and Inner Tubes; Rubber Footwear; Gaskets, Packing and Sealing Devices, and Rubber Hoses and Belting; and Fabricated Rubber Products, Not Elsewhere Classified (SIC 3011-3069, rubber manufacturing only).

5. New benchmarks for copper and lead were added to the electronic and electrical equipment and components except computers (SIC 3612-3699) subsector of sector AC, electronic, electrical, photographic, and optical goods.

6. Updated description of India ink and water colors (Part 4.C.2.7 [MSGP 2000 Part 6.C.2.7)

7. Changed inspection frequency to monthly (Part 4.F.3.4 [MSGP 2000 Part 6.F.3.4])

8. Facility information updated (Part 4.G.1 [MSGP 2000 Part 6.G.1])

9. Added information on covered discharges from exploration and development of metal mining and/or ore dressing facilities (Part 4.G.1.3)

10. Added information on covered discharges from facilities at mining sites and undergoing reclamation (Part 4.G.1.4)

11. Added information on reclamation of mining sites (Part 4.G.2.3)

12. Included discussion of contaminated seeps and spring discharging from waste rock dumps (Part 4.G.3.2 [MSGP 2000 Part 6.G.3.2])

13. Changed text from "Exploration and Construction Phase" to "Exploration and Development Phase" (Part 4.G.4.2 [MSGP 2000 Part 6.G.4.2])

14. Added text on final stabilization (Part 4.G.4.8)

15. Simplified text on clearing, grading, and excavation activities (Part 4.G.5 [MSGP 2000 Part 6.G.5])

16. Deleted text describing activities disturbing 5 or more acres of earth ([MSGP 2000 Part 6.G.5.1]) and on cessation or earth-disturbing activities ([MSGP 2000 Part 6.G.5.2])

17. Added text on management practices for clearing, grading, and excavation activities (Part 4.G.5.1), requirements for inspection of clearing, grading, and excavation activities

(4.G.5.2), maintenance of controls for clearing, grading, and excavation activities (4.G.5.3), and requirements for cessation of clearing, grading, and excavation activities (4.G.5.4)

18. Clarified Stormwater Pollution Prevention Plan (SWPPP) requirements (Part 4.G.6 [MSGP 2000 Part 6.G.6])

19. Removed requirement of including acreage estimates under nature of industrial activities (Part 4.G.6.1 [MSGP 2000 Part 6.G.6.1.1])

20. Site map requirements clarified to include locations of all permitted discharges covered under an individual NPDES permit, outdoor equipment storage, materials handling areas, outdoor storage, outdoor chemicals, and reclaimed areas (Part 4.G.6.2 [MSGP 2000 Part 6.G.6.1.2])

21. Changed site inspection requirements to quarterly inspections unless adverse weather conditions make the site inaccessible and monthly inspections of outstanding waters or waters which are impaired for parameters listed in Table G-2 (Part 4.G.6.4 [MSGP 2000 Part 6.G.6.1.4])

22. Added documentation requirement of employee training requirement in SWPPP (Part 4.G.6.5 [MSGP 2000 Part 6.G.6.1.5])

23. Deleted requirement of explaining why one or more of the BMPs listed are not appropriate for a particular facility (Part 4.G.6.6 [MSGP 2000 Part 6.G.6.1.6])

24. Updated treatment of stormwater runoff requirements (Part 4.G.6.6.5 [MSGP 2000 Part 6.G.6.1.6.5])

25. Clarified that all outfalls covered under the MSGP must be tested or evaluated (Part 4.G.6.6.6 [MSGP 2000 Part 6.G.6.1.6.6])

26. Deleted SWPPP requirements for inactive metal mining facilities ([MSGP 2000 Part 6.G.6.2])

27. Title updated to include inactive sites and sites undergoing reclamation; updated monitoring frequency requirements to include analytic monitoring quarterly in the first year of coverage for the parameters listed in Table G-2 and G-3; samples must be collected as specified (Part 4.G.7.2 [MSGP 2000 Part 6.G.7.2])

28. Monitoring of discharges from waste rock and overburden piles frequency changed from twice per year for the permit term to quarterly in the first year of coverage (Part 4.G.7.3 [MSGP 2000 Part 6.G.7.2.1])

29. Added termination of permit coverage requirements (Part 4.G.8)

30. Added additional discussion on stormwater discharges subject to effluent limitation guidelines (Part 4.I.3.1 [MSGP 2000 Part 6.I.3.1.7])

31. Changed "Good Housekeeping Measures" to "Contact with Waste Water Pollutants at Exploration and Production Facilities" and added descriptive text (Part 4.I.4.5 [MSGP 2000 Part 6.I.4.5])

32. Added covered discharges from inactive facilities (Part 4.J.1.1), covered discharges from active and temporarily inactive facilities (Part 4.J.1.2), covered discharges from exploration and development of metal mining facilities (Part 4.J.1.3), covered discharges from facilities at mining sites and undergoing reclamation (Part 4.J.1.4), prohibition of stormwater discharges (Part 4.J.3.1), prohibition of non-stormwater discharges (Part 4.J.3.2), and final stabilization (Part 4.J.4.8)

33. Added reclamation of mining sites under "Industrial Activities covered by Sector J" (Part J.2.3)

34. Simplified clearing, grading, and excavation activities (Part 4.J.5 [MSGP 2000 Part 6.J.5])

35. Deleted text on obtaining coverage under the Construction General Permit ([MSGP 2000 Part 6.J.5.1]) and cessation of exploration and construction activities ([MSGP 2000 Part 6.J.5.2])

36. Added management practices for clearing, grading, and excavation activities (Part 4.J.5.1), requirements for inspection of clearing, grading, and excavation activities (Part 4.J.5.2), maintenance of controls for clearing, grading, and excavation activities (Part 4.J.5.3), and requirements for cessation of clearing, grading, and excavation activities (Part 4.J.5.4)

37. Clarified Stormwater Pollution Prevention Plan (SWPPP) requirements (Part 4.J.6 [MSGP 2000 Part 6.J.6])

38. Deleted inspection requirements ([MSGP 2000 Part 6.J.6.1])

39. Added nature of industrial activities (Part 4.J.6.1), site map (Part 4.J.6.2), potential pollutant sources (Part 4.J.6.3), site inspections (Part 4.J.6.4), employee training (Part 4.J.6.5), stormwater controls (Part 4.J.6.6)

40. Simplified limitations on coverage (Part 4.K.3 [MSGP 2000 Part 6.K.3]) and moved some text to Part 4.K.3.2

41. Updated inspection frequency to monthly and added information to include inspection of areas where hazardous materials, including mercury switches, and general automotive fluids are stored (Part 4.M.3.4 [MSGP 2000 Part 6.M.3.4])

42. Updated employee training to include proper handling of mercury-containing contact switches (Part 4.M.3.5 [MSGP 2000 Part 6.M.3.5])

43. Added suggestion for mercury spill kits for spills from storage of mercury switches as a good housekeeping measure for scrap and waste recycling facilities as part of the Scrap and Waste Material Stockpiles and Storage (Covered or Indoor Storage) (Part N.4.2.4 [MSGP 2000 Part N.4.2.4])

44. Added suggestion for using a mercury spill kit for any release of mercury from switches, anti-lock brake systems, and switch storage areas (Part N.4.2.7 [MSGP 2000 Part N.4.2.7])

45. Added suggestion for mercury spill kit and emphasis on not vacuuming spilled or leaking mercury to BMP options for waste recycling facilities as part of the Waste Material Storage (Indoor) (Part N.4.3.1 [MSGP 2000 Part N.4.3.1])

46. Changed "Quarterly Inspections" to "Inspections" for consistency, changed the frequency of inspections to monthly, and changed "Quarterly Inspection Program" to "Inspections" (Part 4.N.4.3.4 [MSGP 2000 Part 6.N.4.2.8])

47. Added additional descriptive text (Part 4.P.1 [MSGP 2000 Part 6.P.1])

48. Added detailed description of facilities covered (Part 4.P.2 [MSGP 2000 Parts 6.P.2, 6.P.2.1, and 6.P.2.2

49. Added special coverage conditions (Part 4.P.3)

50. Updated text to include illicit plumbing connections between shop floor drains and the stormwater conveyance system(s) (Part 4.P.4.2 [MSGP 2000 Part 6.P.3.2])

51. Added requirement for SWPPP to describe specific good housekeeping control measures used in each of the facility areas (Part 4.P.4.3 [MSGP 2000 Part 6.P.3.3])

52. Added description of types of facilities (Part S.1 [MSGP 2000 Part 6.S.1])

53. Examples added (Part 4.S.2 [MSGP 2000 Part 6.S.2])

54. Deicing season requirements added (Part 4.S.4.2.1)

55. Added requirement that SWPPP must describe the specific good housekeeping control measures used in each of the facility areas (Part 4.S.4.3 [MSGP 2000 Part 6.S.5.3])

56. Requirement added for describing the controls used for collecting or containing contaminated melt water from collection areas used for disposal of contaminated snow (Part 4.S.4.3.7 [MSGP 2000 Part 6.S.5.3])

57. Added vehicle and equipment washwater requirements (Part 4.S.4.6)

58. Specified that the frequency of inspection is monthly (Part 4.U.4.3 [MSGP 2000 Part 6.U.4.3])

59. Added electrical and electronic equipment and components (Part 4.AC.2.5)

60. Simplified text under covered stormwater discharges (Part 4.AD.1 [MSGP 2000 Part 6.AD.1]) and under eligibility for permit coverage (Part 4.AD.1.1 [MSGP 2000 Part 6.AD.1.1])

2.5 MSGP Part 5 (Permit Conditions Applicable to Specific States, Indian Country Lands, and Territories [MSGP 2000 Part 13])

Permit conditions applicable to specific States, Indian Country Lands, and Territories will be provided by those entities prior to finalization of this permit as their Clean Water Act § 401 certifications.

2.6 MSGP 2006 Appendix A (Definitions and Acronyms, Part A.1 [MSGP 2000 Part 12], Part A.2 [MSGP 2000 Addendum G])

A.1 - Several definitions were deleted, some were added, and some were changed (see below). In addition overall minor changes were made, including replacing "means" with a hyphen and removing the quotation marks around the word defined.

The following definitions were deleted:

- Commencement of construction
- CWA
- Discharge of stormwater associated with construction activity
- Discharge of stormwater associated with industrial activity
- Flow-weighted composite sample
- Large and medium municipal storm sewer systems
- NOI
- NOT

The following definitions were added:

- Co-located industrial activities
- Control measure
- Discharge of a pollutant
- New discharger
- New source
- Person
- Primary industrial activity
- Significant materials

The definitions for industrial activity and industrial stormwater were slightly revised to remove extraneous language.

The definition for municipal storm sewer system was completely revised.

The definition for pollutant was revised to include incinerator residue, filter backwash, munitions, and agricultural waste discharged into water

Stormwater associated with industrial activity was completely revised and now is stormwater discharges associated with industrial activity

A.2 - Several abbreviations and acronyms were deleted and some were added (see below).

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The following abbreviations and acronyms were deleted:

- CNMI
- DEQ
- GPCA
- LOEL
- MRF
- MSWLF
- PPED
- SWQB

The following abbreviation and acronyms were added:

- BAT
- BOD5
- COD

2.7 MSGP 2006 Appendix B (Standard Permit Conditions [MSGP 2000 Part 9])

Added text describing the standard permit conditions in Appendix B (Appendix B [MSGP 2000 Part 9]

Clarified penalties for a second or subsequent conviction for a negligent violation (Part B.1.B.1.1.1 [MSGP 2000 Part 9.1.2.1.1])

Clarified penalties for a second or subsequent conviction for a knowing violation (Part B.1.B.1.1.2 [MSGP 2000 Part 9.1.2.1.2])

Clarified penalties for a second or subsequent conviction for knowing endangerment (Part B.1.B.1.1.3 [MSGP 2000 Part 9.1.2.1.3])

False statement information simplified to state that any person who falsifies, tampers with, or knowing renders inaccurate any monitoring device or method required to be maintained under the act will upon conviction be punished by various penalties; clarified penalties for any person who knowingly makes any false statement, representation, or certification in any record or other document submitted or required to be maintained under the permit (Part B.1.B.1.1.4, Part B.10.E [MSGP 2000 Part 9.1.2.1.4])

Maximum penalty amount updated for civil penalties to $32,500 per day for each violation. This is standard for NPDES program penalties, and not specific to MSGP. EPA is required to adjust civil and administrative penalties in accordance with the Civil Monetary Penalty Inflation Adjustment Rule (61 FR 252, December 31, 1996, pp. 69359-69366, as corrected in 62 FR 54, March 20, 1997, pp.13514-13517) as mandated by the Debt Collection Improvement Act of 1996 for inflation on a periodic basis. The Agency is required to review its penalties at least once every 4 years and to adjust them as necessary for inflation according to a specified formula. Additional information is available at: http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=2004_register&docid=fr13fe04-10.pdf (Part B.1.B.2 [MSGP 2000 Part 9.1.2.2])

Maximum Class I penalty amount updated to $32,500 per day for each violation (Part B.1.B.3.3.1 [MSGP 2000 Part 9.1.2.3.1])

Maximum Class II penalty supporting information updated (Part B.1.B.3.3.2 [MSGP 2000 Part 9.1.2.3.2])

Continuation of expired permit information rearranged and simplified under a heading of "duty to reapply" (Part B.2 [MSGP 2000 Part 9.2])

Duty to mitigate updated to include sludge use or disposal (Part B.4 [MSGP 2000 Part 9.4])

Emphasis on signing SWPPPs added and text rearranged (Parts B.11.B, B.11.B.1, B.11.B.2 [MSGP 2000 Parts 9.7.2, 9.7.2.1, 9.7.2.2, 9.7.2.3])

Deleted information on severability ([MSGP 2000 Part 9.11]), Director's notification ([MSGP 2000 Part 9.12.4]), and state/tribal environmental laws ([MSGP 2000 Part 9.13])

Inspection and entry information updated to allow only EPA or an authorized representative under this permit to inspect (Part B.9 [MSGP 2000 Part 9.15])

Clarified that inspection practices or operations regulated or required under this permit are to be inspected at reasonable times (Part B.9.C [MSGP 2000 Part 9.15.3])

Added text allowing EPA or an authorized representative to sample or monitor any substances or parameters at any location for the purposes of assuring permit compliance or otherwise authorized under the Clean Water Act at reasonable times (Part B.9.D)

Clarified that samples and measurements must be representative of the volume and nature of the monitored activity (Part B.10.A [MSGP 2000 Part 9.16.1])

Records retention requirements updated to include all calibration and maintenance records and all original strip chart recordings for continuous monitoring instrumentation, copies of all reports required by this permit, and records of all data used to complete the application for this permit; requirements updated so that permittees must submit records to the Director upon request (Part B.10.B, B.8 [MSGP 2000 Parts 9.16.2, 9.16.2.1])

Deleted retention of SWPPP information ([MSGP 2000 Part 9.16.2.2])

Record contents requirements updated so that the individual(s) who performed the sampling instead of sampler's initials must be included (Parts B.10.C.2, B.10.C.4 [MSGP 2000 Parts 9.16.3.2, 9.16.3.5]); deleted requirement for time(s) analyses were initiated ([MSGP 2000 Part 9.16.3.4])

Sludge use or disposal information added to monitoring results (Part B.10.D [MSGP 2000 Part 9.16.4])

Permit action information updated to include termination (Part B.6 [MSGP 2000 Part 9.17])

Transfer of permit coverage information simplified (Part B.12.C [MSGP 2000 Part 11.1])

Deleted Notice of Termination information on NPDES permit number ([MSGP 2000 Part 11.2.1]), name and address ([MSGP 2000 Part 11.2.3]), name and street address ([MSGP 2000 Part 11.2.4]), latitude and longitude ([MSGP 2000 Part 11.2.5]), certification ([MSGP 2000 Part 11.2.6]), addresses ([MSGP 2000 Part 11.3]), and facilities eligible for "No Exposure" exemption ([MSGP 2000 Part 11.4])

Added detailed reporting requirements for planned changes (Part B.12.A), anticipated noncompliance (Part B.12.B), monitoring reports (Part B.12.D), compliance schedules (Part B.12.E), twenty-four hour reporting (Part B.12.F), and other noncompliance (Part B.12.G)

Added bypass definitions (Part B.13.A.1), bypasses not exceeding limitations (Part B.13.B), notice of bypasses (Part B.13.C), and prohibited bypasses (Part B.13.D)

Added upset definition (Part B.14.A), effect of an upset (Part B.14.B), conditions necessary for a demonstration of an upset (Part B.14.C), and burden of proof (Part B.14.D)

2.8 MSGP 2006 Appendix C (Areas Covered [MSGP 2000 Part 1.1])

Updated information for Region 4 indicating that coverage is not available under this permit (Part C.4 [MSGP 2000 Part 1.1.4]

Updated information for Region 5 indicating that coverage will be available under this permit (Part C.5 [MSGP 2000 Part 1.1.5])

Updated information for Region 8 indicating that coverage is not available under this permit (Part C.8 [MSGP 2000 Part 1.1.8]

Updated Region 10 states to include Alaska (Part C.10 [MSGP 2000 Part 1.1.10])

2.9 MSGP 2006 Appendix D (Activities Covered [MSGP 2000 Part 1.2.1])

Clarified Sector K facilities to include those that are operating under interim status or a permit under subtitle C of RCRA

Clarified Sector L facilities as those facilities that receive or have received any industrial wastes including those that are subject to regulation under subtitle D of RCRA

Clarified Sector O facilities to include coal handling sites

Clarified Sector T facilities and described what facilities are not included such as farm lands and domestic gardens used for sludge management where sludge is beneficially reused and which are not physically located within the confines of the facility

Updated SIC codes for measuring, analyzing, and controlling instruments; photographic and optical goods, watches and clocks Subsector of Sector AC from 3812 to 3812 – 3873.

2.10 MSGP 2006 Appendix E (Endangered Species Act Procedures [MSGP 2000 Part 1.2.3.6 and Addendum A])

A new eligibility criterion for operators to consider that involves their independent coordination with the FWS or NMFS has been added. This coordination must address the effects of the operator's stormwater discharges on endangered species or critical habitat and must include a written statement from the Services that there will be no adverse effects on species or habitat.

2.11 MSGP 2006 Appendix F (National Historic Properties Act Guidance [MSGP 2000 Part 1.2.3.7 and Addendum B])

For today's MSGP 2006 reissuance, EPA has proposed the following modifications:

Criterion A was revised to specify that the discharger is certifying that its stormwater discharges and allowable non-stormwater discharges "do not have the potential to cause effects" to historic properties as specified in the National Historic Preservation Act (See 36 CFR 800.3(a)(1)). The previous language required that the discharger certify that its discharge or discharge-related activities "do not affect" historic properties. See Section 1.2.4.7. Further discussion is provided in Appendix F.

Another option (Criterion B) was added. You are eligible for coverage if your discharge-related activities (i.e., construction and/or installation of stormwater BMPs that involve subsurface disturbance) will not affect historic properties. This criterion is selected only if you have documented evidence that either no historic properties are present on your site or prior disturbance precluded the existence of historic properties. See Section 1.2.4.7. Further discussion is provided in Appendix F.

Criterion C (previously called Criterion B in the 2000 MSGP) was revised to require written agreements only where the discharge or discharge-related activities have the "potential to cause effects" to historic properties. This criterion now includes a reference to Tribal representatives because MSGP coverage extends to Tribal lands and Tribal representatives play a central role in the protection of historic resources. See Section 1.2.4.7. Further discussion is provided in Appendix F.

A fourth option (Criterion D) for obtaining permit coverage has been added. Permit coverage is granted if you have contacted the State Historic Preservation Officer, Tribal Historic Preservation Officer, or other tribal representative in writing regarding your potential to cause effects to an historic property, and you did not receive a response within 30 days. See Section 1.2.4.7. Further discussion is provided in Appendix F.

The Notice of Intent (NOI) form language has been modified to include the four criteria for permit coverage so that operators must identify which of the four options they are using to ensure eligibility for permit coverage under the MSGP.

The NHPA guidance has also been modified to reflect the above changes and appears in Appendix F rather than Addendum B.

2.12 MSGP 2006 Appendix G (Notice of Intent Components) [MSGP 2000 Section 2 and Addendum D]

Changes to the new form

- The new form asks simply for a Permit Number. The old form asked for a Permit Selection and a New Permit Number.

Under Facility Operator Information

- An IRS employer Information Number is now required.
- An e-mail address now required.
- A Fax number (optional) has been added

Under Facility/Site Information

- The phrase "This facility is □ New □ Existing If your facility is existing and you had coverage under the MSGP 2000, provide the Tracking Number" has been added.
- The "county" entry on the old permit has been expended in the new permit to "county or similar government subdivision."
- Latitude must now be specified in either 1. degrees, minutes, seconds; 2. degrees, minutes and decimals; or 3. decimal.
- Longitude must now be specified in 1. degrees, minutes, seconds; 2. degrees, minutes and decimals; or 3. decimal.
- Added "Is this facility federal? □ Yes □ No."
- Added that if the facility was located on Indian Country lands, provide the "name of reservation, or if not part of a reservation, put "Not Applicable."

- Applicants are now asked to "List the code that best represents your Standard Industrial Classification (SIC) Code(s) for your industrial activity."
- The subsection "*Stormwater Pollution Prevention Plan Contact Information and Location*" has been added. This section asks for "Name," "Location Address (street, city, state, zip code and URL address of stormwater prevention plan (if applicable)."
- Under the new *Endangered Species Act Eligibility* subsection, applicants must select the criterion that they satisfied their Endangered Species Act obligations under and are directed to Appendix E of the MSGP. In the old form, they were directed to Addendum A of the MSGP and did not have to select the criterion.
- In the same section, applicants must now choose from five criteria – A, B, C, D, E and F – to prove they've satisfied their ESA obligations.
- If applicants choose criterion F, they must "provide [the] permit tracking number of the operator under which you are certifying eligibility."
- A new subsection *National Historic Preservation Act Eligibility* has been added.
- Applicants must select the criterion that they satisfied their National Historic Preservation Act obligations under and are directed to "Appendix F of the MSGP" for instructions on these permit criteria. In the old form, they were directed to Addendum B of the MSGP and did not have to select the criterion.
- Under subsection *Certifier Name and Title*, applicants are now asked for their "Title."

Deletions from the old form

- The subsection "Permit Selection" has been eliminated.
- Removed "Permit Applicant: □ Federal □ State □ Tribal □ Private □ Other public entity."
- The 30 boxes that represented applicable sectors of industrial activity (Sector A though AD) have been replaced in the new form by a simplified 2-character data entry point.

2.13 MSGP 2006 Appendix H (Notice of Termination Components) [MSGP 2000 Section 11 and Addendum E]

Changes to the new form

- An "NPDES Permit Tracking Number" is now required. The old form asked for an NPDES Stormwater General Permit Number.
- Applicants are now given four choices to explain their reasons for terminating coverage: "A. You transferred operational control to another operator. B. You terminated facility operations. C. You obtained coverage under an alternative NPDES permit. D. You qualified for a No Exposure Exemption. If you answered yes to "D," you must fill out the No Exposure form instead of the NOT form." The old form had only two choices.

- Under subsection *Facility Operator Information*, applicants are asked for their IRS Employer Identification Number. Applicants are also asked for their fax number (optional) and their e-mail address.
- Under *Facility Information*, the phrase "County or similar government subdivision" has been added. A facility's latitude and longitude must now be specified as either 1. degrees, minutes, seconds; 2. degrees, minutes, decimal, or 3. decimal.
- Under *Certifier Name and Title*, applicants are asked for their "Title."

3. Discussion of Notable Permit Provisions

Today's proposed MSGP 2006 accompanies this fact sheet. The fact sheet does not discuss every provision of the proposed permit, especially if the provision is straight-forward, easily understood and has not changed from MSGP 2000. However, a number of provisions in the proposed MSGP 2006 are worthy of explanation. EPA invites comment on any of these proposed provisions, as well as any other provision of the proposed permit. Where commenters are concerned about specific provisions of this permit, EPA requests that the commenter suggests specific alternatives.

3.1 Extension of Administrative Continuance for Existing Dischargers

MSGP 2000 expired before the issuance of MSGP 2006. Existing dischargers are covered under an administrative continuance, but this continuance is only good until the effective date of MSGP 2006. Because operators cannot submit NOIs until MSGP 2006 has been issued, and because of the 30 day waiting period, EPA is proposing the following provision to ensure that existing dischargers do not have a gap in permit coverage: if an entity is covered by MSGP 2000 on the effective date of MSGP 2006, permit coverage is automatically extended under the MSGP 2000 for a period of up to 120 days provided that the entity submits a timely and complete NOI in accordance with the deadlines in Table 1-2 of MSGP 2006.

3.2 Permit Compliance

EPA specifies that failure to meet any requirement of this permit is an enforceable permit violation. EPA has added emphasis and explanation about what constitutes a permit violation in several places in the permit in order to avoid any ambiguity. However, provisions where this emphasis has not been included are also enforceable requirements.

3.3 Discharge Authorization Waiting Periods

Today's proposed permit includes a new 30 day waiting period for authorization (Part 1.5.2). The 30 day period begins on the day that EPA posts the completed Notice of Intent on the e-NOI web site, http://www.epa.gov/npdes/stormwater/noisearch. The purpose of the 30-day wait is twofold: 1) to provide U.S. Fish and Wildlife Service and National Marine Fisheries Service (the Services) an opportunity to review the proposed discharge for protection of threatened and endangered species and critical habitat consistent with the goals of the Endangered Species Act, and 2) to provide the public an opportunity to comment on the discharge.

The Services may request that EPA delay authorization beyond the 30 day wait period in order to resolve any outstanding questions on the NOI or the discharge. In the event this happens, EPA will delay authorization until such time that EPA determines appropriate actions have been taken.

EPA is establishing a 30-day public comment opportunity in response to an expressed public desire to provide input on individual discharges. Anyone wishing to comment on an NOI, or the relevant proposed discharge, may submit comments to the appropriate EPA Regional Office listed in Part 3.7 of the permit. EPA clarifies that this 30 day period is not a formal permit public notice period; MSGP 2006 is undergoing the formal public notice process right now. However, in the interest of providing the public a chance to comment on individual discharges, EPA will consider any comments received during the 30 day period. EPA does not plan to provide formal response to comments documents on comments received. However, EPA will review comments, and if there is valid concern about the proposed discharge, EPA will take the necessary steps to address the concern, e.g., require the relevant industrial operator to make improvements to the SWPPP. Depending on the nature of the issue and the timing of the comments, EPA will require appropriate action either prior to or following discharge authorization. In addition, EPA may delay authorization if comments received warrant such a delay, or may determine that the discharge is not eligible for authorization under MSGP 2006. The potential burden to EPA of taking public comment on discharges requesting authorization under this general permit is very significant, and thus EPA is hesitant to promise a specific process at this juncture. EPA fully intends to honor a public comment process, but needs some case-by-case flexibility on how this is accomplished.

In order for EPA to act on comments, commenters must be specific, detailed, and address issues over which EPA has authority. EPA cautions that comments lacking clear and relevant information may not be actionable. To ensure that EPA can read, understand and therefore properly respond to public comments, EPA prefers that commenters cite, where possible, the paragraph(s) or sections in the proposed permit, fact sheet or supporting documents to which the comment refers. Commenters should use a separate paragraph for each issue discussed. EPA notes that much of the information about a discharge and controls for the discharge are contained in the Stormwater Pollution Prevention Plan (SWPPP), and not the NOI. Members of the public may request a copy of the SWPPP from the operator of the industrial facility (see discussion below, *Requirement for Availability of SWPPP*). EPA will still receive and consider comments after the 30 day comment period has ended.

EPA also requests comments on whether the 30 day public comment period should be waived for new operators who submit NOIs during the first 30 days after MSGP 2006 goes into effect. The purpose of this would be to allow new facilities no longer able to seek coverage under MSGP 2000 to seek coverage as soon as possible under MSGP 2006.

3.4 Requirement for Availability of SWPPP

A copy of the SWPPP must be kept on site at the facility or be locally available for the use of EPA, or representatives of a State, Tribe, or local agency (e.g., MS4 operator) at the time of an onsite inspection (Part 2.4). The SWPPP must also be made available to any of these agencies and the Fish and Wildlife Service or National Marine Fisheries Service upon request. Since SWPPPs are living documents that change over time, access to the current and full version of the SWPPP is critical in assessing permit compliance.

SWPPPs are considered publicly available information. As with MSGP 2000, MSGP 2006 proposes that operators be required to provide a current copy of the SWPPP in a timely manner to any member of the public making such a request. The mechanism for providing the SWPPP is at the discretion of the operator (e.g., web-based, hard copy). EPA has not included a time limit within which operators must provide their current SWPPPs, only that it must be timely. EPA notes that no more than 2 weeks from receipt of the request should be entirely adequate unless there are extenuating circumstances. In the event an operator receives numerous requests, EPA would find it reasonable for the operator to make a copy available for review at a public and easily accessible location, such as a township office or library in the community where the facility is located. EPA encourages industrial operators to make their SWPPPs available electronically both for ease and timeliness of access for the public and for reduced costs for the operator. Operators may withhold from the public (but not from regulatory agencies) information legitimately justified to be Confidential Business Information.

3.5 Water Quality Standards

In February 2001 two industry groups, the *Federal Water Quality Coalition* and the *Utility Act Group* filed petitions in the Court of Appeals for the District of Columbia asserting that MSGP 2000 did not provide clarity on how the permittee was to meet water quality standards. In particular, the dischargers did not have a clear idea of what constituted compliance with water quality standards and permit eligibility. EPA and the petitioners entered into an agreement in January 2005 in which EPA agreed to take comment, during the public notice period for the proposed MSGP 2006, on specific permit language acceptable to the petitioners. That language, provided in the form of edits to language in MSGP 2000, included as Attachment A to the settlement, follows:

Begin Appendix A, Settlement Agreement

PROPOSED MSGP LANGUAGE

(The boldface and strikeout markings signify differences between the language already incorporated into the 2000 MSGP and the proposed language EPA is considering for the 2005 MSGP (now MSGP 2006))

1.2.3.5 Discharge Compliance with Water Quality Standards. You are not authorized for storm water discharges that the Director, **prior to authorization under this permit,** determines will cause, or have reasonable potential to cause or contribute to~~, violations of~~ **an excursion above any applicable** water quality standards. Where such determinations have been made **prior to authorization,** the Director may notify you that an individual permit application is necessary in accordance with Part 9.12. However, the Director may authorize your coverage under this permit after you have included **in your Storm Water Pollution Prevention Plan** appropriate controls and implementation procedures designed to bring your discharges into compliance with water quality standards ~~in your Storm Water Pollution Prevention Plan~~.

1.2.3.8.2 ~~You are not authorized to discharge any pollutant into any water for which a Total Maximum Daily Load (TMDL) has been either established or approved by the EPA unless your discharge is consistent with that TMDL.~~

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a. You are not eligible for coverage under this permit for discharges of pollutants of concern to waters for which there is a Total Maximum Daily Load (TMDL) established or approved by EPA unless you incorporate into your SWPPP measures or controls, and conditions applicable to your discharge, that are consistent with the assumptions and requirements of such TMDL. If a specific wasteload allocation has been established that would apply to your discharge, you must incorporate that allocation into your SWPPP and implement necessary steps to meet that allocation.

b. In a situation where an EPA-approved or established TMDL has specified a general wasteload allocation applicable to industrial storm water discharges, but no specific requirements for industrial storm water discharges have been identified in the TMDL, you should consult with the State or Federal TMDL authority to confirm that adherence to a SWPPP that meets the requirements of the MSGP will be consistent with the approved TMDL. Where an EPA-approved or EPA-established TMDL has not specified a wasteload allocation applicable to industrial storm water discharges, but has not specifically excluded these discharges, adherence to a SWPPP that meets the requirements of the MSGP will generally be assumed to be consistent with the approved TMDL. If the EPA-approved or EPA-established TMDL specifically precludes such discharges, the operator is not eligible for coverage under this permit.

1.3.1 Basic Eligibility

You may be authorized under this permit only if you have a discharge of storm water associated with industrial activity from your facility. In order to obtain authorization under this permit, you must:

1.3.1.1 Meet the Part 1.2 eligibility requirements; and

1.3.1.2 Develop and implement a Storm Water Pollution Prevention Plan (SWPPP) (see definition in Part 12) according to the requirements in Part 4 of this permit.

1.3.1.3 Submit a complete Notice of Intent (NOI) in accordance with the requirements of Part 2 of this permit. Any new operator at a facility, including those who replace an operator who has previously obtained permit coverage, must submit an NOI to be covered for discharges for which they are the operator.

3.3 **Attainment of** ~~Discharge Compliance With~~ Water Quality Standards **After Authorization**

At any time after authorization, the Director may determine that your storm water discharges may cause, have the reasonable potential to cause, or contribute to an excursion above any applicable water quality standard. If such a determination is made, the Director may require you within a specified time period to:

A. Develop and implement a supplemental BMP action plan describing SWPPP modifications in accordance with Subpart 4.10 to address adequately the identified water quality concerns;

B. Submit valid and verifiable data and information that are representative of ambient conditions and indicate that the receiving water is attaining water quality standards; or

C. Submit an individual permit application according to Subpart 9.12.

All written responses required under this Subpart must include a signed certification consistent with Subpart 9.7.

~~Your discharges must not be causing or have the reasonable potential to cause or contribute to a violation of a water quality standard. Where a discharge is already authorized under this permit and is later determined to cause or have the reasonable potential to cause or contribute to the violation of an applicable water quality standard, the Director will notify you of such violation(s). You must take all necessary actions to ensure future discharges do not cause or contribute to the violation of a water quality standard and document these actions in the Storm Water Pollution Prevention Plan. If violations remain or re-occur, then coverage under this permit may be terminated by the Director, and an alternative general permit or individual permit may be issued. Compliance with this requirement does not preclude any enforcement activity as provided by the Clean Water Act for the underlying violation.~~

4.1 Storm Water Pollution Prevention Plan Requirements

You must prepare a Storm Water Pollution Prevention Plan (SWPPP) for your facility before submitting your Notice of Intent for permit coverage. Your SWPPP must ~~be prepared in accordance with good engineering practices~~ **include BMPs that are selected, installed, implemented and maintained in accordance with good engineering practices to minimize pollutants in the discharge so that the discharge will not cause or contribute to an excursion above any applicable water quality standards**. Use of a registered professional engineer for SWPPP preparation is not required by the permit, but may be independently required under state law and/or local ordinance. Your SWPPP must:

4.1.1 Identify potential sources of pollution which may reasonably be expected to affect the quality of storm water discharges from your facility;

4.1.2 Describe and ensure implementation of practices which you will use to reduce the pollutants in storm water discharges from the facility; and

4.1.3 assure compliance with the terms and conditions of this permit.

4.1.4 include all necessary measures to ensure that the discharge is consistent with any relevant TMDL that has been established or approved by EPA, as required by Subpart 1.2.3.8.2.

10.1 Water Quality Protection

If there is evidence indicating that the storm water discharges authorized by this permit cause, have the reasonable potential to cause, or contribute to ~~a violation of a~~ **an excursion above any applicable** water quality standard, you may be required to obtain an individual permit **or an alternative general permit** in accordance with Part 3.3 of this permit, or the permit may be modified to include different limitations and/or requirements.

End Appendix A, Settlement Agreement

EPA invites comment on the language in Settlement Appendix A, above. Although EPA has reorganized the contents of the sections, in general, the concepts presented in the above language are incorporated into the 2006 MSGP.

Today's proposed MSGP makes clear that the dischargers requirements for meeting water quality standards applied to permit requirements and not to eligibility requirements. Under MSGP 2000 a discharger, discovering possibly a year or more after authorization that a water quality standards provision is not being met, is faced with the situation of having been ineligible for coverage. Petitioners asserted that this situation is ambiguous for the permittee, providing liability not just for the water quality standards violation, but also for an unpermitted discharge believed initially to be authorized.

From EPA's perspective, making the distinction between eligibility and permit requirements is important for getting the most effective resolution of water quality problems. EPA believes that problematic discharges can be much more rapidly remedied within the framework of a permit requirement, including the compliance and enforcement provisions of a permit. Therefore EPA is proposing to include the water quality standards provisions of this permit (Part 1.4) as permit requirements rather than eligibility requirements.

The MSGP 2000 language "Your discharge must not be causing or have the reasonable potential to cause or contribute to a violation of a water quality standards" has been difficult for many operators to apply since their receiving waters are usually subject to dozens of water quality standards, and because the permit does not specify conditions or limitations specific to each one of those standards. Therefore, EPA has not included this general phrase in MSGP 2006. Most of the clarifications suggested by the petitioners are included in MSGP 2006 though most are not verbatim, largely because MSGP 2006 is organized differently from MSGP 2000.

The MSGP, like other NPDES permits, must include provisions to ensure that discharges do not cause or contribute to exceedances of water quality standards in the receiving water [Clean Water Act § 301(b)(1)(C) and 402(p)(3)(A), as well as 40 CFR 122.44(d)(4)]. In MSGP 2006 EPA is proposing to clarify discharge standards, to update benchmarks to reflect current water quality criteria, to strengthen SWPPP requirements, to strengthen accountability requirements (inspections, monitoring, reporting and record-keeping) to assure compliance, and has attempted to remove any ambiguity about what constitutes an enforceable permit violation. EPA believes that a tighter, clearer permit will be easier for operators to understand, and much more protective of water quality.

The proposed MSGP 2006 does include a requirement (Part 2.1.3.1) for operators to determine the water quality standards relevant to their receiving water(s). Applicable water quality standards are compiled at http://www.epa.gov/waterscience/standards/states/ and are also available from state environmental protection or water quality regulatory agencies. EPA believes that this information is relatively easy to acquire, and will be very useful for operators to have as they plan their BMPs.

EPA has not fully incorporated the framework (articulated in Appendix A Parts 1.2.3.5 and 3.3 of the Settlement Agreement) regarding pre- and post-authorization water quality standards exceedances, in which full responsibility for discovering water quality standard exceedances and requiring corrective action rests with EPA. EPA does not believe that an operator seeking coverage under the MSGP should be relieved entirely of responsibility regarding water quality standards-related concerns. It is not practical to expect EPA to evaluate the in-stream water quality effects of individual discharges covered under a general permit on a regular basis. Rather than requiring each discharger to submit all necessary data for EPA to perform a reasonable potential analysis, EPA is relying on the use of key benchmark parameters and the aforementioned provisions regarding permittee responsibilities to act on identified water quality concerns. EPA believes that if an operator were to discover that the discharge contributed to an exceedance of a water quality standard then he/she is obligated to act on that knowledge. The proposed MSGP 2006 describes a process for both the operator and EPA when a water quality standard exceedance is discovered, regardless of the party making the discovery. The permittee is not obligated to seek out water quality standards exceedances through ambient water quality monitoring, but is not relieved of responsibility to respond should he discover or be made aware of a water quality exceedance.

EPA has clarified a requirement to review the SWPPP and take appropriate corrective actions when a discharge is causing or contributing to a water quality standard exceedance, and to conduct follow-up monitoring to verify that the discharge is no longer contributing to an exceedance. Failure to take and carefully document appropriate corrective action or conduct follow-up monitoring is a permit violation. EPA may also decide that an individual permit may be more appropriate for a particular discharge and require the operator to submit an application for an individual permit. EPA believes that this provides a fair and enforceable mechanism for resolving water quality standard exceedances, and relieves the petitioner's primary concern of liability for two specific situations: 1) when there are water quality standard exceedances for pollutants that operators do not believe are present in their discharges and for which the permit does not stipulate specific discharge standards, and thus for which they have not implemented controls, and 2) when BMPs are appropriately planned and implemented, and benchmarks and effluent limits (if applicable) are being met, but due to site- or waterbody-specific circumstances, are not adequately protective of water quality.

EPA requests comments on any of the proposed modifications to how water quality standard requirements are incorporated into this permit.

3.6 Water Quality Impaired and Water Quality Limited Receiving Waters

Today's permit clarifies both eligibility and permit provisions for discharges to water quality impaired and water quality limited receiving waters. EPA has eliminated language from the 2000 MSGP that the discharge must "be consistent with" a TMDL. That terminology was not clear about necessary controls or discharger expectations, and as a result EPA believes that many dischargers undertook no additional measures to reduce pollutants of concern in their discharges, or ensure that their discharges complied with TMDL wasteload allocations.

As an eligibility provision MSGP 2006 prohibits authorization when a TMDL specifically articulates a wasteload allocation requiring more stringent controls than can be achieved with this permit. 'Specifically articulates' means that the TMDL, the TMDL implementation plan, or the TMDL authority must stipulate that the discharge (either specifically or categorically) must be authorized under an individual permit, an alternative general permit, or specifically excludes authorization under MSGP. In a situation where an EPA-approved or established TMDL has specified a general wasteload allocation applicable to industrial storm water discharges, but no specific requirements for individual sites have been identified in the TMDL, you should consult with the State or Federal TMDL authority to confirm that adherence to a SWPPP that meets the requirements of the MSGP will be consistent with the approved TMDL. In addition MSGP 2006 prohibits authorization when a TMDL applies a wasteload allocation of zero to a discharge (either specifically or categorically). Because, to date, most TMDLs do not include these kinds of wasteload allocations for stormwater, this provision is not likely to preclude authorization under this permit of very many industrial stormwater discharges. EPA does believe, however, that this is an important provision in the handful of situations where it may apply.

A large number of MSGP-eligible discharges are to impaired waters, and therefore EPA believes that the best water quality protection is to stipulate clear requirements and a specific process for those facility operators. Some consultation with federal or state TMDL authorities may be necessary, and EPA emphasizes that the responsibility for this initial contact is the industrial operator's. Given the number of state, territorial and tribal areas that today's proposed permit covers EPA does not believe this is an unrealistic framework. EPA has tried to include the necessary direction for those consultations, and welcomes suggestions for improvement. EPA has also clearly stipulated that compliance with the MSGP is adequate if the TMDL authority does not stipulate additional requirements when specifically asked. Operators must document these discussions in their Stormwater Pollution Prevention Plans (SWPPPs).

Today's proposed MSGP 2006 includes provisions for both TMDL and pre-TMDL waters, including a new monitoring requirement for the pollutant(s) of concern. Operators are required to implement TMDL wasteload allocations where one has been established, contact TMDL authorities for clarity where the wasteload allocation is not clear, document all measures taken to comply, monitor their discharge(s) (annually at a minimum) for the pollutant(s) of concern, take corrective actions when endpoints are not being met, and report to EPA all data including exceedances. When the wasteload allocation is expressed only as specific BMP requirements, monitoring may be waived after one year if the pollutant of concern is not detected in the discharge, and the required BMPs have been implemented and documented in the SWPPP.

Discharges to pre-TMDL waters or to TMDL waters where a numeric wasteload allocation has not been expressed are also required to comply with any additional measures that may be stipulated by EPA or the state, territorial or tribal authority. These discharges must also be monitored for the pollutant of concern. If state or tribal authorities have not specified an alternate schedule, the monitoring requirement is waived after one year if the pollutant of concern is not detected in the stormwater discharge, and the operator documents in the SWPPP that there is no exposure of the pollutant of concern to stormwater at the site. Lists of waterbodies with approved TMDLs may be obtained from appropriate State environmental offices or their Internet sites and from EPA's TMDL Internet site at http://www.epa.gov/owow/tmdl/index.html.

EPA invites comment on any proposed provision for discharges to impaired waters.

3.7 Benchmark Monitoring

Benchmark Framework. Benchmarks have been included in prior MSGPs, and have been intended to serve as indicators for permittees about whether or not their stormwater controls are adequate. Exceedances of benchmark concentrations have been intended to serve as action-levels to help operators improve BMPs. Based on repeated exceedances of benchmark values reported to EPA by some facilities, as well as failure of many facilities to report any monitoring data, EPA believes that additional clarity and enhanced accountability are needed (see "DMR Review MSGP – Memo titled Review of Discharge Monitoring Report Data for the MSGP 2000" for more details). Benchmark exceedances do not necessarily indicate that a SWPPP is inadequate, but they do indicate a need for careful review of the SWPPP to ensure that appropriate BMPs are being implemented. Under MSGP 2000 permittees did not begin monitoring until the 2nd year of permit coverage. Based on an evaluation of the discharge monitoring data collected under that permit, EPA determined that a number of pollutant discharge problems went unrecognized for over a year (see "DMR Review MSGP" for more details). Therefore EPA is modifying the permit to require that monitoring begin in the first quarter of permit coverage.

Today's proposed MSGP 2006 provides that following one year (4 quarterly monitoring events) of monitoring, if the average of the 4 monitoring values does not exceed the benchmark, the permittee has fulfilled the monitoring requirements for the duration of the permit term for that pollutant. If the average of the 4 quarterly benchmark monitoring values for a given pollutant exceeds the benchmark concentration, this exceedance immediately triggers a requirement to review the SWPPP to determine whether it includes all appropriate BMPs to eliminate or reduce the pollutant of concern in the discharge. Where the operator determines that the SWPPP does not meet the provisions of Part 2 of the permit he/she must modify the SWPPP within 14 days and implement the revised BMPs prior to the next rainfall event if possible, but in no case later than 60 days, except as otherwise provided by EPA. The operator must then continue quarterly monitoring for 4 more quarters to ensure that corrective actions are effective. EPA emphasizes that even though a benchmark exceedance itself is not a permit violation, failure to review the SWPPP, and take necessary corrective actions determined by the SWPPP review within the stipulated time frames is a violation. In addition, an exceedance may be indicative of other permit violations, such as failure to adequately maintain BMPs.

In some instances, following an exceedance of a benchmark by the average value of the 4 monitoring events, an operator may conduct the SWPPP review and determine that modifications to the SWPPP and BMPs are not warranted. EPA recognizes that there may be circumstances where benchmarks may not be reasonably achieved because of elevated background levels of pollutants. For example, high natural background levels of iron in soils or groundwater could contribute to exceedances of a benchmark. Concern has also been expressed that there may be other circumstances when an operator has taken all economically reasonable and appropriate measures to control pollutants, but a benchmark may still be exceeded. To address these situations, MSGP 2006 is proposing to provide an opportunity for permittees, following a review of their SWPPP, to determine that they are implementing all reasonable and appropriate BMPs to reduce pollutants in the discharge, and to document the basis for this determination in the SWPPP. Following the operator's determination that the SWPPP is adequate, the operator may reduce benchmark monitoring to once per year for the remainder of the permit term. EPA requests comment of all aspects of this proposed provision.

MSGP 2000 Benchmark Data Analysis. EPA undertook an analysis of the monitoring requirements of the MSGP 2000 that included: how effective existing controls on these discharges have been based on the history of discharge monitoring data; Toxics Release Inventory (TRI) data; and results and conclusions from the University of California Los Angeles Final Report, *Industrial Storm Water Monitoring Program Existing Statewide Permit Utility and Proposed Modifications*. One of the primary purposes of these analyses was to determine if elimination of, or modification or addition to, benchmark monitoring requirements was warranted. The full analyses and documentation are included in the docket for this proposed permit (http://www.epa.gov/edocket/, docket number OW-2005-0007). Conclusions from those analyses are presented here.

EPA was prepared to drop any benchmark monitoring requirement where data indicated that a pollutant was not present in the discharge, or occurred consistently at such low levels that monitoring would provide no indicator value to the operator with respect to discharge quality. However, based upon review of TRI data and MSGP 2000 monitoring data EPA only found one benchmark that could be eliminated. EPA dropped the benchmark for manganese because there were no EPA established criteria (there was only Colorado state chronic water quality criteria). However, EPA may consider adding a manganese benchmark back into future permits. Based on this criterion, EPA did conclude that additional benchmarks are necessary to ensure that receiving waters will be adequately protected.

New Benchmark Monitoring Requirements for Certain Sectors. The total suspended solids (TSS) benchmark (100 mg/L), which applies to a number of sectors under MSGP 2000, has been expanded to all discharges authorized under MSGP. TSS is a reasonable screen or indicator of stormwater discharge quality since many stormwater pollutants are themselves suspended solids, or enter receiving waters attached to solids. TSS is a relatively inexpensive parameter to measure, and TSS data are not difficult to interpret for the simple purpose of providing operators an indication of whether or not their BMPs need additional attention.

Inspection of TRI data indicated that the wood preservation subsector (SIC 2491) of sector A (timber products) appeared to be missing some key parameters identified both in the updated industry fact sheets and in the TRI discharge data. SIC 2491 comprises only 27% of the total dischargers reporting to TRI from sector A, however in examining the discharge to stormwater data it was noted that 78% of the total number of discharges to stormwater for the entire sector were from this SIC.

New proposed benchmarks for the wood preserving subsector are chromium, which was targeted for potential historical chromated copper arsenate (CCA) treated wood storage, and phenols as an indicator for pentachlorophenol (PCP), and methyl phenols. While chemical oxygen demand (COD) is a good indicator of organics, PCP was considered a key target due to prevalence of historical use and its overall toxicity. Rather than monitor for PCP directly (which is an expensive approach), a decision was made to use phenols as an indicator. This indicator benchmark targets the current recommended water quality standard of 0.019 mg/L for pentachlorophenol ("EPA-Recommended Ambient Water Quality Criteria" Acute Aquatic Life Freshwater (EPA 822-R-02-047 November 2002)).

TRI data for sector I, oil and gas extraction and refining, revealed that future investigation is warranted for possible inclusion of ammonia, lead, nickel, nitrate-nitrite, and zinc. These pollutants appear at a frequency indicating that they are regularly handled at these facilities, which may pose an unacceptable risk for continued coverage under the MSGP without additional monitoring.

TRI data for sector Y, rubber, miscellaneous plastic products, and miscellaneous manufacturing industries, indicate additional consideration of monitoring for lead, as 32 of 526 incidences of lead and lead compounds were reported discharged to stormwater. While this frequency is somewhat limited, the numbers of occurrences of these compounds in the TRI may be sufficient to warrant additional investigation. The new benchmark monitoring requirement for lead applies only to the following subsectors in sector Y: manufacture of rubber products: tires and inner tubes; rubber footwear; gaskets, packing and sealing devices; rubber hoses and belting; and fabricated rubber products not elsewhere classified.

For the electronic and electrical equipment and components except computers (SIC 3612-3699) subsector of sector AC (electronic, electrical, photographic, and optical goods), monitoring of copper, lead, manganese, and nickel were recommended for additional consideration based on frequency of TRI occurrences. Further inspection of the TRI data revealed that manganese and nickel were not reported at a frequency to warrant additional monitoring. Copper and copper compounds, and lead and lead compounds were observed 872 and 1848 times, respectively with discharge to stormwater reported in 10 and 4.6% of those instances, respectively.

No additional monitoring was added for dioxins and dioxin-like compounds, primarily due to the costs associated with that type of monitoring ($700-$900 per sample). TRI data for dioxins and dioxin-like compounds were reported approximately 150 times between 1999 and 2002, and 25 of those included discharge to stormwater. EPA will continue to monitor TRI data for dioxin and reconsider for the next reissuance of MSGP whether or not dioxin monitoring is appropriate.

EPA welcomes comments on any of these proposed new benchmark monitoring provisions.

Updated Benchmark Values in the 2006 MSGP. Benchmark values are based primarily on water quality criteria. In the 1995 and 2000 MSGP, where an applicable water quality criterion was below the minimum level (ML) of quantification for the most sensitive available analytic method, EPA instead used a value equal to 3.18 times the method detection limit (MDL) for that pollutant in lieu of the water quality criterion. (For a full discussion of EPA's initial approach for the derivation of the benchmarks see the fact sheet for the 1995 MSGP (60 FR 50825).

For the 2006 MSGP, EPA has identified methods for all but two pollutant parameters (total magnesium and total phenols) that have an ML below the applicable water quality criterion. Where there are no established EPA water quality criteria, EPA used other sources of data to determine the appropriate benchmark value. The process that EPA followed in selecting the benchmark values for the 2006 MSGP is as follows: 1) First, if there is an EPA promulgated acute criterion then EPA selected that value for the benchmark; 2) If there is no EPA acute criterion, then EPA selected the chronic criterion as the benchmark value; 3) Finally, in the remaining few instances where there were neither EPA acute or chronic criteria available for a specific pollutant, then EPA selected the benchmark value based on data from runoff studies or technology-based standards.

Table 1 includes all of the pollutants for which the proposed MSGP 2006 specifies benchmarks. Where a benchmark has changed, it has been for one of the following reasons:

The values for 9 benchmarks (arsenic, cadmium, copper, cyanide, lead, mercury, nickel, selenium, and silver) have been revised (e.g., switching from an MDL to an ambient water quality criterion, or updated to reflect a revised WQ criterion).

The values for 4 benchmarks (antimony, lead, magnesium, and zinc) have been rounded to two significant figures.

The existing turbidity benchmark, 5 NTU above background, requires the permittee to monitor both the discharge and the receiving stream. The proposed new benchmark (50 NTU) requires the permittee to monitor only the discharge.

Table 1 below shows a comparison the MSGP 2000 and MSGP 2006 benchmark values and the source of those values. The MSGP 2006 proposed changes to the MSGP 2000 benchmark values are highlighted in the table.

Comparing Benchmark Monitoring Pollutants Sources for 2000 and 2006 MSGP

Pollutant	2000 MSGP Benchmark	2000 MSGP Source	2006 MSGP Proposed Benchmark	2006 MSGP Source	Different basis?
Ammonia*	19 mg/L	10	19 mg/L	1	No
Biochemical Oxygen Demand (5 day)	30 mg/L	4	30 mg/L	4	No
Chemical Oxygen Demand	120 mg/L	5	120 mg/L	5	No
Total Suspended Solids	100 mg/L	7	100 mg/L	7	No
Turbidity	5 NTU above	13	50 NTU	9	Yes

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Comparing Benchmark Monitoring Pollutants Sources for 2000 and 2006 MSGP					
Pollutant	**2000 MSGP Benchmark**	**2000 MSGP Source**	**2006 MSGP Proposed Benchmark**	**2006 MSGP Source**	**Different basis?**
	background				
Nitrate + Nitrite Nitrogen	0.68 mg/L	7	0.68 mg/L	7	No
Total Phosphorus	2.0 mg/L	6	2.0 mg/L	6	No
pH	6.0 - 9.0 s.u.	4	6.0 - 9.0 s.u.	4	No
Aluminum, Total (pH 6.5 - 9)	0.75 mg/L	10	0.75 mg/L	1	No
Antimony, Total	0.636 mg/L	8	0.64 mg/L	12	Yes
Arsenic, Total	0.16854 mg/L	8	0.15 mg/L	3	Yes
Beryllium, Total	0.13 mg/L	2	0.13 mg/L	2	No
Cadmium, Total†	0.0159 mg/L	8	0.0021 mg/L	1	Yes
Chromium, Total†	N/A	N/A	1.8 mg/L	1	Yes; added as a new benchmark in 2006 MSGP
Copper, Total*†	0.0636 mg/L	8	0.014 mg/L	1	Yes
Cyanide	0.0636 mg/L	8	0.022 mg/L	1	Yes
Iron, Total	1.0 mg/L	11	1.0 mg/L	3	No
Lead, Total*†	0.0816 mg/L	10	0.082 mg/L	1	No
Magnesium, Total	0.0636 mg/L	8	0.064 mg/L	8	No
Mercury, Total	0.0024 mg/L	10	0.0014 mg/L	1	criteria updated
Nickel, Total†	1.417 mg/L	10	0.47 mg/L	1	criteria updated
Phenols, Total	N/A	N/A	0.016 mg/L	8	Yes; added as a new benchmark in 2006 MSGP
Selenium, Total*	0.2385 mg/L	8	0.005 mg/L	3	Yes
Silver, Total*†	0.0318 mg/L	8	0.0038 mg/L	1	Yes
Zinc, Total†	0.117 mg/L	10	0.12 mg/L	1	No; criteria updated

* New criteria are currently under development, but values are based on existing criteria.

† These pollutants are dependent on water hardness. The benchmark value listed is based on a hardness of 100 mg/L. If you analyze your water samples for hardness, then an alternate benchmark may apply if you use the equations provided in Part 4.

Sources

1. "EPA Recommended Ambient Water Quality Criteria." Acute Aquatic Life Freshwater (EPA-822-R-02-047 November 2002-CMC)

2. "EPA Recommended Ambient Water Quality Criteria for Beryllium." LOEL Acute Freshwater (EPA-440-5-80-024 October 1980)
3. "EPA-Recommended Ambient Water Quality Criteria." Chronic Aquatic Life Freshwater (EPA-822-R-02-047 November 2002-CCC)
4. Secondary Treatment Regulations (40 CFR 133)
5. Factor of 4 times BOD5 (5 day biochemical oxygen demand) concentration - North Carolina benchmark
6. North Carolina stormwater benchmark derived from NC Water Quality Standards
7. National Urban Runoff Program (NURP) median concentration
8. Minimum Level (ML) based upon highest Method Detection Limit (MDL) times a factor of 3.18
9. Combination of simplified variations on *Stormwater Effects Handbook*, Burton and Pitt, 2001 and water quality standards in Idaho, in conjunction with review of DMR data.
10. "EPA Recommended Ambient Water Quality Criteria." Acute Aquatic Life Freshwater. This is an earlier version of the criteria document that has subsequently been updated. (See source #1)
11. "EPA Recommended Ambient Water Quality Criteria." Chronic Aquatic Life Freshwater. This is an earlier version of the criteria document that has subsequently been updated. (See source #3)
12. "EPA Recommended Ambient Water Quality Criteria" Human Health For the Consumption of Organism Only (EPA-822-R-02-047 November 2002)
13. Consistent with many state numeric Water Quality Criteria. This benchmark was agreed to in negotiations for the 1998 modification to the 1995 MSGP (63 FR 42534).

In most cases, benchmarks have not been significantly revised since the 1995 MSGP. However, six of the benchmarks now have new values based on EPA water quality criteria, which are lower than the previous values. These are cadmium, copper, cyanide, selenium, silver, and nickel. For the first five of these, the values have been changed from 3.18 times the MDL for a particular analytical method, to ambient water quality criteria. In each case, EPA has identified one or more alternate methods with lower detection limits. The changes in methods and MDLs are as follows. (Note: The source of the cost for each method was based on laboratories that specialize in effluent monitoring analysis).

Methods, MDL, and Cost Table.

Pollutant	Previous Analytic Method			New Analytic Method		
	Method ID	MDL	$/sample	Method ID	MDL	$/sample
Cadmium	200.7	4 ug/L	$10	200.8	0.5 ug/L	$12
Copper	220.1	20 ug/L	$20	200.8	0.09 ug/L	$12
Cyanide	335.2	20 ug L	$40	335.3	4 ug/L	$40
Selenium	200.7	75 ug/L	$10	270.2	2 ug/L	$20
Silver	272.1	10 ug/L	$20	200.8	0.11 ug/L	$12

Additional supporting data is available in the docket for this permit (see Previous and New Analytical Methods for MSGP). EPA recognizes that use of the more sensitive methods will involve somewhat higher analytical costs, and notes that the estimated cost increases are between $2 (20%% increase) and $10 (100% increase) per sample, but EPA believes these higher costs are justified because use of the more sensitive methods that have an ML below the applicable acute (or chronic) value will provide information to EPA that may be used to assess whether or not the discharge may have the reasonable potential to cause or contribute to an exceedance of water quality standards. In the case of nickel, the acute WQ standard that formed the basis of the previous benchmark was revised downward in 1996, but the lower benchmark will not require use of a new analytical method.

EPA requests comment on 1) the benchmark values as a screening tool to guide SWPPP revisions and evaluate whether a discharge may have the potential to cause or contribute to an exceedance of a water quality standard and the appropriate bases for these values; 2) the detection levels and estimated additional costs of the more sensitive analytic methods that will be required for some benchmarks; and, 3) the availability of labs within the United States to conduct analyses using the more sensitive methods.

In addition to the revised benchmark values, EPA has revised the benchmark provisions in the 2006 MSGP as follows. If the annual average of four quarterly monitoring results exceeds a benchmark, the permittees are now required to review their SWPPP and document the results of this review. EPA expects that this review would also include consideration of other relevant data, such as results of on-site inspections and visual monitoring, as appropriate. EPA recognizes that exceeding a benchmark does not necessarily mean that changes to the SWPPP are needed, but believes that permittees should review their SWPPPs and document the results of this review. If the permittee determines that no changes to the SWPPP are needed, this must be documented in the SWPPP. In this case, the permittee must continue to monitor for the pollutant exceeding the benchmark for the remainder of the permit term, but the frequency of such monitoring is reduced to annually. On a case-by-case basis, EPA may review monitoring results, as well as background concentrations in the stream, State mixing zone policies, and other relevant data to determine whether a discharge consistently exceeding benchmarks has a reasonable potential to cause or contribute to a violation of State water quality standards. If the permittee determines as a result of the SWPPP review that the SWPPP does not satisfy the requirements of Section 2 of this permit, the permittee must take corrective action and document it in the SWPPP. In this case, the permittee must continue quarterly monitoring of the benchmark parameter for an additional four quarters.

EPA does not intend to change the basic framework for benchmark monitoring established in the 1995 and 2000 permits. During its development of the 2000 permit, EPA received substantial public comment questioning the value of analytic monitoring. EPA responded to these comments, in part, as follows:

"EPA acknowledges that, considering the small number of samples required per monitoring year (four), and the vagaries of storm water discharges, it may be difficult to determine or confirm the existence of a discharge problem as a commenter claimed. When viewed as an indicator, analytic levels considerably above benchmark values can serve as a flag to the operator that his SWPPP needs to be reevaluated and that pollutant loads may need to be reduced. Conversely, analytic levels below or near benchmarks can confirm to the operator that his SWPPP is doing its intended job. EPA believes there is presently no alternative that provides stakeholders with an equivalent indicator of program effectiveness." (FR 65/210, Oct 20, 2000, p 64796)

This response continues to represent EPA's thinking regarding the appropriate use of analytic monitoring. However, EPA believes it would improve SWPPP implementation to require that permittees document their review of their SWPPP when benchmarks are exceeded and take corrective action where needed. EPA requests comment on the revised benchmark values and documentation requirements.

In the Fact Sheet to the 2000 permit, EPA also committed to "...using data from the 1995 and 2000 permits to evaluate the effectiveness of management practices on an industry sector basis and to evaluate the need for changes in the monitoring protocols for the next permit." EPA has prepared an analysis of benchmark data, which is available in the docket for this permit (see DMR Review MSGP – Memo titled "Review of Discharge Monitoring Report Data for the MSGP 2000"). EPA determined, based on this analysis, that available analytic monitoring data indicated that many facilities report routine exceedances of benchmark values. However, EPA has not yet been able to complete this analysis to determine whether these exceedances provide useful indicators of SWPPP inadequacies or potential water quality problems. In developing the 2011 permit, EPA intends to conduct further analysis on selected industry sectors that are discharging to both impaired and unimpaired water bodies to evaluate the usefulness of the monitoring data to the permittee or permitting authority in determining the adequacy of the SWPPP or the potential for water quality standards exceedances. As part of this analysis, EPA will assess the extent to which benchmark exceedances correlate with determinations that corrective action or additional measures to address water quality are needed. EPA requests comment on the following: 1) given the variability of analytic results, are benchmark exceedances a useful indicator of the need for corrective action, 2) are they a useful indicator of reasonable potential to cause or contribute to a violation of water quality standards, 3) are there other values besides water quality criteria that should be considered as the bases for benchmark values, and 4) are there approaches other than analytic monitoring that would be effective in ensuring that SWPPPs are properly designed and implemented? EPA intends to engage interested stakeholders in the development of the study design.

3.8 Inactive and Unstaffed Sites

Today's MSGP allows for a waiver from benchmark monitoring for facilities that are both inactive and unstaffed, when the facility no longer has industrial activities or materials exposed to stormwater. EPA believes that a facility with no industrial activity and no exposed materials should not be contributing pollutants to stormwater discharges. These facilities could alternatively submit a No Exposure Certification, and terminate permit coverage. However, EPA realizes that there are some facilities that may plan to commence industrial activity in the future that would include exposure, and may wish to keep active permit coverage. To qualify for this waiver permittees must certify in their SWPPPs that they are inactive and unstaffed, and that there are no industrial activities or materials exposed to stormwater. Permittees are not required to obtain advance approval for this waiver. This waiver applies only to benchmark monitoring. Annual monitoring requirements for effluent limitation guideline pollutants or other parameters are not waivable.

MSGP 2000 provides a benchmark monitoring waiver only for inactive and unstaffed sites that are remote, because monitoring may be deemed impractical. However, the provision does not require 'no exposure' of industrial materials. The proposed permit expands the waiver to any inactive and unstaffed facility. However, because discharge of pollutants does not cease when industrial materials are still outside, EPA believes that elimination of exposure is a reasonable pre-requisite for this monitoring waiver. EPA requests comment on this provision.

3.9 Representative Outfalls

As with MSGP 2000, today's proposed MSGP allows a facility to reduce its overall benchmark monitoring burden when discharges through separate outfalls are essentially identical. This provision applies to benchmark monitoring requirements, and has been expanded in MSGP 2006 to apply to visual monitoring as well. The 'representative outfall' determination should be based on a consideration of industrial activity, significant materials, and management practices and activities within the area drained by the outfalls. When such a determination is made, the permittee may test the effluent of one such outfall and report that the quantitative data also apply to the essentially identical outfall(s). To do this the permittee must include in the SWPPP a description of the location of the outfalls and a detailed explanation of why the outfalls are expected to discharge substantially identical effluent. In addition, for each outfall that the permittee believes is representative, an estimate of the size of the drainage area (in square feet) and an estimate of the runoff coefficient of the drainage area (e.g., low [under 40 percent], medium [40 to 65 percent], or high [above 65 percent]) must be provided in the plan. Because of the highly variable nature of outdoor activities at industrial facilities EPA cautions operators to carefully consider all factors before selecting this option. Permittees do not need EPA approval to claim that discharges are representative, provided they have documented their rationale within the SWPPP. However, the Director may determine that the discharges are not representative and may require sampling of all non-identical outfalls. Facilities that change any conditions affecting any of the 'representative outfall' discharges are required to reassess their eligibility for this provision.

3.10 Reduced Benchmark Monitoring for Performance Track Facilities

The National Environmental Performance Track Program is a voluntary EPA program that recognizes and rewards private and public facilities that demonstrate strong environmental performance beyond current requirements. Performance Track currently has about 370 members. The program is based on the premise that government should complement its existing programs and regulations with new tools and strategies that not only protect people and the environment, but also capture opportunities for reducing cost and spurring innovation. The Performance Track program (PT) is a facility-based program (not company-wide or corporate). There are four basic criteria that applying facilities must meet: 1) an Environmental Management System (EMS) in place for at least one full cycle that has been assessed by an independent party; 2) a history of sustained compliance; 3) past environmental achievements and a commitment to quantified continuous environmental improvement; and 4) community outreach and annual reporting. Once accepted, members remain in the program for three years, as long as they continue to meet the program criteria. After three years they may apply to renew their membership through a streamlined application process. The program encourages participation by small, medium, and large facilities, and its members are located throughout the United States, including Puerto Rico. Through its members over the past three years the Performance Track program has produced substantial environmental results beyond the legal requirements for the facilities. See http://www.epa.gov/performancetrack/ for more information about the Performance Track program.

EPA is considering reduced benchmark monitoring for facilities that are participating in the National Environmental Performance Track Program. Specifically, EPA is considering waiving benchmark monitoring for the remainder of the permit term by Performance Track facilities if they do not exceed their benchmark monitoring values in either of the first two quarters of monitoring. Alternatively, EPA could waive benchmark monitoring entirely for Performance Track facilities.

The benchmark monitoring requirements in the MSGP serve as a tool for permittees to determine if their BMPs are adequately controlling pollutants in stormwater. However, EPA recognizes that pollution prevention and self-assessment are also inherent components of an Environmental Management System. Therefore, EPA believes that it is appropriate to reduce the burden on those facilities that have taken the extra step toward continuous environmental improvement through the Performance Track program. Under these circumstances EPA considers two quarters of monitoring to be sufficient for demonstrating that the benchmark values will not be exceeded. EPA requests comments on considering reduced benchmark monitoring for Performance Track members.

EPA welcomes comments on benchmark monitoring waivers for Performance Track facilities.

EPA welcomes comments on any of the proposed benchmark provisions.

3.11 Numeric Effluent Limitations

Numeric effluent limitations have been included in previous MSGPs. The effluent limitation guidelines for certain industry-specific discharges and limitations for runoff from coal piles in the 2000 permit are retained in today's proposed MSGP 2006. Monitoring for these parameters must be conducted once each year for the duration of permit coverage.

As with all other types of exceedances, the proposed MSGP 2006 clarifies the requirement for corrective action whenever there is an exceedance of a numeric effluent limit. EPA also clarifies that these numbers are effluent limitations, and an exceedance is a permit violation.

There is also now a requirement to conduct follow up monitoring within 30 days of completing corrective action, or during the next runoff event, in order to verify that modified stormwater controls have satisfactorily reduced pollutants in the discharge. EPA believes that this verification is an important component of accountability, and helps ensure that problems are fixed quickly rather than persisting until the next regularly scheduled monitoring event, which generally would be a year away.

3.12 Quarterly Visual Monitoring

Today's proposed MSGP retains the requirements of the 1995 and 2000 MSGP for quarterly visual examinations of stormwater discharges that EPA continues to believe provide a useful and inexpensive means for permittees to evaluate the effectiveness of their SWPPPs (with immediate feedback), and to make any necessary modifications to address the results of the visual examinations. All sectors of today's proposed MSGP are required to conduct these examinations.

The MSGP requires that grab samples of stormwater discharges be taken and examined visually for the presence of color, odor, clarity, floating solids, settled solids, suspended solids, foam, oil sheen, or other obvious indicators of stormwater pollution. The grab samples must be taken within the first 30 minutes after stormwater discharges begin, or as soon as practicable, but no longer than 1 hour after discharges begin. The sampling must be conducted four times a year, though not necessarily strictly quarterly. In arid or semi-arid climates for instance, areas subject to prolonged dry seasons, one sample must be collected during a dry season storm event, while the remaining three may be collected during the wet season; in the Northeast, stormwater sampling must be designed to attempt capture of the first flush during snow melt, with the balance of sampling distributed throughout the year. The goal of sampling is to capture meaningful data regarding the effectiveness of BMPs and the SWPPP more than to characterize the temporal variability of the stormwater discharge. The reports summarizing these quarterly visual stormwater examinations must be maintained on-site with the SWPPP.

The examination of the sample must be made in well-lit areas. The visual examination is not required if there is insufficient rainfall or snow-melt to run off or if hazardous conditions prevent sampling. Whenever practicable, the same individual should carry out the collection and examination of discharges throughout the life of the permit to ensure the greatest degree of consistency possible in recording observations.

When conducting a stormwater visual examination, the pollution prevention team or team member should attempt to relate the results of the examination to potential sources of stormwater contamination on the site. For example, should an oil sheen be observed facility personnel (preferably members of the pollution prevention team) should conduct an inspection of the area of the site draining to the examined discharge to look for obvious sources of spilled oil, leaks, etc. If a source can be located, then this information allows the facility operator to immediately conduct a clean-up of the pollutant source, and/or to design a change to the SWPPP to eliminate or minimize the contaminant source from recurring.

If the visual examination results in an observation of floating solids, the personnel should carefully examine the solids to see if they are raw materials, waste materials, or other known products stored or used at the site. If an unusual color or odor is sensed, the personnel should attempt to compare the color or odor to the colors or odors of known chemicals and other erials used at the facility. If the examination reveals a large amount of settled solids, the personnel may check for unpaved, unstabilized areas or areas of erosion. If the examination results in a cloudy sample that is very slow to settle out, the personnel should evaluate the site draining to the discharge point for fine particulate material, such as dust, ash, or other pulverized, ground, or powdered chemicals.

To be most effective, the personnel conducting the visual examination should be fully knowledgeable about the SWPPP, the sources of on-site contaminants, the industrial activities exposed to stormwater, and the day-to-day operations that may cause unexpected pollutant releases.

If the visual examination results in a clean and clear sample of the stormwater discharge, this may indicate that no pollutants are present and would be an indication of a high quality result. However, the visual examination will not provide information about dissolved contamination.

EPA believes that this quick and simple assessment will help permittees to determine the plan effectiveness on a regular basis at very little cost. Although the visual examination cannot assess the chemical properties of the stormwater discharged from the site, the examination will provide meaningful results upon which the facility may act quickly. More frequent visual examinations may be conducted to achieve better assessments of the effectiveness of the SWPPP. The frequency of this visual examination will also allow for timely adjustments to be made to the plan. If BMPs are performing ineffectively, corrective action must be implemented. A set of tracking or follow-up procedures must be used to ensure that appropriate actions are taken in ponse to the examinations. The visual examination is intended to be performed by members of the pollution prevention team. This hands-on examination will enhance the staff's understanding of the site's stormwater problems and the effects of the management practices that are included in the plan.

Operators of inactive and unstaffed sites may exercise a visual monitoring waiver if they eliminate all exposure of industrial activities and materials to stormwater and also document the no exposure in the SWPPP. Operators with essentially identical outfalls (more fully described in 3.8) may also elect to undertake quarterly visual monitoring at one representative outfall.

3.13 Monitoring Required by a State or Tribe

Where a State or Tribe has imposed a numeric effluent limitation, has established a wasteload allocation, or has stipulated specific monitoring requirement(s) as a condition for certification under CWA §401, a minimum monitoring frequency of once per year has been included in the final permit. This annual monitoring frequency would apply only if a State failed to provide a monitoring frequency along with their conditional §401 certification.

3.14 Collection and Analysis of Samples

Today's proposed MSGP retains the same requirements as the 1995 and 2000 MSGPs regarding the type of sampling (Part 3.2.6.1). Certain industries have specialized requirements. Permittees should check the industry-specific requirements in Part 4, Section A through Section AD to the permit to confirm these requirements. Grab samples may be used for all monitoring unless otherwise stated. All such samples must be collected from the discharge resulting from a storm event that is greater than 0.1 inch in magnitude and that occurs at least 72 hours from the previously measurable (greater than 0.1 inch rainfall) storm event. The required 72-hour storm event interval may be waived by the permittee when the preceding measurable storm event did not result in a measurable discharge from the facility. The 72-hour requirement may also be waived by the permittee where the permittee documents that less than a 72-hour interval is representative for local storm events during the season when sampling is being conducted. The grab sample must be taken during the first 30 minutes of the discharge. If the collection of a grab sample during the first 30 minutes is impracticable, a grab sample can be taken during the first hour of the discharge, and the discharger must submit with the monitoring report a description of why a grab sample during the first 30 minutes was impracticable. At least one grab is required. When the discharge to be sampled contains both stormwater and non-stormwater, the facility must sample the stormwater component of the discharge at a point upstream of the location where the non-stormwater mixes with the stormwater, if practicable.

3.15 Storm Event Data

Information on the sampled storm event must be documented (Part 3.2.6.2), and must include date and duration of the storm event(s) sampled, rainfall measurements or estimates of the event that generated runoff, the duration between the storm event and the previous event that produced measurable runoff (greater than 0.1 inch), and an estimate of the total volume of the discharge samples.

3.16 Adverse Weather Conditions

When truly adverse weather conditions make sampling dangerous, event monitoring may be postponed to the next runoff event (Part 3.2.6.3). This provision applies only to serious weather conditions such as lightning, flash flooding, and hurricanes. This provision should not be used as an excuse for not conducting sampling under conditions associated with more typical storm events. This provision does not apply to difficult logistical conditions, such as remote facilities with few employees or discharge locations that are difficult to access. This provision applies to all monitoring requirements of MSGP 2006.

3.17 National Historic Preservation Act

The National Historic Preservation Act (NHPA) requires Federal agencies to take into account the effects of "Federal undertakings" on historic properties that are either listed on, or eligible for listing on, the National Register of Historic Places. The term "Federal undertaking" is defined in the existing NHPA regulations to include any project, activity, or program under the direct or indirect jurisdiction of a Federal agency that can result in changes in the character or use of historic properties, if any such historic properties are located in the area of potential effects for that project, activity, or program. See 36 CFR 802(o). Historic properties are defined in the NHPA regulations to include prehistoric or historic districts, sites, buildings, structures, or objects that are included in, or are eligible for inclusion in, the National Register of Historic Places. See 36 CFR 802(e).

Federal undertakings include EPA's issuance of general NPDES permits, including the Multi-Sector General Permit. As part of the EPA's own obligations under the NHPA, applicants seeking coverage under the MSGP are required to make certain certifications regarding the potential effects of their stormwater discharge, allowable non-stormwater discharge, and discharge-related activities on properties listed or eligible for listing on the National Register of Historic Places.

In light of NHPA requirements, EPA included a provision in the eligibility requirements of the 1995 and 2000 MSGP for the consideration of the effects to historic properties. The 2000 MSGP further enhanced the protection of historic properties required under the 1995 MSGP by making permit coverage available only if:

- Stormwater, allowable non-stormwater discharges, and "discharge-related activities" did not affect historic properties; or
- The applicant obtained, and was in compliance with, a written agreement between the applicant and the State Historic Preservation Officer (SHPO) or Tribal Historic Preservation Officer (THPO) that outlines all measures to be taken by the applicant to mitigate or prevent adverse effects to historic property. See Part 1.2.3.7, 65 FR 64746 (September 30, 2000).

Discharge-related activities are defined to include activities which cause, contribute to, or result in stormwater and allowable non-stormwater point source discharges, and measures such as the siting, construction and operation of best management practices (BMPs) to control, reduce, or prevent pollution in the discharges. Discharge-related activities are included to ensure compliance with NHPA requirements to consider the effects of activities which are related to the activity which is permitted, *i.e.*, the stormwater and non-stormwater discharges. Because this change was minor, EPA relied on its 1995 and 1998 consultations with the Advisory Council on Historic Preservation as its basis for reissuance of the 2000 MSGP.

EPA consulted with the Advisory Council on Historic Preservation and the National Conference of State Historic Preservation Officers prior to the proposal of MSGP 2006. The discussion included possible scenarios where stormwater discharges, allowable non-stormwater discharges, and discharge-related activities may impact historic properties. It was determined that subsurface historic artifacts, records, or remains would have the only potential to be affected. These historic properties would be impacted if the ground was physically disturbed while constructing, installing, or modifying selected best management practices (BMPs) that are less than 1 acre in size. In general, if the operator's activities do not disturb the subsurface of the ground the operator will not have the potential to cause effects on historic properties, and may certify eligibility under criterion A.

Facilities seeking coverage under MSGP 2006 that cannot certify compliance with the NHPA requirements must submit individual permit applications to the permitting authority. For facilities already covered by the existing MSGP, the deadline for the individual applications is the same as that for NOIs requesting coverage under the reissued MSGP (90 days after the effective date for MSGP 2006).

3.18 Endangered Species Act

The Endangered Species Act (ESA) of 1973 requires all Federal Agencies to ensure, in consultation with the U.S. Fish and Wildlife Service (FWS) and the National Marine Fisheries Service (NMFS) (both of these federal agencies are collectively known as the "Services"), that any Federal actions carried out by the Agency (e.g., EPA-issued permits authorizing discharges to waters of the United States) are not likely to jeopardize the continued existence of any species that are federally-listed as endangered or threatened ("listed"), or result in the adverse modification or destruction of habitat that is federally-designated as critical ("critical habitat"). See 16 U.S.C. 1536(a)(2), 50 CFR 402 and 40 CFR 122.49(c).

FWS and NMFS are responsible for administration of the ESA and as such are responsible for maintaining a list of protected species and critical habitat. Once listed as endangered or threatened, a species is afforded the full range of protections available under the ESA, including prohibitions on killing, harming or otherwise taking a species. In certain instances, FWS or NMFS may establish a critical habitat for a threatened or endangered species as a means to further protect those species. Critical habitats are areas determined to be essential for the conservation of a species and may not necessarily be in an area currently occupied by the species. Some, but not all, listed species have designated critical habitat. Exact locations of such critical habitat are provided in the Services regulations at 50 CFR Parts 17 and 226.

EPA began conducting informal consultation with the Services on December 8, 2004 to achieve concurrence with EPA's finding of no likelihood of adverse effects on threatened and endangered species and critical habitat resulting from the issuance of the MSGP 2006. EPA is using a permitting approach similar to the endangered species procedures and requirements in the Construction General Permit, effective July 1, 2003, but with clarifications and slight modifications to meet the needs of industrial dischargers.

Operators also have an independent ESA obligation to ensure that any of their activities do not result in prohibited "takes" of listed species. (Section 9 of the ESA prohibits any person from "taking" a listed species [e.g., harassing or harming it] with limited exceptions. See ESA Sec 9; 16 U.S.C. §1538.) This prohibition generally applies to private individuals, businesses and government entities. Many of the measures required in the MSGP and in these instructions to protect species may also assist operators in ensuring that their industrial activities (as opposed to their stormwater discharges) do not result in a prohibited take of species in violation of section 9 of the ESA. Operators who intend to undertake industrial activities in areas that harbor endangered and threatened species may need to be protected from potential takings liability under ESA section 9 by obtaining either an ESA section 10 permit or by requesting coverage under an individual permit and participating in the section 7 consultation process. Operators unsure of what is needed for takings protection should confer with the appropriate FWS or NMFS office.

As with previous stormwater permits, coverage is only available if stormwater and allowable non-stormwater discharges and "discharge-related activities" associated with industrial activity, as defined in Appendix A, will not adversely affect listed species or critical habitat. "Discharge-related activities" are defined to include activities which cause, contribute to or result in stormwater and allowable non-stormwater point source discharges, and measures such as the siting, construction and operation of best management practices (BMPs), to control, reduce or prevent pollution in the discharges. Discharge-related activities are included for compliance with the ESA requirement to consider the effects of activities which are related to the activity being permitted, i.e., the stormwater and allowable non-stormwater discharges.

In addition, operators seeking coverage under MSGP 2006 must certify on their NOI forms that they are eligible for coverage under one of the following six criteria options (see Part 1.2.4.6 of the permit):

A. There are no endangered or threatened species or critical habitat present, determined after checking the various references given in the MSGP for the presence of species or habitat in proximity to the facility. "In proximity" refers to species being located in the stormwater and allowable non-stormwater discharge flow path, or down-gradient areas from the industrial activities to the point of discharge into the receiving water, including around the discharge outfall. A species is also in proximity if it is located in the area of a site where discharge-related activities occur.

B. In the course of a separate federal action involving the facility (e.g., EPA processing an application for an individual NPDES permit, issuance of a CWA Section 404 wetlands dredge and fill permit, etc.), formal or informal consultation with one or both of the Services under Section 7 of the ESA has been concluded. The consultation must have addressed the effects of the stormwater discharges, allowable non-stormwater discharges, and discharge-related activities on listed species and critical habitat. The result must have been either a no jeopardy opinion or a written concurrence by the Service(s) on a finding that the stormwater discharges, allowable non-stormwater discharges, and discharge-related activities are not likely to jeopardize listed species or critical habitat.

C. The activities are authorized under Section 10 of the ESA and that authorization addresses the effects of the stormwater discharges, allowable non-stormwater discharges, and discharge-related activities on listed species and critical habitat.

D. The operator, after determining listed species or critical habitat are nearby, has coordinated with the appropriate Service(s) to address the effects of the stormwater discharges, allowable non-stormwater discharges, and dischargeelated activities on listed species and critical habitat. The result of the coordination must be a written statement from the Services that there are not likely to be any adverse affects to federally-listed species or Federally-designated critical habitat. All prerequisites or stipulations resulting from the coordination become permit requirements.

E. The operator, after determining listed species or critical habitat are nearby, has evaluated the effects of the stormwater discharges, allowable non-stormwater discharges, and discharge-related activities on the species / habitat and concluded there will not likely be any adverse effects. To arrive at this conclusion, the operator must consider whether there is potential jeopardy to species / habitat and what measures are needed to minimize the jeopardy. Typically this would employ the skills of staff members or consultants with expertise in the biology and needs of the species / habitat in question. Rigorous documentation to support the Criterion E selection must be included in the SWPPP.

F. The stormwater and allowable non-stormwater discharges and discharge-related activities were already addressed in another operator's certification of eligibility under Criteria A – E above, provided both facilities' activities and sites are addressed. By certifying eligibility under this Part, an operator agrees to comply with any measures or controls upon which the other operator's certification was based.

All the options listed above except D are similar to the eligibility provisions of previous stormwater general permits. Option D was added to allow operators to certify eligibility after interacting with the Services independently as part of their endangered species due diligence. Option F, while not likely to be widely used, is meant for situations such as airports where one operator (e.g., the airport authority) has covered the entire airport through its certification.

Appendix E of the MSGP 2006 provides instructions for determining whether a facility is eligible for permit coverage with regard to endangered species (i.e., if and how any of the six eligibility criteria can be met). The process and results of the endangered species investigation must be documented and included in the SWPPP. This information, including any other relevant piece of information such as the SWPPP, may be requested by the Services or EPA for review before permit coverage is authorized, or by an inspector after the fact.

Operators who cannot determine if they meet one of the endangered species eligibility criteria cannot submit an NOI to gain coverage under the MSGP 2006; instead they must apply to EPA for an individual NPDES permit. As appropriate, EPA will conduct an ESA section 7 consultation when issuing individual permits. If there are concerns that MSGP coverage for a particular facility is not sufficiently protective of species / habitat, EPA or the Services, through the EPA, may hold up discharge authorization until such concerns are adequately addressed. Regardless of an operator's eligibility certification under one of the six criteria, EPA may require an application for an individual permit on the basis of possible jeopardy to species /habitat.

3.19 Stormwater Pollution Prevention Plan (SWPPP) Requirements

Like the 1995 and 2000 MSGPs, MSGP 2006 requires that all facilities that intend to be covered by the MSGP for stormwater discharges associated with industrial activity prepare and implement a SWPPP. The MSGP addresses stormwater pollution prevention plan requirements for a number of categories of industries. These common requirements may be amended or further clarified in the sector-specific SWPPP requirements, which are found in Part 4 of the proposed permit. These industry-specific requirements are additive for facilities where co-located industrial activities occur.

BMPs should be a suite of stormwater controls that are effective at pollution prevention and reduction AND are also economically reasonable and appropriate in light of current industry practice for your type of facility. "Best" refers to cost-effective measures using controls appropriate for the situation that will result in the necessary pollutant reductions. Prevention measures, such as keeping areas clean, storing materials inside, and properly maintaining equipment, will usually be sufficient. EPA does not typically expect or recommend implementation of highly engineered, complex treatment systems for most industrial sectors or pollutants, although in some cases more advanced treatment may be necessary, such as to address water quality standards exceedances. This would most likely be the case where a wasteload allocation in a total maximum daily load (TMDL) approved or established by EPA called for treatment of stormwater to address a particularly difficult water quality problem. EPA does not require the use of a registered professional engineer to prepare the SWPPP, but this may be independently required under State law and/or local ordinance.

3.20 Pollution Prevention Team

As a first step in the process of developing and implementing a SWPPP, permittees are required to identify a qualified individual or team of individuals to be responsible for developing the plan and assisting the facility or plant manager in its implementation (Part 2.1.1). In selecting members of the team, the facility manager should draw on the expertise of all relevant departments within the facility to ensure that all aspects of facility operations are considered when the plan is developed. The plan must clearly describe the responsibilities of each team member as they relate to specific components of the plan, and it must be readily accessible to all team members either electronically or in paper format. In addition to enhancing the quality of communication between team members and other personnel, clear delineation of responsibilities will ensure that every aspect of the plan is addressed by a specified individual or group of individuals. A pollution prevention team may consist of one individual where appropriate (e.g., in certain small businesses with limited stormwater pollution potential).

3.21 Site Description and Receiving Waters and Wetlands

Each SWPPP must describe activities, materials, and physical features of the facility that may contribute significant amounts of pollutants to stormwater runoff or, during periods of dry weather, result in pollutant discharges through the separate storm sewers or stormwater drainage systems that drain the facility. This assessment of stormwater pollution risk will support subsequent efforts to identify and set priorities for necessary changes in materials, materials management practices, or site features, as well as aiding in the selection of appropriate structural and nonstructural control techniques. Some operators may find that significant amounts of pollutants are running onto the facility property. Such operators should identify and address the contaminated run-on in the SWPPP. If the run-on cannot be addressed or diverted by the permittee, the permitting authority should be notified. If necessary, the permitting authority may require the operator of the adjacent facility to obtain a permit.

The site description (Part 2.1.2) should include activities at the facility, an estimate of impervious surface area, precipitation information, a general location map and a site map. The site map must include a number of features including the location of outfalls covered by the permit (or by other NPDES permits), the pattern of stormwater drainage, an indication of the types of discharges contained in the drainage areas of the outfalls, structural features that control pollutants in runoff,[1] surface water bodies (including wetlands, intermittent streams, dry sloughs, and aroyos), places where significant materials[2] are exposed to rainfall and runoff, and locations of major spills and leaks that occurred in the 3 years prior to the date of developing or updating your SWPPP. The map also must show areas where the following activities take place: fueling, vehicle and equipment maintenance and/or cleaning, loading and unloading, material storage (including tanks or other vessels used for liquid or waste storage), material processing, and waste disposal. The map must indicate the direction of stormwater flow and the pollutants likely to be in the discharge. Flows with a significant potential to cause soil erosion also must be identified. You must also identify all surface waters to which you discharge stormwater (Part 2.1.3).

3.22 Summary of Potential Pollutant Sources

The description of potential pollution sources should clearly address activities, materials, and physical features of the facility that have a reasonable potential to contribute significant amounts of pollutants to stormwater (Part 2.1.4). Any such activities, materials or features must be addressed by the measures and controls subsequently described in the plan. In conducting the assessment, the facility operator must consider the following activities: loading and unloading operations, outdoor storage activities, outdoor manufacturing or processing activities, significant dust- or particulate-generating processes, and on-site waste disposal practices (Part 2.1.4.1). The assessment must list any significant pollutants (e.g., biochemical oxygen demand, suspended solids) associated with each source (Part 2.1.4.2).

[1]Nonstructural features such as grass swales and vegetative buffer strips also should be shown.

[2]Significant materials include, but are not limited to, the following: raw materials; fuels; solvents, detergents, and plastic pellets; finished materials, such as metallic products; raw materials used in food processing or production; hazardous substances designated under section 101(14) of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA); any chemical the facility is required to report pursuant to EPCRA section 313; fertilizers; pesticides; and waste products, such as ashes, slag, and sludge, that have the potential to be released with stormwater discharges. (See 40 CFR 122.26(b)(8).)

3.23 Significant Spills and Leaks

The plan must include a list of any significant spills and leaks of toxic or hazardous pollutants that occurred in the 3 years prior to the date the SWPPP is developed or amended (Part 2.1.4.3). Significant spills include, but are not limited to, releases of oil or hazardous substances in excess of quantities that are reportable under section 311 of the CWA (see 40 CFR 110.10 and 40 CFR 117.21) or section 102 of CERCLA (see 40 CFR 302.4). Significant spills may also include releases of oil or hazardous substances that are not in excess of reporting requirements and releases of materials that are not classified as oil or hazardous substances.

The listing should include a description of the causes of each spill or leak, the actions taken to respond to each release, and the actions taken to prevent similar spills or leaks in the future. This effort will aid the facility operator as she or he examines existing spill prevention and response procedures and develops any additional procedures necessary to fulfill the requirements set forth in Part 2.1.5.4.

3.24 Elimination of Unauthorized Discharges

Each SWPPP must include a certification, signed by an authorized person, that discharges from the site have been tested or evaluated for the presence of non-stormwater discharges, and that all unauthorized discharges have been eliminated (Part 2.1.4.4). The certification must describe any test and/or evaluation conducted to detect such discharges, the results of those evaluations, and measures taken to eliminate any unauthorized discharges that were discovered. Acceptable test or evaluation techniques include dye tests, television surveillance, visual observation of outfalls or other appropriate locations during dry weather, water balance calculations, and analysis of piping and drainage schematics.[3] A combination of these mechanisms may be necessary to complete a thorough evaluation.

When unauthorized discharges are discovered, the certification must also include a description of how those discharges were eliminated. Common unauthorized discharges and common resolutions include: re-routing sanitary wastes (e.g., sinks, drinking fountains, toilets) to sanitary sewer systems; obtaining an appropriate NPDES permit for cooling water or industrial process wastewater discharges; capping or plugging floor drains; and prohibiting practices such as paint brush washing or wash bucket dumping into storm drain inlets.

EPA recognizes that full certification might not be feasible where facility personnel do not have access to an outfall, manhole, or other point of discharge. The permit allows less than full certification provided that the plan must describe why certification was not feasible. Permittees that are not able to certify that discharges have been evaluated and unauthorized discharges eliminated must so notify EPA within 14 days after submitting the NOI. Failure to certify that unauthorized discharges have been eliminated, or alternately provide the appropriate notification that certification cannot be completed, is a permit violation.

[3] In general, smoke tests should not be used for evaluating the discharge of non-stormwater to a separate storm sewer as many sources of non-stormwater typically pass through a trap that would limit the effectiveness of the smoke test.

3.25 Monitoring Data

Any existing data on the quality or quantity of stormwater discharges from the facility must be described in the plan (Part 2.1.4.7). At a minimum the operator should include data gathered in the 5 years prior to development or update of this SWPPP, including discharge monitoring data collected in fulfillment of MSGP 2000 requirements. These data may be useful for locating sources and causes of stormwater pollutants.

3.26 Selection and Implementation of Stormwater Controls

Following completion of the source identification and assessment phase, the permit requires the permittee to evaluate, select, and describe the pollution prevention measures, and other controls that will be implemented at the facility. BMPs include processes, procedures, schedules of activities, prohibitions on practices, installed devices, structures, vegetation and other management practices that prevent or minimize the discharge of pollutants in stormwater runoff.

Sections 402(p)(3)(A) and 301 of the Clean Water Act require that permits for discharges of industrial stormwater meet all applicable provisions for technology-based and water quality-based controls. Best Management Practices are considered Best Available Technology economically achievable (BAT) and Best Conventional Technology (BCT) for most stormwater discharges. BMPs are also usually adequate to meet the water quality requirements of the Act. Therefore proper design and implementation of BMPs form the foundation of stormwater controls. MSGP 2006 does stipulate a number of sector-specific BMPs (Part 4), and also requires all operators to implement certain types of BMPs (Part 2.1.5). Each operator is required to design effective controls for the relevant set of pollutants, operations and site conditions. To achieve this each operator has some discretion in designing a suite of BMPs for his/her industrial operation. Failure to adequately design, implement or maintain appropriate BMPs is a violation of the permit.

EPA emphasizes the implementation of pollution prevention measures and BMPs that reduce possible pollutant discharges at the source. Pollution prevention measures include preventive maintenance, chemical substitution, spill prevention, good housekeeping, training, eliminating exposure, diverting stormwater around handling and storage areas, and proper materials management. Where such practices are not appropriate or do not effectively reduce pollutant discharges, other economically reasonable and appropriate measures may be necessary.

The SWPPP must discuss how selected controls and practices will, individually and in conjunction with each other, address one or more of the potential pollution sources identified in the plan. The plan must also include a schedule specifying how each control or practice will be implemented, including the schedule of activities where appropriate.

3.27 Required Stormwater Controls

- Good Housekeeping (Part 2.1.5.1). Good housekeeping involves using practical, cost-effective methods to maintain a clean and orderly facility and keep contaminants out of stormwater discharges. It includes establishing protocols to reduce the possibility of mishandling chemicals or equipment, and training employees in good housekeeping techniques. Good housekeeping measures are often quite simple and practical, and include tasks such as sweeping loading docks on a regular basis; keeping dumpster lids closed; and cleaning up filings, shavings and sawdust. These protocols must be described in the plan and communicated to appropriate plant personnel.
- Eliminating and Minimizing Exposure (Part 2.1.5.2). Protecting potential pollutant sources from exposure to stormwater is an important control option. Operators should try to maximize opportunities to store materials and conduct industrial activities, such as loading and unloading, inside or under cover. Elimination of all exposure to stormwater may also make the facility eligible for the "No Exposure Certification" exclusion from permitting at 40 CFR 122.26(g).
- Preventive Maintenance (Part 2.1.5.3). Permittees must develop a preventive maintenance program that involves regular inspection and maintenance of stormwater management devices and other equipment and systems. The program description must identify the devices, equipment, and systems that will be inspected; provide a schedule for inspections and tests; and address appropriate adjustment, cleaning, repair, or replacement of devices, equipment, and systems. For stormwater management devices such as catch basins and oil and water separators, the preventive maintenance program must provide for periodic removal of debris to ensure that the devices are operating efficiently. For other equipment and systems, the program must reveal and enable the correction of conditions that could cause breakdowns or failures that may result in the release of pollutants.
- Spill Prevention and Response Procedures (Part 2.1.5.4). Based on an assessment of possible spill scenarios, permittees must specify appropriate material handling procedures, storage requirements, containment or diversion equipment, and spill cleanup procedures that will minimize the potential for spills and, in the event of a spill, enable proper and timely response. Areas and activities that typically pose a high risk for spills include loading and unloading areas, storage areas, process activities, and waste disposal activities. These activities and areas, and their accompanying drainage points, must be described in the plan. For a spill prevention and response program to be effective, employees must clearly understand the proper procedures and requirements and have the appropriate spill response supplies and equipment readily available.
- Routine Facility Inspections (Part 2.1.5.5). In addition to the comprehensive site evaluation, facilities are required to conduct periodic inspections of designated equipment and areas of the facility. Inspections are to be conducted monthly unless another frequency is justified in the SWPPP. Industry-specific requirements for such inspections, if any, are set forth in Part 4. When inspections are required, qualified

personnel must be identified to conduct the inspections at appropriate intervals specified in the plan. A set of tracking or follow-up procedures must be used to ensure that appropriate actions are taken in response to the inspections. Records of inspections must be maintained. These periodic inspections are different from the comprehensive site evaluation, although the former may be incorporated into the latter. Equipment, area, or other inspections are typically visual and are normally conducted on a regular basis (e.g., daily inspections of loading areas).

- Employee Training (Part 2.1.5.6). The SWPPP must describe a program for informing personnel at all levels of responsibility of the components and goals of the SWPPP. The training program should address topics such as good housekeeping, materials management, and spill response procedures. When appropriate, contractor personnel also must be trained in relevant aspects of stormwater pollution prevention. A schedule for conducting training must be provided in the plan. EPA recommends that facilities conduct training at least annually. However, more frequent training might be necessary at facilities with high employee turnover or where employee participation is essential to carrying out the SWPPP.
- Erosion and Sedimentation Controls (Part 2.1.5.7). The SWPPP must identify areas that, because of topography, activities, soils, cover materials, or other factors, have a high potential for significant soil erosion. The plan must identify measures that will be implemented to limit erosion in these areas.
- Management of Runoff (Part 2.1.5.8). The plan must contain a description of stormwater management practices that divert, infiltrate, reuse, or otherwise manage stormwater runoff to reduce contact with pollutants and reduce the discharge of pollutants. Appropriate measures may include vegetative swales, collection and reuse of stormwater, inlet controls, snow management, and infiltration practices.
- Salt Storage Piles or Piles Containing Salt (Part 2.1.5.9). The plan must contain a description of how the salt pile will be covered or enclosed. The plan must also include a description of how materials and runoff from handling activities, i.e. adding to or removing from the pile, will be managed.
- Sector Specific BMPs (Part 2.1.5.10 referencing sector specific sections of Part 4). The plan must include a description of all BMP requirements stipulated in Part 4 of the permit.
- Controls on other Specific Activities (Part 2.1.5.11). The proposed MSGP includes a requirement to implement controls on solid materials, including floating debris. In addition, off-site tracking of raw, final, or waste materials or sediment and the generation of dust must be minimized. Tracking or blowing of raw, final, or waste materials from areas of no exposure to exposed areas must be minimized.
- All other necessary controls (Part 2.1.5.12). The operator must determine if BMPs, in addition to those in 2.1.5.1 through 2.1.5.11, are necessary to adequately control pollutants in stormwater discharges to meet the provisions of the permit. If so, the SWPPP must include a description of those measures.

3.28 Controls for Allowable Non-Stormwater Discharges

Where an allowable non-stormwater discharge has been identified, appropriate controls for that discharge must be included in the SWPPP (Part 2.1.4.5). In many cases, the same types of controls for contaminated stormwater would suffice, but the nature and volume of potential pollutants in the non-stormwater discharges must be taken into consideration in selecting controls.

3.29 Special Requirements for Discharges Associated with Specific Industrial Activity

A number of changes to SWPPP requirements were introduced for specific industrial sectors. The sector-specific sections of Part 4 of the proposed MSGP 2006 provide requirements for each industrial sector. The following describe notable changes to industrial sectors:

Sector G – Metal Mining. Added the construction requirements applicable to the mining section.

Sector I – Oil and Gas Refining. Clarification on limitations of coverage in I.3.1 for discharges subject to effluent limitations guidelines of 40 CFR 419 and 435, and added discussion of why most Sector I stormwater discharges are not eligible for MSGP coverage. Changed the title and added discussion regarding contact with wastewater pollutants at exploration and production facilities in the place of "Good Housekeeping".

Sector J – Mineral Mining. Many of the same changes from Sector G and Construction General Permit were incorporated here.

Sector K - Hazardous Waste Treatment, Storage, or Disposal Facilities. For facilities identified under activity code HZ, primary comments are in limitation on coverage for commercial TSDF facilities, and several are region specific.

Sector Y - Rubber, Miscellaneous Plastic Products, and Miscellaneous Manufacturing Industries. The most significant changes added industrial dischargers active in the manufacture of Pens, Pencils, and other Artists' Materials (SIC 3951-3955, except 3952 as Specified in Sector C); Costume Jewelry, Costume Novelties, Buttons, and Miscellaneous Notions, Except Precious Metal (SIC 3961, 3965); and Miscellaneous Manufacturing Industries (SIC 3991-3999)

Sector AC - Electronic and Electrical Equipment and Components, Photographic and Optical Goods. Revisions included adding the broader activity description for manufacture of electrical and electronic equipment and components to the industrial activities covered under sector AC in AC.2.5, and added specific SIC codes to Table AC-1.

Sector AD – Stormwater Discharges Designated by the Director as Requiring Permits. Clarification regarding facilities identified as needing permits, but not falling into one of the established industrial sectors.

3.30 Mercury Switch Removal

For the MSGP 2006, EPA is considering a requirement for Sectors M (Automobile Salvage Yards) and N (Scrap Recycling and Waste Recycling Facilities) to properly remove, store and dispose of mercury-containing switches from automobiles. BMP options could include: (a) pop out mercury-containing "capsules" from hood and trunk unit; (b) remove anti-lock braking system units that contain mercury switches; (c) store switches and ABS units indoors in a secure container marked "Universal Waste" until sufficient numbers are collected to be recycled; (d) send mercury switches as Universal Waste to a mercury recycler that is permitted under the Resource Conservation and Recovery Act (RCRA) or to the state mercury switch collection facility; and, (e) provide employee training for the management of mercury switches.

For this requirement a readily available practice for facilities in Sectors M and N would be to participate in, or to purchase car hulks that have come through, state programs that ensure mercury switch removal. Consideration of these provisions for the stormwater permit is part of EPA's overall effort to avoid mercury releases related to the recycling of automobiles. EPA has been examining state programs and other voluntary and regulatory approaches with state regulators, as well as with representatives of affected industries and other stakeholders.

EPA could include this requirement for all relevant facilities in Sectors M and N, or could apply this provision only to facilities that crush automobiles, since this is the process that releases mercury to the environment. EPA solicits comment on whether or not mercury switch removal should be a requirement of MSGP 2006, and if so, how broadly it should be applied.

3.31 State or Tribal Requirements

Part 5 of the final MSGP 2006 will contain conditions provided by States and Tribes as part of Clean Water Act § 401 certification. Those provisions are not included in the proposed MSGP 2006, but will be included in the final MSGP 2006. Any requirement stipulated by a State or Tribe in the final permit must be incorporated into the SWPPP and implemented.

3.32 Maintenance

All BMPs identified in the SWPPP must be maintained at all times in effective operating condition (Part 2.2).

3.33 Comprehensive Site Compliance Evaluation

Today's proposed MSGP requires that the SWPPP describe the scope of the comprehensive site evaluation (Part 3.1). Inspections must be conducted by qualified personnel, and the inspection team must include at least one member of the Pollution Prevention Team. Qualified personnel are those who possess the knowledge and skills to assess conditions and activities that could impact stormwater quality at your facility, and who can also evaluate the effectiveness of BMPs selected. While EPA does not stipulate specific qualifications for these personnel, a combination of relevant education, training and experience is necessary.

Note that the comprehensive site evaluations are not the same as routine inspections. Routine inspections are relatively frequent and informal checks to ensure that problems are not developing. Comprehensive site evaluations, as the term implies, include a much more in-depth review of the site and all operations, as they relate to stormwater management and the requirements of the SWPPP. However, in the instances when frequencies of routine inspections and the comprehensive site compliance evaluation overlap, they may be combined to allow for efficiency as long as the requirements for both types of inspections are met. The plan must indicate the frequency of comprehensive evaluations, which must be at least once a year. Material handling and storage areas and other potential sources of pollution must be visually inspected for evidence of actual or potential pollutant discharges to the drainage system. Inspectors must also observe erosion controls and structural stormwater management devices to ensure that each is operating correctly. Equipment needed to implement the SWPPP, such as that used during spill response activities, must be inspected to confirm that it is readily available and in proper working order.

The results of each comprehensive site evaluation must be documented in a report signed by an authorized company official. The report must describe the scope of the comprehensive site evaluation, the personnel making the comprehensive site evaluation, the date(s) of the comprehensive site evaluation, and any major observations relating to implementation of the SWPPP.

Based on the results of each comprehensive site evaluation, the description in the plan of potential pollution sources and measures and controls must be revised as appropriate within 14 calendar days after each comprehensive site evaluation. If existing BMPs need to be modified or if additional BMPs are necessary, implementation must be completed before the next anticipated storm, or not more than 60 days after completion of the comprehensive site evaluation unless this time frame is extended by EPA. EPA reiterates that this time frame is not a grace period from permit violations.

3.34 Signature

The SWPPP must be signed and certified in accordance with Appendix B, section 11 of the permit.

3.35 Purpose of Corrective Action Schedules

Several provisions of MSGP 2006, including Parts 2.3 and 3.3, stipulate time limits for implementing actions to remedy deficiencies. EPA emphasizes that these time frames are not grace periods within which an operator is relieved of any liability for a permit violation. If the original inadequacy constitutes a permit violation, then that violation is not deferred by the time frame EPA has allotted for corrective action. The time limits are those that EPA considers reasonable for making the necessary repairs or modifications, and are included specifically so that inadequacies are not allowed to persist indefinitely. Failure to take the necessary corrective action within the stipulated time limit constitutes an additional and independent permit violation.

3.36 Reporting

EPA has included reporting requirements in MSGP 2006 that ensure that EPA, and other parties as necessary, are made aware of potential water quality problems. Discharge monitoring reports must be submitted to EPA no later than 30 days after all analytical data from a monitoring event are received. This is a change from MSGP 2000 where operators could submit results of multiple monitoring events once per year.

EPA will have on-line electronic reporting associated with the e-NOI system by the time MSGP 2006 is finalized, so that permittees may electronically report discharge monitoring data. EPA also intends to develop electronic reporting for follow-up monitoring reports (Part 3.4) and reports of spills and other unauthorized discharges (Part 3.5.1), though these components of the e-reporting system may not be available until a later date.

Follow-up monitoring results should be reported via the electronic system (when available) or in writing to the appropriate EPA Regional Office (Part 3.7) within 30 days of receiving the results. The report should include the permit identification number; facility name, address and location; receiving water; monitoring data from this and the preceding monitoring event(s); an explanation of the situation; what has been done and shall be done to further reduce pollutants in the discharge; and an appropriate contact name and phone number.

In addition, MSGP 2006 clarifies that spills and other unauthorized discharges must be reported to EPA. In the case where discharges may affect drinking water supplies, recreational waters, elicit fish kills, or may otherwise endanger human health or the environment the discharge must be reported orally to the appropriate EPA regional office within 24 hours from the time or discovery, followed by an electronic or written report (per the requirements of Appendix B, section 12(F)) within 5 days. EPA also encourages operators to report the releases that may have human health ramifications to the appropriate local authorities, e.g., public water supply operator, health department. EPA requests comments on whether or not reporting to these local authorities should be encouraged or required.

4. Eligible Discharges

4.1 Areas Covered

Today's proposed MSGP would authorize discharges associated with industrial activities in areas where EPA is the permitting authority (see Appendix C of the permit).

Proposed Coverage for Arizona Non-Indian Lands

The 2006 MSGP is being proposed to cover non-Indian lands in the State of Arizona even though EPA authorized the State of Arizona to administer the NPDES permit program in late 2002. EPA's 2002 decision to grant program authorization to the State was challenged by two petitions which contended that the decision was inconsistent with the requirements of the Endangered Species Act. On August 22, 2005, the Ninth Circuit Court of Appeals agreed with the petitioners and vacated EPA's decision to authorize the State of Arizona to administer the program. Defenders of Wildlife v. EPA, No. 03-71439.

The Court decision has not yet become effective pending the outcome of the requests for a rehearing which have been filed by EPA and certain other parties. However, if the Court decision does become effective the authority to issue and enforce NPDES permits in non-Indian lands in Arizona would revert to EPA.

The Arizona Department of Environmental Quality (ADEQ) has been administering EPA's 2000 MSGP since ADEQ assumed responsibility for NPDES permitting in 2002. ADEQ is also in process of issuing its own MSGP to replace the 2000 MSGP. However, ADEQ could no longer continue its program if the Court decision were to go into effect.

In view of the large number of industrial facilities subject to stormwater permitting, and the similarity of most discharges, EPA believes that general permitting is the most appropriate permitting option for most facilities. EPA is proposing the 2006 MSGP in non-Indian lands in Arizona as a contingency measure to ensure that general permitting continues to be available if the Court decision does take effect. It is still possible that the Court decision may be modified or reversed as a result of future requests for rehearing filed with the Court. If so, EPA's proposed MSGP may never be finalized for non-Indian lands in Arizona, and the ADEQ permitting program could continue.

4.2 Industrial Sectors Covered

Today's proposed MSGP would authorize stormwater discharges associated with industrial activity from the categories of facilities shown in Table 2.

Table 2. Industrial Sectors and Subsectors in Proposed MSGP 2006		
Subsector	**SIC code**	**Activity represented**
Sector A. Timber Products		
1	2421	General Sawmills and Planing Mills
2	2491	Wood Preserving
3	2411	Log Storage and Handling
4	2426	Hardwood Dimension and Flooring Mills
	2429	Special Product Sawmills, Not Elsewhere Classified
	2431-2439 (except 2434)	Millwork, Veneer, Plywood, and Structural Wood (see Sector W)
	2448, 2449	Wood Containers
	2451, 2452	Wood Buildings and Mobile Homes
	2493	Reconstituted Wood Products
	2499	Wood Products, Not Elsewhere Classified
Sector B. Paper and Allied Products		
1	2611	Pulp Mills
2	2621	Paper Mills
3	2631	Paperboard Mills
4	2652-2657	Paperboard Containers and Boxes
5	2671-2679	Converted Paper and Paperboard Products, Except Containers and Boxes
Sector C. Chemical and Allied Products		
1	2812-2819	Industrial Inorganic Chemicals
2	2821-2824	Plastics Materials and Synthetic Resins, Synthetic Rubber, Cellulosic and Other Manmade Fibers, Except Glass
3	2833-2836	Medicinal Chemicals and Botanical Products; Pharmaceutical Preparations; *in Vitro* and *in Vivo* Diagnostic Substances; Biological Products, Except Diagnostic Substances
4	2841-2844	Soaps, Detergents, and Cleaning Preparations; Perfumes, Cosmetics, and Other Toilet Preparations
5	2851	Paints, Varnishes, Lacquers, Enamels, and Allied Products
6	2861-2869	Industrial Organic Chemicals
7	2873-2879	Agricultural Chemicals, Including Facilities That Make Fertilizer Solely from Leather Scraps and Leather Dust
8	2891-2899	Miscellaneous Chemical Products
9	3952 (limited to list)	Inks and Paints, Including China Painting Enamels, India Ink, Drawing Ink, Platinum Paints for Burnt Wood or Leather Work, Paints for China Painting, Artist's Paints, and Artist's Watercolors
Sector D. Asphalt Paving and Roofing Materials and Lubricants		
1	2951, 2952	Asphalt Paving and Roofing Materials

Table 2. Industrial Sectors and Subsectors in Proposed MSGP 2006		
Subsector	**SIC code**	**Activity represented**
2	2992, 2999	Miscellaneous Products of Petroleum and Coal
Sector E. Glass, Clay, Cement, Concrete, and Gypsum Products		
1	3211	Flat Glass
	3221, 3229	Glass and Glassware, Pressed or Blown
	3231	Glass Products Made of Purchased Glass
	3281	Cut Stone and Stone Products
	3291-3292	Abrasive and Asbestos Products
	3296	Mineral Wool
	3299	Nonmetallic Mineral Products, Not Elsewhere Classified
2	3241	Hydraulic Cement
3	3251-3259	Structural Clay Products
	3261-3269	Pottery and Related Products
	3297	Non-Clay Refractories
4	3271-3275	Concrete, Gypsum, and Plaster Products
	3295	Minerals and Earths, Ground or Otherwise Treated
Sector F. Primary Metals		
1	3312-3317	Steel Works, Blast Furnaces, and Rolling and Finishing Mills
2	3321-3325	Iron and Steel Foundries
3	3331-3339	Primary Smelting and Refining of Nonferrous Metals
4	3341	Secondary Smelting and Refining of Nonferrous Metals
5	3351-3357	Rolling, Drawing, and Extruding of Nonferrous Metals
6	3363-3369	Nonferrous Foundries (Castings)
7	3398, 3399	Miscellaneous Primary Metal Products
Sector G. Metal Mining (Ore Mining and Dressing)		
1	1011	Iron Ores
2	1021	Copper Ores
3	1031	Lead and Zinc Ores
4	1041, 1044	Gold and Silver Ores
5	1061	Ferroalloy Ores, Except Vanadium
6	1081	Metal Mining Services
7	1094, 1099	Miscellaneous Metal Ores
Sector H. Coal Mines and Coal Mining-Related Facilities		
NA	1221-1241	Coal Mines and Coal Mining-Related Facilities
Sector I. Oil and Gas Extraction and Refining		
1	1311	Crude Petroleum and Natural Gas
2	1321	Natural Gas Liquids
3	1381-1389	Oil and Gas Field Services
4	2911	Petroleum refineries

Table 2. Industrial Sectors and Subsectors in Proposed MSGP 2006		
Subsector	**SIC code**	**Activity represented**
Sector J. Mineral Mining and Dressing		
1	1411	Dimension Stone
	1422-1429	Crushed and Broken Stone, Including Rip Rap
	1481	Nonmetallic Minerals, Except Fuels
2	1442, 1446	Sand and Gravel
3	1455, 1459	Clay, Ceramic, and Refractory Materials
4	1474-1479	Chemical and Fertilizer Mineral Mining
	1499	Miscellaneous Nonmetallic Minerals, Except Fuels
Sector K. Hazardous Waste Treatment, Storage, and Disposal Facilities		
NA	HZ	Hazardous Waste Treatment, Storage, or Disposal
Sector L. Landfills, Land Application Sites, and Open Dumps		
NA	LF	Landfills, Land Application Sites, and Open Dumps
Sector M. Automobile Salvage Yards		
NA	5015	Automobile Salvage Yards
Sector N. Scrap Recycling Facilities		
NA	5093	Scrap Recycling Facilities
Sector O. Steam Electric Generating Facilities		
NA	SE	Steam Electric Generating Facilities
Sector P. Land Transportation and Warehousing		
1	4011, 4013	Railroad Transportation
2	4111-4173	Local and Highway Passenger Transportation
3	4212-4231	Motor Freight Transportation and Warehousing
4	4311	United States Postal Service
5	5171	Petroleum Bulk Stations and Terminals
Sector Q. Water Transportation		
NA	4412-4499	Water Transportation
Sector R. Ship and Boat Building and Repairing Yards		
NA	3731, 3732	Ship and Boat Building and Repairing Yards
Sector S. Air Transportation Facilities		
NA	4512-4581	Air Transportation Facilities
Sector T. Treatment Works		
NA	TW	Treatment Works
Sector U. Food and Kindred Products		
1	2011-2015	Meat Products
2	2021-2026	Dairy Products
3	2032	Canned, Frozen, and Preserved Fruits, Vegetables, and Food Specialties
4	2041-2048	Grain Mill Products
5	2051-2053	Bakery Products

Table 2. Industrial Sectors and Subsectors in Proposed MSGP 2006		
Subsector	**SIC code**	**Activity represented**
6	2061-2068	Sugar and Confectionery Products
7	2074-2079	Fats and Oils
8	2082-2087	Beverages
9	2091-2099	Miscellaneous Food Preparations and Kindred Products
	2111-2141	Tobacco Products
Sector V. Textile Mills, Apparel, and Other Fabric Product Manufacturing; Leather and Leather Products		
1	2211-2299	Textile Mill Products
2	2311-2399	Apparel and Other Finished Products Made From Fabrics and Similar Materials
	3131-3199 (except 3111)	Leather and Leather Products, Except Leather Tanning and Finishing (see Sector Z).
Sector W. Furniture and Fixtures		
NA	2511-2599	Furniture and Fixtures
	2434	Wood Kitchen Cabinets
Sector X. Printing and Publishing		
NA	2711-2796	Printing, Publishing, and Allied Industries
Sector Y. Rubber, Miscellaneous Plastic Products, and Miscellaneous Manufacturing Industries		
1	3011	Tires and Inner Tubes
	3021	Rubber and Plastics Footwear
	3052, 3053	Gaskets, Packing and Sealing Devices, and Rubber and Plastics Hose and Belting
	3061, 3069	Fabricated Rubber Products, Not Elsewhere Classified
2	3081-3089	Miscellaneous Plastics Products
	3931	Musical Instruments
	3942-3949	Dolls, Toys, Games, and Sporting and Athletic Goods
	3951-3955 (except 3952 as specified in Sector C)	Pens, Pencils, and Other Artists' Materials
	3961, 3965	Costume Jewelry, Costume Novelties, Buttons, and Miscellaneous Notions, Except Precious Metal
	3991-3999	Miscellaneous Manufacturing Industries
Sector Z. Leather Tanning and Finishing		
NA	3111	Leather Tanning and Finishing
Sector AA. Fabricated Metal Products		
1	3411-3499	Fabricated Metal Products, Except Machinery and Transportation Equipment and Coating, Engraving, and Allied Services
	3911-3915	Jewelry, Silverware, and Plated Ware
2	3479	Coating, Engraving, and Allied Services

Table 2. Industrial Sectors and Subsectors in Proposed MSGP 2006		
Subsector	**SIC code**	**Activity represented**
Sector AB. Transportation Equipment, Industrial, and Commercial Machinery		
NA	3511-3599 (except 3571-3579)	Industrial and Commercial Machinery (except Computer and Office Equipment - see Sector AC)
NA	3711-3799 (except 3731, 3732)	Transportation Equipment (except Ship and Boat Building and Repairing - see Sector R)
Sector AC. Electronic, Electrical, Photographic, and Optical Goods		
NA	3612-3699	Electronic and Electrical Equipment and Components, Except Computer Equipment
	3812-3873	Measuring, Analyzing, and Controlling Instruments; Photographic and Optical Goods, Watches, and Clocks
	3571-3579	Computer and Office Equipment
Sector AD. Reserved for Facilities Not Covered Under Other Sectors and Designated by the Director		

"NA" indicates industry sectors in which subdivision into subsectors was determined to be not applicable.

Although the Office of Management and Budget's North American Industry Classification System is intended to replace the 1987 Standard Industrial Classification Code, EPA has decided to continue using the 1987 SIC code system as the primary classification system under the MSGP because the stormwater regulations (40 CFR 122.26(b)(14)) refer to these codes and because this code system identifies facilities adequately.

5. Cost Estimates

EPA has prepared an analysis of costs of complying with this permit. The analysis includes low, average and high level facility costs and shows both the total costs and incremental costs relative to the 2000 MSGP permit.

EPA observed that 3,656 facilities were covered by the 2000 MSGP in July, 2005. The Agency used the same number of facilities to estimate costs for the 2006 permit. This was done to look at changes in the permit and the impact of only those changes; in other words, the analysis was performed such that the Agency could make like comparisons. However, there are likely to be some additional permittees in the 2006 permit.

Initial EPA analysis indicated that average additional incremental cost to MSGP 2006 from MSGP 2000 will be approximately $60 per year. Based on specific laboratory cost information obtained after the conclusion of this analysis, EPA believes that this estimate is conservative, and costs will be somewhat less. EPA estimates that the low end total cost for existing facilities is approximately $1,000 per facility per year. The high end cost is estimated at approximately $27,000 per facility per year. However, EPA estimates that the actual cost will be far closer to the low end estimate for the majority of facilities and has estimated an average cost estimate of approximately $2,000 per year per existing facility. Furthermore, EPA estimates the median cost will be below $2,000 per facility per year. The complete cost analysis is available in the docket for the proposed permit. Several specific cost elements are described below. See "Cost Analyses" file in the docket for more detail on cost analyses.

5.1 Analytical Benchmark Monitoring

Some sectors and subsectors that did not previously perform benchmark monitoring will be required to do so. Generally, the monitoring requirements will be for TSS, a relatively inexpensive laboratory test. Using a conservative estimation scheme, the Agency estimates an increased cost of approximately $126 dollars per year in monitoring costs for these facilities. Based on analytical cost data obtained after this analysis was completed, the agency believes this estimate is high.

5.2 Reporting

EPA will release a new electronic reporting system in concurrence with the final permit that will reduce time required per reporting event. In the 2000 Permit, EPA estimated that facilities would need 2 hours per annual reporting event. However, in the 2006 Permit, EPA estimates that facilities will need 1 hour for the first quarterly reporting event, and 15 minutes for each event thereafter. If the 2000 reporting mechanism applied to the MSGP 2006, EPA estimates an increased burden of approximately 900 hours in the first year and 1200 hours in the second year. Hence, the new reporting mechanism should save 2,100 hours, or approximately 0.6 hours or $26 per facility over the course of the 5 year permit.

EPA no longer will require permittees to contact their local municipalities. EPA estimates that this will save $19 in the first year for all facilities.

Some facilities will need to check with their TMDL authorities if they discharge to impaired waters to see what steps they need to take. EPA calculated a high end estimate of $300 incurred the first year for these select facilities. These costs are reflected in the high end estimate.

6. Economic Impact (Executive Order 12866)

Under Executive Order 12866 (58 FR 51735, October 4, 1993), the Agency must determine whether the regulatory action is "significant" and therefore subject to OMB review and the requirements of the Executive Order. The Executive Order defines "significant regulatory action" as one that is likely to result in a rule that may have an annual effect on the economy of $100 million or more or adversely affect in a material way the economy, a sector of the economy, productivity, competition, jobs, the environment, public health or safety, or State, local, or Tribal governments or communities; create a serious inconsistency or otherwise interfere with an action taken or planned by another agency; materially alter the budgetary impact of entitlements, grants, user fees, or loan programs or the rights and obligations of recipients thereof; or raise novel legal or policy issues arising out of legal mandates, the President's priorities, or the principles set forth in the Executive Order.

EPA has determined that the proposed MSGP is not a "significant regulatory action" under the terms of Executive Order 12866 and is therefore not subject to formal OMB review prior to proposal.

7. Unfunded Mandates Reform Act

Section 201 of the Unfunded Mandates Reform Act (UMRA), Pub.L. 104-4, generally requires Federal agencies to assess the effects of their "regulatory actions" on State, local, and Tribal governments and the private sector. EPA has determined that today's MSGP reissuance does not result in expenditures of $100 million or more for State, local, and Tribal governments, in the aggregate, or the private sector, in any one year.

The Agency also believes that the proposed MSGP will not significantly nor uniquely affect small governments. For UMRA purposes, "small governments" is defined by reference to the definition of "small governmental jurisdiction" under the RFA. (See UMRA Section 102(1), referencing 2 U.S.C. 658, which references Section 601(5) of the RFA.) "Small governmental jurisdiction" means governments of cities, counties, towns, etc., with a population of less than 50,000, unless the agency establishes an alternative definition.

Today's proposed MSGP also will not uniquely affect small governments because compliance with the final permit conditions affects small governments in the same manner as any other entities seeking coverage under the final permit.

8. Paperwork Reduction Act

EPA has reviewed the requirements imposed on regulated facilities resulting from the proposed MSGP under the Paperwork Reduction Act (PRA) of 1980, 44 U.S.C. 3501 et seq. The information collection requirements of MSGP 2000 have already been approved in previous submissions made for the NPDES permit program under the provisions of the CWA. The paperwork requirements in the proposed MSGP 2006 are similar to those of MSGP 2000. EPA is currently evaluating whether the existing PRA approval adequately covers the paperwork requirements in MSGP 2006. EPA requests comments on these requirements. EPA will seek approval of the Office of Management and Budget for any paperwork requirements it determines are not adequately covered in an existing Information Collection Request (ICR) approval.

9. Impact on Small Business

EPA considered the impact of this general permit on small businesses, small organizations, and small governmental jurisdictions. A small entity is defined as: (1) a small business based on SBA size standards; (2) a small governmental jurisdiction that is a government of a city, county, town, school district or special district with a population of less than 50,000; and (3) a small organization that is any not-for-profit enterprise which is independently owned and operated and is not dominant in its field.

After considering the economic impacts of the general permit requirements on small entities, the Agency believes that this action will not have a significant economic impact on a substantial number of small entities. The Agency has reached the conclusion that the majority of associated costs with the MSGP were covered by the initial 1991 Phase I rule analysis, with additional analysis being performed for the 1995 MSGP. The Agency has reviewed summary statistics from the 2002 Economic Census from the United States Census Bureau (available at: http://www.census.gov/econ/census02/). These values were then inflated from 2002 to 2005 dollars by using a conversion factor of 1.075. The agency surveyed statistics for companies with 0-4 employees from approximately 12 industry groups representative of various subsectors. Facilities with 0-4 employees were selected because they were assumed to be the smallest businesses and those that would see the greatest percentage of their gross revenue committed to the permit. Groups selected included Leather and Tanning, Paper Mills, Wood Kitchen Cabinets, Household Furniture, Fluid Milk Manufacturing, Creamery Butter manufacturing, Cheese manufacturing, Carpet & rug mills, Gold ore mining, and Iron Ore Mining. For all groups, the additional incremental cost associated with the MSGP 2006 permit appears to be 0.00% (Iron Ore and Gold Ore Mining) to 0.15% (Wood Kitchen Cabinets) of average gross revenue. In order for the MSGP permit to be greater than 3% of gross revenue, implementation costs would need to exceed from approximately $2,600 per facility per year (Wood Kitchen Cabinets) to $ 41,000 per facility per facility per year (cheese manufacturing). Based on EPA's estimates of full implementation cost of the permit, the total cost should not exceed 3% per year of gross revenue, and will be well under 1% of gross revenue for almost all facilities. Average gross revenue was calculated by dividing the total value of shipments per sector by the total number of facilities with 0-4 employees per sector. We also surveyed Water Transportation, but 2002 numbers were not broken down by the number of employees. We instead looked at inland water transportation, Excursion and Sightseeing, assuming industries in this sector would be smaller businesses. This sector will also remain well below the 3% threshold, requiring approximately $192,000 per facility per year to cross the 3% limit. Numerous other sectors for which data is available in the economic census were scanned to be sure their results were consistent with this analysis.

United States Environmental Protection Agency (EPA)
National Pollutant Discharge Elimination System (NPDES)

MULTI-SECTOR GENERAL PERMITS FOR STORMWATER DISCHARGES ASSOCIATED WITH INDUSTRIAL ACTIVITY (MSGP)

AUTHORIZATION TO DISCHARGE UNDER THE NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM

In compliance with the provisions of the Clean Water Act (CWA), as amended (33 U.S.C. 1251 *et seq.*), any operator who:

- develops and implements a Stormwater Pollution Prevention Plan (SWPPP) in accordance with Part 2,
- submits a complete Notice of Intent (NOI) in accordance with Part 1.5.1,
- for a discharge of stormwater associated with industrial activities,
- that is located in a state, territory or Indian Country where EPA is the permitting authority (see Appendix C for a detailed list), and
- that is eligible for permit coverage under Part 1.2

is authorized to discharge stormwater to waters of the United States in accordance with the requirements set forth herein. Definitions of permit-specific terms used in this permit are provided in Appendix A. Standard permit conditions applicable to all authorized discharges are included in Appendix B.

This permit becomes effective on **[insert date of FR publication]**.

This permit and the authorization to discharge expire at midnight, **[insert date 5 years]**.

Signed and issued this day of , 2006
Name
Title, Region 1

Signed and issued this day of , 2006
Name
Title, Region 2

Signed and issued this day of , 2006
Name
Title, Region 2, Caribbean Office

Signed and issued this day of , 2006
Name
Title, Region 3

Signed and issued this day of , 2006
Name
Title, Region 5

Signed and issued this day of , 2006
Name
Title, Region 6

Signed and issued this day of , 2006
Name
Title, Region 9

Signed and issued this day of , 2006
Name
Title, Region 10

NPDES MULTI-SECTOR GENERAL PERMITS FOR STORMWATER DISCHARGES ASSOCIATED WITH INDUSTRIAL ACTIVITY
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1. Coverage under this Permit.

1.1 Permit Structure.

This permit is structured as follows:

- general requirements that apply to all facilities are found in Parts 1 through 3;
- industry sector-specific conditions are found in Part 4; and
- specific requirements applicable to individual States or Tribes are found in Part 5.

The Appendices (A through H) contain detailed information on additional permit conditions. Please note that permit numbers are assigned by the location of the facility. You can find your permit location number in Appendix C.

1.2 Eligibility.

In order to be eligible for coverage under this permit you must meet the eligibility requirements described below. If you do not meet the eligibility requirements then resulting discharges will be considered unpermitted discharges.

1.2.1 Facilities Covered.

Your may obtain authorization to discharge under this permit only for discharges from facilities in the 30 "sectors" of industrial activity summarized in Appendix D.

Co-located Activities. If you have other industrial activities on-site in addition to your primary industrial activity, you must also comply with any sector-specific requirements of this permit for those co-located industrial activities.

1.2.2 Allowable Stormwater Discharges.

The following discharges are eligible for coverage under this permit:

1.2.2.1 Stormwater discharges associated with the industrial categories of activity detailed in Appendix D;

1.2.2.2 Discharges designated by EPA as needing a stormwater permit to implement an approved TMDL or to address exceedances of water quality standards as outlined in 40 CFR 122.26(a)(9)(C) or (D); and

1.2.2.3 Discharges that are not required to obtain NPDES permit authorization, but are co-mingled with discharges that are authorized under this permit.

1.2.2.4 Discharges subject to any of the stormwater-specific effluent limitations guidelines listed in Table 1-1, below;

1.2.2.5 For any facility where the New Source Performance Standards (NSPS) identified in Table 1-1 apply (i.e., where facilities commenced operation after the promulgation of that industry's NSPS), you must obtain and retain the following with your SWPPP, prior to submitting your NOI:

- documentation from EPA of "No Significant Impact"; or
- a completed Environmental Impact Statement in accordance with an environmental review conducted by EPA pursuant to 40 CFR 6.102(a)(6).

Table 1-1. Stormwater-Specific Effluent Limitations Guidelines

40 CFR Part/Subpart	Eligible Discharges	Affected MSGP Sector	Applicable NSPS?
Part 411, Subpart C	Runoff from material storage piles at cement manufacturing facilities	E	Yes
Part 418, Subpart A	Runoff from phosphate fertilizer manufacturing facilities	C	Yes
Part 423	Coal pile runoff at steam electric generating facilities	O	Yes
Part 429, Subpart I	Discharges resulting from spray down or intentional wetting of logs at wet deck storage areas	A	Yes
Part 436, Subpart B	Mine dewatering discharges at crushed stone mines	J	No
Part 436, Subpart C	Mine dewatering discharges at construction sand and gravel mines	J	No
Part 436, Subpart D	Mine dewatering discharges at industrial sand mines	J	No
Part 443, Subpart A	Runoff from asphalt emulsion facilities	D	Yes
Part 445, Subparts A and B	Runoff from landfills	K, L	Yes

1.2.3 Allowable Non-Stormwater Discharges.

The following non-stormwater discharges are authorized under this permit:

- Discharges from fire-fighting activities;
- Fire hydrant flushings;
- Potable water, including water line flushings;
- Uncontaminated air conditioning or compressor condensate;
- Irrigation drainage;
- Landscape watering provided all pesticides, herbicides, and fertilizer have been applied in accordance with manufacturer's instructions;
- Pavement wash waters where no detergents are used and no spills or leaks of toxic or hazardous materials have occurred (unless all spilled material has been removed);
- Routine external building washdown that does not use detergents;
- Uncontaminated ground water or spring water;
- Foundation or footing drains where flows are not contaminated with process materials; and
- Incidental windblown mist from cooling towers that collects on rooftops or adjacent portions of your facility, but NOT intentional discharges from the cooling tower (e.g., "piped" cooling tower blowdown or drains).

1.2.4 Limitations on Coverage.

1.2.4.1 ***Discharges Mixed with Non-Stormwater.*** You are not authorized to discharge stormwater that is mixed with sources of non-stormwater other than those listed in Part 1.2.3.

1.2.4.2 ***Stormwater Discharges Associated with Construction Activity.*** You are not authorized for stormwater discharges associated with construction activity unless in conjunction with mining activities, provided the applicable sector-specific requirements for construction stormwater discharges as specified in Sector G and Sector J of this permit are met. Construction activity is defined in 40 CFR 122.26(b)(14)(x) or 40 CFR 122.26(b)(15). These activities are covered by EPA's Construction General Permit (www.epa.gov/npdes/cgp).

1.2.4.3 ***Discharges Currently or Previously Covered by another Permit.*** You are not authorized to discharge:

- Stormwater discharges associated with industrial activity that are currently covered under an individual permit or an alternative general permit;
- Discharges previously covered by an individual permit or alternative general permit where that permit established site-specific numeric water quality-based limitations developed for the stormwater component of the discharge (except

generic pH range limitations not included to address a known exceedances of water quality standards);

- Discharges previously covered by an individual permit or alternative general permit where the permittee fails to implement Best Management Practices (BMPs) that provide equal or better pollution prevention or pollutant removal as required by the previous permit; or
- Discharges from facilities where any NPDES permit has been or is in the process of being denied, terminated, or revoked by EPA (this does not apply to the routine reissuance of permits every five years).

1.2.4.4 *Wasteload Allocations.* You are not authorized for discharges when a Total Maximum Daily Load (TMDL) specifically articulates a wasteload allocation requiring more stringent controls than required by this permit, OR when a Total Maximum Daily Load (TMDL) applies a wasteload allocation of zero (0) to your discharge (either specifically or by category). In a situation where an EPA-approved or established TMDL has specified a general wasteload allocation applicable to industrial storm water discharges, but no specific requirements for individual sites have been identified in the TMDL, you should consult with the State or Federal TMDL authority to confirm that adherence to a SWPPP that meets the requirements of the MSGP will be consistent with the approved TMDL.

1.2.4.5 *Discharges Subject to Effluent Limitations Guidelines.* You are not authorized for discharges subject to any effluent limitation guideline (i.e., discharges identified in 40 CFR, Subchapter N) that is not identified in Table 1-1.

1.2.4.6 *Endangered and Threatened Species and Critical Habitat Protection.* Coverage under this permit is available only if your stormwater discharges, allowable non-stormwater discharges, and stormwater discharge-related activities are not likely to jeopardize the continued existence of any species that are federally-listed as endangered or threatened ("listed") under the Endangered Species Act (ESA) or result in the adverse modification or destruction of habitat that is federally-designated as critical under the ESA ("critical habitat"). In order to be eligible for coverage under this permit you must certify that you meet one or more of the six criteria (A-F) detailed in Appendix E, Endangered Species Act Procedures, PRIOR to submitting your Notice of Intent.

1.2.4.7 *Historic Properties Preservation.* Coverage under this permit is available only if your stormwater discharges, allowable non-stormwater discharges, and stormwater discharge-related activities are in compliance with the National Historic Preservation Act (NHPA). In order to be eligible for coverage under this permit, you must certify that you meet one or more of the four criteria (A-D) detailed in Appendix F, National Historic Preservation Act Procedures, PRIOR to submitting your Notice of Intent.

1.2.4.8 *Hazardous Substances.* Discharges of a hazardous substance or oil in excess of reporting quantities caused by a non-stormwater discharge (e.g., a spill of oil into a separate storm sewer) are not authorized by this permit. In the event of a spill, the requirements of Section 311 of the CWA and other applicable provisions of Sections 301 and 402 of the CWA continue to apply. In addition, the reporting requirements of Part 3.6.3, Reporting Unauthorized Releases or Discharges, of this permit apply.

1.2.4.9 *New Discharges to Water Quality Impaired Receiving Waters.* The provisions of this part apply to operators of new discharges, as defined in Appendix A, proposing to discharge to an impaired water for which a TMDL has not yet been developed. To satisfy the requirements of 40 CFR 122.4(i) that the discharge from the construction or operation of a new discharger not cause or contribute to a violation of water quality standards, the operator of the facility that is the new discharger must: 1) eliminate all exposure to stormwater of the pollutant(s) for which the waterbody is impaired, and properly document no exposure in the SWPPP, or 2) obtain written clarification from the appropriate State or Tribal water quality agency that the discharge is not expected to cause or contribute to a violation of a water quality standard, and file such notification with the SWPPP.

1.2.4.10 *Stormwater Discharges Subject to Anti-degradation Water Quality Standards.* New dischargers, as defined in Appendix A, are not authorized for discharges that do not comply with the applicable State or Tribal anti-degradation policy for water quality standards.

1.3 Permit Compliance.

Any noncompliance with the requirements of this Permit constitutes a violation of the Clean Water Act. For provisions specifying a time period to remedy noncompliance (including, but not limited to, Parts 2.2, 2.3 and 3.3), the initial BMP or SWPPP deficiency constitutes a violation of the Permit and the Clean Water Act (unless specifically otherwise stipulated), and subsequent failure to remedy such deficiencies within the specified time periods constitutes an independent, additional violation of the Permit and Clean Water Act. Therefore, any time periods specified for remedying noncompliance do not absolve parties of the initial underlying noncompliance.

To provide clarity for operators, there are additional reminders in certain sections of this permit about what constitutes a permit violation. The absence of such a reminder in a particular section does not mean that failure to meet that requirement is not a permit violation.

Where requirements and schedules for taking corrective actions are included, the time intervals are not grace periods, but are time limits considered reasonable for making repairs and improvements. They are included in the permit to ensure that inadequacies are not allowed to persist indefinitely.

1.4 Water Quality Provisions.

Pursuant to Clean Water Act § 301(b)(1)(C) and 402(p)(3)(A), as well as 40 CFR 122.44(d), this permit includes provisions to ensure that discharges do not cause or contribute to exceedances of water quality standards. This permit sets technology-based limitations in the form of Best Management Practices that apply to all pollutants associated with industrial activity, and some numeric effluent limitations (effluent limit guidelines, coal pile runoff) more specifically targeted to specific activities.

1.4.1 Numeric Effluent Limitations.

This permit stipulates numeric effluent limitations for coal pile runoff and effluent limitation guidelines (Part 3.2.3). Failure to comply with the effluent limitations applicable to your discharge is a violation of this permit.

1.4.2 Benchmarks.

This permit stipulates pollutant benchmark concentrations applicable to your discharge (Part 3.2.2). The benchmark concentrations do not constitute direct numeric effluent limitations; a benchmark exceedance, therefore, is not a permit violation. Benchmark monitoring data are primarily for your use (and EPA's use as described in Part 1.4.3) to determine the overall effectiveness of your SWPPP and to assist you in knowing when additional corrective action may be necessary to protect water quality. If the average of four quarterly discharge samples exceed a benchmark concentration you must review your Stormwater Pollution Prevention Plan (SWPPP) and your BMPs to determine whether any improvement or additional controls are needed to reduce that pollutant in your stormwater discharge(s). Failure to undertake and document the review, take the necessary corrective actions, or follow the EPA notification procedures stipulated in this permit are violations of this permit.

1.4.3 Water Quality Standards.

If at any time you or EPA determine(s) that your discharge causes or contributes to an exceedance of applicable water quality standards, you must take corrective actions and conduct follow-up monitoring. If you discover or are informed (by an entity other than EPA) of the exceedances you must take corrective action and conduct follow-up monitoring as stipulated in Parts 3.3 and 3.4; you must also report the exceedances(s) to EPA as stipulated in Part 3.4. If EPA makes the determination that your discharge causes or contributes to an exceedance of a water quality standard, you must comply with any requirements or schedules, including submitting additional information concerning the potential cause of the exceedance, provided by EPA, and those requirements and schedules will supercede those of Parts 3.3 and 3.4, where such requirements conflict. In addition, one of the following will apply: EPA may continue to authorize your coverage under this permit after you modify your SWPPP and your BMPs to adequately reduce pollutants in your discharge, and verify through monitoring. Alternatively, EPA may notify you that an individual permit application is necessary in accordance with Part 1.8.1. On a case by case basis EPA may look at monitoring data as well as background concentrations in the stream, State mixing zone policies, if available, and other relevant information to determine whether the discharge has the reasonable potential to cause or contribute to a violation of the established water quality standard. Failure to take the appropriate action is a violation of this permit.

1.4.4 Water Quality Impaired Receiving Waters.

Impaired waters include both those with established TMDLs, and those for which TMDL development has been identified as necessary, but for which one has not yet been established. For a more detailed definition see Appendix A.

1.4.4.1*Discharge to an Impaired Water with an Established TMDL.* If a wasteload allocation (WLA) has been established that applies to your discharge, you must develop the SWPPP accordingly (Part 2.1.3.2), and implement all necessary controls to meet that allocation. You must verify that your discharge complies with the WLA through the appropriate discharge monitoring (Part 3.2.5.2). Failure to comply with a relevant WLA is a violation of this permit.

If you have properly complied with the requirements of Part 2.1.3.2 and Part 5 of this permit, and find that the applicable TMDL does not specify a wasteload allocation or other requirements either individually or categorically for your discharge (including disallowing such discharge), compliance with this permit will be deemed adequate to meet the requirements of the TMDL.

1.4.4.2*Discharge to an Impaired Water without an Established TMDL.* If a TMDL has not been established that applies to your discharge you must comply with the requirements of this permit and any additional conditions stipulated by EPA or your State or Tribe (Part 2.1.3.2 and Part 5). If you have properly complied with all such requirements then compliance with this permit will be deemed adequate to meet the requirements for discharging to an impaired water. You are also subject to the monitoring requirement of Part 3.2.5.1. Failure to comply with applicable conditions is a violation of this permit.

1.5 Authorization under this Permit.

1.5.1 How to Obtain Authorization.

To obtain authorization under this permit, you must:

- Meet the Part 1.2 eligibility requirements; and
- Develop and implement a SWPPP according to the requirements in Part 2 of this permit; and
- Submit a complete NOI in accordance with the requirements of Appendix G of this permit. All new and existing facilities must submit NOIs. NOIs must be submitted in accordance with the deadlines in Table 1-2.

Table 1-2. Deadlines for NOI Submittal for Coverage under this Permit	
Category	Deadline
Existing discharges covered under MSGP 2000	No later than 90 days after the effective date of MSGP 2006.
Existing discharges without permit coverage	No later than 90 days after the effective date of MSGP 2006.
New discharges	A minimum of 30 days prior to commencing operation of the facility.
New owner/operator of existing discharges	A minimum of 30 days prior to assuming operation of the facility.

You are strongly encouraged to apply for permit coverage using EPA's Electronic Notice of Intent (eNOI) system (www.epa.gov/npdes/eNOI). Submitting an electronic NOI is the fastest and easiest way to obtain permit coverage. Using the electronic system will ensure that your form is complete.

1.5.2 Effective Date of Permit Coverage.

You are authorized to discharge under the terms and conditions of this permit 30 days after EPA posts your complete NOI on EPA's website at: www.epa.gov/npdes/stormwater/noisearch, unless notified otherwise by EPA. EPA may extend the waiting period for further review, or deny coverage under this permit and require submission of an application for an individual NPDES permit based on a review of your NOI or other information (see Part 1.8). If your NOI is incomplete EPA will return it to you, and a new 30 day wait period will commence when EPA receives a complete NOI.

1.5.3 Continuation of the Expired General Permit.

If you are covered by MSGP 2000 on the effective date of this permit, your coverage is automatically extended under the 2000 general permit for a period of up to 120 days provided you submit a timely and complete NOI in accordance with the deadlines in Table 1-2.

If this permit is not reissued or replaced prior to the expiration date, it will be administratively continued in accordance with the Administrative Procedure Act and remain in force and effect. If you were granted permit coverage prior to the expiration date, you will automatically remain covered by this permit until the earliest of:

- Your authorization for coverage under a reissuance or replacement of this permit, following your timely and appropriate submittal of a complete NOI requesting authorization to discharge under the new permit and compliance with the requirements of the new permit; or
- Your submittal of a Notice of Termination; or
- Issuance or denial of an individual permit for the facility discharges; or

- A formal permit decision by EPA not to reissue this general permit, at which time you must seek coverage under an alternative general permit or an individual permit.

1.6 Terminating Coverage.

1.6.1 Submitting a Notice of Termination.

If you wish to terminate coverage under this permit, you must submit a Notice of Termination (NOT) in accordance with Appendix H. You must continue to comply with this permit until you submit an NOT. Your authorization to discharge under the permit terminates at midnight of the day that a complete NOT is processed and posted on EPA's website (www.epa.gov/npdes/noisearch).

1.6.2 When to Submit an NOT.

You may use the eNOI system to file your NOT. You must submit an NOT within 30 days after one or more of the following conditions have been met:

- a new owner or operator has assumed responsibility for the facility; or
- you have ceased operations at the facility and there no longer are discharges of stormwater associated with industrial activity from the facility and you have already implemented necessary sediment and erosion controls as required by Part 2.1.5.7; or
- you have obtained coverage under an individual or alternative general permit for all discharges required to be covered by an NPDES permit.

1.6.3 Discharges After the NOT Is Submitted.

If you submit an NOT without meeting one or more of the conditions identified in Part 1.6.2, then your NOT is not valid and you must continue to comply with the requirements of this permit.

1.7 Conditional Exclusion for No Exposure.

If you are covered by this permit, and become eligible for a no exposure exclusion from permitting under 40 CFR 122.26(g), you may file a No Exposure Certification. You are no longer authorized by nor required to comply with this permit upon submission of a no exposure certification to EPA. If you are no longer required to have permit coverage because of a no exposure exclusion and have submitted a No Exposure Certification form to EPA, you are not required to submit an NOT. A copy of the No Exposure Certification form is available from EPA (www.epa.gov/npdes/stormwater/msgp). You may file your No Exposure Certification using the eNOI system.

1.8 Permit Exclusions.

1.8.1 EPA Requiring Coverage under an Alternate Permit.

EPA may require you to apply for and/or obtain either an individual NPDES permit or an alternative NPDES general permit. Any interested person may petition EPA to take action under this paragraph. If EPA requires you to apply for an individual NPDES permit, EPA will notify you in writing that a permit application is required. This notification will include a brief statement of the reasons for this decision and application information. In addition, if you are an existing permittee covered under this permit, the notice will set a deadline to file the application, and will include a statement that on the effective date of the individual NPDES permit, or the alternative general permit as it applies to you, coverage under this general permit will automatically terminate. EPA may grant additional time to submit the application following your request. If you are covered under this permit and fail to submit an individual NPDES permit application as required by EPA, then the applicability of this permit to you is automatically terminated at the end of the day specified by EPA as the deadline for application submittal. EPA may take appropriate enforcement action for the unpermitted discharge.

When an individual NPDES permit is issued to you, or you are authorized to discharge under an alternative NPDES general permit, your coverage under this permit is automatically terminated on the effective date of the individual permit or the date of authorization of coverage under the alternative general permit.

1.8.2 Permittee Requesting Coverage under an Alternate Permit.

You may request to be excluded from the coverage of this general permit by applying for an individual permit. In such a case, you must submit an individual permit application in accordance with the requirements of 40 CFR §122.26(c)(1)(ii), with reasons supporting the request, to EPA at the applicable EPA Regional Office listed in Part 3.7 of this permit. The request may be granted by issuance of an individual permit or an alternative general permit if your reasons are adequate to support the request.

When an individual NPDES permit is issued to you, or you are authorized to discharge under an alternative NPDES general permit, your coverage under this permit is automatically terminated on the effective date of the individual permit or the date of authorization of coverage under the alternative general permit.

1.8.3 Termination of Coverage under the MSGP.

EPA may terminate permit coverage for any reason specified in 40 CFR § 122.64. Terminating permit coverage shall not preclude any enforcement by EPA.

1.8.4 Modification or Revocation and Reissuance.

The permit may be modified or revoked for any reason stated in 40 CFR §§ 122.62 and 122.63. Permit modification or revocation will be in accordance with 40 CFR §124.5.

2. Stormwater Pollution Prevention Plan (SWPPP).

You must prepare and implement a SWPPP for your facility before submitting your Notice of Intent (NOI) for permit coverage. If you prepared a SWPPP for coverage under a previous MSGP you must review and update it to meet all provisions of this permit prior to submitting your NOI. Your SWPPP must include Best Management Practices (BMPs), economically reasonable and appropriate in light of current industry practices, that are selected, designed, installed, implemented and maintained in accordance with good engineering practices to eliminate or reduce all pollutants in your discharge, as well as any more stringent measures necessary to meet the water quality standards provisions of Parts 1.4.3 and 1.4.4. EPA does not require you to use a registered professional engineer to prepare your SWPPP, but this may be independently required under State law and/or local ordinance. Your SWPPP must remain compliant with relevant State, Tribal and local regulations.

Your SWPPP must:

- identify all potential sources of pollution that may reasonably be expected to affect the quality of stormwater discharges from your facility;
- describe and ensure implementation of practices you will use to eliminate or reduce all pollutants in stormwater discharges from the facility;
- ensure compliance with the terms and conditions of this permit; and
- include all necessary measures to ensure that the discharge complies with all water quality provisions of Part 1.4.

2.1 Contents of the SWPPP.

2.1.1 Pollution Prevention Team.

You must identify the staff members (by name or title) that comprise the facility's stormwater pollution prevention team. Your pollution prevention team is responsible for assisting the facility manager in developing, implementing, maintaining, revising and ensuring compliance with the facility's SWPPP. Specific responsibilities of each staff individual on the team must be identified and listed in the SWPPP. Each member of the stormwater pollution prevention team must have ready access to either an electronic or paper copy of applicable portions of this permit and the SWPPP.

2.1.2 Site Description.

Your SWPPP must include the following:

- *Activities at the Facility.* Provide a description of the nature of the industrial activities at your facility.
- *Impervious Surface Estimate.* Provide an estimate of the percent imperviousness of your site:

$$\left[\frac{(\text{Area of Roofs} + \text{Area of Paved and Other Impervious Surfaces})}{}\right] \times 100$$

Total Area of Facility

- *Precipitation Information.* Provide average annual precipitation information for your locale (this can be obtained from almanacs or from the closest airport, etc.). Note which months or seasons are usually the wettest and include such details as expected rainfall and storm intensity, e.g., wet season: May - September; typical amount: 0.5 inches - 2 inches over 2 hours.
- *General location map.* Provide a general location map, e.g., U.S. Geological Survey (USGS) quadrangle map, with enough detail to identify the location of your facility and the receiving waters.
- *Site map.* Provide a map showing:
  - the size of the property in acres;
  - the location and extent of significant structures and impervious surfaces;
  - directions of stormwater flow (use arrows);
  - locations of all existing structural and source control BMPs;
  - locations of all surface water bodies within 1 mile of the site, including all receiving waters for your stormwater discharges;
  - locations of all stormwater conveyances including ditches, pipes and swales;
  - locations of potential pollutant sources identified under Part 2.1.4.2;
  - locations where significant spills or leaks identified under Part 2.1.4.3 have occurred;
  - locations of stormwater inlets and outfalls, and an approximate outline of the areas draining to each outfall;
  - municipal storm sewer systems, where your stormwater discharges to them;
  - locations and descriptions of all non-stormwater discharges;
  - locations of the following activities where such activities are exposed to precipitation:
    - fueling stations,
    - vehicle and equipment maintenance and/or cleaning areas,
    - loading/unloading areas,
    - locations used for the treatment, storage or disposal of wastes,
    - liquid storage tanks,
    - processing and storage areas,
    - access roads, rail cars, and tracks,
    - transfer areas for substances in bulk,
    - machinery; and
  - locations and sources of run-on to your site from adjacent property that contains significant quantities of pollutants. An evaluation of how the quality of the stormwater running onto your facility impacts your stormwater discharges must be included.

2.1.3 Receiving Waters and Wetlands.

You must provide the name(s) of all surface waters that receive discharges from your site, including intermittent streams, dry sloughs, and arroyos. You must also provide the size and description of wetlands or other "special aquatic sites" (see Appendix A for definition) that may receive discharges from your facility. If your facility discharges through any municipal separate storm sewer system(s) (MS4), you must identify the MS4 operator(s), and the receiving water to which the MS4 discharges.

2.1.3.1 ***Water Quality Standards.*** Your SWPPP must identify the water quality standards applicable to your receiving waters. Applicable water quality standards are compiled at http://www.epa.gov/waterscience/standards/states/ and are also available from your state environmental protection or water quality regulatory agency.

2.1.3.2 ***Water Quality Impaired Receiving Waters.*** Your SWPPP must identify if any receiving water into which you discharge is on your state's or tribe's impaired waters (see definition in Appendix A) list, and/or has an approved TMDL. Information on impaired waters and approved TMDLs is compiled at http://cfpub.epa.gov/surf/locate/index.cfm. You may need to contact your State or Tribal water quality agency for up-to-date information or for clarification. Those contacts are provided at http://www.epa.gov/npdes/stormwater/contacts. Your SWPPP must specify the relevant waterbodies, the pollutants for which they are impaired, and your potential to discharge any of those pollutants.

- *Receiving Waters with an Approved TMDL.* You must determine the specific TMDL-related requirements applicable to your discharge. If not stipulated in Part 5 (State and Tribal Requirements) of this permit, you must ascertain from your State or Tribal environmental agency: the wasteload allocation (WLA) applicable to your discharge, the corresponding effluent limitation with which you must comply, and the monitoring requirements with which you must comply. Your SWPPP must include appropriate BMPs, and monitoring (Part 3.2.5.2) to verify that you are meeting the WLA. Your SWPPP must document any consultation with state or federal authorities on TMDL-related requirements and activities.

- *Impaired Waters without an Established TMDL.* If not stipulated in Part 5 (State and Tribal Requirements) of this permit, you must ascertain from your State or Tribal environmental agency if there are any discharge standards with which you must comply for the pollutant for which your receiving water is impaired. If your State or Tribal environmental agency specifies no additional requirements, you must comply with all general provisions of this permit, including the additional discharge monitoring requirements of Part 3.2.5.1. Your SWPPP must document any consultation with state or federal authorities on water quality impairment-related requirements and activities.

2.1.4 Summary of Potential Pollutant Sources.

You must identify each area at your facility where industrial materials or activities are exposed to stormwater. *Industrial materials or activities* include, but are not limited to: material handling equipment or activities; industrial machinery; raw materials; industrial production and processes; intermediate products, by-products, final products and waste products. *Material handling activities* include, but are not limited to: the storage, loading and unloading, transportation, disposal, or conveyance of any raw material, intermediate product, final product and waste product. For each area identified, the description must include:

2.1.4.1 ***Activities in the area.*** A list of the activities (e.g., material storage, equipment fueling and cleaning, cutting steel beams).

2.1.4.2 ***Pollutants.*** For each identified activity, a list of the associated pollutant(s) or pollutant constituents(s) (e.g., crankcase oil, zinc, sulfuric acid, cleaning solvents). The pollutant list must include all significant materials handled, treated, stored, or disposed that have been exposed to stormwater in the 3 years prior to the date you prepare or amend your SWPPP. This list must include any hazardous substances or oil at the facility.

2.1.4.3 ***Spills and Leaks.*** You must identify where potential spills and leaks could occur that could contribute pollutants to stormwater discharges, and the corresponding outfall(s). You must document in your SWPPP all significant spills and leaks of toxic or hazardous pollutants that actually occurred at exposed areas, or that drained to a stormwater conveyance in the 3 years prior to the date you prepare or amend your SWPPP.

Significant spills and leaks include, but are not limited to, releases of oil or hazardous substances in excess of quantities that are reportable under CWA §311 (see 40 CFR 110.6 and 40 CFR 117.21) or Section 102 of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). Significant spills may also include releases of oil or hazardous substances that are not in excess of reporting requirements. This permit does not relieve you of the reporting requirements of 40 CFR 110, 40 CFR 117, and 40 CFR 302 relating to spills or other releases of oils or hazardous substances.

2.1.4.4 ***Elimination of Unauthorized Discharges.*** Non-stormwater discharges to waters of the United States that are not authorized by an NPDES permit are unlawful and must be eliminated (see Part 2.1.4.5 below for SWPPP requirements regarding allowable non-stormwater discharges).

- *Signature and Certification.* Your SWPPP must include a certification that all discharges (i.e., outfalls) have been tested or evaluated for the presence of non-stormwater, and that all unauthorized discharges have been eliminated. The certification must be signed in accordance with Subsection 11 of Appendix B of this permit (General Permit Provisions, Signatory Requirements) and must include:

- the date of any testing and/or evaluation,
- a description of the evaluation criteria or testing method used,
- a list of the outfalls or onsite drainage points that were directly observed during the test,
- a description of the results of any test and/or evaluation for the presence of non-stormwater discharges, i.e. identification of unauthorized discharge(s) origin and composition,
- the action(s) taken to eliminate unauthorized discharge(s), if any were identified. For example, a floor drain was sealed, a sink drain was re-routed to sanitary, or an NPDES permit application was submitted for a cooling water discharge.

- *Previous Certifications.* You do not need to sign a new certification if you completed one for the 2000 version of the MSGP, provided conditions relating to non-stormwater discharges at your facility have not changed. The previous certification must be included in your SWPPP. If prior certification pre-dates your coverage under the MSGP 2000, you must provide a new certification.

- *Notification of EPA.* If you are unable to provide the certification required for the non-stormwater discharge test and elimination in your SWPPP this will not be deemed a violation of this permit provided that you notify EPA (Part 3.7) no more than 14 days after you submit your NOI:

  - why certification was not possible,
  - the procedure that you followed in any test attempted,
  - the results of such test or other relevant observations, and
  - any potential sources of non-stormwater discharges that have not been eliminated.

  Failure to provide this notification to EPA is a violation of this permit.

2.1.4.5 ***Allowable Non-Stormwater Discharges.*** Discharges of certain sources of non-stormwater are allowed under this permit (see Part 1.2.3, Allowable Non-Stormwater Discharges). For each allowable non-stormwater source (except flows from fire-fighting activities) your SWPPP must include:

- the discharge location(s); and
- descriptions of appropriate BMPs for each source.

If mist blown from cooling towers is one of your allowable non-stormwater discharges, you must specifically evaluate the discharge for the presence of chemicals used in the cooling tower. These data must be included in your SWPPP.

Allowable non-stormwater discharges are subject to all of the provisions of this permit, including numeric effluent limitations, benchmarks and monitoring requirements.

2.1.4.6 ***Salt Storage.*** Identification of any storage piles containing salt used for deicing or other commercial or industrial purposes.

2.1.4.7 ***Monitoring Data.*** You must provide a summary of existing stormwater discharge sampling data previously taken at your facility. The summary must include, at a minimum, any data collected during the previous permit term.

2.1.5 Stormwater Controls. You must implement BMPs for all areas identified in Part 2.1.4 to prevent or control pollutants in your stormwater discharges. You must also take all reasonable steps to control or address the quality of discharges from your site that may not originate at your facility. In your SWPPP describe the type, location and implementation of all BMPs for each area where industrial materials or activities are exposed to stormwater.

Consider the following when selecting BMPs:

- that preventing stormwater from coming into contact with polluting materials is much more effective than trying to remove pollutants from stormwater;
- BMPs generally must be used in combination with each other for most effective water quality protection;
- the type and quantity of pollutants, including their potential to impact receiving water quality;
- that minimizing impervious areas at your facility will reduce runoff and improve groundwater recharge and stream base flows in local streams (taking into account the potential for ground water contamination).
- flow attenuation by use of open vegetated swales and natural depressions,
- diverting flow from areas of materials handling, storage or use,
- conservation or restoration of riparian buffers,
- infiltration of runoff onsite, (including bioretention cells, green roofs, and pervious pavement),
- treatment interceptors (e.g., swirl separators and sand filters).

You **must** implement all of the following types of BMPs to prevent and control pollutants in your stormwater discharges, unless you demonstrate that such controls are not relevant to your discharge (e.g., you have no storage piles containing salt). You must keep abreast of new BMPs or new applications of existing BMPs for the most effective means of achieving water quality protection, and include these in your SWPPP as appropriate.

2.1.5.1 ***Good Housekeeping.*** You must keep clean all exposed areas that are potential sources of pollutants. Typical problem areas are around trash containers, storage areas, loading docks, and vehicle fueling and maintenance areas. You must include a schedule for regular pickup and disposal of waste materials, along with routine inspections for leaks and conditions of drums, tanks and containers.

2.1.5.2 ***Eliminating and Minimizing Exposure.*** To the extent practicable locate industrial materials and activities inside, or protect them with storm-resistant coverings to prevent exposure to rain, snow, snowmelt and runoff (although significant enlargement of impervious surface area is not recommended). Note that if you are able to eliminate exposure at all industrial areas you may be eligible for the "No Exposure" exclusion and not need to have a permit (see 40 CFR 122.26(g) and the *Guidance Manual for Conditional Exclusion from Stormwater Permitting Based on "No Exposure" of Industrial Activities to Stormwater* found at www.epa.gov/npdes/stormwater).

2.1.5.3 ***Preventive Maintenance.*** You must have a preventive maintenance program that includes regular inspecting, testing, maintaining and repairing of all industrial equipment and systems to avoid situations that may result in leaks, spills and other releases. These measures are in addition to specific BMP maintenance as required under Part 2.2 (Maintenance of BMPs).

2.1.5.4 ***Spill Prevention and Response Procedures.*** Describe your procedures for preventing and responding to spills and leaks.

- Preventive measures include barriers between material storage and traffic areas, secondary containment provisions, and procedures for material storage and handling.
- Response procedures must include notification of appropriate facility personnel, emergency agencies, and regulatory agencies, and procedures for stopping, containing and cleaning up spills. Measures for cleaning up hazardous material spills or leaks must be consistent with applicable Resource Conservation and Recovery Act (RCRA) regulations at 40 CFR Part 264 and 40 CFR Part 265. Employees who may cause, detect or respond to a spill or leak must be trained in these procedures and have necessary spill response equipment available. If possible, one of these individuals should be a member of your Pollution Prevention Team.
- Include in your SWPPP, and in other locations where it will be readily available, contact information for individuals and agencies that must be notified in the event of a spill. Where a release containing a hazardous substance or oil in an amount equal to or in excess of a reportable quantity established under either 40 CFR 110, 40 CFR 117, or 40 CFR 302, occurs during a 24-hour period, you must notify the National Response Center (NRC) at (800) 424-8802 or, in the Washington, DC, metropolitan area, call (202) 267-2675 in accordance with the requirements of 40 CFR 110, 40 CFR 117, and 40 CFR 302 as soon as you have knowledge of the discharge. State or local requirements may necessitate reporting spills or discharges to local emergency, public health or drinking water supply agencies.

2.1.5.5 ***Routine Facility Inspections.*** Qualified facility personnel (for definition see Appendix A) must regularly inspect all areas of the facility where industrial materials or activities are exposed to stormwater, and assess how well stormwater BMPs are operating (in addition to the comprehensive site evaluation required under Part 3.1). Qualified facility personnel are those who possess the knowledge and skills to assess conditions and activities that could impact stormwater quality at your facility, and who can also evaluate the effectiveness of BMPs selected. At least one member of your Pollution Prevention Team must participate in routine facility inspections. Routine inspections must occur at least monthly unless you document in your SWPPP the justification that another inspection frequency is adequate to ensure that BMPs are operating properly. Some types of equipment, processes and BMPs will require more frequent checks than others. Your SWPPP must specify the relevant inspection schedules. All inspections and inspection findings must be documented in your SWPPP.

2.1.5.6 ***Employee Training.*** You must implement a stormwater employee training program. Include a schedule for all types of necessary training. Document all training sessions and the employees who received the training. All employees who work in areas where industrial materials or activities are exposed to stormwater, or are responsible for implementing activities identified in the SWPPP (e.g., inspectors, maintenance personnel), must participate in the training, as must all members of your Pollution Prevention Team. Training must cover the components and goals of your SWPPP, and include such topics as spill response, good housekeeping, material management practices, BMP operation and maintenance, etc.

2.1.5.7 ***Erosion and Sedimentation Controls.*** You must identify the areas at your facility that, due to topography, land disturbance (e.g., construction, landscaping, site grading), or other factors, have a potential for soil erosion, and implement structural, vegetative, and/or stabilization BMPs to prevent or control on-site erosion and sedimentation.

2.1.5.8 ***Management of Runoff.*** You must describe the stormwater runoff management practices, i.e., permanent structural BMPs for your facility. These are typically used to divert, infiltrate, reuse, contain or otherwise reduce pollutants in your discharges. Such BMPs may be required by a state or local authority. Structural BMPs associated with wetlands may require a separate permit under section 404 of the CWA before installation.

2.1.5.9 ***Salt Storage Piles or Piles Containing Salt.*** For storage piles of salt or piles containing salt used for deicing or other commercial or industrial purposes, you must enclose or cover these piles to prevent exposure to precipitation. You must implement appropriate measures (e.g., good housekeeping, diversions, containment) to minimize exposure resulting from adding to or removing materials from the pile. Piles do not need to be enclosed or covered only if stormwater from the pile is not discharged directly or indirectly to waters of the United States or discharges from the piles are authorized and controlled under another NPDES permit.

2.1.5.10 ***Sector Specific BMPs.*** You must develop and implement all controls stipulated in the relevant sector-specific section(s) of Part 4 of this permit.

2.1.5.11 ***Controls on Other Specific Activities.***

- You must implement controls to ensure that no solid materials, including floatable debris, are discharged to waters of the United States, except as authorized by a permit issued under section 404 of the CWA.
- The generation of dust, along with off-site vehicle tracking of raw, final or waste materials, or sediments, must be minimized.

- The introduction of raw, final or waste materials to exposed areas must be minimized.
- Flow velocity dissipation devices must be placed at discharge locations and along the length of any outfall channel if the flows would otherwise create erosive conditions.

2.1.5.12 *Other Necessary Controls.* You must implement any additional BMPs that are economically reasonable and appropriate in light of current industry practice, and that are necessary to eliminate or reduce pollutants in your stormwater discharges.

2.1.6 Additional Documentation.

2.1.6.1 *Documentation Regarding Endangered Species.* Your SWPPP must include documentation supporting your determination with regard to Part 1.2.4.6 (Endangered and Threatened Species and Critical Habitat Protection), including:

- information on whether listed endangered or threatened species, or critical habitat are found in proximity to your facility;
- whether such species or habitat may be affected by your stormwater discharges or stormwater discharge-related activities, i.e., BMP installation;
- results of your Appendix E endangered species screening determinations; and
- a description of the measures you must implement to protect listed endangered or threatened species, or critical habitat, including any conditions imposed under the eligibility requirements of Part 1.2.4.6 and detailed in Appendix E. If you fail to document and implement such measures, your discharges are ineligible for coverage under this permit and you cannot submit a Notice of Intent.

2.1.6.2 *Documentation Regarding Historic Properties.* Your SWPPP must include documentation supporting your determination with regard to Part 1.2.4.7 (Historic Properties Preservation), including:

- information on whether your stormwater discharges, allowable non-stormwater discharges, or stormwater discharge-related activities would have an effect on a property that is listed or eligible for listing on the National Register of Historic Properties (NRHP);
- where such effects may occur and any written documents you have sent to or written agreements you have made with the State Historic Preservation Officer (SHPO), Tribal Historic Preservation Officer (THPO), or other Tribal representative to mitigate those effects;
- results of your Appendix F historic places screening investigations; and
- a description of the measures you must implement to avoid or minimize adverse impacts on places listed, or eligible for listing, on the NRHP, including any conditions imposed under the eligibility requirements of Part 1.2.4.7 and detailed in Appendix F. If you fail to document and implement such measures, your discharges are ineligible for coverage under this permit and you cannot submit a Notice of Intent.

2.1.7 SWPPP Signature.

You must sign and date your SWPPP in accordance with subpart 11 of Appendix B, including the date of signature. A signature and date is required both for initial plan preparation and for any revisions to the plan.

2.2 Maintenance of BMPs.

You must maintain all BMPs identified in your SWPPP and implemented at your facility in effective operating condition at all times. Failure to do so is a violation of this permit. Your SWPPP must describe procedures and a regular schedule for preventive maintenance of all BMPs, including the amount of time required for maintenance and repair, and what back-up practices you have in place should a run-off event occur while a BMP is off-line. Nonstructural BMPs must also be diligently maintained (e.g., spill response supplies available, personnel trained).

When, during inspections required by Parts 2.1.5.5 or 3.1, or any other event or observation, you identify BMPs that are not operating effectively, they must be repaired or maintained before the next anticipated storm event. If maintenance prior to the next storm event is not possible, maintenance must be completed as soon as possible, and you must document in your SWPPP the justification for the extended repair schedule. In the interim, you must have back-up measures in place to ensure that the quality of your stormwater discharge is not diminished. There is no grace period for making BMP repairs.

You must document all maintenance and repairs in your SWPPP. Dates of regular maintenance should be documented. For repairs, the date of deficiency discovery and the date on which the BMP was restored to full-function should also be documented in the SWPPP.

2.3 Maintaining an Updated SWPPP.

You must review, and amend your SWPPP as appropriate whenever there is: construction or a change in design, operation or maintenance at your facility such that these situations have a significant impact on the discharge, or potential for discharge, of pollutants from your facility; whenever your routine inspection or compliance evaluation determines deficiencies in your BMPs; whenever an inspection by a local, State, Tribal or Federal (other than EPA, see Part 2.5) official determines that modifications to your SWPPP are necessary; whenever you have a spill, leak or other release at your facility; or any time there is an unauthorized discharge from your facility.

SWPPP modifications must be made within 14 calendar days after discovery, observation or event requiring a SWPPP modification. Implementation of new or modified BMPs (distinct from regular preventive maintenance of existing BMPs described in 2.2) must be initiated before the next storm event if possible, but no later than 60 days after discovery, or as otherwise provided or approved by EPA. The amount of time taken to modify a BMP or implement additional BMPs must be documented in your SWPPP.

If the SWPPP modification is based on a release or unauthorized discharge, include a description and date of the release; the circumstances leading to the release and actions taken in response to the release; and measures to prevent the recurrence of such releases. Unauthorized releases and discharges are subject to the reporting requirements of Part 3.5.2 of this permit.

2.4 SWPPP Availability.

You must retain a copy of the current SWPPP required by this permit at the facility, and it must be immediately available to EPA; a State, Tribal or local agency approving stormwater management plans; the operator of an MS4 receiving discharges from the site; and representatives of the U.S. Fish and Wildlife Service (USFWS) or the National Marine Fisheries Service (NMFS) at the time of an on-site inspection or upon request. Also, you must provide a copy of your SWPPP to any member of the public who makes such a request in writing. Confidential Business Information (CBI) may not be withheld from regulatory agencies, but may be withheld from the public. All portions of the SWPPP not justifiably considered CBI, must be provided to the public upon request.

2.5 Notification by EPA of Inadequacy.

EPA may notify you at any time that your SWPPP, your BMPs or other components of your stormwater program do not meet one or more of the requirements of this permit. This notification may be the result of comments on your SWPPP that EPA receives from the public. The notification will identify specific provisions of this permit that are not being met, and may include required modifications to your stormwater program, stipulated deadlines, additional monitoring requirements and special reporting requirements.

3. Compliance Evaluations, Monitoring, Corrective Action, Reporting, and Record Keeping.

3.1 Comprehensive Site Compliance Evaluation.

3.1.1 Frequency of Comprehensive Site Compliance Evaluations.

You must conduct comprehensive site compliance evaluations at least once a year. An inspection frequency of greater than once a year is recommended, and should be documented in the SWPPP.

3.1.2 Personnel Qualified to Perform Comprehensive Site Compliance Evaluations.

Comprehensive site compliance evaluations must be conducted by qualified personnel. Qualified personnel are those who possess the knowledge and skills to assess conditions and activities that could impact stormwater quality at your facility, and who can also evaluate the effectiveness of BMPs selected. At least one member of your Pollution Prevention Team must participate in comprehensive site compliance evaluations.

3.1.3 Scope of the Compliance Evaluation.

Your inspections must cover all the areas identified in Part 2.1.4 where industrial materials or activities are exposed to stormwater, along with areas where spills and leaks have occurred in the past 3 years. Inspectors must examine the following: (a) industrial materials, residue or trash that may have or could come into contact with stormwater; (b) leaks or spills from industrial equipment, drums, tanks and other containers; (c) offsite tracking of industrial or waste materials, or sediment where vehicles enter or exit the site; (d) tracking or blowing of raw, final or waste materials from areas of no exposure to exposed areas; (e) evidence of, or the potential for, pollutants entering the drainage system; and (f) evidence of pollutants discharging to surface waters at all facility outfall(s), and the condition of and around the outfall, including flow dissipation measures to prevent scouring.

Inspectors must consider the results of the past year's visual and analytical monitoring when planning and conducting inspections. Stormwater BMPs identified in your SWPPP must be observed during active operation, i.e., during a stormwater runoff event, to ensure that they are functioning correctly. If discharge locations are inaccessible, nearby downstream locations must be inspected.

3.1.4 Credit as a Routine Facility Inspection.

When compliance evaluation schedules overlap with routine facility inspections required under Part 2.1.5.5, your annual compliance evaluation may also be used as one of the routine inspections, as long as all components of both types of inspections are included.

3.1.5 Compliance Evaluation Report.

You must generate a report of your compliance evaluation that includes: the date and scope of the inspection, the names of inspectors, and all observations relating to the implementation of the SWPPP, including elements stipulated in Part 3.1.3 (a) through (f). You must incorporate this report into your SWPPP and retain it for at least 3 years from the date permit coverage expires or is terminated. Observations include such things as the locations of discharges of pollutants from the site; locations of previously unidentified sources of pollutants; locations of BMPs needing maintenance or repair; locations of failed BMPs that need replacement; and locations where additional BMPs are needed. The report must also document any incidents of noncompliance observed. If there is no noncompliance, you must include a certification stating the facility is in compliance with the SWPPP and permit. Compliance evaluation reports and compliance certifications must be signed in accordance with subsection 11 of Appendix B.

3.2 Monitoring.

There are several types of monitoring requirements your facility may be subject to under this permit:

- visual inspection (see Part 3.2.1 for details),
- benchmark monitoring (see Part 3.2.2 for details),
- effluent limitations monitoring (see Part 3.2.3 for details), and
- area-specific monitoring for limitations required by a state or tribe, including area-specific water quality standards; antidegradation and water quality certification requirements; and monitoring requirements for impaired waters (see Part 3.2.5 for details).

Part 4, Section A through Section AD of this permit specifies monitoring requirements applicable to each sector of industrial activity. You must comply with the requirements stipulated in the relevant sector-specific section. When stormwater from co-located activities is co-mingled, you must comply with monitoring requirements for all applicable sectors.

Part 5 contains additional requirements that apply selectively to facilities located in particular States or Indian Country lands. You must comply with the requirements of the relevant State or Indian Country land.

Unlike previous MSGPs, all eligible dischargers have some form of routine analytical monitoring requirement under this permit. Unless otherwise specified, limitations and monitoring requirements under Part 3, and any additional requirements in Parts 4 and 5, are additive.

Where more than one limitation for a specific parameter applies to a discharge, compliance with the more restrictive limitation is required. When monitoring requirements overlap, e.g., total suspended solids once per year for an effluent limitation and once per quarter for benchmark monitoring, you may use a single sample to satisfy both monitoring requirements.

3.2.1 Quarterly Visual Monitoring of Discharges.

The requirements and procedures for quarterly visual monitoring are applicable to all facilities covered under this permit, regardless of your sector of industrial activity.

- You must perform and document a quarterly visual examination of a stormwater discharge associated with industrial activity from each outfall, except as provided for in Part 3.2.6.3, Adverse Weather Conditions. The visual examination must be made during daylight hours. If no storm event resulted in runoff during daylight hours from the facility during a monitoring quarter, you are excused from the visual monitoring requirement for that quarter, provided you document in your monitoring records that no runoff occurred. You must sign and certify the documentation in accordance with Subpart 11 of Appendix B.

- Your visual examinations must be made on samples collected within the first 30 minutes (or as soon thereafter as practical, but not to exceed 1 hour) of when the runoff or snowmelt begins discharging from your facility. All samples must be collected from a storm event discharge that is greater than 0.1 inch in magnitude and that occurs at least 72 hours from the previously measurable (greater than 0.1 inch rainfall) storm event. The 72-hour storm interval is waived when the preceding measurable storm did not yield a measurable discharge, or if you are able to document that less than a 72-hour interval is representative for local storm events during the sampling period. The examination must document observations of:

  - color
  - odor
  - clarity
  - floating solids,
  - settled solids,
  - suspended solids,
  - foam,
  - oil sheen,
  - and other obvious indicators of stormwater pollution.

- The examination must be conducted in a well-lit area. Where possible, the same individual should carry out the collection and examination of discharges for the entire permit term.

- You must maintain your visual examination reports onsite with the SWPPP. The report must include the examination date and time, inspection personnel, nature of the discharge (i.e., runoff or snow melt), visual quality of the stormwater discharge (including observations of color, odor, clarity, floating solids, settled solids, suspended solids, foam, oil sheen, and other obvious indicators of stormwater pollution), and probable sources of any observed stormwater contamination.

- You may exercise a waiver of the visual monitoring requirement at a facility that is inactive and unstaffed, as long as there are no industrial materials or activities exposed to stormwater. If you exercise this waiver, you must maintain a certification with your SWPPP stating that the site is inactive and unstaffed, and that there are no industrial materials or activities exposed to stormwater. If you do not plan to commence industrial activities at the site, you may submit a No Exposure Certification (Part 1.7), and terminate coverage under this permit.

- *Representative Outfalls.* If your facility has two or more outfalls that you believe discharge substantially identical effluents, based on similarities of the industrial activities, significant materials, size of drainage areas, and stormwater management practices occurring within the drainage areas of the outfalls, you may conduct visual monitoring of the discharge at just one of the outfalls and report that the results also apply to the substantially identical outfall(s). For this to be permissible, you must describe in the SWPPP the following: locations of the outfalls, why the outfalls are expected to discharge substantially identical effluents, estimates of the size of the drainage area (in square feet) for each of the outfalls, and an estimate of the runoff coefficient of the drainage areas (low: under 40 percent; medium: 40 to 65 percent; high: above 65 percent). This provision is available only for quarterly visual monitoring (and benchmark monitoring per Part 3.2.2.5), and does not apply to other monitoring requirements in this permit.

3.2.2. Benchmark Monitoring and Reporting.

You must monitor for all benchmark parameters specified for the industrial sector(s) (Part 4) applicable to your discharge. Your industry-specific benchmark concentrations are listed in the tables in the sector-specific sections of Part 4. Monitoring for all benchmark parameters must be conducted according to the procedures in Part 3.2.6.

3.2.2.1 ***Benchmark Monitoring Schedule.*** Unless otherwise specified in Part 4 (Section A – Section AD), benchmark monitoring must be conducted in each of the first four quarters of permit coverage, except as provided in Parts 3.2.2.4 and 3.2.2.5. Quarters correspond to the 3-month intervals beginning in January, April, July and October. If your permit coverage becomes effective less than 1 month from the end of a quarter, your first monitoring quarter starts with the next respective monitoring quarter. In arid and semi-arid climates where limited rainfall occurs during many parts of the year, the four monitoring events may be distributed during seasons when precipitation occurs. In areas subject to snow, one monitoring event should be scheduled to capture the first snowmelt discharge. If quarterly monitoring extends beyond the first year of permit coverage, the same quarters apply in subsequent years.

3.2.2.2 ***Benchmark Data Reporting.*** You must submit results from all benchmark monitoring to EPA. Discharge monitoring reports (DMRs) must be submitted electronically via the e-

NOI Center or in paper form to the DMR address in Part 3.7 no later than 30 days after you have received your lab results.

3.2.2.3 ***Data Not Exceeding Benchmarks.*** Following 4 quarters of benchmark monitoring, if the average of the 4 monitoring values does not exceed the benchmark, you have fulfilled your monitoring requirements for that parameter for the permit term.

3.2.2.4 ***Data Exceeding Benchmarks.*** If the average of the 4 monitoring values exceeds the benchmark you must review your SWPPP within 14 days to determine if it satisfies the requirements of Part 2 of this permit. You must document the date and findings of your review in your SWPPP. If you determine that your SWPPP satisfies the requirements of Part 2 you must document the justification for this determination in your SWPPP. Following this determination you may reduce monitoring for that pollutant to once per year for the duration of the permit term. If you determine that your SWPPP does not satisfy the requirements of Part 2 you must initiate the Corrective Action provisions of Part 3.3; and continue quarterly benchmark monitoring for the relevant pollutant(s) for an additional 4 quarters.

3.2.2.5 *Special Exceptions to Benchmark Monitoring*

- *Inactive and Unstaffed Sites*. You may exercise a waiver of the benchmark monitoring requirement at a facility that is inactive and unstaffed, as long as there are no industrial materials or activities exposed to stormwater. If you exercise this waiver, you must maintain a certification with your SWPPP stating that the site is inactive and unstaffed, and that there are no industrial materials or activities exposed to stormwater. You must sign and certify the waiver in accordance with Part 11 of Appendix B. If you do not plan to commence industrial activities at the site, you may submit a No Exposure Certification (Part 1.7), and terminate coverage under this permit.

- *Representative Outfalls*. If your facility has two or more outfalls that you believe discharge substantially identical effluents, based on similarities of the industrial activities, significant materials, size of drainage areas, and stormwater management practices occurring within the drainage areas of the outfalls, you may test the effluent of just one of the outfalls and report that the quantitative data also apply to the substantially identical outfall(s). For this to be permissible, you must describe in the SWPPP the following: locations of the outfalls, why the outfalls are expected to discharge substantially identical effluents, estimates of the size of the drainage area (in square feet) for each of the outfalls, and an estimate of the runoff coefficient of the drainage areas (low: under 40 percent; medium: 40 to 65 percent; high: above 65 percent). This provision is available only for benchmark monitoring (and quarterly visual monitoring per Part 3.2.1), and does not apply to other monitoring requirements in this permit.

3.2.3 Effluent Limitations Monitoring and Reporting.

3.2.3.1 ***Coal Pile Runoff Effluent Limitations.*** If your facility has discharges of stormwater from coal storage piles, you must comply with the limitations and monitoring requirements of Table 3-2 for all discharges containing the coal pile runoff, regardless of your facility's sector of industrial activity. You must monitor annually, and your monitoring year begins the day that your discharge is authorized. You must collect and analyze samples for TSS and pH at least once during each monitoring year in which you maintain coverage under this permit.

You must not dilute coal pile runoff with stormwater or other flows to meet this limitation. If your facility is designed, constructed, and operated to treat the volume of coal pile runoff that is associated with a 10-year, 24-hour rainfall event, any untreated overflow of coal pile runoff from the treatment unit is not subject to the 50 mg/L limitation for total suspended solids. Monitoring for all benchmark parameters must be conducted according to the procedures in Parts 3.2.6. You must submit results from all monitoring to EPA. Discharge monitoring reports must be submitted electronically or in paper form (see Part 3.7) no later than 30 days after you have received your lab results. If at any time your monitoring data exceed an effluent limitation for TSS or pH you are subject to the Corrective Action requirements of Part 3.3 and the Follow-up Monitoring and Reporting requirements of Part 3.4.

Table 3-2. Effluent Limitations for Coal Pile Runoff

Parameter	**Limitation**	**Monitoring Frequency**	**Sample Type**
Total Suspended Solids (TSS)	50 mg/l, max.	1/year	Grab
pH	6.0 min. - 9.0 max.	1/year	Grab

3.2.3.2 ***Effluent Limitation Guidelines.*** Table 1-1 of Part 1.2.2 of the permit identifies stormwater discharges subject to effluent limitation guidelines that are authorized for coverage under the permit. Facilities subject to stormwater effluent limitation guidelines are required to conduct compliance monitoring of their discharges for these parameters. Your effluent limitations are specified in your industry's sector specific section of Part 4. Compliance monitoring for effluent limitation guideline parameters is required once per year for the entire term of the permit, and your monitoring year begins the day that your discharge is authorized. Monitoring for all parameters must be conducted according to the procedures in Parts 3.2.6. You must submit results from all monitoring to EPA. Discharge monitoring reports must be submitted electronically or in paper form (see Part 3.7) no later than 30 days after you have received your lab results. If at any time your monitoring data exceed a relevant effluent limitation you are subject to the Corrective Action requirements of Part 3.3 and the Follow-up Monitoring and Reporting requirements of Part 3.4.

3.2.4 State or Tribe Provisions Monitoring and Reporting.

You must monitor for any pollutant for which a discharge limitation applicable to your discharge has been established in Part 5, or in fulfillment of any monitoring requirements applicable to your discharge stipulated in Part 5. If a monitoring frequency is not stipulated in Part 5, you must monitor once per year for the entire permit term, and your monitoring year begins the day that your discharge is authorized. Monitoring for all parameters must be conducted according to the procedures in Parts 3.2.6. You must submit results from all monitoring to EPA. Discharge monitoring reports must be submitted electronically or in paper form (see Part 3.7) no later than 30 days after you have received your lab results.

If at any time your monitoring data exceed a discharge limitation specified in Part 5 you are subject to the Corrective Action requirements of Part 3.3 and the Follow-up Monitoring and Reporting requirements of Part 3.4.

3.2.5 Discharges to Impaired Receiving Waters Monitoring and Reporting.

Monitoring is required for discharges to impaired waters (See Appendix A for definition) identified under Part 2.1.3.2. Monitoring for all parameters must be conducted according to the procedures in Parts 3.2.6. You must submit results from all monitoring to EPA. Discharge monitoring reports must be submitted electronically or in paper form (see Part 3.7) no later than 30 days after you have received your lab results.

3.2.5.1 ***Discharges to impaired waters with no applicable wasteload allocation.*** For discharges that are conveyed directly or indirectly to impaired waters, monitoring for the pollutant of concern must be conducted at a minimum of once each permit year throughout the term of the permit unless this permit already assigns your discharge an effluent limitation or a benchmark for the pollutant of concern, or specific monitoring requirements in Part 5, in which case you must follow the effluent limitation, benchmark, or Part 5 monitoring schedule. Your monitoring year begins on the day that your discharge is authorized.

This monitoring requirement is waived after one year if the pollutant of concern is not detected in your stormwater discharge, and you document in your SWPPP that there is no exposure of the pollutant of concern to stormwater at your site.

3.2.5.2 ***Discharges to impaired waters with an applicable wasteload allocation.*** For discharges that are conveyed directly or indirectly to waters for which EPA has approved or established a TMDL with a wasteload allocation applicable to your discharge (either specifically or categorically), monitoring for the wasteload allocation pollutant of concern must be conducted, consistent with any instructions in TMDL documentation. If the TMDL documentation does not specify specific monitoring requirements, monitoring for the pollutant of concern must be conducted at a minimum of once each permit year throughout the term of the permit, unless this permit already assigns your discharge an effluent limitation or a benchmark for the pollutant of concern, in which case you must follow the effluent limitation or benchmark monitoring schedule. Your monitoring year begins on the day your discharge is authorized. This monitoring must be conducted in addition to all other monitoring requirements prescribed in this permit. Monitoring of a pollutant of concern for which your discharge has been assigned a wasteload allocation cannot be waived unless the WLA is specified *only* in terms of BMPs, in which case the monitoring requirement is waived after one year if the pollutant of concern is not detected in your stormwater discharge and you document in your SWPPP that you have adopted the required BMPs.

If at any time your monitoring data exceed a relevant waste load allocation you are subject to the Corrective Action requirements of Part 3.3 and the Follow-up Monitoring and Reporting requirements of Part 3.4.

3.2.6 Monitoring Instructions.

3.2.6.1 *Collection and Analysis of Samples.* You must collect samples for relevant parameters at all outfalls. You must collect and analyze your samples in accordance with the requirements of Subsection 12.D of Appendix B of the permit. In addition, you must sample in accordance with the following provisions:

- *When and How to Sample.* Take a minimum of one grab sample from a discharge resulting from a storm event with at least 0.1 inch of precipitation (defined as a "measurable" event), provided the interval since the preceding measurable storm is at least 72 hours. The 72-hour storm interval is waived when the preceding measurable storm did not yield a measurable discharge, or if you are able to document that less than a 72-hour interval is representative for local storm events during the sampling period.

  Take the grab sample during the first 30 minutes of the discharge. If it is not possible to take the sample during the first 30 minutes, sample during the first hour of discharge and describe why a grab sample during the first 30 minutes was not possible. Submit this information on or with the Discharge Monitoring Report. If the sampled discharge co-mingles with discharges not authorized under this permit prior to reaching the receiving water body, attempt to sample the stormwater discharge before it mixes with other waste streams.

- *Approved Collection and Analytical Methods.* Sample collection, preservation and analysis must be conducted according to test procedures approved under 40 CFR Part 136, unless other test procedures have been specified in the relevant section of Part 4 of this permit.

3.2.6.2 ***Storm Event Data.*** Along with the results of your monitoring, you must provide the date and duration (in hours) of the storm event(s) sampled, rainfall measurements or estimates (in inches) of the storm event that generated the sampled runoff, the duration between the storm event samples and the end of the previous measurable (greater than 0.1 inch rainfall) storm event, and an estimate of the total volume (in liters) of the discharge samples.

3.2.6.3 *Adverse Weather Conditions.* When adverse weather conditions prevent the collection of samples according to the relevant monitoring schedule, take a substitute sample during the next qualifying storm event. Adverse conditions (i.e., those that are dangerous or create inaccessibility for personnel) may include events such as local flooding, high winds, electrical storms, or situations that otherwise make sampling illogical, such as drought or extended frozen conditions.

3.2.7 Monitoring Required by EPA.

EPA may provide written notice requiring additional discharge monitoring. Any such notice will briefly state the reasons for the monitoring, locations and parameters to be monitored, frequency and period of monitoring, sample types, and reporting requirements.

3.3 Corrective Actions.

You must take corrective action whenever:

- your routine facility inspections, comprehensive site compliance evaluations, or any other process, observation or event result in discovery of any deficiency; or
- there is any exceedance of an effluent limitation (including coal pile runoff), water quality standard, or requirement stipulated in Part 5; or
- following a benchmark exceedance, based on the average of 4 quarterly monitoring events, you determine as a result of reviewing your SWPPP that your SWPPP does not meet the requirements of Part 2 of this permit.

You must review your SWPPP and modify it as necessary to address the deficiency(ies). You must complete revisions to the SWPPP within 14 calendar days following the discovery. When BMPs need to be modified or added (distinct from regular preventive maintenance of existing BMPs described in 2.2), implementation must be completed before the next anticipated storm event if possible, but no later than 60 days after discovering the deficiency, or as otherwise provided or approved by EPA. The amount of time taken to modify a BMP or implement additional BMPs must be documented in your SWPPP.

Failure to undertake the necessary corrective actions within the stipulated time frames constitutes a violation of your permit. The underlying cause of the inadequacy or discharge standard exceedance, e.g., failure to properly implement the SWPPP, may also constitute an independent violation of the permit.

Any corrective actions taken as a result of your inspections must be documented and retained for the 3-year period following permit expiration or termination. Reports of corrective actions must be signed in accordance with subsection 11 of Appendix B.

3.4 Follow-up Monitoring and Reporting.

If at any time your monitoring results indicate that your discharge exceeds an effluent limitation or a specific wasteload allocation, or you become aware that your discharge causes or contributes to an exceedance of a water quality standard, you must take immediate steps to eliminate the exceedances in accordance with Part 3.3, Corrective Actions. Within 30 calendar days of implementing the relevant corrective action(s) (or during the next qualifying runoff event, should none occur within 30 calendar days) you must undertake additional monitoring to verify that your modified BMPs are effectively protecting water quality. You need only conduct follow-up monitoring for pollutant(s) with prior exceedances unless you have reason to believe that your modifications may have reduced pollutant prevention or removal capacity for other pollutants of concern.

If the follow-up monitoring value does not exceed the effluent limitation or other relevant standard, you must submit the follow-up monitoring data to EPA no later than 30 days after you have received your lab results. In this case, no additional follow-up monitoring for this monitoring event is required.

Should the follow-up monitoring indicate that the effluent limitation, wasteload allocation, water quality standard or other relevant standard is still being exceeded, you must submit an Exceedance Report no later than 30 days after you have received your lab results. Your report must include your permit identification number; facility name, address and location; receiving water; monitoring data from this and the preceding monitoring event(s); an explanation of the situation; what you have done and intend to do (should your corrective actions not yet be complete) to further reduce pollutants in the discharge; and an appropriate contact name and phone number. You must continue to conduct follow-up monitoring at an appropriate frequency, but no less often than quarterly, until your discharge no longer exceeds the standard, unless the requirement for additional follow-up monitoring is waived by EPA.

Failure to complete follow-up monitoring and reporting within the stipulated time frames constitutes a violation of your permit.

Additional monitoring following benchmark exceedances is address in Part 3.2.2.4.

3.5 Additional Reporting.

In addition to reporting requirements stipulated in this Part, you are also subject to the standard permit reporting provisions of Appendix B, Section 12. You must submit any reports required by this permit to EPA at the address of the appropriate Regional Office listed in Part 3.7 or using EPA's eNOI reporting system, as applicable.

3.5.1 Unauthorized Releases or Discharges Report.

Any unauthorized release or discharge must be reported to EPA within 30 days. However, if the discharge or release has the potential to or will endanger human health or the environment, it must be reported orally to the appropriate EPA regional office within 24 hours from the time you become aware of the circumstances. You must provide detailed information on such unauthorized releases or discharges to EPA in a written report within 5 days. The report should include all information specified in Appendix B, Section 12.

3.6 Recordkeeping.

You must retain copies of your SWPPP (including any modifications made during the term of this permit), all reports, monitoring data, and certifications required by this permit, along with records of all data used to complete the NOI, for a period of at least 3 years from the date that the facility's coverage under this permit expires or is terminated. The administrative records of the facility must accurately reflect:

- a traceable record of BMP installation, maintenance, and monitoring results;
- revision of structural control and non-structural practices implemented; and
- the data collected to support continued maintenance of those practices or their abandonment in lieu of more effective control mechanisms.

3.7 EPA Addresses.

Discharge monitoring reports, follow-up monitoring reports and Exceedance Reports may be submitted electronically, via EPA's eNOI center. If you choose to send paper copies of these reports, please send them via U.S. mail to:

U.S. Environmental Protection Agency
Office of Water, Water Permits Division
Mail Code 4203M
1200 Pennsylvania Avenue NW
Washington, D.C. 20460

Notices of Intent and Notices of Termination should be sent to EPA's NOI Center (see Appendix G.

All other written correspondence concerning discharges in any State, Indian Country land, Territory, or from any Federal facility covered under this permit and directed to the EPA, including individual permit applications, must be sent to the address of the appropriate EPA Regional Office listed below:

3.7.1 Region 1: Connecticut, Massachusetts, Maine, and New Hampshire, Rhode Island, Vermont.

U.S. EPA Region 1
Office of Ecosystem Protection
One Congress Street - CIP
Boston, MA 02114

3.7.2 Region 2: New Jersey, New York, Puerto Rico, and Virgin Islands.

U.S. EPA Region 2
Caribbean Environmental Protection Division
Environmental Management Branch
Centro Europa Building
1492 Ponce de Leon Avenue, Suite 417
San Juan, PR 00907-4127

3.7.3 Region 3: Delaware, District of Columbia, Maryland, Pennsylvania, Virginia, West Virginia.

U.S. EPA Region 3
Water Protection Division (3WP13)
Stormwater Coordinator
1650 Arch Street
Philadelphia, PA 19103

3.7.4 Region 4: Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee.

(Coverage Not Available under This Permit.)

U.S. EPA Region 4
Clean Water Act Enforcement Section
Water Programs Enforcement Branch
Water Management Division
Atlanta Federal Center
61 Forsyth Street SW
Atlanta, GA 30303

3.7.5 Region 5: Illinois, Indiana, Michigan, Minnesota, Ohio, Wisconsin.

U.S. EPA Region 5
Water Division
NPDES Programs Branch
77 W. Jackson Blvd.
Mail Code WN16J
Chicago, IL 60604

3.7.6 Region 6: Arkansas, Louisiana, Oklahoma, Texas, and New Mexico (except see Region 9 for Navajo lands, and see Region 8 for Ute Mountain Reservation lands).

Note: no coverage under this permit is available in Arkansas.

U.S. EPA Region 6
Stormwater Staff
Compliance Assurance and Enforcement Division (6EN-WC)
EPA SW MSGP
P.O. Box 50625
Dallas, TX 75205

3.7.7 Region 7: Iowa, Kansas, Missouri, Nebraska.

(Coverage Not Available under This Permit.)

U.S. EPA - Region 7
901 N. 5th Street
Kansas City, KS 66101

3.7.8 Region 8: Colorado, Montana, North Dakota, South Dakota, Wyoming, Utah (except see Region 9 for Goshute Reservation and Navajo Reservation lands), the Ute Mountain Reservation in New Mexico, and the Pine Ridge Reservation in Nebraska.

(Coverage Not Available under This Permit.)

U.S. EPA Region 8
Stormwater Coordinator (8P-W-P)
999 18th Street, Suite 300
Denver, CO 80202-2466

3.7.9 Region 9: Arizona, California, Hawaii, Nevada, Guam, American Samoa, the Commonwealth of the Northern Mariana Islands, the Goshute Reservation in Utah and Nevada, the Navajo Reservation in Utah, New Mexico, and Arizona, the Duck Valley Reservation in Idaho, Fort McDermitt Reservation in Oregon.

U.S. EPA Region 9
Water Management Division, WTR-5
Stormwater Staff
75 Hawthorne Street
San Francisco, CA 94105

3.7.10 Region 10: Alaska, Idaho, Oregon (except see Region 9 for Fort McDermitt Reservation), Washington.

U.S. EPA Region 10
Office of Water OW-130
Stormwater Staff
1200 6th Avenue
Seattle, WA 98101

3.8 State and Tribal Addresses.

See Part 5 (States and Tribes) for the addresses of applicable States or Tribes that require submission of information to their agencies.

Part 4 - Sector-Specific Requirements
Subsection A - Sector - Specific Requirements for Industrial Activity -Sector A - Timber Products.

A.1 Covered Stormwater Discharges.

The requirements in Subsection A apply to stormwater discharges associated with industrial activity from timber products facilities as identified by the SIC Codes specified under Sector A in Table D-1 of Appendix D of the permit.

A.2 Industrial Activities Covered by Sector A.

The types of activities that permittees under Sector A are primarily engaged in are:

A.2.1 cutting timber and pulpwood (those that have log storage or handling areas);

A.2.2 mills, including merchant, lath, shingle, cooperage stock, planing, plywood, and veneer;

A.2.3 producing lumber and wood basic materials;

A.2.4 wood preserving;

A.2.5 manufacturing finished articles made entirely of wood or related materials except wood kitchen cabinet manufacturers (covered under Appendix W); and

A.2.6 manufacturing wood buildings or mobile homes.

A.3 Limitation on Coverage

A.3.1 *Prohibition of Discharges.* (See also Part 1.2.4) Not covered by this permit: stormwater discharges from areas where there may be contact with the chemical formulations sprayed to provide surface protection. These discharges must be covered by a separate NPDES permit.

A.3.2 *Authorized Non-Stormwater Discharges.* (See also Part 1.2.3) Also authorized by this permit, provided the non-stormwater component of the discharge is in compliance with SWPPP requirements in Part 2.1.5 (Stormwater Controls): discharges from the spray down of lumber and wood product storage yards where no chemical additives are used in the spray-down waters and no chemicals are applied to the wood during storage.

A.4 Stormwater Pollution Prevention Plan (SWPPP) Requirements.

In addition to the following requirements, you must also comply with the requirements listed in Part 2 of the permit.

A.4.1 *Drainage Area Site Map.* (See also Part 2.1.2) Identify where any of the following may be exposed to precipitation or surface runoff: processing areas, treatment chemical storage areas, treated wood and residue storage areas, wet decking areas, dry decking areas, untreated wood and residue storage areas, and treatment equipment storage areas.

A.4.2 *Inventory of Exposed Materials.* (See also Part 2.1.5.2) Where such information exists, if your facility has used chlorophenolic, creosote, or chromium-copper-arsenic formulations for wood surface protection or preserving, identify the following: areas where contaminated soils, treatment equipment, and stored materials still remain and the management practices employed to minimize the contact of these materials with stormwater runoff.

A.4.3 *Description of Stormwater Management Controls.* (See also Part 2.1.5) Describe and implement measures to address the following activities and sources: log, lumber, and wood product storage areas; residue storage areas; loading and unloading areas; material handling areas; chemical storage areas; and equipment and vehicle maintenance, storage, and repair areas. If your facility performs wood surface protection and preservation activities, address the specific BMPs for these activities.

A.4.4 *Good Housekeeping.* (See also Part 2.1.5.1) In areas where storage, loading and unloading, and material handling occur, perform good housekeeping to limit the discharge of wood debris, minimize the leachate generated from decaying wood materials, and minimize the generation of dust.

A.4.5 *Inspections.* (See also Part 2.1.5.5) If your facility performs wood surface protection and preservation activities, inspect processing areas, transport areas, and treated wood storage areas monthly to assess the usefulness of practices to minimize the deposit of treatment chemicals on unprotected soils and in areas that will come in contact with stormwater discharges.

A.5 Monitoring and Reporting Requirements. (See also Part 3 of the permit.)

Table A-1. Sector-specific Numeric Limitations and Benchmark Monitoring

Subsector (Discharges may be subject to requirements for more than one sector/subsector)	**Parameter**	**Benchmark Monitoring Concentration[1]**	**Effluent Limitation Guidelines[2]**
General Sawmills and Planing Mills (SIC 2421)	Chemical Oxygen Demand (COD)	120.0 mg/L	--
	Total Suspended Solids (TSS)	100 mg/L	--
	Total Recoverable Zinc[3]	0.12 mg/L	--
Wood Preserving (SIC 2491)	Total Recoverable Arsenic	0.15 mg/L	--
	Total Recoverable Copper[4]	0.014 mg/L	--

Table A-1. Sector-specific Numeric Limitations and Benchmark Monitoring			
Subsector (Discharges may be subject to requirements for more than one sector/subsector)	**Parameter**	**Benchmark Monitoring Concentration[1]**	**Effluent Limitation Guidelines[2]**
	Total Recoverable Chromium[5]	1.8 mg/L	–
	Phenols	0.016 mg/L[6]	--
	Total Suspended Solids (TSS)	100 mg/L	--
Log Storage and Handling (SIC 2411)	Total Suspended Solids (TSS)	100 mg/L	--
Wet Decking Discharges at Log Storage and Handling Areas (SIC 2411)	pH	--	6.0 - 9.0 s.u
	Total Suspended Solids (TSS)	100.0 mg/L	--
	Debris (woody material such as bark, twigs, branches, heartwood, or sapwood)	--	No discharge of debris that will not pass through a 2.54-cm (1-in.) diameter round opening
Hardwood Dimension and Flooring Mills; Special Products Sawmills, not elsewhere classified; Millwork, Veneer, Plywood, and Structural Wood; Wood Containers; Wood Buildings and Mobile Homes; Reconstituted Wood Products; and Wood Products Facilities not elsewhere classified (SIC 2426, 2429, 2431-2439 (except 2434), 2448, 2449, 2451, 2452, 2493, and 2499)	Chemical Oxygen Demand (COD)	120.0 mg/L	--
	Total Suspended Solids (TSS)	100.0 mg/L	--
Nailed Wood Boxes and Shook (SIC 2441)	Total Suspended Solids (TSS)	100.0 mg/L	--

[1]You must monitor quarterly in the first year of your coverage for each benchmark parameter (see Part 3.2.2.1). For each parameter, no additional benchmark monitoring is required if the average of your 4 monitoring values does not exceed the benchmark (see Part 3.2.2.3). However, for each parameter there are additional requirements if the average of your four monitoring values exceeds the benchmark (see Part 3.2.2.4).

[2]Monitor once per year for each monitoring year.

[3] The benchmark value of zinc is determined as a function of hardness (in units of mg/L) in the water column. The value given in Table A-1 (i.e. 0.12 mg/L) corresponds to a hardness of 100 mg/L and should be used if you either did not analyze water hardness, other hardness data are not available, or the water hardness is less than 100 mg/L. If a laboratory analysis indicates that the water hardness is below 100 mg/L, then you should use the benchmark for 100 mg/L. If a laboratory analysis indicates that the water hardness is greater than 100 mg/L, then the following equation may be used to determine the benchmark value for zinc:

$$\text{Benchmark} = (e^{[(0.8473)(\ln \mathit{hardness}) + 0.884]})/1000$$

Example: Laboratory analysis of your water sample indicates the hardness is 175 mg/L.

$$\begin{aligned}\text{Benchmark} &= (e^{[(0.8473)(\ln 175) + 0.884]})/1000 \\ &= (e^{5.26})/1000 \\ &= 192.51/1000 \\ &= 0.19 \text{ mg/L}\end{aligned}$$

The following are example benchmark values for zinc:

Hardness (mg/L)	Benchmark value (mg/L)
100	0.12
125	0.14
150	0.17
175	0.19
200	0.22
225	0.24
250	0.26

[4] The benchmark value of copper is determined as a function of hardness (in units of mg/L) in the water column. The value given in Table A-1 (i.e. 0.014 mg/L) corresponds to a hardness of 100 mg/L and should be used if you either did not analyze water hardness, other hardness data are not available, or the water hardness is less than 100 mg/L. If a laboratory analysis indicates that the water hardness is below 100 mg/L, then you should use the benchmark for 100 mg/L. If a laboratory analysis indicates that the water hardness is greater than 100 mg/L, then the following equation may be used to determine the benchmark value for copper:

$$\text{Benchmark} = (e^{[(0.9422)(\ln \mathit{hardness}) - 1.700]})/1000$$

Example: Laboratory analysis of your water sample indicates the hardness is 175 mg/L.

$$\begin{aligned}\text{Benchmark} &= (e^{[(0.9422)(\ln 175) - 1.700]})/1000 \\ &= (e^{3.166})/1000 \\ &= 23.72/1000 \\ &= 0.024 \text{ mg/L}\end{aligned}$$

The following are example benchmark values for copper:

Hardness (mg/L)	Benchmark value (mg/L)
100	0.014
125	0.017
150	0.021
175	0.024
200	0.027
225	0.030
250	0.033

[5] The benchmark value of chromium is determined as a function of hardness (in units of mg/L) in the water column. The value given in Table A-1 (i.e. 1.8 mg/L) corresponds to a hardness of 100 mg/L and should be used if you either

did not analyze water hardness, other hardness data are not available, or the water hardness is less than 100 mg/L. If a laboratory analysis indicates that the water hardness is below 100 mg/L, then you should use the benchmark for 100 mg/L. If a laboratory analysis indicates that the water hardness is greater than 100 mg/L, then the following equation may be used to determine the benchmark value for chromium:

$$\text{Benchmark} = (e^{[(0.8190)(\ln \textit{hardness}) + 3.7256]})/1000$$

Example: Laboratory analysis of your water sample indicates the hardness is 175 mg/L.

$$\text{Benchmark} = (e^{[(0.8190)(\ln 175) + 3.7256]})/1000$$
$$= (e^{7.96})/1000$$
$$= 2851.4/1000$$
$$= 2.9 \text{ mg/L}$$

The following are example benchmark values for chromium:

Hardness (mg/L)	Benchmark value (mg/L)
100	1.8
125	2.2
150	2.5
175	2.9
200	3.2
225	3.5
250	3.8

[6]Benchmark cutoff concentration for phenols based on ML for the reference method times 3.18.

Part 4 - Sector-Specific Requirements for Industrial Activity
Subsection B - Sector B - Paper and Allied Products Manufacturing.

B.1 Covered Stormwater Discharges.

The requirements in Subsection B apply to stormwater discharges associated with industrial activity from paper and allied products manufacturing facilities, as identified by the SIC Codes specified under Sector B in Table D-1 of Appendix D of the permit.

B.2 Industrial Activities Covered by Sector B.

Permittees under Sector B are primarily engaged in the following types of activities

B.2.1 manufacture of pulps from wood and other cellulose fibers and from rags;

B.2.2 manufacture of paper and paperboard into converted products (e.g., paper coated off the paper machine, paper bags, paper boxes, paper envelopes) and

B.2.3 manufacture of bags of plastic film and sheet.

B.3 Monitoring and Reporting Requirements. (See also Part 3 of the permit.)

Table B-1. Sector-specific Numeric Effluent Limitations and Benchmark Monitoring

Subsector (Discharges may be subject to requirements for more than one sector/subsector)	Parameter	Benchmark Monitoring Concentration[1]	Effluent Limitation Guidelines
Paperboard Mills (SIC Code 2631)	Total Suspended Solids (TSS)	100 mg/L	--
	Chemical Oxygen Demand (COD)	120 mg/L	--
Pulp Mills; Paper Mills; Paperboard Containers and Boxes; and Converted Paper and Paperboard Products, except Containers and Boxes (SIC 2611, 2621, 2652-2657, 2671-2679)	Total Suspended Solids (TSS)	100 mg/L	--

[1]You must monitor quarterly in the first year of your coverage for each benchmark parameter (see Part 3.2.2.1). For each parameter, no additional benchmark monitoring is required if the average of your 4 monitoring values does not exceed the benchmark (see Part 3.2.2.3). However, for each parameter there are additional requirements if the average of your four monitoring values exceeds the benchmark (see Part 3.2.2.4).

Part 4 - Sector - Specific Requirements for Industrial Activity
Subsection C - Sector C - Chemical and Allied Products Manufacturing.

C.1 Covered Stormwater Discharges.

The requirements in Subsection C of Attachment 1 apply to stormwater discharges associated with industrial activity from Chemical and Allied Products Manufacturing facilities, as identified by the SIC Codes specified under Sector C in Table D-1 of Appendix D of the permit.

C.2 Industrial Activities Covered by Sector C.

The requirements listed under this Part apply to stormwater discharges associated with industrial activity from a facility engaged in manufacturing the following products

C.2.1 basic industrial inorganic chemicals;

C.2.2 plastic materials and synthetic resins, synthetic rubbers, and cellulosic and other human-made fibers, except glass;

C.2.3 soap and other detergents, including facilities producing glycerin from vegetable and animal fats and oils; specialty cleaning, polishing, and sanitation preparations; surface active preparations used as emulsifiers, wetting agents, and finishing agents, including sulfonated oils; and perfumes, cosmetics, and other toilet preparations;

C.2.4 paints (in paste and ready-mixed form); varnishes; lacquers; enamels and shellac; putties, wood fillers, and sealers; paint and varnish removers; paint brush cleaners; and allied paint producers;

C.2.5 industrial organic chemicals;

C.2.6 industrial and household adhesives, glues, caulking compounds, sealants, and linoleum, tile, and rubber cements from vegetable, animal, or synthetic plastic materials; explosives; printing ink, including gravure, screen process, and lithographic inks; miscellaneous chemical preparations such as fatty acids, essential oils, gelatin (except vegetable), sizes, bluing, laundry soaps, writing and stamp pad ink, industrial compounds such as boiler and heat insulating compounds, and chemical supplies for foundries;

C.2.7 ink and paints, including china painting enamels, India ink (a type of drawing ink), platinum paints for burnt wood or leather work, paints for china painting, artist's paints and water colors; and

C.2.8 nitrogenous and phosphatic basic fertilizers, mixed fertilizers, pesticides, and other agricultural chemicals.

C.3 Limitations on Coverage.

C.3.1 *Prohibition of Non-Stormwater Discharges.* (See also Part 1.2.4) The following are not covered by this permit: non-stormwater discharges containing inks, paints, or substances (hazardous, nonhazardous, etc.) resulting from an onsite spill, including materials collected in drip pans; washwater from material handling and processing areas; and washwater from drum, tank, or container rinsing and cleaning.

C.4 Stormwater Pollution Prevention Plan (SWPPP) Requirements.

In addition to the following requirements, you must also comply with the requirements listed in Part 2 of the permit.

C.4.1 *Drainage Area Site Map.* (See also Part 2.1.2) Identify where any of the following may be exposed to precipitation or surface runoff: processing and storage areas; access roads, rail cars, and tracks; areas where substances are transferred in bulk; and operating machinery.

C.4.2 *Potential Pollutant Sources.* (See also Part 2.1.4) Describe the following sources and activities that have potential pollutants associated with them: loading, unloading, and transfer of chemicals; outdoor storage of salt, pallets, coal, drums, containers, fuels, and fueling stations; vehicle and equipment maintenance and cleaning areas; areas where the treatment, storage, or disposal (on- or off-site) of waste and wastewater occur; storage tanks and other containers; processing and storage areas; access roads, rail cars, and tracks; areas where the transfer of substances in bulk occurs; and areas where machinery operates.

C.4.3 *Good Housekeeping Measures.* (See also Part 2.1.5.1) As part of your good housekeeping program, include a schedule for regular pickup and disposal of garbage and waste materials, or adopt other appropriate measures to reduce the potential for discharging stormwater that has contacted garbage or waste materials. Routinely inspect the condition of drums, tanks, and containers for potential leaks.

C.5 Monitoring and Reporting Requirements. (See also Part 3 of the permit.)

Table C-1. Sector-specific Numeric Effluent Limitations and Benchmark Monitoring

Subsector (Discharges may be subject to requirements for more than one sector/subsector)	Parameter	Benchmark Monitoring Concentration[1]	Effluent Limitation Guidelines[2]
Phosphate Subcategory of the Fertilizer Manufacturing Point Source Category (40 CFR §418.10) - applies to precipitation runoff that, during manufacturing or processing, comes into contact with any raw materials, intermediate product, finished product, by-products, or waste product (SIC 2874)	Total Phosphorus (as P)	--	105.0 mg/L, daily maximum
			35 mg/L, 30-day avg.
	Fluoride	--	75.0 mg/L, daily maximum
			25.0 mg/L, 30-day avg.
	Total Suspended Solids (TSS)	100 mg/L	--
Agricultural Chemicals (SIC 2873-2879)	Nitrate plus Nitrite Nitrogen	0.68 mg/L	--
	Total Recoverable Lead[3]	0.082 mg/L	--
	Total Recoverable Iron	1.0 mg/L	--
	Total Recoverable Zinc[4]	0.12 mg/L	--
	Total Suspended Solids (TSS)	100 mg/L	--
	Phosphorus	2.0 mg/L	--
Industrial Inorganic Chemicals (SIC 2812-2819)	Total Recoverable Aluminum	0.75 mg/ L	--
	Total Recoverable Iron	1.0 mg/L	--
	Total Recoverable Zinc[4]	0.12 mg/L	--
	Total Suspended Solids (TSS)	100 mg/L	--
	Nitrate plus Nitrite Nitrogen	0.68 mg/L	--
Soaps, Detergents, Cosmetics, and Perfumes (SIC 2841-2844)	Nitrate plus Nitrite Nitrogen	0.68 mg/L	--
	Total Recoverable Zinc[4]	0.12 mg/L	--

Table C-1. Sector-specific Numeric Effluent Limitations and Benchmark Monitoring			
Subsector (Discharges may be subject to requirements for more than one sector/subsector)	**Parameter**	**Benchmark Monitoring Concentration[1]**	**Effluent Limitation Guidelines[2]**
	Total Suspended Solids (TSS)	100 mg/L	--
Plastics, Synthetics, and Resins (SIC 2821-2824)	Total Recoverable Zinc[4]	0.12 mg/L	--
	Total Suspended Solids (TSS)	100 mg/L	--
Medicinal Chemicals and Botanical Products; Pharmaceutical Preparations; in vitro and in vivo Diagnostic Substances, Biological Products (except Diagnostic Substances); Paints, Varnishes, Lacquers, Enamels, and Allied Products; Industrial Organic Chemicals; Miscellaneous Chemical Products; and Inks and Paints, including China Painting Enamels, India Ink, Drawing Ink, Platinum Paints for Burnt Wood or Leather Work, Paints for China Painting, Artist's Paints and Artist's Watercolors (SIC 2833-2836, 2851, 2861-2869, 2891-2899, 3952 (limited to list))	Total Suspended Solids (TSS)	100 mg/L	--

[1]You must monitor quarterly in the first year of your coverage for each benchmark parameter (see Part 3.2.2.1). For each parameter, no additional benchmark monitoring is required if the average of your 4 monitoring values does not exceed the benchmark (see Part 3.2.2.3). However, for each parameter there are additional requirements if the average of your four monitoring values exceeds the benchmark (see Part 3.2.2.4).

[2]Monitor once per year for each monitoring year.

[3] The benchmark value of lead is determined as a function of hardness (in units of mg/L) in the water column. The value given in Table C-1 (i.e. 0.082 mg/L) corresponds to a hardness of 100 mg/L and should be used if you either did not analyze water hardness, other hardness data are not available, or the water hardness is less than 100 mg/L. If a laboratory analysis indicates that the water hardness is below 100 mg/L, then you should use the benchmark for 100 mg/L. If a laboratory analysis indicates that the water hardness is greater than 100 mg/L, then the following equation may be used to determine the benchmark value for lead:

$$\text{Benchmark} = (e^{[(1.273)(\ln \textit{hardness}) - 1.460]})/1000$$

Example: Laboratory analysis of your water sample indicates the hardness is 175 mg/L.

$$\begin{aligned}\text{Benchmark} &= (e^{[(1.273)(\ln 175) - 1.460]})/1000 \\ &= (e^{5.1148})/1000 \\ &= 166.46/1000 \\ &= 0.17 \text{ mg/L}\end{aligned}$$

The following are example benchmark value for lead:

Hardness (mg/L)	Benchmark value (mg/L)
100	0.082
125	0.11
150	0.14
175	0.17
200	0.20
225	0.23
250	0.26

[4] The benchmark value of zinc is determined as a function of hardness (in units of mg/L) in the water column. The value given in Table C-1 (i.e. 0.12 mg/L) corresponds to a hardness of 100 mg/L and should be used if you either did not analyze water hardness, other hardness data are not available, or the water hardness is less than 100 mg/L. If a laboratory analysis indicates that the water hardness is below 100 mg/L, then you should use the benchmark for 100 mg/L. If a laboratory analysis indicates that the water hardness is greater than 100 mg/L, then the following equation may be used to determine the benchmark value for zinc:

$$\text{Benchmark} = (e^{[(0.8473)(\ln \textit{hardness}) + 0.884]})/1000$$

Example: Laboratory analysis of your water sample indicates the hardness is 175 mg/L.

$$\text{Benchmark} = (e^{[(0.8473)(\ln 175) + 0.884]})/1000$$
$$= (e^{5.26})/1000$$
$$= 192.51/1000$$
$$= 0.19 \text{ mg/L}$$

The following are example benchmark values for zinc:

Hardness (mg/L)	Benchmark value (mg/L)
100	0.12
125	0.14
150	0.17
175	0.19
200	0.22
225	0.24
250	0.26

Part 4 - Sector - Specific Requirements for Industrial Activity
Subsection D - Sector D - Asphalt Paving and Roofing Materials and Lubricant Manufacturing.

D.1 Covered Stormwater Discharges.

The requirements in Subsection D of Attachment 1 apply to stormwater discharges associated with industrial activity from asphalt paving and roofing materials and lubricant manufacturing facilities, as identified by the SIC Codes specified under Sector D in Table D-1 of Appendix D of the permit.

D.2 Industrial Activities Covered by Sector D.

Permittees under Sector D are primarily engaged in the following types of activities:

D.2.1 manufacturing asphalt paving and roofing materials;

D.2.2 portable asphalt plant facilities; and

D.2.3 manufacturing lubricating oils and greases.

D.3 Limitations on Coverage.

The following stormwater discharges associated with industrial activity are not authorized by this permit

D.3.1 discharges from petroleum refining facilities, including those that manufacture asphalt or asphalt products that are classified as SIC Code 2911; or

D.3.2 discharges from oil recycling facilities; or

D.3.3 discharges associated with fats and oils rendering.

D.4 Stormwater Pollution Prevention Plan (SWPPP) Requirements.

In addition to the following requirements, you must also comply with the requirements listed in Part 2 of the permit.

D.4.1 *Inspections.* (See also Part 2.1.5.5) Inspect at least once per month, as part of the maintenance program, the following areas: material storage and handling areas; liquid storage tanks, hoppers, and silos; vehicle and equipment maintenance, cleaning, and fueling areas; and material handling vehicles, equipment, and processing areas. Ensure that appropriate action is taken in response to the inspection by implementing tracking or follow-up procedures.

D.5 Monitoring and Reporting Requirements. (See also Part 3 of the permit.)

Table D-1. Sector-specific Numeric Limitations and Benchmark Monitoring

Subsector (Discharges may be subject to requirements for more than one sector/subsector)	Parameter	Benchmark Monitoring Concentration[1]	Effluent Limitation Guidelines[2]
Asphalt Paving and Roofing Materials (SIC 2951, 2952)	Total Suspended Solids (TSS)	100 mg/L	--
Discharges from Areas Where Production of Asphalt Paving and Roofing Emulsions Occurs (SIC 2951, 2952)	Total Suspended Solids (TSS)	--	23.0 mg/L, daily maximum
			15.0 mg/L, 30-day avg.
	pH	--	6.0 - 9.0 s.u.
	Oil and Grease	--	15.0 mg/L, daily maximum
			10 mg/L, 30-day avg.
Miscellaneous Products of Petroleum and Coal (SIC 2992, 2999)	Total Suspended Solids (TSS)	100 mg/L	--

[1]You must monitor quarterly in the first year of your coverage for each benchmark parameter (see Part 3.2.2.1). For each parameter, no additional benchmark monitoring is required if the average of your 4 monitoring values does not exceed the benchmark (see Part 3.2.2.3). However, for each parameter there are additional requirements if the average of your four monitoring values exceeds the benchmark (see Part 3.2.2.4).

[2]Monitor once per year for each monitoring year.

Part 4 - Sector-Specific Requirements for Industrial Activity
Subsection E - Sector E - Glass, Clay, Cement, Concrete, and Gypsum Products.

E.1 Covered Stormwater Discharges.

The requirements in Subsection E of Attachment 1 apply to stormwater discharges associated with industrial activity from glass, clay, cement, concrete, and gypsum products facilities, as identified by the SIC Codes specified under Sector E in Table D-1 of Appendix D of the permit.

E.2 Industrial Activities Covered by Sector E.

The requirements listed under this permit apply to stormwater discharges associated with industrial activity from a facility engaged in either manufacturing the following products or performing the following activities

E.2.1 flat, pressed, or blown glass or glass containers;

E.2.2 hydraulic cement;

E.2.3 clay products, including tile and brick;

E.2.4 pottery and porcelain electrical supplies;

E.2.5 concrete products;

E.2.6 gypsum products;

E.2.7 minerals and earths, ground or otherwise treated;

E.2.8 non-clay refractories;

E.2.9 lime manufacturing;

E.2.10 cut stone and stone products;

E.2.11 asbestos products; and

E.2.12 mineral wool and mineral wool insulation products.

E.3 Stormwater Pollution Prevention Plan (SWPPP) Requirements.

In addition to the following requirements, you must also comply with the requirements listed in Part 2 of the permit.

E.3.1 *Drainage Area Site Map.* (See also Part 2.1.2) Identify the locations of the following, as applicable: bag house or other dust control device; recycle/sedimentation pond, clarifier, or other device used for the treatment of process wastewater; and the areas that drain to the treatment device.

E.3.2 *Good Housekeeping Measures.* (See also Part 2.1.5.1) With good housekeeping, prevent or minimize the discharge of spilled cement, aggregate (including sand or gravel), kiln dust, fly ash, settled dust, or other significant material in stormwater from paved portions of the site that are exposed to stormwater. Consider sweeping regularly or using other equivalent measures to minimize the presence of these materials. Indicate in your SWPPP the frequency of sweeping or equivalent measures. Determine the frequency from the amount of industrial activity occurring in the area and the frequency of precipitation, but it must be performed at least once a week if cement, aggregate, kiln dust, fly ash, or settled dust are being handled or processed. You must also prevent the exposure of fine granular solids (cement, fly ash, kiln dust, etc.) to stormwater, where practicable, by storing these materials in enclosed silos, hoppers, or buildings, or under other covering.

E.3.3 *Inspections.* (See also Part 2.1.5.5) Perform inspections while the facility is in operation and include all of the following areas exposed to stormwater: material handling areas; above-ground storage tanks, hoppers, or silos; dust collection and containment systems; and truck wash down and equipment cleaning areas.

E.3.4 *Certification.* (See also Part 2.1.4.4) For facilities producing ready-mix concrete, concrete block, brick, or similar products, include in the non-stormwater discharge certification a description of measures that ensure that process waste water resulting from washing trucks, mixers, transport buckets, forms, or other equipment are discharged in accordance with NPDES requirements or are recycled.

E.4 Monitoring and Reporting Requirements. (See also Part 3 of the permit.)

Table E-1. Sector-specific Numeric Limitations and Benchmark Monitoring

Subsector (Discharges may be subject to requirements for more than one sector/subsector)	Parameter	Benchmark Monitoring Cutoff Concentration[1]	Effluent Limitation Guidelines[2]
Clay Product Manufacturers (SIC 3251-3259, 3261-3269)	Total Recoverable Aluminum	0.75 mg/L	--
	Total Suspended Solids (TSS)	100 mg/L	--
Concrete and Gypsum Product Manufacturers (SIC 3271-3275)	Total Suspended Solids (TSS)	100 mg/L	--
	Total Recoverable Iron	1.0 mg/L	--
Cement Manufacturing Facility, Material Storage Runoff: Any discharge composed of runoff that derives from the storage of materials, including raw materials, intermediate products, finished products, and waste materials that are used in or derived from the manufacture of cement.	Total Suspended Solids (TSS)	--	50 mg/L, daily maximum
	pH	--	6.0 - 9.0 s.u.
Flat Glass; Glass and Glassware, Pressed or Blown; Glass Products Made of Purchased Glass; Hydraulic Cement; Cut Stone and Stone Products; and Abrasive, Asbestos, and Miscellaneous Nonmetallic Mineral Products (SIC 3211, 3221, 3229, 3231, 3241, 3281, 3291-3299)	Total Suspended Solids (TSS)	100 mg/L	--

[1]You must monitor quarterly in the first year of your coverage for each benchmark parameter (see Part 3.2.2.1). For each parameter, no additional benchmark monitoring is required if the average of your 4 monitoring values does not exceed the benchmark (see Part 3.2.2.3). However, for each parameter there are additional requirements if the average of your four monitoring values exceeds the benchmark (see Part 3.2.2.4).

[2]Monitor once per year for each monitoring year.

Part 4 - Sector-Specific Requirements for Industrial Activity
Subsection F - Sector F - Primary Metals

F.1 Covered Stormwater Discharges.

The requirements in Subsection F of Attachment 1 apply to stormwater discharges associated with industrial activity from primary metals facilities, as identified by the SIC Codes specified under Sector F in Table D-1 of Appendix D of the permit.

F.2 Industrial Activities Covered by Sector F.

Facilities under Sector F are primarily engaged in the following types of activities

F.2.1 steel works, blast furnaces, and rolling and finishing mills, including steel wire drawing and steel nails and spikes; cold-rolled steel sheet, strip, and bars; and steel pipes and tubes;

F.2.2 iron and steel foundries, including gray and ductile iron, malleable iron, steel investment, and steel foundries not elsewhere classified;

F.2.3 primary smelting and refining of nonferrous metals, including primary smelting and refining of copper, and primary production of aluminum;

F.2.4 secondary smelting and refining of nonferrous metals;

F.2.5 rolling, drawing, and extruding of nonferrous metals, including rolling, drawing, and extruding of copper; rolling, drawing, and extruding of nonferrous metals except copper and aluminum; and drawing and insulating of nonferrous wire;

F.2.6 nonferrous foundries (castings), including aluminum die-casting, nonferrous die-casting except aluminum, aluminum foundries, copper foundries, and nonferrous foundries except copper and aluminum;

F.2.7 miscellaneous primary metal products, not elsewhere classified, including metal heat treating and primary metal products not elsewhere classified;

Activities covered include but are not limited to stormwater discharges associated with cooking operations, sintering plants, blast furnaces, smelting operations, rolling mills, casting operations, heat treating, extruding, drawing, or forging all types of ferrous and nonferrous metals, scrap, and ore.

F.3 Stormwater Pollution Prevention Plan (SWPPP) Requirements.

In addition to the following requirements, you must also comply with the requirements listed in Part 2 of the permit.

F.3.1 *Drainage Area Site Map.* (See also Part 2.1.2) Identify where any of the following activities may be exposed to precipitation or surface runoff: storage or disposal of wastes such as spent solvents and baths, sand, slag and dross; liquid storage tanks and drums; processing areas including pollution control equipment (e.g., baghouses); and storage areas of raw material such as coal, coke, scrap, sand, fluxes, refractories, or metal in any form. In addition, indicate where an accumulation of significant amounts of particulate matter could occur from such sources as furnace or oven emissions, losses from coal and coke handling operations, etc., and that could result in a discharge of pollutants to waters of the United States.

F.3.2 *Inventory of Exposed Material.* (See also Part 2.1.5.2) Include in the inventory of materials handled at the site that potentially may be exposed to precipitation or runoff, areas where deposition of particulate matter from process air emissions or losses during material-handling activities are possible.

F.3.3 *Good Housekeeping Measures.* (See also Part 2.1.5.1) As part of your good housekeeping program, include a cleaning and maintenance program for all impervious areas of the facility where particulate matter, dust, or debris may accumulate, especially areas where material loading and unloading, storage, handling, and processing occur; and the paving of areas where vehicle traffic or material storage occur but where vegetative or other stabilization methods are not practicable (institute a sweeping program in these areas too). For unstabilized areas where sweeping is not practicable, consider using stormwater management devices such as sediment traps, vegetative buffer strips, filter fabric fence, sediment filtering boom, gravel outlet protection, or other equivalent measures that effectively trap or remove sediment.

F.3.4 *Inspections.* (See also Part 2.1.5.5) Conduct inspections monthly and address all potential sources of pollutants, including (if applicable) air pollution control equipment (e.g., baghouses, electrostatic precipitators, scrubbers, and cyclones), for any signs of degradation (e.g., leaks, corrosion, or improper operation) that could limit their efficiency and lead to excessive emissions. Consider monitoring air flow at inlets and outlets (or use equivalent measures) to check for leaks (e.g., particulate deposition) or blockage in ducts. Also inspect all process and material handling equipment (e.g., conveyors, cranes, and vehicles) for leaks, drips, or the potential loss of material; and material storage areas (e.g., piles, bins, or hoppers for storing coke, coal, scrap, or slag, as well as chemicals stored in tanks and drums) for signs of material losses due to wind or stormwater runoff.

F.4 Monitoring and Reporting Requirements. (See also Part 3 of the permit.)

Table F-1. Sector-specific Numeric Effluent Limitations and Benchmark Monitoring			
Subsector (Discharges may be subject to requirements for more than one sector/subsector)	**Parameter**	**Benchmark Monitoring Cutoff Concentration[1]**	**Effluent Limitation Guidelines**
Steel Works, Blast Furnaces, and Rolling and Finishing Mills (SIC 3312-3317)	Total Recoverable Aluminum	0.75 mg/L	--
	Total Recoverable Zinc[2]	0.12 mg/L	--
	Total Suspended Solids (TSS)	100 mg/L	--
Iron and Steel Foundries (SIC 3321-3325)	Total Recoverable Aluminum	0.75 mg/L	--
	Total Suspended Solids (TSS)	100 mg/L	--
	Total Recoverable Copper[3]	0.014 mg/L	--
	Total Recoverable Iron	1.0 mg/L	--
	Total Recoverable Zinc[2]	0.12 mg/L	--
Rolling, Drawing, and Extruding of Nonferrous Metals (SIC 3351-3357)	Total Recoverable Copper[3]	0.014 mg/L	--
	Total Recoverable Zinc[2]	0.12 mg/L	--
	Total Suspended Solids (TSS)	100 mg/L	--
Nonferrous Foundries (SIC 3363-3369)	Total Recoverable Copper[3]	0.014 mg/L	--
	Total Recoverable Zinc[2]	0.12 mg/L	--
	Total Suspended Solids (TSS)	100 mg/L	--
Primary Smelting and Refining of Nonferrous Metals; Secondary Smelting and Refining of Nonferrous Metals; and Miscellaneous Primary Metal Products (SIC 3331-3339, 3341, 3398, 3399)	Total Suspended Solids (TSS)	100 mg/L	--

[1]You must monitor quarterly in the first year of your coverage for each benchmark parameter (see Part 3.2.2.1). For each parameter, no additional benchmark monitoring is required if the average of your 4 monitoring values does not

exceed the benchmark (see Part 3.2.2.3). However, for each parameter there are additional requirements if the average of your four monitoring values exceeds the benchmark (see Part 3.2.2.4).

[2] The benchmark value of zinc is determined as a function of hardness (in units of mg/L) in the water column. The value given in Table F-1 (i.e. 0.12 mg/L) corresponds to a hardness of 100 mg/L and should be used if you either did not analyze water hardness, other hardness data are not available, or the water hardness is less than 100 mg/L. If a laboratory analysis indicates that the water hardness is below 100 mg/L, then you should use the benchmark for 100 mg/L. If a laboratory analysis indicates that the water hardness is greater than 100 mg/L, then the following equation may be used to determine the benchmark value for zinc:

$$\text{Benchmark} = (e^{[(0.8473)(\ln \textit{hardness}) + 0.884]})/1000$$

Example: Laboratory analysis of your water sample indicates the hardness is 175 mg/L.

$$\begin{aligned}\text{Benchmark} &= (e^{[(0.8473)(\ln 175) + 0.884]})/1000\\ &= (e^{5.26})/1000\\ &= 192.51/1000\\ &= 0.19 \text{ mg/L}\end{aligned}$$

The following are example benchmark values for zinc:

Hardness (mg/L)	Benchmark value (mg/L)
100	0.12
125	0.14
150	0.17
175	0.19
200	0.22
225	0.24
250	0.26

[3] The benchmark value of copper is determined as a function of hardness (in units of mg/L) in the water column. The value given in Table F-1 (i.e. 0.014 mg/L) corresponds to a hardness of 100 mg/L and should be used if you either did not analyze water hardness, other hardness data are not available, or the water hardness is less than 100 mg/L. If a laboratory analysis indicates that the water hardness is below 100 mg/L, then you should use the benchmark for 100 mg/L. If a laboratory analysis indicates that the water hardness is greater than 100 mg/L, then the following equation may be used to determine the benchmark value for copper:

$$\text{Benchmark} = (e^{[(0.9422)(\ln \textit{hardness}) - 1.700]})/1000$$

Example: Laboratory analysis of your water sample indicates the hardness is 175 mg/L.

$$\begin{aligned}\text{Benchmark} &= (e^{[(0.9422)(\ln 175) - 1.700]})/1000\\ &= (e^{3.166})/1000\\ &= 23.72/1000\\ &= 0.024 \text{ mg/L}\end{aligned}$$

The following are example benchmark values for copper:

Hardness (mg/L)	Benchmark value (mg/L)
100	0.014
125	0.017

150	0.021
175	0.024
200	0.027
225	0.030
250	0.033

Part 4 - Sector-Specific Requirements for Industrial Activity
Subsection G - Sector G - Metal Mining

G.1 Covered Stormwater Discharges.

The requirements in Subsection G apply to stormwater discharges associated with industrial activity from metal mining facilities, including mines abandoned on Federal lands, as identified by the SIC Codes specified under Sector G in Table D-1 of Appendix D. Coverage is required for metal mining facilities that discharge stormwater contaminated by contact with, or that has come into contact with, any overburden, raw material, intermediate product, finished product, byproduct, or waste product located on the site of the operation.

G.1.1 Covered Discharges from Inactive Facilities. All stormwater discharges.

G.1.2 Covered Discharges from Active and Temporarily Inactive Facilities. Only the stormwater discharges from the following areas are covered: waste rock and overburden piles if composed entirely of stormwater and not combining with mine drainage; topsoil piles; offsite haul and access roads; onsite haul and access roads constructed of waste rock, overburden, or spent ore if composed entirely of stormwater and not combining with mine drainage; onsite haul and access roads not constructed of waste rock, overburden, or spent ore except if mine drainage is used for dust control; runoff from tailings dams or dikes when not constructed of waste rock or tailings and no process fluids are present; runoff from tailings dams or dikes when constructed of waste rock or tailings and no process fluids are present, if composed entirely of stormwater and not combining with mine drainage; concentration building if no contact with material piles; mill site if no contact with material piles; office or administrative building and housing if mixed with stormwater from industrial area; chemical storage area; docking facility if no excessive contact with waste product that would otherwise constitute mine drainage; explosive storage; fuel storage; vehicle and equipment maintenance area and building; parking areas (if necessary); power plant; truck wash areas if no excessive contact with waste product that would otherwise constitute mine drainage; unreclaimed, disturbed areas outside of active mining area; reclaimed areas released from reclamation bonds prior to December 17, 1990; and partially or inadequately reclaimed areas or areas not released from reclamation bonds.

G.1.3 Covered Discharges from Exploration and Development of Metal Mining and/or Ore Dressing Facilities: All stormwater discharges.

G.1.4 Covered Discharges from Facilities at Mining Sites and Undergoing Reclamation. All stormwater discharges.

G.2 Industrial Activities Covered by Sector G.

NOTE: "metal mining" will connote any of the separate activities listed in Part G.2. Permittees under Sector G are primarily engaged in the following types of activities:

G.2.1 exploring for metallic minerals (ores), developing mines, and the mining of ores;

G.2.2 ore dressing and beneficiating, whether performed at collocated, dedicated mills, or at separate (i.e., custom) mills.

G.2.3 reclamation of mining sites.

G.3 Limitations on Coverage.

G.3.1 *Prohibition of Stormwater Discharges.* Stormwater discharges not authorized by this permit: discharges from active metal mining facilities that are subject to effluent limitation guidelines for the Ore Mining and Dressing Point Source Category (40 CFR Part 440).

NOTE: Discharges that come in contact with overburden or waste rock are subject to 40 CFR Part 440, providing that the discharges drain to a point source (either naturally or as a result of intentional diversion) and they combine with "mine drainage" that is otherwise regulated under the Part 440 regulations. Discharges from overburden or waste rock can be covered under this permit if they are composed entirely of stormwater, do not combine with sources of mine drainage that are subject to 40 CFR Part 440, and meet other eligibility criteria contained in Part 1.2.2.1.

G.3.2 *Prohibition of Non-Stormwater* Discharges. Not authorized by this permit: adit drainage and contaminated springs or seeps. Contaminated seeps and springs discharging from waste rock dumps that do not directly result from precipitation events are not authorized by this permit (see also the standard Limitations on Coverage in Part 1.2.4).

G.4 Definitions.

The following definitions are not intended to supersede the definitions of active and inactive mining facilities established by 40 CFR 122.26(b)(14)(iii).

G.4.1 *Mining operation* - typically consists of three phases, any one of which individually qualifies as a "mining activity." The phases are the exploration and development phase, the active phase, and the reclamation phase.

G.4.2 *Exploration and Development phase* - entails exploration and land disturbance activities to determine the financial viability of a site. Development includes the building of site access roads and removal of overburden and waste rock to expose mineable minerals.

G.4.3 *Active phase* - activities including each step from extraction through production of a salable product.

G.4.4 *Reclamation phase* - activities intended to return the land to its pre-mining use

G.4.5 *Active metal mining facility* - a place where work or other activity related to the extraction, removal, or recovery of metal ore is being conducted. For surface mines, this definition does not include any land where grading has returned the earth to a desired contour and reclamation has begun.

G.4.6 *Inactive metal mining facility* - a site or portion of a site where metal mining and/or milling occurred in the past but is not an active facility as defined above, and where the inactive portion is not covered by an active mining permit issued by the applicable State or Federal agency.

G.4.7 *Temporarily inactive metal mining facility* - a site or portion of a site where metal mining and/or milling occurred in the past but currently are not being actively undertaken, and the facility is covered by an active mining permit issued by the applicable State or Federal agency.

G.4.8 *Final Stabilization* - a site or portion of a site is "finally stabilized" when:

a. All soil disturbing activities at the site have been completed and either of the two following criteria are met:

   i. A uniform (e.g., evenly distributed, without large bare areas) perennial vegetative cover with a density of 70 percent of the native background vegetative cover for the area has been established on all unpaved areas and areas not covered by permanent structures, or

   ii. Equivalent permanent stabilization measures (such as the use of riprap, gabions, or geotextiles) have been employed.

b. When background native vegetation will cover less than 100 percent of the ground (e.g., arid areas, beaches), the 70 percent coverage criteria is adjusted as follows: if the native vegetation covers 50 percent of the ground, 70 percent of 50 percent (0.70 x 0.50 = 0.35) would require 35 percent total cover for final stabilization. On a beach with no natural vegetation, no stabilization is required.

G.5 Clearing, Grading, and Excavation Activities.

Clearing, grading, and excavation activities being conducted as part of the exploration and development phase of a mining operation are covered under this permit.

G.5.1 Management Practices for Clearing, Grading, and Excavation Activities.

G.5.1.1 *Selecting and installing control measures*. A combination of erosion and sedimentation control measures are required to achieve maximum pollutant prevention and removal. All control measures must be properly selected, installed, and maintained in accordance with any relevant manufacturer specifications and good engineering practices.

G.5.1.2 *Removal of Sediment.* If sediment escapes the site, off-site accumulations of sediment must be removed at a frequency sufficient to prevent off-site impacts.

G.5.1.3 *Good Housekeeping.* Litter, debris, and chemicals must be prevented from becoming a pollutant source in stormwater discharges.

G.5.1.4 *Velocity Dissipation.* Velocity dissipation devices must be placed at discharge locations and along the length of any outfall channel to provide a non-erosive flow velocity from disturbed areas and from any stormwater retention or detention facilities to a water course so that the natural physical and biological characteristics and functions are maintained and protected (e.g., no significant changes in the hydrological regime of the receiving water).

G.5.1.5 *Retention and Detention of Stormwater Runoff.* For drainage locations serving more than one acre, sediment basins and/or temporary sediment traps should be used. At a minimum, silt fences, vegetative buffer strips, or equivalent sediment controls are required for all down slope boundaries (and for those side slope boundaries deemed appropriate as dictated by individual site conditions) of the development area unless a sediment basin providing storage for a calculated volume of runoff from a 2-year, 24-hour storm or 3,600 cubic feet of storage per acre drained is provided.

G.5.1.6 *Temporary Stabilization of Disturbed Areas.* Stabilization measures must be initiated immediately in portions of the site where development activities have temporarily or permanently ceased, but in no case more than 14 days after the construction activity in that portion of the site has temporarily or permanently ceased. In arid, semiarid, and drought-stricken areas where initiating perennial vegetative stabilization measures is not possible within 14 days after construction activity has temporarily or permanently ceased, final vegetative stabilization measures must be initiated as soon as possible. Until full vegetative stabilization is achieved, interim measures such as blankets and tackifiers must be employed.

G.5.2 Requirements for Inspection of Clearing, Grading, and Excavation Activities.

G.5.2.1 *Inspection Frequency.* Inspections must be conducted at least once every 7 calendar days or at least once every 14 calendar days and within 24 hours of the end of a storm event of 0.5 inches or greater. Inspection frequency may be reduced to at least once every month if the entire site is temporarily stabilized, if runoff is unlikely due to winter conditions (e.g., site is covered with snow, ice, or the ground is frozen), or construction is occurring during seasonal arid periods in arid areas and semi-arid areas.

G.5.2.2 *Qualified Personnel for Inspections.* Inspections must be conducted by qualified personnel. "Qualified personnel" means a person knowledgeable in the principles and practice of erosion and sediment control who possesses the skills to assess conditions at the construction site that could impact stormwater quality and the effectiveness of any sediment and erosion control measures selected to control the quality of stormwater discharges from the clearing, grading, and excavation activities.

G.5.2.3 *Location of Inspections*. Inspections must include all areas of the site disturbed by clearing, grading, and excavation activities and areas used for storage of materials that are exposed to precipitation. Sedimentation and erosion control measures identified in the SWPPP must be observed to ensure proper operation. Discharge locations must be inspected to ascertain whether erosion control measures are effective in preventing significant impacts to waters of the United States, where accessible. Where discharge locations are inaccessible, nearby downstream locations must be inspected to the extent that such inspections are practicable. Locations where vehicles enter or exit the site must be inspected for evidence of off-site sediment tracking.

G.5.2.4 *Inspection Reports*. For each inspection required above, you must complete an inspection report. At a minimum, the inspection report must include:

a. The inspection date;

b. Names, titles, and qualifications of personnel making the inspection;

c. Weather information for the period since the last inspection (or note if it is the first inspection) including a best estimate of the beginning of each storm event, duration of each storm event, approximate amount of rainfall for each storm event (in inches), and whether any discharges occurred;

d. Weather information and a description of any discharges occurring at the time of the inspection;

e. Location(s) of discharges of sediment or other pollutants from the site;

f. Location(s) of BMPs that need to be maintained;

g. Location(s) of BMPs that failed to operate as designed or proved inadequate for a particular location;

h. Location(s) where additional BMPs are needed that did not exist at the time of inspection; and

i. Corrective action(s) required, including any changes to the SWPPP necessary and implementation dates.

A record of each inspection and of any actions taken in accordance with this Part must be retained as part of the SWPPP for at least three years from the date that permit coverage expires or is terminated. The inspection reports must identify any incidents of non-compliance with the permit conditions. Where a report does not identify any incidents of non-compliance, the report must contain a certification that the clearing, grading, and excavation activities are in compliance with the SWPPP and this permit. The report must be signed in accordance with Subpart 11 of Appendix B.

G.5.3 Maintenance of Controls for Clearing, Grading, and Excavation Activities

G.5.3.1 *Maintenance of BMPs*. All erosion and sediment control measures and other protective measures identified in the SWPPP must be maintained in effective operating condition. If site inspections required by Section G.5.2 identify BMPs that are not operating effectively, maintenance must be performed as soon as possible and before the next storm event whenever practicable to maintain the continued effectiveness of stormwater controls.

G.5.3.2 *Modification of BMPs*. Existing BMPs need to be modified or, if additional BMPs are necessary for any reason, implementation must be completed before the next storm event whenever practicable. If implementation before the next storm event is impracticable, the situation must be documented in the SWPPP and alternative BMPs must be implemented as soon as possible.

G.5.3.3 *Maintenance of sediment traps and ponds*. Sediment from sediment traps or sedimentation ponds must be removed when design capacity has been reduced by 50 percent.

G.5.4 Requirements for Cessation of Clearing, Grading, and Excavation Activities.

G.5.4.1 *Inspections and Maintenance*. Inspections and maintenance of BMPs associated with clearing, grading, and excavation activities being conducted as part of the exploration and construction phase of a mining operation must continue until final stabilization has been achieved on all portions of the disturbed area.

G.5.4.2 *Final Stabilization*. Stabilization measures must be initiated immediately in portions of the site where development activities have permanently ceased, but in no case more than 14 days after the construction activity in that portion of the site has permanently ceased. In arid, semiarid, and drought-stricken areas where initiating perennial vegetative stabilization measures is not possible within 14 days after construction activity has temporarily or permanently ceased, final vegetative stabilization measures must be initiated as soon as possible. Until final stabilization is achieved temporary stabilization measures, such as blankets and tackifiers, must be used.

G.6 Stormwater Pollution Prevention Plan (SWPPP) Requirements.

The SWPPP requirements in Part G.6 are applicable for active metal mining facilities, inactive mining facilities, temporarily inactive metal mining facilities, temporarily inactive metal mining facilities, and sites undergoing reclamation. In addition to the following requirements, you must also comply with the requirements listed in Part 2 in the permit.

G.6.1 *Nature of Industrial Activities*. (See also Part 2.1.2.) Briefly describe the mining and associated activities that can potentially affect the stormwater discharges covered by this permit, including a general description of the location of the site relative to major transportation routes and communities.

G.6.2 *Site Map*. (See also Part 2.1.2) Also identify the locations of the following (as appropriate): mining or milling site boundaries; access and haul roads; outline of the drainage areas of each stormwater outfall within the facility with indications of the types of discharges from the drainage areas; location(s) of all permitted discharges covered under an individual NPDES permit, outdoor equipment storage, fueling, and maintenance areas; materials handling areas; outdoor manufacturing, outdoor storage, and material disposal areas; outdoor chemicals and explosives storage areas; overburden, materials, soils, or waste storage areas; location of mine drainage (where water leaves mine) or other process water; tailings piles and ponds (including proposed ones); heap leach pads; off-site points of discharge for mine drainage and process water; surface waters; boundary of tributary areas that are subject to effluent limitations guidelines; and location(s) of reclaimed areas.

G.6.3 *Potential Pollutant Sources*. (See also Part 2.1.4) For each area of the mine or mill site where stormwater discharges associated with industrial activities occur, identify the types of pollutants (e.g., heavy metals, sediment) likely to be present in significant amounts. Consider these factors: the mineralogy of the ore and waste rock (e.g., acid forming); toxicity and quantity of chemicals used, produced, or discharged; the likelihood of contact with stormwater; vegetation of site (if any); and history of significant leaks or spills of toxic or hazardous pollutants. Also include a summary of any existing ore or waste rock or overburden characterization data and test results for potential generation of acid rock. If any new data is acquired due to changes in ore type being mined, update your SWPPP with this information.

G.6.4 *Site Inspections*. (See also Part 2.1.5.5 and G.5.2) Inspect sites at least monthly unless adverse weather conditions make the site inaccessible. Sites which discharge to waters which are designated as outstanding waters or waters which are impaired for parameters listed in Table G-2 must be inspected monthly.

G.6.5 *Employee Training*. (See also Part 2.1.5.6) Conduct employee training at least annually at active and temporarily inactive sites. All employee training(s) must be documented in the SWPPP.

G.6.6 *Stormwater Controls*. (See also Part 2.1.5) Consider each of the following BMPs. The potential pollutants identified in Part G.6.3 shall determine the priority and appropriateness of the BMPs selected. If BMPs are implemented or planned but are not listed here (e.g., substituting a less toxic chemical for a more toxic one), include descriptions of them in your SWPPP.

G.6.6.1 *Stormwater Diversions*: Consider diverting stormwater away from potential pollutant sources. Following are some BMP options: interceptor or diversion controls (e.g., dikes, swales, curbs, or berms); pipe slope drains; subsurface drains; conveyance systems (e.g., channels or gutters, open-top box culverts, and waterbars; rolling dips and road sloping; roadway surface water deflector and culverts); or their equivalents.

G.6.6.2 *Sediment and Erosion Control*: (See also Part 2.1.5.7) Consider a range of erosion controls within the broad categories of: flow diversion (e.g., swales); stabilization (e.g., temporary or permanent seeding); and structural controls (e.g., sediment traps, dikes, silt fences).

G.6.6.3 *Management of Runoff*: (See also Part 2.1.5.8) Consider the potential pollutant sources given in Part G.6.3 when determining reasonable and appropriate measures for managing runoff.

G.6.6.4 *Capping*: When capping is necessary to minimize pollutant discharges in stormwater, identify the source being capped and the material used to construct the cap.

G.6.6.5 *Treatment*: If treatment of stormwater (e.g., chemical or physical systems, oil and water separators, artificial wetlands) is necessary to protect water quality, describe the type and location of treatment used. Passive and/or active treatment of stormwater runoff is encouraged. Treated runoff may be discharged as a stormwater source regulated under this permit provided the discharge is not combined with discharges subject to effluent limitation guidelines for the Ore Mining and Dressing Point Source Category (40 CFR Part 440).

G.6.6.6 *Certification of Discharge Testing*: (See also Part 2.1.4.4) Test or evaluate all outfalls covered under this permit for the presence of specific mining-related non-stormwater discharges such as seeps or adit discharges, or discharges subject to effluent limitations guidelines (e.g., 40 CFR Part 440), such as mine drainage or process water. Alternatively (if applicable), you may certify in your SWPPP that a particular discharge composed of commingled stormwater and non-stormwater is covered under a separate NPDES permit, and that permit subjects the non-stormwater portion to effluent limitations prior to any commingling. This certification must identify the non-stormwater discharges, the applicable NPDES permit(s), the effluent limitations placed on the non-stormwater discharge by the permit(s), and the points at which the limitations are applied.

G.7 Monitoring and Reporting Requirements. (See also Part 3 of the permit.)

G.7.1 *Analytic Monitoring for Copper Ore Mining and Dressing Facilities.* Active copper ore mining and dressing facilities must sample and analyze stormwater discharges for the pollutants listed in Table G-1.

Table G-1 Sector-specific Numeric Effluent Limitations and Benchmark Monitoring for Copper Ore Mining and Dressing Facilities			
Subsector (Discharges may be subject to requirements for more than one sector/subsector)	**Parameter**	**Benchmark Monitoring Concentration[1]**	**Effluent Limitation Guidelines**
Copper Ore Mining and Dressing Facilities (SIC 1021)	Total Suspended Solids (TSS)	100 mg/L	--
	Nitrate plus Nitrite Nitrogen	0.68 mg/L	--
	Chemical Oxygen Demand (COD)	120 mg/L	--

[1] You must monitor quarterly in the first year of your coverage for each benchmark parameter (see Part 3.2.2.1). For each parameter, no additional benchmark monitoring is required if the average of your 4 monitoring values does not exceed the benchmark (see Part 3.2.2.3). However, for each parameter there are additional requirements if the average of your four monitoring values exceeds the benchmark (see Part 3.2.2.4).

G.7.2 Analytic Monitoring Requirements for Discharges From Waste Rock and Overburden Piles at Active Sites, Inactive Sites, and Sites Undergoing Reclamation. For discharges from waste rock and overburden piles, perform analytic monitoring quarterly in the first year of your coverage for the parameters listed in Table G-2 (see Part 3.2.2.1). Permittees must also conduct analytic monitoring quarterly in the first year of your coverage for the parameters listed in Table G-3 (see Part 3.2.2.1). The monitoring schedule is specified in Part 3.2.2.1. The Director may also notify you that you must perform additional monitoring to accurately characterize the quality and quantity of pollutants discharged from your waste rock and overburden piles.

Table G-2. Sector-specific Numeric Effluent Limitations and Benchmark Monitoring for Discharges from Waste Rock and Overburden Piles from Active Ore Mining or Dressing Facilities, and Sites Undergoing Reclamation			
Subsector (Discharges may be subject to requirements for more than one sector/subsector)	**Parameter**	**Benchmark Monitoring Cutoff Concentration[1]**	**Effluent Limitation Guidelines**
Iron Ores; Copper Ores; Lead and Zinc Ores; Gold and Silver Ores; Ferroalloy Ores, Except Vanadium; and Miscellaneous Metal Ores (SIC Codes 1011, 1021, 1031, 1041, 1044, 1061, 1081, 1094, 1099)	Total Suspended Solids (TSS)	100 mg/L	--
	Turbidity	50 NTU	--
	pH	6.0-9.0 s.u.	--
	Hardness (as $CaCO_3$; calc. From Ca, Mg)[2]	no benchmark value	--
See above, as applicable (when analyzing hardness for a suite of metals, it is more cost effective to add analysis of calcium and magnesium, and	Total Recoverable Antimony	0.64 mg/L	--
	Total Recoverable Arsenic	0.15 mg/ L	--

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Table G-2. Sector-specific Numeric Effluent Limitations and Benchmark Monitoring for Discharges from Waste Rock and Overburden Piles from Active Ore Mining or Dressing Facilities, and Sites Undergoing Reclamation			
Subsector (Discharges may be subject to requirements for more than one sector/subsector)	**Parameter**	**Benchmark Monitoring Cutoff Concentration[1]**	**Effluent Limitation Guidelines**
have hardness calculated than to require hardness analysis separately)	Total Recoverable Beryllium	0.13 mg/L	--
	Total Recoverable Cadmium[3]	0.0021 mg/L	--
	Total Recoverable Copper[4]	0.014 mg/L	--
	Total Recoverable Iron	1.0 mg/L	--
	Total Recoverable Lead[5]	0.082 mg/L	--
	Total Recoverable Mercury	0.0014 mg/L	--
	Total Recoverable Nickel[6]	0.47 mg/L	--
	Total Recoverable Selenium	0.005 mg/L	--
	Total Recoverable Silver[7]	0.0038 mg/L	--
	Total Recoverable Zinc[8]	0.12 mg/L	--

[1] You must monitor quarterly in the first year of your coverage for each benchmark parameter (see Part 3.2.2.1). For each parameter, no additional benchmark monitoring is required if the average of your 4 monitoring values does not exceed the benchmark (see Part 3.2.2.3). However, for each parameter there are additional requirements if the average of your four monitoring values exceeds the benchmark (see Part 3.2.2.4).

[2]Benchmark monitoring cutoff concentrations for hardness dependent elements are based on a nominal hardness of 100 mg/L $CaCO_3$.

[3] The benchmark value of cadmium is determined as a function of hardness (in units of mg/L) in the water column. The value given in Table G-2 (i.e. 0.0021 mg/L) corresponds to a hardness of 100 mg/L and should be used if you either did not analyze water hardness, other hardness data are not available, or the water hardness is less than 100 mg/L. If a laboratory analysis indicates that the water hardness is below 100 mg/L, then you should use the benchmark for 100 mg/L. If a laboratory analysis indicates that the water hardness is greater than 100 mg/L, then the following equation may be used to determine the benchmark value for cadmium:

$$\text{Benchmark} = (e^{[(1.0166)(\ln \mathit{hardness}) - 3.924]})/1000$$

Example: Laboratory analysis of your water sample indicates the hardness is 175 mg/L.

$$\text{Benchmark} = (e^{[(1.0166)(\ln 175) - 3.924]})/1000$$
$$= (e^{1.327})/1000$$
$$= 3.76/1000$$
$$= 0.0038 \text{ mg/L}$$

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The following are example benchmark values for cadmium:

Hardness (mg/L)	Benchmark value (mg/L)
100	0.0021
125	0.0027
150	0.0032
175	0.0038
200	0.0043
225	0.0049
250	0.0054

[4] The benchmark value of copper is determined as a function of hardness (in units of mg/L) in the water column. The value given in Table G-2 (i.e. 0.014 mg/L) corresponds to a hardness of 100 mg/L and should be used if you either did not analyze water hardness, other hardness data are not available, or the water hardness is less than 100 mg/L. If a laboratory analysis indicates that the water hardness is below 100 mg/L, then you should use the benchmark for 100 mg/L. If a laboratory analysis indicates that the water hardness is greater than 100 mg/L, then the following equation may be used to determine the benchmark value for copper:

$$\text{Benchmark} = (e^{[(0.9422)(\ln \textit{hardness}) - 1.700]})/1000$$

Example: Laboratory analysis of your water sample indicates the hardness is 175 mg/L.

$$\begin{aligned}\text{Benchmark} &= (e^{[(0.9422)(\ln 175) - 1.700]})/1000 \\ &= (e^{3.166})/1000 \\ &= 23.72/1000 \\ &= 0.024 \text{ mg/L}\end{aligned}$$

The following are example benchmark values for copper:

Hardness (mg/L)	Benchmark value (mg/L)
100	0.014
125	0.017
150	0.021
175	0.024
200	0.027
225	0.030
250	0.033

[5] The benchmark value of lead is determined as a function of hardness (in units of mg/L) in the water column. The value given in Table G-2 (i.e. 0.082 mg/L) corresponds to a hardness of 100 mg/L and should be used if you either did not analyze water hardness, other hardness data are not available, or the water hardness is less than 100 mg/L. If a laboratory analysis indicates that the water hardness is below 100 mg/L, then you should use the benchmark for 100 mg/L. If a laboratory analysis indicates that the water hardness is greater than 100 mg/L, then the following equation may be used to determine the benchmark value for lead:

$$\text{Benchmark} = (e^{[(1.273)(\ln \textit{hardness}) - 1.460]})/1000$$

Example: Laboratory analysis of your water sample indicates the hardness is 175 mg/L.

$$\text{Benchmark} = (e^{[(1.273)(\ln 175) - 1.460]})/1000$$
$$= (e^{5.1148})/1000$$
$$= 166.46/1000$$
$$= 0.17 \text{ mg/L}$$

The following are example benchmark value for lead:

Hardness (mg/L)	Benchmark value (mg/L)
100	0.082
125	0.11
150	0.14
175	0.17
200	0.20
225	0.23
250	0.26

[6] The benchmark value of nickel is determined as a function of hardness (in units of mg/L) in the water column. The value given in Table G-2 (i.e. 0.47 mg/L) corresponds to a hardness of 100 mg/L and should be used if you either did not analyze water hardness, other hardness data are not available, or the water hardness is less than 100 mg/L. If a laboratory analysis indicates that the water hardness is below 100 mg/L, then you should use the benchmark for 100 mg/L..If a laboratory analysis indicates that the water hardness is greater than 100 mg/L, then the following equation may be used to determine the benchmark value for nickel:

$$\text{Benchmark} = (e^{[(0.8460)(\ln \textit{hardness}) + 2.255]})/1000$$

Example: Laboratory analysis of your water sample indicates the hardness is 175 mg/L.

$$\text{Benchmark} = (e^{[(0.8460)(\ln 175) + 2.255]})/1000$$
$$= (e^{6.624})/1000$$
$$= 753.26/1000$$
$$= 0.75 \text{ mg/L}$$

The following are example benchmark values for nickel:

Hardness (mg/L)	Benchmark value (mg/L)
100	0.47
125	0.57
150	0.66
175	0.75
200	0.84
225	0.93
250	1.02

[7] The benchmark limitation value of silver is determined as a function of hardness (in units of mg/L) in the water column. The value given in Table G-2 (i.e. 0.0038 mg/L) corresponds to a hardness of 100 mg/L and should be used if you either did not analyze water hardness, other hardness data are not available, or the water hardness is less than 100 mg/L. If a laboratory analysis indicates that the water hardness is below 100 mg/L, then you should use the benchmark for 100 mg/L. If a laboratory analysis indicates that the water hardness is greater than 100 mg/L, then the following equation may be used to determine the benchmark value for silver:

$$\text{Benchmark} = (e^{[(1.72)(\ln \textit{hardness}) - 6.59]})/1000$$

Example: Laboratory analysis of your water sample indicates the hardness is 175 mg/L.

$$\text{Benchmark} = (e^{[(1.72)(\ln 175) - 6.59]})/1000$$
$$= (e^{2.293})/1000$$
$$= 9.909/1000$$
$$= 0.0099 \text{ mg/L}$$

The following are example benchmark values for silver:

Hardness (mg/L)	Benchmark value (mg/L)
100	0.0038
125	0.0056
150	0.0076
175	0.0099
200	0.013
225	0.015
250	0.018

[8] The benchmark value of zinc is determined as a function of hardness (in units of mg/L) in the water column. The value given in Table G-2 (i.e. 0.12 mg/L) corresponds to a hardness of 100 mg/L and should be used if you either did not analyze water hardness, other hardness data are not available, or the water hardness is less than 100 mg/L. If a laboratory analysis indicates that the water hardness is below 100 mg/L, then you should use the benchmark for 100 mg/L. If a laboratory analysis indicates that the water hardness is greater than 100 mg/L, then the following equation may be used to determine the benchmark value for zinc:

$$\text{Benchmark} = (e^{[(0.8473)(\ln \mathit{hardness}) + 0.884]})/1000$$

Example: Laboratory analysis of your water sample indicates the hardness is 175 mg/L.

$$\text{Benchmark} = (e^{[(0.8473)(\ln 175) + 0.884]})/1000$$
$$= (e^{5.26})/1000$$
$$= 192.51/1000$$
$$= 0.19 \text{ mg/L}$$

The following are example benchmark values for zinc:

Hardness (mg/L)	Benchmark value (mg/L)
100	0.12
125	0.14
150	0.17
175	0.19
200	0.22
225	0.24
250	0.26

G.7.3 *Additional Analytic Monitoring Requirements for Discharges From Waste Rock and Overburden Piles.* Table G-3 contains additional monitoring requirements for specific ore mine categories. Perform the monitoring quarterly in the first year of coverage (see Part

3.2.2.1). The monitoring schedule is specified in Part 3.2.2.1. The initial sampling event for a pollutant parameter required in Table G-2 satisfies the requirement for the first sample of any pollutant measurement in Table G-3.

Table G-3. Additional Monitoring Requirements for Discharges from Waste Rock and Overburden Piles from Active Ore Mining or Dressing Facilities, Inactive Sites, and Sites Undergoing Reclamation

Supplemental Requirements			
Type of Ore Mined	**Pollutants of Concern**		
	Total Suspended Solids (TSS)	**pH**	**Metals, Total Recoverable**
Tungsten Ore	X	X	Arsenic, Cadmium (H), Copper (H), Lead (H), Zinc (H)
Nickel Ore	X	X	Arsenic, Cadmium (H), Copper (H), Lead (H), Zinc (H)
Aluminum Ore	X	X	Iron
Mercury Ore	X	X	Nickel (H)
Iron Ore	X	X	Iron (Dissolved)
Platinum Ore			Cadmium (H), Copper (H), Mercury, Lead (H), Zinc (H)
Titanium Ore	X	X	Iron, Nickel (H), Zinc (H)
Vanadium Ore	X	X	Arsenic, Cadmium (H), Copper (H), Lead, Zinc (H)
Copper, Lead, Zinc, Gold, Silver, and Molybdenum	X	X	Arsenic, Cadmium (H), Copper (H), Lead, Mercury, Zinc (H)
Uranium, Radium, and Vanadium	X	X	Chemical Oxygen Demand, Arsenic, Radium (Dissolved and Total), Uranium, Zinc (H)

Note: (H) indicates that hardness must also be measured when this pollutant is measured.

G.7.4 *Reporting Requirements for Stormwater Discharges from Waste Rock and Overburden Piles.* Submit monitoring results for each outfall discharging stormwater from waste rock and overburden piles, or certifications in accordance with Part 3.6.

Table G-4. Applicability of the Multi-Sector General Permit to Stormwater Runoff From Active Mining and Dressing Sites, Temporarily Inactive Sites, and Sites Undergoing Reclamation	
Discharge/Source of Discharge	**Note/Comment**
Piles	
Waste rock/overburden	If composed entirely of stormwater and not combining with mine drainage. See note below.
Topsoil	
Roads constructed of waste rock or spent ore	
Onsite haul roads	If composed entirely of stormwater and not combining with mine drainage. See note below.
Offsite haul and access roads	
Roads not constructed of waste rock or spent ore	
Onsite haul roads	Except if mine drainage is used for dust control
Offsite haul and access roads	
Milling/concentrating	
Runoff from tailings dams and dikes when constructed of waste rock/tailings	Except if process fluids are present and only if composed entirely of stormwater and not combining with mine drainage. See Note below.
Runoff from tailings dams/dikes when not constructed of waste rock and tailings	Except if process fluids are present
Concentration building	If stormwater only and no contact with piles
Mill site	If stormwater only and no contact with piles
Ancillary areas	
Office and administrative building and housing	If mixed with stormwater from the industrial area
Chemical storage area	
Docking facility	Except if excessive contact with waste product that would otherwise constitute mine drainage
Explosive storage	
Fuel storage (oil tanks/coal piles)	
Vehicle and equipment maintenance area/building	
Parking areas	But coverage unnecessary if only employee and visitor-type parking

Table G-4. Applicability of the Multi-Sector General Permit to Stormwater Runoff From Active Mining and Dressing Sites, Temporarily Inactive Sites, and Sites Undergoing Reclamation	
Power plant	
Truck wash area	Except when excessive contact with waste product that would otherwise constitute mine drainage
Reclamation-related areas	
Any disturbed area (unreclaimed)	Only if not in active mining area
Reclaimed areas released from reclamation bonds prior to Dec. 17, 1990	
Partially/inadequately reclaimed areas or areas not released from reclamation bond	
Note: Stormwater runoff from these sources are subject to the NPDES program for stormwater unless mixed with discharges subject to the 40 CFR Part 440 that are not regulated by another permit prior to mixing. Non-stormwater discharges from these sources are subject to NPDES permitting and may be subject to the effluent limitation guidelines under 40 CFR Part 440. Discharges from overburden/waste rock and overburden/waste rock-related areas are not subject to 40 CFR Part 440 unless: (1) it drains naturally (or is intentionally diverted) to a point source; and (2) combines with "mine drainage" that is otherwise regulated under the Part 440 regulations. For such sources, coverage under this permit would be available if the discharge composed entirely of stormwater does not combine with other sources of mine drainage that are not subject to 40 CFR Part 440, as well as meeting other eligibility criteria contained in Part I.B. of the permit. Permit applicants bear the initial responsibility for determining the applicable technology-based standard for such discharges. EPA recommends that permit applicants contact the relevant NPDES permit issuance authority for assistance to determine the nature and scope of the "active mining area" on a mine-by-mine basis, as well as to determine the appropriate permitting mechanism for authorizing such discharges.	

G.8. Termination of Permit Coverage

G.8.1 *Termination of Permit Coverage for Sites Reclaimed After December 17, 1990.* A site or a portion of a site that has been released from applicable state or federal reclamation requirements after December 17, 1990, is no longer required to maintain coverage under this permit, provided that the covered stormwater discharges do not have the potential to cause or contribute to violations of state water quality standards. If the site or portion of a site reclaimed after December 17, 1990, was not subject to reclamation requirements, the site or portion of the site is no longer required to maintain coverage under this permit if the site or portion of the site has been reclaimed as defined in Part G.8.2.

G.8.2 *Termination of Permit Coverage for Sites Reclaimed Before December 17, 1990.* A site or portion of a site that was released from applicable state or federal reclamation requirements before December 17, 1990, or that was otherwise reclaimed before December 17, 1990, is no longer required to maintain coverage under this permit if the site or portion of the site has been reclaimed. A site or portion of a site is considered to have been reclaimed if stormwater runoff that comes into contact with 1) raw materials, intermediate byproducts, finished products, and waste products does not have the potential to cause or contribute to violations of state water quality standards, (2) soil disturbing activities related to mining at the sites or portion of the site have been completed, (3) the site or portion of the site has been stabilized to minimize soil erosion, and (4) as appropriate depending on location, size, and the potential to contribute pollutants to stormwater discharges, the site or portion of the site has been revegetated, will be amenable to natural revegetation, or will be left in a condition consistent with the post-mining land use.

Part 4 - Sector-Specific Requirements for Industrial Activity
Subsection H - Sector H - Coal Mines and Coal Mining-Related Facilities.

H.1 Covered Stormwater Discharges.

The requirements in Subsection H apply to stormwater discharges associated with industrial activity from coal mines and coal mining-related facilities as identified by the SIC Codes specified under Sector H in Table D-1 of Appendix D.

H.2 Industrial Activities Covered by Sector H.

Stormwater discharges from the following areas of coal mines may be eligible for this permit.

H.2.1 haul roads (nonpublic roads on which coal or coal refuse is conveyed);

H.2.2 access roads (nonpublic roads providing light vehicular traffic within the facility property and to public roadways);

H.2.3 railroad spurs, siding, and internal haulage lines (rail lines used for hauling coal within the facility property and to offsite commercial railroad lines or loading areas);

H.2.4 conveyor belts, chutes, and aerial tramway haulage areas (areas under and around coal or refuse conveyer areas, including transfer stations); and

H.2.5 equipment storage and maintenance yards, coal handling buildings and structures, and inactive coal mines and related areas (abandoned and other inactive mines, refuse disposal sites, and other mining-related areas).

H.3 Limitations on Coverage.

H.3.1 *Prohibition of Non-Stormwater Discharges.* (See also Part 1.2.4) Not covered by this permit: discharges from pollutant seeps or underground drainage from inactive coal mines and refuse disposal areas that do not result from precipitation events, and discharges from floor drains in maintenance buildings and other similar drains in mining and preparation plant areas.

H.3.2 *Discharges Subject to Stormwater Effluent Guidelines.* (See also Part 1.2.4.5) Not authorized by this permit: stormwater discharges subject to an existing effluent limitation guideline at 40 CFR Part 434.

H.4 Stormwater Pollution Prevention Plan (SWPPP) Requirements.

In addition to the following requirements, you must also comply with the requirements listed in Part 2 of the permit.

H.4.1 *Other Applicable Regulations*. Most active coal mining-related areas (SIC Codes 1221-1241) are subject to sediment and erosion control regulations of the U.S. Office of Surface Mining (OSM) that enforces the Surface Mining Control and Reclamation Act (SMCRA). OSM has granted authority to most coal-producing states to implement SMCRA through State SMCRA regulations. All SMCRA requirements regarding control of stormwater-related pollutant discharges must be addressed in the SWPPP (directly or by reference).

H.4.2 *Drainage Area Site Map*. (See also Part 2.1.2) Identify where any of the following may be exposed to precipitation or surface runoff: all applicable mining-related areas described in Part H.2; acidic spoil, refuse, or unreclaimed disturbed areas; and liquid storage tanks containing pollutants such as caustics, hydraulic fluids, and lubricants.

H.4.3 *Potential Pollutant Sources*. (See also Part 2.1.4) Describe the following sources and activities that have potential pollutants associated with them: truck traffic on haul roads and resulting generation of sediment subject to runoff and dust generation; fuel or other liquid storage; pressure lines containing slurry, hydraulic fluid, or other potential harmful liquids; and loading or temporary storage of acidic refuse or spoil.

H.4.4 *Good Housekeeping Measures*. (See also Part 2.1.5.1) As part of your good housekeeping program, consider using sweepers and covered storage, watering haul roads to minimize dust generation, and conserving vegetation (where possible) to minimize erosion.

H.4.5 *Preventive Maintenance*. (See also Part 2.1.5.3) Perform inspections or other equivalent measures of storage tanks and pressure lines of fuels, lubricants, hydraulic fluid, and slurry to prevent leaks due to deterioration or faulty connections.

H.4.6 *Inspections of Active Mining-Related Areas and Inactive Areas Under SMCRA Bond Authority*. (See also Part 2.1.5.5) Perform quarterly inspections of areas covered by this permit, corresponding with the inspections as performed by SMCRA inspectors, of all mining-related areas required by SMCRA. Also maintain the records of the SMCRA authority representative.

H.4.7 *Sediment and Erosion Control*. (See also Part 2.1.5.7) As indicated in Part H.4.1, SMCRA requirements regarding sediment and erosion control measures are primary requirements of the SWPPP for mining-related areas subject to SMCRA authority.

H.4.8 *Comprehensive Site Compliance Evaluation*. (See also Part 3.1) Your evaluation program must include inspections for pollutants entering the drainage system from activities located on or near coal mining-related areas. Among the areas to be inspected are haul and access roads; railroad spurs, sliding, and internal hauling lines; conveyor belts, chutes, and aerial tramways; equipment storage and maintenance yards; coal handling buildings and structures; and inactive mines and related areas.

H.5 Monitoring and Reporting Requirements. (See also Part 3 of the permit.)

Table H-1. Sector-specific Numeric Effluent Limitations and Benchmark Monitoring			
Subsector (Discharges may be subject to requirements for more than one sector/subsector)	**Parameter**	**Benchmark Monitoring Concentration[1]**	**Effluent Limitation Guidelines**
Coal Mines and Related Areas (SIC 1221-1241)	Total Recoverable Aluminum	0.75 mg/L	--
	Total Recoverable Iron	1.0 mg/L	--
	Total Suspended Solids (TSS)	100 mg/L	--

[1]You must monitor quarterly in the first year of your coverage for each benchmark parameter (see Part 3.2.2.1). For each parameter, no additional benchmark monitoring is required if the average of your 4 monitoring values does not exceed the benchmark (see Part 3.2.2.3). However, for each parameter there are additional requirements if the average of your four monitoring values exceeds the benchmark (see Part 3.2.2.4).

Part 4 - Sector-Specific Requirements for Industrial Activity
Subsection I - Sector I-Oil and Gas Extraction and Refining.

I.1 Covered Stormwater Discharges.

The requirements in Subsection I apply to stormwater discharges associated with industrial activity from Oil and Gas Extraction and Refining facilities as identified by the SIC Codes specified under Sector I in Table D-1 of Appendix D of the permit.

I.2 Industrial Activities Covered By Sector I.

Permittees under Sector I are primarily engaged in the following types of activities:

I.2.1 oil and gas exploration, production, processing or treatment operations, or transmission facilities; and

I.2.2 extraction and production of crude oil, natural gas, oil sands, and shale; the production of hydrocarbon liquids and natural gas from coal; and associated oil field service, supply, and repair industries.

I.3 Limitations on Coverage.

I.3.1 *Stormwater Discharges Subject to Effluent Limitation Guidelines.* This permit does not authorize stormwater discharges from petroleum refining or drilling operations that are subject to nationally established effluent limitation guidelines found at 40 CFR Parts 419 and 435, respectively.

NOTE: Most contaminated discharges at petroleum refining and drilling facilities are subject to these effluent guidelines and are not eligible for coverage by this permit. (e.g., stormwater runoff which comes into contact with any raw material, intermediate produce, finished product, by-product or waste product located on petroleum refinery property, deck drainage (which includes stormwater) from oil and gas extraction facilities in the Offshore and Coastal Subcategories, etc.).

I.3.2 *Non-Stormwater Discharges.* Discharges of vehicle and equipment washwater, including tank cleaning operations, are not authorized by this permit. Alternatively, washwater discharges must be authorized under a separate NPDES permit, or be discharged to a sanitary sewer in accordance with applicable industrial pretreatment requirements.

I.4 Stormwater Pollution Prevention Plan (SWPPP) Requirements.

In addition to the following requirements, you must also comply with the requirements listed in Part 2 of the permit.

I.4.1 *Drainage Area Site Map.* (See also Part 2.1.2) Identify where any of the following may be exposed to precipitation or surface runoff: Reportable Quantity (RQ) releases; locations used for the treatment, storage, or disposal of wastes; processing areas and storage areas; chemical mixing areas; construction and drilling areas; all areas subject to the effluent guidelines requirements for "No Discharge" in accordance with 40 CFR 435.32; and the structural controls to achieve compliance with the "No Discharge" requirements.

I.4.2 *Potential Pollutant Sources.* (See also Part 2.1.4) Also describe the following sources and activities that have potential pollutants associated with them: chemical, cement, mud, or gel mixing activities; drilling or mining activities; and equipment cleaning and rehabilitation activities. In addition, include information about the RQ release that triggered the permit application requirements: the nature of the release (e.g., spill of oil from a drum storage area), amount of oil or hazardous substance released, amount of substance recovered, date of the release, cause of the release (e.g., poor handling techniques and lack of containment in the area), areas affected by the release (i.e., land and water), procedure to clean up release, actions or procedures implemented to prevent or improve response to a release, and remaining potential contamination of stormwater from release (taking into account human health risks, the control of drinking water intakes, and the designated uses of the receiving water).

I.4.3 *Inspections.* (See also Part 2.1.5.5)

I.4.3.1 *Inspection Frequency.* Inspect all equipment and areas addressed in the SWPPP at least monthly. Also inspect equipment and vehicles that store, mix (including all on- and offsite mixing tanks), or transport chemicals or hazardous materials (including those transporting supplies to oil field activities) on a monthly basis.

I.4.3.2 *Temporarily or Permanently Inactive Oil and Gas Extraction Facilities.* For facilities that are remotely located and unstaffed, perform the inspections at least annually.

I.4.4 *Erosion and Sedimentation Control.* (See also Part 2.1.5.7.) Unless covered by the current Construction General Permit (CGP), the additional sediment and erosion control requirements for well drillings and sand/shale mining areas include the following:

I.4.4.1 *Site Description.* Also include a description of the nature of the exploration activity, estimates of the total area of site and area disturbed due to exploration activity, an estimate of runoff coefficient of the site, a site drainage map, including approximate slopes, and the names of all receiving waters. All erosion and sedimentation control measures must be inspected every 7 days.

I.4.4.2 *Vegetative Controls.* Describe and implement vegetative practices designed to preserve existing vegetation, where attainable, and revegetate open areas as soon as practicable after grade drilling. Consider the following (or equivalent measures): temporary or permanent seeding, mulching, sod stabilization, vegetative buffer strips, and tree protection practices. Begin implementing appropriate vegetative practices on all disturbed areas within 14 days following the last activity in that area.

I.4.5 *Contact with Waste Water Pollutants at Exploration and Production Facilities.* Take measures necessary to prevent discharge of stormwater coming into contact with waste water pollutants from any sources associated with production, field exploration, drilling, well completion, or well treatment (i.e., produced water, drilling muds, drill cuttings, and produced sand).

I.4.5.1 *Vehicle and Equipment Storage Areas.* Confine vehicles and equipment awaiting or having undergone maintenance to designated areas (as marked on the site map). Describe and implement measures to minimize contaminants from these areas (e.g., drip pans under equipment, indoor storage, use of berms or dikes, or other equivalent measures).

I.4.5.2 *Material and Chemical Storage Areas.* Maintain these areas in good condition to prevent contamination of stormwater. Plainly label all hazardous materials.

I.4.5.3 *Chemical Mixing Areas.* (See also Part 2.1.4.) Describe and implement measures that prevent or minimize contamination of stormwater runoff from chemical mixing areas.

I.5 Monitoring and Reporting Requirements. (See also Part 3 of the permit.)

Table I-1. Sector-specific Numeric Effluent Limitations and Benchmark Monitoring

Subsector (Discharges may be subject to requirements for more than one sector/subsector)	Parameter	Benchmark Monitoring Concentration[1]	Effluent Limitation Guidelines
Oil and Gas Extraction and Refining (SIC 1311, 1321, 1381-1389, 2911)	Total Suspended Solids (TSS)	100 mg/L	--
Oil Refining (SIC 2911)	Total Recoverable Lead[2]	0.082 mg/L	--
	Total Recoverable Nickel[3]	0.47 mg/L	--
	Total Recoverable Zinc[4]	0.12 mg/L	--
	Ammonia Nitrogen	19 mg/L	--
	Nitrate+Nitrite Nitrogen	0.68 mg/L	--

[1]You must monitor quarterly in the first year of your coverage for each benchmark parameter (see Part 3.2.2.1). For each parameter, no additional benchmark monitoring is required if the average of your 4 monitoring values does not exceed the benchmark (see Part 3.2.2.3). However, for each parameter there are additional requirements if the average of your four monitoring values exceeds the benchmark (see Part 3.2.2.4).

[2] The benchmark value of lead is determined as a function of hardness (in units of mg/L) in the water column. The value given in Table I-1 (i.e. 0.082 mg/L) corresponds to a hardness of 100 mg/L and should be used if you either did not analyze water hardness, other hardness data are not available, or the water hardness is less than 100 mg/L. If a laboratory analysis indicates that the water hardness is below 100 mg/L, then you should use the benchmark for 100 mg/L. If a laboratory analysis indicates that the water hardness is greater than 100 mg/L, then the following equation may be used to determine the benchmark value for lead:

$$\text{Benchmark} = (e^{[(1.273)(\ln \textit{hardness}) - 1.460]})/1000$$

Example: Laboratory analysis of your water sample indicates the hardness is 175 mg/L.

$$\begin{aligned}\text{Benchmark} &= (e^{[(1.273)(\ln 175) - 1.460]})/1000\\ &= (e^{5.1148})/1000\\ &= 166.46/1000\\ &= 0.17 \text{ mg/L}\end{aligned}$$

The following are example benchmark value for lead:

Hardness (mg/L)	Benchmark value (mg/L)
100	0.082
125	0.11
150	0.14
175	0.17
200	0.20
225	0.23
250	0.26

[3] The benchmark value of nickel is determined as a function of hardness (in units of mg/L) in the water column. The value given in Table I-1 (i.e. 0.47 mg/L) corresponds to a hardness of 100 mg/L and should be used if you either did not analyze water hardness, other hardness data are not available, or the water hardness is less than 100 mg/L. If a laboratory analysis indicates that the water hardness is below 100 mg/L, then you should use the benchmark for 100 mg/L. If a laboratory analysis indicates that the water hardness is greater than 100 mg/L, then the following equation may be used to determine the benchmark value for nickel:

$$\text{Benchmark} = (e^{[(0.8460)(\ln \textit{hardness}) + 2.255]})/1000$$

Example: Laboratory analysis of your water sample indicates the hardness is 175 mg/L.

$$\begin{aligned}\text{Benchmark} &= (e^{[(0.8460)(\ln 175) + 2.255]})/1000\\ &= (e^{6.624})/1000\\ &= 753.26/1000\\ &= 0.75 \text{ mg/L}\end{aligned}$$

The following are example benchmark values for nickel:

Hardness (mg/L)	Benchmark value (mg/L)
100	0.47
125	0.57
150	0.66
175	0.75
200	0.84
225	0.93
250	1.02

[4] The benchmark value of zinc is determined as a function of hardness (in units of mg/L) in the water column. The value given in Table I-1 (i.e. 0.12 mg/L) corresponds to a hardness of 100 mg/L and should be used if you either did not analyze water hardness, other hardness data are not available, or the water hardness is less than 100 mg/L. If a laboratory analysis indicates that the water hardness is below 100 mg/L, then you should use the benchmark for 100

mg/L. If a laboratory analysis indicates that the water hardness is greater than 100 mg/L, then the following equation may be used to determine the benchmark value for zinc:

$$\text{Benchmark} = (e^{[(0.8473)(\ln \textit{hardness}) + 0.884]})/1000$$

Example: Laboratory analysis of your water sample indicates the hardness is 175 mg/L.

$$\text{Benchmark} = (e^{[(0.8473)(\ln 175) + 0.884]})/1000$$
$$= (e^{5.26})/1000$$
$$= 192.51/1000$$
$$= 0.19 \text{ mg/L}$$

The following are example benchmark values for zinc:

Hardness (mg/L)	Benchmark value (mg/L)
100	0.12
125	0.14
150	0.17
175	0.19
200	0.22
225	0.24
250	0.26

Part 4 - Sector-Specific Requirements for Industrial Activity
Subsection J - Sector J-Mineral Mining and Dressing

J.1 Covered Stormwater Discharges.

The requirements in Subsection J apply to stormwater discharges associated with industrial activity from active and inactive mineral mining and dressing facilities as identified by the SIC Codes specified under Sector J in Table D-1 of Appendix D of the permit.

J.1.1 Covered Discharges from Inactive Facilities. All stormwater discharges.

J.1.2 *Covered Discharges from Active and Temporarily Inactive Facilities.* Only the stormwater discharges from the following areas are covered: waste rock and overburden piles if composed entirely of stormwater and not combining with mine drainage; topsoil piles; offsite haul and access roads; onsite haul and access roads constructed of waste rock or overburden if composed entirely of stormwater and not combining with mine drainage; onsite haul and access roads not constructed of waste rock or overburden, except if mine drainage is used for dust control; runoff from dams or dikes when not constructed of waste rock and no process fluids are present; runoff from dams or dikes when constructed of waste rock and no process fluids are present, if composed entirely of stormwater and not combining with mine drainage; concentration building if no contact with material piles; mill site if no contact with material piles; office or administrative building and housing if mixed with stormwater from industrial area; chemical storage area; docking facility if no excessive contact with waste product that would otherwise constitute mine drainage; explosive storage; fuel storage; vehicle and equipment maintenance area and building; parking areas (if necessary); power plant; truck wash areas if no excessive contact with waste product that would otherwise constitute mine drainage; unreclaimed, disturbed areas outside of active mining area; reclaimed areas released from reclamation bonds prior to December 17, 1990; and partially or inadequately reclaimed areas or areas not released from reclamation bonds.

J.1.3 Covered Discharges from Exploration and Development of Mineral Mining Facilities. All stormwater discharges.

J.1.4 Covered Discharges from Facilities at Mining Sites and Undergoing Reclamation. All stormwater discharges.

J.2 Industrial Activities Covered by Sector J.

Permittees under Sector J are primarily engaged in the following types of activities:

J.2.1 exploring for minerals (e.g., stone, sand, clay, chemical and fertilizer minerals, non-metallic minerals), developing mines, and the mining of minerals; and

J.2.2 mineral dressing and non-metallic mineral services, and

J.2.3 reclamation of mining sites.

J.3 Limitations on Coverage.

Most stormwater discharges subject to an existing effluent limitation guideline at 40 CFR Part 436 are not authorized by this permit. The exceptions to this limitation, which are covered by this permit, are mine dewatering discharges composed entirely of stormwater or ground water seepage from construction sand and gravel, industrial sand, and crushed stone mining facilities in Regions 1, 2, 3, 6, 8, 9, and 10.

J.3.1 *Prohibition of Stormwater Discharges.* Stormwater discharges not authorized by this permit: discharges from active mineral mining facilities that are subject to effluent limitation guidelines for the Mineral Mining and Processing Point Source Category (40 CFR Part 436).

NOTE: Discharges that come in contact with overburden or waste rock are subject to 40 CFR Part 436, providing that the discharges drain to a point source (either naturally or as a result of intentional diversion) and they combine with "mine drainage" that is otherwise regulated under the Part 440 regulations. Discharges from overburden or waste rock can be covered under this permit if they are composed entirely of stormwater, do not combine with sources of mine drainage that are subject to 40 CFR Part 440, and meet other eligibility criteria contained in Part 1.2.2.1.

J.3.2 *Prohibition of Non-Stormwater Discharges.* Not authorized by this permit: adit drainage and contaminated springs or seeps. Contaminated seeps and springs discharging from waste rock dumps that do not directly result from precipitation events are not authorized by this permit (see also the standard Limitations on Coverage in Part 1.2.3).

J.4 Definitions.

J.4.1 *Mining operation* - typically consists of three phases, any one of which individually qualifies as a "mining activity." The phases are the exploration and construction phase, the active phase, and the reclamation phase.

J.4.2 *Exploration and construction phase* - entails exploration and land disturbance activities to determine the financial viability of a site. Construction includes the building of site access roads and removal of overburden and waste rock to expose mineable minerals.

J.4.3 *Active phase* - activities including each step from extraction through production of a salable product.

J.4.4 *Reclamation phase* - activities intended to return the land to its pre-mining state.

NOTE: The following definitions are not intended to supersede the definitions of active and inactive mining facilities established by 40 CFR 122.26(b)(14)(iii).

J.4.5 *Active Mineral Mining Facility* - a place where work or other activity related to the extraction, removal, or recovery of minerals is being conducted. This definition does not include any land where grading has returned the earth to a desired contour and reclamation has begun.

J.4.6 *Inactive Mineral Mining Facility* - a site or portion of a site where mineral mining and/or dressing occurred in the past but that is not an active facility as defined above, and where the inactive portion is not covered by an active permit issued by the applicable State or Federal government agency.

J.4.7 *Temporarily Inactive Mineral Mining Facility* - a site or portion of a site where mineral mining and/or dressing occurred in the past but that is not currently being actively undertaken, and where the facility is covered by an active mining permit issued by the applicable State or Federal government agency.

J.4.8 *Final Stabilization* - a site or portion of a site is "finally stabilized" when:

a. All soil disturbing activities at the site have been completed and either of the two following criteria are met:
   i. A uniform (e.g., evenly distributed, without large bare areas) perennial vegetative cover with a density of 70 percent of the native background vegetative cover for the area has been established on all unpaved areas and areas not covered by permanent structures, or
   ii. Equivalent permanent stabilization measures (such as the use of riprap, gabions, or geotextiles) have been employed.

b. When background native vegetation will cover less than 100 percent of the ground (e.g., arid areas, beaches), the 70 percent coverage criteria is adjusted as follows: if the native vegetation covers 50 percent of the ground, 70 percent of 50 percent (0.70 x 0.50 = 0.35) would require 35 percent total cover for final stabilization. On a beach with no natural vegetation, no stabilization is required.

J.5 Clearing, Grading, and Excavation Activities.

Clearing, grading, and excavation activities being conducted as part of the exploration and development phase of a mining operation are covered under this permit.

J.5.1 *Management Practices for Clearing, Grading, and Excavation Activities.*

J.5.1.1 *Selecting and installing control measures.* A combination of sediment and erosion control measures are required to achieve maximum pollutant removal. All control measures must be properly selected, installed, and maintained in accordance with any relevant manufacturer specifications and good engineering practices.

J.5.1.2 *Removal of Sediment.* If sediment escapes the site, off-site accumulations of sediment must be removed at a frequency sufficient to minimize off-site impacts.

J.5.1.3 *Good Housekeeping.* Litter, debris, and chemicals that could be exposed to stormwater must be prevented from becoming a pollutant source in stormwater discharges.

J.5.1.4 *Velocity Dissipation.* Velocity dissipation devices must be placed at discharge locations and along the length of any outfall channel to provide a non-erosive flow velocity from disturbed areas and from any stormwater retention or detention facilities to a water course so that the natural physical and biological characteristics and functions are maintained and protected (e.g., no significant changes in the hydrological regime of the receiving water).

J.5.1.5 *Retention and Detention of Stormwater Runoff.* For drainage locations serving more than one acre, sediment basins and/or temporary sediment traps should be used. At a minimum, silt fences, vegetative buffer strips, or equivalent sediment controls are required for all down slope boundaries (and for those side slope boundaries deemed appropriate as dictated by individual site conditions) of the development area unless a sediment basin providing storage for a calculated volume of runoff from a 2-year, 24-hour storm or 3,600 cubic feet of storage per acre drained is provided.

J.5.1.6 *Temporary Stabilization of Disturbed Areas.* Stabilization measures must be initiated as soon as practicable in portions of the site where development activities have temporarily or permanently ceased, but in no case more than 14 days after the construction activity in that portion of the site has temporarily or permanently ceased. In arid, semiarid, and drought-stricken areas where initiating perennial vegetative stabilization measures is not possible within 14 days after construction activity has temporarily or permanently ceased, final vegetative stabilization measures must be initiated as soon as practicable.

J.5.2 *Requirements for Inspection of Clearing, Grading, and Excavation Activities.*

J.5.2.1 *Inspection Frequency.* Inspections must be conducted at least once every 7 calendar days or at least once every 14 calendar days and within 24 hours of the end of a storm event of 0.5 inches or greater. Inspection frequency may be reduced to at least once every month if the entire site is temporarily stabilized, if runoff is unlikely due to winter conditions (e.g., site is covered with snow, ice, or the ground is frozen), or construction is occurring during seasonal arid periods in arid areas and semi-arid areas.

J.5.2.2 *Qualified Personnel for Inspections.* Inspections must be conducted by qualified personnel. "Qualified personnel" means a person knowledgeable in the principles and practice of erosion and sediment control who possesses the skills to assess conditions at the construction site that could impact stormwater quality and the effectiveness of any sediment and erosion control measures selected to control the quality of stormwater discharges from the clearing, grading, and excavation activities.

J.5.2.3 *Location of Inspections.* Inspections must include all areas of the site disturbed by clearing, grading, and excavation activities and areas used for storage of materials that are exposed to precipitation. Sedimentation and erosion control measures identified in the SWPPP must be observed to ensure proper operation. Discharge locations must be inspected to ascertain whether erosion control measures are effective in preventing significant impacts to waters of the United States, where accessible. Where discharge locations are inaccessible, nearby downstream locations must be inspected to the extent that such inspections are practicable. Locations where vehicles enter or exit the site must be inspected for evidence of off-site sediment tracking.

J.5.2.4 *Inspection Reports.* For each inspection required above, you must complete an inspection report. At a minimum, the inspection report must include:

a. The inspection date;
b. Names, titles, and qualifications of personnel making the inspection;
c. Weather information for the period since the last inspection (or note if it is the first inspection) including a best estimate of the beginning of each storm event, duration of each storm event, approximate amount of rainfall for each storm event (in inches), and whether any discharges occurred;
d. Weather information and a description of any discharges occurring at the time of the inspection;
e. Location(s) of discharges of sediment or other pollutants from the site;
f. Location(s) of BMPs that need to be maintained;
g. Location(s) of BMPs that failed to operate as designed or proved inadequate for a particular location;
h. Location(s) where additional BMPs are needed that did not exist at the time of inspection; and
i. Corrective action(s) required, including any changes to the SWPPP necessary and implementation dates.

A record of each inspection and of any actions taken in accordance with this Part must be retained as part of the SWPPP for at least three years from the date that permit coverage expires or is terminated. The inspection reports must identify any incidents of non-compliance with the permit conditions. Where a report does not identify any incidents of non-compliance, the report must contain a certification that the clearing, grading, and excavation activities are in compliance with the SWPPP and this permit. The report must be signed in accordance with Subpart 11 of Appendix B.

J.5.3 *Maintenance of Controls for Clearing, Grading, and Excavation Activities*

J.5.3.1 *Maintenance of BMPs.* All erosion and sediment control measures and other protective measures identified in the SWPPP must be maintained in effective operating condition. If site inspections required by Section J.5.2 identify BMPs that are not operating effectively, maintenance must be performed as soon as possible and before the next storm event whenever practicable to maintain the continued effectiveness of stormwater controls.

J.5.3.2 *Modification of BMPs*. Existing BMPs need to be modified or, if additional BMPs are necessary for any reason, implementation must be completed before the next storm event whenever practicable. If implementation before the next storm event is impracticable, the situation must be documented in the SWPPP and alternative BMPs must be implemented as soon as possible.

J.5.3.3 *Maintenance of sediment traps and ponds*. Sediment from sediment traps or sedimentation ponds must be removed when design capacity has been reduced by 50 percent.

J.5.4 *Requirements for Cessation of Clearing, Grading, and Excavation Activities*. Inspections and maintenance of BMPs associated with clearing, grading, and excavation activities being conducted as part of the exploration and construction phase of a mining operation must continue until final stabilization has been achieved on all portions of the disturbed area.

J.6 Stormwater Pollution Prevention Plan (SWPPP) Requirements.

The SWPPP requirements in Part J.6 are applicable for active mineral mining facilities, inactive mining facilities, temporarily inactive mineral mining facilities, temporarily inactive mineral mining facilities, and sites undergoing reclamation. In addition to the following requirements, you must also comply with the requirements listed in Part 2 in the permit.

J.6.1 *Nature of Industrial Activities*. (See also Part 2.1.2) Briefly describe the mining and associated activities that can potentially affect the stormwater discharges covered by this permit, including a general description of the location of the site relative to major transportation routes and communities.

J.6.2 *Site Map*. (See also Part 2.1.2.) Also identify the locations of the following (as appropriate): mining or milling site boundaries; access and haul roads; outline of the drainage areas of each stormwater outfall within the facility with indications of the types of discharges from the drainage areas; location(s) of all permitted discharges covered under an individual NPDES permit, outdoor equipment storage, fueling, and maintenance areas; materials handling areas; outdoor manufacturing, outdoor storage, and material disposal areas; outdoor chemicals and explosives storage areas; overburden, materials, soils, or waste storage areas; location of mine drainage (where water leaves mine) or other process water; heap leach pads; off-site points of discharge for mine drainage and process water; surface waters; boundary of tributary areas that are subject to effluent limitations guidelines; and location(s) of reclaimed areas.

J.6.3 *Potential Pollutant Sources*. (See also Part 2.1.4) For each area of the mine or mill site where stormwater discharges associated with industrial activities occur, identify the types of pollutants (e.g., heavy metals, sediment) likely to be present in significant amounts. Consider these factors: the mineralogy of the waste rock (e.g., acid forming); toxicity and quantity of chemicals used, produced, or discharged; the likelihood of contact with stormwater; vegetation of site (if any); and history of significant leaks or spills of toxic or hazardous pollutants. Also include a summary of any existing waste rock or overburden characterization data and test results for potential generation of acid rock.

J.6.4 *Site Inspections.* (See also Part 2.1.5.5 and J.5.2.) Inspect sites at least monthly unless adverse weather conditions make the site inaccessible. Sites which discharge to waters which are designated as outstanding waters or waters which are impaired for sediment or nitrogen must be inspected monthly.

J.6.5 *Employee Training.* (See also Part 2.1.5.6) Conduct employee training at least annually at active and temporarily inactive sites. All employee training(s) must be documented in the SWPPP.

J.6.6 *Stormwater Controls.* (See also Part 2.1.5) Consider each of the following BMPs. The potential pollutants identified in Part J.6.3 shall determine the priority and appropriateness of the BMPs selected. If BMPs are implemented or planned but are not listed here (e.g., substituting a less toxic chemical for a more toxic one), include descriptions of them in your SWPPP.

J.6.6.1 *Stormwater Diversions*: Consider diverting stormwater away from potential pollutant sources. Following are some BMP options: interceptor or diversion controls (e.g., dikes, swales, curbs, or berms); pipe slope drains; subsurface drains; conveyance systems (e.g., channels or gutters, open-top box culverts, and waterbars; rolling dips and road sloping; roadway surface water deflector and culverts); or their equivalents.

J.6.6.2 *Erosion and Sedimentation Control*: (See also Part 2.1.5.7) Consider a range of erosion controls within the broad categories of: flow diversion (e.g., swales); stabilization (e.g., temporary or permanent seeding); and structural controls (e.g., sediment traps, dikes, silt fences).

J.6.6.3 *Management of Runoff*: (See also Part 2.1.5.8) Consider the potential pollutant sources given in Part J.6.3 when determining reasonable and appropriate measures for managing runoff.

J.6.6.4 *Capping*: When capping is necessary to minimize pollutant discharges in stormwater, identify the source being capped and the material used to construct the cap.

J.6.6.5 *Treatment*: If treatment of stormwater (e.g., chemical or physical systems, oil and water separators, artificial wetlands) is necessary to protect water quality, describe the type and location of treatment used. Passive and/or active treatment of stormwater runoff is encouraged. Treated runoff may be discharged as a stormwater source regulated under this permit provided the discharge is not combined with discharges subject to effluent limitation guidelines for the Mineral Mining and Processing Point Source Category (40 CFR Part 436).

J.6.6.6 *Certification of Discharge Testing*: (See also Part 2.1.4.4) Test or evaluate all outfalls covered under this permit for the presence of specific mining-related non-stormwater discharges such as seeps or adit discharges, or discharges subject to effluent limitations guidelines (e.g., 40 CFR Part 436), such as mine drainage or process water. Alternatively (if applicable), you may certify in your SWPPP that a particular discharge composed of commingled stormwater and non-stormwater is covered under a separate NPDES permit, and that permit subjects the non-stormwater portion to effluent limitations prior to any commingling. This certification must identify the non-stormwater discharges, the applicable NPDES permit(s), the effluent limitations placed on the non-stormwater discharge by the permit(s), and the points at which the limitations are applied.

J.7 Monitoring and Reporting Requirements. (See also Part 3 of the permit.)

Table J-1. Sector-specific Numeric Effluent Limitations and Benchmark Monitoring

Subsector (Discharges may be subject to requirements for more than one sector/subsector)	Parameter	Benchmark Monitoring Concentration[1]	Effluent Limitation Guidelines[2]
Mine Dewatering Activities at Construction Sand and Gravel; Industrial Sand; and Crushed Stone Mining Facilities (SIC 1422-1429, 1442, 1446)	Total Suspended Solids (TSS)	100 mg/L	25 mg/L, monthly avg.
			45 mg/L, daily maximum
	pH	--	6.0 - 9.0
Sand and Gravel Mining (SIC 1442, 1446)	Nitrate plus Nitrite Nitrogen	0.68 mg/L	--
	Total Suspended Solids (TSS)	100 mg/L	--
Dimension and Crushed Stone and Nonmetallic Minerals (except fuels) (SIC 1411, 1422-1429, 1481, 1499)	Total Suspended Solids (TSS)	100 mg/L	--
Clay, Ceramic, and Refractory Materials; Chemical and Fertilizer Mineral Mining (SIC 1455, 1459, 1474-1479)	Total Suspended Solids (TSS)	100 mg/L	--

[1]You must monitor quarterly in the first year of your coverage for each benchmark parameter (see Part 3.2.2.1). For each parameter, no additional benchmark monitoring is required if the average of your 4 monitoring values does not exceed the benchmark (see Part 3.2.2.3). However, for each parameter there are additional requirements if the average of your four monitoring values exceeds the benchmark (see Part 3.2.2.4).

[2]Monitor once per year for each monitoring year.

J.7.2 Analytic Monitoring Requirements for Discharges From Waste Rock and Overburden Piles at Active Sites, Inactive Sites, and Sites Undergoing Reclamation. For discharges from waste rock and overburden piles, perform analytic monitoring quarterly as explained in Part 3.2.1.2 of the 2005 MSGP for the parameters listed in Table J-1. The Director may also notify you that you must perform additional monitoring to accurately characterize the quality and quantity of pollutants discharged from your waste rock and overburden piles.

J.7.3 *Reporting Requirements for Storm Water Discharges From Waste Rock and Overburden Piles.* Submit monitoring results for each outfall discharging storm water from waste rock and overburden piles, or certifications in accordance with Part 3.2.4. Submit monitoring reports on DMR forms postmarked no later than 60 days after collection for each sampling event.

J.8. Termination of Permit Coverage

J.8.1 *Termination of Permit Coverage for Sites Reclaimed After December 17, 1990.* A site or a portion of a site that has been released from applicable state or federal reclamation requirements after December 17, 1990, is no longer required to maintain coverage under this permit, provided that the covered storm water discharges do not have the potential to cause or contribute to violations of state water quality standards. If the site or portion of a site reclaimed after December 17, 1990, was not subject to reclamation requirements, the site or portion of the site is no longer required to maintain coverage under this permit if the site or portion of the site has been reclaimed as defined in Part J.8.2.

J.8.2 *Termination of Permit Coverage for Sites Reclaimed Before December 17, 1990.* A site or portion of a site that was released from applicable state or federal reclamation requirements before December 17, 1990, or that was otherwise reclaimed before December 17, 1990, is no longer required to maintain coverage under this permit if the site or portion of the site has been reclaimed. A site or portion of a site is considered to have been reclaimed if storm water runoff that comes into contact with 1) raw materials, intermediate byproducts, finished products, and waste products does not have the potential to cause or contribute to violations of state water quality standards, (2) soil disturbing activities related to mining at the sites or portion of the site have been completed, (3) the site or portion of the site has been stabilized to minimize soil erosion, and (4) as appropriate depending on location, size, and the potential to contribute pollutants to storm water discharges, the site or portion of the site has been revegetated, will be amenable to natural revegetation, or will be left in a condition consistent with the post-mining land use.

Part 4 - Sector-Specific Requirements for Industrial Activity
Subsection K - Sector K-Hazardous Waste Treatment, Storage, or Disposal Facilities

K.1 Covered Stormwater Discharges.

The requirements in Subsection K apply to stormwater discharges associated with industrial activity from hazardous waste treatment, storage, or disposal facilities (TSDFs) as identified by the Activity Code HZ specified under Sector K in Table D-1 of Appendix D of the permit.

K.2 Industrial Activities Covered by Sector K.

This permit authorizes stormwater discharges associated with industrial activity from facilities that treat, store, or dispose of hazardous wastes, including those that are operating under interim status or a permit under subtitle C of RCRA.

K.3 Limitations on Coverage.

K.3.1 *Prohibition of Non-Stormwater Discharges.* (See also Part 1.2.4) The following are not authorized by this permit: leachate, gas collection condensate, drained free liquids, contaminated ground water, laboratory-derived wastewater, and contact washwater from washing truck and railcar exteriors and surface areas that have come in direct contact with solid waste at the landfill facility.

K.3.2 *Limitations on Coverage for Facilities Providing Commercial TSDF Services.* For facilities located in Region 6 (see Appendix C) coverage is limited to hazardous waste TSDFs that are self-generating (including occasionally accepting wastes from community household hazardous waste collection events as public service), handle only residential wastes, and/or only store hazardous wastes and do not treat or dispose of them. Coverage under this permit is not available to commercial waste disposal and treatment facilities located in Region 6 that dispose and treat on a commercial basis any produced hazardous wastes (i.e., not their own) as a service to commercial or industrial generators.

K.4 Definitions.

K.4.1 *Contaminated stormwater* - stormwater that comes in direct contact with landfill wastes, the waste handling and treatment areas, or landfill wastewater as defined in Part K.4.5. Some specific areas of a landfill that may produce contaminated stormwater include (but are not limited to) the open face of an active landfill with exposed waste (no cover added); the areas around wastewater treatment operations; trucks, equipment, or machinery that has been in direct contact with the waste; and waste dumping areas.

K.4.2 *Drained free liquids* - aqueous wastes drained from waste containers (e.g., drums) prior to landfilling.

K.4.3 *Land treatment facility* - a facility or part of a facility at which hazardous waste is applied onto or incorporated into the soil surface; such facilities are considered disposal facilities if the waste will remain after closure.

K.4.4 *Landfill* - an area of land or an excavation in which wastes are placed for permanent disposal, but that is not a land application or land treatment unit, surface impoundment, underground injection well, waste pile, salt dome formation, salt bed formation, underground mine, or cave as these terms are defined in 40 CFR 257.2, 258.2, and 260.10.

K.4.5 *Landfill wastewater* - as defined in 40 CFR Part 445 (Landfills Point Source Category), all wastewater associated with, or produced by, landfilling activities except for sanitary wastewater, noncontaminated stormwater, contaminated groundwater, and wastewater from recovery pumping wells. Landfill wastewater includes, but is not limited to, leachate, gas collection condensate, drained free liquids, laboratory derived wastewater, contaminated stormwater, and contact washwater from washing truck, equipment, and railcar exteriors and surface areas that have come in direct contact with solid waste at the landfill facility.

K.4.6 *Leachate* - liquid that has passed through or emerged from solid waste and contains soluble, suspended, or miscible materials removed from such waste.

K.4.7 *Noncontaminated stormwater* - stormwater that does not come into direct contact with landfill wastes, the waste handling and treatment areas, or landfill wastewater as defined in Part K.4.5. Noncontaminated stormwater includes stormwater that flows off the cap, cover, intermediate cover, daily cover, and/or final cover of the landfill.

K.4.8 *Pile* - any noncontainerized accumulation of solid, nonflowing hazardous waste that is used for treatment or storage and that is not a containment building.

K.4.9 *Surface impoundment* - a facility or part of a facility that is a natural topographic depression, human-made excavation, or diked area formed primarily of earthen materials (although it may be lined with man-made materials), which is designed to hold an accumulation of liquid wastes or wastes containing free liquids, and which is not an injection well. Examples of surface impoundments are holding, storage, settling, and aeration pits, ponds, and lagoons.

K.5 Numeric Limitations, Monitoring and Reporting Requirements. (See also Part 3 of the permit.)

Table K-1. Sector-specific Numeric Effluent Limitations and Benchmark Monitoring			
Subsector (Discharges may be subject to requirements for more than one sector/subsector)	**Parameter**	**Benchmark Monitoring Concentration[1]**	**Effluent Limitation Guidelines[2]**
ALL - Industrial Activity Code "HZ" (Note: permit coverage limited in some States)	Ammonia	19 mg/L	--
	Total Recoverable Magnesium	0.064 mg/L	--
	Chemical Oxygen Demand (COD)	120 mg/L	--
	Total Recoverable Arsenic	0.15 mg/L	--
	Total Recoverable Cadmium[3]	0.0021 mg/L	--
	Total Cyanide	0.022 mg/ L	--
	Total Recoverable Lead[4]	0.082 mg/ L	--
	Total Recoverable Mercury	0.0014 mg/ L	--
	Total Recoverable Selenium	0.005 mg/L	--
	Total Recoverable Silver[5]	0.0038 mg/ L	--
	Total Suspended Solids (TSS)	100 mg/L	--
ALL - Industrial Activity Code "HZ" Subject to the Provisions of 40 CFR Part 445, Subpart A	Biochemical Oxygen Demand (BOD_5)	--	220 mg/L, daily maximum
			56 mg/L, monthly avg. maximum
	Total Suspended Solids (TSS)	100 mg/L	88 mg/L, daily maximum
		--	27 mg/L, monthly avg. maximum
	Ammonia	--	10 mg/L, daily maximum
		--	4.9 mg/L, monthly avg. maximum
	Alpha Terpineol	--	0.042 mg/L, daily maximum

Table K-1. Sector-specific Numeric Effluent Limitations and Benchmark Monitoring			
Subsector (Discharges may be subject to requirements for more than one sector/subsector)	**Parameter**	**Benchmark Monitoring Concentration[1]**	**Effluent Limitation Guidelines[2]**
		--	0.019 mg/L, monthly avg. maximum
	Aniline	--	0.024 mg/L, daily maximum
		--	0.015 mg/L, monthly avg. maximum
	Benzoic Acid	--	0.119 mg/L, daily maximum
		--	0.073 mg/L, monthly avg. maximum
	Naphthalene	--	0.059 mg/L, daily maximum
		--	0.022 mg/L, monthly avg. maximum
	p-Cresol	--	0.024 mg/L, daily maximum
		--	0.015 mg/L, monthly avg. maximum
	Phenol	--	0.048 mg/L, daily maximum
		--	0.029 mg/L, monthly avg. maximum
	Pyridine	--	0.072 mg/L, daily maximum
		--	0.025 mg/L, monthly avg. maximum
	Total Recoverable Arsenic	0.15 mg/L	1.1 mg/L, daily maximum
		--	0.54 mg/L, monthly avg. maximum
	Total Recoverable Chromium	--	1.1 mg/L, daily maximum
		--	0.46 mg/L, monthly avg. maximum

Table K-1. Sector-specific Numeric Effluent Limitations and Benchmark Monitoring			
Subsector (Discharges may be subject to requirements for more than one sector/subsector)	**Parameter**	**Benchmark Monitoring Concentration[1]**	**Effluent Limitation Guidelines[2]**
	Total Recoverable Zinc	--	0.535 mg/L, daily maximum
		--	0.296 mg/L, monthly avg. maximum
	pH	--	Within the range of 6-9 pH units

[1]You must monitor quarterly in the first year of your coverage for each benchmark parameter (see Part 3.2.2.1). For each parameter, no additional benchmark monitoring is required if the average of your 4 monitoring values does not exceed the benchmark (see Part 3.2.2.3). However, for each parameter there are additional requirements if the average of your four monitoring values exceeds the benchmark (see Part 3.2.2.4).

[2]Monitor once per year for each monitoring year. As set forth at 40 CFR Part 445 Subpart A, these numeric limitations apply to contaminated stormwater discharges from hazardous waste landfills subject to the provisions of RCRA Subtitle C at 40 CFR Parts 264 (Subpart N) and 265 (Subpart N) except for any of the following facilities:

(a) landfills operated in conjunction with other industrial or commercial operations when the landfill receives only wastes generated by the industrial or commercial operation directly associated with the landfill;

(b) landfills operated in conjunction with other industrial or commercial operations when the landfill receives wastes generated by the industrial or commercial operation directly associated with the landfill and also receives other wastes, provided that the other wastes received for disposal are generated by a facility that is subject to the same provisions in 40 CFR Subchapter N as the industrial or commercial operation or that the other wastes received are of similar nature to the wastes generated by the industrial or commercial operation;

(c) landfills operated in conjunction with Centralized Waste Treatment (CWT) facilities subject to 40 CFR Part 437, so long as the CWT facility commingles the landfill wastewater with other non-landfill wastewater for discharge. A landfill directly associated with a CWT facility is subject to this part if the CWT facility discharges landfill wastewater separately from other CWT wastewater or commingles the wastewater from its landfill only with wastewater from other landfills; or

(d) landfills operated in conjunction with other industrial or commercial operations when the landfill receives wastes from public service activities, so long as the company owning the landfill does not receive a fee or other remuneration for the disposal service.

[3] The benchmark value of cadmium is determined as a function of hardness (in units of mg/L) in the water column. The value given in Table K-1 (i.e. 0.0021 mg/L) corresponds to a hardness of 100 mg/L and should be used if you either did not analyze water hardness, other hardness data are not available, or the water hardness is less than 100 mg/L. If a laboratory analysis indicates that the water hardness is below 100 mg/L, then you should use the benchmark for 100 mg/L. If a laboratory analysis indicates that the water hardness is greater than 100 mg/L, then the following equation may be used to determine the benchmark value for cadmium:

$$\text{Benchmark} = (e^{[(1.0166)(\ln \textit{hardness}) - 3.924]})/1000$$

Example: Laboratory analysis of your water sample indicates the hardness is 175 mg/L.

$$\text{Benchmark} = (e^{[(1.0166)(\ln 175) - 3.924]})/1000$$
$$= (e^{1.327})/1000$$
$$= 3.76/1000$$
$$= 0.0038 \text{ mg/L}$$

The following are example benchmark values for cadmium:

Hardness (mg/L)	Benchmark value (mg/L)
100	0.0021
125	0.0027
150	0.0032
175	0.0038
200	0.0043
225	0.0049
250	0.0054

[4] The benchmark value of lead is determined as a function of hardness (in units of mg/L) in the water column. The value given in Table K-1 (i.e. 0.082 mg/L) corresponds to a hardness of 100 mg/L and should be used if you either did not analyze water hardness, other hardness data are not available, or the water hardness is less than 100 mg/L. If a laboratory analysis indicates that the water hardness is below 100 mg/L, then you should use the benchmark for 100 mg/L. If a laboratory analysis indicates that the water hardness is greater than 100 mg/L, then the following equation may be used to determine the benchmark value for lead:

$$\text{Benchmark} = (e^{[(1.273)(\ln \textit{hardness}) - 1.460]})/1000$$

Example: Laboratory analysis of your water sample indicates the hardness is 175 mg/L.

$$\text{Benchmark} = (e^{[(1.273)(\ln 175) - 1.460]})/1000$$
$$= (e^{5.1148})/1000$$
$$= 166.46/1000$$
$$= 0.17 \text{ mg/L}$$

The following are example benchmark value for lead:

Hardness (mg/L)	Benchmark value (mg/L)
100	0.082
125	0.11
150	0.14
175	0.17
200	0.20
225	0.23
250	0.26

[5] The benchmark limitation value of silver is determined as a function of hardness (in units of mg/L) in the water column. The value given in Table K-1 (i.e. 0.0038 mg/L) corresponds to a hardness of 100 mg/L and should be used if you either did not analyze water hardness, other hardness data are not available, or the water hardness is less than 100 mg/L. If a laboratory analysis indicates that the water hardness is below 100 mg/L, then you should use the benchmark for 100 mg/L. If a laboratory analysis indicates that the water hardness is greater than 100 mg/L, then the following equation may be used to determine the benchmark value for silver:

$$\text{Benchmark} = (e^{[(1.72)(\ln \textit{hardness}) - 6.59]})/1000$$

Example: Laboratory analysis of your water sample indicates the hardness is 175 mg/L.

$$\begin{aligned}\text{Benchmark} &= (e^{[(1.72)(\ln 175) - 6.59]})/1000 \\ &= (e^{2.293})/1000 \\ &= 9.909/1000 \\ &= 0.0099 \text{ mg/L}\end{aligned}$$

The following are example benchmark values for silver:

Hardness (mg/L)	Benchmark value (mg/L)
100	0.0038
125	0.0056
150	0.0076
175	0.0099
200	0.013
225	0.015
250	0.018

Part 4 - Sector-Specific Requirements for Industrial Activity
Subsection L - Sector L-Landfills, Land Application Sites, and Open Dumps.

L.1 Covered Stormwater Discharges.

The requirements in Subsection L apply to stormwater discharges associated with industrial activity from landfills and land application sites and open dumps as identified by the Activity Code specified under Sector L in Table D-1 of Appendix D of the permit.

L.2 Industrial Activities Covered by Sector L.

This permit may authorize stormwater discharges for Sector L facilities associated with waste disposal at landfills, land application sites, and open dumps that receive or have received industrial waste, including sites subject to regulation under Subtitle D of RCRA.

L.3 Limitations on Coverage.

L.3.1 *Prohibition of Non-Stormwater Discharges.* (See also Part 1.2.4) The following are not authorized by this permit: leachate, gas collection condensate, drained free liquids, contaminated ground water, laboratory wastewater, and contact washwater from washing truck and railcar exteriors and surface areas that have come in direct contact with solid waste at the landfill facility.

L.4 Definitions.

L.4.1 *Contaminated stormwater* - stormwater that comes in direct contact with landfill wastes, the waste handling and treatment areas, or landfill wastewater. Some areas of a landfill that may produce contaminated stormwater include (but are not limited to) the open face of an active landfill with exposed waste (no cover added); the areas around wastewater treatment operations; trucks, equipment, or machinery that has been in direct contact with the waste; and waste dumping areas.

L.4.2 *Drained free liquids* - aqueous wastes drained from waste containers (e.g., drums) prior to landfilling.

L.4.3 *Landfill wastewater* - as defined in 40 CFR Part 445 (Landfills Point Source Category) all wastewater associated with, or produced by, landfilling activities except for sanitary wastewater, non-contaminated stormwater, contaminated groundwater, and wastewater from recovery pumping wells. Landfill process wastewater includes, but is not limited to, leachate; gas collection condensate; drained free liquids; laboratory-derived wastewater; contaminated stormwater; and contact washwater from washing truck, equipment, and railcar exteriors and surface areas that have come in direct contact with solid waste at the landfill facility.

L.4.4 *Leachate* - liquid that has passed through or emerged from solid waste and contains soluble, suspended, or miscible materials removed from such waste.

L.4.5 *Non-contaminated stormwater* - stormwater that does not come in direct contact with landfill wastes, the waste handling and treatment areas, or landfill wastewater. Non-contaminated stormwater includes stormwater that flows off the cap, cover, intermediate cover, daily cover, and/or final cover of the landfill.

L.5 Stormwater Pollution Prevention Plan (SWPPP) Requirements.

In addition to the following requirements, you must also comply with the requirements listed in Part 2 of the permit.

L.5.1 *Drainage Area Site Map.* (See also Part 2.1.2) Identify where any of the following may be exposed to precipitation or surface runoff: active and closed landfill cells or trenches, active and closed land application areas, locations where open dumping is occurring or has occurred, locations of any known leachate springs or other areas where uncontrolled leachate may commingle with runoff, and leachate collection and handling systems.

L.5.2 *Summary of Potential Pollutant Sources.* (See also Part 2.1.4) Describe the following sources and activities that have potential pollutants associated with them: fertilizer, herbicide, and pesticide application; earth and soil moving; waste hauling and loading or unloading; outdoor storage of significant materials, including daily, interim, and final cover material stockpiles as well as temporary waste storage areas; exposure of active and inactive landfill and land application areas; uncontrolled leachate flows; and failure or leaks from leachate collection and treatment systems.

L.5.3 *Good Housekeeping Measures.* (See also Part 2.1.5.1) As part of your good housekeeping program, consider providing protected storage areas for pesticides, herbicides, fertilizer, and other significant materials.

L.5.4 *Preventive Maintenance Program.* (See also Part 2.1.5.3) As part of your preventive maintenance program, maintain the following: all containers used for outdoor chemical and significant materials storage, to prevent leaking; all elements of leachate collection and treatment systems, to prevent commingling of leachate with stormwater; the integrity and effectiveness of any intermediate or final cover (including repairing the cover as necessary), to minimize the effects of settlement, sinking, and erosion.

L.5.5 *Inspections.* (See also Part 2.1.5.5)

L.5.5.1 *Inspections of Active Sites.* Inspect operating landfills, open dumps, and land application sites at least once every 7 days. Focus on areas of landfills that have not yet been finally stabilized; active land application areas, areas used for storage of material and wastes that are exposed to precipitation, stabilization, and structural control measures; leachate collection and treatment systems; and locations where equipment and waste trucks enter and exit the site. Ensure that sediment and erosion control measures are operating properly. For stabilized sites and areas where land application has been completed, or where the climate is seasonally arid (annual rainfall averages from 0 to 10 inches) or semi-arid (annual rainfall averages from 10 to 20 inches), conduct inspections at least once every month.

L.5.5.2 *Inspections of Inactive Sites.* Inspect inactive landfills, open dumps, and land application sites at least monthly. Qualified personnel must inspect landfill (or open dump) stabilization and structural erosion control measures, leachate collection and treatment systems, and all closed land application areas.

L.5.6 *Recordkeeping and Internal Reporting.* Implement a tracking system for the types of wastes disposed of in each cell or trench of a landfill or open dump. For land application sites, track the types and quantities of wastes applied in specific areas.

L.5.7 *Non-Stormwater Discharge Test Certification.* (See also Part 2.1.4.4) The discharge test and certification must also be conducted for the presence of leachate and vehicle washwater.

L.5.8 *Erosion and Sedimentation Control.* (See also Part 2.1.5.7) Provide temporary stabilization (e.g., temporary seeding, mulching, and placing geotextiles on the inactive portions of stockpiles) for the following: materials stockpiled for daily, intermediate, and final cover; inactive areas of the landfill or open dump; landfills or open dump areas that have gotten final covers but where vegetation has yet to establish itself; and land application sites where waste application has been completed but final vegetation has not yet been established.

L.5.9 *Comprehensive Site Compliance Evaluation.* (See also Part 3.1) Evaluate areas contributing to a stormwater discharge associated with industrial activities at landfills, open dumps, and land application sites for evidence of, or the potential for, pollutants entering the drainage system.

L.6 Numeric Limitations, Monitoring and Reporting Requirements. (See also Part 3 of the permit.)

Table L-1. Sector-specific Numeric Effluent Limitations and Benchmark Monitoring			
Subsector (Discharges may be subject to requirements for more than one sector/subsector)	**Parameter**	**Benchmark Monitoring Concentration[1]**	**Effluent Limitation Guidelines[2]**
All Landfill, Land Application Sites and Open Dumps (Industrial Activity Code "LF")	Total Suspended Solids (TSS)	100 mg/L	--
All Landfill, Land Application Sites and Open Dumps, except Municipal Solid Waste Landfill (MSWLF) Areas Closed in Accordance with 40 CFR 258.60 (Industrial Activity Code "LF")	Total Recoverable Iron	1.0 mg/L	--
All Landfills Subject to the Requirements of 40 CFR Part 445 Subpart B (Industrial Activity Code "LF").	Biochemical Oxygen Demand (BOD_5)	--	140 mg/L, daily maximum
			37 mg/L, monthly avg. maximum
	Total Suspended Solids (TSS)	--	88 mg/L, daily maximum
			27 mg/L, monthly avg. maximum
	Ammonia	--	10 mg/L, daily maximum
			4.9 mg/L, monthly avg. maximum
	Alpha Terpineol	--	0.033 mg/L, daily maximum
			0.016 mg/L monthly avg. maximum
	Benzoic Acid	--	0.12 mg/L, daily maximum

Table L-1. Sector-specific Numeric Effluent Limitations and Benchmark Monitoring			
Subsector (Discharges may be subject to requirements for more than one sector/subsector)	**Parameter**	**Benchmark Monitoring Concentration[1]**	**Effluent Limitation Guidelines[2]**
			0.071 mg/L, monthly avg. maximum
	p-Cresol	--	0.025 mg/L, daily maximum
			0.014 mg/L, monthly avg. maximum
	Phenol	--	0.026 mg/L, daily maximum
			0.015 mg/L, monthly avg. maximum
	Total Recoverable Zinc	--	0.20 mg/L, daily maximum
			0.11 mg/L, monthly avg. maximum
	pH	--	Within the range of 6-9 pH units

[1]You must monitor quarterly in the first year of your coverage for each benchmark parameter (see Part 3.2.2.1). For each parameter, no additional benchmark monitoring is required if the average of your 4 monitoring values does not exceed the benchmark (see Part 3.2.2.3). However, for each parameter there are additional requirements if the average of your four monitoring values exceeds the benchmark (see Part 3.2.2.4).

[2] Monitor once per year for each monitoring year. As set forth at 40 CFR Part 445 Subpart B, these numeric limitations apply to contaminated stormwater discharges from MSWLFs that have not been closed in accordance with 40 CFR 258.60, and to contaminated stormwater discharges from those landfills that are subject to the provisions of 40 CFR Part 257 except for discharges from any of the following facilities:

(a) landfills operated in conjunction with other industrial or commercial operations, when the landfill receives only wastes generated by the industrial or commercial operation directly associated with the landfill;

(b) landfills operated in conjunction with other industrial or commercial operations, when the landfill receives wastes generated by the industrial or commercial operation directly associated with the landfill and also receives other wastes, provided that the other wastes received for disposal are generated by a facility that is subject to the same provisions in 40 CFR Subchapter N as the industrial or commercial operation, or that the other wastes received are of similar nature to the wastes generated by the industrial or commercial operation;

(c) landfills operated in conjunction with CWT facilities subject to 40 CFR Part 437, so long as the CWT facility commingles the landfill wastewater with other non-landfill wastewater for discharge. A landfill directly associated with a CWT facility is subject to this part if the CWT facility discharges landfill wastewater separately from other CWT wastewater or commingles the wastewater from its landfill only with wastewater from other landfills; or

(d) landfills operated in conjunction with other industrial or commercial operations when the landfill receives wastes from public service activities, so long as the company owning the landfill does not receive a fee or other remuneration for the disposal service.

Part 4 - Sector-Specific Requirements for Industrial Activity
Subsection M - Sector M-Automobile Salvage Yards

M.1 Covered Stormwater Discharges.

The requirements in Subsection M apply to stormwater discharges associated with industrial activity from automobile salvage yards as identified by the Activity Code specified under Sector M in Table D-1 of Appendix D of this permit.

M.2 Industrial Activities Covered by Sector M.

The types of activities that permittees under Sector M are primarily engaged in are dismantling or wrecking used motor vehicles for parts recycling or resale and for scrap.

M.3 Stormwater Pollution Prevention Plan (SWPPP) Requirements.

In addition to the following requirements, you must also comply with the requirements listed in Part 2.

M.3.1 *Drainage Area Site Map.* (See also Part 2.1.2) Indicate the location of each monitoring point and estimate the total acreage used for industrial activity including, but not limited to, dismantling, storage, and maintenance of used motor vehicle parts. Also identify where any of the following may be exposed to precipitation or surface runoff: dismantling areas, parts (e.g., engine blocks, tires, hub caps, batteries, hoods, mufflers) storage areas, and liquid storage tanks and drums for fuel and other fluids.

M.3.2 *Potential Pollutant Sources.* (See also Part 2.1.4) Assess the potential for the following to contribute pollutants to stormwater discharges: vehicle storage areas, dismantling areas, parts storage areas (e.g., engine blocks, tires, hub caps, batteries, hoods, mufflers), and fueling stations.

M.3.3 *Spill and Leak Prevention Procedures.* (See also Part 2.1.4.3) Drain vehicles intended to be dismantled of all fluids upon arrival at the site (or as soon thereafter as feasible), or employ some other equivalent means to prevent spills and leaks.

M.3.4 *Inspections.* (See also Part 2.1.5.5) Immediately (or as soon thereafter as feasible) inspect vehicles arriving at the site for leaks. Inspect monthly, for signs of leakage, all equipment containing oily parts, hydraulic fluids, any other types of fluids, or mercury switches. Also inspect monthly, for signs of leakage, all vessels and areas where hazardous materials and general automotive fluids are stored, including, but not limited to, mercury switches, brake fluid, transmission fluid, radiator water, and antifreeze.

M.3.5 *Employee Training.* (See also Part 2.1.5.6) If applicable to your facility, address the following areas (at a minimum) in your employee training program: proper handling (collection, storage, and disposal) of oil, used mineral spirits, anti-freeze, mercury switches, and solvents.

M.3.6 *Management of Runoff.* (See also Part 2.1.5.8) Consider the following management practices: berms or drainage ditches on the property line (to help prevent run-on from neighboring properties); berms for uncovered outdoor storage of oily parts, engine blocks, and above-ground liquid storage; installation of detention ponds; and installation of filtering devices and oil and water separators.

M.4 Monitoring and Reporting Requirements. (See also Part 3 of the permit.)

Table M-1. Sector-specific Numeric Limitations and Benchmark Monitoring

Subsector (Discharges may be subject to requirements for more than one sector/subsector)	Parameter	Benchmark Monitoring Concentration[1]	Effluent Limitation Guidelines
Automobile Salvage Yards (SIC 5015)	Total Suspended Solids (TSS)	100 mg/L	--
	Total Recoverable Aluminum	0.75 mg/L	--
	Total Recoverable Iron	1.0 mg/L	--
	Total Recoverable Lead[2]	0.082 mg/L	--

[1]You must monitor quarterly in the first year of your coverage for each benchmark parameter (see Part 3.2.2.1). For each parameter, no additional benchmark monitoring is required if the average of your 4 monitoring values does not exceed the benchmark (see Part 3.2.2.3). However, for each parameter there are additional requirements if the average of your four monitoring values exceeds the benchmark (see Part 3.2.2.4).

[2] The benchmark value of lead is determined as a function of hardness (in units of mg/L) in the water column. The value given in Table M-1 (i.e. 0.082 mg/L) corresponds to a hardness of 100 mg/L and should be used if you either did not analyze water hardness, other hardness data are not available, or the water hardness is less than 100 mg/L. If a laboratory analysis indicates that the water hardness is below 100 mg/L, then you should use the benchmark for 100 mg/L. If a laboratory analysis indicates that the water hardness is greater than 100 mg/L, then the following equation may be used to determine the benchmark value for lead:

$$\text{Benchmark} = (e^{[(1.273)(\ln hardness) - 1.460]})/1000$$

Example: Laboratory analysis of your water sample indicates the hardness is 175 mg/L.

$$\text{Benchmark} = (e^{[(1.273)(\ln 175) - 1.460]})/1000$$
$$= (e^{5.1148})/1000$$
$$= 166.46/1000$$
$$= 0.17 \text{ mg/L}$$

The following are example benchmark value for lead:

Hardness (mg/L)	Benchmark value (mg/L)
100	0.082
125	0.11
150	0.14
175	0.17
200	0.20
225	0.23
250	0.26

Part 4 - Sector-Specific Requirements for Industrial Activity
Subsection N - Sector N-Scrap Recycling and Waste Recycling Facilities.

N.1 Covered Stormwater Discharges.

The requirements in Subsection N apply to stormwater discharges associated with industrial activity from scrap recycling and waste recycling facilities as identified by the SIC Codes specified under Sector N in Table D-1 of Appendix D of the permit.

N.2 Industrial Activities Covered by Sector N.

Permittees under Sector N are primarily engaged in the following types of activities:

N.2.1 processing, reclaiming, and wholesale distribution of scrap and waste materials, such as ferrous and nonferrous metals, paper, plastic, cardboard, glass, and animal hides; and

N.2.2 reclaiming and recycling of liquid wastes, such as used oil, antifreeze, mineral spirits, and industrial solvents.

N.3 Limitation on Coverage.

Separate permit requirements have been established for recycling facilities that only receive source-separated recyclable materials primarily from non-industrial and residential sources (i.e., common consumer products including paper, newspaper, glass, cardboard, plastic containers, and aluminum and tin cans). This includes recycling facilities commonly referred to as material recovery facilities (MRF).

N.3.1 *Prohibition of Non-Stormwater Discharges.* (See also Part 1.2.4) Non-stormwater discharges from turnings containment areas are not covered by this permit (see also Part N.4.2.3). Discharges from containment areas in the absence of a storm event are prohibited unless covered by a separate NPDES permit.

N.4 Stormwater Pollution Prevention Plan (SWPPP) Requirements.

In addition to the following requirements, you must also comply with the requirements listed in Part 2 of the MSGP. Part N.4.1 contains a requirement that applies to all recycling facilities and is followed by Parts N.4.2 to N.4.4.4, which have requirements for specific types of recycling facilities. Implement and describe in your SWPPP a program to address those items that apply. Included are lists of BMP options that, along with any functional equivalents, should be considered for implementation. Selection or deselection of a particular BMP or approach is up to the best professional judgment (BPJ) of the operator, as long as the objective of the requirement is met.

N.4.1 *Drainage Area Site Map.* (See also Part 2.1.2) Identify the locations of any of the following activities or sources that may be exposed to precipitation or surface runoff:

scrap and waste material storage, outdoor scrap and waste processing equipment; and containment areas for turnings exposed to cutting fluids.

N.4.2 *Scrap and Waste Recycling Facilities (Non-Source Separated, Nonliquid Recyclable Materials).* Requirements for facilities that receive, process, and do wholesale distribution of nonliquid recyclable wastes (e.g., ferrous and nonferrous metals, plastics, glass, cardboard, and paper). These facilities may receive both nonrecyclable and recyclable materials. This section is not intended for those facilities that accept recyclables only from primarily nonindustrial and residential sources.

N.4.2.1 *Inbound Recyclable and Waste Material Control Program.* Minimize the chance of accepting materials that could be significant sources of pollutants by conducting inspections of inbound recyclables and waste materials. Following are some BMP options: (a) provide information and education to suppliers of scrap and recyclable waste materials on draining and properly disposing of residual fluids (e.g., from vehicles and equipment engines, radiators and transmissions, oil filled transformers, and individual containers or drums) and removal of mercury switches before delivery to your facility; (b) establish procedures to minimize the potential of any residual fluids from coming into contact with precipitation or runoff; (c) establish procedures for accepting scrap lead-acid batteries (additional requirements for the handling, storage, and disposal or recycling of batteries are contained in the scrap lead-acid battery program provisions in N.4.2.6); (d) provide training targeted for those personnel engaged in the inspection and acceptance of inbound recyclable materials; and (e) establish procedures to ensure that liquid wastes, including used oil, are stored in materially compatible and non-leaking containers and are disposed of or recycled in accordance with RCRA.

N.4.2.2 *Scrap and Waste Material Stockpiles and Storage (Outdoor).* Minimize contact of stormwater runoff with stockpiled materials, processed materials, and nonrecyclable wastes. Following are some BMP options: (a) permanent or semi-permanent covers; (b) sediment traps, vegetated swales and strips, catch basin filters, and sand filters to facilitate settling or filtering of pollutants; (c) dikes, berms, containment trenches, culverts, and surface grading to divert runoff from storage areas; (d) silt fencing; and (e) oil and water separators, sumps, and dry absorbents for areas where potential sources of residual fluids are stockpiled (e.g., automobile engine storage areas).

N.4.2.3 *Stockpiling of Turnings Exposed to Cutting Fluids (Outdoor Storage).* Minimize contact of surface runoff with residual cutting fluids. Following are two BMP options that can be used singularly or in combination: (a) store all turnings exposed to cutting fluids under some form of permanent or semi-permanent cover. Stormwater discharges from these areas are permitted, provided the runoff is first treated by an oil and water separator or its equivalent. Identify procedures to collect, handle, and dispose of or recycle residual fluids that may be present; (b) establish dedicated containment areas for all turnings that have been exposed to cutting fluids. Stormwater runoff from these areas can be discharged, provided that the containment areas are constructed of concrete, asphalt, or other equivalent types of impermeable material; there is a barrier around the perimeter of the containment areas (e.g., berms, curbing, elevated pads) to prevent contact with stormwater runon; there is a drainage collection system for runoff generated from containment areas; you have a schedule to maintain the oil and water separator (or its equivalent); and you identify procedures for properly disposing of or recycling collected residual fluids.

N.4.2.4 *Scrap and Waste Material Stockpiles and Storage (Covered or Indoor Storage).* Minimize contact of residual liquids and particulate matter from materials stored indoors or under cover with surface runoff. Following are some BMP options: (a) good housekeeping measures, including the use of dry absorbents or wet vacuuming to contain, dispose of, or recycle residual liquids originating from recyclable containers, or mercury spill kits for spills from storage of mercury switches; (b) not allowing washwater from tipping floors or other processing areas to discharge to the storm sewer system; and (c) disconnecting or sealing off all floor drains connected to the storm sewer system.

N.4.2.5 *Scrap and Recyclable Waste Processing Areas.* Minimize surface runoff from coming in contact with scrap processing equipment. Pay attention to operations that generate visible amounts of particulate residue (e.g., shredding) to minimize the contact of accumulated particulate matter and residual fluids with runoff (i.e., through good housekeeping, preventive maintenance, etc.). Following are some BMP options: (a) regularly inspect equipment for spills or leaks and malfunctioning, worn, or corroded parts or equipment; (b) establish a preventive maintenance program for processing equipment; (c) remove mercury switches from the hood and trunk lighting units, and remove anti-lock brake system units containing mercury switches (d) use dry-absorbents or other cleanup practices to collect and dispose of or recycle spilled or leaking fluids or use mercury spill kits for spills from storage of mercury switches; and (e) on unattended hydraulic reservoirs over 150 gallons in capacity, install protection devices such as low-level alarms or equivalent devices, or secondary containment that can hold the entire volume of the reservoir; (f) containment or diversion structures such as dikes, berms, culverts, trenches, elevated concrete pads, and grading to minimize contact of stormwater runoff with outdoor processing equipment or stored materials; (g) oil and water separators or sumps; (h) permanent or semi-permanent covers in processing areas where there are residual fluids and grease; (i) retention or detention ponds or basins; sediment traps, and vegetated swales or strips (for pollutant settling and filtration); and (j) catch basin filters or sand filters.

N.4.2.6 *Scrap Lead-Acid Battery Program.* Properly handle, store, and dispose of scrap lead-acid batteries. Following are some BMP options (a) segregate scrap lead-acid batteries from other scrap materials; (b) properly handle, store, and dispose of cracked or broken batteries; (c) collect and dispose of leaking lead-acid battery fluid; (d) minimize or eliminate (if possible) exposure of scrap lead-acid batteries to precipitation or runoff; and (e) provide employee training for the management of scrap batteries.

N.4.2.7 *Spill Prevention and Response Procedures.* (See also Part 2.1.5.4) Minimize stormwater contamination at loading and unloading areas, and from equipment or container failures. Following are some BMP options (a) prevention and response measures for areas that are potential sources of fluid leaks or spills and (b) immediate containment and clean up of spills and leaks. If malfunctioning equipment is responsible for the spill or leak, repairs also should be conducted as soon as possible; (c) cleanup measures, including the use of dry absorbents. If this method is employed, an adequate supply of dry absorbent materials should be kept onsite, and used absorbent must be properly disposed of; (d) store drums containing liquids — especially oil and lubricants — indoors, in a bermed area, in overpack containers or spill pallets, or in other containment devices; (e) install overfill prevention devices on fuel pumps or tanks; and (f) place drip pans or equivalent measures under leaking stationary equipment until the leak is repaired. The drip pans should be inspected for leaks and potential overflow, and all liquids must be properly disposed of (as per RCRA); and (g) install alarms and/or pump shutoff systems on outdoor equipment with hydraulic reservoirs exceeding 150 gallons in the event of a line break. Alternatively, a secondary containment system capable of holding the entire contents of the reservoir plus room for precipitation can be used. Use a mercury spill kit for any release of mercury from switches, anti-lock brake systems, and switch storage areas.

N.4.2.8 *Inspections.* (See also Part 2.1.5.5) Inspect all designated areas of the facility and equipment identified in the plan monthly.

N.4.2.9 *Supplier Notification Program.* As appropriate, notify major suppliers which scrap materials will not be accepted at the facility or will be accepted only under certain conditions.

N.4.3 Waste Recycling Facilities (Liquid Recyclable Materials).

N.4.3.1 *Waste Material Storage (Indoor).* Minimize or eliminate contact between residual liquids from waste materials stored indoors and from surface runoff. The plan may refer to applicable portions of other existing plans, such as Spill Prevention, Containment, and Countermeasure (SPCC) plans required under 40 CFR Part 112. Following are some BMP options (a) procedures for material handling (including labeling and marking); (b) clean up spills and leaks with dry absorbent materials, a wet vacuum system, or a mercury spill kit (never vacuum spilled or leaking mercury); (c) appropriate containment structures (trenching, curbing, gutters, etc.); and (d) a drainage system, including appurtenances (e.g., pumps or ejectors, manually operated valves), to handle discharges from diked or bermed areas. Drainage should be discharged to an appropriate treatment facility or sanitary sewer system, or otherwise disposed of properly. These discharges may require coverage under a separate NPDES wastewater permit or industrial user permit under the pretreatment program.

N.4.3.2 *Waste Material Storage (Outdoor).* Minimize contact between stored residual liquids and precipitation or runoff. The plan may refer to applicable portions of other existing plans, such as SPCC plans required under 40 CFR Part 112. Discharges of precipitation from containment areas containing used oil must also be in accordance with applicable sections of 40 CFR Part 112. Following are some BMP options (a) appropriate containment structures (e.g., dikes, berms, curbing, pits) to store the volume of the largest tank, with sufficient extra capacity for precipitation; (b) drainage control and other diversionary structures; (c) corrosion protection and/or leak detection systems for storage tanks; and (d) dry-absorbent materials or a wet vacuum system to collect spills.

N.4.3.3 *Trucks and Rail Car Waste Transfer Areas.* Minimize pollutants in discharges from truck and rail car loading and unloading areas. Include measures to clean up minor spills and leaks resulting from the transfer of liquid wastes. Following are two BMP options (a) containment and diversionary structures to minimize contact with precipitation or runoff, and (b) dry clean-up methods, wet vacuuming, roof coverings, or runoff controls.

N.4.3.4 *Inspections.* (See also Part 2.1.5.5) The inspections must be performed monthly and include, at a minimum, all areas where waste is generated, received, stored, treated, or disposed of and that are exposed to either precipitation or stormwater runoff.

N.4.4 *Recycling Facilities (Source-Separated Materials).* The following identifies considerations for facilities that receive only source-separated recyclables, primarily from nonindustrial and residential sources.

N.4.4.1 *Inbound Recyclable Material Control.* Minimize the chance of accepting nonrecyclables (e.g., hazardous materials) that could be a significant source of pollutants by conducting inspections of inbound materials. Following are some BMP options (a) providing information and education measures to inform suppliers of recyclables which materials are acceptable and which are not, (b) training drivers responsible for pickup of recycled material, (c) clearly marking public drop-off containers regarding which materials can be accepted, (d) rejecting nonrecyclable wastes or household hazardous wastes at the source, and (e) establishing procedures for handling and disposal of nonrecyclable material.

N.4.4.2 *Outdoor Storage.* Minimize exposure of recyclables to precipitation and runoff. Use good housekeeping measures to prevent accumulation of particulate matter and fluids, particularly in high traffic areas. Following are some BMP options (a) provide totally enclosed drop-off containers for the public; (b) install a sump and pump with each container pit and treat or discharge collected fluids to a sanitary sewer system; (c) provide dikes and curbs for secondary containment (e.g., around bales of recyclable waste paper); (d) divert surface water runoff away from outside material storage areas; (e) provide covers over containment bins, dumpsters, and roll-off boxes; and (f) store the equivalent of one day's volume of recyclable material indoors.

N.4.4.3 *Indoor Storage and Material Processing.* Minimize the release of pollutants from indoor storage and processing areas. Following are some BMP options (a) schedule routine good housekeeping measures for all storage and processing areas, (b) prohibit tipping floor washwater from draining to the storm sewer system, and (c) provide employee training on pollution prevention practices.

N.4.4.4 *Vehicle and Equipment Maintenance.* Following are some BMP options for areas where vehicle and equipment maintenance occur outdoors (a) prohibit vehicle and equipment washwater from discharging to the storm sewer system, (b) minimize or eliminate outdoor maintenance areas whenever possible, (c) establish spill prevention and clean-up procedures in fueling areas, (d) avoid topping off fuel tanks, (e) divert runoff from fueling areas, (f) store lubricants and hydraulic fluids indoors, and (g) provide employee training on proper handling and storage of hydraulic fluids and lubricants.

N.5 Monitoring and Reporting Requirements. (See also Part 3 of the permit.)

Table N-1. Sector-specific Numeric Effluent Limitations and Benchmark Monitoring

Subsector (Discharges may be subject to requirements for more than one sector/subsector)	Parameter	Benchmark Monitoring Concentration[1]	Effluent Limitation Guidelines
Scrap Recycling Facility (SIC 5093)	Chemical Oxygen Demand (COD)	120 mg/L	--
	Total Suspended Solids (TSS)	100 mg/L	--
	Total Recoverable Aluminum	0.75 mg/L	--
	Total Recoverable Copper[2]	0.014 mg/L	--
	Total Recoverable Iron	1.0 mg/L	--
	Total Recoverable Lead[3]	0.082 mg/L	--
	Total Recoverable Zinc[4]	0.12 mg/L	--

[1]You must monitor quarterly in the first year of your coverage for each benchmark parameter (see Part 3.2.2.1). For each parameter, no additional benchmark monitoring is required if the average of your 4 monitoring values does not exceed the benchmark (see Part 3.2.2.3). However, for each parameter there are additional requirements if the average of your four monitoring values exceeds the benchmark (see Part 3.2.2.4).

[2] The benchmark value of copper is determined as a function of hardness (in units of mg/L) in the water column. The value given in Table N-1 (i.e. 0.014 mg/L) corresponds to a hardness of 100 mg/L and should be used if you either did not analyze water hardness, other hardness data are not available, or the water hardness is less than 100

mg/L. If a laboratory analysis indicates that the water hardness is below 100 mg/L, then you should use the benchmark for 100 mg/L. If a laboratory analysis indicates that the water hardness is greater than 100 mg/L, then the following equation may be used to determine the benchmark value for copper:

$$\text{Benchmark} = (e^{[(0.9422)(\ln \textit{hardness}) - 1.700]})/1000$$

Example: Laboratory analysis of your water sample indicates the hardness is 175 mg/L.

$$\begin{aligned}\text{Benchmark} &= (e^{[(0.9422)(\ln 175) - 1.700]})/1000\\ &= (e^{3.166})/1000\\ &= 23.72/1000\\ &= 0.024 \text{ mg/L}\end{aligned}$$

The following are example benchmark values for copper:

Hardness (mg/L)	Benchmark value (mg/L)
100	0.014
125	0.017
150	0.021
175	0.024
200	0.027
225	0.030
250	0.033

[3] The benchmark value of lead is determined as a function of hardness (in units of mg/L) in the water column. The value given in Table N-1 (i.e. 0.082 mg/L) corresponds to a hardness of 100 mg/L and should be used if you either did not analyze water hardness, other hardness data are not available, or the water hardness is less than 100 mg/L. If a laboratory analysis indicates that the water hardness is below 100 mg/L, then you should use the benchmark for 100 mg/L. If a laboratory analysis indicates that the water hardness is greater than 100 mg/L, then the following equation may be used to determine the benchmark value for lead:

$$\text{Benchmark} = (e^{[(1.273)(\ln \textit{hardness}) - 1.460]})/1000$$

Example: Laboratory analysis of your water sample indicates the hardness is 175 mg/L.

$$\begin{aligned}\text{Benchmark} &= (e^{[(1.273)(\ln 175) - 1.460]})/1000\\ &= (e^{5.1148})/1000\\ &= 166.46/1000\\ &= 0.17 \text{ mg/L}\end{aligned}$$

The following are example benchmark value for lead:

Hardness (mg/L)	Benchmark value (mg/L)
100	0.082
125	0.11
150	0.14
175	0.17
200	0.20
225	0.23
250	0.26

[4] The benchmark value of zinc is determined as a function of hardness (in units of mg/L) in the water column. The value given in Table N-1 (i.e. 0.12 mg/L) corresponds to a hardness of 100 mg/L and should be used if you either did not analyze water hardness, other hardness data are not available, or the water hardness is less than 100 mg/L. If a laboratory analysis indicates that the water hardness is below 100 mg/L, then you should use the benchmark for 100 mg/L. If a laboratory analysis indicates that the water hardness is greater than 100 mg/L, then the following equation may be used to determine the benchmark value for zinc:

$$\text{Benchmark} = (e^{[(0.8473)(\ln \textit{hardness}) + 0.884]})/1000$$

Example: Laboratory analysis of your water sample indicates the hardness is 175 mg/L.

$$\begin{aligned}\text{Benchmark} &= (e^{[(0.8473)(\ln 175) + 0.884]})/1000 \\ &= (e^{5.26})/1000 \\ &= 192.51/1000 \\ &= 0.19 \text{ mg/L}\end{aligned}$$

The following are example benchmark values for zinc:

Hardness (mg/L)	Benchmark value (mg/L)
100	0.12
125	0.14
150	0.17
175	0.19
200	0.22
225	0.24
250	0.26

Part 4 - Sector-Specific Requirements for Industrial Activity
Subsection O - Sector O - Steam Electric Generating Facilities.

O.1 Covered Stormwater Discharges.

The requirements in Subsection O apply to stormwater discharges associated with industrial activity from Steam Electric Power Generating Facilities as identified by the Activity Code specified under Sector O in Table D-1 of Appendix D.

O.2 Industrial Activities Covered by Sector O.

This permit authorizes stormwater discharges from the following industrial activities at Sector O facilities

O.2.1 steam electric power generation using coal, natural gas, oil, nuclear energy, etc., to produce a steam source, including coal handling areas;

O.2.2 coal pile runoff, including effluent limitations established by 40 CFR Part 423; and

O.2.3 dual fuel co-generation facilities.

O.3 Limitations on Coverage.

O.3.1 *Prohibition of Non-Stormwater Discharges.* Non-stormwater discharges subject to effluent limitations guidelines are not covered by this permit.

O.3.2 *Prohibition of Stormwater Discharges.* The following are not covered by this permit: stormwater discharges from ancillary facilities (e.g., fleet centers, gas turbine stations and substations) that are not contiguous to a stream electric power generating facility and heat capture co-generation facilities.

O.4 Stormwater Pollution Prevention Plan (SWPPP) Requirements.

In addition to the following requirements, you must also comply with the requirements listed in Part 2 in the permit.

O.4.1 *Drainage Area Site Map.* (See also Part 2.1.2) Identify the locations of any of the following activities or sources that may be exposed to precipitation or surface runoff: storage tanks, scrap yards, and general refuse areas; short- and long-term storage of general materials (including but not limited to supplies, construction materials, paint equipment, oils, fuels, used and unused solvents, cleaning materials, paint, water treatment chemicals, fertilizer, and pesticides); landfills and construction sites; and stock pile areas (e.g., coal or limestone piles).

O.4.2 *Good Housekeeping Measures*. (See also Part 2.1.5.1)

O.4.2.1 *Fugitive Dust Emissions*. Describe and implement measures that prevent or minimize fugitive dust emissions from coal handling areas. To minimize the tracking of coal dust offsite, consider procedures such as installing specially designed tires or washing vehicles in a designated area before they leave the site and controlling the wash water.

O.4.2.2 *Delivery Vehicles*. Describe and implement measures that prevent or minimize contamination of stormwater runoff from delivery vehicles arriving at the plant site. Consider procedures to inspect delivery vehicles arriving at the plant site and ensure overall integrity of the body or container and procedures to deal with leakage or spillage from vehicles or containers.

O.4.2.3 *Fuel Oil Unloading Areas*. Describe and implement measures that prevent or minimize contamination of precipitation or surface runoff from fuel oil unloading areas. Consider, at a minimum (or their equivalents), using containment curbs in unloading areas, having personnel familiar with spill prevention and response procedures present during deliveries to ensure that any leaks or spills are immediately contained and cleaned up, and using spill and overflow protection (e.g., drip pans, drip diapers, or other containment devices placed beneath fuel oil connectors to contain potential spillage during deliveries or from leaks at the connectors).

O.4.2.4 *Chemical Loading and Unloading*. Describe and implement measures that prevent or minimize contamination of precipitation or surface runoff from chemical loading and unloading areas. Consider, at a minimum (or their equivalents), using containment curbs at chemical loading and unloading areas to contain spill, having personnel familiar with spill prevention and response procedures present during deliveries to ensure that any leaks or spills are immediately contained and cleaned up, and loading and unloading in covered areas and storing chemicals indoors.

O.4.2.5 *Miscellaneous Loading and Unloading Areas*. Describe and implement measures that prevent or minimize contamination of precipitation or surface runoff from loading and unloading areas. Consider, at a minimum, covering the loading area; grading, berming, or curbing around the loading area to divert runon; locating the loading and unloading equipment and vehicles so that leaks are contained in existing containment and flow diversion systems; or equivalent procedures.

O.4.2.6 *Liquid Storage Tanks*. Describe and implement measures that prevent or minimize contamination of surface runoff from above-ground liquid storage tanks. Consider, at a minimum, protective guards around tanks, containment curbs, spill and overflow protection, dry cleanup methods, or equivalent measures.

O.4.2.7 *Large Bulk Fuel Storage Tanks.* Describe and implement measures that prevent or minimize contamination of surface runoff from large bulk fuel storage tanks. Consider, at a minimum, containment berms (or its equivalent). You must also comply with applicable State and Federal laws, including SPCC.

O.4.2.8 *Spill Reduction Measures.* Describe and implement measures to reduce the potential for an oil or chemical spill, or reference the appropriate part of your SPCC plan. At a minimum, visually inspect, on a weekly basis, the structural integrity of all above-ground tanks, pipelines, pumps, and related equipment, and effect any necessary repairs immediately.

O.4.2.9 *Oil-Bearing Equipment in Switchyards.* Describe and implement measures that prevent or minimize contamination of surface runoff from oil-bearing equipment in switchyard areas. Consider using level grades and gravel surfaces to retard flows and limit the spread of spills, or collecting runoff in perimeter ditches.

O.4.2.10 *Residue-Hauling Vehicles.* Inspect all residue-hauling vehicles for proper covering over the load, adequate gate sealing, and overall integrity of the container body. Repair, as soon as practicable, vehicles without load covering or adequate gate sealing, or with leaking containers or beds.

O.4.2.11 *Ash Loading Areas.* Describe and implement procedures to reduce or control the tracking of ash and residue from ash loading areas. When practicable, clear the ash building floor and immediately adjacent roadways of spillage, debris, and excess water before departure of each loaded vehicle.

O.4.2.12 *Areas Adjacent to Disposal Ponds or Landfills.* Describe and implement measures that prevent or minimize contamination of surface runoff from areas adjacent to disposal ponds or landfills. Develop procedures to reduce ash residue that may be tracked on to access roads traveled by residue handling vehicles, and reduce ash residue on exit roads leading into and out of residue handling areas.

O.4.2.13 *Landfills, Scrap yards, Surface Impoundments, Open Dumps, General Refuse Sites.*

Address these areas in your SWPPP and include appropriate BMPs as referred to in Part 2 of the permit.

O.4.2.14 *Vehicle Maintenance Activities.* For vehicle maintenance activities performed on the plant site, use the applicable BMPs outlined in Attachment 1, Subsection P.

O.4.2.15 *Material Storage Areas.* Describe and implement measures that prevent or minimize contamination of stormwater runoff from material storage areas (including areas used for temporary storage of miscellaneous products and construction materials stored in lay-down areas). Consider the following (or their equivalents): using flat yard grades; collecting runoff in graded swales or ditches; using erosion protection measures at steep outfall sites (e.g., concrete chutes, riprap, stilling basins); covering lay-down areas; storing materials indoors; and covering materials temporarily with polyethylene, polyurethane, polypropylene, or hypalon. Stormwater runon may be minimized by constructing an enclosure or building a berm around the area.

O.4.3 *Comprehensive Site Compliance Evaluation.* (See also Part 3.1) As part of your evaluation, inspect the following areas monthly: coal handling areas, loading or unloading areas, switchyards, fueling areas, bulk storage areas, ash handling areas, areas adjacent to disposal ponds and landfills, maintenance areas, liquid storage tanks, and long term and short term material storage areas.

O.5 Monitoring and Reporting Requirements. (See also Part 3 of the permit.)

Table O-1. Sector-specific Numeric Effluent Limitations and Benchmark Monitoring

Subsector (Discharges may be subject to requirements for more than one sector/subsector)	Parameter	Benchmark Monitoring Concentration[1]	Effluent Limitation Guidelines
Steam Electric Generating Facilities (Industrial Activity Code "SE")	Total Recoverable Iron	1.0 mg/L	--
	Total Suspended Solids (TSS)	100 mg/L	--

[1]You must monitor quarterly in the first year of your coverage for each benchmark parameter (see Part 3.2.2.1). For each parameter, no additional benchmark monitoring is required if the average of your 4 monitoring values does not exceed the benchmark (see Part 3.2.2.3). However, for each parameter there are additional requirements if the average of your four monitoring values exceeds the benchmark (see Part 3.2.2.4).

Part 4 - Sector-Specific Requirements for Industrial Activity
Subsection P - Sector P-Land Transportation and Warehousing

P.1 Covered Stormwater Discharges.

The requirements in Subsection P apply to stormwater discharges associated with industrial activity from Land Transportation and Warehousing facilities as identified by the SIC Codes in Major Groups 40, 41, 42, 43 and SIC 5171, as specified under Sector P in Table D-1 of Appendix D of the permit, namely motor freight transportation facilities (SIC 4212-4231); passenger transportation facilities (SIC 4111-4173); petroleum bulk oil stations and terminals (SIC 5171); rail transportation facilities (SIC 4011, 4013); and United States Postal Service facilities (SIC 4311).

P.2 Industrial Activities Covered by This Permit.

The types of activities that Land Transportation and Warehousing facilities are primarily engaged in are vehicle and equipment fluid changes; mechanical repairs; parts cleaning; Sanding, refinishing and painting; fueling and lubrication; locomotive sanding (loading sand for traction); storage of vehicles and equipment waiting for repair or maintenance; storage of the related materials and waste materials, such as oil, fuel, batteries, tires, or oil filters; and equipment cleaning operations, including areas where the following types of activities take place: vehicle exterior wash down; interior trailer washouts; tank washouts; rinsing of transfer equipment.

P.3 Limitation on Coverage

P.3.1 *Prohibited Discharges* (see also Part 1.2.4 and P.4.6) This permit does not authorize the discharge of vehicle/equipment/surface washwater, including tank cleaning operations. Such discharges must be authorized under a separate NPDES permit, discharged to a sanitary sewer in accordance with applicable industrial pretreatment requirements, or recycled on-site.

P.4 Stormwater Pollution Prevention Plan (SWPPP) Requirements.

In addition to the requirements contained in Part 2 of the permit, the following specific elements must be included in any SWPPP for a land transportation or warehousing facility authorized under this permit:

P.4.1 *Drainage Area Site Map.* (See also Part 2.1.2) The site map must also identify the following areas of the facility and indicate whether activities occurring there may be exposed to precipitation/surface runoff: Fueling stations; vehicle/equipment maintenance or cleaning areas; storage areas for vehicle/equipment with actual or potential fluid leaks; loading/unloading areas; areas where treatment, storage or disposal of wastes occur; liquid storage tanks; processing areas; and storage areas.

P.4.2 *Potential Pollutant Sources.* (See also Part 2.1.4) Describe and assess the potential for the following activities and facility areas to contribute pollutants to stormwater discharges: Onsite waste storage or disposal; dirt/gravel parking areas for vehicles awaiting maintenance; illicit plumbing connections between shop floor drains and the stormwater conveyance system(s); and fueling areas.

P.4.3 *Good Housekeeping Measures.* (See also Part 2.1.5.1) The SWPPP must describe the specific good housekeeping control measures used in each of the following facility areas. Recommended measures are discussed as indicated:

P.4.3.1 *Vehicle and Equipment Storage Areas.* Confine the storage of leaky or leak-prone vehicles/equipment awaiting maintenance to designated areas. Consider the following (or other equivalent measures): The use of drip pans under vehicles/equipment, indoor storage of vehicles and equipment, installation of berms or dikes, use of absorbents, roofing or covering storage areas, and cleaning pavement surfaces to remove oil and grease. *Note: The discharge of vehicle and equipment washwater, including tank cleaning operations, are not authorized by this permit and must be covered under a separate NPDES permit or discharged to a sanitary sewer in accordance with applicable industrial pretreatment requirements.*

P.4.3.2 *Fueling Areas.* Implement and describe measures that prevent or minimize contamination of stormwater runoff from fueling areas. Consider the following (or other equivalent measures): Covering the fueling area; using spill/overflow protection and cleanup equipment; minimizing stormwater runon/runoff to the fueling area; using dry cleanup methods; and treating and/or recycling collected stormwater runoff.

P.4.3.3 *Material Storage Areas.* Maintain all material storage vessels (e.g., for used oil/oil filters, spent solvents, paint wastes, hydraulic fluids) to prevent contamination of stormwater and plainly label them (e.g., "Used Oil," "Spent Solvents," etc.). Consider the following (or other equivalent measures): storing the materials indoors; installing berms/dikes around the areas; minimizing runoff of stormwater to the areas; using dry cleanup methods; and treating and/or recycling collected stormwater runoff.

P.4.3.4 *Vehicle and Equipment Cleaning Areas.* Implement and describe measures that prevent or minimize contamination of stormwater runoff from all areas used for vehicle/equipment cleaning. Consider the following (or other equivalent measures): performing all cleaning operations indoors; covering the cleaning operation, ensuring that all washwater drains to a proper collection system (i.e., not the stormwater drainage system unless NPDES permitted); treating and/or recycling collected stormwater runoff, or other equivalent measures.

P.4.3.5 *Vehicle and Equipment Maintenance Areas.* Implement and describe measures that prevent or minimize contamination of stormwater runoff from all areas used for vehicle/equipment maintenance. Consider the following (or other equivalent measures): performing maintenance activities indoors; using drip pans; keeping an organized inventory of materials used in the shop; draining all parts of fluid prior to disposal; prohibiting wet clean up practices if these practices would result in the discharge of pollutants to stormwater drainage systems; using dry cleanup methods; treating and/or recycling collected stormwater runoff, minimizing run on/runoff of stormwater to maintenance areas.

P.4.3.6 *Locomotive Sanding (Loading Sand for Traction) Areas.* Consider the following (or other equivalent measures): covering sanding areas; minimizing stormwater run on/runoff; or appropriate sediment removal practices to minimize the offsite transport of sanding material by stormwater.

P.4.4 *Inspections.* (See also Part 2.1.5.5) Inspect all the following areas/activities: storage areas for vehicles/equipment awaiting maintenance, fueling areas, indoor and outdoor vehicle/equipment maintenance areas, material storage areas, vehicle/equipment cleaning areas and loading/unloading areas.

P.4.5 *Employee Training.* (See also Part 2.1.5.6) Train personnel at least once a year and address the following activities, as applicable: used oil and spent solvent management; fueling procedures; general good housekeeping practices; proper painting procedures; and used battery management.

P.4.6 *Vehicle and Equipment Washwater Requirements.* Attach to or reference in your SWPPP, a copy of the NPDES permit issued for vehicle/equipment washwater or, if an NPDES permit has not been issued, a copy of the pending application. If an industrial user permit is issued under a local pretreatment program, attach a copy to your SWPPP. In any case, describe and implement all non-stormwater discharge permit conditions or pretreatment conditions in your SWPPP. If washwater is handled in another manner (e.g., hauled offsite), describe the disposal method and attach all pertinent documentation/information (e.g., frequency, volume, destination, etc.) in the plan.

P.5 Monitoring and Reporting Requirements. (See also Part 3 of the permit.)

Table P-1. Sector-specific Numeric Effluent Limitations and Benchmark Monitoring

Subsector (Discharges may be subject to requirements for more than one sector/subsector)	**Parameter**	**Benchmark Monitoring Concentration[1]**	**Effluent Limitation Guidelines**
Land Transportation and Warehousing (SIC 4011, 4013, 4111-4173, 4212-4231, 4311, 5171)	Total Suspended Solids (TSS)	100 mg/L	--

[1]You must monitor quarterly in the first year of your coverage for each benchmark parameter (see Part 3.2.2.1). For each parameter, no additional benchmark monitoring is required if the average of your 4 monitoring values does not exceed the benchmark (see Part 3.2.2.3). However, for each parameter there are additional requirements if the average of your four monitoring values exceeds the benchmark (see Part 3.2.2.4).

Part 4 - Sector-Specific Requirements for Industrial Activity
Subsection Q - Sector Q - Water Transportation

Q.1 Covered Stormwater Discharges.

The requirements in Subsection Q apply to stormwater discharges associated with industrial activity from Water Transportation facilities as identified by the Activity Code specified under Sector Q in Table D-1 of Appendix D of the permit.

Q.2 Industrial Activities Covered by Sector Q.

The requirements listed under this part apply to stormwater discharges associated with the following activities

Q.2.1 water transportation facilities classified in SIC Code Major Group 44 that have vehicle (vessel) maintenance shops and/or equipment cleaning operations, including

Q.2.1.1 water transportation industry, including facilities engaged in foreign or domestic transport of freight or passengers in deep sea or inland waters;

Q.2.1.2 marine cargo handling operations;

Q.2.1.3 ferry operations;

Q.2.1.4 towing and tugboat services; and

Q.2.1.5 marinas.

Q.3 Limitations on Coverage.

Q.3.1 *Prohibition of Non-Stormwater Discharges.* (See also Part 1.2.4) Not covered by this permit: bilge and ballast water, sanitary wastes, pressure wash water, and cooling water originating from vessels.

Q.4 Stormwater Pollution Prevention Plan (SWPPP) Requirements.

In addition to the following requirements, you must also comply with the requirements listed in Part 2 of the permit.

Q.4.1 *Drainage Area Site Map.* (See also Part 2.1.2) Identify where any of the following may be exposed to precipitation or surface runoff: fueling; engine maintenance and repair; vessel maintenance and repair; pressure washing; painting; sanding; blasting; welding; metal fabrication; loading and unloading areas; locations used for the treatment, storage, or disposal of wastes; liquid storage tanks; liquid storage areas (e.g., paint, solvents, resins); and material storage areas (e.g., blasting media, aluminum, steel, scrap iron).

Q.4.2 *Summary of Potential Pollutant Sources.* (See also Part 2.1.4) Describe the following additional sources and activities that have potential pollutants associated with them: outdoor manufacturing or processing activities (e.g., welding, metal fabricating) and significant dust or particulate generating processes (e.g., abrasive blasting, sanding, painting.)

Q.4.3 *Good Housekeeping Measures.* (See also Part 2.1.5.1)

Q.4.3.1 *Pressure Washing Area.* If pressure washing is used to remove marine growth from vessels, the discharge water must be permitted by a separate NPDES permit. Describe the following in the SWPPP: the measures to collect or contain the discharges from the pressures washing area, the method for the removal of the visible solids, the methods of disposal of the collected solids, and where the discharge will be released.

Q.4.3.2 *Blasting and Painting Area.* Implement and describe measures to prevent spent abrasives, paint chips, and overspray from discharging into the receiving water or the storm sewer systems. Consider containing all blasting and painting activities or use other measures to prevent or minimize the discharge of the contaminants (e.g., hanging plastic barriers or tarpaulins during blasting or painting operations to contain debris). When necessary, regularly clean stormwater conveyances of deposits of abrasive blasting debris and paint chips. Detail in the SWPPP any standard operating practices relating to blasting and painting (e.g., prohibiting uncontained blasting and painting over open water or prohibiting blasting and painting during windy conditions, which can render containment ineffective).

Q.4.3.3 *Material Storage Areas.* Store and plainly label all containerized materials (e.g., fuels, paints, solvents, waste oil, antifreeze, batteries) in a protected, secure location away from drains. Implement and describe measures to prevent or minimize the contamination of precipitation or surface runoff from the storage areas. Specify which materials are stored indoors, and consider containment or enclosure for those stored outdoors. If abrasive blasting is performed, discuss the storage and disposal of spent abrasive materials generated at the facility. Consider implementing an inventory control plan to limit the presence of potentially hazardous materials onsite.

Q.4.3.4 *Engine Maintenance and Repair Areas.* Implement and describe measures to prevent or minimize the contamination of precipitation or surface runoff from all areas used for engine maintenance and repair. Consider the following (or their equivalents): performing all maintenance activities indoors, maintaining an organized inventory of materials used in the shop, draining all parts of fluid prior to disposal, prohibiting the practice of hosing down the shop floor, using dry cleanup methods, and treating and/or recycling stormwater runoff collected from the maintenance area.

Q.4.3.5 *Material Handling Area.* Implement and describe measures to prevent or minimize the contamination of precipitation or surface runoff from material handling operations and areas (e.g., fueling, paint and solvent mixing, disposal of process wastewater streams from vessels). Consider the following (or their equivalents): covering fueling areas, using spill and overflow protection, mixing paints and solvents in a designated area (preferably indoors or under a shed), and minimizing runoff of stormwater to material handling areas.

Q.4.3.6 *Drydock Activities.* Describe your procedures for routinely maintaining and cleaning the drydock to prevent or minimize pollutants in stormwater runoff. Address the cleaning of accessible areas of the drydock prior to flooding, and final cleanup following removal of the vessel and raising the dock. Include procedures for cleaning up oil, grease, and fuel spills occurring on the drydock. Consider the following (or their equivalents): sweeping rather than hosing off debris and spent blasting material from accessible areas of the drydock prior to flooding and making absorbent materials and oil containment booms readily available to clean up or contain any spills.

Q.4.3.7 *General Yard Area.* Implement and describe a schedule for routine yard maintenance and cleanup. Regularly remove from the general yard area scrap metal, wood, plastic, miscellaneous trash, paper, glass, industrial scrap, insulation, welding rods, packaging, etc.

Q.4.4 *Preventive Maintenance.* (See also Part 2.1.5.3) As part of your preventive maintenance program, perform timely inspection and maintenance of stormwater management devices (e.g., cleaning oil and water separators and sediment traps to ensure that spent abrasives, paint chips, and solids will be intercepted and retained prior to entering the storm drainage system), as well as inspecting and testing facility equipment and systems to uncover conditions that could cause breakdowns or failures resulting in discharges of pollutants to surface waters.

Q.4.5 *Inspections.* (See also Part 2.1.5.5) Include the following in all monthly inspections: pressure washing area; blasting, sanding, and painting areas; material storage areas; engine maintenance and repair areas; material handling areas; drydock area; and general yard area.

Q.4.6 *Employee Training.* (See also Part 2.1.5.6) As part of your employee training program, address, at a minimum, the following activities (as applicable): used oil management, spent solvent management, disposal of spent abrasives, disposal of vessel wastewaters, spill prevention and control, fueling procedures, general good housekeeping practices, painting and blasting procedures, and used battery management.

Q.4.7 *Comprehensive Site Compliance Evaluation.* (See also Part 3.1) Conduct regularly scheduled evaluations at least once a year and address areas contributing to a stormwater discharge associated with industrial activity (e.g., pressure washing area, blasting and sanding areas, painting areas, material storage areas, engine maintenance and repair areas, material handling areas, and drydock area). Inspect these sources for evidence of, or the potential for, pollutants entering the drainage system.

Q.5 Monitoring and Reporting Requirements. (See also Part 3 of the permit.)

Table Q-1. Sector-specific Numeric Effluent Limitations and Benchmark Monitoring			
Subsector (Discharges may be subject to requirements for more than one sector/subsector)	**Parameter**	**Benchmark Monitoring Concentration[1]**	**Effluent Limitation Guidelines**
Water Transportation Facilities (SIC 4412-4499)	Total Recoverable Aluminum	0.75 mg/L	--
	Total Recoverable Iron	1.0 mg/L	--
	Total Recoverable Lead[2]	0.082 mg/L	--
	Total Recoverable Zinc[3]	0.12 mg/L	--
	Total Suspended Solids (TSS)	100 mg/L	--

[1]You must monitor quarterly in the first year of your coverage for each benchmark parameter (see Part 3.2.2.1). For each parameter, no additional benchmark monitoring is required if the average of your 4 monitoring values does not exceed the benchmark (see Part 3.2.2.3). However, for each parameter there are additional requirements if the average of your four monitoring values exceeds the benchmark (see Part 3.2.2.4).

[2] The benchmark value of lead is determined as a function of hardness (in units of mg/L) in the water column. The value given in Table Q-1 (i.e. 0.082 mg/L) corresponds to a hardness of 100 mg/L and should be used if you either did not analyze water hardness, other hardness data are not available, or the water hardness is less than 100 mg/L. If a laboratory analysis indicates that the water hardness is below 100 mg/L, then you should use the benchmark for 100 mg/L. If a laboratory analysis indicates that the water hardness is greater than 100 mg/L, then the following equation may be used to determine the benchmark value for lead:

$$\text{Benchmark} = (e^{[(1.273)(\ln \textit{hardness}) - 1.460]})/1000$$

Example: Laboratory analysis of your water sample indicates the hardness is 175 mg/L.

$$\begin{aligned} \text{Benchmark} &= (e^{[(1.273)(\ln 175) - 1.460]})/1000 \\ &= (e^{5.1148})/1000 \\ &= 166.46/1000 \\ &= 0.17 \text{ mg/L} \end{aligned}$$

The following are example benchmark value for lead:

Hardness (mg/L)	Benchmark value (mg/L)
100	0.082
125	0.11
150	0.14
175	0.17
200	0.20
225	0.23
250	0.26

[3] The benchmark value of zinc is determined as a function of hardness (in units of mg/L) in the water column. The value given in Table Q-1 (i.e. 0.12 mg/L) corresponds to a hardness of 100 mg/L and should be used if you either did not analyze water hardness, other hardness data are not available, or the water hardness is less than 100 mg/L. If a laboratory analysis indicates that the water hardness is below 100 mg/L, then you should use the benchmark for

100 mg/L. If a laboratory analysis indicates that the water hardness is greater than 100 mg/L, then the following equation may be used to determine the benchmark value for zinc:

$$\text{Benchmark} = (e^{[(0.8473)(\ln hardness) + 0.884]})/1000$$

Example: Laboratory analysis of your water sample indicates the hardness is 175 mg/L.

$$\text{Benchmark} = (e^{[(0.8473)(\ln 175) + 0.884]})/1000$$
$$= (e^{5.26})/1000$$
$$= 192.51/1000$$
$$= 0.19 \text{ mg/L}$$

The following are example benchmark values for zinc:

Hardness (mg/L)	Benchmark value (mg/L)
100	0.12
125	0.14
150	0.17
175	0.19
200	0.22
225	0.24
250	0.26

Part 4 - Sector-Specific Requirements for Industrial Activity
Subsection R - Sector R-Ship and Boat Building and Repair Yards

R.1 Covered Stormwater Discharges.

The requirements in Subsection R apply to stormwater discharges associated with industrial activity from ship and boat building and repair yards as identified by the Activity Codes specified under Sector R in Table D-1 of Appendix D of the permit.

R.2 Industrial Activities Covered by Sector R.

Permittees under Sector R are primarily engaged in the following types of activities:

R.2.1 ship building and repairing and boat building and repairing[1]

R.3 Limitations on Coverage.

R.3.1 *Prohibition of Non-Stormwater Discharges.* (See also Part 1.2.4) Discharges containing bilge and ballast water, sanitary wastes, pressure wash water, and cooling water originating from vessels are not covered by this permit.

R.4 Stormwater Pollution Prevention Plan (SWPPP) Requirements.

In addition to the following requirements, you must also comply with the requirements listed in Part 2 of the permit.

R.4.1 *Drainage Area Site Map.* (See also Part 2.1.2) Identify where any of the following may be exposed to precipitation or surface runoff: fueling; engine maintenance or repair; vessel maintenance or repair; pressure washing; painting; sanding; blasting; welding; metal fabrication; loading and unloading areas; treatment, storage, and waste disposal areas; liquid storage tanks; liquid storage areas (e.g., paint, solvents, resins); and material storage areas (e.g., blasting media, aluminum, steel, scrap iron).

R.4.2 *Potential Pollutant Sources.* (See also Part 2.1.4) Describe the following additional sources and activities that have potential pollutants associated with them (if applicable): outdoor manufacturing or processing activities (e.g., welding, metal fabricating) and significant dust or particulate generating processes (e.g., abrasive blasting, sanding, painting).

[1]According to the U.S. Coast Guard, a vessel 65 feet or greater in length is referred to as a ship, and a vessel smaller than 65 feet is a boat.

R.4.3 *Good Housekeeping Measures.* (See also Part 2.1.5.1)

R.4.3.1 *Pressure Washing Area.* If pressure washing is used to remove marine growth from vessels, the discharged water must be permitted as a process wastewater by a separate NPDES permit.

R.4.3.2 *Blasting and Painting Area.* Implement and describe measures to prevent spent abrasives, paint chips, and overspray from discharging into the receiving water or the storm sewer systems. Consider containing all blasting and painting activities, or use other measures to prevent the discharge of the contaminants (e.g., hanging plastic barriers or tarpaulins during blasting or painting operations to contain debris). When necessary, regularly clean stormwater conveyances of deposits of abrasive blasting debris and paint chips. Detail in the SWPPP any standard operating practices relating to blasting and painting (e.g., prohibiting uncontained blasting and painting over open water or prohibiting blasting and painting during windy conditions, which can render containment ineffective).

R.4.3.3 *Material Storage Areas.* Store and plainly label all containerized materials (e.g., fuels, paints, solvents, waste oil, antifreeze, batteries) in a protected, secure location away from drains. Implement and describe measures to prevent or minimize the contamination of precipitation or surface runoff from the storage areas. Specify which materials are stored indoors, and consider containment or enclosure for those stored outdoors. If abrasive blasting is performed, discuss the storage and disposal of spent abrasive materials generated at the facility. Consider implementing an inventory control plan to limit the presence of potentially hazardous materials onsite.

R.4.3.4 *Engine Maintenance and Repair Areas.* Implement and describe measures to prevent or minimize the contamination of precipitation or surface runoff from all areas used for engine maintenance and repair. Consider the following (or their equivalents): performing all maintenance activities indoors, maintaining an organized inventory of materials used in the shop, draining all parts of fluid prior to disposal, prohibiting the practice of hosing down the shop floor, using dry cleanup methods, and treating and/or recycling stormwater runoff collected from the maintenance area.

R.4.3.5 *Material Handling Area.* Implement and describe measures to prevent or minimize the contamination of precipitation or surface runoff from material handling operations and areas (e.g., fueling, paint and solvent mixing, disposal of process wastewater streams from vessels). Consider the following (or their equivalents): covering fueling areas, using spill and overflow protection, mixing paints and solvents in a designated area (preferably indoors or under a shed), and minimizing stormwater runon to material handling areas.

R.4.3.6 *Drydock Activities.* Describe your procedures for routinely maintaining and cleaning the drydock to prevent or minimize pollutants in stormwater runoff. Address the cleaning of accessible areas of the drydock prior to flooding and final cleanup following removal of the vessel and raising the dock. Include procedures for cleaning up oil, grease, or fuel spills occurring on the drydock. Consider the following (or their equivalents): sweeping rather than hosing off debris and spent blasting material from accessible areas of the drydock prior to flooding, and having absorbent materials and oil containment booms readily available to clean up and contain any spills.

R.4.3.7 *General Yard Area.* Implement and describe a schedule for routine yard maintenance and cleanup. Regularly remove from the general yard area scrap metal, wood, plastic, miscellaneous trash, paper, glass, industrial scrap, insulation, welding rods, packaging, etc.

R.4.4 *Preventive Maintenance.* (See also Part 2.1.5.3) As part of your preventive maintenance program, perform timely inspection and maintenance of stormwater management devices (e.g., cleaning oil and water separators and sediment traps to ensure that spent abrasives, paint chips, and solids will be intercepted and retained prior to entering the storm drainage system), as well as inspecting and testing facility equipment and systems to uncover conditions that could cause breakdowns or failures resulting in discharges of pollutants to surface waters.

R.4.5 *Inspections.* (See also Part 2.1.5.5) Include the following in all monthly inspections: pressure washing area; blasting, sanding, and painting areas; material storage areas; engine maintenance and repair areas; material handling areas; drydock area; and general yard area.

R.4.6 *Employee Training.* (See also Part 2.1.5.6) As part of your employee training program, address, at a minimum, the following activities (as applicable): used oil management, spent solvent management, disposal of spent abrasives, disposal of vessel wastewaters, spill prevention and control, fueling procedures, general good housekeeping practices, painting and blasting procedures, and used battery management.

R.4.7 *Comprehensive Site Compliance Evaluation.* (See also Part 3.1) Conduct regularly scheduled evaluations at least once a year and address areas contributing to a stormwater discharge associated with industrial activity (e.g., pressure washing, blasting and sanding, painting, material storage, engine maintenance and repair, material handling, and drydock areas). These areas must be visually inspected for evidence of, or the potential for, pollutants entering the drainage system.

R.5 Monitoring and Reporting Requirements. (See also Part 3 of the permit.)

Table R-1. Sector-specific Numeric Effluent Limitations and Benchmark Monitoring			
Subsector (Discharges may be subject to requirements for more than one sector/subsector)	Parameter	Benchmark Monitoring Concentration[1]	Effluent Limitation Guidelines
Ship and Boat Building and Repairing Yards (SIC 3731, 3732)	Total Suspended Solids (TSS)	100 mg/L	--

[1]You must monitor quarterly in the first year of your coverage for each benchmark parameter (see Part 3.2.2.1). For each parameter, no additional benchmark monitoring is required if the average of your 4 monitoring values does not exceed the benchmark (see Part 3.2.2.3). However, for each parameter there are additional requirements if the average of your four monitoring values exceeds the benchmark (see Part 3.2.2.4).

Part 4 - Sector-Specific Requirements for Industrial Activity
Subsection S - Sector S-Air Transportation

S.1 Covered Stormwater Discharges.

The requirements in Subsection S apply to stormwater discharges associated with industrial activity from Air Transportation facilities identified by the SIC Codes in Major Group 45, as specified under Sector S in Table D-1 of Appendix D of the permit, namely air transportation, scheduled, and air courier (SIC 4512 and 4513); air transportation, non scheduled (SIC 4522); airports, flying fields, except those maintained by aviation clubs, and airport terminal services including: air traffic control, except government; aircraft storage at airports; aircraft upholstery repair; airfreight handling at airports; airport hangar rental; airport leasing, if operating airport; airport terminal services; and hangar operations; and airport and aircraft service and maintenance including: aircraft cleaning and janitorial service; aircraft servicing/repairing, except on a factory basis; vehicle maintenance shops; material handling facilities; equipment clearing operations; and airport and aircraft deicing/anti-icing. (SIC 4581)

S.2 Industrial Activities Covered by Sector S.

The types of activities that Air Transportation facilities are primarily engaged in are:

- Servicing, repairing, or maintaining aircraft and ground vehicles
- Equipment cleaning and maintenance (including vehicle and equipment rehabilitation mechanical repairs, painting, fueling, and lubrication)
- Deicing/anti-icing operations which conduct the above described activities

Note: "deicing" will generally be used to imply both deicing (removing frost, snow or ice) and anti-icing (preventing accumulation of frost, snow or ice) activities, unless specific mention is made regarding anti-icing and/or deicing activities.

S.3 Limitation on Coverage

S.3.1 *Limitations on Coverage.* This permit authorizes stormwater discharges from only those portions of the air transportation facility that are involved in vehicle maintenance (including vehicle rehabilitation, mechanical repairs, painting, fueling and lubrication), equipment cleaning operations or deicing operations.

S.3.2 *Prohibition of Non-Stormwater Discharges.* (See also Part 1.2.4 and Part S.4) This permit does not authorize the discharge of aircraft, ground vehicle, runway and equipment washwaters; nor the dry weather discharge of deicing chemicals. Such discharges must be covered by separate NPDES permit(s).

S.3.3 *Hazardous Substances or Oil.* (See also Part 2.1.4.3) Each individual permittee is required to report spills equal to or exceeding the reportable quantity (RQ) levels specified at 40 CFR 110, 117 and 302 as described at Part 2.1.4.3. If an airport authority is the sole permittee under this permit, then the sum total of all spills at the airport must be assessed against the RQ. I f the airport authority is a co-permittee with other deicing operators at the airport (such as numerous different airlines), the assessed amount must be the summation of spills by each co-permittee. If separate, distinct individual permittees exist at the airport, then the amount spilled by each separate permittee must be the assessed amount for the RQ determination.

S.4 Stormwater Pollution Prevention Plan (SWPPP) Requirements.

In addition to the requirements contained in Part 2, the following specific elements must be included in any SWPPP for a air transportation facility authorized under this permit. An airport authority and tenants of the airport are encouraged to work in partnership in the development and implementation of a stormwater pollution prevention plan. If an airport tenant obtains authorization under this permit and develops a SWPPP for discharges from his own areas of the airport, that SWPPP must be coordinated and integrated with the plan SWPPP for the entire airport. Tenants of the airport facility include air passenger or cargo companies, fixed based operators and other parties who have contracts with the airport authority to conduct business operations on airport property and whose operations result in stormwater discharges associated with industrial activity.

S.4.1 *Drainage Area Site Map.* (See also Part 2.1.2) The site map must also identify the following areas of the facility and indicate whether activities occurring there may be exposed to precipitation/surface runoff: aircraft and runway deicing operations; fueling stations; aircraft, ground vehicle and equipment maintenance/cleaning areas; storage areas for aircraft, ground vehicles and equipment awaiting maintenance.

S.4.2 *Potential Pollutant Sources.* (See also Part 2.1.4) In your inventory of exposed materials, describe and assess the potential for the following activities and facility areas to contribute pollutants to stormwater discharges: aircraft, runway, ground vehicle and equipment maintenance and cleaning; aircraft and runway deicing operations (including apron and centralized aircraft deicing stations, runways, taxiways and ramps). If you use deicing chemicals, you must maintain a record of the types (including the Material Safety Data Sheets [MSDS]) used and the monthly quantities, either as measured or, in the absence of metering, as estimated to the best of your knowledge. This includes all deicing chemicals, not just glycols and urea (e.g., potassium acetate), because large quantities of these other chemicals can still have an adverse impact on receiving waters. Tenants or other fixed-based operations that conduct deicing operations must provide the above information to the airport authority for inclusion in any comprehensive airport SWPPPs.

S.4.2.1 Deicing Season. (See also S.4.4.) The SWPPP must define the average seasonal timeframe (e.g., December- February, October - March, etc.) during which deicing activities typically occur at the facility. Implementation of BMPs, facility inspections and monitoring must be conducted with particular emphasis throughout the defined deicing season.

S.4.3 *Good Housekeeping Measures.* (See also 2.1.5.1) The SWPPP must describe the specific good housekeeping control measures used in each of the following facility areas. Recommended measures are discussed as indicated:

S.4.3.1 Aircraft, Ground Vehicle and Equipment Maintenance Areas. Describe and implement measures that prevent or minimize the contamination of stormwater runoff from all areas used for aircraft, ground vehicle and equipment maintenance (including the maintenance conducted on the terminal apron and in dedicated hangers). Consider the following practices (or their equivalents): performing maintenance activities indoors; maintaining an organized inventory of material used in the maintenance areas; draining all parts of fluids prior to disposal; prohibiting the practice of hosing down the apron or hanger floor; using dry cleanup methods; and collecting the stormwater runoff from the maintenance area and providing treatment or recycling.

S.4.3.2 Aircraft, Ground Vehicle and Equipment Cleaning Areas. (see also S.4.6) Clean equipment only in the areas identified in the SWPPP and site map and clearly demarcate these areas on the ground using signage or other appropriate means. Describe and implement measures that prevent or minimize the contamination of stormwater runoff from cleaning areas.

S.4.3.3 Aircraft, Ground Vehicle and Equipment Storage Areas. Store all aircraft, ground vehicles and equipment awaiting maintenance in designated areas only. Consider the following BMPs (or their equivalents): storing aircraft and ground vehicles indoors; using drip pans for the collection of fluid leaks; and perimeter drains, dikes or berms surrounding the storage areas.

S.4.3.4 Material Storage Areas. Maintain the vessels of stored materials (e.g., used oils, hydraulic fluids, spent solvents, and waste aircraft fuel) in good condition, to prevent or minimize contamination of stormwater. Also plainly label the vessels (e.g., "used oil," "Contaminated Jet A," etc.). Describe and implement measures that prevent or minimize contamination of precipitation/runoff from these areas. Consider the following BMPs (or their equivalents): storing materials indoors; storing waste materials in a centralized location; and installing berms/dikes around storage areas.

S.4.3.5 Airport Fuel System and Fueling Areas. Describe and implement measures that prevent or minimize the discharge of fuel to the storm sewer/surface waters resulting from fuel servicing activities or other operations conducted in support of the airport fuel system. Consider the following BMPs (or their equivalents): implementing spill and overflow practices (e.g., placing absorptive materials beneath aircraft during fueling operations); using only dry cleanup methods; and collecting stormwater runoff.

S.4.3.6 Source Reduction. Consider all feasible alternatives to the use of urea and glycol-based deicing chemicals to reduce the aggregate amount of deicing chemicals used and/or lessen the environmental impact. Chemical options to replace ethylene glycol, propylene glycol and urea include: potassium acetate; magnesium acetate; calcium acetate; anhydrous sodium acetate.

S.4.3.6.1 Runway Deicing Operation: Evaluate, at a minimum, whether over-application of deicing chemicals occurs by analyzing application rates and adjusting as necessary, consistent with considerations of flight safety. Also consider these BMP options (or their equivalents): metered application of chemicals; pre-wetting dry chemical constituents prior to application; installing a runway ice detection system; implementing anti-icing operations as a preventive measure against ice buildup.

S.4.3.6.2 Aircraft Deicing Operations. Determine whether excessive application of deicing chemicals occurs and adjust as necessary, consistent with considerations of flight safety. EPA intends for this evaluation to be carried out by the personnel most familiar with the particular aircraft and flight operations in question (vice an outside entity such as the airport authority). Consider using alternative deicing/anti-icing agents as well as containment measures for all applied chemicals. Also consider these BMP options (or their equivalents) for reducing deicing fluid use: forced-air deicing systems, computer-controlled fixed-gantry systems, infrared technology, hot water, varying glycol content to air temperature, enclosed-basket deicing trucks, mechanical methods, solar radiation, hangar storage, aircraft covers, thermal blankets for MD-80s and DC-9s. Also consider using ice-detection systems and airport traffic flow strategies and departure slot allocation systems.

S.4.3.7 Management of Runoff. Where deicing operations occur, describe and implement a program to control or manage contaminated runoff to reduce the amount of pollutants being discharged from the site. Describe the controls used for collecting or containing contaminated melt water from collection areas used for disposal of contaminated snow. Consider these BMP options (or their equivalents): a dedicated deicing facility with a runoff collection/ recovery system; using vacuum/collection trucks; storing contaminated stormwater/deicing fluids in tanks and releasing controlled amounts to a publicly owned treatment works; collecting contaminated runoff in a wet pond for biochemical decomposition (be aware of attracting wildlife that may prove hazardous to flight operations); and directing runoff into vegetative swales or other infiltration measures. Also consider recovering deicing materials when these materials are applied during non-precipitation events (e.g., covering storm sewer inlets, using booms, installing absorptive interceptors in the drains, etc.) to prevent these materials from later becoming a source of stormwater contamination. Used deicing fluid should be recycled whenever possible.

S.4.4 *Inspections.* (See also Part 2.1.5.5) Specify the frequency of inspections in your SWPPP. At a minimum they must be conducted monthly during the deicing season (e.g., October through April for most mid-latitude airports). If your facility needs to deice before or after this period, expand the monthly inspections to include all months during which deicing chemicals may be used. Also, if significantly or deleteriously large quantities of deicing chemicals are being spilled or discharged, or if water quality impacts have been reported, increase the frequency of your inspections to weekly until such time as the chemical spills/discharges or impacts are reduced to acceptable levels. The Director may specifically require you to increase inspections and SWPPP reevaluations as necessary.

S.4.5 *Comprehensive Site Compliance Evaluation.* (See also Part 3.1) Using only qualified personnel, conduct your annual site compliance evaluations during periods of actual deicing operations, if possible. If not practicable during active deicing or the weather is too inclement, conduct the evaluations when deicing operations are likely to occur and the materials and equipment for deicing are in place.

S.4.6 *Vehicle and Equipment Washwater Requirements.* Attach to or reference in your SWPPP, a copy of the NPDES permit issued for vehicle/equipment washwater or, if an NPDES permit has not been issued, a copy of the pending application. If an industrial user permit is issued under a local pretreatment program, attach a copy to your SWPPP. In any case, describe and implement all non-stormwater discharge permit conditions or pretreatment conditions in your SWPPP. If washwater is handled in another manner (e.g., hauled offsite, retained onsite), describe the disposal method and attach all pertinent documentation/information (e.g., frequency, volume, destination, etc.) in the plan.

S.5 Monitoring and Reporting Requirements. (See also Part 3 of the permit.)

Monitor per the requirements in Table S-1. Collect a minimum of four (4) samples only during the timeframe defined in Part S.4.2.1 when deicing activities are occurring, for the year 1 of your permit coverage, and four times per year thereafter during the permit term, depending on comparison of monitoring results to benchmark monitoring cutoff concentrations.

Table S-1. Sector-specific Numeric Effluent Limitations and Benchmark Monitoring

Subsector (Discharges may be subject to requirements for more than one sector/subsector)	Parameter	Benchmark Monitoring Concentration[1]	Effluent Limitation Guidelines
Facilities at airports that use more that 100,000 gallons of glycol-based deicing/anti-icing chemicals and/or 100 tons or more of urea on an average annual basis: monitor ONLY those outfalls from the airport facility that collect runoff from areas where deicing/anti-icing activities occur (SIC 4512-4581).	Biochemical Oxygen Demand (BOD_5)	30 mg/L	--
	Chemical Oxygen Demand (COD)	120 mg/L	--
	Ammonia	19 mg/L	--
	pH	6.0 - 9.0 s.u.	--
	Total Suspended Solids (TSS)	100 mg/L	--

[1]You must monitor quarterly in the first year of your coverage for each benchmark parameter (see Part 3.2.2.1). For each parameter, no additional benchmark monitoring is required if the average of your 4 monitoring values does not exceed the benchmark (see Part 3.2.2.3). However, for each parameter there are additional requirements if the average of your four monitoring values exceeds the benchmark (see Part 3.2.2.4).

Part 4 - Sector-Specific Requirements for Industrial Activity
Subsection T - Sector T-Treatment Works

T.1 Covered Stormwater Discharges.

The requirements in Subsection T apply to stormwater discharges associated with industrial activity from treatment works as identified by the Activity Code specified under Sector T in Table D-1 of Appendix D of the permit.

T.2 Industrial Activities Covered by Sector T.

The requirements listed under this part apply to all existing point source stormwater discharges associated with the following activities

T.2.1 treatment works treating domestic sewage, or any other sewage sludge or wastewater treatment device or system used in the storage, treatment, recycling, and reclamation of municipal or domestic sewage; including land dedicated to the disposal of sewage sludge; that are located within the confines of the facility with a design flow of 1.0 million gallons per day (MGD) or more; or are required to have an approved pretreatment program under 40 CFR Part 403.

T.2.2 The following are not required to have permit coverage: farm lands, domestic gardens or lands used for sludge management where sludge is beneficially reused and which are not physically located within the facility, or areas that are in compliance with Section 405 of the CWA.

T.3 Limitations on Coverage.

T.3.1 *Prohibition of Non-Stormwater Discharges.* (See also Part 1.2.4) Sanitary and industrial wastewater and equipment and vehicle washwater are not authorized by this permit.

T.4 Stormwater Pollution Prevention Plan (SWPPP) Requirements.

In addition to the following requirements, you must also comply with the requirements listed in Part 2 of the permit.

T.4.1 *Site Map.* (See also Part 2.1.2) Identify where any of the following may be exposed to precipitation or surface runoff: grit, screenings, and other solids handling, storage, or disposal areas; sludge drying beds; dried sludge piles; compost piles; septage or hauled waste receiving station; and storage areas for process chemicals, petroleum products, solvents, fertilizers, herbicides, and pesticides.

T.4.2 *Potential Pollutant Sources.* (See also Part 2.1.4) Describe the following additional sources and activities that have potential pollutants associated with them, as applicable: grit, screenings, and other solids handling, storage, or disposal areas; sludge drying beds;

dried sludge piles; compost piles; septage or hauled waste receiving station; and access roads and rail lines.

T.4.3 *Best Management Practices (BMPs).* (See also Part 2.1.5) In addition to the other BMPs, consider the following: routing stormwater to the treatment works; or covering exposed materials (i.e., from the following areas: grit, screenings, and other solids handling, storage, or disposal areas; sludge drying beds; dried sludge piles; compost piles; and septage or hauled waste receiving station).

T.4.4 *Inspections.* (See also Part 2.1.5.5) Include the following areas in all inspections: access roads and rail lines; grit, screenings, and other solids handling, storage, or disposal areas; sludge drying beds; dried sludge piles; compost piles; and septage or hauled waste receiving station.

T.4.5 *Employee Training.* (See also Part 2.1.5.6) At a minimum, training must address the following areas when applicable to a facility: petroleum product management; process chemical management; spill prevention and controls; fueling procedures; general good housekeeping practices; and proper procedures for using fertilizer, herbicides, and pesticides.

T.4.6 *Wastewater and Washwater Requirements.* Attach to your SWPPP a copy of all your current NPDES permits issued for wastewater and industrial, vehicle, and equipment washwater discharges or, if an NPDES permit has not yet been issued, a copy of the pending applications. Address any requirements and conditions from the other permits, as appropriate, in the SWPPP. If the washwater is handled in another manner, the disposal method must be described and all pertinent documentation must be attached to the plan.

T.5 Monitoring and Reporting Requirements. (See also Part 3 of the permit.)

Table T-1. Sector-specific Numeric Effluent Limitations and Benchmark Monitoring			
Subsector (Discharges may be subject to requirements for more than one sector/subsector)	**Parameter**	**Benchmark Monitoring Concentration[1]**	**Effluent Limitation Guidelines**
Treatment Works (SIC TW)	Total Suspended Solids (TSS)	100 mg/L	--

[1]You must monitor quarterly in the first year of your coverage for each benchmark parameter (see Part 3.2.2.1). For each parameter, no additional benchmark monitoring is required if the average of your 4 monitoring values does not exceed the benchmark (see Part 3.2.2.3). However, for each parameter there are additional requirements if the average of your four monitoring values exceeds the benchmark (see Part 3.2.2.4).

Part 4 - Sector-Specific Requirements for Industrial Activity
Subsection U - Sector U-Food and Kindred Products

U.1 Covered Stormwater Discharges.

The requirements in Subsection U apply to stormwater discharges associated with industrial activity from food and kindred products facilities as identified by the SIC Codes specified in Table D-1 of Appendix D of the permit.

U.2 Industrial Activities Covered by Sector U.

Permittees under Sector U are primarily engaged in the following types of activities:

U.2.1 meat products;

U.2.2 dairy products;

U.2.3 canned, frozen, and preserved fruits, vegetables, and food specialties;

U.2.4 grain mill products;

U.2.5 bakery products;

U.2.6 sugar and confectionery products;

U.2.7 fats and oils;

U.2.8 beverages; and

U.2.9 miscellaneous food preparations and kindred products and tobacco products manufacturing.

U.3 Limitations on Coverage.

The following are not covered by this permit: stormwater discharges identified under Part 1.2.4 from industrial plant yards; material handling sites; refuse sites; sites used for application or disposal of process wastewaters; sites used for storage and maintenance of material handling equipment; sites used for residential wastewater treatment, storage, or disposal; shipping and receiving areas; manufacturing buildings; and storage areas for raw material and intermediate and finished products. This includes areas where industrial activity has taken place in the past and significant materials remain. Material handling activities include the storage, loading and unloading, transportation, or conveyance of any raw material, intermediate product, finished product, by-product, or waste product.

U.3.1 *Prohibition of Non-Stormwater Discharges.* (See also Part 1.2.4) The following are not authorized by this permit: discharges subject to Part 1.2.2.2, which includes discharges containing boiler blowdown, cooling tower overflow and blowdown, ammonia refrigeration purging, and vehicle washing and clean-out operations.

U.4 Stormwater Pollution Prevention Plan (SWPPP) Requirements.

In addition to the following requirements, you must also comply with the requirements listed in Part 2 of the permit.

U.4.1 *Drainage Area Site Map.* (See also Part 2.1.2) Identify the locations of the following activities if they are exposed to precipitation or runoff: vents and stacks from cooking, drying, and similar operations; dry product vacuum transfer lines; animal holding pens; spoiled product; and broken product container storage areas.

U.4.2 *Potential Pollutant Sources.* (See also Part 2.1.4) Describe, in addition to food and kindred products processing-related industrial activities, application and storage of pest control chemicals (e.g., rodenticides, insecticides, fungicides) used on plant grounds.

U.4.3 *Inspections.* (See also Part 2.1.5.5) Inspect on a monthly basis, at a minimum, the following areas where the potential for exposure to stormwater exists: loading and unloading areas for all significant materials; storage areas, including associated containment areas; waste management units; vents and stacks emanating from industrial activities; spoiled product and broken product container holding areas; animal holding pens; staging areas; and air pollution control equipment.

U.4.4 *Employee Training.* (See also Part 2.1.5.6) Address pest control in the training program.

U.5 Monitoring and Reporting Requirements. (See also Part 3 of the permit.)

Table U-1. Sector-specific Numeric Effluent Limitations and Benchmark Monitoring

Subsector (Discharges may be subject to requirements for more than one Sector / Subsector)	Parameter	Benchmark Monitoring Concentration[1]	Effluent Limitation Guidelines
Grain Mill Products (SIC 2041-2048)	Total Suspended Solids (TSS)	100 mg/L	--
Fats and Oils Products (SIC 2074-2079)	Biochemical Oxygen Demand (BOD_5)	30 mg/L	--
	Chemical Oxygen Demand (COD)	120 mg/L	--
	Nitrate plus Nitrite Nitrogen	0.68 mg/L	--
	Total Suspended Solids (TSS)	100 mg/L	--

Table U-1. Sector-specific Numeric Effluent Limitations and Benchmark Monitoring			
Subsector (Discharges may be subject to requirements for more than one Sector / Subsector)	**Parameter**	**Benchmark Monitoring Concentration[1]**	**Effluent Limitation Guidelines**
Meat Products; Dairy Products; Canned, Frozen, and Preserved Fruits, Vegetables, and Food Specialties; Bakery Products; Sugar and Confectionery Products; Beverages; Miscellaneous Food Preparations and Kindred Products; and Tobacco Products (SIC 2011-2015, 2021-2026, 2032-2038, 2051-2053, 2061-2068, 2082-2087, 2091-2099, 2111-2141)	Total Suspended Solids (TSS)	100 mg/L	--

[1] You must monitor quarterly in the first year of your coverage for each benchmark parameter (see Part 3.2.2.1). For each parameter, no additional benchmark monitoring is required if the average of your 4 monitoring values does not exceed the benchmark (see Part 3.2.2.3). However, for each parameter there are additional requirements if the average of your four monitoring values exceeds the benchmark (see Part 3.2.2.4).

Part 4 - Sector-Specific Requirements for Industrial Activity
Subsection V - Sector V-Textile Mills, Apparel, and Other Fabric Products

V.1 Covered Stormwater Discharges.

The requirements in Subsection V apply to stormwater discharges associated with industrial activity from textile mills, apparel, and other fabric product manufacturing as identified by the Activity Code specified under Sector V in Table D-1 of Appendix D of the permit.

V.2 Industrial Activities Covered by Sector V.

Permittees under Sector V are primarily engaged in the following types of activities:

V.2.1 textile mill product preparation, including preparation of fiber and subsequent manufacturing of yarn, thread, braids, twine, and cordage; and the manufacture of broadwoven fabrics, narrow-woven fabrics, knit fabrics, and carpets and rugs from yarn;

V.2.2 processes involved in the dyeing and finishing of fibers, yarn fabrics, and knit apparel;

V.2.3 integrated manufacturing of knit apparel and other finished articles of yarn;

V.2.4 manufacturing of felt goods (e.g., wool), lace goods, non-woven fabrics, miscellaneous textiles, and other apparel products.

V.3 Limitations on Coverage.

V.3.1 *Prohibition of Non-Stormwater Discharges.* (See also Part 1.2.4) The following are not authorized by this permit: discharges of wastewater (e.g., wastewater resulting from wet processing or from any processes relating to the production process), reused or recycled water, and waters used in cooling towers. If you have these types of discharges from your facility, you must cover them under a separate NPDES permit.

V.4 Stormwater Pollution Prevention Plan (SWPPP) Requirements.

In addition to the following requirements, you must also comply with the requirements listed in Part 4 of the permit.

V.4.1 *Potential Pollutant Sources.* (See also Part 2.1.4) Describe the following additional sources and activities that have potential pollutants associated with them: industry-specific significant materials and industrial activities (e.g., backwinding, beaming, bleaching, backing bonding, carbonizing, carding, cut and sew operations, desizing, drawing, dyeing locking, fulling, knitting, mercerizing, opening, packing, plying, scouring, slashing, spinning, synthetic-felt processing, textile waste processing, tufting, turning, weaving, web forming, winging, yarn spinning, and yarn texturing).

V.4.2 *Good Housekeeping Measures.* (See also Part 2.1.5.1)

V.4.2.1 *Material Storage Areas.* Plainly label and store all containerized materials (e.g., fuels, petroleum products, solvents, and dyes) in a protected area, away from drains. Describe and implement measures that prevent or minimize contamination of the stormwater runoff from such storage areas, including a description of the containment area or enclosure for those materials stored outdoors. Also consider an inventory control plan to prevent excessive purchasing of potentially hazardous substances. For storing empty chemical drums or containers, ensure that the drums and containers are clean (consider triple-rinsing) and that there is no contact of residuals with precipitation or runoff. Collect and dispose of washwater from these cleanings properly.

V.4.2.2 *Material Handling Areas.* Describe and implement measures that prevent or minimize contamination of stormwater runoff from material handling operations and areas. Consider the following (or their equivalents): use of spill and overflow protection; covering fueling areas; and covering or enclosing areas where the transfer of material may occur. When applicable, address the replacement or repair of leaking connections, valves, transfer lines, and pipes that may carry chemicals, dyes, or wastewater.

V.4.2.3 *Fueling Areas.* Describe and implement measures that prevent or minimize contamination of stormwater runoff from fueling areas. Consider the following (or their equivalents): covering the fueling area, using spill and overflow protection, minimizing runon of stormwater to the fueling areas, using dry cleanup methods, and treating and/or recycling stormwater runoff collected from the fueling area.

V.4.2.4 *Above-Ground Storage Tank Area.* Describe and implement measures that prevent or minimize contamination of the stormwater runoff from above-ground storage tank areas, including the associated piping and valves. Consider the following (or their equivalents): regular cleanup of these areas; preparing the SPCC program to provide spill and overflow protection; minimizing runoff of stormwater from adjacent areas; restricting access to the area; inserting filters in adjacent catch basins; providing absorbent booms in unbermed fueling areas; using dry cleanup methods; and permanently sealing drains within critical areas that may discharge to a storm drain.

V.4.3 *Inspections.* (See also Part 2.1.5.5) Inspect, at least monthly, the following activities and areas (at a minimum): transfer and transmission lines, spill prevention, good housekeeping practices, management of process waste products, and all structural and nonstructural management practices.

V.4.4 *Employee Training.* (See also Part 2.1.5.6) As part of your employee training program, address, at a minimum, the following activities (as applicable): use of reused and recycled waters, solvents management, proper disposal of dyes, proper disposal of petroleum products and spent lubricants, spill prevention and control, fueling procedures, and general good housekeeping practices.

V.4.5 *Comprehensive Site Compliance Evaluation.* (See also Part 3.1) Conduct regularly scheduled evaluations at least once a year, and address those areas contributing to a stormwater discharge associated with industrial activity for evidence of, or the potential for, pollutants entering the drainage system. Inspect, at a minimum, as appropriate: storage tank areas, waste disposal and storage areas, dumpsters and open containers stored outside, materials storage areas, engine maintenance and repair areas, and material handing areas and loading dock areas.

V.5 Monitoring and Reporting Requirements. (See also Part 3 of the permit.)

Table V-1. Sector-specific Numeric Effluent Limitations and Benchmark Monitoring

Subsector (Discharges may be subject to requirements for more than one sector/subsector)	Parameter	Benchmark Monitoring Concentration[1]	Effluent Limitation Guidelines
Textile Mills, Apparel, and Other Fabric Product Manufacturing; and Leather and Leather Products (SIC 2211-2299, 2311-2399, 3131-3199, except 3111)	Total Suspended Solids (TSS)	100 mg/L	--

[1]You must monitor quarterly in the first year of your coverage for each benchmark parameter (see Part 3.2.2.1). For each parameter, no additional benchmark monitoring is required if the average of your 4 monitoring values does not exceed the benchmark (see Part 3.2.2.3). However, for each parameter there are additional requirements if the average of your four monitoring values exceeds the benchmark (see Part 3.2.2.4).

Part 4 - Sector-Specific Requirements for Industrial Activity
Subsection W - Sector W-Furniture and Fixtures

W.1 Covered Stormwater Discharges.

The requirements in Subsection W apply to stormwater discharges associated with industrial activity from furniture and fixtures facilities as identified by the Activity Code specified under Sector W in Table D-1 of Appendix D of the permit.

W.2 Industrial Activities Covered by Sector W.

Permittees under Sector W are primarily engaged in are the manufacturing of the following types of products:

W.2.1 wood kitchen cabinets;

W.2.2 household furniture;

W.2.3 office furniture;

W.2.4 public buildings and related furniture;

W.2.5 partitions, shelving, lockers, and office and store fixtures; and

W.2.6 miscellaneous furniture and fixtures.

W.3 Stormwater Pollution Prevention Plan (SWPPP) Requirements.

In addition to the following requirements, you must also comply with the requirements listed in Part 2 of this permit.

W.3.1 *Drainage Area Site Map.* (See also Part 2.1.2) Identify where any of the following may be exposed to precipitation or surface runoff: material storage (including tanks or other vessels used for liquid or waste storage) areas; outdoor material processing areas; areas where wastes are treated, stored, or disposed of; access roads; and rail spurs.

W.4 Monitoring and Reporting Requirements. (See also Part 3 of the permit.)

Table W-1. Sector-specific Numeric Effluent Limitations and Benchmark Monitoring			
Subsector (Discharges may be subject to requirements for more than one sector/subsector)	Parameter	Benchmark Monitoring Concentration[1]	Effluent Limitation Guidelines
Furniture and Fixtures (SIC 2434, 2511-2599)	Total Suspended Solids (TSS)	100 mg/L	--

[1]You must monitor quarterly in the first year of your coverage for each benchmark parameter (see Part 3.2.2.1). For each parameter, no additional benchmark monitoring is required if the average of your 4 monitoring values does not exceed the benchmark (see Part 3.2.2.3). However, for each parameter there are additional requirements if the average of your four monitoring values exceeds the benchmark (see Part 3.2.2.4).

Part 4 -Sector-Specific Requirements for Industrial Activity
Subsection X - Sector X-Printing and Publishing

X.1 Covered Stormwater Discharges.

The requirements in Subsection X apply to stormwater discharges associated with industrial activity from printing and publishing facilities as identified by the Activity Code specified under Sector X in Table D-1 of Appendix D of the permit.

X.2 Industrial Activities Covered by Sector X

Permittees under Sector X are primarily engaged in the following types of activities:

X.2.1 book printing;

X.2.2 commercial printing and lithographics;

X.2.3 platemaking and related services;

X.2.4 commercial printing, gravure; and

X.2.5 commercial printing not elsewhere classified.

X.3 Stormwater Pollution Prevention Plan Requirements.

In addition to the following requirements, you must also comply with the requirements listed in Part 2 of the permit.

X.3.1 *Drainage Area Site Map.* (See also Part 2.1.2) Identify where any of the following may be exposed to precipitation or surface runoff: above-ground storage tanks, drums, and barrels permanently stored outside.

X.3.2 *Potential Pollutant Sources.* (See also Part 2.1.4) Describe the following additional sources and activities that have potential pollutants associated with them, as applicable: loading and unloading operations, outdoor storage activities, significant dust or particulate generating processes, and onsite waste disposal practices (e.g., blanket wash). Also identify the pollutant or pollutant parameter (e.g., oil and grease, scrap metal) associated with each pollutant source.

X.3.3 *Good Housekeeping Measures.* (See also Part 2.1.5.1)

X.3.3.1 *Material Storage Areas.* Plainly label and store all containerized materials (e.g., skids, pallets, solvents, bulk inks, hazardous waste, empty drums, portable and mobile containers of plant debris, wood crates, steel racks, fuel oil) in a protected area, away from drains. Describe and implement measures that prevent or minimize contamination of the stormwater runoff from such storage areas, including a description of the containment area or enclosure for those materials stored outdoors. Also consider an inventory control plan to prevent excessive purchasing of potentially hazardous substances.

X.3.3.2 *Material Handling Area.* Describe and implement measures that prevent or minimize contamination of stormwater runoff from material handling operations and areas (e.g., blanket wash, mixing solvents, loading and unloading materials). Consider the following (or their equivalents): using spill and overflow protection, covering fueling areas, and covering or enclosing areas where the transfer of materials may occur. When applicable, address the replacement or repair of leaking connections, valves, transfer lines, and pipes that may carry chemicals or wastewater.

X.3.3.3 *Fueling Areas.* Describe and implement measures that prevent or minimize contamination of stormwater runoff from fueling areas. Consider the following (or their equivalents): covering the fueling area, using spill and overflow protection, minimizing runoff of stormwater to the fueling areas, using dry cleanup methods, and treating and/or recycling stormwater runoff collected from the fueling area.

X.3.3.4 *Above Ground Storage Tank Area.* Describe and implement measures that prevent or minimize contamination of the stormwater runoff from above-ground storage tank areas, including the associated piping and valves. Consider the following (or their equivalents): regularly cleaning these areas, preparing the SPCC program, providing spill and overflow protection, minimizing stormwater runoff from adjacent areas, restricting access to the area, inserting filters in adjacent catch basins, providing absorbent booms in unbermed fueling areas, using dry cleanup methods, and permanently sealing drains within critical areas that may discharge to a storm drain.

X.3.4 *Employee Training.* (See also Part 2.1.5.6) As part of your employee training program, address, at a minimum, the following activities (as applicable): spent solvent management, spill prevention and control, used oil management, fueling procedures, and general good housekeeping practices.

X.4 Monitoring and Reporting Requirements. (See also Part 3 of the permit.)

Table X-1. Sector-specific Numeric Effluent Limitations and Benchmark Monitoring			
Subsector (Discharges may be subject to requirements for more than one sector/subsector)	**Parameter**	**Benchmark Monitoring Concentration[1]**	**Effluent Limitation Guidelines**
Printing and Publishing (SIC 2711-2796)	Total Suspended Solids (TSS)	100 mg/L	--

[1]You must monitor quarterly in the first year of your coverage for each benchmark parameter (see Part 3.2.2.1). For each parameter, no additional benchmark monitoring is required if the average of your 4 monitoring values does not exceed the benchmark (see Part 3.2.2.3). However, for each parameter there are additional requirements if the average of your four monitoring values exceeds the benchmark (see Part 3.2.2.4).

Part 4 - Sector-Specific Requirements for Industrial Activity
Subsection Y - Sector Y-Rubber, Miscellaneous Plastic Products, and Miscellaneous Manufacturing Industries.

Y.1 Covered Stormwater Discharges.

The requirements in Subsection Y apply to stormwater discharges associated with industrial activity from rubber, miscellaneous plastic products, and miscellaneous manufacturing industries facilities as identified by the SIC Codes specified under Sector Y in Table D-1 of Appendix D of the permit.

Y.2 Stormwater Pollution Prevention Plan (SWPPP) Requirements.

In addition to the following requirements, you must also comply with the requirements listed in Part 2 of the permit.

Y.2.1 *Potential Pollutant Sources for Rubber Manufacturers.* (See also Part 2.1.4) Review the use of zinc at your facility and the possible pathways through which zinc may be discharged in stormwater runoff.

Y.2.2 *Controls for Rubber Manufacturers.* (See also Part 2.1.5) Describe and implement specific controls to minimize the discharge of zinc in your stormwater discharges. Parts Y.2.2.1 to Y.2.2.5 give possible sources of zinc to be reviewed and list some specific BMPs to be considered for implementation (or their equivalents). Following are some general BMP options to consider: using chemicals purchased in pre-weighed, sealed polyethylene bags; storing in-use materials in sealable containers, ensuring an airspace between the container and the cover to minimize "puffing" losses when the container is opened, and using automatic dispensing and weighing equipment.

Y.2.2.1 *Inadequate Housekeeping.* Review the handling and storage of zinc bags at your facility. Following are some BMP options: employee training on the handling and storage of zinc bags, indoor storage of zinc bags, cleanup of zinc spills without washing the zinc into the storm drain, and the use of 2,500-pound sacks of zinc rather than 50- to 100-pound sacks.

Y.2.2.2 *Dumpsters.* Reduce discharges of zinc from dumpsters. Following are some BMP options: covering the dumpster, moving the dumpster indoors, or providing a lining for the dumpster.

Y.2.2.3 *Malfunctioning Dust Collectors or Baghouses.* Review dust collectors or baghouses as possible sources in zinc in stormwater runoff. Replace or repair, as appropriate, improperly operating dust collectors or baghouses.

Y.2.2.4 *Grinding Operations.* Review dust generation from rubber grinding operations and, as appropriate, install a dust collection system.

Y.2.2.5 *Zinc Stearate Coating Operations.* Detail appropriate measures to prevent or clean up drips and spills of zinc stearate slurry that may be released to the storm drain. One BMP option is to use alternative compounds to zinc stearate.

Y.2.3 *Controls for Plastic Products Manufacturers.* Describe and implement specific controls to minimize the discharge of plastic resin pellets in your stormwater discharges. BMPs to be considered for implementation (or their equivalents) include minimizing spills, cleaning up of spills promptly and thoroughly, sweeping thoroughly, pellet capturing, employee education, and disposal precautions.

Y.3 Monitoring and Reporting Requirements. (See also Part 3 of the permit.)

Table Y-1. Sector-specific Numeric Effluent Limitations and Benchmark Monitoring

Subsector (Discharges may be subject to requirements for more than one sector/subsector)	Parameter	Benchmark Monitoring Concentration[1]	Effluent Limitation Guidelines
Tires and Inner Tubes; Rubber Footwear; Gaskets, Packing and Sealing Devices; and Rubber Hose and Belting; and Fabricated Rubber Products, Not Elsewhere Classified (SIC 3011-3069, rubber manufacturing only)	Total Recoverable Zinc[2]	0.12 mg/L	--
	Total Recoverable Lead[3]	0.082 mg/L	--
	Total Suspended Solids (TSS)	100 mg/L	–
Miscellaneous Plastics Products (SIC 3081-3089); Musical Instruments (SIC 3931); Dolls, Toys, Games and Sporting and Athletic Goods (SIC 3942-3949); Pens, Pencils, and other Artists' Materials (SIC 3951-3955, except 3952 as Specified in Sector C); Costume Jewelry, Costume Novelties, Buttons, and Miscellaneous Notions, Except Precious Metal (SIC 3961, 3965); and Miscellaneous Manufacturing Industries (SIC 3991-3999)	Total Suspended Solids (TSS)	100 mg/L	--

[1]You must monitor quarterly in the first year of your coverage for each benchmark parameter (see Part 3.2.2.1). For each parameter, no additional benchmark monitoring is required if the average of your 4 monitoring values does not exceed the benchmark (see Part 3.2.2.3). However, for each parameter there are additional requirements if the average of your four monitoring values exceeds the benchmark (see Part 3.2.2.4).

[2] The benchmark value of zinc is determined as a function of hardness (in units of mg/L) in the water column. The value given in Table Y-1 (i.e. 0.12 mg/L) corresponds to a hardness of 100 mg/L and should be used if you either did not analyze water hardness, other hardness data are not available, or the water hardness is less than 100 mg/L. If a laboratory analysis indicates that the water hardness is below 100 mg/L, then you should use the benchmark for 100 mg/L. If a laboratory analysis indicates that the water hardness is greater than 100 mg/L, then the following equation may be used to determine the benchmark value for zinc:

$$\text{Benchmark} = (e^{[(0.8473)(\ln \textit{hardness}) + 0.884]})/1000$$

Example: Laboratory analysis of your water sample indicates the hardness is 175 mg/L.

$$\text{Benchmark} = (e^{[(0.8473)(\ln 175) + 0.884]})/1000$$
$$= (e^{5.26})/1000$$
$$= 192.51/1000$$
$$= 0.19 \text{ mg/L}$$

The following are example benchmark values for zinc:

Hardness (mg/L)	Benchmark value (mg/L)
100	0.12
125	0.14
150	0.17
175	0.19
200	0.22
225	0.24
250	0.26

[3] The benchmark value of lead is determined as a function of hardness (in units of mg/L) in the water column. The value given in Table Y-1 (i.e. 0.082 mg/L) corresponds to a hardness of 100 mg/L and should be used if you either did not analyze water hardness, other hardness data are not available, or the water hardness is less than 100 mg/L. If a laboratory analysis indicates that the water hardness is below 100 mg/L, then you should use the benchmark for 100 mg/L. If a laboratory analysis indicates that the water hardness is greater than 100 mg/L, then the following equation may be used to determine the benchmark value for lead:

$$\text{Benchmark} = (e^{[(1.273)(\ln \textit{hardness}) - 1.460]})/1000$$

Example: Laboratory analysis of your water sample indicates the hardness is 175 mg/L.

$$\text{Benchmark} = (e^{[(1.273)(\ln 175) - 1.460]})/1000$$
$$= (e^{5.1148})/1000$$
$$= 166.46/1000$$
$$= 0.17 \text{ mg/L}$$

The following are example benchmark value for lead:

Hardness (mg/L)	Benchmark value (mg/L)
100	0.082
125	0.11
150	0.14
175	0.17
200	0.20
225	0.23
250	0.26

Part 4 - Sector-Specific Requirements for Industrial Activity
Subsection Z - Sector Z-Leather Tanning and Finishing

Z.1 Covered Stormwater Discharges.

The requirements in Subsection Z apply to stormwater discharges associated with industrial activity from leather tanning and finishing facilities as identified by the Activity Code specified under Sector Z in Table D-1 of Appendix D of the permit.

Z.2 Industrial Activities Covered by Sector Z.

Permittees under Sector Z are primarily engaged are leather tanning, currying, and finishing activities.

Z.3 Stormwater Pollution Prevention Plan (SWPPP) Requirements.

In addition to the following requirements, you must also comply with the requirements listed in Part 2 of the permit.

Z.3.1 *Drainage Area Site Map.* (See also Part 2.1.2) Identify where any of the following may be exposed to precipitation or surface runoff: processing and storage areas of the beamhouse, tanyard, and re-tan wet finishing and dry finishing operations; and haul roads, access roads, and rail spurs.

Z.3.2 *Potential Pollutant Sources.* (See also Part 2.1.4) At a minimum, describe the following additional sources and activities that have potential pollutants associated with them (as appropriate): temporary or permanent storage of fresh and brine-cured hides; extraneous hide substances and hair; leather dust, scraps, trimmings, and shavings; chemical drums, bags, containers, and above-ground tanks; empty chemical containers and bags; spent solvents; floor sweepings and washings; refuse, waste piles, and sludge; and significant dust/particulate generating processes (e.g., buffing).

Z.3.3 *Good Housekeeping Measures.* (See also Part 2.1.5.1)

Z.3.3.1 *Storage Areas for Raw, Semiprocessed, or Finished Tannery By-products.* Pallets and bales of raw, semiprocessed, or finished tannery by-products (e.g., splits, trimmings, shavings) should be stored indoors or protected by polyethylene wrapping, tarpaulins, roofed storage, etc. Consider placing materials on an impermeable surface and enclosing or putting berms (or equivalent measures) around the area to prevent stormwater runon and runoff.

Z.3.3.2 *Material Storage Areas.* Label storage containers of all materials (e.g., specific chemicals, hazardous materials, spent solvents, waste materials). Describe and implement measures that prevent or minimize contact with stormwater.

Z.3.3.3 *Buffing and Shaving Areas.* Describe and implement measures that prevent or minimize contamination of stormwater runoff with leather dust from buffing and shaving areas. Consider dust collection enclosures, preventive inspection and maintenance programs, or other appropriate preventive measures.

Z.3.3.4 *Receiving, Unloading, and Storage Areas.* Describe and implement measures that prevent or minimize contamination of stormwater runoff from receiving, unloading, and storage areas. If these areas are exposed, consider the following (or their equivalents): covering all hides and chemical supplies, diverting drainage to the process sewer, or grade berming or curbing the area to prevent stormwater runoff.

Z.3.3.5 *Outdoor Storage of Contaminated Equipment.* Describe and implement measures that prevent or minimize contact of stormwater with contaminated equipment. Consider the following (or their equivalents): covering equipment, diverting drainage to the process sewer, and cleaning thoroughly prior to storage.

Z.3.3.6 *Waste Management.* Describe and implement measures that prevent or minimize contamination of stormwater runoff from waste storage areas. Consider the following (or their equivalents): establishing inspection and maintenance programs for leaking containers or spills, covering dumpsters, moving waste management activities indoors, covering waste piles with temporary covering material such as tarpaulins or polyethylene, and minimizing stormwater runoff by enclosing the area or building berms around the area.

Z.4 Monitoring and Reporting Requirements. (See also Part 3 of the permit.)

Table Z-1. Sector-specific Numeric Effluent Limitations and Benchmark Monitoring

Subsector (Discharges may be subject to requirements for more than one sector/subsector)	Parameter	Benchmark Monitoring Concentration[1]	Effluent Limitation Guidelines
Leather Tanning and Finishing (SIC 3111)	Total Suspended Solids (TSS)	100 mg/L	--

[1]You must monitor quarterly in the first year of your coverage for each benchmark parameter (see Part 3.2.2.1). For each parameter, no additional benchmark monitoring is required if the average of your 4 monitoring values does not exceed the benchmark (see Part 3.2.2.3). However, for each parameter there are additional requirements if the average of your four monitoring values exceeds the benchmark (see Part 3.2.2.4).

Part 4 - Sector-Specific Requirements for Industrial Activity
Subsection AA - Sector AA-Fabricated Metal Products.

AA.1 Covered Stormwater Discharges.

The requirements in Subsection AA apply to stormwater discharges associated with industrial activity from fabricated metal products facilities as identified by the Activity Code specified under Sector AA in Table D-1 of Appendix D of the permit.

AA.2 Industrial Activities Covered by Sector AA.

Permittees under Sector AA are primarily engaged in the following types of activities:

AA.2.1 fabricated metal products; except for electrical related industries;

AA.2.2 fabricated metal products; except machinery and transportation equipment; and

AA.2.3 jewelry, silverware, and plated ware.

AA.3 Stormwater Pollution Prevention Plan (SWPPP) Requirements.

In addition to the following requirements, you must also comply with the requirements listed in Part 2 of the permit.

AA.3.1 *Drainage Area Site Map.* (See also Part 2.1.2) Identify where any of the following may be exposed to precipitation or surface runoff: raw metal storage areas; finished metal storage areas; scrap disposal collection sites; equipment storage areas; retention and detention basins; temporary and permanent diversion dikes or berms; right-of-way or perimeter diversion devices; sediment traps and barriers; processing areas, including outside painting areas; wood preparation; recycling; and raw material storage.

AA.3.2 *Spills and Leaks.* (See also Part 2.1.4.3) When listing significant spills and leaks, pay attention to the following materials (at a minimum): chromium, toluene, pickle liquor, sulfuric acid, zinc and other water priority chemicals, and hazardous chemicals and wastes.

AA.3.3 *Potential Pollutant Sources.* (See also Part 2.1.4) Describe the following additional sources and activities that have potential pollutants associated with them: loading and unloading operations for paints, chemicals, and raw materials; outdoor storage activities for raw materials, paints, empty containers, corn cobs, chemicals, and scrap metals; outdoor manufacturing or processing activities such as grinding, cutting, degreasing, buffing, and brazing; onsite waste disposal practices for spent solvents, sludge, pickling baths, shavings, ingot pieces, and refuse and waste piles.

AA.3.4 *Good Housekeeping Measures.* (See also Part 2.1.5.1)

AA.3.4.1 *Raw Steel Handling Storage.* Describe and implement measures for controlling or recovering scrap metals, fines, and iron dust. Include measures for containing materials within storage handling areas.

AA.3.4.2 *Paints and Painting Equipment.* Describe and implement measures to prevent or minimize exposure of paint and painting equipment to stormwater.

AA.3.5 *Spill Prevention and Response Procedures.* (See also Part 2.1.5.4) Ensure that the necessary equipment to implement a cleanup is available to personnel. The following areas should be addressed

AA.3.5.1 Metal Fabricating Areas. Describe and implement measures for maintaining clean, dry, orderly conditions in these areas. Consider using dry clean-up techniques.

AA.3.5.2 *Storage Areas for Raw Metal.* Describe and implement measures to keep these areas free of conditions that could cause spills or leakage of materials. Consider the following (or their equivalents): maintaining storage areas so that there is easy access in the event of a spill, and labeling stored materials to aid in identifying spill contents.

AA.3.5.3 *Receiving, Unloading, and Storage Areas.* Describe and implement measures to prevent spills and leaks, plan for quick remedial clean up, and instruct employees on clean-up techniques and procedures.

AA.3.5.4 *Storage of Equipment.* Describe and implement measures for preparing equipment for storage and the proper storage of equipment. Consider the following (or their equivalents): protecting equipment with covers, storing equipment indoors, and cleaning potential pollutants from equipment to be stored outdoors.

AA.3.5.5 *Metal Working Fluid Storage Areas.* Describe and implement measures for storage of metal working fluids.

AA.3.5.6 *Cleaners and Rinse Water.* Describe and implement measures to control and clean up spills of solvents and other liquid cleaners, control sand buildup and disbursement from sand-blasting operations, and prevent exposure of recyclable wastes. Substitute environmentally benign cleaners when possible.

AA.3.5.7 *Lubricating Oil and Hydraulic Fluid Operations.* Consider using monitoring equipment or other devices to detect and control leaks and overflows. Consider installing perimeter controls such as dikes, curbs, grass filter strips, or equivalent measures.

AA.3.5.8 *Chemical Storage Areas.* Describe and implement proper storage methods that prevent stormwater contamination and accidental spillage. Include a program to inspect containers and identify proper disposal methods.

AA.3.6 *Inspections.* (See also Part 2.1.5.5) At a minimum, include the following areas in all inspections: raw metal storage areas, finished product storage areas, material and chemical storage areas, recycling areas, loading and unloading areas, equipment storage areas, paint areas, and vehicle fueling and maintenance areas.

AA.3.7 *Comprehensive Site Compliance Evaluation.* (See also Part 3.1) As part of your evaluation, also inspect areas associated with the storage of raw metals, spent solvents and chemicals storage areas, outdoor paint areas, and drainage from roof. Potential pollutants include chromium, zinc, lubricating oil, solvents, aluminum, oil and grease, methyl ethyl ketone, steel, and related materials.

AA.4 Monitoring and Reporting Requirements. (See also Part 3 of the permit.)

Table AA-1. Sector-specific Numeric Limitations and Benchmark Monitoring

Subsector (Discharges may be subject to requirements for more than one sector/subsector)	Parameter	Benchmark Monitoring Concentration[1]	Effluent Limitation Guidelines
Fabricated Metal Products, except Coating (SIC 3411-3499; 3911-3915)	Total Recoverable Aluminum	0.75 mg/L	--
	Total Recoverable Iron	1.0 mg/L	--
	Total Recoverable Zinc[2]	0.12 mg/L	--
	Total Suspended Solids (TSS)	100 mg/L	--
	Nitrate plus Nitrite Nitrogen	0.68 mg/L	--
Fabricated Metal Coating and Engraving (SIC 3479)	Total Recoverable Zinc[2]	0.12 mg/L	--
	Total Suspended Solids (TSS)	100 mg/L	--
	Nitrate plus Nitrite Nitrogen	0.68 mg/L	--

[1]You must monitor quarterly in the first year of your coverage for each benchmark parameter (see Part 3.2.2.1). For each parameter, no additional benchmark monitoring is required if the average of your 4 monitoring values does not exceed the benchmark (see Part 3.2.2.3). However, for each parameter there are additional requirements if the average of your four monitoring values exceeds the benchmark (see Part 3.2.2.4).

[2] The benchmark value of zinc is determined as a function of hardness (in units of mg/L) in the water column. The value given in Table AA-1 (i.e. 0.12 mg/L) corresponds to a hardness of 100 mg/L and should be used if you either did not analyze water hardness, other hardness data are not available, or the water hardness is less than 100 mg/L. If a laboratory analysis indicates that the water hardness is below 100 mg/L, then you should use the benchmark for 100 mg/L. If a laboratory analysis indicates that the water hardness is greater than 100 mg/L, then the following equation may be used to determine the benchmark value for zinc:

$$\text{Benchmark} = (e^{[(0.8473)(\ln \textit{hardness}) + 0.884]})/1000$$

Example: Laboratory analysis of your water sample indicates the hardness is 175 mg/L.

$$\text{Benchmark} = (e^{[(0.8473)(\ln 175) + 0.884]})/1000$$
$$= (e^{5.26})/1000$$
$$= 192.51/1000$$
$$= 0.19 \text{ mg/L}$$

The following are example benchmark values for zinc:

Hardness (mg/L)	Benchmark value (mg/L)
100	0.12
125	0.14
150	0.17
175	0.19
200	0.22
225	0.24
250	0.26

Part 4 - Sector-Specific Requirements for Industrial Activity
Subsection AB - Sector AB-Transportation Equipment, Industrial and Commercial Machinery

AB.1 Covered Stormwater Discharges.

The requirements in Subsection AB apply to stormwater discharges associated with industrial activity from transportation equipment, industrial or commercial machinery facilities as identified by the Activity Code specified under Sector AB in Table D-1 of Appendix D of the permit.

AB.2 Industrial Activities Covered by Sector AB.

Permittees under Sector AB are primarily engaged in the following types of activities:

AB.2.1 Industrial and commercial machinery (except computer and office equipment) (see Sector AC) and

AB.2.2 Transportation equipment (except ship and boat building and repairing) (see Sector R);

AB.3 Stormwater Pollution Plan (SWPPP) Requirements.

In addition to the following requirements, you must also comply with the requirements listed in Part 2 of the permit.

AB.3.1 *Drainage Area Site Map.* (See also Part 2.1.2) Identify where any of the following may be exposed to precipitation or surface runoff: vents and stacks from metal processing and similar operations.

AB.3.2 *Non-Stormwater Discharges.* (See also Part 2.1.4.5) If your facility has a separate NPDES permit (or has applied for a permit) authorizing discharges of wastewater, attach a copy of the permit (or the application) to your SWPPP. Any new wastewater permits issued or reissued to you must then replace the old one in your SWPPP. If you discharge wastewater, other than solely domestic wastewater, to a Publicly Owned Treatment Works (POTW), you must notify the POTW of the discharge (identify the types of wastewater discharged, including any stormwater). As proof of this notification, attach to your SWPPP a copy of the permit issued to your facility by the POTW or a copy of your notification to the POTW.

AB.4 Monitoring and Reporting Requirements. (See also Part 3 of the permit.)

Table AB-1. Sector-specific Numeric Effluent Limitations and Benchmark Monitoring			
Subsector (Discharges may be subject to requirements for more than one sector/subsector)	**Parameter**	**Benchmark Monitoring Concentration[1]**	**Effluent Limitation Guidelines**
Transportation Equipment, Industrial, or Commercial Machinery (SIC 3511-3599, except 3571-3579, 3711-3799, except 3731and 3732)	Total Suspended Solids (TSS)	100 mg/L	--

[1]You must monitor quarterly in the first year of your coverage for each benchmark parameter (see Part 3.2.2.1). For each parameter, no additional benchmark monitoring is required if the average of your 4 monitoring values does not exceed the benchmark (see Part 3.2.2.3). However, for each parameter there are additional requirements if the average of your four monitoring values exceeds the benchmark (see Part 3.2.2.4).

Part 4 - Sector-Specific Requirements for Industrial Activity
Subsection AC - Sector AC-Electronic and Electrical Equipment and Components, Photographic and Optical Goods.

AC.1 Covered Stormwater Discharges.

The requirements in Subsection AC apply to stormwater discharges associated with industrial activity from facilities that manufacture electronic and electrical equipment and components, photographic and optical goods as identified by the SIC Codes specified in Table D-1 of Appendix D of the permit.

AC.2 Industrial Activities Covered by Sector AC.

Permittees under Sector AC are primarily engaged in the manufacturing of the following types of products:

AC.2.1 measuring, analyzing, and controlling instruments;

AC.2.2 photographic, medical, and optical goods;

AC.2.3 watches and clocks;

AC.2.4 computer and office equipment; and

AC.2.5 electrical and electronic equipment and components.

AC.3 Stormwater Pollution Prevention Plan (SWPPP) Requirements.

No additional sector-specific requirements apply.

AC.4 Monitoring and Reporting Requirements. (See also Part 3 of the permit.)

Table AC-1. Sector-specific Numeric Effluent Limitations and Benchmark Monitoring			
Subsector (Discharges may be subject to requirements for more than one sector/subsector)	Parameter	Benchmark Monitoring Concentration[1]	Effluent Limitation Guidelines
Electronic, Electrical, Photographic, and Optical Goods (SIC 3571-3579, 3812-3873)	Total Suspended Solids (TSS)	100 mg/L	--
Electronic and Electrical Equipment and Components, except Computers (SIC 3612-3699)	Total Suspended Solids (TSS)	100 mg/L	--
	Total Recoverable Copper[2]	0.014 mg/L	--
	Total Recoverable Lead[3]	0.082 mg/L	--

[1]You must monitor quarterly in the first year of your coverage for each benchmark parameter (see Part 3.2.2.1). For each parameter, no additional benchmark monitoring is required if the average of your 4 monitoring values does not exceed the benchmark (see Part 3.2.2.3). However, for each parameter there are additional requirements if the average of your four monitoring values exceeds the benchmark (see Part 3.2.2.4).

[2] The benchmark value of copper is determined as a function of hardness (in units of mg/L) in the water column. The value given in Table AC-1 (i.e. 0.014 mg/L) corresponds to a hardness of 100 mg/L and should be used if you either did not analyze water hardness, other hardness data are not available, or the water hardness is less than 100 mg/L. If a laboratory analysis indicates that the water hardness is below 100 mg/L, then you should use the benchmark for 100 mg/L. If a laboratory analysis indicates that the water hardness is greater than 100 mg/L, then the following equation may be used to determine the benchmark value for copper:

$$\text{Benchmark} = (e^{[(0.9422)(\ln \textit{hardness}) - 1.700]})/1000$$

Example: Laboratory analysis of your water sample indicates the hardness is 175 mg/L.

$$\begin{aligned}\text{Benchmark} &= (e^{[(0.9422)(\ln 175) - 1.700]})/1000 \\ &= (e^{3.166})/1000 \\ &= 23.72/1000 \\ &= 0.024 \text{ mg/L}\end{aligned}$$

The following are example benchmark values for copper:

Hardness (mg/L)	Benchmark value (mg/L)
100	0.014
125	0.017
150	0.021
175	0.024
200	0.027
225	0.030
250	0.033

[3] The benchmark value of lead is determined as a function of hardness (in units of mg/L) in the water column. The value given in Table AC-1 (i.e. 0.082 mg/L) corresponds to a hardness of 100 mg/L and should be used if you either did not analyze water hardness, other hardness data are not available, or the water hardness is less than 100 mg/L. If a laboratory analysis indicates that the water hardness is below 100 mg/L, then you should use the benchmark for 100 mg/L. If a laboratory analysis indicates that the water hardness is greater than 100 mg/L, then the following equation may be used to determine the benchmark value for lead:

$$\text{Benchmark} = (e^{[(1.273)(\ln \textit{hardness}) - 1.460]})/1000$$

Example: Laboratory analysis of your water sample indicates the hardness is 175 mg/L.

$$\text{Benchmark} = (e^{[(1.273)(\ln 175) - 1.460]})/1000$$
$$= (e^{5.1148})/1000$$
$$= 166.46/1000$$
$$= 0.17 \text{ mg/L}$$

The following are example benchmark value for lead:

Hardness (mg/L)	Benchmark value (mg/L)
100	0.082
125	0.11
150	0.14
175	0.17
200	0.20
225	0.23
250	0.26

Part 4 - Sector-Specific Requirements for Industrial Activity
Subsection AD - Sector AD-Stormwater Discharges Designated by the Director as Requiring Permits.

AD.1 Covered Stormwater Discharges.

Sector AD is used to provide permit coverage for facilities designated by the Director as needing a stormwater permit, and any discharges of stormwater associated with industrial activity that do not meet the description of an industrial activity covered by Sectors A-AC.

AD.1.1 *Eligibility for Permit Coverage.* Because this sector is primarily intended for use by discharges designated by the Director as needing a stormwater permit (which is an atypical circumstance), and your facility may or may not normally be discharging stormwater associated with industrial activity, you must obtain the Director's written permission to use this permit prior to submitting an NOI. If you are authorized to use this permit, you will still be required to ensure that your discharges meet the basic eligibility provisions of this permit at Part 1.2.

AD.2 Stormwater Pollution Prevention Plan (SWPPP) Requirements.

The Director will establish any additional site specific SWPPP requirements for your facility above and beyond those found in Part 2 prior to authorizing you to be covered by this permit. Additional requirements necessary for protection of water quality or compliance with the Act would be based on the nature of activities at your facility and your stormwater discharges.

AD.3 Monitoring and Reporting Requirements. (See also Part 3 of the permit.)

Table AD-1. Sector-specific Numeric Effluent Limitations and Benchmark Monitoring			
Subsector (Discharges may be subject to requirements for more than one sector/subsector)	**Parameter**	**Benchmark Monitoring Concentration[1]**	**Effluent Limitation Guidelines**
Non-Classified Facilities, Others (SIC N/A)	Total Suspended Solids (TSS)	100 mg/L	--

[1]You must monitor quarterly in the first year of your coverage for each benchmark parameter (see Part 3.2.2.1). For each parameter, no additional benchmark monitoring is required if the average of your 4 monitoring values does not exceed the benchmark (see Part 3.2.2.3). However, for each parameter there are additional requirements if the average of your four monitoring values exceeds the benchmark (see Part 3.2.2.4).

The Director will establish any additional monitoring and reporting requirements for your facility prior to authorizing you to be covered by this permit. Additional monitoring requirements would be based on the nature of activities at your facility and your stormwater discharges.

Part 5. State and Tribal Specific Requirements

Permit conditions applicable to specific states, Indian country, or territories will be addressed in the final permit through the 401 certification process.

Appendix A
Definitions, Abbreviations and Acronyms

Appendix A. Definitions.

Best Management Practices (BMPs) - schedules of activities, practices (and prohibitions of practices), structures, vegetation, maintenance procedures, and other management practices to prevent or reduce the discharge of pollutants to waters of the United States. BMPs also include treatment requirements, operating procedures, and practices to control plant site runoff, spillage or leaks, sludge or waste disposal, or drainage from raw material storage.

Co-located Industrial Activities – occurs when a facility has industrial activities included in more than one industrial sector. Stormwater discharges from co-located activities must comply with requirements for all relevant sectors.

Control Measure - refers to any BMP or other method (including effluent limitations) used to prevent or reduce the discharge of pollutants to waters of the United States.

Director - a regional administrator of the Environmental Protection Agency or an authorized representative.

Discharge - when used without qualification, means the "discharge of a pollutant."

Discharge of a pollutant - any addition of any "pollutant" or combination of pollutants to "waters of the United States" from any "point source," or any addition of any pollutant or combination of pollutants to the waters of the "contiguous zone" or the ocean from any point source other than a vessel or other floating craft which is being used as a means of transportation. This includes additions of pollutants into waters of the United States from: surface runoff which is collected or channeled by man; discharges through pipes, sewers, or other conveyances, leading into privately owned treatment works.

Discharge-related activities - activities which cause, contribute to, or result in stormwater and allowable non-stormwater point source discharges, and measures such as the siting, construction and operation of BMPs to control, reduce, or prevent pollution in the discharges.

Facility or Activity - any NPDES "point source" or any other facility or activity (including land or appurtenances thereto) that is subject to regulation under the NPDES program.

Impaired Water – a water is impaired if it does not meet its designated use(s). For purposes of this permit 'impaired' refers to threatened and impaired waters in categories 4a (those for which TMDLs have been established), 4b (those for which existing controls such as permits are expected to resolve the impairment), and 5 (those needing a TMDL) of a state's or tribe's integrated report on water quality. Impaired waters compilations are also sometimes referred to as 303(d) lists; 303(d) lists generally include only waters for which TMDLs have not yet been developed. States will generally have associated, but separate lists of impaired waters for which TMDLs have already been established.

Indian Country - (a) all land within the limits of any Indian reservation under the jurisdiction of the United States Government, notwithstanding the issuance of any patent, and including rights-of-way running through the reservation; (b) all dependent Indian communities within the borders of the United States, whether within the original or subsequently acquired territory thereof, and whether within or without the limits of a State, and (c) all Indian allotments, the Indian titles to which have not been extinguished, including rights-of-way running through the same. This definition includes all land held in trust for an Indian Tribe. (18 U.S.C. 1151)

Industrial Activity - the 11 categories of industrial activities included in the definition of "stormwater discharges associated with industrial activity."

Industrial Stormwater - stormwater runoff associated with the definition of "stormwater discharges associated with industrial activity."

Municipal Separate Storm Sewer - a conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains):

(i) Owned or operated by a State, city, town, borough, county, parish, district, association, or other public body (created by or pursuant to State law) having jurisdiction over disposal of sewage, industrial wastes, stormwater, or other wastes, including special districts under State law such as a sewer district, flood control district or drainage district, or similar entity, or an Indian tribe or an authorized Indian tribal organization, or a designated and approved management agency under section 208 of the CWA that discharges to waters of the United States;
(ii) Designed or used for collecting or conveying stormwater;
(iii) Which is not a combined sewer; and
(iv) Which is not part of a Publicly Owned Treatment Works (POTW) as defined at 40 CFR 122.2.

New Discharger - as used in this permit, means an operator applying for coverage under this permit for discharges not covered previously under an NPDES general or individual permit.

New Source - any building, structure, facility, or installation from which there is or may be a "discharge of pollutants," the construction of which commenced:

- after promulgation of standards of performance under section 306 of the CWA which are applicable to such source, or
- after proposal of standards of performance in accordance with section 306 of the CWA which are applicable to such source, but only if the standards are promulgated in accordance with section 306 within 120 days of their proposal.

No exposure - all industrial materials or activities are protected by a storm-resistant shelter to prevent exposure to rain, snow, snowmelt, and/or runoff.

Owner or operator - the owner or operator of any "facility or activity" subject to regulation under the NPDES program.

Person - an individual, association, partnership, corporation, municipality, State or Federal agency, or an agent or employee thereof.

Point source - any discernible, confined, and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, landfill leachate collection system, vessel, or other floating craft from which pollutants are or may be discharged. This term does not include return flows from irrigated agriculture or agricultural stormwater runoff.

Primary industrial activity - includes any activities performed on-site which are identified in the narrative descriptions of 122.26(b)(14)(i), (iv), (v), or (vii), and (ix); and activities which are identified by the facility's primary SIC code. [It is recommended that this determination be based on the value of receipts or revenues or, if such information is not available for a particular facility, the number of employees or production rate for each process may be compared. The operation that generates the most revenue or employs the most personnel is the operation in which the facility is primarily engaged.] Narrative descriptions identified above include: (i) activities subject to stormwater effluent limitations guidelines, new source performance standards, or toxic pollutant effluent standards; (iv) hazardous waste treatment storage, or disposal facilities including those that are operating under interim status or a permit under subtitle C of the Resource Conservation and Recovery Act (RCRA); (v) landfills, land application sites and open dumps that receive or have received industrial wastes; (vii) steam electric power generating facilities; and (ix) sewage treatment works with a design flow of 1.0 mgd or more.

Pollutant - dredged spoil, solid waste, incinerator residue, filter backwash, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt, and industrial, municipal and agricultural waste discharged into water.

Qualified Personnel - Qualified personnel are those who possess the knowledge and skills to assess conditions and activities that could impact stormwater quality at your facility, and who can also evaluate the effectiveness of BMPs.

Reportable Quantity Release – a release of a hazardous substance at or above the established legal threshold that requires emergency notification. Refer to 40 CFR Parts110, 177, and 302 for complete definitions and reportable quantities for which notification is required.

Runoff coefficient - the fraction of total rainfall that will appear at the conveyance as runoff.

Significant materials - includes, but is not limited to: raw materials; fuels; materials such as solvents, detergents, and plastic pellets; finished materials such as metallic products; raw materials used in food processing or production; hazardous substances designated under section 101(14) of CERCLA; any chemical the facility is required to report pursuant to section 313 of Title III of SARA; fertilizers; pesticides; and waste products such as ashes, slag and sludge that have the potential to be released with stormwater discharges.

Special Aquatic Sites - sites identified in 40 CFR 230 Subpart E. These are geographic areas, large or small, possessing special ecological characteristics of productivity, habitat, wildlife protection, or other important and easily disrupted ecological values. These areas are generally recognized as significantly influencing or positively contributing to the general overall environmental health or vitality of the entire ecosystem of a region.

Stormwater - stormwater runoff, snow melt runoff, and surface runoff and drainage.

Stormwater Discharges Associated with Construction Activity - a discharge of pollutants in stormwater runoff from areas where soil disturbing activities (e.g., clearing, grading, or excavation), construction materials, or equipment storage or maintenance (e.g., fill piles, borrow areas, concrete truck washout, fueling), or other industrial stormwater directly related to the construction process (e.g., concrete or asphalt batch plants) are located. (See 40 CFR 122.26(b)(14)(x) and 40 CFR 122.26(b)(15) for the two regulatory definitions on regulated stormwater associated with construction sites.)

Stormwater Discharges Associated with Industrial Activity - the discharge from any conveyance that is used for collecting and conveying stormwater and that is directly related to manufacturing, processing or raw materials storage areas at an industrial plant. The term does not include discharges from facilities or activities excluded from the NPDES program under Part 122. For the categories of industries identified in this section, the term includes, but is not limited to, stormwater discharges from industrial plant yards; immediate access roads and rail lines used or traveled by carriers of raw materials, manufactured products, waste material, or by-products used or created by the facility; material handling sites; refuse sites; sites used for the application or disposal of process waste waters (as defined at part 401 of this chapter); sites used for the storage and maintenance of material handling equipment; sites used for residual treatment, storage, or disposal; shipping and receiving areas; manufacturing buildings; storage areas (including tank farms) for raw materials, and intermediate and final products; and areas where industrial activity has taken place in the past and significant materials remain and are exposed to stormwater. For the purposes of this paragraph, material handling activities include storage, loading and unloading, transportation, or conveyance of any raw material, intermediate product, final product, by-product or waste product. The term excludes areas located on plant lands separate from the plant's industrial activities, such as office buildings and accompanying parking lots as long as the drainage from the excluded areas is not mixed with stormwater drained from the above described areas. Industrial facilities include those that are federally, State, or municipally owned or operated that meet the description of the facilities listed in Appendix D of this permit. The term also includes those facilities designated under the provisions of 40 CFR 122.26(a)(1)(v).

Total Maximum Daily Loads (TMDLs) - A TMDL is the sum of the allowable loads of a single pollutant from all contributing point and nonpoint sources. It is a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, and an allocation of that amount to the pollutant's sources. A TMDL stipulates wasteload allocations (WLAs) for point souce discharges, load allocations (LAs) for nonpoint sources, and a margin of safety (MOS).

Waters of the United States - means:

- All waters which are currently used, were used in the past, or may be susceptible to use in interstate or foreign commerce, including all waters that are subject to the ebb and flow of the tide;
- All interstate waters, including interstate "wetlands";
- All other waters, such as interstate lakes, rivers, streams (including intermittent streams), mudflats, sandflats, wetlands, sloughs, prairie potholes, wet meadows, playa lakes, or natural ponds, the use, degradation, or destruction of which would affect or could affect interstate or foreign commerce, including any such waters
  a. Which are or could be used by interstate or foreign travelers for recreational or other purposes;
  b. From which fish or shellfish are or could be taken and sold in interstate or foreign commerce; or
  c. Which are or could be used for industrial purposes by industries in interstate commerce;
- All impoundments of waters otherwise defined as waters of the United States under this definition;
- Tributaries of waters identified in paragraphs (1) through (4) of this definition;
- The territorial sea; and
- Wetlands adjacent to waters (other than waters that are themselves wetlands) identified in paragraphs 1 through 6 of this definition.

Waste treatment systems, including treatment ponds or lagoons designed to meet the requirements of the CWA (other than cooling ponds for steam electric generation stations as specified in 40 CFR 423) which also meet the criteria of this definition, are not waters of the United States. Waters of the United States do not include prior converted cropland. Notwithstanding the determination of an area's status as prior converted cropland by any other Federal agency, for the purposes of the CWA, the final authority regarding CWA jurisdiction remains with EPA.

Water Quality Impaired – See 'Impaired Water'.

"You" and "Your" - as used in this permit, are intended to refer to the permittee, the operator, or the discharger as the context indicates and that party's facility or responsibilities. The use of "you" and "your" refers to a particular facility and not to all facilities operated by a particular entity. For example, "you must submit" means the permittee must submit something for that particular facility. Likewise, "all your discharges" would refer only to discharges at that one facility.

A.2. ABBREVIATIONS AND ACRONYMS

ACHP – Advisory Council on Historic Preservation

APA – Administrative Procedure Act

BAT – Best Available Technology Economically Achievable

BOD5 – Biochemical Oxygen Demand (5-day test)

BMP – Best Management Practice

BPJ – Best Professional Judgment

BPT – Best Practicable Control Technology Currently Available

CAA – Clean Air Act

CERCLA – Comprehensive Environmental Response, Compensation and Liability Act

CGP – Construction General Permit

COD – Chemical Oxygen Demand

CSGWPP – Comprehensive State Ground Water Protection Program

CWA – Clean Water Act (or the Federal Water Pollution Control Act, 33 U.S.C. §1251 *et seq*)

CWT – Centralized Waste Treatment

DMR – Discharge Monitoring Report

ELG – Effluent Limitations Guidelines

EPA – U. S. Environmental Protection Agency

EPCRA – Emergency Planning and Community Right-to-know Act

ESA – Endangered Species Act

FEMA – U. S. Federal Emergency Management Agency

FWS – U. S. Fish and Wildlife Service

LA – Load Allocation

MGD – Million Gallons per Day

MOS – Margin of Safety

MS4 – Municipal Separate Storm Sewer System

MSDS – Material Safety Data Sheet

MSGP – Multi-Sector General Permit

NAICS – North American Industry Classification System

NEPA – National Environmental Policy Act

NHPA – National Historic Preservation Act

NMFS – U. S. National Marine Fisheries Service

NOI – Notice of Intent

NOT – Notice of Termination

NPDES – National Pollutant Discharge Elimination System

NRC – National Response Center

NRHP – National Register of Historic Places

NSPS – New Source Performance Standard

NTU – Nephelometric Turbidity Unit

NURP – Nationwide Urban Runoff Program

OMB – U. S. Office of Management and Budget

ORW – Outstanding Resource Water

OSM – U. S. Office of Surface Mining

POTW – Publicly Owned Treatment Works

PRA – Paperwork Reduction Act

RCRA – Resource Conservation and Recovery Act

RFA – Regulatory Flexibility Act

RQ – Reportable Quantity

SARA – Superfund Amendments and Reauthorization Act

SBREFA – Small Business Regulatory Enforcement Fairness Act

SDWA – Safe Drinking Water Act

SHPO – State Historic Preservation Officer

SIC – Standard Industrial Classification

SMCRA – Surface Mining Control and Reclamation Act

SPCC – Spill Prevention, Control, and Countermeasure

SWPPP – Stormwater Pollution Prevention Plan

THPO – Tribal Historic Preservation Officer

TMDL – Total Maximum Daily Load

TRI – Toxic Release Inventory

TSDF – Treatment, Storage, or Disposal Facility

TSS – Total Suspended Solids

UMRA – Unfunded Mandates Reform Act

USGS – United States Geological Survey

WLA – Wasteload Allocation

WQS – Water Quality Standard

Appendix B
Standard Permit Conditions

Appendix B. Standard Permit Conditions.

Standard permit conditions in Appendix B are consistent with the general permit provisions required under 40 CFR 122.41. Additional instructions may be included, however these standard conditions shall apply directly as incorporated from regulations.

B.1. Duty To Comply

You must comply with all conditions of this permit. Any permit noncompliance constitutes a violation of the Clean Water Act and is grounds for enforcement action; for permit termination, revocation and reissuance, or modification; or for denial of a permit renewal application.

A. You must comply with effluent standards or prohibitions established under section 307(a) of the Clean Water Act for toxic pollutants and with standards for sewage sludge use or disposal established under section 405(d) of the CWA within the time provided in the regulations that establish these standards or prohibitions or standards for sewage sludge use or disposal, even if the permit has not yet been modified to incorporate the requirement.

B. Penalties for Violations of Permit Conditions: The Director will adjust the civil and administrative penalties listed below in accordance with the Civil Monetary Penalty Inflation Adjustment Rule (61 FR 252, December 31, 1996, pp. 69359-69366, as corrected in 62 FR 54, March 20, 1997, pp.13514-13517) as mandated by the Debt Collection Improvement Act of 1996 for inflation on a periodic basis. This rule allows EPA's penalties to keep pace with inflation. The Agency is required to review its penalties at least once every 4 years thereafter and to adjust them as necessary for inflation according to a specified formula. The civil and administrative penalties following were adjusted for inflation starting in 1996.

1. Criminal Penalties.

1.1 Negligent Violations. The CWA provides that any person who negligently violates permit conditions implementing Sections 301, 302, 306, 307, 308, 318, or 405 of the Act is subject to criminal penalties of $2,500 to $25,000 per day of violation, or imprisonment of not more than one year, or both. In the case of a second or subsequent conviction for a negligent violation, a person shall be subject to criminal penalties or not more than $50,000 per day of violation or by imprisonment of not more than two years, or both.

1.2. *Knowing Violations.* The CWA provides that any person who knowingly violates permit conditions implementing Sections 301, 302, 306, 307, 308, 318, or 405 of the Act is subject to a fine of not less than $5,000 nor more than $50,000 per day of violation, or by imprisonment for not more than 3 years, or both. In the case of a second or subsequent conviction for a knowing violation, a person shall be subject to criminal penalties of not more than $100,000 per day of violation, or imprisonment of not more than 6 years, or both.

1.3. *Knowing Endangerment.* The CWA provides that any person who knowingly violates permit conditions implementing Sections 301, 302, 306, 307, 308, 318, or 405 of the Act and who knows at that time that he or she is placing another person in imminent danger of death or serious bodily injury shall upon conviction be subject to a fine of not more than $250,000 or by imprisonment of not more than 15 years, or both. In the case of a second or subsequent conviction for a knowing endangerment violation, a person shall be subject to a fine of not more than $500,000 or by imprisonment of not more than 30 years, or both. An organization, as defined in section 309(c)(3)(B)(iii) of the Act, shall, upon conviction of violating the imminent danger provision be subject to a fine of not more than $1,000,000 and can fined up to $2,000,000 for second or subsequent convictions.

1.4. *False Statement.* The CWA provides that any person who falsifies, tampers with, or knowingly renders inaccurate any monitoring device or method required to be maintained under this permit shall, upon conviction, be punished by a fine of not more than $10,000, or by imprisonment for not more than 2 years, or both. If a conviction of a person is for a violation committed after a first conviction of such person under this paragraph, punishment is a fine of not more than $20,000 per day of violation, or by imprisonment of not more than 4 years, or both. The Act further provides that any person who knowingly makes any false statement, representation, or certification in any record or other document submitted or required to be maintained under this permit, including monitoring reports or reports of compliance or non-compliance shall, upon conviction, be punished by a fine of not more than $10,000 per violation, or by imprisonment for not more than 6 months per violation, or by both.

2. *Civil Penalties.* The CWA provides that any person who violates a permit condition implementing Sections 301, 302, 306, 307, 308, 318, or 405 of the Act is subject to a civil penalty not to exceed the maximum amounts authorized by Section 309(d) of the Act and the Federal Civil Penalties Inflation Adjustment Act (28 U.S.C. § 2461 note) as amended by the Debt Collection Improvement Act (31 U.S.C. § 3701 note) (currently $32,500 per day for each violation).

3. *Administrative Penalties.* The CWA provides that any person who violates a permit condition implementing Sections 301, 302, 306, 307, 308, 318, or 405 of the Act is subject to an administrative penalty, as follows

3.1. *Class I Penalty.* Not to exceed the maximum amounts authorized by Section 309(g)(2)(A) of the Act and the Federal Civil Penalties Inflation Adjustment Act (28 U.S.C. § 2461 note) as amended by the Debt Collection Improvement Act (31 U.S.C. § 3701 note) (currently $11,000 per violation, with the maximum amount of any Class I penalty assessed not to exceed $32,500).

3.2. *Class II Penalty.* Not to exceed the maximum amounts authorized by Section 309(g)(2)(B) of the Act and the Federal Civil Penalties Inflation Adjustment Act (28 U.S.C. § 2461 note) as amended by the Debt Collection Improvement Act (31 U.S.C. § 3701 note) (currently $11,000 per day for each day during which the violation continues, with the maximum amount of any Class II penalty not to exceed $157,500).

B.2. Duty to Reapply

If you wish to continue an activity regulated by this permit after the expiration date of this permit, you must apply for and obtain a new permit.

B.3. Need to Halt or Reduce Activity Not a Defense

It shall not be a defense for you in an enforcement action that it would have been necessary to halt or reduce the permitted activity in order to maintain compliance with the conditions of this permit.

B.4. Duty to Mitigate

You must take all reasonable steps to minimize or prevent any discharge or sludge use or disposal in violation of this permit which has a reasonable likelihood of adversely affecting human health or the environment.

B.5. Proper Operation and Maintenance

You must at all times properly operate and maintain all facilities and systems of treatment and control (and related appurtenances) which are installed or used by you to achieve compliance with the conditions of this permit, including the requirements of your SWPPP. Proper operation and maintenance also includes adequate laboratory controls and appropriate quality assurance procedures. This provision requires the operation of backup or auxiliary facilities or similar systems which are installed by you only when the operation is necessary to achieve compliance with the conditions of this permit.

B.6. Permit Actions

This permit may be modified, revoked and reissued, or terminated for cause. Your filing of a request for a permit modification, revocation and reissuance, or termination, or a notification of planned changes or anticipated noncompliance does not stay any permit condition.

B.7. Property Rights

This permit does not convey any property rights of any sort, or any exclusive privileges.

B.8. Duty to Provide Information

You must furnish to EPA or an authorized representative (including an authorized contractor acting as a representative of EPA), within a reasonable time, any information which EPA may request to determine whether cause exists for modifying, revoking and reissuing, or terminating this permit or to determine compliance with this permit. You must also furnish to EPA upon request, copies of records required to be kept by this permit.

B.9. Inspection and Entry

You must allow EPA, or an authorized representative (including an authorized contractor acting as a representative of EPA), upon presentation of credentials and other documents as may be required by law, to:

A. Enter upon your premises where a regulated facility or activity is located or conducted, or where records must be kept under the conditions of this permit;

B. Have access to and copy, at reasonable times, any records that must be kept under the conditions of this permit;

C. Inspect at reasonable times any facilities, equipment (including monitoring and control equipment), practices, or operations regulated or required under this permit; and

D. Sample or monitor at reasonable times, for the purposes of assuring permit compliance or as otherwise authorized by the Clean Water Act, any substances or parameters at any location.

B.10. Monitoring and Records

A. Samples and measurements taken for the purpose of monitoring must be representative of the volume and nature of the monitored activity.

B. You must retain records of all monitoring information, including all calibration and maintenance records and all original strip chart recordings for continuous monitoring instrumentation, copies of all reports required by this permit, and records of all data used to complete the application for this permit, for a period of at least five years from the date of the sample, measurement, report or application. This period may be extended by request of EPA at any time.

C. Records of monitoring information must include:

1. The date, exact place, and time of sampling or measurements;

2. The individual(s) who performed the sampling or measurements;

3. The date(s) analyses were performed

4. The individual(s) who performed the analyses;

5. The analytical techniques or methods used; and

6. The results of such analyses.

D. Monitoring results must be conducted according to test procedures approved under 40 CFR Part 136 or, in the case of sludge use or disposal, approved under 40 CFR Part 136 unless otherwise specified in 40 CFR Part 503, unless other test procedures have been specified in the permit.

E. The Clean Water Act provides that any person who falsifies, tampers with, or knowingly renders inaccurate any monitoring device or method required to be maintained under this permit shall, upon conviction, be punished by a fine of not more than $10,000, or by imprisonment for not more than 2 years, or both. If a conviction of a person is for a violation committed after a first conviction of such person under this paragraph, punishment is a fine of not more than $20,000 per day of violation, or by imprisonment of not more than 4 years, or both.

B.11. Signatory Requirements

A. All applications, including NOIs, must be signed as follows:

1. For a corporation: By a responsible corporate officer. For the purpose of this subsection, a responsible corporate officer means: (i) a president, secretary, treasurer, or vice-president of the corporation in charge of a principal business function, or any other person who performs similar policy- or decision-making functions for the corporation, or (ii) the manager of one or more manufacturing, production, or operating facilities, provided, the manager is authorized to make management decisions which govern the operation of the regulated facility including having the explicit or implicit duty of making major capital investment recommendations, and initiating and directing other comprehensive measures to assure long term environmental compliance with environmental laws and regulations; the manager can ensure that the necessary systems are established or actions taken to gather complete and accurate information for permit application requirements; and where authority to sign documents has been assigned or delegated to the manager in accordance with corporate procedures.

2. For a partnership or sole proprietorship: By a general partner or the proprietor, respectively; or

3. For a municipality, state, federal, or other public agency: By either a principal executive officer or ranking elected official. For purposes of this subsection, a principal executive officer of a federal agency includes (i) the chief executive officer of the agency, or (ii) a senior executive officer having responsibility for the overall operations of a principal geographic unit of the agency (e.g., Regional Administrator of EPA).

B. All reports, including SWPPPs, inspection reports, annual reports, monitoring reports, reports on training and other information required by this permit must be signed by a person described in Appendix B, Subsection 11.A above or by a duly authorized representative of that person. A person is a duly authorized representative only if:

1. The authorization is made in writing by a person described in Appendix B, Subsection 11.A;

2. The authorization specifies either an individual or a position having responsibility for the overall operation of the regulated facility or activity such as the position of plant manager, operator of a well or a well field, superintendent, position of equivalent responsibility, or an individual or position having overall responsibility for environmental matters for the company. (A duly authorized representative may thus be either a named individual or any individual occupying a named position); and

3. The signed and dated written authorization is included in the SWPPP. A copy must be submitted to EPA, if requested.

C. Changes to Authorization. If an authorization under Appendix B, Subsection 11.B is no longer accurate because a different operator has responsibility for the overall operation of the construction site, a new NOI satisfying the requirements of Subsection 11.B must be submitted to EPA prior to or together with any reports, information, or applications to be signed by an authorized representative.

D. Any person signing documents required under the terms of this permit must include the following certification:

> "I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

E. The CWA provides that any person who knowingly makes any false statement, representation, or certification in any record or other document submitted or required to be maintained under this permit, including monitoring reports or reports of compliance or non-compliance shall, upon conviction, be punished by a fine of not more than $10,000 per violation, or by imprisonment for not more than 6 months per violation, or by both.

B.12. Reporting Requirements

A. Planned changes. You must give notice to EPA as soon as possible of any planned physical alterations or additions to the permitted facility. Notice is required only when:

1. The alteration or addition to a permitted facility may meet one of the criteria for determining whether a facility is a new source in 40 CFR §122.29(b); or

2. The alteration or addition could significantly change the nature or increase the quantity of pollutants discharged. This notification applies to pollutants which are subject neither to effluent limitations in the permit, nor to notification requirements under 40 CFR §122.42(a)(1).

B. Anticipated noncompliance. You must give advance notice to EPA of any planned changes in the permitted facility or activity which may result in noncompliance with permit requirements.

C. Transfers. This permit is not transferable to any person except after notice to EPA. EPA may require modification or revocation and reissuance of the permit to change the name of the permittee and incorporate such other requirements as may be necessary under the Clean Water Act. (See 40 CFR §122.61; in some cases, modification or revocation and reissuance is mandatory.)

D. Monitoring reports. Monitoring results must be reported at the intervals specified elsewhere in this permit.

1. Monitoring results must be reported on a Discharge Monitoring Report (DMR) or forms (paper or electronic) provided or specified by EPA for reporting results of monitoring of sludge use or disposal practices.

2. If you monitor any pollutant more frequently than required by the permit using test procedures approved under 40 CFR Part 136 or, in the case of sludge use or disposal, approved under 40 CFR Part 136 unless otherwise specified in 40 CFR Part 503, or as specified in the permit, the results of this monitoring must be included in the calculation and reporting of the data submitted in the DMR or sludge reporting form specified by EPA.

3. Calculations for all limitations which require averaging of measurements must use an arithmetic mean and non-detected results must be incorporated in calculations as the limit of quantitation for the analysis.

E. Compliance schedules. Reports of compliance or noncompliance with, or any progress reports on, interim and final requirements contained in any compliance schedule of this permit must be submitted no later than 14 days following each schedule date.

F. Twenty-four hour reporting.

1. You must report any noncompliance which may endanger health or the environment. Any information must be provided orally within 24 hours from the time you become aware of the circumstances. A written submission must also be provided within five days of the time you become aware of the circumstances. The written submission must contain a description of the noncompliance and its cause; the period of noncompliance, including exact dates and times, and if the noncompliance has not been corrected, the anticipated time it is expected to continue; and steps taken or planned to reduce, eliminate, and prevent reoccurrence of the noncompliance.

2. The following shall be included as information which must be reported within 24 hours under this paragraph.

   a. Any unanticipated bypass which exceeds any effluent limitation in the permit. (See 40 CFR §122.41(g).)

   b. Any upset which exceeds any effluent limitation in the permit

   c. Violation of a maximum daily discharge limitation for any of the pollutants listed by EPA in the permit to be reported within 24 hours. (See 40 CFR §122.44(g).)

3. EPA may waive the written report on a case-by-case basis for reports under Appendix B, Subsection 12.F.2 if the oral report has been received within 24 hours.

G. Other noncompliance. You must report all instances of noncompliance not reported under Appendix B, Subsections 12.D, 12.E, and 12.F, at the time monitoring reports are submitted. The reports must contain the information listed in Appendix B, Subsection 12.F.

H. Other information. Where you become aware that you failed to submit any relevant facts in a permit application, or submitted incorrect information in a permit application or in any report to the Permitting Authority, you must promptly submit such facts or information.

B.13. Bypass

A. Definitions.

1. Bypass means the intentional diversion of waste streams from any portion of a treatment facility

2. Severe property damage means substantial physical damage to property, damage to the treatment facilities which causes them to become inoperable, or substantial and permanent loss of natural resources which can reasonably be expected to occur in the absence of a bypass. Severe property damage does not mean economic loss caused by delays in production.

B. Bypass not exceeding limitations. You may allow any bypass to occur which does not cause effluent limitations to be exceeded, but only if it also is for essential maintenance to assure efficient operation. These bypasses are not subject to the provisions of Appendix B, Subsections 13.C and 13.D.

C. Notice–

1. Anticipated bypass. If you know in advance of the need for a bypass, you must submit prior notice, if possible at least ten days before the date of the bypass.

2. Unanticipated bypass. You must submit notice of an unanticipated bypass as required in Appendix B, Subsection 12.F (24-hour notice).

D. Prohibition of bypass.

1. Bypass is prohibited, and EPA may take enforcement action against you for bypass, unless:

   a. Bypass was unavoidable to prevent loss of life, personal injury, or severe property damage;

   b. There were no feasible alternatives to the bypass, such as the use of auxiliary treatment facilities, retention of untreated wastes, or maintenance during normal periods of equipment downtime. This condition is not satisfied if adequate back-up equipment should have been installed in the exercise of reasonable engineering judgment to prevent a bypass which occurred during normal periods of equipment downtime or preventive maintenance; and

   c. You submitted notices as required under Appendix B, Subsection 13.C.

2. EPA may approve an anticipated bypass, after considering its adverse effects, if EPA determines that it will meet the three conditions listed above in Appendix B, Subsection 13.D.1.

B.14. Upset

A. Definition. Upset means an exceptional incident in which there is unintentional and temporary noncompliance with technology based permit effluent limitations because of factors beyond your reasonable control. An upset does not include noncompliance to the extent caused by operational error, improperly designed treatment facilities, inadequate treatment facilities, lack of preventive maintenance, or careless or improper operation.

B. Effect of an upset. An upset constitutes an affirmative defense to an action brought for noncompliance with such technology based permit effluent limitations if the requirements of Appendix B, Subsection 14.C are met. No determination made during administrative review of claims that noncompliance was caused by upset, and before an action for noncompliance, is final administrative action subject to judicial review.

C. Conditions necessary for a demonstration of upset. A permittee who wishes to establish the affirmative defense of upset must demonstrate, through properly signed, contemporaneous operating logs, or other relevant evidence that:

1. An upset occurred and that you can identify the cause(s) of the upset;

2. The permitted facility was at the time being properly operated; and

3. You submitted notice of the upset as required in Appendix B, Subsection 12.F.2.b (24 hour notice).

4. You complied with any remedial measures required under Appendix B, Subsection 4.

D. Burden of proof. In any enforcement proceeding, you, as the one seeking to establish the occurrence of an upset, has the burden of proof.

Appendix C
Areas Covered

Appendix C. Permit Area.

EPA can only provide permit coverage in these areas and for classes of discharges that are outside the scope of a State's NPDES program authorization. For stormwater discharges outside the areas of coverage identified below, please contact your State NPDES permitting authority to obtain a State-issued NPDES permit.

C.1 EPA Region 1: Connecticut, Massachusetts, Maine, New Hampshire, Rhode Island, Vermont.

This permit offers NPDES permit coverage for stormwater discharges associated with industrial activity from the following areas in EPA Region 1:

Permit Number	Areas of Coverage/Where EPA Is Permitting Authority
CTR0500I	Indian Country lands within the State of Connecticut
MAR050000	Commonwealth of Massachusetts, except Indian Country lands
MAR05000I	Indian Country lands within the Commonwealth of Massachusetts
MER05000I	Indian Country lands within the State of Maine
NHR050000	State of New Hampshire
RIR05000I	Indian Country lands within the State of Rhode Island
VTR05000F	Federal facilities in the State of Vermont

For stormwater discharges in EPA Region 1 outside the areas of coverage identified above, please contact your State NPDES permitting authority to obtain a State-issued NPDES permit.

C.2 EPA Region 2: New Jersey, New York, Puerto Rico, Virgin Islands.

This permit offers NPDES permit coverage for stormwater discharges associated with industrial activity from the following areas in EPA Region 2:

Permit Number	Areas of Coverage/Where EPA Is Permitting Authority
PRR050000	Commonwealth of Puerto Rico

For stormwater discharges in EPA Region 2 outside the areas of coverage identified above, please contact your State NPDES permitting authority to obtain a State-issued NPDES permit.

C.3 EPA Region 3: Delaware, District of Columbia, Maryland, Pennsylvania, Virginia, West Virginia.

This permit offers NPDES permit coverage for stormwater discharges associated with industrial activity from the following areas in EPA Region 3:

Permit Number	Areas of Coverage/Where EPA Is Permitting Authority
DCR050000	District of Columbia
DER05000F	Federal facilities in the State of Delaware

For stormwater discharges in EPA Region 3 outside the areas of coverage identified above, please contact your State NPDES permitting authority to obtain a State-issued NPDES permit.

C.4 EPA Region 4: Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee (Coverage not available under this permit).

For stormwater discharges in EPA Region 4, please contact your State NPDES permitting authority to obtain a State-issued NPDES permit.

C.5 EPA Region 5: Illinois, Indiana, Michigan, Minnesota, Ohio, Wisconsin.

This permit offers NPDES permit coverage for stormwater discharges associated with industrial activity from the following areas in EPA Region 5:

Permit Number	Areas of Coverage/Where EPA Is Permitting Authority
MIR05000I	Indian Country lands within the State of Michigan
MNR05000I	Indian Country lands within the State of Minnesota
WIR05000I	Indian Country lands within the State of Wisconsin

For stormwater discharges in EPA Region 5 outside the areas of coverage identified above, please contact your State NPDES permitting authority to obtain a State-issued NPDES permit.

C.6 EPA Region 6: Arkansas, Louisiana, Oklahoma, Texas, and New Mexico (except see Region 9 for Navajo lands, and see Region 8 for Ute Mountain Reservation lands).

This permit offers NPDES permit coverage for stormwater discharges associated with industrial activity from the following areas in EPA Region 6:

Permit Number	Areas of Coverage/Where EPA Is Permitting Authority
LAR05000I	Indian Country lands within the State of Louisiana
NMR050000	The State of New Mexico, except Indian Country lands
NMR05000I	Indian Country lands within the State of New Mexico, except Ute Mountain Reservation lands that are covered under Colorado permit COR05000I listed in Part C.8 and Navajo Reservation lands that are covered under Arizona permit AZR05000I listed in Part C.9.
OKR05000I	Indian Country lands within the State of Oklahoma

Permit Number	Areas of Coverage/Where EPA Is Permitting Authority
OKR05000F	Facilities in the State of Oklahoma not under the jurisdiction of the Oklahoma Department of Environmental Quality, except those on Indian Country lands. EPA jurisdiction facilities include SIC Codes 1311, 1381, 1382, 1389, and 5171 and point source (but not nonpoint source) discharges associated with agricultural production, services, and silviculture.
TXR05000F	Facilities in the State of Texas not under the jurisdiction of the Texas Commission on Environmental Quality, except those on Indian Country lands. EPA-jurisdiction facilities include SIC Codes 1311, 1321, 1381, 1382, and 1389 (other than oil field service company "home base" facilities).
TXR05000I	Indian Country lands within the State of Texas

For stormwater discharges in EPA Region 6 outside the areas of coverage identified above, please contact your State NPDES permitting authority to obtain a State-issued NPDES permit.

C.7 EPA Region 7: Iowa, Kansas, Missouri, Nebraska (Coverage <u>not available</u> under this permit).

For stormwater discharges in EPA Region 7, please contact your State NPDES permitting authority to obtain a State-issued NPDES permit.

C.8 EPA Region 8: Colorado, Montana, North Dakota, South Dakota, Wyoming, Utah (Coverage <u>not available</u> under this permit).

For stormwater discharges in EPA Region 8 please contact EPA Region 8 or your State NPDES permitting authority to obtain an NPDES permit.

C.9 EPA Region 9: Arizona, California, Hawaii, Nevada, Guam, American Samoa, the Commonwealth of the Northern Mariana Islands, the Confederated Tribes of the Goshute Reservation in Utah and Nevada, Indian Country lands within the State of Arizona including the Navajo Reservation in Utah and New Mexico and Arizona, the Duck Valley Reservation in Idaho, and the Fort McDermitt Reservation in Oregon.

This permit offers NPDES permit coverage for stormwater discharges associated with industrial activity from the following areas in EPA Region 9:

Permit Number	Areas of Coverage/Where EPA Is Permitting Authority
ASR050000	The islands of American Samoa
AZR050000	The State of Arizona, except Indian Country lands
AZR05000I	Indian Country lands within the State of Arizona, including Navajo Reservation lands in New Mexico and Utah
CAR05000I	Indian Country lands within the State of California
GUR050000	The island of Guam

Permit Number	Areas of Coverage/Where EPA Is Permitting Authority
JAR050000	Johnston Atoll
MWR050000	Midway Island and Wake Island
NIR050000	Commonwealth of the Northern Mariana Islands
NVR05000I	Indian Country lands within the State of Nevada, including the Duck Valley Reservation in Idaho, the Fort McDermitt Reservation in Oregon and the Confederated Tribes of the Goshute Reservation in Utah

For stormwater discharges in EPA Region 9 outside the areas of coverage identified above, please contact your State NPDES permitting authority to obtain a State-issued NPDES permit.

C.10 Region 10: Alaska, Idaho (except see Region 9 for Duck Valley Reservation lands), Oregon (except see Region 9 for Fort McDermitt Reservation), Washington.

This permit offers NPDES permit coverage for stormwater discharges associated with industrial activity from the following areas in EPA Region 10:

Permit Number	Areas of Coverage/Where EPA Is Permitting Authority
AKR050000	The State of Alaska, except Indian Country lands
AKR05000I	Indian Country lands within Alaska
IDR050000	The State of Idaho, except Indian Country lands
IDR05000I	Indian Country lands within the State of Idaho, except Duck Valley Reservation lands, which are covered under Nevada permit NVR05000I listed in Part C.9
ORR05000I	Indian Country lands within the State of Oregon, except Fort McDermitt Reservation lands, which are covered under Nevada permit NVR05000I listed in Part C.9
WAR05000I	Indian Country lands within the State of Washington
WAR05000F	Federal facilities in the State of Washington, except those located on Indian Country lands

For stormwater discharges in EPA Region 10 outside the areas of coverage identified above, please contact your State NPDES permitting authority to obtain a State-issued NPDES permit.

Appendix D
Activities Covered

Appendix D. Facilities and Activities Covered

Your permit eligibility is limited to discharges from facilities in the "sectors" of industrial activity summarized in Table D-1. These sector descriptions are based on Standard Industrial Classification (SIC) Codes and Industrial Activity Codes. References to "sectors" in this permit (e.g., sector-specific monitoring requirements) refer to these groupings.

Table D-1. Sectors of Industrial Activity Covered by This Permit

SIC Code or Activity Code[1]	Activity Represented
SECTOR A: TIMBER PRODUCTS	
2411	Log Storage and Handling (Wet deck storage areas authorized only if no chemical additives are used in the spray water or applied to the logs)
2421	General Sawmills and Planing Mills
2426	Hardwood Dimension and Flooring Mills
2429	Special Product Sawmills, Not Elsewhere Classified
2431-2439 (except 2434)	Millwork, Veneer, Plywood, and Structural Wood (see Sector W)
2441-2449	Wood Containers
2451, 2452	Wood Buildings and Mobile Homes
2491	Wood Preserving
2493	Reconstituted Wood Products
2499	Wood Products, Not Elsewhere Classified
SECTOR B: PAPER AND ALLIED PRODUCTS	
2611	Pulp Mills
2621	Paper Mills
2631	Paperboard Mills
2652-2657	Paperboard Containers and Boxes
2671-2679	Converted Paper and Paperboard Products, Except Containers and Boxes
SECTOR C: CHEMICALS AND ALLIED PRODUCTS	
2812-2819	Industrial Inorganic Chemicals
2821-2824	Plastics Materials and Synthetic Resins, Synthetic Rubber, Cellulosic and Other Manmade Fibers Except Glass
2833-2836	Medicinal Chemicals and Botanical Products; Pharmaceutical Preparations; in vitro and in vivo Diagnostic Substances; and Biological Products, Except Diagnostic Substances
2841-2844	Soaps, Detergents, and Cleaning Preparations; Perfumes, Cosmetics, and Other Toilet Preparations
2851	Paints, Varnishes, Lacquers, Enamels, and Allied Products
2861-2869	Industrial Organic Chemicals
2873-2879	Agricultural Chemicals
2891-2899	Miscellaneous Chemical Products

Table D-1. Sectors of Industrial Activity Covered by This Permit	
SIC Code or Activity Code[1]	Activity Represented
3952 (limited to list)	Inks and Paints, Including China Painting Enamels, India Ink, Drawing Ink, Platinum Paints for Burnt Wood or Leather Work, Paints for China Painting, Artist's Paints and Artist's Watercolors
SECTOR D: ASPHALT PAVING AND ROOFING MATERIALS AND LUBRICANTS	
2951, 2952	Asphalt Paving and Roofing Materials
2992, 2999	Miscellaneous Products of Petroleum and Coal
SECTOR E: GLASS, CLAY, CEMENT, CONCRETE, AND GYPSUM PRODUCTS	
3211	Flat Glass
3221, 3229	Glass and Glassware, Pressed or Blown
3231	Glass Products Made of Purchased Glass
3241	Hydraulic Cement
3251-3259	Structural Clay Products
3261-3269	Pottery and Related Products
3271-3275	Concrete, Gypsum, and Plaster Products
3281	Cut Stone and Stone Products
3291-3299	Abrasive, Asbestos, and Miscellaneous Nonmetallic Mineral Products
SECTOR F: PRIMARY METALS	
3312-3317	Steel Works, Blast Furnaces, and Rolling and Finishing Mills
3321-3325	Iron and Steel Foundries
3331-3339	Primary Smelting and Refining of Nonferrous Metals
3341	Secondary Smelting and Refining of Nonferrous Metals
3351-3357	Rolling, Drawing, and Extruding of Nonferrous Metals
3363-3369	Nonferrous Foundries (Castings)
3398, 3399	Miscellaneous Primary Metal Products
SECTOR G: METAL MINING (ORE MINING AND DRESSING)	
1011	Iron Ores
1021	Copper Ores
1031	Lead and Zinc Ores
1041, 1044	Gold and Silver Ores
1061	Ferroalloy Ores, Except Vanadium
1081	Metal Mining Services
1094, 1099	Miscellaneous Metal Ores
SECTOR H: COAL MINES AND COAL MINING-RELATED FACILITIES	
1221-1241	Coal Mines and Coal Mining-Related Facilities
SECTOR I: OIL AND GAS EXTRACTION AND REFINING	
1311	Crude Petroleum and Natural Gas
1321	Natural Gas Liquids
1381-1389	Oil and Gas Field Services
2911	Petroleum Refineries

Table D-1. Sectors of Industrial Activity Covered by This Permit	
SIC Code or Activity Code[1]	**Activity Represented**
SECTOR J: MINERAL MINING AND DRESSING	
1411	Dimension Stone
1422-1429	Crushed and Broken Stone, Including Rip Rap
1442, 1446	Sand and Gravel
1455, 1459	Clay, Ceramic, and Refractory Materials
1474-1479	Chemical and Fertilizer Mineral Mining
1481	Nonmetallic Minerals Services, Except Fuels
1499	Miscellaneous Nonmetallic Minerals, Except Fuels
SECTOR K: HAZARDOUS WASTE TREATMENT, STORAGE, OR DISPOSAL FACILITIES	
HZ	Hazardous Waste Treatment, Storage, or Disposal Facilities, including those that are operating under interim status or a permit under subtitle C of RCRA
SECTOR L: LANDFILLS, LAND APPLICATION SITES, AND OPEN DUMPS	
LF	Landfills, Land Application Sites, and Open Dumps that receive or have received any industrial wastes (waste that is received from any of the facilities described in Table D-1) including those that are subject to regulation under subtitle D of RCRA
SECTOR M: AUTOMOBILE SALVAGE YARDS	
5015	Automobile Salvage Yards
SECTOR N: SCRAP RECYCLING FACILITIES	
5093	Scrap Recycling Facilities
SECTOR O: STEAM ELECTRIC GENERATING FACILITIES	
SE	Steam Electric Generating Facilities, including coal handling sites
SECTOR P: LAND TRANSPORTATION AND WAREHOUSING	
4011, 4013	Railroad Transportation
4111-4173	Local and Highway Passenger Transportation
4212-4231	Motor Freight Transportation and Warehousing
4311	United States Postal Service
5171	Petroleum Bulk Stations and Terminals
SECTOR Q: WATER TRANSPORTATION	
4412-4499	Water Transportation
SECTOR R: SHIP AND BOAT BUILDING AND REPAIRING YARDS	
3731, 3732	Ship and Boat Building or Repairing Yards
SECTOR S: AIR TRANSPORTATION FACILITIES	
4512-4581	Air Transportation Facilities

Table D-1. Sectors of Industrial Activity Covered by This Permit	
SIC Code or Activity Code[1]	Activity Represented
SECTOR T: TREATMENT WORKS	
TW	Treatment Works treating domestic sewage or any other sewage sludge or wastewater treatment device or system, used in the storage, treatment, recycling, and reclamation of municipal or domestic sewage, including land dedicated to the disposal of sewage sludge that are located within the confines of the facility, with a design flow of 1.0 mgd or more, or required to have an approved pretreatment program under 40 CFR Part 403. Not included are farm lands, domestic gardens or lands used for sludge management where sludge is beneficially reused and which are not physically located in the confines of the facility, or areas that are in compliance with section 405 of the CWA.
SECTOR U: FOOD AND KINDRED PRODUCTS	
2011-2015	Meat Products
2021-2026	Dairy Products
2032-2038	Canned, Frozen, and Preserved Fruits, Vegetables, and Food Specialties
2041-2048	Grain Mill Products
2051-2053	Bakery Products
2061-2068	Sugar and Confectionery Products
2074-2079	Fats and Oils
2082-2087	Beverages
2091-2099	Miscellaneous Food Preparations and Kindred Products
2111-2141	Tobacco Products
SECTOR V: TEXTILE MILLS, APPAREL, AND OTHER FABRIC PRODUCT MANUFACTURING; LEATHER AND LEATHER PRODUCTS	
2211-2299	Textile Mill Products
2311-2399	Apparel and Other Finished Products Made from Fabrics and Similar Materials
3131-3199 (except 3111)	Leather and Leather Products, Except Leather Tanning and Finishing (see Sector Z)
SECTOR W: FURNITURE AND FIXTURES	
2434	Wood Kitchen Cabinets
2511-2599	Furniture and Fixtures
SECTOR X: PRINTING AND PUBLISHING	
2711-2796	Printing, Publishing, and Allied Industries
SECTOR Y: RUBBER, MISCELLANEOUS PLASTIC PRODUCTS, AND MISCELLANEOUS MANUFACTURING INDUSTRIES	
3011	Tires and Inner Tubes
3021	Rubber and Plastics Footwear
3052, 3053	Gaskets, Packing and Sealing Devices, and Rubber and Plastic Hoses and Belting
3061, 3069	Fabricated Rubber Products, Not Elsewhere Classified
3081-3089	Miscellaneous Plastics Products
3931	Musical Instruments
3942-3949	Dolls, Toys, Games, and Sporting and Athletic Goods

Table D-1. Sectors of Industrial Activity Covered by This Permit	
SIC Code or Activity Code[1]	**Activity Represented**
3951-3955 (except 3952 facilities as specified in Sector C)	Pens, Pencils, and Other Artists' Materials
3961, 3965	Costume Jewelry, Costume Novelties, Buttons, and Miscellaneous Notions, Except Precious Metal
3991-3999	Miscellaneous Manufacturing Industries
SECTOR Z: LEATHER TANNING AND FINISHING	
3111	Leather Tanning and Finishing
SECTOR AA: FABRICATED METAL PRODUCTS	
3411-3499	Fabricated Metal Products, Except Machinery and Transportation Equipment, and Coating, Engraving, and Allied Services.
3911-3915	Jewelry, Silverware, and Plated Ware
SECTOR AB: TRANSPORTATION EQUIPMENT, INDUSTRIAL OR COMMERCIAL MACHINERY	
3511-3599 (except 3571-3579)	Industrial and Commercial Machinery, Except Computer and Office Equipment (see Sector AC)
3711-3799 (except 3731, 3732)	Transportation Equipment Except Ship and Boat Building and Repairing (see Sector R)
SECTOR AC: ELECTRONIC, ELECTRICAL, PHOTOGRAPHIC, AND OPTICAL GOODS	
3571-3579	Computer and Office Equipment
3612-3699	Electronic and Electrical Equipment and Components, Except Computer Equipment
3812-3873	Measuring, Analyzing, and Controlling Instruments; Photographic and Optical Goods, Watches, and Clocks
SECTOR AD: NON-CLASSIFIED FACILITIES	
N/A	Other stormwater discharges designated by the Director as needing a permit (see 40 CFR 122.26(a)(9)(i)(C) & (D)) or any facility discharging stormwater associated with industrial activity not described by any of Sectors A-AC. NOTE: Facilities may not elect to be covered under Sector AD. Only the Director may assign a facility to Sector AD.

[1] A complete list of SIC Codes (and conversions from the newer North American Industry Classification System" (NAICS)) can be obtained from the Internet at www.census.gov/epcd/www/naics.html or in paper form from various locations in the document titled *Handbook of Standard Industrial Classifications*, Office of Management and Budget, 1987.

Appendix E
Eligibility and screening procedures relating to species listed and critical habitat designated under the Endangered Species Act

Appendix E. Eligibility and screening procedures relating to species listed and critical habitat designated under the Endangered Species Act.

You must meet one or more of the following six criteria (A-F) to be eligible for coverage under the permit:

Criterion A. No federally-listed threatened or endangered species or their designated critical habitat are in proximity to your facility as defined in Addendum G; or

Criterion B. Consultation between a Federal agency and the Fish and Wildlife Service and/or the National Marine Fisheries Service (together, the "Services") under section 7 of the ESA has been concluded. Consultations can be either formal or informal, and would have occurred only as a result of a separate federal action (e.g., during application for an individual wastewater discharge permit, the issuance of a wetlands dredge and fill permit, or as a result of a NEPA review).

The consultation must have addressed the effects of the facility's stormwater discharges, allowable non-stormwater discharges, and stormwater discharge-related activities on federally-listed threatened or endangered species and federally-designated critical habitat, and resulted in either:

i. a biological opinion finding no jeopardy to federally-listed species or destruction/adverse modification of federally-designated critical habitat, or

ii. written concurrence from the Service(s) with a finding that the facility's stormwater discharges associated with industrial activity and allowable non-stormwater discharges are not likely to adversely affect federally-listed species or federally-designated critical habitat; or

Criterion C. The industrial activities are authorized through the issuance of a permit under section 10 of the ESA, and that authorization addresses the effects of the stormwater discharges associated with industrial activity and allowable non-stormwater discharges on federally-listed species and federally-designated critical habitat; or

Criterion D. Coordination between the operator and the Fish and Wildlife Service and/or the National Marine Fisheries Service has been concluded. The coordination must have addressed the effects of the facility's storm water discharges associated with industrial activity and allowable non-storm water discharges on federally-listed threatened or endangered species and federally-designated critical habitat. The result of the coordination must be a written statement from the Services that there are not likely to be any adverse affects to federally-listed species or federally-designated critical habitat. Any conditions or prerequisites deemed necessary to achieve no adverse effects become eligibility conditions for MSGP coverage; or

Criterion E. Stormwater discharges associated with industrial activity and allowable non-stormwater discharges are not likely to adversely affect any federally-listed endangered and threatened ("listed") species or designated critical habitat ("critical habitat"); or

Criterion F. The facility's stormwater discharges associated with industrial activity and allowable non-stormwater discharges were already addressed in another operator's valid certification of eligibility under Criteria A-E which included the industrial activities and there is no reason to believe that federally-listed species or federally-designated critical habitat not considered in the prior certification may be present or located in proximity to the facility. To certify eligibility under this criterion there must be no lapse of coverage in the other operator's certification. By certifying eligibility under this criterion, you agree to comply with any measures or controls upon which the other operator's certification was based. You must comply with any applicable terms, conditions, or other requirements developed in the process of meeting the eligibility requirements of the criteria in this section to remain eligible for coverage under this permit. Such terms and conditions must be documented and incorporated into your Stormwater Pollution Prevention Plan (SWPPP).

Assessing Your Facility Discharges

You must follow the procedures in this addendum to assess the potential effects of stormwater discharges and stormwater discharge-related activities on listed species and their critical habitat. When evaluating these potential effects, you must evaluate your entire facility. For purposes of this Addendum, the term "facility" is inclusive of the term "Action Area." Action area is defined in 50 CFR §402.02 as all areas to be affected directly or indirectly by the federal action and not merely the immediate area involved in the action. This includes areas beyond the footprint of the facility that may be affected by stormwater discharges and stormwater discharge related activities. "Facility" is defined in Appendix A. Note that dischargers who are eligible and able to certify eligibility under Criterion B, C, D, or F because of a previously issued ESA section 10 permit, a previously completed ESA section 7 consultation, or because their activities were already addressed in another discharger's certification of eligibility may proceed directly to Step Four.

Step One: *Determine if Listed Threatened or Endangered Species and Critical Habitat are Present On or Near Your Facility.*

You must first determine whether federally-listed species commonly reside in your area. Federally-listed threatened and endangered species are usually found in county-specific or sometimes township-specific listings. The local offices of the U.S. Fish and Wildlife Service (FWS), National Marine Fisheries Service (NOAA Fisheries Service), and State or Tribal Heritage Centers often maintain such lists on their internet sites. The types of species that may be present determine which Service office you should contact (in general, National Marine Fisheries Service has jurisdiction over marine, estuaries, and anadromous species). Visit www.epa.gov/npdes/stormwater/cgp to find the appropriate site for your state or check with your local office. If there are listed species in your county or township, you must then determine, as best you are able, whether any of the species are located on or near your property (use the Services or Heritage Centers, as necessary).

You must also check to see if critical habitat has been designated and whether such areas overlap or are near your facility by contacting your local FWS, NOAA Fisheries Service, or

State or Tribal Heritage Center. Critical habitat areas may be designated independently from the listed species for your county, so even if there are no listed species in your county or township, you must still contact one of the agencies mentioned above to determine if there are any critical habitat areas on or near your project area. You can also find critical habitat designations and associated requirements at 50 CFR Parts 17 and 226 http://www.access.gpo.gov.

If there are no listed species in your county or township, no critical habitat areas on or near your project area, or if your local FWS, NOAA Fisheries Service, or State or Tribal Heritage Center indicates that listed species are not a concern in your part of the county or township, you have satisfied your eligibility obligations under Criterion A (check box A on the Notice of Intent Form). If there are listed species and if your local FWS, NOAA Fisheries Service, or State or Tribal Heritage Center indicates that these species could exist on or near your project area, you will need to do one or more of the following:

Conduct visual inspections. This method may be particularly suitable for facilities that are smaller in size or located in non-natural settings such as highly urbanized areas or industrial parks where there is little or no natural habitat, or for facilities that discharge directly into municipal separate storm sewer systems.

- Conduct a formal biological survey (typically performed by environmental consulting firms). In some cases, particularly for larger facilities with extensive stormwater discharges, biological surveys may be an appropriate way to assess whether species are located on or near the project area and whether there are likely adverse effects to such species. A biological survey may in some cases be useful in conjunction with Steps Two, Three or Four of these instructions.
- Conduct an environmental assessment under the National Environmental Policy Act (NEPA). Such reviews may indicate if listed species are in proximity to the facility. Coverage under this MSGP may trigger such a review for new sources (that is, dischargers subject to New Source Performance Standards under section 306 of the Clean Water Act). Other facilities might require review under NEPA for other reasons, such as federal funding or other federal involvement in the facility. If listed threatened or endangered species or critical habitat are present in the project area, you must look at impacts to species and/or habitat when following Steps Two through Four. Note that many but not all measures imposed to protect listed species under these steps will also protect critical habitat. Thus, meeting the eligibility requirements of this MSGP may require measures to protect critical habitat that are separate from those to protect listed species.

Step Two: *Determine if your facility's Stormwater Discharge Associated With Industrial Activity or Allowable Non-Stormwater Discharges Are Likely to Adversely Affect Listed Threatened or Endangered Species or Designated Critical Habitat*

To receive MSGP coverage, you must assess whether your stormwater discharges associated with industrial activity or allowable non-stormwater discharges are likely to adversely affect listed threatened or endangered species or designated critical habitat that are present on or near your facility. Potential adverse effects from stormwater discharges associated with industrial activity include:

- **Hydrological.** Stormwater discharges may cause siltation, sedimentation or induce other changes in receiving waters such as temperature, salinity or pH. These effects will vary with the amount of stormwater discharged and the volume and condition of the receiving water. Where a stormwater discharge constitutes a minute portion of the total volume of the receiving water, adverse hydrological effects are less likely. Industrial activity itself may also alter drainage patterns on a site where construction occurs that can impact listed species or critical habitat.

- **Habitat.** Site development, grading or other surface disturbances from industrial activities, including storage of materials and the installation or placement of stormwater BMPs, may adversely affect listed species or their habitat. Stormwater may drain or inundate listed species habitat.
- **Toxicity.** In some cases pollutants in stormwater may have toxic effects on listed species.

The scope of effects to consider will vary with each site. If you are having difficulty determining whether your facility is likely to adversely affect listed species or critical habitat, or one of the Services has already raised concerns to you, you must contact the appropriate office of the FWS, NOAA Fisheries Service or Natural Heritage Center for assistance. If adverse effects are not likely, you have satisfied your eligibility obligations under Criterion E (check box E on the NOI form) and can apply for coverage under the MSGP. If your stormwater discharge may adversely affect listed species or critical habitat, you must follow Step Three.

Step Three: *Determine if Measures Can Be Implemented to Avoid Adverse Effects.*

If you make a preliminary determination that adverse effects to listed species and/or critical habitat are likely to occur, you can still receive coverage under Criterion E if appropriate measures are undertaken to avoid or eliminate the likelihood of adverse effects prior to applying for MSGP coverage. These measures may be relatively simple, e.g., re-routing a stormwater discharge to bypass an area where species are located, relocating BMPs, or changing the "footprint" of the industrial activity. If you cannot ascertain which measures to implement to avoid the likelihood of adverse effects, you must follow Step Four (iii).

Step Four: *Determine if the Eligibility Requirements of Criterion B, C, D or F Can Be Met.*

Where adverse effects are likely and you are uncertain about how to avoid or eliminate the likelihood of adverse effects, you must contact the FWS and/or NOAA Fisheries Service (see subpart iii below). However, you may still be eligible for MSGP coverage if any likely adverse effects can be addressed through meeting Criterion B, C, D, or F as follows:

i. A consultation under ESA Section 7 has been performed for your industrial activity (see Criterion B).

ii. An incidental taking permit under Section 10 of the ESA has been issued for your activity (see Criterion C). Stormwater discharges from your industrial facility may be authorized by this MSGP if some activity is authorized through the issuance of a permit under section 10 of the ESA and that authorization addressed the effects of your stormwater discharges on federally-listed species and designated critical habitat. You must follow FWS and/or NOAA Fisheries Service procedures when applying for an ESA Section 10 permit (see 50 CFR §17.22(b)(1) for FWS and §222.22 for NOAA Fisheries Service). Application instructions for section 10 permits for FWS and NOAA Fisheries Service can be obtained by accessing the FWS and NOAA Fisheries Service websites (http://www.fws.gov and http://www.nmfs.noaa.gov) or by contacting the appropriate FWS and NOAA Fisheries Service regional office.

iii. You have coordinated your activities with the appropriate Service office (see Criterion D). In the absence of any other conditions set forth in Step Four, you may still be able to qualify for coverage under this MSGP if you coordinate with the FWS or NOAA Fisheries Service and the Service provides a letter or memorandum concluding that the direct and indirect effects of permitting your stormwater discharges will be unlikely to adversely affect listed species or to adversely modify designated critical habitat. If you adopt measures to avoid or eliminate adverse effects, per the Service's requirements or recommendations, you must abide by those measures for the duration of your coverage under the MSGP. Any such measures must be described in the Stormwater Pollution Prevention Plan and are enforceable MSGP conditions and/or conditions for meeting the eligibility criteria in Subpart 1.2.3.6.

iv. You are covered under the eligibility certification of another operator for the project area (see Criterion F). Your stormwater discharges were already addressed in another discharger's certification of eligibility under Criteria A through E, which also included your facility and determined that federally listed endangered or threatened species or designated critical habitat would not be jeopardized. To certify eligibility under this criterion there must be no lapse of coverage in the other operator's certification. By certifying eligibility under Criterion F, you agree to comply with any measures or controls upon which the other discharge certification under Criterion B, C, or D was based. Certification under Criterion F is discussed in more detail in the Fact Sheet that accompanies this permit.

You must comply with any terms and conditions imposed under the eligibility requirements of Criterion A through F to ensure that your stormwater discharges are protective of listed species and/or critical habitat. Such terms and conditions must be incorporated in the project's Stormwater Pollution Prevention Plan (SWPPP). If the eligibility requirements cannot be met, then you are not eligible for coverage under this MSGP. In these instances, you may consider applying to EPA for an individual permit.

Appendix F
Eligibility and screening procedures relating to historic properties and the National Historic Preservation Act

Appendix F – Eligibility and screening procedures relating to historic properties and the National Historic Preservation Act

Section 106 of the National Historic Preservation Act (NHPA) requires Federal agencies to take into account the effects of Federal "undertakings" on historic properties that are either listed on, or eligible for listing on, the National Register of Historic Places. The term Federal "undertaking" is defined in the NHPA regulations to include a project, activity, or program of a Federal agency including those carried out by or on behalf of a Federal agency, those carried out with Federal financial assistance, and those requiring a Federal permit, license or approval. See 36 CFR 800.16(y). Historic properties are defined in the NHPA regulations to include prehistoric or historic districts, sites, buildings, structures, or objects that are included in, or are eligible for inclusion in, the National Register of Historic Places. This term includes artifacts, records, and remains that are related to and located within such properties. See 36 CFR 800.16(1).

EPA's issuance of the Multi-Sector General Permit is a Federal undertaking within the meaning of the NHPA regulations. To address any issues relating to historic properties in connection with issuance of the permit, EPA has included criteria for certifications by applicants that potential impacts of their covered activities on historic properties have been appropriately considered and addressed. Although individual applications for coverage under the general permit do not constitute separate Federal undertakings, the screening criteria and certifications provide an appropriate site-specific means of addressing historic property issues in connection with EPA's issuance of the permit. Applicants seeking coverage under the MSGP are thus required to make certain certifications regarding the potential effects of their stormwater discharge, allowable non-stormwater discharge, and discharge-related activities on properties listed or eligible for listing on the National Register of Historic Places.

You must meet one or more of the following four criteria (A-D) to be eligible for coverage under this permit:

Criterion A. Your stormwater discharges and allowable non-stormwater discharges do not have the potential to have an effect on historic properties and you are not constructing or installing stormwater BMPs – or, for existing facilities seeking renewal of previous permit coverage, new BMPs – on your site that cause less than 1 acre of subsurface disturbance; or

Criterion B. Your discharge-related activities (i.e., construction and/or installation of stormwater best management practices that involve subsurface disturbance) will not affect historic properties; or

Criterion C. Your stormwater discharges, allowable non-stormwater discharges, and discharge-related activities have the potential to have an effect on historic properties, and you have obtained and are in compliance with a written agreement with the State Historic Preservation Officer (SHPO), Tribal Historic Preservation Officer (THPO), or other tribal representative that outlines all measures you will carry out to mitigate or prevent any adverse effects on historic properties; or

Criterion D. You have contacted the State Historic Preservation Officer, Tribal Historic Preservation Officer, or other tribal representative in writing informing them that you have the potential to have an effect on historic properties and you did not receive a response within 30 days.

Activities with No Potential to Have an Effect on Historic Properties

A determination that a Federal undertaking has no potential to have an effect on historic properties fulfills an agency's obligations under the NHPA. EPA has reason to believe that the vast majority of activities authorized under the MSGP have no potential to have effects on historic properties. The purpose of this permit is to control pollutants that may be transported in stormwater runoff from industrial facilities. EPA does not anticipate effects on historic properties from the pollutants in the stormwater and allowable non-stormwater discharges from these industrial facilities. Thus, to the extent EPA's issuance of this general permit authorizes discharges of such constituents, confined to existing stormwater channels or natural drainage areas, the permitting action does not have the potential to cause effects on historic properties.

In addition, the overwhelming majority of sources covered under this permit will be facilities that are seeking renewal of previous permit coverage. These existing dischargers should have already addressed NHPA issues in the 2000 MSGP as they were required to certify that they were either not affecting historic properties or they had obtained written agreement from the applicable State Historic Preservation Officer (SHPO) or Tribal Historic Preservation Officer (THPO) regarding methods of mitigating potential impacts. Both existing and new dischargers must follow the historic property screening process to determine their eligibility. EPA is not aware of any impacts on historic properties under the 2000 MSGP, or, for that matter, any need for a written agreement. Therefore, to the extent this permit authorizes renewal of prior coverage without relevant changes in operations, it has no potential to have an effect on historic properties.

Activities with Potential to Have an Effect on Historic Properties

EPA believes this permit may have some potential to have an effect on historic properties where the MSGP authorizes the construction and/or installation of stormwater best management practices (BMPs) that involve subsurface disturbance and impact less than 1 acre of land. (Ground disturbances of 1 acre or more require coverage under a different permit, the Construction General Permit.) Where you have to disturb the land through the construction and/or installation of BMPs, there is a possibility that underground artifacts, records, or remains associated with historic properties could be impacted. Therefore, if you are establishing new or altering existing BMPs to manage your stormwater that will involve subsurface ground disturbance of less than 1 acre, you will need to ensure that historic properties will not be impacted by your activities or that you are in compliance with a written agreement with the SHPO, THPO, or other tribal representative that outlines all measures you will carry out to mitigate or prevent any adverse effects on historic properties.

Examples of BMPs Which Involve Subsurface Disturbance

EPA reviewed all BMPs currently employed to determine which practices involve some level of earth disturbance. The following is a non-inclusive list of BMPs that are presumptively expected to cause subsurface ground disturbance:

Dikes	Berms	Catch Basins
Ponds	Ditch	Trench
Culvert	Land manipulation: contouring, sloping, and grading	Channels
Perimeter Drain	Swales	Other

EPA cautions dischargers that this list is non-inclusive. Any installation and/or construction of BMPs that involve earth disturbing activities that are not on this list will need to be further examined for the potential to affect historic properties.

Historic Property Screening Process

You should follow the following screening process in order to certify your compliance with historic property eligibility requirements under this permit (see Section 1.2.4.7). The following three steps describe how applicants can meet the permit eligibility criteria for protection of historic properties under this permit:

Step One: *Are you an existing facility that is reapplying for certification under the 2006 MSGP?*

If you are an existing facility you should have already addressed NHPA issues. To gain coverage under the 2000 MSGP you were required to certify that you were either not affecting historic properties or had obtained written agreement from the relevant SHPO or THPO regarding methods of mitigating potential impacts. As long as you are not constructing or installing any new stormwater BMPs then you have met eligibility Criterion A of the MSGP. After you submit your NOI, there is a 30-day waiting period during which the SHPO, THPO, or other tribal representative may review your NOI. The SHPO, THPO, or other tribal representative may request that EPA hold authorization based on concerns about potential adverse impacts to historic properties.

If you are an existing facility and will construct or install stormwater BMPs that require subsurface disturbance of less than 1 acre then you should proceed to Step 2.

If you are a new facility then you should proceed to Step 2.

Step Two: *Are You Constructing or Installing Any Stormwater BMPs That Require Subsurface Disturbance of Less Than 1 acre?*

If, as part of your coverage under this permit, you are not building or installing BMPs on your site that cause less than 1 acre of subsurface disturbance, then your discharge-related activities do not have the potential to have an effect on historic properties. You have no further obligations relating to historic properties. You have met eligibility Criterion A of the MSGP. After you submit your NOI, there is a 30-day waiting period during which the SHPO, THPO, or other tribal representative may review your NOI. The SHPO, THPO, or other tribal representative may request that EPA hold authorization based on concerns about potential adverse impacts to historic properties.

If the answer to the Step 2 question is yes, then you should proceed to Step 3.

Step 3: *Have Prior Earth Disturbances Determined That Historic Properties Do Not Exist, or Have Prior Disturbances Precluded the Existence of Historic Properties?*

If previous construction either revealed the absence of historic properties or prior disturbances preclude the existence of historic properties, then you have no further obligations relating to historic properties. You have met eligibility Criterion B of the MSGP. After you submit your NOI, there is a 30-day waiting period during which the SHPO, THPO, or other tribal representative may review your NOI. The SHPO, THPO, or other tribal representative may request that EPA hold authorization based on concerns about potential adverse impacts to historic properties.

If the answer to the Step 3 question is no, then you should proceed to Step 4.

Step 4: *Contact the Appropriate Historic Property Authorities*

Where you are building and/or installing BMPs affecting less than 1 acre of land to control stormwater or allowable non-stormwater discharges associated with this permit, and the answer to Step 3 is no, then you should contact the relevant SHPO, THPO, or other tribal representative to determine the likelihood that subsurface artifacts, records, or remains are potentially present on your site. This may involve examining local records to determine if historic artifacts have been found in nearby areas, as well as limited subsurface examination carried out by qualified professionals.

If through this process it is determined that such historic properties potentially exist and may be impacted by your construction or installation of BMPs, you should contact the relevant SHPO, THPO, or tribal representative in writing and request to discuss mitigation or prevention of any adverse effects. The letter should describe your facility, the nature and location of subsurface disturbance activities that are contemplated, any known or suspected historic properties in the area, and any anticipated effects on such properties. The letter should state that if the SHPO, THPO, or tribal representative does not respond within 30 days of receiving your letter, you may submit your NOI. EPA encourages applicants to contact the appropriate authorities as soon as possible in the event of a potential adverse effect to an historic property.

If you receive a response within 30 days and enter into, and comply with, a written agreement with the SHPO, THPO, or other tribal representative regarding how to address any adverse impacts on historic properties, you have met eligibility Criterion C. After you submit your NOI, there is a 30-day waiting period during which the SHPO, THPO, or other tribal representative may review your NOI. The SHPO, THPO, or other tribal representative may request that EPA hold authorization based on concerns about potential adverse impacts to historic properties.

If you receive a response within 30 days but an agreement cannot be reached between you and the SHPO, THPO, or other tribal representative, you should contact the appropriate EPA Regional Office (addresses listed in Part 3.8) or EPA Headquarters (Water Permits Division, Mail Code 4203M, 1200 Pennsylvania Avenue, NW, Washington, DC 20460-0001).

If you have contacted the SHPO, THPO, or other tribal representative in writing regarding your potential have an effect on historic properties and did not receive a response within 30 days, you have met eligibility Criterion D. After you submit your NOI, there is a 30-day waiting period during which the SHPO, THPO, or other tribal representative may review your NOI. The SHPO, THPO, or other tribal representative may request that EPA hold authorization based on concerns about potential adverse impacts to historic properties.

Addresses for State Historic Preservation Officers and Tribal Historic Preservation Officers may be found on the Advisory Council on Historic Preservation's website (http://www.achp.gov/programs.html). In instances where a Tribe does not have a Tribal Historic Preservation Officer, you should contact the appropriate Tribal government office when responding to this permit eligibility condition.

You are reminded that you must comply with applicable State, Tribal, and local laws concerning protection of historic properties and include documentation supporting your determination of permit eligibility with regard to Part 1.2.4.7 (Historic Places) within your Stormwater Pollution Prevention Plan (SWPPP) (See Part 2.1.6.2 for documentation regarding historic properties that must be included in your Stormwater Pollution Prevention Plan).

Appendix G
Information required for the Notice of Intent (NOI)

Appendix G – Information required for the Notice of Intent (NOI)

As part of applying for coverage under MSGP 2006, the permittee will be required to submit a Notice of Intent (NOI). The following is the preliminary updated NOI form that must be submitted.

NPDES Form ____-_

EPA

United States Environmental Protection Agency
Washington, DC 20460
Notice of Intent (NOI) for Stormwater Discharges Associated with INDUSTRIAL ACTIVITY under the Multi-Sector NPDES General Permit

Form Approved
OMB No. ____-____

Submission of this completed Notice of Intent (NOI) constitutes notice that the entity in Section B intends to be authorized to discharge pollutants to waters of the United States, from the facility or site identified in Section C, under EPA's Stormwater Multi-Sector General Permit (MSGP). Submission of the NOI also constitutes notice that the party identified in Section B of this form has read, understands, and meets the eligibility conditions of Part 1 of the MSGP; agrees to comply with all applicable terms and conditions of the MSGP; understands that continued authorization under the MSGP is contingent on maintaining eligibility for coverage, and that implementation of the permittee's pollution prevention plan is required two days after a complete NOI is mailed. In order to be granted coverage, all information required on this form must be completed. Please read and make sure you comply with all permit requirements, including the requirement to prepare and implement a stormwater pollution prevention plan.

A. **Permit Number:** _ _ _ _ _ _ _ _ _ (see Appendix C of the MSGP for the list of eligible permit numbers)

B. **Facility Operator Information**

1. Name: ____________________

2. IRS Employer Information Number: _ _-_ _ _ _ _ _ _

3. Mailing Address: a. Street: ______________________________

 b. City: ____________________ c. State: _ _ d. Zip code: _ _ _ _ _ - _ _ _ _

 e. Phone: _ _ _ - _ _ _ - _ _ _ _ f. Fax (Optional): _ _ _ - _ _ _ _ - _ _ _ _

 g. E-mail: ____________________

C. **Facility Information**

1. Facility Name: ______________________________

2. This discharge is ☐ New ☐ Existing

 If you have an existing stormwater discharge associated with industrial activity and you had coverage under the MSGP 2000, provide the Tracking Number: _ _ _ _ _ _ _ _ _

3. Location Address: a. Street: ______________________________

 b. City: ____________________ c. County or similar government subdivision: ____________________

 d. State: _ _ e. Zip code: _ _ _ _ _ - _ _ _ _

 f. Latitude: 1. _ _° _ _' _ _"N (degrees, minutes, seconds)
 2. _ _° _ _ . _ _' N (degrees, minutes, decimal)
 3. _ _ . _ _ _ _° N (decimal)

 g. Longitude: 1. _ _ _° _ _' _ _" W (degrees, minutes, seconds)
 2. _ _ _° _ _ . _ _' W (degrees, minutes, decimal)
 3. _ _ _ . _ _ _ _° W (decimal)

4. Is this facility federal? ☐ Yes ☐ No

5. Is this facility located on Indian Country lands? ☐ Yes ☐ No

 If yes, name of reservation, or if not part of a reservation, put "Not Applicable:" ____________

6. Discharge of Stormwater

 a. List the name(s) of the receiving water(s) that that you discharge stormwater into: ____________

 b. Does your facility discharge stormwater into a Municipal separate storm sewer system (MS4)? ☐ Yes ☐ No

 If yes, name of MS4 operator: ____________________

7. List the code that best represents your Standard Industrial Classification (SIC) Code(s) for your industrial activity: _ _ _ _

D. **StormWater Pollution Prevention Plan Contact Information and Location**

1. Name: ____________________

2. Location Address: a. Street: ______________________________

 b. City: ____________________ c. State: _ _ d. Zip code: _ _ _ _ _ - _ _ _ _

 e. Phone number _ _ _ - _ _ _ - _ _ _ _ ext. _ _ _

 f. URL address of Stormwater Prevention Plan (if applicable): ______________________________

E. Endangered Species Act Eligibility

Based on the instructions provided in Appendix E of the MSGP, under which criterion have you satisfied your Endangered Species Act obligations? ☐ A ☐ B ☐ C ☐ D ☐ E ☐ F

If you select criterion F, provide permit tracking number of the operator under which you are certifying eligibility:
_ _ R _ _ _ _ _ _

F. National Historic Preservation Act Eligibility

Based on the instruction provided in Appendix F of the MSGP, under which permit criterion have you satisfied your National Historic Preservation Act obligations? ☐ A ☐ B ☐ C ☐ D

G. Certifier Name and Title

Do you certify under penalty of law that this document and all attachments were prepared under your direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted? Based on your inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, do you certify that the information submitted is, to the best of your knowledge and belief, true, accurate, and complete? Do you certify that you are aware that there are significant penalties for submitting false information, including the possibility of fines and imprisonment for knowing violations?

Print Name: ____________________

Title: ____________________

Signature: ____________________ Date: _ _ - _ _ - _ _

Appendix H
Information required for the Notice of Termination (NOT)

Appendix H – Information required for the Notice of Intent (NOT)

As part terminating coverage under MSGP 2006, the permittee will be required to submit a Notice of Termination (NOI). The following is the proposed update to the NOT form that must be submitted.

This Form Replaces Previous Form 2040-0086 Form Approved. OMB No ____-____
Please See Instructions Before Completing This Form

NPDES FORM **EPA** **Notice of Termination (NOT) of Coverage under a NPDES General Permit for Stormwater Discharges Associated with Industrial Activity**
____ -_

Submission of this notice of termination constitutes notice that the party identified in Section II of this form is no longer authorized to discharge Stormwater associated with industrial activity under the NPDES program for the facility identified in Section III of this form. All necessary information must be included on this form. Refer to the instructions at the end of this form.

A. **Permit Information**

1. NPDES Permit Tracking Number: _ _ _ _ _ _ _ _ _

2. Reason for Termination (check one only): a. ☐ You transferred operational control to another operator. b. ☐ You terminated facility operations.

c. ☐ You obtained coverage under an alternative NPDES permit. d. ☐ You qualified for a No Exposure Exemption. If you answered yes to "d," you must fill out the No Exposure Form instead of the NOT Form.

B. **Facility Operator Information**

1. Name: ______________________

2. IRS Employer Identification Number: ________________

3. Mailing Address: a. Street: ____

b. City: ____________ c. State: _ _ d. Zip Code: _ _ _ _ _ - _ _ _ _ _ e. Phone: _ _ _ - _ _ _ - _ _ _ _

f. Fax (optional): _ _ _ - _ _ _ - _ _ _ _ g. E-mail: ____________________

C. **Facility Information**

1. Facility name: ____

2. Location Address: a. Street: ____

b. City: ______________ c. County or similar government subdivision: ______________________

d. State: _ _ e. Zip Code: _ _ _ _ _ - _ _ _ _

f. Latitude: 1. _ _°_ _'_ _"N (degrees, minutes, seconds) g. Longitude: 1. _ _ _°_ _'_ _" W (degrees, minutes, seconds)
2. _ _°_ _._ _' N (degrees, minutes, decimal) 2. _ _ _°_ _._ _' W (degrees, minutes, decimal)
3. _ _._ _ _ _° N (decimal) 3. _ _ _._ _ _ _° W (decimal)

D. **Certifier Name and Title:**
I certify under penalty of law that all stormwater discharges associated with industrial activity from the identified facility that are authorized by a NPDES general permit have been eliminated or that I am no longer the operator of the facility or construction site. I understand that by submitting this Notice of Termination, I am no longer authorized to discharge stormwater associated with industrial activity under this general permit, and that discharging pollutants in stormwater associated with industrial activity to waters of the United States is unlawful under the Clean Water Act where the discharge is not authorized by a NPDES permit. I also understand that the submittal of this Notice of Termination does not release an operator from liability for any violations of this permit or the Clean Water Act.

Print Name: ____

Title: ____

Signature: ______________________________________ Date: _ _ - _ _ - _ _

Memorandum: Compliance Schedules for Water Quality Based Effluent limitations in NPDES Permit

By:
James A. Hanlon, Office of Watershed Management, EPA

A013022

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

MAY 10 2007

OFFICE OF WATER

MEMORANDUM

SUBJECT: Compliance Schedules for Water Quality-Based Effluent Limitations in NPDES Permits

FROM: James A. Hanlon, Director
Office of Wastewater Management

TO: Alexis Strauss, Director
Water Division
EPA Region 9

Recently, in discussions with Region 9, questions have been raised concerning the use of compliance schedules in National Pollutant Discharge Elimination System (NPDES) permits consistent with the Clean Water Act (CWA) and its implementing regulations at 40 C.F.R. § 122.47. The use of compliance schedules in NPDES permits is also the subject of ongoing litigation in California. The purpose of this memo is to provide a framework for the review of permits consistent with the CWA and its implementing regulations.

<u>When may a permitting authority include a compliance schedule in a permit for the purpose of achieving a water quality-based effluent limitation?</u>

In *In The Matter of Star-Kist Caribe, Inc.*, 3 E.A.D. 172, 175, 177 (1990), the EPA Administrator interpreted section 301(b)(1)(C) of the CWA to mean that 1) after July 1, 1977, permits must require immediate compliance with (*i.e.*, may not contain compliance schedules for) effluent limitations based on water quality standards adopted before July 1, 1977, and 2) compliance schedules are allowed for effluent limitations based on standards adopted after that date <u>only</u> if the State has clearly indicated in its water quality standards or implementing regulations that it intends to allow them.

<u>What principles are applicable to assessing whether a compliance schedule for achieving a water quality-based effluent limitation is consistent with the CWA and its implementing regulations?</u>

1. "When appropriate," NPDES permits may include "a schedule of compliance leading to compliance with CWA and regulations . . . as soon as possible, but not later than the applicable statutory deadline under the CWA." 40 C.F.R. § 122.47(a)(1). Compliance schedules that are longer than one year in duration must set forth interim requirements and dates for their achievement. 40 C.F.R. § 122.47(a)(3).

2. Any compliance schedule contained in an NPDES permit must be an "enforceable sequence of actions or operations leading to compliance with a [water quality-based] effluent limitation ["WQBEL"]" as required by the definition of "schedule of compliance" in section 502(17) of the CWA. *See also* 40 C.F.R. § 122.2 (definition of schedule of compliance).

3. Any compliance schedule contained in an NPDES permit must include an enforceable final effluent limitation and a date for its achievement that is within the timeframe allowed by the applicable state or federal law provision authorizing compliance schedules as required by CWA sections 301(b)(1)(C); 502(17); the Administrator's decision in *Star-Kist Caribe, Inc.* 3 E.A.D. 172, 175, 177-178 (1990); and EPA regulations at 40 C.F.R. §§ 122.2, 122.44(d) and 122.44(d)(1)(vii)(A).

4. Any compliance schedule that extends past the expiration date of a permit must include the final effluent limitations in the permit in order to ensure enforceability of the compliance schedule as required by CWA section 502(17) and 40 C.F.R. § 122.2 (definition of schedule of compliance).

5. In order to grant a compliance schedule in an NPDES permit, the permitting authority has to make a reasonable finding, adequately supported by the administrative record, that the compliance schedule "will lead[ ] to compliance with an effluent limitation . . . " "to meet water quality standards" by the end of the compliance schedule as required by sections 301(b)(1)(C) and 502(17) of the CWA. *See also* 40 C.F.R. §§ 122.2, 122.44(d)(1)(vii)(A).

6. In order to grant a compliance schedule in an NPDES permit, the permitting authority has to make a reasonable finding, adequately supported by the administrative record and described in the fact sheet (40 C.F.R. § 124.8), that a compliance schedule is "appropriate" and that compliance with the final WQBEL is required "as soon as possible." *See* 40 C.F.R. §§ 122.47(a), 122.47(a)(1).

7. In order to grant a compliance schedule in an NPDES permit, the permitting authority has to make a reasonable finding, adequately supported by the administrative record, that the discharger cannot immediately comply with the WQBEL upon the effective date of the permit. 40 C.F.R. §§ 122.47, 122.47(a)(1).

8. Factors relevant to whether a compliance schedule in a specific permit is "appropriate" under 40 C.F.R. § 122.47(a) include: how much time the discharger has already had to meet the WQBEL(s) under prior permits; the extent to which the discharger has made good faith efforts to comply with the WQBELs and other requirements in its prior permit(s); whether there is any need for modifications to treatment facilities, operations or measures to meet the WQBELs and if so, how long would it take to implement the modifications to treatment, operations or other measures; or whether the discharger would be expected to use the same treatment facilities, operations or other measures to meet the WQBEL as it would have used to meet the WQBEL in its prior permit.

9. Factors relevant to a conclusion that a particular compliance schedule requires compliance with the WQBEL "as soon as possible," as required by 40 C.F.R. § 122.47(a)(1) include: consideration of the steps needed to modify or install treatment facilities, operations or other measures and the time those steps would take. The permitting authority should not simply presume that a compliance schedule be based on the maximum time period allowed by a State's authorizing provision.

10. A compliance schedule based solely on time needed to develop a Total Maximum Daily Load is not appropriate, consistent with EPA's letter of October 23, 2006, to Celeste Cantu, Executive Director of the California State Water Resources Control Board, in which EPA disapproved a provision of the Policy for Implementation of Toxic Standards for Inland Surface Waters, Enclosed Bays, and Estuaries for California.

11. A compliance schedule based solely on time needed to develop a Use Attainability Analysis is also not appropriate, consistent with EPA's letter of February 20, 2007, to Doyle Childers, Director Missouri Department of Natural Resources, nor is a compliance schedule based solely on time needed to develop a site specific criterion, for the same reasons as set forth in the October 23, 2006, (referenced in Paragraph 10) and February 20, 2007 letters.

If you have any questions, please contact me at (202) 564-0748 or have your staff contact Linda Boornazian at (202) 564-0221.

the United States, with each discharger to the non-municipal conveyance a co-permittee to that permit.

(ii) Where there is more than one operator of a single system of such conveyances, all operators of storm water discharges associated with industrial activity must submit applications.

(iii) Any permit covering more than one operator shall identify the effluent limitations, or other permit conditions, if any, that apply to each operator.

(7) *Combined sewer systems.* Conveyances that discharge storm water runoff combined with municipal sewage are point sources that must obtain NPDES permits in accordance with the procedures of § 122.21 and are not subject to the provisions of this section.

(8) Whether a discharge from a municipal separate storm sewer is or is not subject to regulation under this section shall have no bearing on whether the owner or operator of the discharge is eligible for funding under title II, title III or title VI of the Clean Water Act. *See* 40 CFR part 35, subpart I, appendix A(b)H.2.j.

(9)(i) On and after October 1, 1994, for discharges composed entirely of storm water, that are not required by paragraph (a)(1) of this section to obtain a permit, operators shall be required to obtain a NPDES permit only if:

(A) The discharge is from a small MS4 required to be regulated pursuant to § 122.32;

(B) The discharge is a storm water discharge associated with small construction activity pursuant to paragraph (b)(15) of this section;

(C) The Director, or in States with approved NPDES programs either the Director or the EPA Regional Administrator, determines that storm water controls are needed for the discharge based on wasteload allocations that are part of "total maximum daily loads" (TMDLs) that address the pollutant(s) of concern; or

(D) The Director, or in States with approved NPDES programs either the Director or the EPA Regional Administrator, determines that the discharge, or category of discharges within a geographic area, contributes to a violation of a water quality standard or is a significant contributor of pollutants to waters of the United States.

(ii) Operators of small MS4s designated pursuant to paragraphs (a)(9)(i)(A), (a)(9)(i)(C), and (a)(9)(i)(D) of this section shall seek coverage under an NPDES permit in accordance with §§ 122.33 through 122.35. Operators of non-municipal sources designated pursuant to paragraphs (a)(9)(i)(B), (a)(9)(i)(C), and (a)(9)(i)(D) of this section shall seek coverage under an NPDES permit in accordance with paragraph (c)(1) of this section.

(iii) Operators of storm water discharges designated pursuant to paragraphs (a)(9)(i)(C) and (a)(9)(i)(D) of this section shall apply to the Director for a permit within 180 days of receipt of notice, unless permission for a later date is granted by the Director (see § 124.52(c) of this chapter).

(b) *Definitions.* (1) *Co-permittee* means a permittee to a NPDES permit that is only responsible for permit conditions relating to the discharge for which it is operator.

(2) *Illicit discharge* means any discharge to a municipal separate storm sewer that is not composed entirely of storm water except discharges pursuant to a NPDES permit (other than the NPDES permit for discharges from the municipal separate storm sewer) and discharges resulting from fire fighting activities.

(3) *Incorporated place* means the District of Columbia, or a city, town, township, or village that is incorporated under the laws of the State in which it is located.

(4) *Large municipal separate storm sewer system* means all municipal separate storm sewers that are either:

(i) Located in an incorporated place with a population of 250,000 or more as determined by the 1990 Decennial Census by the Bureau of the Census (Appendix F of this part); or

(ii) Located in the counties listed in appendix H, except municipal separate storm sewers that are located in the incorporated places, townships or towns within such counties; or

(iii) Owned or operated by a municipality other than those described in paragraph (b)(4) (i) or (ii) of this section and that are designated by the Director as part of the large or medium

(A) Participate in a permit application (to be a permittee or a co-permittee) with one or more other operators of discharges from the large or medium municipal storm sewer system which covers all, or a portion of all, discharges from the municipal separate storm sewer system;

(B) Submit a distinct permit application which only covers discharges from the municipal separate storm sewers for which the operator is responsible; or

(C) A regional authority may be responsible for submitting a permit application under the following guidelines:

(*1*) The regional authority together with co-applicants shall have authority over a storm water management program that is in existence, or shall be in existence at the time part 1 of the application is due;

(*2*) The permit applicant or co-applicants shall establish their ability to make a timely submission of part 1 and part 2 of the municipal application;

(*3*) Each of the operators of municipal separate storm sewers within the systems described in paragraphs (b)(4) (i), (ii), and (iii) or (b)(7) (i), (ii), and (iii) of this section, that are under the purview of the designated regional authority, shall comply with the application requirements of paragraph (d) of this section.

(iv) One permit application may be submitted for all or a portion of all municipal separate storm sewers within adjacent or interconnected large or medium municipal separate storm sewer systems. The Director may issue one system-wide permit covering all, or a portion of all municipal separate storm sewers in adjacent or interconnected large or medium municipal separate storm sewer systems.

(v) Permits for all or a portion of all discharges from large or medium municipal separate storm sewer systems that are issued on a system-wide, jurisdiction-wide, watershed or other basis may specify different conditions relating to different discharges covered by the permit, including different management programs for different drainage areas which contribute storm water to the system.

(vi) Co-permittees need only comply with permit conditions relating to discharges from the municipal separate storm sewers for which they are operators.

(4) *Discharges through large and medium municipal separate storm sewer systems.* In addition to meeting the requirements of paragraph (c) of this section, an operator of a storm water discharge associated with industrial activity which discharges through a large or medium municipal separate storm sewer system shall submit, to the operator of the municipal separate storm sewer system receiving the discharge no later than May 15, 1991, or 180 days prior to commencing such discharge: the name of the facility; a contact person and phone number; the location of the discharge; a description, including Standard Industrial Classification, which best reflects the principal products or services provided by each facility; and any existing NPDES permit number.

(5) *Other municipal separate storm sewers.* The Director may issue permits for municipal separate storm sewers that are designated under paragraph (a)(1)(v) of this section on a system-wide basis, jurisdiction-wide basis, watershed basis or other appropriate basis, or may issue permits for individual discharges.

(6) *Non-municipal separate storm sewers.* For storm water discharges associated with industrial activity from point sources which discharge through a non-municipal or non-publicly owned separate storm sewer system, the Director, in his discretion, may issue: a single NPDES permit, with each discharger a co-permittee to a permit issued to the operator of the portion of the system that discharges into waters of the United States; or, individual permits to each discharger of storm water associated with industrial activity through the non-municipal conveyance system.

(i) All storm water discharges associated with industrial activity that discharge through a storm water discharge system that is not a municipal separate storm sewer must be covered by an individual permit, or a permit issued to the operator of the portion of the system that discharges to waters of into that designated area for the maintenance or production of harvestable freshwater, estuarine, or marine plants or animals.

(2) *Designated project area* means the portions of the waters of the United States within which the permittee or permit applicant plans to confine the cultivated species, using a method or plan or operation (including, but not limited to, physical confinement) which, on the basis of reliable scientific evidence, is expected to ensure that specific individual organisms comprising an aquaculture crop will enjoy increased growth attributable to the discharge of pollutants, and be harvested within a defined geographic area.

§ 122.26 Storm water discharges (applicable to State NPDES programs, see § 123.25).

(a) *Permit requirement.* (1) Prior to October 1, 1994, discharges composed entirely of storm water shall not be required to obtain a NPDES permit except:

(i) A discharge with respect to which a permit has been issued prior to February 4, 1987;

(ii) A discharge associated with industrial activity (see § 122.26(a)(4));

(iii) A discharge from a large municipal separate storm sewer system;

(iv) A discharge from a medium municipal separate storm sewer system;

(v) A discharge which the Director, or in States with approved NPDES programs, either the Director or the EPA Regional Administrator, determines to contribute to a violation of a water quality standard or is a significant contributor of pollutants to waters of the United States. This designation may include a discharge from any conveyance or system of conveyances used for collecting and conveying storm water runoff or a system of discharges from municipal separate storm sewers, except for those discharges from conveyances which do not require a permit under paragraph (a)(2) of this section or agricultural storm water runoff which is exempted from the definition of point source at § 122.2.

The Director may designate discharges from municipal separate storm sewers on a system-wide or jurisdiction-wide basis. In making this determination the Director may consider the following factors:

(A) The location of the discharge with respect to waters of the United States as defined at 40 CFR 122.2.

(B) The size of the discharge;

(C) The quantity and nature of the pollutants discharged to waters of the United States; and

(D) Other relevant factors.

(2) The Director may not require a permit for discharges of storm water runoff from mining operations or oil and gas exploration, production, processing or treatment operations or transmission facilities, composed entirely of flows which are from conveyances or systems of conveyances (including but not limited to pipes, conduits, ditches, and channels) used for collecting and conveying precipitation runoff and which are not contaminated by contact with or that has not come into contact with, any overburden, raw material, intermediate products, finished product, byproduct or waste products located on the site of such operations.

(3) *Large and medium municipal separate storm sewer systems.* (i) Permits must be obtained for all discharges from large and medium municipal separate storm sewer systems.

(ii) The Director may either issue one system-wide permit covering all discharges from municipal separate storm sewers within a large or medium municipal storm sewer system or issue distinct permits for appropriate categories of discharges within a large or medium municipal separate storm sewer system including, but not limited to: all discharges owned or operated by the same municipality; located within the same jurisdiction; all discharges within a system that discharge to the same watershed; discharges within a system that are similar in nature; or for individual discharges from municipal separate storm sewers within the system.

(iii) The operator of a discharge from a municipal separate storm sewer which is part of a large or medium municipal separate storm sewer system must either:

source performance standards, or toxic pollutant effluent standards under 40 CFR subchapter N (except facilities with toxic pollutant effluent standards which are exempted under category (xi) in paragraph (b)(14) of this section);

(ii) Facilities classified as Standard Industrial Classifications 24 (except 2434), 26 (except 265 and 267), 28 (except 283), 29, 311, 32 (except 323), 33, 3441, 373;

(iii) Facilities classified as Standard Industrial Classifications 10 through 14 (mineral industry) including active or inactive mining operations (except for areas of coal mining operations no longer meeting the definition of a reclamation area under 40 CFR 434.11(l) because the performance bond issued to the facility by the appropriate SMCRA authority has been released, or except for areas of non-coal mining operations which have been released from applicable State or Federal reclamation requirements after December 17, 1990) and oil and gas exploration, production, processing, or treatment operations, or transmission facilities that discharge storm water contaminated by contact with or that has come into contact with, any overburden, raw material, intermediate products, finished products, byproducts or waste products located on the site of such operations; (inactive mining operations are mining sites that are not being actively mined, but which have an identifiable owner/operator; inactive mining sites do not include sites where mining claims are being maintained prior to disturbances associated with the extraction, beneficiation, or processing of mined materials, nor sites where minimal activities are undertaken for the sole purpose of maintaining a mining claim);

(iv) Hazardous waste treatment, storage, or disposal facilities, including those that are operating under interim status or a permit under subtitle C of RCRA;

(v) Landfills, land application sites, and open dumps that receive or have received any industrial wastes (waste that is received from any of the facilities described under this subsection) including those that are subject to regulation under subtitle D of RCRA;

(vi) Facilities involved in the recycling of materials, including metal scrapyards, battery reclaimers, salvage yards, and automobile junkyards, including but limited to those classified as Standard Industrial Classification 5015 and 5093;

(vii) Steam electric power generating facilities, including coal handling sites;

(viii) Transportation facilities classified as Standard Industrial Classifications 40, 41, 42 (except 4221–25), 43, 44, 45, and 5171 which have vehicle maintenance shops, equipment cleaning operations, or airport deicing operations. Only those portions of the facility that are either involved in vehicle maintenance (including vehicle rehabilitation, mechanical repairs, painting, fueling, and lubrication), equipment cleaning operations, airport deicing operations, or which are otherwise identified under paragraphs (b)(14) (i)–(vii) or (ix)–(xi) of this section are associated with industrial activity;

(ix) Treatment works treating domestic sewage or any other sewage sludge or wastewater treatment device or system, used in the storage treatment, recycling, and reclamation of municipal or domestic sewage, including land dedicated to the disposal of sewage sludge that are located within the confines of the facility, with a design flow of 1.0 mgd or more, or required to have an approved pretreatment program under 40 CFR part 403. Not included are farm lands, domestic gardens or lands used for sludge management where sludge is beneficially reused and which are not physically located in the confines of the facility, or areas that are in compliance with section 405 of the CWA;

(x) Construction activity including clearing, grading and excavation, except operations that result in the disturbance of less than five acres of total land area. Construction activity also includes the disturbance of less than five acres of total land area that is a part of a larger common plan of development or sale if the larger common plan will ultimately disturb five acres or more;

(xi) Facilities under Standard Industrial Classifications 20, 21, 22, 23, 2434, 25, 265, 267, 27, 283, 285, 30, 31 (except 311), 323, 34 (except 3441), 35, 36, 37 (except 373), 38, 39, and 4221–25;

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body (created by or pursuant to State law) having jurisdiction over disposal of sewage, industrial wastes, storm water, or other wastes, including special districts under State law such as a sewer district, flood control district or drainage district, or similar entity, or an Indian tribe or an authorized Indian tribal organization, or a designated and approved management agency under section 208 of the CWA that discharges to waters of the United States;

(ii) Designed or used for collecting or conveying storm water;

(iii) Which is not a combined sewer; and

(iv) Which is not part of a Publicly Owned Treatment Works (POTW) as defined at 40 CFR 122.2.

(9) *Outfall* means a *point source* as defined by 40 CFR 122.2 at the point where a municipal separate storm sewer discharges to waters of the United States and does not include open conveyances connecting two municipal separate storm sewers, or pipes, tunnels or other conveyances which connect segments of the same stream or other waters of the United States and are used to convey waters of the United States.

(10) *Overburden* means any material of any nature, consolidated or unconsolidated, that overlies a mineral deposit, excluding topsoil or similar naturally-occurring surface materials that are not disturbed by mining operations.

(11) *Runoff coefficient* means the fraction of total rainfall that will appear at a conveyance as runoff.

(12) *Significant materials* includes, but is not limited to: raw materials; fuels; materials such as solvents, detergents, and plastic pellets; finished materials such as metallic products; raw materials used in food processing or production; hazardous substances designated under section 101(14) of CERCLA; any chemical the facility is required to report pursuant to section 313 of title III of SARA; fertilizers; pesticides; and waste products such as ashes, slag and sludge that have the potential to be released with storm water discharges.

(13) *Storm water* means storm water runoff, snow melt runoff, and surface runoff and drainage.

(14) *Storm water discharge associated with industrial activity* means the discharge from any conveyance that is used for collecting and conveying storm water and that is directly related to manufacturing, processing or raw materials storage areas at an industrial plant. The term does not include discharges from facilities or activities excluded from the NPDES program under this part 122. For the categories of industries identified in this section, the term includes, but is not limited to, storm water discharges from industrial plant yards; immediate access roads and rail lines used or traveled by carriers of raw materials, manufactured products, waste material, or by-products used or created by the facility; material handling sites; refuse sites; sites used for the application or disposal of process waste waters (as defined at part 401 of this chapter); sites used for the storage and maintenance of material handling equipment; sites used for residual treatment, storage, or disposal; shipping and receiving areas; manufacturing buildings; storage areas (including tank farms) for raw materials, and intermediate and final products; and areas where industrial activity has taken place in the past and significant materials remain and are exposed to storm water. For the purposes of this paragraph, material handling activities include storage, loading and unloading, transportation, or conveyance of any raw material, intermediate product, final product, by-product or waste product. The term excludes areas located on plant lands separate from the plant's industrial activities, such as office buildings and accompanying parking lots as long as the drainage from the excluded areas is not mixed with storm water drained from the above described areas. Industrial facilities (including industrial facilities that are federally, State, or municipally owned or operated that meet the description of the facilities listed in paragraphs (b)(14)(i) through (xi) of this section) include those facilities designated under the provisions of paragraph (a)(1)(v) of this section. The following categories of facilities are considered to be engaging in "industrial activity" for purposes of paragraph (b)(14):

(i) Facilities subject to storm water effluent limitations guidelines, new municipal separate storm sewer system due to the interrelationship between the discharges of the designated storm sewer and the discharges from municipal separate storm sewers described under paragraph (b)(4) (i) or (ii) of this section. In making this determination the Director may consider the following factors:

(A) Physical interconnections between the municipal separate storm sewers;

(B) The location of discharges from the designated municipal separate storm sewer relative to discharges from municipal separate storm sewers described in paragraph (b)(4)(i) of this section;

(C) The quantity and nature of pollutants discharged to waters of the United States;

(D) The nature of the receiving waters; and

(E) Other relevant factors; or

(iv) The Director may, upon petition, designate as a large municipal separate storm sewer system, municipal separate storm sewers located within the boundaries of a region defined by a storm water management regional authority based on a jurisdictional, watershed, or other appropriate basis that includes one or more of the systems described in paragraph (b)(4) (i), (ii), (iii) of this section.

(5) *Major municipal separate storm sewer outfall* (or "major outfall") means a municipal separate storm sewer outfall that discharges from a single pipe with an inside diameter of 36 inches or more or its equivalent (discharge from a single conveyance other than circular pipe which is associated with a drainage area of more than 50 acres); or for municipal separate storm sewers that receive storm water from lands zoned for industrial activity (based on comprehensive zoning plans or the equivalent), an outfall that discharges from a single pipe with an inside diameter of 12 inches or more or from its equivalent (discharge from other than a circular pipe associated with a drainage area of 2 acres or more).

(6) *Major outfall* means a major municipal separate storm sewer outfall.

(7) *Medium municipal separate storm sewer system* means all municipal separate storm sewers that are either:

(i) Located in an incorporated place with a population of 100,000 or more but less than 250,000, as determined by the 1990 Decennial Census by the Bureau of the Census (Appendix G of this part); or

(ii) Located in the counties listed in appendix I, except municipal separate storm sewers that are located in the incorporated places, townships or towns within such counties; or

(iii) Owned or operated by a municipality other than those described in paragraph (b)(7) (i) or (ii) of this section and that are designated by the Director as part of the large or medium municipal separate storm sewer system due to the interrelationship between the discharges of the designated storm sewer and the discharges from municipal separate storm sewers described under paragraph (b)(7) (i) or (ii) of this section. In making this determination the Director may consider the following factors:

(A) Physical interconnections between the municipal separate storm sewers;

(B) The location of discharges from the designated municipal separate storm sewer relative to discharges from municipal separate storm sewers described in paragraph (b)(7)(i) of this section;

(C) The quantity and nature of pollutants discharged to waters of the United States;

(D) The nature of the receiving waters; or

(E) Other relevant factors; or

(iv) The Director may, upon petition, designate as a medium municipal separate storm sewer system, municipal separate storm sewers located within the boundaries of a region defined by a storm water management regional authority based on a jurisdictional, watershed, or other appropriate basis that includes one or more of the systems described in paragraphs (b)(7) (i), (ii), (iii) of this section.

(8) *Municipal separate storm sewer* means a conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, manmade channels, or storm drains):

(i) Owned or operated by a State, city, town, borough, county, parish, district, association, or other public

WETLANDS
SCIENCE
PROGRAM

Comparison of Methods to Map California Riparian Areas

Final Report Prepared for the California Riparian Habitat Joint Venture

CONTRIBUTION NO. 522
DECEMBER 2006

Produced by:
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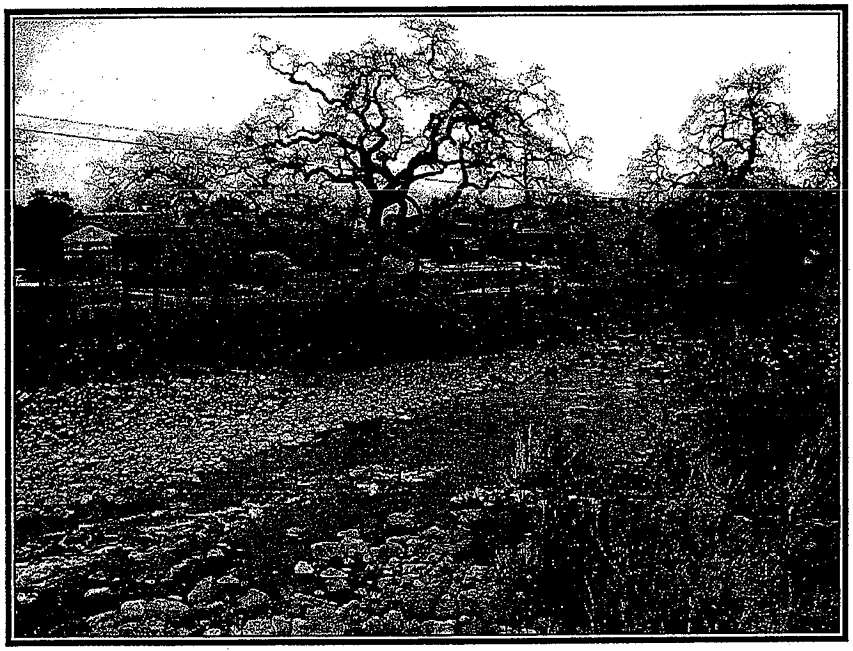

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Ann Chrisney
Coordinator
RHJV

California Riparian Habitat Joint Venture
River Partners, National Fish and Wildlife Foundation, National Audubon Society, PRBO Conservation Science, The Nature Conservancy, Trust for Public Land, US Bureau of Land Management, US Fish and Wildlife Service, US Forest Service, US Geological Survey, US National Park Service, US Bureau of Reclamation, US Natural Resources Conservation Service, California Dept. Fish and Game, California Dept. Water Resources, California Resources Agency, California State Lands Commission, California Wildlife Conservation Board

Comparison of Methods to Map California Riparian Areas

Executive Summary

The purpose of this report is to compare and contrast definitions and methods for mapping existing and potential riparian areas throughout California. This report has been produced for the California Riparian Habitat Joint Venture (RHJV); the use of any of the findings or recommendations from this report by any government agency or other organization is voluntary.

The riparian definition adopted by the RHJV was developed by the National Research Council in 2002. It is more inclusive than the definitions commonly used in California. Simply stated, the NRC definition indicates that every length of every lakeshore, stream or river channels, estuarine or marine shoreline, and wetland margin is riparian to some degree. The more traditional definitions focus almost exclusively on vegetation along the banks of rivers and streams.

The broader definition offered by the NRC presents two challenges for mapping riparian areas. The first challenge is to map all boundaries of all aquatic and semi-aquatic areas. First-order channels in the uppermost reaches of watersheds are especially important and challenging to map. Although they usually comprise most of the drainage network of a watershed, they are seldom well represented on existing maps and are often inconspicuous in the available imagery. The amount of first-order riparian areas can be estimated from samples, however. The second challenge is to decide how wide the riparian areas are when they are not obviously delimited by vegetation or other visible features. This challenge is met by setting width rules based on existing studies relating width to riparian function for various environmental settings, and using these rules to automate riparian mapping in a Geographic Information System (GIS).

Six methods for mapping existing riparian habitat have been developed using combinations of rules supported by the scientific literature. These methods range from just mapping what is obviously riparian vegetation (Method 1), to accounting for the effects of vegetation height and topography on the width of riparian areas for broad suites of riparian functions (Method 6). Four methods of mapping potential riparian habitat were also compared. These methods range from simply adopting the FEMA 100-yr flood hazard maps (Method 7) to predictive maps based on regional relationships between fluvial channel geometry and drainage area (Method 10).

Based on their accuracy and cost, Method 6 for mapping existing riparian areas and Method 10 for mapping potential areas seem optimal. Method 10 needs further development, however, to work well in all settings. Method 6 is best at identifying the full extent of riparian form and function. It can be standardized throughout California by many work centers using existing data.

Given that the RHJV definition of riparian habitat is not yet widely recognized in California, we recommend that further analyses of its ramifications for existing state environmental policies and programs be encouraged. This report can help inform those analyses by showing how different mapping methods translate the definition into measures of the existing and potential extent of riparian resources. We also recommend that this report be published through formal peer review to further establish its scientific credibility. Finally, we note that one or more of the methods discussed in this report will be used in the existing State Wetland Demonstration Project (WDP) of the Resources Agency and related projects funded through the State Coastal Non-point Source Program during 2007-09. The RHJV might participate in the WDP Steering Committee to help assess the efficacy of these riparian mapping methods as they are being implemented.

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Comparison of Methods to Map California Riparian Areas

Purpose

The purpose of this report is to compare and contrast definitions and methods of mapping existing and potential riparian areas throughout California. This report has been produced for the California Riparian Habitat Joint Venture (RHJV); the use of any of the findings or recommendations from this report by any government agency or other organization is voluntary.

Background

A comprehensive map of California riparian areas is needed for their conservation and restoration. This need is reflected by the State's increasing awareness of the ecological and economic importance of riparian areas. In 1993 the State adopted a Wetland Conservation Policy calling for a statewide inventory of wetlands (67). Pursuant to Assembly Bill 2286 (2000), which was passed to help implement the Wetland Conservation Policy, the California Resources Agency is working with the National Wetlands Inventory (NWI) of the U.S. Fish and Wildlife Service and other partners to develop a comprehensive State Wetlands Inventory (68). It is a compilation of existing and new NWI maps, some parts of which predate the State's and NWI's interest in riparian mapping and therefore do not include riparian areas. But the need to include riparian areas in future inventories of the state's natural resources is well recognized (181). Updates to the Forest Practice Rules in 2000 (74, 75) increased attention to riparian resources. The State is developing a comprehensive vegetation map (72, 73) that identifies riparian vegetation types (i.e., plant species that are indicative of riparian condition), although it does not indicate the extent of riparian areas per se (see section below on riparian definitions). As the interest in riparian conservation has grown, hundreds of ecological restoration projects that involve riparian areas in California have been initiated that highlight the need for a consistent riparian definition and mapping approach (69). The California Resources Agency has recently begun working with other state agencies to develop a comprehensive program for wetland and riparian assessment and monitoring (70, 181). The program plan calls for a statewide inventory of riparian areas as well as wetlands, and involves new, standardized methods of riparian assessment (71, 181). The North Coast and San Francisco Bay Regional Water Quality Control Boards are drafting amendments to their Water Quality Control Plans (Basin Plans) to protect stream and wetlands systems including riparian areas and floodplains (79). There is a clear need to standardize the definition and mapping approach for riparian areas.

The Riparian Habitat Joint Venture (RHJV) has been working since 2001 to develop a comprehensive map of California riparian areas. The RHJV has produced workshops with riparian experts from academia, science-based NGOs, the private sector, and federal and state agencies to outline a technical approach. The workshops have included representatives from NWI, the State Wetlands Inventory, and the State's wetland monitoring demonstration project in hopes of developing an approach to riparian mapping that will satisfy the needs of these related programs. This study is an outgrowth of those workshops.

Intellectual Framework

Definition of Existing Riparian Area

The term, riparian, has numerous definitions in the technical and policy-related literature. The lack of a consistent definition impedes coordination among federal and state programs to protect riparian areas (1, 81). Appendix A provides a sample of definitions from such programs in California. The National Research Council (NRC) has synthesized a definition that seems fundamental to most interests (57, 58). This definition has been adopted by the California Riparian Habitat Joint Venture (RHJV) and is therefore used in this report:

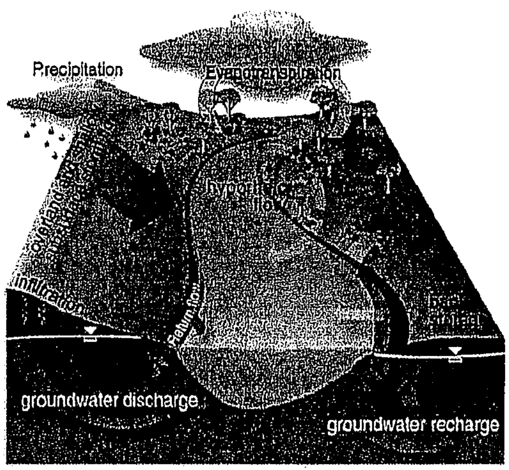


Figure 1: Diagram of terrestrial, riparian, and freshwater aquatic system in the context of the hydrological cycle; from National Research Council 2002 (58).

"Riparian Areas are transitional between terrestrial and aquatic ecosystems and are distinguished by gradients in biophysical conditions, ecological processes and biota. They are areas through which surface and subsurface hydrology connect water bodies with their adjacent uplands. They include those portions of terrestrial ecosystems that significantly influence exchanges of energy and matter with aquatic ecosystems. Riparian areas are adjacent to perennial, intermittent, and ephemeral streams, lakes and estuarine-marine shorelines." It's clear from the NRC report that the term, waterbody, refers to wetlands as well as streams, lakes, and estuaries.

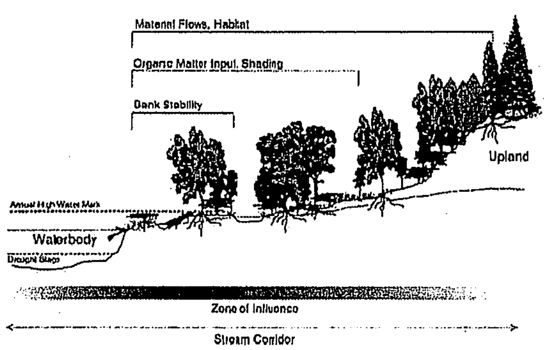


Figure 2: Diagram of zonation of riparian functions between uplands and adjacent waterbodies; from National Research Council 2002 (58).

Numerous technical studies and reviews (e.g. 23, 37, 56) recognize that riparian areas consist of two or more zones of varying widths and distinguishing structure and function that parallel the adjacent waterbody (Figure 2). The zone nearest the stream features tightly coupled stream-riparian interactions (e.g., bank stabilization, predation on aquatic biota). The next zone further from the channel features processes of the riparian area itself (e.g., shading, flood water storage). Another zone further from the channel is more about buffering the other zones and the stream from upland stressors (e.g., non-point source runoff, encroachment by people). In British Columbia, riparian interests commonly combine the first two zones into one (37). A similar scheme has been suggested for the United States (89).

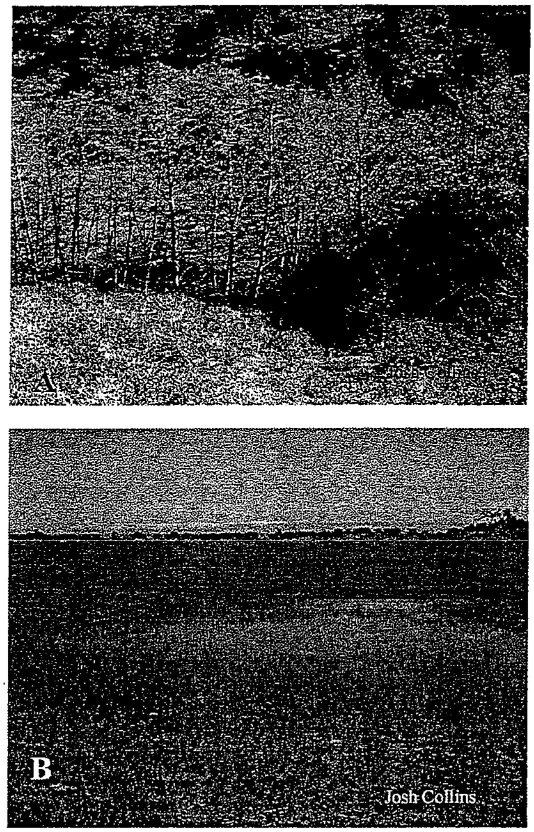


Figure 3: Examples of (A) a lacustrine wetland with overhanging riparian forest canopy, and (B) a vernal pool with less distinctive riparian grassland.

The subdivision of riparian areas into functional zones is justified by the changes in physical and ecological conditions that naturally occur between the aquatic and terrestrial environments, and by the need to accommodate associated changes in land use objectives and policies. Many studies emphasize, however, that the apparent riparian zones and the adjacent aquatic and terrestrial environments function together as river corridors, estuarine and lake shores, or as wetland ecosystems, and that the boundaries between them vary in location and distinctiveness in space and over time (e.g., 1, 3, 4).

Wetlands and their riparian areas `can be difficult to distinguish. Both occupy the transition between dry and wet environments. But wetlands are restricted to places of saturation or standing water that support indicative wetland vegetation (182), whereas riparian areas can include these places plus associated beaches, tidal flats, point bars, and other non-wetland areas. Riparian areas can also include uplands and terrestrial vegetation that are excluded from wetlands. Riparian areas and wetlands commonly coincide, at least in part, either because the riparian areas encompass the wetlands, as in the case of a riverine riparian forest that encompasses wetlands on a floodplain, or because the riparian vegetation actually overlaps the wetlands, as in the case of a lacustrine riparian forest canopy that hangs over wetlands along the lakeshore (Figure 3A). The exact boundary between riparian areas and wetlands can be difficult to discern in seasonal wetlands with indistinct margins, such as vernal pools (Figure 3B).

A distinction must be made between riparian buffers and riparian areas. Riparian buffers are designated for the protection of adjacent waterbodies. They are not necessarily designated to protect the intrinsic functions of the riparian area per se, or to protect the functional interactions between the riparian area and the adjacent uplands. A buffer might not include all of the riparian area, as defined by the National Research Council. Some of the larger studies and reviews of riparian habitat conditions (e.g., 9, 53, 75, 78, 80) have distinguished between riparian areas necessary to sustain the physical stream environment and those needed to sustain near-channel microclimate and appropriate riparian communities.

For example, studies of California forested streams show that their physical integrity is more likely to be sustained if appropriate tree-fall characteristics are maintained within a buffer that is no wider than the average mature height of the stream-side trees. But much of the woody input from trees growing along the stream bank can result from these trees being struck by other trees naturally falling from farther away (76). Furthermore, the microclimate indicative of forested riparian communities requires a riparian width equal to two or three tree heights (77, 78).

Synonyms for Riparian Area and Buffer

There are many published terms referring to riparian areas or buffers. The following list is not exhaustive, but it contains the most common synonyms found in scientific and policy-related literature written in English:

- riparian areas
- riparian zones
- riparian habitats
- riparian buffers
- buffer strips
- watercourse and lake protection zones
- streamside management zones
- streamside protection zones
- riparian ecosystems
- riparian reserves
- special management zones
- forested riparian zones
- watercourse buffer zones
- areas of concern
- riparian management areas

Permutations of these terms are also evident.

In general, broader riparian buffers result from considering more riparian functions. Strategies to conserve the riparian areas in their entirety, including their interactions with adjacent uplands, will tend to involve broader areas than less comprehensive strategies that focus on a subset of riparian functions, such as stream protection. Simply stated, riparian areas are usually broader and more extensive than riparian buffers. This project is about mapping riparian areas.

Definition of Channel

Given that a map of riparian areas is needed and that some amount of riparian area attends every surface channel that conveys water (57, 58), then a definition of channels that can be used to map riparian areas would be helpful. All the recovered, published definitions of a channel are somewhat circular in reasoning because they rely upon one or more channel synonyms such as creek, river, stream, stream bed, conduit, creek bank, etc. But the literature suggests that, in essence, a channel is a long series of generally u- or v-shaped topographic cross-sections that together confine the gravitational flow of surface water. Natural channels are created and maintained by the flows they convey (183). Unnatural channels are usually designed to convey a predicted flow (174). The following published definition was selected for its agreement with these basic concepts and its overall simplicity.

> *A channel is an open conduit either naturally or artificially created which periodically or continuously contains moving water, or which forms a connecting link between two water bodies (185).*

River, creek, stream, run, branch, anabranch, and tributary are some of the terms used to describe natural channels, which may be single or braided. Canal, ditch, and floodway are some of the terms used to describe artificial channels. A braided or anastomosing channel is characterized by a successive division and rejoining of overland water flow though anabranches, which are diverging and converging secondary channels that together comprise the braided channel as a whole (185).

Definition of Potential Riparian Area

The RHJV recognizes a need to map *existing* riparian habitat for its protection and to map *potential* habitat as a first step toward assessing and prioritizing riparian restoration opportunities. The science advisors to the RHJV have recommended developing separate definitions and mapping methods for existing and potential habitat.

Changes in the distribution of riparian habitat result from changes in the extent or location of a waterbody, especially a lake, lagoon, river, stream, or wetland, or from a change in the location of emergent groundwater that drains to a waterbody (58, 84). The distribution of riparian habitat can be changed by river migration, the rising or falling of water tables, the removal or construction of dams and levees, water diversions, stream channelization, excavations of stream terraces, and the infilling of wetlands and active floodplains. In order to affect riparian functions, these changes have to last long enough to alter the way material and energy tends to be processed between the waterbody and the adjacent uplands. Some concomitant change in the structure of the plant community in the area of hydrological change would be expected. Based on these considerations, the following definition of potential riparian area seems appropriate.

> *Potential riparian areas are uplands or former riparian areas that are likely to become hydrologically connected or re-connected to a waterbody due to its migration, enlargement, realignment, or due to an increase in surface or subsurface runoff to the waterbody.*

Areas that are expected to be permanently exposed by retreating or shrinking waterbodies also represent potential riparian areas. This is an uncommon scenario at this time, but might become more common because of dam decommissions (e.g., 144) or decreased rainfall as affected by global warming (e.g., 106). These potential areas cannot be mapped without knowing the case-specific bathymetry behind the decommissioned dams, or the local effects of global warming on runoff. Efforts to map potential riparian areas due to expanding lakes and reservoirs would also need to be addressed on a case-specific basis. The assessment of potential riparian areas therefore focuses on uplands or former riparian areas that would tend to be flooded in the absence of unnatural channel entrenchment, levees, or other flood control measures (e.g., 143).

This definition of potential riparian areas does not necessarily exclude any land uses or cover types. However, for the purposes of this study, land uses that are not compatible with flooding, saturated soils, or very high water tables are excluded from potential riparian areas. For example, industrial and residential land uses within known or probable flood zones are excluded from potential riparian areas.

Quantitative estimates of potential riparian areas are not common. A literature search using key terms such as riparian potential, riparian prediction, and riparian creation produced numerous references to riparian habitat rehabilitation, restoration, or enhancement (e.g., 98-103), but fewer studies of the full extent of probable riparian response to expected or possible hydrological changes (e.g., 85-88, 143). Site plans for new reservoirs, water-related restoration projects, and land developments seldom consider riparian areas in their entirety; the riparian focus is almost always on the amount of buffer needed to protect associated aquatic resources (e.g., 53, 91-97). This emphasis on riparian buffer design is evident in many land use plans, ordinances, and related reviews (e.g., 14, 41, 55, 80, 81, 90). Forecasts of riparian response to climatic change are necessarily theoretical (e.g., 105, 106), and mostly focus on how floodwaters might be re-distributed across the land.

<u>Scope and Applicability</u>

According to the purpose of this report, the comparison of methods and any resulting recommendations for riparian mapping should pertain to all of California. This means that the methods and related terminology, including the definitions of existing and potential riparian habitat must be broadly applicable across the State's great diversity of climatic, physiographic, and ecological conditions. It also means that the methods must meet the needs of the large community of environmental scientists, regulators, and managers that is concerned with the conservation of riparian resources. The following considerations have guided the selection of methods to compare.

- The definition of riparian provided by the National Research Council (58) does not depend on waterbody type, substrate type, spatial scale, degree of naturalness, geomorphic setting, or plant community composition. It indicates that every length of channel, shoreline, and wetland edge, whether natural or man-made, has some amount of riparian function. A riparian area is essentially defined by the predictable, physical exchanges of material and energy that connect a waterbody to its adjacent uplands. Simply stated, the riparian area *is* the connection. The width of the area varies according to a variety of factors (126-128), and may be almost nil under severely unnatural conditions.
- The methods should not be inherently biased for or against any particular physiographic or climatic setting. They should provide

comparable maps across the full range of riparian conditions well represented in California.

- To be applicable throughout California in a timely way, the methods should be easy to use, inexpensive, and distributable among many work centers, in addition to being scientifically defensible, adequately accurate, and repeatable.
- To remain relevant, the methods must be "up-gradable" to accommodate new mapping technologies, so long as they do not reduce the methods' broad applicable and cost-effectiveness.

Field-based approaches tend to be more expensive than non-field methods, especially for the remote areas that comprise much of California. Statewide field-based maps of riparian areas are not likely to get completed. This study therefore compares various existing approaches that use remote data, such as Digital Elevation Models (DEMs) and aerial imagery. The comparisons can be spot-checked, however, against field conditions.

The efficacy of approaches to map riparian areas is likely to vary with elevation, aspect, geology, channel order, annual rainfall, land use, vegetation cover, and other factors that influence the extent, composition, and structure of riparian systems (e.g., 14, 145). This study therefore involved selecting test watersheds that encompass broad ranges in environmental factors typical of different environmental settings.

Methods and Results

Selection of Test Watersheds

Criteria were developed to select two test watersheds that represent a broad range of environmental conditions commonly encountered in California. The primary criteria were climate and accessibility; it was decided that one semi-arid and one wetter watershed within which related work was already being conducted should be selected. Based on these primary criteria, a set of candidate watersheds was created. Secondary criteria addressed the budgetary and time limits for the study. The RHJV developed a list of mapping methods or approaches that would be useful to compare, and this lead to discussions about the kinds of data that the candidate methods require. The major datasets include digital elevation models (DEMs), recent high-resolution geo-rectified imagery (1m pixal resolution), stereo aerial photography, vegetation maps showing dominant cover species in riparian settings, and existing or updated maps of the National Wetlands Inventory (NWI). Table 1 of Appendix C shows how the major data types are distributed among the candidate mapping methods. This project could not afford to develop most of the data types that were needed, and therefore depended on available data. Most future efforts to implement any of these methods will also depend on available data. The availability of these data was therefore used to help select the test watersheds. Tables 2 and 3 of Appendix C score the candidate watersheds based on the availability of key datasets, as identified in Table 1 of Appendix C. Based on these criteria, Napa Watershed in northern California and Ventura Watershed in southern California were selected as the test watersheds.

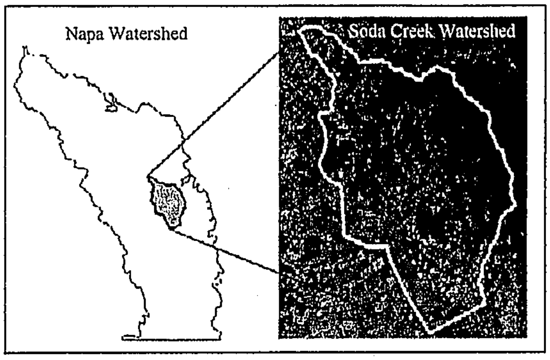


Figure 4: Example index area. Soda Creek Watershed was chosen as one of two similar-sized index areas of the larger Napa Watershed.

Selection of Index Areas within Test Watersheds

As the data for the test watersheds were compiled, their incompleteness became evident. Few of the major datasets covered either test watershed in its entirety. This necessitated the selection of sub-watersheds, termed "index areas," within each watershed for which the major datasets were most complete and could support the broadest comparisons of mapping methods (Figure 4). Two index areas were selected in Napa Watershed to capture its full range of geomorphic and topographic conditions. Only one index area was needed for the Ventura Watershed. The index areas comprise between 5% and 10% of the total surface area of each test watershed. The index areas are classified as Planning Watersheds according to the California watershed classification system (see Table 4 of Appendix C).

Mapping Drainage Networks

Any comprehensive effort to map existing or potential riparian areas must begin with a complete map of all the lakeshores, estuarine shorelines, perennial channels, ephemeral and intermittent channels, and artificial drainage channels that together comprise the drainage network. It can be assumed that every part of the boundary of the network supports some amount of riparian area (see discussion of riparian area beginning on page 2 above). If the map of the drainage network is incomplete, then the map of the riparian areas must also be incomplete.

The most common set of data for depicting the drainage network of any watersheds in the Unites States consists of the "blue lines" of rivers and streams and shorelines from the 1:24000 scale topographic quadrangles produced by the U.S. Geological Survey (USGS). The blue lines comprise part of the standard 1:24000 Digital Line Graph (DLG) dataset commonly available to the public. It has long been known, however, that the blue lines do not represent the complete drainage network for any watershed (45, 46). This is especially true with regard to mapping riparian areas, since they can attend artificial drainage channels as well as natural ephemeral and intermittent streams that are seldom comprehensively included in the DLG (Figure 5 below).

A variety of computer-based methods exists to construct maps of drainage networks based on Digital Terrain Models (DTMs). A DTM is a grid of elevation points. The size of the spaces (i.e., the size of the square cells of the grid) dictates the resolution of the DTM. Cell size is also termed node distance, which is the shortest distance between the intersections of the grid lines. As node distance increases, DTM resolution decreases.

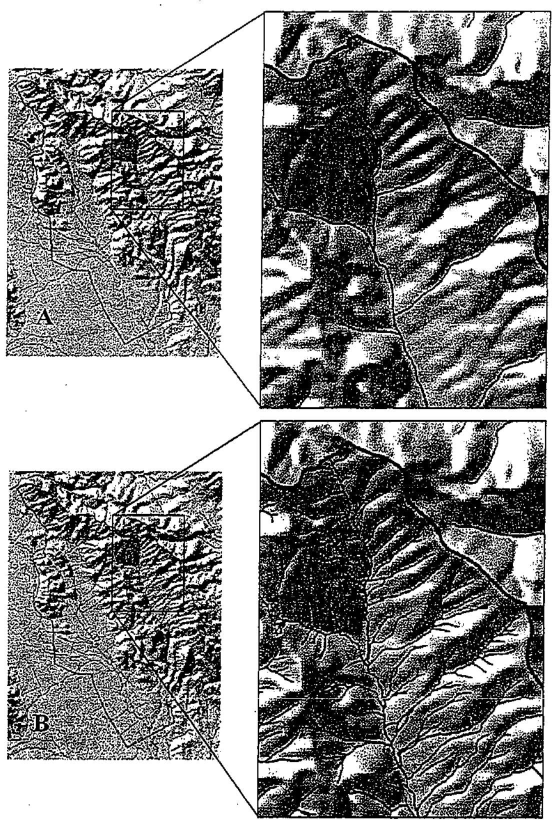


Figure 5: Comparison of drainage networks for the Soda Creek index area of Napa Watershed based on (A) USGS 1:24,000 DLG and (B) heads-up digitizing from 10m DEM plus interpretation of 1m pixel resolution natural color aerial imagery.

Large-node DTMs can only be used to produce relatively coarse, generalized topographic maps (40, 42-45, 110, 111). DTMs can also be used to generate maps of land slope, which can help determine the limits of valley bottoms and flood plains as potential riparian areas (e.g., 46, 88, 100, 143), and to adjust models of riparian buffer width to account for the effects of slope on runoff and tree fall (e.g., 48, 76, 77).

The DTMs produced by the USGS are termed DEMs (Digital Elevation Models). The 30-m DTM and 10-m DTM are commonly available in California. Of these two DTMs, the higher-resolution 10-m DTM is much superior for generating drainage networks (42, 45, 143). The USGS 10-m DTM was used in this study because it is the highest-resolution DTM available throughout California.

LIDAR (i.e., Light Detection and Ranging, or Laser Imaging Detection and Ranging) is a recent technology that can be used to develop detailed DTMs from which topographic maps and drainage networks can be derived. LIDAR determines the distance from a sensor on an airplane or satellite to the ground surface by measuring the time delay between transmission of a laser pulse and detection of the reflected signal. Detailed DTMs with node distances less than 1 meter are routinely produced using LIDAR (112-114). Enough measurements can be taken per unit area to describe the 3-D form of individual trees (e.g., 107-109). Very high resolution DTMs based on LIDAR can be used in some situations to quantify channel cross-sections and longitudinal profiles (115), although most LIDAR does not penetrate water. A 1-m DTM was developed from LIDAR for the Napa Watershed as part of an effort to address sedimentation problems in the Napa River (116). The Napa 1-m DTM was used in this study to help assess the general efficacy of using LIDAR to generate drainage networks for riparian mapping.

After testing the efficacy of the 1-m and 10-m DEMs for the Napa Watershed index areas (see results below), it was decided that the most cost-effective method to comprehensively map drainage networks was to augment the 1:24000 DLG with automated generation of first- and second-order channels using ArcHydro (186) operating on the 10-m DEM, and "heads-up" editing of the Arc Hydro network based on the recent geo-rectified 1-m resolution imagery provided by the National Agricultural Imagery Program (NAIP) (187), existing NWI, vegetation maps (discussed more fully below), and slope maps generated from the 10-m DEM. Using this approach, comprehensive drainage maps were developed for all three index areas.

Mapping Existing Habitat

National Wetlands Inventory

The National Wetland Inventory (NWI) is charged with estimating changes in the amounts of wetlands and riparian areas throughout the United States. It has developed mapping methods that can be fully implemented with the kinds of data, equipment, and expertise most broadly available in California. NWI has published its methods (5) and they are being adopted by the Federal Geographic Data Committee (2). But the NWI methodology is not inflexible. NWI has adjusted its methods for new technologies, and in California NWI has developed partnerships with regional data sources and map developers to improve the relevance of NWI products for local interests. NWI has advised the RHJV and it is interested in this study as a possible source of new methods to improve its capacity to map riparian habitat in California (188).

The current NWI methodology relies mainly on the recognition of vegetation indicative of riparian conditions in the best available stereo aerial photography (5). Every ecological province of California has a flora indicative of riparian conditions (73). These indicator plant species and assemblages, when evident in the kinds of planimetric imagery commonly available for habitat mapping, can be used to help delineate the extent of riparian areas. In some cases, the riparian areas can be delineated by visible differences in plant stature or morphometry along the upland-riparian boundary, rather than plant community composition (58, 76, 80). Not all riparian conditions are represented by indicative vegetation, however.

The NWI method also accounts for some riparian areas that cannot be discerned based on vegetation. This is done by assigning a default constant buffer width of 2.5m to both sides of channels depicted by single blue lines in the 1:24000 scale DLG (5). The mapped riparian areas are then classified according to the NWI riparian scheme. Recent NWI updates have included annotations for water source based on the hydro-geomorphic (HGM) classification system (117).

The resulting map of riparian areas based on current NWI protocol consists of polygons of obvious riparian vegetation plus standard riparian widths applied to both sides of the mid line of small channels and the upland side of lakeshores that are represented by single blue lines on the 1:24000 DLG and lack obvious riparian vegetation. This leaves out channels not shown in the DLG, and the riparian areas of most palustrine (i.e., depressional and slope wetlands according to the HGM system) and estuarine wetlands.

Functional Riparian Width

Knowing how wide riparian areas tend to be is important for mapping areas that lack distinctive vegetation or other indicative features. Not all riparian areas are vegetated (5, 57, 58), and they aren't always clearly distinguishable from adjacent uplands based on vegetation. For example, upland and riparian vegetation assemblages look very similar in aerial imagery for ephemeral or intermittent streams in the headwater reaches of densely forested watersheds and in very arid environments. Also, lakes and streams in urban and farmed areas do not always support distinctive riparian vegetation. All of these examples are common occurrences that in aggregate might represent a significant percentage of the total length of channel and shoreline in California. For the associated riparian areas, criteria other than plant stature or community composition must be used to define the upland boundaries.

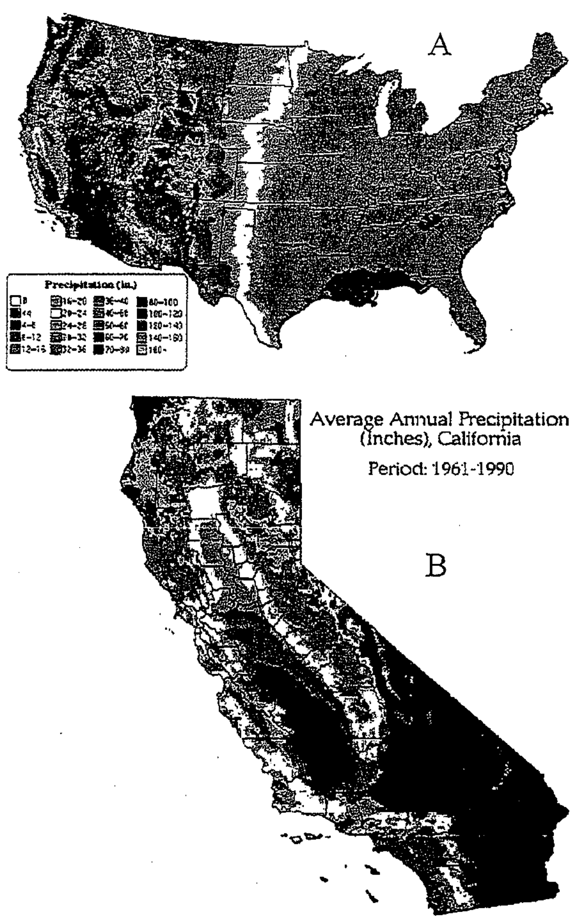


Figure 6: Climatic diversity of (A) the coterminous United States and (B) California (187).

In the absence of indicative vegetation, one alternative approach to mapping riparian areas is to assume a default riparian width based upon relationships between width and riparian function reported in the pertinent literature.

Information about the functional width of riparian areas from throughout the temperate world is applicable to California because of the State's great physiographic and climatic diversity. For example, in terms of average precipitation, which is a controlling factor for the distribution and abundance of vegetation and riparian conditions, California includes all of the climatic zones represented elsewhere in the United States (Figure 5). The same can be said for topographic range.

The search for literature about riparian form, structure, and functional width was therefore geographically broad. The number of technical reports about the nature of riparian areas has been increasing rapidly (58). This has lead to published reviews that summarize much of the pertinent literature. The results of the literature search about riparian functional width are summarized in Appendix D. The findings are further summarized in Table 1 below.

Riparian Function	Average Recommended or Observed Minimum Riparian Width (rounded to the nearest 5m)	Average Recommended or Observed Maximum Riparian Width (rounded to the nearest 5m)
Sediment Entrapment	10	75
Contaminant Filtration or Chemical Transformation	10	115
Large Woody Debris Input to Water Body	40	80
Leaf Litter Input to Water Body	5	25
Flood Hazard Reduction	15	65
Aquatic Wildlife Support	20	60
Bank or Shoreline Stabilization	15	25
Riparian Wildlife Support	40	160
Water Body Cooling	20	40
Riparian Microclimate Control	70	130
When Multiple Functions Are Considered in Conjunction with Riparian Wildlife Support (Part 2 of Appendix D)	30	120

Table 1: Summary of recommended riparian functional widths based on Appendix D.

The literature generally indicates that the total number of functions of a riparian area tends to increase with its overall width and length. The level of any given function also tends to increase with riparian width, but not without limit and not always in a linear way. Most functions increase in level quickly over the first 5m-10m and then level-off within 30m-100m. Some functions, such as bank stabilization and contaminant filtration, can be well supported by relatively narrow riparian areas (e.g., see summaries in references 9 and 129). For protecting the water quality of water bodies (especially regarding nitrogen and phosphorus loading), the average minimum and maximum recommended riparian widths are about 15m and 100m. To protect channel banks and shorelines, the suggested minimum and maximum widths average about 15m and 25m. To provide flood control (i.e., to measurably decrease peak stage of the hydrograph or to increase the residence time of water in a watershed) and to support aquatic resources in adjoining water bodies, most of the recommended riparian widths fall between about 15m and 60m. To sustain natural riparian microclimates, a functional width of about 70m-130m is indicated. Maintaining the intrinsic ecological functions of riparian areas, such as their support of riparian wildlife, require the broadest areas (57, 104). The average minimum and maximum recommended riparian widths to support riparian wildlife are about 40m and 160m, although widths greater than 200m are also suggested (i.e., 51, 52). For studies that reviewed and summarized recommended riparian width for multiple functions, the average minimum and maximum values are about 20m and 80m, with overall averages of about 30m and 120m when riparian wildlife support and other functions are combined (see Part 3 of Appendix D).

A single width can be used to approximately cover all expected riparian functions (e.g., 76, 104), or the width can vary by selected functions (e.g., 139, 53). Functional widths can also vary based on local controlling such water body type, plant community composition, geomorphology, and hydrology (123, 14, 124, 145). Although default widths disregard these local controls (126, 128, 145-147), they are commonly used to map riparian areas. For example, the fixed-width approach is used by the NWI for small streams that lack distinctive riparian vegetation (5), and it is commonly used by different states to design riparian buffers (125).

Most of the studies of riparian width pertain to forested systems and focus on the protection of adjoining rivers and streams. Fewer studies focus on grasslands or shrub systems and most of these are about sediment and nutrient removal by grass strip buffers in agricultural or urban settings. They indicate that 50-90% of suspended sediment and 25-90% of nutrients can be filtered by grass strips 5-10m wide (e.g., 131-140).

Studies of functional width for riparian forests in California are commonly concerned with the beneficial shading and cooling of adjoining streams and the input of large woody debris (LWD) provided by riparian trees. In these regards, the federal agencies tend to assess riparian width in terms of Site Potential Tree Height. SPTH is defined as the average maximum height of the tallest mature tree of the dominant tree species at a given site (53). Several studies indicate that most of the aquatic ecological benefits of riparian vegetation depend on the 5m-30m of riparian areas nearest the adjoining water body. For example, riparian areas that are 30m wide can provide at least 50% of the total riparian benefits to associates streams (e.g., 14). But such "rules of thumb" ignore the effect of tree species on tree height, and the effect of tree height on shading and LWD input. They also neglect the influence of tree species on overall riparian structure and wildlife support. When these factors are taken into consideration, the specifications for riparian areas de-emphasize fixed widths and instead relate width to vegetation structure. Widths ranging from 1-3 SPTH have been recommended (53. 39, 49).

The input of terrestrial or riparian materials into water bodies (i.e., allocthanous input) can be a very important function of riparian areas (53, 156, 158), especially for headwater channels (49, 58, 157, 161). The likelihood of allocthanous input can be affected by the steepness of the terrain (51, 161). Functional widths based on allocthanous input might therefore get narrower as the terrain gets steeper. One way to account for this affect is to reduce the SPTH value as a function of the slope of the riparian areas (157).

Landsliding and other mass-wasting processes, apart from bank erosion, can account for most of the allocthanous input in steep terrain (160, 161). Functional riparian widths might therefore increase in steeper terrain to accommodate hillslope processes. Other studies suggest that, for the purposes of chemical filtration and sediment entrapment, riparian buffers should increase in width as their slope increases (Table 2 below). The rationale is that broader buffers are needed to filter faster runoff in steeper terrain (23, 40, 48, 162). The recommendations generally call for an increase in buffer width per unit increase in percent slope, starting at a minimum buffer width. Some studies also recommend a minimum percent slope below which no adjustments are made. Overall, the recommended minimum functional width averages about 30m, and the minimum slope threshold below which no adjustment is made is about 20%. In other words, the average recommended adjustment is an increase of about 1m in width for every unit increase in

Reference	Recommended Adjustment of Buffer Width (m) for Slope (% as integer)	Slope Threshold (% as integer)	Buffer Width Threshold (m)	Vegetation Type
164	1.25 X slope	None	30.0	NA
163	1.50 X slope	None	30.0	NA
165	1.20 X slope	None	30.0	NA
9	0.60 X slope	None	30.0	NA
166	1.50 X slope	30.0	20.0	Forest
167	0.50 X slope	20.0	20.0	Forest
24	1.33 X slope	15.0	30.0	Forest
Averages	1.12 X slope	18.5	27.1	Mostly Forest

Table 2: Example adjustments in riparian width to account for slope of riparian and adjacent terrain.

slope above a threshold of 20%, starting at a minimum riparian width of 30m. Applying this formula to an area with a 70% slope, which is much steeper than most areas, yields an overall buffer width of 100m, which is comparable to the most commonly recommended maximum default buffer width to accommodate most riparian functions (see Table 1 above and Appendix D).

There are very few studies of the effectiveness of riparian buffers along man-made channels, such as irrigation ditches (137). Most of these buffers are grass strips less than 10m wide. Studies of these buffers have shown that 77-90% of nutrients (137, 138) and 50-90% of the sediments (139, 140) are trapped within grass buffer strips 5m wide along ditches. Grass buffers 12-24m wide can remove 10-40% of herbicides (141), and grass buffers 10m wide can remove 74% of fecal coliform (142).

It should be noted that irrigation and drainage ditches in agricultural and urban settings are not expected to have as much potential for ecological functions as more natural streams of the same size. The literature about riparian areas along ditches is scant, but suggests that relatively narrow areas can provide most of their potential functions.

Vegetation

Maps of dominant plant species or assemblages can help identify the extent of riparian areas. This is because the moisture regimes that characterize riparian areas tend to give rise to indicative riparian flora.

This fact has encouraged the development of remote sensing methods to automate riparian mapping based on the spectral signatures of known riparian plant species. Once a library of signatures has been produced, it can be used to classify the vegetation in multi-spectral imagery. The use of spectral analyses to map riparian areas has been fraught with technical complications, however. First, riparian areas do not necessarily have abundant vegetation (5, 58). Second, spectral analysis does not generally provide accurate classifications of riparian vegetation (148, 149). There can be more spectral variation for a given species than the dictionaries of spectral signatures contain, and the bandwidth of the remote sensors may be too broad to discern differences between species (150, 153, 155). The classification errors can sometimes be corrected by field verification and local expert review, but this adds considerable time and cost to the remote sensing approach. The time required to correct the automated maps can be comparable to original, ground-based mapping. Third, spectral analyses fail to determine the lateral extent of riparian conditions when upland and riparian vegetation is indistinguishable (150), which is not an uncommon situation in California. Some of the more successful remote sensing efforts to map riparian areas have been restricted to valley bottoms where the riparian vegetation tends to be most distinctive (e.g., 147, 154). The approach may one day prove to be more broadly applicable and cost-effective than it is at this time. But given the expense in developing adequate dictionaries of species-specific spectral signatures, and given that adequate dictionaries will not be available for the State in the foreseeable future, remote sensing of riparian areas based on the spectral signatures of riparian plants was not attempted in this study.

Figure 7: Examples of (A) CALVEG mapping and (B) vegetation map based on the California Vegetation Manual.

Two existing vegetation maps were used to help estimate functional riparian width (Figure 7).

CALVEG is a hierarchical classification system designed to assess vegetation-related resources throughout California (119). The system was devised in the late 1970's by the Pacific Southwest Region of the U.S. Forest Service. CALVEG mapping was done between 1979 and 1981 by the U.S. Forest Service based on interpretation of 1:250,000 scale color infrared prints of Landsat Multispectral Scanner (MSS) imagery acquired between 1977 and 1979 (119). The minimum mapping unit (MMU) was 400-800 acres, so the spatial resolution of the resulting map was rather coarse. The California Department of Forestry and Fire Protection had the manuscript maps scanned and converted to ArcInfo coverages. CALVEG maps were acquired for all three index areas for this study. Any obvious problems with classification were resolved before the maps were used.

In addition to the CALVEG maps, the vegetation of Napa Watershed has been mapped through the Information Center for the Environment (ICE) at the University if California at Davis using the California Vegetation Manual (118). The CVM is a newer hierarchical system of vegetation classification and mapping than CALVEG. The CVM maps are more resolute and generally more accurate than the corresponding CALVEG maps (Figure 7). This is because the CVM uses much more resolute imagery that affords a much smaller minimum mapping unit and more accurate classification. The CVM maps are also subjected to randomized field checks (118, 121, 122). The CVM data for Napa Watershed are available at different levels of the CVM hierarchy. The most detailed data were used in this study.

Land Use Maps

The National Land Cover Dataset (NLCD) is a source of statewide land use data (189). The NLCD is a component of the USGS National Land Cover Characterization Program. The NLCD contains 21 categories of land cover suitable for a variety of State and regional applications, including landscape analysis and runoff modeling. The NLCD is distributed as 30m resolution raster images. More detailed land cover datasets are available for some regions of the state, but they are not standardized in terms of resolution, vintage, or land cover classification. They can also be expensive to purchase. The NLCD can help to standardize statewide land use analyses.

Roads

The maps of existing riparian areas exclude the surface area of roads. A standard width was assigned to each road classification in the USGS DLG file based on other studies (177-179). All roads in the DLG file were converted into polygons based on the assigned width values. Overlaps between riparian areas and road areas were then subtracted from the riparian areas.

Watershed	Imagery	Scale or Pixel Size	Vintage
Napa	USGS Digital Orthoquadrangles	1:24,000 scale	1994
	National Agricultural Image Program (NAIP) Color ortho-photos	1m pixel size	2005
	AirPhoto USA true color ortho-photos	0.6m pixel resolution	2002
	NWI Stereo Color IR diapositives	1:58,000 scale	1982
	Napa County true color ortho-photos	0.3m pixel size	2006
Ventura	National Agricultural Image Program (NAIP) Color ortho-photos	1m pixel size	2005
	USGS Digital Orthoquadrangles	1:24,000 scale	1994
	NWI Stereo Color IR diapositives	1:40,000 scale	2002

Table 3: List of imagery used to map riparian areas for this study.

Supportive Imagery

All the methods used in this study to map riparian areas rely on geo-rectified stereo aerial photography and other digital imagery. In general, imagery from different years, seasons, and times of day provide a variety of views that can help identify wetlands, lentic water bodies, drainage networks, and the associated riparian areas. It is helpful to acquire all available imagery for a given watershed. Google Earth© can also be helpful when identifying stream courses by creating oblique views of DEMs with image overlays (151, 152). Being able to see topographic contour lines superimposed on high-resolution photography can be especially helpful in identifying low-order channels in the headwater reaches of watersheds. Table 3 lists the imagery used in this study. The same or comparable imagery is available throughout California.

Selected Mapping Methods

This study evaluates six approaches to mapping existing riparian areas, including a "gold standard" (Method 6) against which the other methods could be objectively compared (Table 4 below). The standard incorporates as much information about site-specific conditions that might affect riparian width as the study could afford, without having to conduct more field work than needed to spot-check the methods. All of these methods, including Method 6, could be applied throughout California using existing software and data that are readily available to the public.

The six alternative methods represent a broad range of readily usable tools for estimating the total amount of fully functional riparian area for any landscape in California. They are not intended to estimate the amount of riparian buffer needed to provide a particular suite of functions, such as protection of adjoining water bodies or support of riparian wildlife; the methods are intended to yield maps of riparian areas as ecosystems in their entirety. There are no significant estimates of riparian area for palustine or depression wetlands, slope wetlands, and estuarine wetlands because these wetland classes were either scarcely represented or entirely absent from the study watersheds and their index areas.

Method 1: *Existing National Wetlands Inventory*

Existing NWI maps of riparian areas were available for the Ventura Watershed but not for the Napa Watershed. The Ventura Watershed riparian NWI maps were produced in 2002-3 and were acquired for this study directly from NWI (Figure 8A). The existing riparian maps for Napa Watershed were produced in 2006 through this study and have not yet been subjected to NWI review. The maps for Napa Watershed cannot be referred to as NIW maps until they have been reviewed and accepted by NWI. However, the NWI riparian maps used to represent existing NWI for the Napa Watershed were developed by experts at the San Francisco Estuary Institute who have previously produced riparian maps for NWI under its direction. For Napa Watershed, the minimum mapping unit (MMU) that was adopted for forested areas is approximately equal to the area covered by the combined canopy of three contiguous riparian trees, or about 0.02 ha (0.05 acres). This is much smaller than the MMU of 0.1 ha (0.25 acres) generally employed by NWI for wetlands and riparian areas (5). The smaller MMU for forested riparian areas was adopted in this study because it is consistent with the natural character of riparian forests in arid parts of California, where a few riparian trees can greatly increase the overall riparian ecological service. For areas of shrubs and non-vegetated areas, the NWI MMU was adopted for this study. This allowed the mapping of point bars, beaches, and other non-vegetated natural features along water bodies as parts of riparian areas.

Method 2: *Single Fixed Riparian Width*

This method simply applies a fixed width of 100m to all water bodies (Figure 8B). The selected width is the most commonly cited riparian width in the literature.

Method	Source of Drainage Network Map	Digitization of Visible Riparian Vegetation and Physiography	Default Functional Riparian Width	Use of Site Potential Tree Height (SPTH)
1. Existing NWI Protocol	1:24,000 DLG plus limited additional channels through photo interpretation; single line "blue lines" from DLG assumed to be 5m wide total.	Yes, based on 1:58,000- or 1:40,000-scale stereo aerial imagery	None	None
2. Single Fixed Functional Width	Comprehensive digitizing of all wetlands, lentic features, and channels	None	100m for all channel banks, shorelines, and wetland margins	None
3. Multiple Fixed Functional Widths	Comprehensive digitizing of all wetlands, lentic features, and channels	None	100m for areas of forest, 30m for areas of shrubs; 10m for grassy areas; 1m for bare ground	None
4. Multiple Fixed Functional Widths Plus SPTH Adjusted for Hillslope to Account for Allocthanous Input	Comprehensive digitizing of all wetlands, lentic features, and channels	None	Twice SPTH for forested areas; 10m for areas of shrub; 5m for grassy areas; 1m for bare ground	Twice SPTH based on tallest dominant tree species
5. Method 4 plus NWI Protocol for Areas Not Included in Method 4	Comprehensive digitizing of all wetlands, lentic features, and channels	Yes, based on geo-rectified 1m pixel resolution color imagery plus slope maps from 10m DEM, existing NWI, Google Earth ™ etc	Same as Method 4	Twice SPTH based on tallest dominant tree species
6. Method 5 Plus Adjustment to Account for Hillslope Process	Comprehensive digitizing of all wetlands, lentic features, and channels	Yes, same as Method 5	Same as Method 4 plus a 1m increase in width for every 1% increase in hillslope for any slope greater than 20%.	Twice SPTH based on tallest dominant tree species

Table 4: Brief descriptions of riparian mapping Methods 1-6 compared in this study.

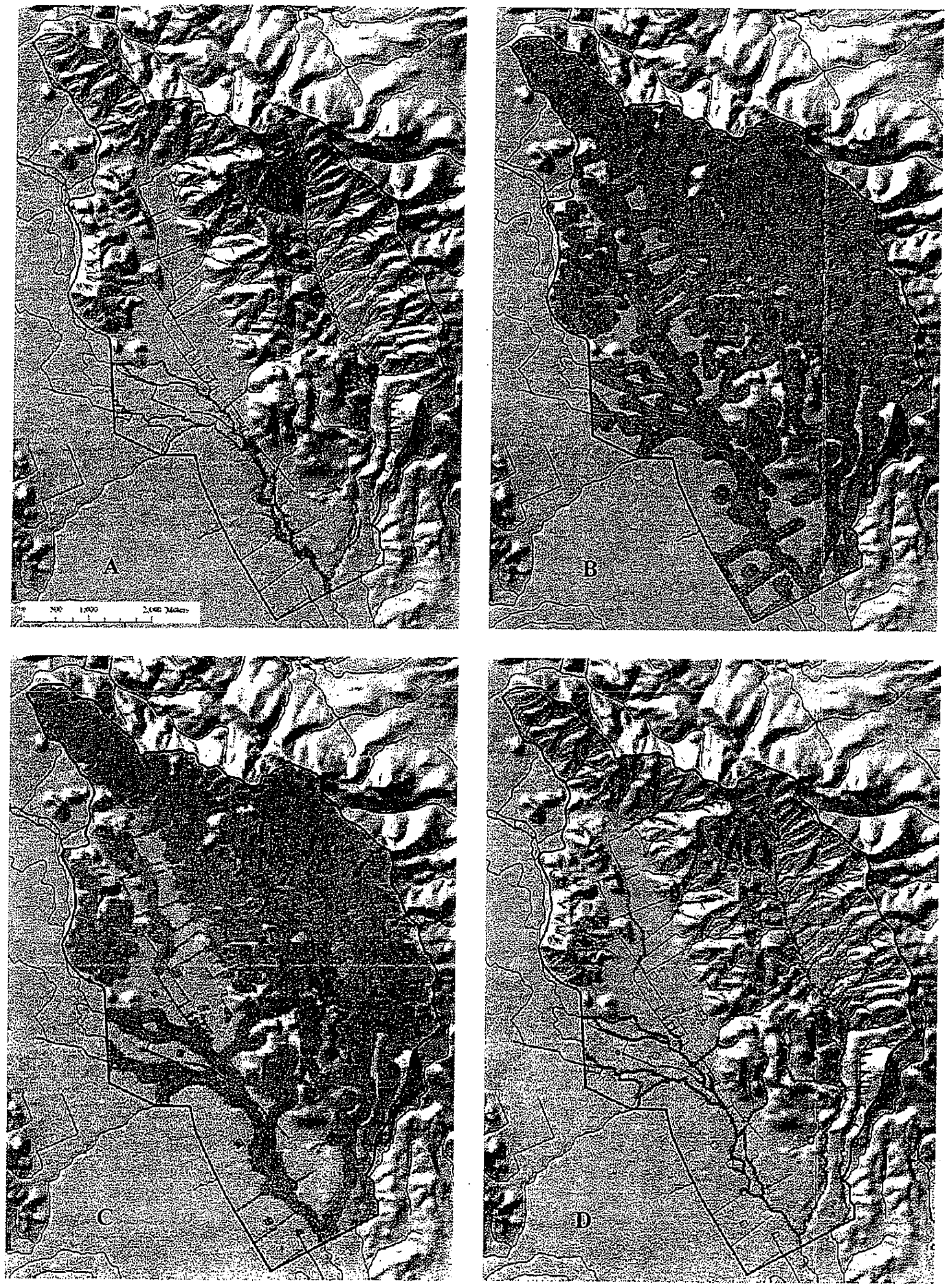


Figure 8 Example results of riparian mapping for Method 1 (A), Method 2 (B), Method 3 (C), and Method 4 (D) for the Soda Creek index area of Napa Watershed.

Method 3: *Multiple Fixed Riparian Widths*

In this approach, different default widths are applied to the drainage network of each index area depending on the dominating major ground cover type (Figure 8C above). The maximum width recommended from the literature was applied in each case. Where trees were dominant, the width was set at 100m, regardless of tree species. Where any species of shrubs was dominant, the width was set at 30m. Where grasses were dominant, the default riparian width was set at 10m. For bare ground the width was set a 1m. The classification of vegetation into trees, shrubs, and grasses was based on species, rather than plant height, and followed the designations of whichever vegetation map was being employed (i.e., either the California Vegetation Manual (73) in Napa Watershed or the CALVEG (119) classification system for the Ventura Watershed).

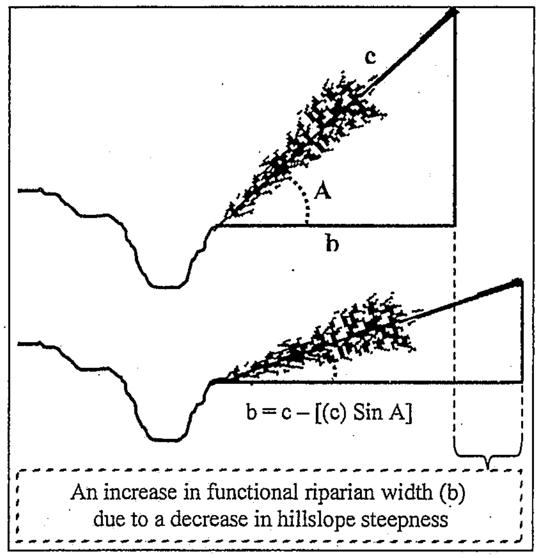


Figure 9: Schematic of method used to adjust SPTH for hillslope steepness; where c = SPTH; A = hillslope in degrees; and b = minimum riparian width for tree top to fall into channel. For any given SPTH, as A increases, b decreases.

Method 4: *Multiple Fixed Riparian Widths plus SPTH*

In this approach, widths are assigned to forested areas based on the SPTH of the dominant tree species, as adjusted for hillside steepness (Figure 8D above). Based on the vegetation maps, and a look-up table of species-specific SPTH, forested areas are assigned a riparian width of 2SPTH. Hillslope steepness, as determined from the 10m DEM, is used to adjust the SPTH values to account for the effect of slope on the minimum distance from a waterbody at which allocthanous input from a tree of height twice SPTH is likely (Figure 9). Default widths for areas dominated by shrubs or grasses are average values from the literature (10m for shrubs, 5m for grasses, 1m for bare ground), rather than the maximum values used in Method 3.

Method 5: *Method 4 Plus NWI Protocol*

A comparison of Methods 1 and 4 revealed that Method 4 can exclude some potentially significant places of distinctive riparian forest along high-order channels, while including other places that appear to lack distinctive riparian vegetation (Figure 10 below). The latter situation was deemed acceptable for the following reasons: (a) some of the indicative vegetation may not be visible in the imagery along the upland boundary (i.e., it may be immature or hidden in shadows); (b) riparian vegetation may be well mixed with upland plant species (81) and therefore misclassified as non-riparian; and (c) some amount of riparian function does not depend on plant cover (58, and see Appendix D), such that the functional riparian area extends further into the terrestrial environment than can be discerned in the imagery. However, the exclusion of obvious riparian vegetation was deemed unacceptable for the following reasons: (a) the excluded areas tend to be portions of the largest obviously riparian areas encountered, and failure to map these areas in their entirety would not help to protect them; (b) larger riparian areas tend to have greater levels and diversity of riparian functions, and a failure to protect them might therefore significantly degrade the riparian functions overall; and (c) the default riparian widths are based on rather conservative average values and their reduction is not clearly justified.

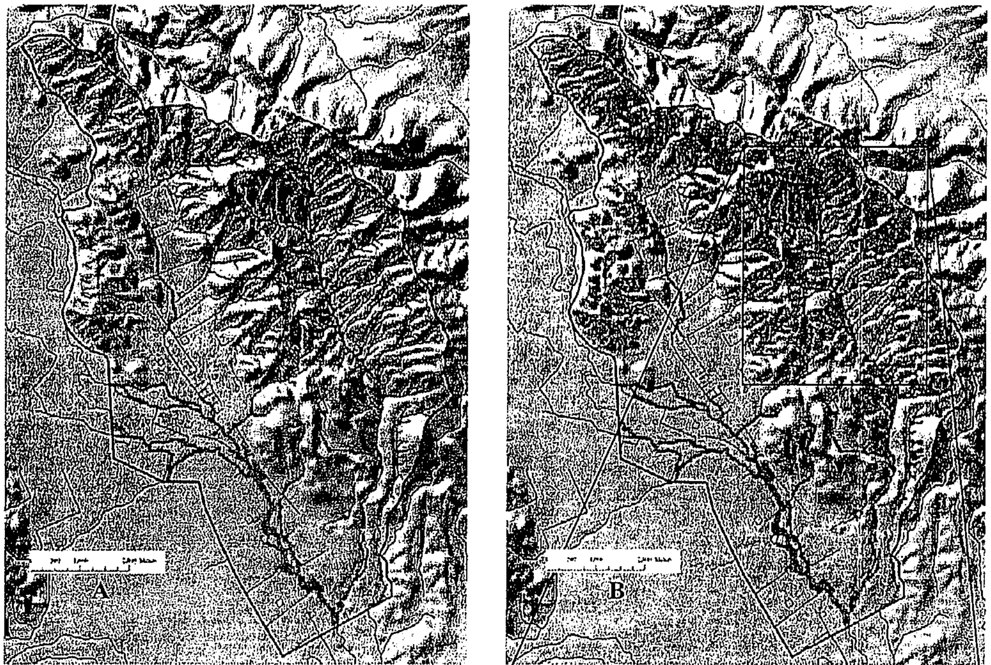
Figure 10: Comparison between results of Methods 1 and 4. Red boxes indicate where Method 1 (green) provides more comprehensive coverage of obvious riparian vegetation than Method 4 (beige). Elsewhere, Method 4 indicates there is more functional riparian area than indicated by Method 1. Blue areas are channels and other water bodies.

Method 5 generally does a good job of encompassing riparian vegetation without grossly overestimating its extent (Figure 10). The rather minor part of the estimated area that exceeds the boundaries of indicative vegetation (i.e., places where beige color surrounds the green color in Figure 10) is not considered a problem because, as stated above, while riparian forests and other riparian vegetation can increase the overall ecological functions of riparian areas, their functions are not entirely eliminated by the absence of such vegetation. Example results from Method 5 are presented in Figure 11A below.

Method 6: *Method 5 plus Hillslope Process*

This method recognizes that some portions of the hillslope processes of low-order channels in the headward reaches of watersheds are riparian in nature (Figure 11B and 11C below) and that they can strongly influence downstream geomorphology, hydrology, and ecology. The headwaters or headward reaches of watersheds are where most water naturally originates within a drainage network (209, 210). They are characterized by interactions among hydrologic, geomorphic, and biological processes that vary from hillslopes to stream channels and from terrestrial to aquatic environments (199, 205, 206, 211). In other words, Headwater areas are riparian in nature.

Headwater areas typically comprise most (70% to 80%) of the total drainage area of watersheds (207, 210). And, since the relative influence of riparian areas on stream ecology tends to increase as stream size decreases (161), headwater areas can be



especially influential on downstream conditions (157, 198). They are important sources of nutrients, sediment, and large woody debris (193, 195-197, 200, 201, 206); they affect downstream channel geometry (183) and landslide probability (206, 210); and the movements of detritus and invertebrates from headwater reaches support downstream food webs (212).

Hillslope erosion processes such as landsliding, dry raveling of soils, and debris avalanches that characterize the headward reaches of watersheds can be dominant sources of allocathanous input of sediment and organic matter (e.g., 194, 213, 214). The magnitude and extent of these mass-wasting processes can greatly increase following wildlife (196, 197).

The immediate drainage areas of first-order channels (i.e., first-order and zero-order basins) are usually "variable source areas" (190). The runoff entering these areas can occur as overland flow (i.e.,

Figure 11: Example results from riparian mapping Method 5 (A) and Method 6 (B), plus details of results for Method 6 in the headwater reaches of the Soda Creek index area of Napa Watershed (C). Blue areas are stream channels.

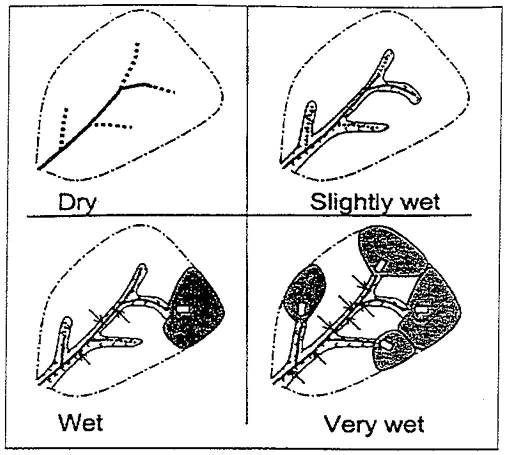


Figure 12. Conceptual model of headwater hydrology. Ephemeral channels mark dry season conditions. Sub-surface flow initiates near the channel as areas get wetter. The preferential flow (thin arrows) and overland flow (broad white arrows) in zero-order basins (shaded areas) increases as conditions become wetter. Figure from reference 205.

precipitation that exceeds infiltration moves downslope as surface sheet flow) (191), lateral subsurface flow (i.e., precipitation that infiltrates and is transported downslope through the soil profile), and preferential flow (i.e., precipitation that moves downslope as flow through rodent tunnels, root channels, etc). This flow by-passes the soil matrix. The variable source areas of zero-order and first-order basins closely resemble the riparian areas generated by Method 6 (Figure 12 cf. Figure 11C).

The various component results of Method 6 can be displayed separately (Figure 13). This can be helpful to understand how the automated riparian widths based on vegetation and hillside slope plus the heads-up digitizing of obvious riparian conditions outside of the automated widths contribute to the results as a whole.

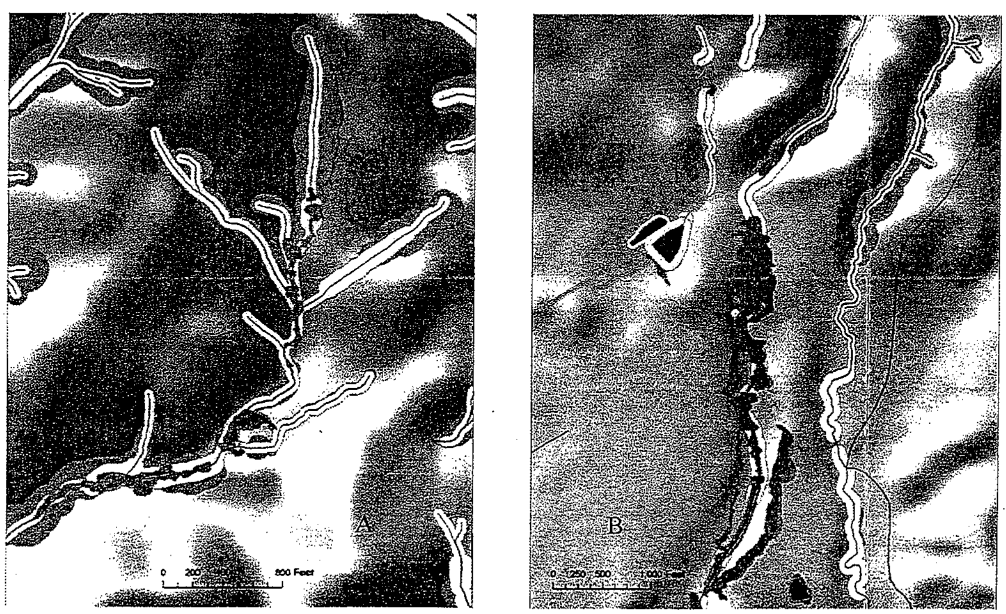


Figure 13: Examples of the drainage network mapping (blue), automated riparian width based on vegetation type (white), automated width based on hillside slope (brown) plus heads-up digitizing of obvious riparian vegetation outside of the automated widths (green for Method 6 in areas were these components overlap (A), and don't overlap (B).

Mapping Potential Riparian Areas

Method 7: *FEMA 100-yr Flood Map*

Given that surface hydrology, especially flooding, is a controlling factor for the distribution of riparian conditions, maps of the expected boundaries for 100-yr floods can be reasonable approximations of potential riparian areas (81). The 100-yr flood is delimited by the elevation contour that has a 1% chance of being wetted or inundated by flood waters each year. The 100-yr flood maps available for the Napa and Ventura watersheds were produced by The Federal Emergency Management Agency (FEMA) under its National Flood Insurance Program (Figure. 14A below). These maps were produced in three steps:

1. The streamflow associated with a 100-year flood is estimated using peak flow data from USGS gauging stations and other reputable hydrological data;
2. The flood elevation profile (the elevation of the flood along the length of a waterway) for the 100-year flood flow is determined using a hydraulic model;
3. The inundated areas associated with that profile are mapped. The flood maps for these and other California watersheds need to be updated and modernized in terms of their hydrologic data, topographic data, representation of water control structures, and the models used to simulate flooding. The existing maps must be regarded as approximations of the 100-yr flood zones in the test watersheds.

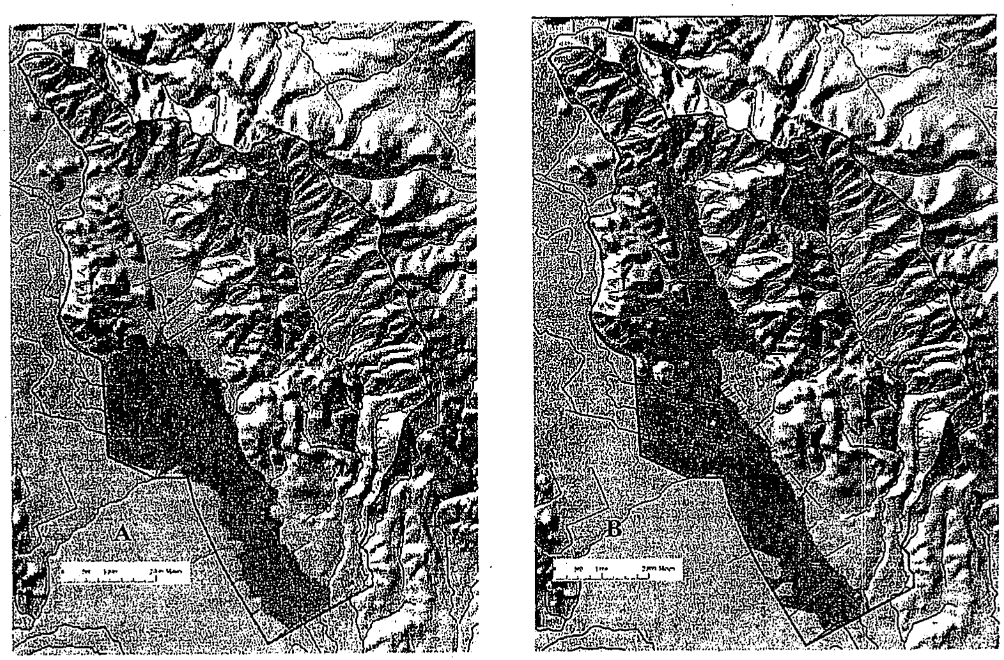


Figure 14: Examples results for mapping potential riparian areas based on (A) FEMA 100-yr flood hazard area, and (B) NRCS soils maps.

Method 8. *Soils Map*

The Natural Resources Conservation Service (NRCS) distributes its soil survey data online from their Soil Data Mart located at http://soildatamart.nrcs.usda.gov/. Their digital soil survey is generally the most detailed level of soil geographic data developed by the National Cooperative Soil Survey. The information was prepared by digitizing existing maps, compiling new information onto a basemap and digitizing the compilations, or by revising digitized maps using remotely sensed data and other information. The soils data used in this project were compiled from the NRCS for Napa Watershed only (Figure 14B); a soils map was not developed for Ventura Watershed County. NRCS staff at the Napa County Resource Conservation District advised the identification of soil types most likely to be associated with riparian conditions. It was noted that riparian soils, per se, are not mapped by the NRCS or anyone else, and that soil types associated with riparian areas are also associated with other, non-riparian areas. The Napa Watershed analysis used the Map Unit Symbol (MuSym) feature of the digital data catalogue and the typical terrain descriptors to select soil types. The selected Map Unit Name and corresponding Map Unit Symbols are Bale clay loam (0 to 2 percent slopes), Bale clay loam (2 to 5 percent slopes, Clear Lake clay drained, Clear Lake clay overwashed, Cole silt loam (0 to 2 percent slopes), Egbert silty clay loam, Reyes silty clay loam, Riverwash, and Yolo loam (0 to 2 percent slopes). Residential and industrial land uses were subtracted from the soils map based on the assumption that such land uses would not be converted into riparian areas.

Figure 15: Example results of the GREM model (Method 9) to estimate the potential riparian area for the Soda Creek index area of Napa Watershed.

Method 9. *Geomorphic Model*

The Southern California Coastal Water Research Project (SCCWRP) developed the Geomorphic Riparian Extent Model (GREM) as a method to map potential riparian areas in southern California coastal watersheds (143). The GREM is a GIS-based method that uses topographic data of varying spatial resolutions to map potential riparian boundaries (Figure 15). It can be developed at two resolutions, a more detailed, local watershed-specific version and a more generalized regional version. In essence, a DTM is used to identify steep topographic inclines or breaks in topographic slopes that are expected to significantly block flooding or stream migration. These features are regarded as landward limits to flooding and to riparian conditions. The methodology of the local version involves field work to validate the DEM and to assign thresholds of elevation or slope to bound the draft model output, and to validate the final model. GREM assumes that the potential riparian area is synonymous with the floodplain or valley floor. In this regard, GREM is similar to the method based on FEMA flood mapping, except that GREM does not employ any hydrological data. Although riparian areas also occur along the edges of lakes and estuaries, GREM only applies to riverine riparian habitat (143).

The field work required to develop and validate GREM for the test watersheds or their index areas exceeded the capacity of this study. A more general regional model was therefore used (Figure 15 above). Residential and industrial land uses were subtracted from the maps of potential riparian areas based on the assumption that such land uses would not be converted into riparian areas.

Method 10. *Hydro-geomorphic Model*

This method is designed to provide a coarse estimate of the potential distribution of ecologically significant floodwaters along a drainage network. It differs from the geomorphic model described above by involving basic information about water heights. But it does not involve enough hydrological information to predict the extent of flooding for specific events, such as the 100-yr flood. In this regard it differs from the FEMA effort to map flood hazards. It also differs from the FEMA effort by being readily applicable to small tributaries and other drainages that are not gauged and therefore lack the local hydrological data that FEMA mapping requires.

This hydro-geomorphic model uses regional hydraulic geometry curves (aka "Regional Curves") and the 10m DEM to delimit the area that would tend to be flooded enough to be riparian, assuming that the drainage network is neither entrenched (i.e., the channel bed is not severely incised), or aggraded (i.e., the bed has not filled-in). Regional Curves are log-log plots relating drainage area to channel width, mean depth, and cross-sectional area at 'bankfull discharge" (168, 169). They are based on standard stage-frequency data from gauging stations (168, 172). They can be developed for one watershed (e.g., 171) or for a group of watersheds having similar rainfall (168, 170). Their development is being encouraged by the USDA within California (170) and throughout the country (172).

The regional curves provide estimates of average local bankfull depth, which corresponds to the height of the active floodplain above a stable bed (168). By doubling the bankfull depth, the flood prone height is estimated. The flood-prone height can be used to estimate the height of floodwaters relative to the cross-section of the channel (Figure 16). The flood-prone area probably encompasses moderate floods with recurrence intervals less

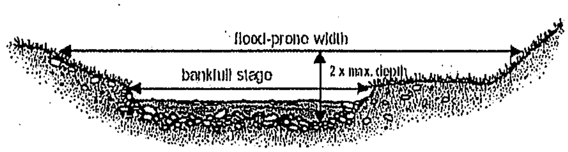


Figure 16: Schematic of a channel cross-section showing the relationships between bankfull and flood-prone depths and widths.

than 50 yrs (175). What role these floods play in creating and maintaining riparian areas is not well known. But they comprise most of the flood events over the typical lifespan of many native riparian tree species, and therefore are likely to strongly influence riparian plant community structure (3). They are also likely to influence aquatic life support in watersheds of the central and northern coast of California (176).

The model uses the 10m DEM to create a three-dimensional map of the drainage network. The model then "walks" upstream along the midline of each channel, stopping approximately every 10m to draw horizontal lines due east and west from the midline of the channel to the land surface (i.e., the lines stop where they intersect the topographic surface represented by the 10m DEM). In doing this, the model first calculates the total drainage area upstream of the stopping point, then uses the drainage area calculation to derive bankfull depth from the regional curve, then doubles the bankfull depth to estimate flood-prone depth, and finally converts the flood-prone depth to flood-prone elevation above the channel bed, based on the DEM. After the model has drawn all the flood-prone contour lines, it attempts to connect their end points to create a polygon as the estimated flood-prone area for any section of channel (Figure 17) or for the drainage network as a whole. Residential and industrial land uses can be subtracted from the maps of potential riparian areas based on the assumption that such land uses would not be converted into riparian areas.

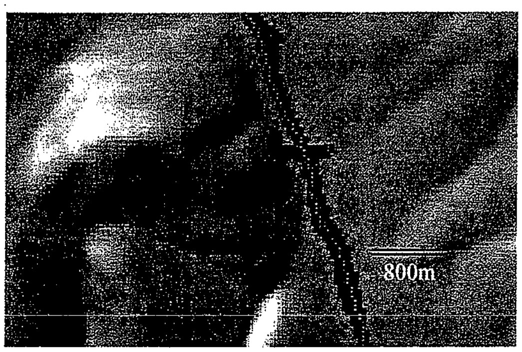


Figure 17: Example results of the hydro-geomorphic model (Method 10) for estimating potential riparian area for a reach of the Soda Creek tributary of the Napa

Standardized Cost Assessments

The approximate costs to apply the methods described above for mapping existing and potential riparian areas were estimated per 1:24,000 scale USGS quadrangle by extrapolation from the selected index areas. The costs were separated into categories for acquiring data, developing drainage networks, mapping riparian areas, running models, and editing the results. The costs for developing models were excluded unless they pertain to each future application of the models. One-time development costs were ignored, even if the models were developed in this study. Costs were estimated in terms of labor hours and materials. The cost estimates are reported below in Table 5.

Estimates of Map Accuracy

The accuracy of each of the nine methods for mapping existing or potential riparian areas was assessed in terms of the total acres mapped relative to Method 6, which is regarded as the most comprehensive and realistic method tested. The estimates of accuracy are reported below in Table 6.

Discussion

Riparian Definition

According to the riparian definition adopted by the RHJV, realistic estimates of the total amount of riparian area in any watershed must reflect the total length of both banks of all ephemeral, intermittent, and perennial natural channels of all orders; plus the banks of unnatural ditches and other engineered channels; plus all uncovered water storage compartments such as lakes, playas, estuaries, lagoons, reservoirs, stock ponds, water traps on golf courses, treatment ponds, etc.; plus the margins of all non-riverine wetlands. In essence, every length of every channel bank, shoreline, and wetland edge has some amount of associated riparian function, and therefore has some amount of riparian area.

This broad riparian definition is well supported in the scientific literature, but it is likely to conflict with some long-standing conventions about what is, and is not, riparian. Most policies and practices to protect and manage riparian areas focus almost exclusively on riparian forests, meaning stands of trees along rivers, streams, and lakeshores. The RHJV will need to undertake a program of outreach and education to vet the broad riparian definition within the government agencies and other institutions that manage and regulate riparian areas. Given the statewide interests of the RHJV, the policies and programs of particular interest at this time include the emerging Stream and Wetland Protection of the Region 1 and Region 2 Water Quality Control Boards, the Dredge and Fill Policy slated for revision by the State Water Resources Control Board, the Forest Practice Rules of the State Board of Forestry, and the National Wetlands Inventory that is updating the statewide wetland and riparian maps through the State Wetland Inventory Program of the California Resources Agency. The riparian definition and mapping protocols of the RHJV may be able to advance these policies and programs over time through their further review, revision, and phased implementation.

Developing Drainage Networks

The most important aspect of mapping riparian areas for any watershed is developing a comprehensive map of the drainage network. As indicated in the paragraph above, this involves mapping all channels, lakes and ponds, and wetlands.

As the availability of high-resolution, geo-rectified imagery and DEMs improves, comprehensive maps of drainage networks become easier to produce. At this time, the most efficient approach to mapping drainage networks involves a combination of heads-up digitizing based on interpretation of 1-m pixel resolution color imagery (e.g., the NAIP imagery), basic drainage network modeling using the 10m DEM, and post-processing the of DEM-derived network to clean up any obvious errors.

While Lidar can be used to generate very detailed DTMs, they often misrepresent the networks of low-gradient terrain that lacks much topographic relief (113). Lidar has been used to generate accurate drainage networks in steep terrain (47), but much of California is not steep. The Lidar-based drainage network for Napa Watershed omitted some low- and medium-order channels that have been diverted from their natural courses, and it tended to include channels that have been buried as storm drains but that follow their historical pathways. In many cases, Lidar produces a DTM that is more resolute than the available imagery, which therefore does not register well on the Lidar-based drainage network. This misalignment between the imagery and the Lidar-based channels can greatly complicate the effort to map riparian areas based on visible riparian vegetation. For example, an unrealistically large amount of indicative riparian vegetation can appear outside of the functional areas derived from the Lidar-based DEM, and adding these areas of vegetation through "heads-up" digitizing as called for in Methods 5 and 6 can inflate the estimates of riparian area. The amount of post-processing to remove erroneous channels on flat lands and to correctly align channels can be daunting and very expensive (see Table 5 below).

Regardless of the dataset used to derive the DTM, the next challenge is to account for the riparian areas of first-order channels. One aspect of the challenge is deciding the minimum size channel to map. In this study, the smallest channels visible in the 1-m pixel resolution NAIP imagery were mapped if they corresponded to swales, draws, or other places where topography indicated a channel would likely form. Standardizing the DTM used to generate the drainage network and standardizing the resolution of supporting imagery will help standardize decisions about minimum mapping units.

Once a decision was made about the minimum size channel to map, the challenge became mapping all the small channels. This part of the study was coordinated with a related effort at the California State University at Northridge. Both studies found that mapping all first-order channels could take an impractical amount of effort. The problem stemmed from the fact that the 10m DEM, while very useful for creating a map of the rest of the drainage network, was too course to generate an adequate map of first-order channels. As a result, many channels generated by the DEM had to be edited, and even more channel has to be added by "heads-up" digitizing.

The following alternative to mapping all first-order channels was developed. It is recommended for use when an estimate of first-order riparian area will suffice without a map of all the associated channels. It is assumed that the total area to be mapped is at least as large as a Planning Watershed as defined by CalWater 2.0, or an 8-digit HUC as defined by the Federal system of watershed classification. The first step is to generate a drainage network from the 10m DEM. The second step is to select a number of fourth- or fifth-order drainage systems as "index areas" that reasonably represent the overall geology and topography of the total area to be mapped, and that together represent 5-10% of that area. All the first-order channels of the index areas are then mapped, using the minimum mapping units and ancillary data sets described in this study. The riparian area of these channels is then determined using whichever of the selected Methods 1-6. A series of tests are then conducted using the 10m DEM to see which threshold value for minimum cell array yields an automated map of first-order channels that most closely approximates the map produced for the index areas. The chosen threshold value is then used to re-generate the larger drainage network for the entire area to be mapped, and to estimate its overall number of first-order channels. This number of first-order channels is then multiplied by the average amount of riparian area per first-order channel in the index areas to estimate the overall amount of first-order riparian area.

Table 5: Acres of existing and potential riparian areas as indicated by different mapping methods, standardized against the method that provides the most accurate maps (Method 6).

Index Area	Method 1		Method 2		Method 3		Method 4		Method 5		Method 6		Method 7		Method 8		Method 9		Method 10	
	Acres	% of no. 6	Acres	% of no. 6	Acres	% of no. 6	Acres,	% of no. 6	Acres	% of no. 6	Acres	% of no. 6	Acres	% of no. 6	Acres	% of no. 6	Acres	% of no. 6	Acres	% of no. 6
Napa 1	248	10	6967	290	5633	235	1133	47	1203	50	2390	100	1824	76	2339	98	5382	225	NA	NA
Napa 2	121	7	4006	230	3821	210	1063	58	1122	62	1817	100	366	20	271	15	2972	163	NA	NA
Ventura	324	20	2314	143	1830	113	319	20	339	21	3824	100	3824	237	3824	236	885	55	NA	NA
Average		12		221		186		42		44	1615	100		111		116		148		NA

Note: Method 10 requires further development.

Table 6: Estimated costs for different methods used in this study to map existing and potential riparian areas.

Task	Method	Data Acquisition	Data Development (Digitizing, Model Running, etc.)		Post Processing (Line Editing.)	Total Costs
Develop Drainage Network Map	Lidar-based DTM	Labor: 2 hrs	Run Model to create DTM Labor: 8 hrs		Labor: 250 hrs	Labor: 260 hrs
	10m DEM	Labor: 2 hrs	Run Model to Create DTM Labor: 8 hrs		Labor:120 hrs	Labor: 130 hrs
Map Existing Riparian Areas	Method 1: Heads-up digitizing of distinct vegetation	Labor: 6 hrs	Labor: 200 hrs		Labor: 20 hrs	Labor: 226 + 130 = 356 hrs
	Method 2: Single Default Width	Labor: 6 hrs	Labor: 1 hrs		Labor: 8 hrs	Labor: 15 + 130 = 145 hrs
	Method 3: Multiple Default Widths	Labor: 6 hrs	Labor: 4 hrs		Labor: 8 hrs	Labor: 18 + 130 = 148 hrs
	Method 4: Method 3 Plus SPTH	Labor: 6 hrs	Set-up SPTH Tables Labor: 16 hrs		Labor: 8 hrs	Labor: 30 + 130 = 160 hrs
	Method 5: Method 4 Plus Method 1 (in part)	Labor: 6 hrs	Run Widths Model Labor: 16hrs	Heads-up Digitizing Labor: 10 hrs	Labor:8 hrs	Labor: 32 + 130 = 162 hrs
	Method 6: Method 5 Plus Hillslope Processes	Labor: 6 hrs	Run Widths Model Labor: 16hrs	Heads-up Digitizing Labor: 10 hrs	Labor: 8 hrs	Labor: 32 + 130 = 162 hrs
Map Potential Riparian Areas	Method 7: FEMA 100-yr Flood Map	Labor: 4 hrs	Extract land use Labor: 2 hrs		Labor: 0 hrs	Labor: 6 hrs
	Method 8: NRCS Soils map (in part)	Labor: 4 hrs	Extract land use Labor: 2 hrs		Labor: 4 hrs	Labor: 8 hrs
	Method 9: Geomorphic Model (GREM)	Labor: 3 hrs	Calibrate Model and Extract Land Use Labor: 100 hrs		Labor: 10 hrs	Labor:113 + 130 = 243 hrs
	Method 10: Hydro-geomorphic Model	Labor: 4hrs	Model Set-up Labor: 16 hrs		Labor: 4 hrs	Labor: 24 + 130 = 154 hrs

The drainage network maps for index areas provide evidence of the characteristic lengths, plan form geometry, and density of first-order channels. The estimates of average riparian area per first-order channel, average length of first-order channels, and the variability of these parameters can be reported with the estimate of overall first-order riparian area. This approach can more than halve the time required to estimate the total amount of riparian area in planning watersheds or 1:24000 scale quadrangles.

The time required to estimate the total first-order riparian area can also be reduced by involving mappers who recognize and understand the field conditions and processes they are mapping. The use of ancillary data, such as a soils map, vegetation maps, the 1:24000 scale DLG, slope maps, and software that allows the mappers to rotate the imagery on-screen can also reduce the mapping time.

Using the DLG road file to subtract areas of roadway from the riparian areas incurs the inaccuracy of the roadway positions relative to the channels (180). Although the drainage network derived from the 10m DEM was edited to fit the imagery, the DLG road file was not so edited. This means that the apparent overlaps between the road areas and the riparian areas are wrong to some degree. The amount of error in the overlaps has not been assessed. It is assumed that the actual overlaps are larger than measured in some cases, smaller in others, and that these differences cancel each other, such that the total amount of overlap is reasonably well represented for each watershed as a whole.

Existing Riparian Areas

Relative Accuracy

The comparative values for acres of riparian areas derived by the various approaches to mapping are summarized in Table 5 above. For each method, the results are standardized relative to Method 6, and the standardized values are averaged across the index areas.

For the three index areas, it can be inferred that the total amount of existing habitat is largely underestimated by only mapping the areas that are evidenced by indicative vegetation (Method 1). This is because much of the riparian areas support vegetation that cannot be distinguished from upland vegetation in the aerial imagery that is commonly available across the State. There are also riparian area that lack vegetation. The underestimates are lower for arid areas where the drainage networks are simpler and the riparian vegetation is more obvious. It is also apparent that the results of Method 1 can vary between mappers. This is exemplified by differences between the two versions of NWI maps recently produced for the Ventura Watershed. This study increased the NWI acreage for the Ventura Watershed index area by more than 20%. Acres of riparian area were added to the existing NWI through the review of the draft maps by local experts. This highlights the importance of involving local experts who know the field conditions and can help interpret the imagery.

The simpler buffering approaches over-correct the underestimates provided by Method 1. Using the high range of default widths from the literature, Methods 2 and 3 result in acreage estimates that are between about 186% and 230% greater that the most realistic estimates provided by Method 6. The application of a single large default width (Method

2) produces the largest over-estimates of all six methods to calculate existing riparian areas. These over-estimates are greater for the Napa Watershed in large part because it has many more agricultural ditches and pond margins that are grossly misrepresented by large default riparian widths. Default widths are probably less applicable to areas with abundant irrigation, unless the selected widths are very narrow.

Methods 4 and 5 both use the same conservative default widths for shrubs and grasslands, and the same species-specific SPTH values for forested areas. Method 5 adds areas of obvious riparian vegetation that appear outside of the default widths. Both methods tend to yield about half the expected riparian area for wetter conditions, and less than a quarter of the expected area for arid conditions. These underestimates are due mainly to the disregard of hillslope processes in steep terrain. They are much greater for Ventura Watershed for a number of reasons: the arid watershed has fewer ditches and other features for which the default riparian widths grossly over-estimate riparian area, and Ventura Watershed has many more channels draining steep terrain with broad areas of riparian hillslope processes that are ignored by Methods 4 and 5.

Although Methods 4 and 5 provide very similar results, the slight differences may be ecologically significant. Method 5 captures the existing riparian areas that are broader than the default riparian widths. These tend to be the larger riparian areas in the watersheds, and might therefore represent the more important areas to protect.

Method 6 mainly differs from the other five methods to map existing riparian areas by accounting for the riparian hillslope processes, such as mass wasting and natural water source area variability, that characterize steep terrain. The result is a map of riparian areas that expand in the upstream limits of the drainage networks. Of all the methods tested, this is perhaps the most radical deviation from conventional riparian mapping. Where the density of first-and second-order channels is especially high, Method 6 can indicate that more than 75% of the area between the upstream limits of the channels and the watershed boundary is riparian.

Relative Costs

The costs of the various approaches to mapping existing riparian areas are summarized in Table 6 above. All costs are in hours of labor for one 1:24000 scale quadrangle. Actual costs could vary greatly due to differences in wages and watershed complexity.

Each method to map existing riparian areas requires a base map of the drainage network. Cost estimates for the base map assume that it will be generated from the 10m DEM, with post-processing to produce detailed maps of first-order channels for two index areas. The index areas account for about half of the total cost for mapping the drainage network. The use of Lidar more than doubles the cost of the drainage network map because of all of the editing required to eliminate spurious channels and to add ditches and other engineered channels that aren't predictable from topography.

Of the six methods for mapping existing riparian areas, heads-up digitizing of riparian vegetation (Method 1) is most expensive. This is due to the time required to examine various datasets, including stereo aerial photography, while making enumerable decisions about the probable extent of faint riparian influences. The bias among mappers and their differences in experience can become very obvious in this method, since it relies on a combination of expert photo-interpretation and knowledge of field conditions. The wages of people with these capabilities tend to be above usual technician scale, which can aso increase the budget for Method 1. The cost estimates provided by NWI for riparian mapping are less that the estimates from this study, which probably reflects NWI's use of the basic DLG as a drainage network, its disregard of ditches, and its application of default widths for small natural channels.

Methods 2-6 are comparable in cost due to their common dependence on automated mapping procedures. Almost 90% of their costs are due to comprehensive mapping of drainage networks. Methods 5 and 6 incur an additional cost for developing look-up tables of default riparian widths and SPTH values.

Potential Riparian Areas

Relative Accuracy

The acres of potential riparian area derived by the various mapping methods are summarized in Table 5 above. All four methods can only provide very coarse estimates of the amount of uplands that could become riparian due to changes in the distribution of alluvial floodwaters. There is no "gold standard" forecast of likely flooding throughout any of the index areas or their encompassing watersheds that can be used to evaluate the efficacy of these methods. They can only be evaluated based on their agreement with general expectations about the possible distribution of riparian functions based on local knowledge of field conditions.

The 100-yr flood hazard map produced by FEMA (Method 7), excluding land uses that tend to be protected from flooding, is based on well-documented procedures, although they need to be modernized to incorporate new technologies and the existing maps need to be updated. The FEMA map includes all of the existing riparian areas within the modeled 100-yr flood boundary. But the flood hazard maps usually only pertain to large valleys and other places where substantial human life and property is threatened by flooding. The maps seldom extend into smaller tributary systems and therefore thee do not usually represent the potential riparian areas in watersheds as a whole.

The soils maps produced by the NRCS (Method 8) can be used to map potential riparian areas throughout most watersheds, but the areas are over-estimates of the extent of actual riparian conditions. The reason is that none of the soil types are specifically riparian, and many of the types that are associated with sedimentary fluvial processes extend far beyond the limits of existing riparian areas. These soil types can represent many millennia of natural channel migration across valley bottoms and alluvial fans. Even the most restrictive criteria for selecting "riparian and flood plain soils" yield a map that can grossly over-estimate the extent of potential riparian areas by including terraces and abandoned fans.

The GREM (Method 9) can provide a better map of potential riparian areas than standard flood hazard mapping (Method 7) because it can be applied to the smaller drainages to which Method 7 is seldom applied, and it does better than standard soils maps because it does not extend as far beyond the likely extent of floodwaters. However, the GREM largely over-estimates the potential riparian areas in low-gradient terrain where the topographic controls for the model are weak. It's less meaningful for these areas than the flood mapping (Method 7) because it does not use hydrological data or actual flood history to delimit flood boundaries. The GREM is best suited for confined channels in steeper terrain, where the valley floor and the maximum flood zone can be more or less synonymous. In these settings, the regionalized version of GREM provides a useful approximation of the potential limits of riparian conditions.

A combination of maps generated with the FEMA Flood Hazard Mapping, which works reasonably well for valley bottoms, and the GREM, which works reasonable well for the steeper tributaries, might be useful for entire watersheds. The problem is that there is no rule for setting the boundary between the two methods. Efforts to draft a rule based on topographic slope were fraught with inconsistent results.

Development of the hydro-geomorphic approach (Method 10) began late in the study, after the other methods had been developed and tested. The intent was to develop a rudimentary model of flooding based on regional correlations between drainage area and flood-prone width that could be used to inscribe flood-prone contours on the 10m DEM. The flood-prone height is conservatively calculated as twice the average bankfull height, as reported on the regional curves, rather than twice the *maximum* bankfull height, which is the convention (173, 174). The potential riparian areas might therefore be larger than what would be indicated by Method 10.

Method 10 assumes that the DEM provides a reasonable elevation for the channel bottom. The likelihood of this assumption being met decreases as the channel gets narrower, since this increase the chance the elevation data from the DEM will fall outside the channel. Variability in the regional correlations between drainage area and flood-prone height also provides some uncertainty in the model, as does any error of the hydrological data employed in the regional correlations. Correcting these deficiencies would require field surveys and flow studies that are not likely to be conducted throughout California in the foreseeable future.

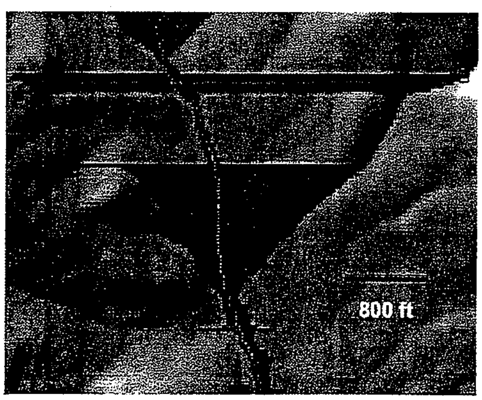


Figure 18: Example results from Method 10 showing places where the GIS and DEM do not adequately constrain flood-prone width.

Development of the hydro-geomorphic approach was halted before it could be adequately tested. A technical problem was encountered that could not be solved with the available funding. The problem has to do with the method used by the GIS software to trace the flood-prone contour on the DEM. The contour consists of a series of points indicated by the intersections of the DEM with horizontal lines drawn by the GIS at the flood-prone elevation from the midline of the channel. The GIS only allows these lines to be drawn to the east and west. Where the channel runs east or west, the lines can lead out of the channel and into space, as the channel runs downhill below the line. There is no limit to possible line length. Lines that leave first-order channels at high elevation can cross whole watersheds (Figure 18). As funds become available, the model will be revised to only run lines perpendicular to the channel. This should largely eliminate the problem of unconfined flooding.

Conclusions

This study compares a variety of methods to map existing and potential riparian areas using commonly available data sources and techniques that could be used by a variety of work centers to inventory the riparian areas throughout California.

The conservation and restoration of riparian resources throughout the State requires that they be defined commonly for all interests, and that the definition be broad enough to include the full range of riparian functions and conditions. The definition provided by the National Research Council (58) and adopted by the Riparian Habitat Joint Venture (RHJV) can satisfy these requirements. This definition is broader than others commonly in use, however. Vetting this broad definition with the large community of riparian interests will require outreach and education. While the RHJV does not intend for this definition and the associated mapping protocols to be used in any regulatory context, it also recognizes that such uses may evolve. This possibility creates a need for broad review of the meaning of the riparian definition in the regulatory context.

Existing riparian areas, potential riparian areas, and riparian buffers are distinct landscape features. Existing areas can be mapped based upon field indicators that are visible in commonly available aerial photography. Areas that are not distinctive can be estimated based on functional widths (i.e., the widths over which riparian functions are expected to occur according to the scientific literature). Buffers are portions of riparian areas that support selected functions, usually to protect adjoining aquatic resources. Potential riparian areas are uplands or historical riparian areas that are likely to be flooded due to management of water supplies or their natural variability.

The most important aspect of mapping existing and potential riparian areas is the development of a comprehensive drainage network that includes all channels, lentic features, and wetlands. The most cost-effective and broadly practicable method to map the channels is to use the USGS 10m DEM to generate a draft network that is then refined based on heads-up digitizing from high-resolution aerial imagery. The cost of estimating the total riparian area associated with first-order channels in a large watershed can be reduced by extrapolation from a sample of sub-watersheds. Remote sensing of riparian areas and the use of Lidar to develop a DEM are not cost-effective at this time because they incur very large costs for post-processing, validation, and editing.

The optimal method for mapping the existing riparian areas is basically a three step process: (1) apply default functional widths to channels, shorelines, and wetland edges based on the associated dominant vegetation; (2) adjust the widths by adding 1m for every 1% slope increase over a 20% slope threshold; and (3) revise the map produced at step 2 to include recognizable riparian areas that are outside the adjusted default functional widths. The default functional width for forested areas should be two SPTH. The default widths for shrubs and grasslands should be 10m and 5m respectively. Orchards should be treated as forests. Croplands should be treated as shrubs. This approach can provide a comprehensive inventory of riparian areas that recognizes their intrinsic ecological functions as well as their support and protection of terrestrial and aquatic resources.

The methods examined in this study to map potential riparian areas can only provide very broad estimates of the amount of uplands (including previous riparian areas) that might become riparian due to existing or possible future changes in the distribution of floodwaters. They provide examples of what can be done to map potential riparian areas throughout the State using easily developed or existing data. Existing FEMA maps of 100-yr flood hazards provide inexpensive, reasonable estimates of potential riparian areas in larger, low-gradient valleys. The GREM model can provide moderately expensive estimates for high-gradient areas. It may be most practical to employ Regional Hydraulic Geometry Curves (i.e., "Regional Curves) to estimate flood-prone contours on the 10m DEM. California is lagging behind other regions of the country in developing Regional Curves. Areas of land use that are not likely to be converted to riparian functions must be subtracted from the maps of potential riparian areas generated by any of these methods. Given the large assumptions and generalities of these models, they might best be used in initial surveys of riparian conservation and restoration opportunities.

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Appendix A: Selected Federal and State Agency Definitions of "Riparian."

Agency (reference)	Definition
National Research Council (57, 58)	*Riparian Areas are transitional between terrestrial and aquatic ecosystems and are distinguished by gradients in biophysical conditions, ecological processes and biota. They are areas through which surface and subsurface hydrology connect water bodies with their adjacent uplands. They include those portions of terrestrial ecosystems that significantly influence exchanges of energy and matter with aquatic ecosystems. Riparian areas are adjacent to perennial, intermittent, and ephemeral streams, lakes and estuarine-marine shorelines*
US Bureau of Land Management (60)	*A riparian area is an area of land directly influenced by permanent water. It has visible vegetation or physical characteristics reflective of permanent water influence. Lake shores and stream banks are typical riparian areas. Excluded are such sites as ephemeral streams or washes that do not exhibit the presence of vegetation dependent upon free water in the soil.*
US Fish and Wildlife Service (61)	*Riparian areas are plant communities contiguous to and affected by surface and sub-surface hydrologic features of perennial or intermittent lotic and lentic water bodies (rivers, streams, lakes, or drainage ways). Riparian areas have one or both of the following characteristics: (1) distinctively different vegetative species than adjacent areas, and (2) species similar to adjacent areas but exhibiting more vigorous or robust growth forms. Riparian areas are usually transitional between wetlands and upland.*
US Forest Service (62)	*Riparian areas are geographically delineated areas, with distinctive resource values and characteristics, that are comprised of the aquatic and riparian ecosystems, floodplains, and wetlands. They include all areas within a horizontal distance of 100 feet from the edge of perennial streams or other water bodies.... A riparian ecosystem is a transition between the aquatic ecosystem and the adjacent terrestrial ecosystem and is identified by soil characteristics and distinctive vegetation communities that require free and unbound water.*
US Forest Service Region 9 (63)	*Riparian areas are composed of aquatic ecosystems, riparian ecosystems and wetlands. They have three dimensions: longitudinal extending up and down streams and along the shores; lateral to the estimated boundary of land with direct land-water interactions; and vertical from below the water table to above the canopy of mature site-potential trees.*
US Department of Agriculture NRCS (64)	*Riparian areas are ecosystems that occur along watercourses and water bodies. They are distinctly different from the surrounding lands because of unique soil and vegetation characteristics that are strongly influenced by free or unbound water in the soil. Riparian ecosystems occupy the transitional area between the terrestrial and aquatic ecosystems. Typical examples would include floodplains, streambanks, and lakeshores.*
US EPA and NOAA Coastal Zone Management Act (65)	*Riparian areas are vegetated ecosystems along a water body through which energy, materials and water pass. Riparian areas characteristically have a high water table and are subject to periodic flooding and influence from the adjacent waterbody. These systems encompass wetlands, uplands, or some combinations of these two land forms. They will not in all cases have all the characteristics necessary for them to be classified as wetlands.*

Appendix A: Selected Federal and State Agency Definitions of "Riparian" (continued)

US EPA (53)	*Riparian Reserves are portions of watersheds where riparian-dependent resources receive primary emphasis and where special standards and guidelines apply to attain Aquatic Conservation Strategy objectives. Riparian Reserves include those portions of a watershed required for maintaining hydrologic, geomorphic, and ecologic processes that directly affect standing and flowing waterbodies such as lakes and ponds, wetlands, and streams.*
Forest Health Monitoring Group, US Forest Service (66)	*Riparian areas are three-dimensional eco-tones of interaction that include terrestrial and aquatic ecosystems that extend into the groundwater, up above the canopy, outward across the floodplain, up the near-slopes that drain to the water, laterally into the terrestrial ecosystem, and along the water course at a variable width.*
Ca Wildlife Conservation Board.	*Riparian habitat is composed of the trees and other vegetation and physical features normally found on the stream banks and flood plains associated with streams, lakes, or other bodies of water.*
Ca Fish and Game Code (59)	*Riparian habitat means lands which contain habitat which grows close to and which depends upon soil moisture from a nearby freshwater source.*
US ACE Wetlands Regulatory Assistance Program (56)	*A vegetated upland or wetland area next to rivers, streams, lakes, or other open waters which separates the open water from developed areas, including agricultural land. Vegetated buffers provide a variety of aquatic habitat functions and values (e.g., aquatic habitat for fish and other aquatic organisms, moderation of water temperature changes, and detritus for aquatic food webs) and help improve or maintain local water quality. A vegetated buffer can be established by maintaining an existing vegetated area or planting native trees, shrubs, and herbaceous plants on land next to open waters. Mowed lawns are not considered vegetated buffers because they provide little or no aquatic habitat functions and values. The establishment and maintenance of vegetated buffers is a method of compensatory mitigation that can be used in conjunction with the restoration, creation, enhancement, or preservation of aquatic habitats to ensure that activities authorized by NWPs result in minimal adverse effects to the aquatic environment.*
Forest Ecosystem Management Team (53)	*Riparian Zone refers to those areas where the vegetation complex and microclimate conditions are products of the combined presence and influence of perennial and/or intermittent water, associated high water tables, and soils that exhibit some wetness characteristics." It is the "zone within which plants grow rooted in the water table of these rivers, streams, lakes, ponds, reservoirs, springs, marshes, seeps, bogs and wet meadow.*
Stanislaus National Forest (17)	*"he transition between aquatic and terrestrial ecosystems, characterized by distinctive vegetation which requires free or unbound water.*
Inyo National Forest (17)	*Geographically delineable areas with distinctive resource values and characteristics that are comprised of the aquatic and riparian ecosystems.*

Appendix A: Selected Federal and State Agency Definitions of "Riparian" (continued)

Tahoe National Forest (17)	*As a minimum, riparian areas are defined to be (1) areas a 100-foot horizontal distance from the edge of standing bodies of water; (2) areas a horizontal distance of 100 feet on each side of perennial stream channels; and (3) all wetlands." Riparian-dependent resources include: "those natural, intrinsic resources directly dependent upon the riparian area for their existence, including: water, fish, certain wildlife species, riparian related aesthetics, and riparian related vegetation" Streamside management zones "are administratively designated zones adjacent to perennial, intermittent, and in some cases ephemeral streams, and are designed to call attention to the need for special management practices aimed at the maintenance and/or improvement of watershed resources (e.g. water quality, channel stability). They may include wetlands, flood plains, riparian areas, inner gorges, perennial streams, intermittent streams, ephemeral streams, and the terrestrial ecosystem adjacent to these areas.*
Sequoia National Forest (17)	*Riparian area: includes the aquatic ecosystem, riparian vegetation, 100-year floodplain and Streamside Management Zone. The extent of riparian areas is directly affected by the steepness of stream side slopes, with the steeper slopes having the narrower habitat. Aquatic ecosystem: extends to the normal bank high water mark. Riparian vegetation: defined as vegetation communities that require free or unbound water. 100-year floodplain has a one percent chance of being flooded in any one year. This floodplain provides storage for flood flows, helps reduce the velocity and peak flow, moderates downstream flooding, reduces deposition of sediment in stream channels. The floodplain and the vegetation associated with it help reduce flood intensities.*
Eldorado National Forest (17)	*Riparian areas: consist of streamside ecosystems, aquatic ecosystems, wetlands and flood plains. Riparian encompasses all areas within a horizontal distance of 100 feet from both edges of perennial streams or other water bodies. Wet meadows are included in the riparian zone. Wetlands: included in total riparian area. Defined as: those areas inundated by surface or ground water with a frequency sufficient to support a prevalence of vegetation or aquatic life that requires saturated or seasonally saturated soil conditions for growth and reproduction. Includes marshes, wet meadows, alpine meadows, springs, seeps, potholes, river overflows and natural ponds, and may or may not be associated with Streamside Management Zone.*
National Wetlands Inventory, US Fish and Wildlife Service (5, 6)	*Riparian areas are plant communities contiguous to and affected by surface and subsurface hydrologic features of perennial or intermittent lotic and lentic water bodies (rivers, streams, lakes or drainage ways). Riparian areas have one or both of the following characteristics: 1) distinctively different vegetative species than adjacent areas, and 2) species similar to adjacent areas but exhibiting more vigorous or robust growth forms. Riparian areas are usually transitional between wetland and upland.*

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Appendix B: California Forest Practice Rules Stream Classes

Class I Watercourse: Domestic supplies, including springs, on site and/or within 100 feet downstream of the operations area and/or fish always or seasonally present onsite, including habitat to sustain fish migration and spawning.

Class II Watercourse: Fish always or seasonally present offsite within 1000 feet downstream and/or aquatic habitat for non-fish aquatic species, excluding Class III waters that are tributary to Class I waters.

Class III Watercourse: No aquatic life present, watercourse showing evidence of being capable of sediment transport to Class I and II waters under normal high water flow conditions after completion of timber operations.

Class IV Watercourse: Man-made watercourses, usually downstream, established domestic, agricultural, hydroelectric supply or other beneficial use.

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Appendix C: Data Types and Test Watershed Selection

Table 1: Matrix of mapping approaches and needed data. Mapping approaches were selected for this project by the RHJV Technical Committee. Bold approaches were expected to be most useful. The score for each data type equals its number of cell entries. Scores for bold approaches are doubled. The more important data types are the 10-m DEM and geo-rectified imagery.

Approach	Data Types									
	Historical Soils Maps	Current Soils Maps	Current Vegetation Map	FEMA Flood Zone Map	Current NHD or Digital Streams	Geology	**10-m Node DEM**	**Current 1-3m resolution geo-rectified imaging**	Updated NWI	Regional Bankfull Discharge Curves
Hydro-geomorphic Modeling[1]					X		X			
Vegetation Mapping[2]			X					X		
Flood Mapping				X	X		X	X		X
Soils Mapping	X	X				X		X		
Geology Mapping	X	X			X	X	X	X		
NWI[3]							X	X	X	
Integrated Approach[4]			X		X		X	X	X	
Data Type Score	2	2	3	1	5	2	7	8	4	1

[1] This refers to an approach developed through SCCWRP based on digital elevation models, and an approach by SFEI using regional hydraulic geometry.
[2] This refers to maps of vegetation based on the California Vegetation Manual.
[3] This refers to the method of riparian mapping published by the National Wetlands Inventory of the USFWS.
[4] This refers to the method developed by SFEI that combines the NWI method with a digital elevation model and vegetation map.

Appendix C: Data Types and Test Watershed Selection

Table 2: Matrix for selecting the Bay Area test watershed. Cell entries are the data type ranks from Table 1. A blank cell means that data type is not available for that watershed. The sum of the entries for each watershed equals its score. Napa Watershed scored the highest and was therefore selected as the Bay Area test watershed.

Criteria	Candidate Bay Area Watersheds									
	Coyote Creek	Alameda Creek	Sonoma Creek	Petaluma River	Napa River	Corte Madera Creek	Lagunitas Creek	Olema Creek	Wildcat Creek	Guadalupe River
Historical Soils Maps	2	2	2	2	2	2		2	2	2
Current Soils Maps	2	2	2	2	2	2	2	2	2	2
Current Vegetation Map					4		4	4		
FEMA Flood Zone Map	1	1	1	1	1	1	1		1	1
Current NHD or Digital Streams	6	6	6	6	6	6			6	6
Geology	2				2					2
10-m Node DEM	8	8	8	8	8	8	8	8	8	8
Current 1-3m pixel resolution geo-rectified imaging	9	9	9		9	9	9	9	9	9
Updated NWI					4					
Regional Bankfull Discharge Curves	1	1	1	1	1	1	1	1	1	1
Total Score	31	29	29	20	39	29	25	26	29	31

Appendix C: Data Types and Test Watershed Selection

Table 3: Matrix for selecting the Southern California test watershed. The criteria are the data types from Table 1. Cell entries are the data type ranks from Table 1. A blank cell means that data type does not apply to that watershed. The sum of the entries for each watershed equals its score. Ventura River watershed scored the highest and was therefore selected as the Southern California test watershed.

Criteria	Candidate Bay Area Watersheds				
	San Gabriel River	**Ventura River**	San Diego Creek	Escondido Creek	Carpinteria Creek
Historical Soils Maps	2	2	2	2	2
Current Soils Maps	2	2	2	2	2
Current Vegetation Map		4			
FEMA Flood Zone Map	1	1	1	1	1
Current NHD or Digital Streams	6	6	6	6	6
Geology	2	2	2	2	2
10-m Node DEM	8	8	8		8
Current 1-3m pixel resolution geo-rectified imaging	9	9	9	9	9
Updated NWI		4		4	
Regional Bankfull Discharge Curves	1	1	1	1	1
Total Score	31	**39**	31	27	31

Appendix C: Data Types and Test Watershed Selection

Table 4: The selected watersheds and their index areas correspond to Federal WED Levels 5-7, and California designations Sub-areas, Super Planning Watersheds, and Planning Watersheds, respectively.

Federal WBD Level	Federal Designations	Federal Hydrologic Unit Code	Federal Area (approx.)	State of California Designations	California Area (approx.)
Level 1	Region	2 digit	180,000 sq miles 115,193,577 acres		
Level 2	Sub-region	4 digit	16,844 sq miles 10,779,559 acres	Hydrologic Region	12,735 sq miles 8,150,000 acres
Level 3	Basin	6 digit (formerly "accounting unit")	10,600 sq miles 6,783,622 acres	Hydrologic Units	672 sq miles 430,000 acres
Level 4	Sub-basin	8 digit (formerly "cataloging unit")	703-1,735 sq miles 449,895 □ 1,110,338 acres	Hydrologic Areas	244 sq miles 156,000 acres
Level 5	Watershed	10 digit (formerly 11 digit in NRCS)	63-391 sq miles 40,000 to 250,000 acres	Hydrologic Sub-areas	195 sq miles 125,000 acres
Level 6	Sub-watershed	12 digit (formerly 14 digit in NRCS)	16-63 sq miles 10,000 to 40,000 acres	Super Planning Watershed	78 sq miles 50,000 acres
Level 7*	Drainage	14 digit	15 sq miles 10,000 acres	Planning Watersheds	5-16 sq miles 3,000-10,000
Level 8*	Site	16 digit	1 sq mile 650 acres		

* Levels 7 and 8 are extensions of the Federal designations for use at the local watershed level.

Appendix D Part 1

Minimum and Preferred Buffer Widths (m)
in Relation to Riparian Function

Function	Reference	Minimum Width (m)	Average	Maximum or Preferred width (m)	Average
Riparian Sediment Entrapment	7	5	12	45	77
	14	5		25	
	50	10		90	
	51	30		183	
	52	8		91	
	53	NA		1 SPTH (≈30)	
Riparian Chemical. Filtration or Transformer	7	10	12	45	116
	18	8		NA	
	50	4.5		60	
	51	30		262	
	52	4		183	
	54	15		30	
Large Woody Debris Input into Channel	13	8	40	15	78
	14	NA		25	
	39	60 or 1 SPTH (greater of two)		100 or 2 SPTH (greater of two)	
	49	1 SPTH (≈30)		2 SPTH or 90 (greater of two)	
	51	80		100	
	52	30		61	
	53	NA		1 SPTH (≈ 30)	
	76	1 SPTH (≈30)		200	
Leaf Litter Input into Channel	49	0.5	0.5	1 SPTH (≈30)	≈ 23
	53	NA		0.5 SPTH (≈15)	
Flood Control	7	25	16	70	65
	50	7.5		60	
Aquatic Life Support	18	NA	19	30	58
	25	20		110	
	50	18		33.5	
Bank Stabilization	7	5	14	15	25
	50	7.5		17	
	52	30		38	
	53	NA		1 SPTH (≈30)	
Bed Stabilization	7	NA	NA	45	45
Riparian Wildlife Support	7	50	41	150	162
	29	50		100	
	50	7.5		90	
	51	100		200	
	52	8		300	
	53	30		183	
	57	NA		100	
	104	NA		175	

Appendix D Part 1 (cont'd)

Minimum and Preferred Buffer Widths (m)
in Relation to Riparian Function

Function	Reference	Minimum Width (m)	Average	Maximum or Preferred width (m)	Average
Aquatic Habitat Cooling	10, 11	NA	19	15	41
	14	NA		23	
	15	NA		50	
	16	NA		100	
	38	NA		30	
	39	NA		30	
	49	NA		45	
	50	15		33.5	
	51	30		43	
	52	11		46	
	53	NA		1 SPTH (≈30)	
Riparian Climate Maintenance	39	90	70	150	129
	49	NA		45	
	53	1 SPTH (≈30)		3 SPTH (≈90)	
	51	100		200	
	52	61		160	
Overall Averages (m)			24		72

Appendix D Part 2

Minimum and Preferred Buffer Widths (m)
for Multiple Riparian Functions Excluding Wildlife Support

Reference	Minimum Width (m)	Maximum or Preferred Width (m)
10	50	100
19	15	30
20	15	200
21	35	60
24	20	100
25, 26	20	110
27	20	60
28 (cited in 24)	20	30
30, 31	3	30
32	10	20
33, 34	30	90
35, 36	15	100
24	15	90
37	20	100
24	30	90
Average Widths (m)	21	81

Appendix D Part 3

Average Minimum and Preferred Buffer Widths (m)
For Multiple Riparian Functions Including Wildlife Support

Average Recommended *Minimum* Multiple Function buffer width (excluding wildlife support) from Part 2 above	Average Recommended *Minimum* Buffer Width for Wildlife Support from Part 1 above	Average *Minimum* Buffer Width Recommendation for Multiple Functions Including Wildlife Support
21	**41**	**30**
Average Recommended *Preferred* Multiple Function buffer width (excluding wildlife support) from Part 2 above	Average Recommended *Preferred* Buffer Width for Wildlife Support from Part 1 above	Average *Preferred* Buffer Width Recommendation for Multiple Functions Including Wildlife Support
81	**162**	**121**

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Appendix E: Stepwise Instructions for Mapping Existing Riparian Areas

Note: this methodology will evolve through initisl implementation efforts.

I. Summary

For the whole area to be mapped, conduct the following steps.

1. Select 4th order or 5th order sub-watersheds as index areas that together comprise 5-10% of the total area to be mapped.
2. Generate a comprehensive drainage network including all 1st order channels, agricultural ditches, etc., using the 10m DEM.
3. Separate the channel network into two layers: (a) 1st order channels; and (b) all other channels (2nd order and higher-order channels).
4. Align the 2nd order and larger channels with the aerial imagery.
5. For all 2nd order and larger channels represented on the map by a single line, buffer each side of the line by 1.25m.
6. Create hillside slope layers in degree and percent, using 10m DEM.
7. Using existing vegetation data and reference materials, determine Site Potential Tree Height (SPTH) for each dominant tree species in the vegetation data.
8. Attribute the 2nd order and larger channels and other water bodies except natural 1st order channels with vegetation data (vegetation classes, tree heights, and standard buffer widths, accounting for SPTH and hillside slope angle).
9. For all 2nd order and larger channels and other water bodies except natural 1st order channels, calculate the riparian buffer width for forested riparian areas using the assigned SPTH values and hillside slope angle.
10. Use heads-up digitizing to add obvious riparian areas that were not included in the automated widths in Step 9.
11. Convert the riparian polygons created by Step 10 into a line feature (i.e., create outlines of the newly created riparian polygons).
12. Attribute the riparian outlines from Step 11 with hillside slope angle in percent.
13. Increase riparian widths by 1 meter for each increase in slope percent over 20% (e.g., increase the riparian width by 1 meter for 21% slope, 2 meters for 22% slope, 3 meters for 23% slope, etc).
14. Merge the results of Steps 10 and 13.
15. Conduct any additional editing or clean-ups of the GIS layers.
16. Clip to the boundary of the mapping extent. Check topology.
17. Select 4th order or 5th order sub-watersheds as index areas that together comprise 5-10% of the total area to be mapped.
18. For each index area, repeat steps 4-16 for 1st order channels.
19. Multiply the total number of 1st order channels in the whole area to be mapped (from Step 2) by average riparian area per 1st order channel in the index areas.

II. Data

Elevation data

USGS National Elevation Dataset (NED)

Download 10-meter NED for the area to be mapped.
http://seamless.usgs.gov/

Aerial Photography

Main imagery:

- ☐ National Agriculture Imagery Program (NAIP) true color imagery (2005) http://archive.casil.ucdavis.edu/casil/remote_sensing/naip_2005/ (As more recent NAIP imagery becomes available, this web site might change.)

Ancillary imagery:

- ☐ Color-infrared stereo pair imagery (e.g., National Aerial Photography Program (NAPP) imagery, National High Altitude Photography (NHAP))
- ☐ DOQQ
- ☐ Locally available imagery

Vegetation Data

- ☐ CALVEG (Classification and Assessment with LANDSAT™ of Visible Ecological Groupings) by USDA Forest Service
- ☐ Locally/publicly available and reliable vegetation data (Note: The quality of the vegetation data would affect the quality of riparian area buffer.)

III. Data preparation

Slope data (degree and percent)

1. If necessary, "Clip" NED data for the area to be mapped. (Note: "Export" option creates some noise in the output, so "Clip" is preferred for subset.)

2. Project the NED into appropriate projection (e.g., UTM NAD83). The projection to be used is preferably in meter unit (for creating slope data). Select "Bilinear" for Resampling option (Nearest neighbor option adds artificial lines in the output layers.)

3. Create Slope layers in degree and percent, using **Spatial /3D Analyst: Surface Analysis -- Slope...** Select Degree option for creating Slope Degree layer and Percent for creating Slope Percent layer. The output layers will be raster layers with slope values in float.

4. Round the slope degree and percent values, using Raster Calculator (ArcMap - Spatial Analyst – Raster Calculator). Round the slope values for each layer separately.

Use the script below in one line (the script is from ESRI support website):

G2 = INT(CON([FILENAME] > 0,CON(ABS([FILENAME] - INT([FILENAME])) >= 0.5,CEIL([FILENAME]),FLOOR([FILENAME])),CON(ABS([FILENAME] - INT([FILENAME])) >= 0.5,FLOOR([FILENAME]),CEIL([FILENAME]))))

Note: This script does the rounding of slope values and creates the raster layer G2 (in this case).

G2 = This is a temporarily created file, so if several rounds of this process have been done, make sure to change the name, e.g., to G3, G4, SlopeDegRound etc. because G2 may already exists, which will give you an error message.

[FILENAME] = file name (the name of the slope degree and slope percent layers.) If the name of the slope percent layer is "SlopePercent," then it should be [SlopePercent]. In Table of Content in ArcMap, the filenames can also be changed to an alias name.

5. Convert the raster layers with rounded slope degree values and rounded percent values (i.e., G2) into polygon layers: **(Spatial analyst – Convert..)** The output polygon layers should be (1) slope degree polygon layer and (2) slope percent polygon layer.

Stream channels with channel orders

1. Use Hydrology Tools (under Spatial Analyst Tools, ArcTools) and NED data to create stream channel lines.

   Hydrology tools: Fill, Flow Direction, Flow Accumulation, Stream Order, Stream to Feature

   Use elevation cell value of 114 to create stream lines from the 1st order and larger. (The elevation value 114 was calculated using two index areas in Napa watershed. Thus, this value might not be applicable for different regions. Testing different values would be recommended for different regions in order to obtain the best result for creating stream lines.) The stream line layer will contain channel orders in its attribute.

   (Alternatively, if the area to be mapped is a small area, requiring greater details, then, manually digitizing stream lines would be an option. Heads-up digitize and code the channel segments with appropriate channel orders (e.g., 1, 2, 3, etc) and habitat types (e.g., stream, ditch, etc). This will require a longer time to complete.)

2. Select all the 1st order channels from the stream channel layer and create a layer containing only the 1st order channels. Remove the 1st order channels from the original stream layer. Before removing 1st order channels, it may be a good idea to save an intact version of the entire stream channels as a back-up. The original stream line layer without 1st order channels will be used for Method 5 riparian habitat buffers.

3. Clean/edit both the 1st order channels and 2nd and higher channels for any erroneous lines.

   Note: The stream lines produced with the 10m DEM will not always align with the higher resolution aerial imagery used in "heads-up" digitizing of indicative riparian vegetation. The stream lines will therefore need to be adjusted to fit the imagery. The amount of adjustment will vary within and between watersheds.

Ponds/reservoirs

1. Use the existing pond/reservoir GIS layer (e.g., NWI layer's pond features or locally available data). (If pond/reservoir layer is not available, it might be necessary to allocate the time to digitize ponds/reservoirs.)

2. Create a line layer from ponds/reservoirs polygon layer. (ArcTool: Data Management Tools: Features: Feature To Line). The outlines of the ponds/reservoirs are created by Feature to Line process.

3. At this point, the stream line (2nd order and higher) and ponds/reservoirs could be merged. Streams and ponds/reservoirs should have separate codes (e.g., Channel order field can be added to ponds/reservoirs and assigned as "0" in the field so that pond lines can be separated from stream lines)

Vegetation data

Vegetation maps usually portray land cover types, plant communities, or plant assemblages that can be reclassified into the following basic categories Grass/Forbs, Shrub/Scrub, Woodland/Forest, Agriculture, Bare Soil. A default riparian width is assigned to each category except for Woodland/Forest (Table 1).

Table 1. Default Riparian Widths for Major Vegetation Categories

Category	Default Riparian Width (m)
Barren	1
Grass/Forbs	5
Agriculture	5
Shrub/Scrub	10
Woodland/Forest	SPTH assigned to dominant species
Unknown	Usually a tree species

Woodland/Forest category

Select a dominant tree species for each Woodland/Forest polygon. Based on the pertinent literature, assign a SPTH value (m) to each dominant species (e.g., Table 2 below). An average SPTH can be applied to mixed forests The SPTH values will be used to calculate the widths of forested riparian areas.

Table 2. SPTH values used in this study for Napa Watershed. The plant alliances are provided by the California Vegetation Manual

Map Unit Name	SPTH (m)
Black Oak Alliance	18
Blue Oak Alliance	6
California Bay - Madrone - Coast Live Oak - (Black Oak Big - Leaf Maple) NFD Super Alliance	12
Coast Live Oak - Blue Oak - (Foothill Pine) NFD Association	6
Coast Live Oak Alliance	12
Douglas-fir Alliance	20
Eucalyptus Alliance	20
Mixed Oak Alliance	6
Valley Oak Alliance	12
Winter-Rain Sclerophyll Forests/Woodlands Formation	15

Adding width and tree height in the table

There are two options.

1. A separate table can be created, with the fields containing vegetation classes, tree heights, and standard riparian widths for each plant cover category. For categories not dominated by trees, the value for tree heights is "0." For the categories dominated by trees, the data field for standard riparian width is left blank. This table saved in dbf file format can be joined later to the stream line layer attribute file after stream lines are intersected with the vegetation layer (this process is covered in the later section).

   One problem that might occur with this option is that sometimes the vegetation class names can be very long, and the dbf format file often truncates long names. This causes some vegetation classes to have no tree height assignment, if vegetation class name was to be used as the common field to join tables. To prevent this problem, vegetation class needs to be renamed with some foreshortened code or ID.

2. Create new fields in the existing vegetation data layer for standard riparian widths and SPTH values. Thus, when the stream line layer is intersected with the vegetation data layer, SPTH values and standard riparian widths are automatically transferred to the map.

IV. Details of Method 5 As Required to Conduct Method 6

Adding vegetation and slope degree data to streams and ponds/reservoirs

"Intersect" the line layer containing channel lines and ponds/reservoir shorelines with the vegetation data and slope degree layer in the following order:

1. stream/pond line layer;
2. vegetation layer;
3. slope degree layer

The output line layer will have attributes containing vegetation class names, SPTH values, and the standard riparian widths.

Calculating riparian width for Woodland/Forest type

1. Add new fields in the attribute of the stream line layer from above, with vegetation and slope values. These new fields will be used to input riparian width (e.g., "M5Buf") and actual width to be used (i.e., the width incorporating the width of stream channels. e.g., "M5BufDist").

2. Select the non-Woodland/Forest classes and assign "M5Buf" field with the standard width values. Select the Woodland/Forest classes and assign the riparian width in the "M5Buf" field with the values calculated with the formula below:

   ([TreeHT] * 2) - (([TreeHT] * 2) * Sin ([SlopeDegree] * 0.0174532925))

   Note: when there are many records, the "calculation" using above formula sometimes does not work properly. If the calculated values look just like the tree heights, then break up the formula into 2 sections as follows:

   Part 1: (([TreeHT] * 2) * Sin ([SlopeDegree] * 0.0174532925))

   Part 2: + ([TreeHT] * 2)

   Note: the values calculated from **Part 1** can be temporarily stored in "M5BufDist" and the calculation from **Part 2** should be "M5BufDist" + **([TreeHT] * 2),** where the values are calculated and assigned to the field, "M5Buf.")

   Note: the calculated values should be spot-checked for accuracy.

2. After riparian width field (e.g., "M5Buf") is assigned with values (no NULL values in "M5Buf" at this time), then "calculate" the values used for the actual buffering operation – i.e., riparian width + stream channel buffer (1.25m). Assign the values in the second field (e.g., "M5BufDist").

Buffering riparian habitat areas

Buffer the stream line using the values stored in the attribute field, containing riparian width + channel width (e.g., "M5BufDist"). Select the option for merging all the fields. The output polygon is one riparian area.

Heads-up digitizing of additional riparian habitat areas

1. Using NAIP, other aerial photography (stereo pairs), Google Earth, and any other ancillary data, digitize indicative riparian vegetation patches that are not included in the results thus far obtained.
2. Merge all results into one riparian layer. This completes Method 5.

V. Details of Method 6

Adding slope percent data to the Method 5 polygons

1. Create line feature layer from the riparian polygon created in the last stepof Method 5 (use the "Data Management Tool - Feature to Line"). The line will be the outer line of the riparian polygon created by Method 5.
2. Intersect the riparian outline layer with slope percent polygon layer. The riparian outline layer will be attributed with slope percent values.

Buffering riparian areas based on percent slope

1. Add a new field in the riparian outline layer (e.g., "SLPerBuf")
2. Select GRIDCODE < 21. Calculate "SLPerBUF" = 0.

Note: GRIDCODE is most likely the field name containing slope percent values, but this needs to be checked. The line segments containing slope percent values from 0-20. Places with 0 values will not be buffered.

3. Switch Selection (i.e., GRIDCODE > 20).

Note: switch selection can take longer than just re-selecting by GRIDCODE > 20.

While the line segments with the slope percent values more than 20% are selected, Calculate: SLPerBuf = GRIDCODE – 20. SLPerBuf field should not have any NULL values at this time.

4. Buffer the line layer, using the values in the field SLPerBuf. Select the option for merging all the fields. The output polygon is one riparian area polygon created using the slope percent.

Merging Method 5 and 6 riparian buffer polygons

1. Merge the riparian polygon layers from Method 5 and 6 (ArcTool: UPDATE)
2. Update the combined layer with stream and ponds/reservoirs layers and wetland layers (ArcTool: UPDATE)
3. If necessary, "clip" the layer (Method 5 & 6, streams and ponds/reservoirs and wetlands) by the study area boundary.

Additional notes

1. Intersecting polygon or line layers with a large slope degree or percent layers may cause some problems (e.g., ArcMap crash/freeze) or may simply take a

very long time. It may be necessary to do the operations in smaller portions (e.g., in a couple of sub-watersheds at a time), depending on the size of the area to be mapped.

2. Buffering and merging polygons also may or may not take a long time, depending on how complex or large is the area to be mapped.

VI. 1st order riparian area estimation

Mapping 1st order channels can be very time consuming and costly. When mapping all the 1st order channels in the study area is not feasible, then the following approach can be used to estimate the total amount of 1st order riparian area from a sample.

1. Use the stream line layer from containing only the 1st order channels.
2. Select 4th order or 5th order sub-watersheds as index areas that comprise between 5-10% of the area to be mapped.
3. Within the boundaries of the index areas, conduct the same steps described above (from Section **II.** to **V.**) to create Method 5 and Method 6 riparian areas for the 1st order channels of the index areas.
4. For all index areas combined, calculate the average riparian area per 1st order channel.
5. Using the stream line layer containing all the 1st order channels for the entire area to be mapped, obtain the total number of 1st order channels.
6. Multiply the total number of 1st order channels by the average riparian area per 1st order channel calculated for the index areas. The product is an estimate of the total riparian area for the entire area to be mapped.

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EPA

Principles for the Ecological Restoration of Aquatic Resources

Restoration – the return of a degraded ecosystem to a close approximation of its remaining natural potential – is experiencing a groundswell of support across the United States. The number of stream, river, lake, wetland and estuary restoration projects grows yearly. Current Federal initiatives call for a wide range of restoration actions, including improving or restoring 25,000 miles of stream corridor; achieving a net increase of 100,000 acres of wetlands each year; and establishing two million miles of conservation buffers. Many on-going or completed restoration projects now offer valuable lessons. To help build on these lessons and promote effective restoration, the Watershed Ecology Team of the Office of Wetlands, Oceans, and Watersheds has assembled the following list of principles that have been critical to the success of a wide range of aquatic resource restoration projects. These principles apply to different stages in the life of a restoration project – from early planning to post-implementation monitoring – and are offered here for use by a wide variety of people and organizations, ranging from Federal, State, Tribal, and local agencies to outdoor recreation or conservation groups, corporations, landowners, and citizens' groups.

These principles focus on scientific and technical issues, but as in all environmental management activities, the importance of community perspectives and values should not be overlooked. The presence or absence of public support for a restoration project can be the difference between positive results and failure. Coordination with the people and organizations that may be affected by the project can help build the support needed to get the project moving and ensure long-term protection of the restored area. In addition, partnership with stakeholders can also add useful resources, ranging from money and technical expertise to volunteer help with implementation and monitoring.

Restoration Guiding Principles

- Preserve and protect aquatic resources
- Restore ecological integrity
- Restore natural structure
- Restore natural function
- Work within the watershed/landscape context
- Understand the potential of the watershed
- Address ongoing causes of degradation
- Develop clear, achievable and measurable goals
- Focus on feasibility
- Use reference sites
- Anticipate future changes
- Involve a multi-disciplinary team
- Design for self-sustainability
- Use passive restoration, when appropriate
- Restore native species, avoid non-native species
- Use natural fixes and bioengineering
- Monitor and adapt where changes are necessary

Watershed Ecology Team, US EPA Office of Wetlands, Oceans and Watersheds

Restoration Guiding Principles

Preserve and protect aquatic resources. Existing, relatively intact ecosystems are the keystone for conserving biodiversity, and provide the biota and other natural materials needed for the recovery of impaired systems. Thus, restoration does not replace the need to protect aquatic resources in the first place. Rather, restoration is a complementary activity that, when combined with protection and preservation, can help achieve overall improvements in a greater percentage of the Nation's waters. Even with waterbodies for which restoration is planned, the first objective should be to prevent further degradation.

Restore ecological integrity. Restoration should reestablish insofar as possible the ecological integrity of degraded aquatic ecosystems. Ecological integrity refers to the condition of an ecosystem -- particularly the structure, composition, and natural processes of its biotic communities and physical environment. An ecosystem with integrity is a resilient and self-sustaining natural system able to accommodate stress and change. Its key ecosystem processes, such as nutrient cycles, succession, water levels and flow patterns, and the dynamics of sediment erosion and deposition, are functioning properly within the natural range of variability. Biologically, its plant and animal communities are good examples of the native communities and diversity found in the region. Structurally, physical features such as the dimensions of its stream channels are dynamically stable. Restoration strives for the greatest progress toward ecological integrity achievable within the current limits of the watershed, by using designs that favor the natural processes and communities that have sustained native ecosystems through time.

Restore natural structure. Many aquatic resources in need of restoration have problems that originated with harmful alteration of channel form or other physical characteristics, which in turn may have led to problems such as habitat degradation, changes in flow regimes, and siltation. Stream channelization, ditching in wetlands, disconnection from adjacent ecosystems, and shoreline modifications are examples of structural alterations that may need to be addressed in a restoration project. In such cases, restoring the original site morphology and other physical attributes is essential to the success of other aspects of the project, such as improving water quality and bringing back native biota.

Restore natural function. Structure and function are closely linked in river corridors, lakes, wetlands, estuaries and other aquatic resources. Reestablishing the appropriate natural structure can bring back beneficial functions. For example, restoring the bottom elevation in a wetland can be critical for reestablishing the hydrological regime, natural disturbance cycles, and nutrient fluxes. In order to maximize the societal and ecological benefits of the restoration project, it is essential to identify what functions should be present and make missing or impaired functions priorities in the restoration. Verifying whether desired functions have been reestablished can be a good way to determine whether the restoration project has succeeded.

Work within the watershed and broader landscape context. Restoration requires a design based on the entire watershed, not just the part of the waterbody that may be the most degraded site. Activities throughout the watershed can have adverse effects on the aquatic resource that is being restored. A localized restoration project may not be able to change what goes on in the whole watershed, but it can be designed to better accommodate watershed effects. New and future urban development may, for example, increase runoff volumes, stream downcutting and bank erosion, and pollutant loading. By considering the watershed context in this case, restoration planners may be able to design a project for the desired benefits of restoration, while also withstanding or even helping to remediate the effects of adjacent land uses on runoff and nonpoint pollution. For example, in choosing a site for a wetland restoration project, planners should consider how the proposed project may be used to further other related efforts in the watershed, such as increasing riparian habitat continuity, reducing flooding, and/or enhancing downstream water quality. Beyond the watershed, the broader landscape context also influences restoration through factors such as interactions with terrestrial habitats in adjacent watersheds, or the deposition of airborne pollutants from other regions.

Understand the natural potential of the watershed. A watershed has the capacity to become only what its physical and biological setting -- its ecoregion's climate, geology, hydrology, and biological characteristics -- will support. Establishing restoration goals for a waterbody requires knowledge of the historical range of conditions that existed on the site prior to degradation and what future conditions might be. This information can then be used in determining appropriate goals for the restoration project. In some cases, the extent and magnitude of changes in the watershed may constrain the ecological potential of the site. Accordingly, restoration planning should take into account any irreversible changes in the watershed that may affect the system being restored, and focus on restoring its remaining natural potential.

Address ongoing causes of degradation. Restoration efforts are likely to fail if the sources of degradation persist. Therefore, it is essential to identify the causes of degradation and eliminate or remediate ongoing stresses wherever possible. While degradation can be caused by one direct impact such as the filling of a wetland, much degradation is caused by the cumulative effect of numerous, indirect impacts, such as changes in surface flow caused by gradual increases in the amount of impervious surfaces in the watershed. In identifying the sources of degradation, it is important to look at upstream and up-slope activities as well as at direct impacts on the immediate project site. Further, in some situations, it may also be necessary to consider downstream modifications such as dams and channelization.

Develop clear, achievable, and measurable goals. Restoration may not succeed without good goals. Goals direct implementation and provide the standards for measuring success. Simple conceptual models are a useful starting point to define the problems, identify the type of solutions needed, and develop a strategy and goals. Restoration teams should evaluate different alternatives to assess which can best accomplish project goals. The chosen goals should be achievable ecologically, given the natural potential of the area, and socioeconomically, given the available resources and the extent of community support for the project. Also, all parties affected by the restoration should understand each project goal clearly to avoid subsequent misunderstandings. Good goals provide focus and increase project efficiency.

Focus on feasibility. Particularly in the planning stage, it is critical to focus on whether the proposed restoration activity is feasible, taking into account scientific, financial, social and other considerations. Remember that solid community support for a project is needed to ensure its long-term viability. Ecological feasibility is also critical. For example, a wetlands restoration project is not likely to succeed if the hydrological regime that existed prior to degradation cannot be reestablished.

Use a reference site. Reference sites are areas that are comparable in structure and function to the proposed restoration site before it was degraded. As such, reference sites may be used as models for restoration projects, as well as a yardstick for measuring the progress of the project. While it is possible to use historic information on sites that have been altered or destroyed, historic conditions may be unknown and it may be most useful to identify an existing, relatively healthy, similar site as a guide for your project. Remember, however, that each restoration project will present a unique set of circumstances, and no two aquatic systems are truly identical. Therefore, it is important to tailor your project to the given situation and account for any differences between the reference site and the area being restored.

Anticipate future changes. The environment and our communities are both dynamic. Although it is impossible to plan for the future precisely, many foreseeable ecological and societal changes can and should be factored into restoration design. For example, in repairing a stream channel, it is important to take into account potential changes in runoff resulting from projected increases in upstream impervious surface area due to development. In addition to potential impacts from changes in watershed land use, natural changes such as plant community succession can also influence restoration. For instance, long-term, post-project monitoring should take successional processes such as forest regrowth in a stream corridor into account when evaluating the outcome of the restoration project.

Involve the skills and insights of a multi-disciplinary team. Restoration can be a complex undertaking that integrates a wide range of disciplines including ecology, aquatic biology, hydrology and hydraulics, geomorphology, engineering, planning, communications and social science. It is important that, to the extent that resources allow, the planning and implementation of a restoration project involve people with experience in the disciplines needed for the particular project. Universities, government agencies, and private organizations may be able to provide useful information and expertise to help ensure that restoration projects are based on well-balanced and thorough plans. With more complex restoration projects, effective leadership will also be needed to bring the various disciplines, viewpoints, and styles together as a functional team.

Design for self-sustainability. Perhaps the best way to ensure the long-term viability of a restored area is to minimize the need for continuous maintenance of the site, such as supplying artificial sources of water, vegetation management, or frequent repairing of damage done by high water events. High maintenance approaches not only add costs to the restoration project, but also make its long-term success dependent upon human and financial resources that may not always be available. In addition to limiting the need for maintenance, designing for self-sustainability also involves favoring ecological integrity, as an ecosystem in good condition is more likely to have the ability to adapt to changes.

Use passive restoration, when appropriate. "Time heals all wounds" applies to many restoration sites. Before actively altering a restoration site, determine whether passive restoration (i.e., simply reducing or eliminating the sources of degradation and allowing recovery time) will be enough to allow the site to naturally regenerate. Many times there are reasons for restoring a waterbody as quickly as possible, but there are other situations when immediate results are not critical. For some rivers and streams, passive restoration can reestablish stable channels and floodplains, regrow riparian vegetation, and improve in-stream habitats without a specific restoration project. With wetlands that have been drained or otherwise had their natural hydrology altered, restoring the original hydrological regime may be enough to let time reestablish the native plant community, with its associated habitat value. It is important to note that, while passive restoration relies on natural processes, it is still necessary to analyze the site's recovery needs and determine whether time and natural processes can meet them.

Restore native species and avoid non-native species. American natural areas are experiencing significant problems with invasive, non-native (exotic) species, to the great detriment of our native ecosystems and the benefits we've long enjoyed from them. Many invasive species outcompete natives because they are expert colonizers of disturbed areas and lack natural controls. The temporary disturbance present during restoration projects invites colonization by invasive species which, once established, can undermine restoration efforts and lead to further spread of these harmful species. Invasive, non-native species should not be used in a restoration project, and special attention should be given to avoiding the unintentional introduction of such species at the restoration site when the site is most vulnerable to invasion. In some cases, removal of non-native species may be the primary goal of the restoration project.

Use natural fixes and bioengineering techniques, where possible. Bioengineering is a method of construction combining live plants with dead plants or inorganic materials, to produce living, functioning systems to prevent erosion, control sediment and other pollutants, and provide habitat. Bioengineering techniques can often be successful for erosion control and bank stabilization, flood mitigation, and even water treatment. Specific projects can range from the creation of wetland systems for the treatment of storm water, to the restoration of vegetation on river banks to enhance natural decontamination of runoff before it enters the river.

Monitor and adapt where changes are necessary. Every combination of watershed characteristics, sources of stress, and restoration techniques is unique and, therefore, restoration efforts may not proceed exactly as planned. Adapting a project to at least some change or new information should be considered normal. Monitoring before and during the project is crucial for finding out whether goals are being achieved. If they are not, "mid-course" adjustments in the project should be undertaken. Post-project monitoring will help determine whether additional actions or adjustments are needed and can provide useful information for future restoration efforts. This process of monitoring and adjustment is known as adaptive management. Monitoring plans should be feasible in terms of costs and technology, and should always provide information relevant to meeting the project goals.

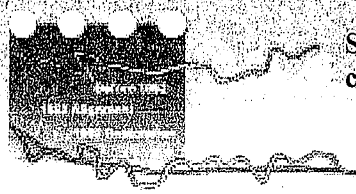
* * * * *

This publication should be cited as: *USEPA, 2000. Principles for the Ecological Restoration of Aquatic Resources. EPA841-F-00-003. Office of Water (4501F), United States Environmental Protection Agency, Washington, DC. 4 pp.* To order single, free copies, call 1-800-490-9198 and request document number EPA841-F-00-003. The document is also on the OWOW Restoration Website at http://www.epa.gov/owow/restore/

Stream Corridor Restoration

Principles, Processes, and Practices

http://www.usda.gov/stream_restoration



See this site for downloads, addenda, and a catalog of the book's images.

By: The Federal Interagency Stream Restoration Working Group

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Stream Corridor Restoration: Principles, Processes, and Practices

Introduction

There is a phenomenal resiliency in the mechanisms of the earth. A river or lake is almost never dead. If you give it the slightest chance...then nature usually comes back.

— Rene Dubos 1981

Why Is Stream Corridor Restoration Important?

The United States has more than 3.5 million miles of rivers and streams that, along with closely associated floodplain and upland areas, comprise corridors of great economic, social, cultural, and environmental value. These corridors are complex ecosystems that include the land, plants, animals, and network of streams within them. They perform a number of ecological functions such as modulating streamflow, storing water, removing harmful materials from water, and providing habitat for aquatic and terrestrial plants and animals. Stream corridors also have vegetation and soil characteristics distinctly different from surrounding uplands and support higher levels of species diversity, species densities, and rates of biological productivity than most other landscape elements.

Streams and stream corridors evolve in concert with and in response to surrounding ecosystems. Changes within a surrounding ecosystem (e.g., watershed) will impact the physical, chemical, and biological processes occurring within a stream corridor. Stream systems normally function within natural ranges of flow, sediment movement, temperature, and other variables, in what is termed "dynamic equilibrium." When changes in these variables go beyond their natural ranges, dynamic equilibrium may be lost, often resulting in adjustments in the ecosystem that might conflict with societal needs. In some circumstances, a new dynamic equilibrium may

Fig. 1.1: Stream corridor in the Midwest. Stream corridors have great economic, social, cultural, and environmental values.

eventually develop, but the time frames in which this happens can be lengthy, and the changes necessary to achieve this new balance significant.

Over the years, human activities have contributed to changes in the dynamic equilibrium of stream systems across the nation. These activities center on manipulating stream corridor systems for a wide variety of purposes, including domestic and industrial water supplies, irrigation, transportation, hydropower, waste disposal, mining, flood control, timber management, recreation, aesthetics, and more recently, fish and wildlife habitat. Increases in human population and industrial, commercial, and residential development place heavy demands on this country's stream corridors.

The cumulative effects of these activities result in significant changes, not only to stream corridors, but also to the ecosystems of which they are a part. These changes include degradation of water quality, decreased water storage and conveyance capacity, loss of habitat for fish and wildlife, and decreased recreational and aesthetic values (National Research Council 1992). According to the 1994 National Water Quality Inventory of 617,806 miles of rivers and streams, only 56 percent fully supported multiple uses, including drinking water supply, fish and wildlife habitat, recreation, and agriculture, as well as flood prevention and erosion control. Sedimentation and excess nutrients were the most significant causes of degradation (USEPA 1997) in the remaining 44 percent.

Human activity has profoundly affected rivers and streams in all parts of the world, to such an extent that it is now extremely difficult to find any stream which has not been in some way altered, and probably quite impossible to find any such river.

— H.B.N. Hynes 1970

Fig. I.2: Concrete-lined channel. *Stream systems across the nation have been altered for a wide variety of purposes.*

Given these statistics, the potential for restoring the conditions in our nation's rivers and streams and protecting them from further damage is almost boundless.

What Is Meant by Restoration?

Restoration is a complex endeavor that begins by recognizing natural or human-induced disturbances that are damaging the structure and functions of the ecosystem or preventing its recovery to a sustainable condition (Pacific Rivers Council 1996). It requires an understanding of the structure and functions of stream corridor ecosystems and

Restoration, Rehabilitation, and Reclamation

- Restoration *is reestablishment of the structure and function of ecosystems (National Research Council, 1992). Ecological restoration is the process of returning an ecosystem as closely as possible to predisturbance conditions and functions. Implicit in this definition is that ecosystems are naturally dynamic. It is therefore not possible to recreate a system exactly. The restoration process reestablishes the general structure, function, and dynamic but self-sustaining behavior of the ecosystem.*
- Rehabilitation *is making the land useful again after a disturbance. It involves the recovery of ecosystem functions and processes in a degraded habitat (Dunster and Dunster 1996). Rehabilitation does not necessarily reestablish the predisturbance condition, but does involve establishing geological and hydrologically stable landscapes that support the natural ecosystem mosaic.*
- Reclamation *is a series of activities intended to change the biophysical capacity of an ecosystem. The resulting ecosystem is different from the ecosystem existing prior to recovery (Dunster and Dunster 1996). The term has implied the process of adapting wild or natural resources to serve a utilitarian human purpose such as the conversion of riparian or wetland ecosystems to agricultural, industrial, or urban uses.*

Restoration differs from rehabilitation and reclamation in that restoration is a holistic process not achieved through the isolated manipulation of individual elements. While restoration aims to return an ecosystem to a former natural condition, rehabilitation and reclamation imply putting a landscape to a new or altered use to serve a particular human purpose (National Research Council 1992).

the physical, chemical, and biological processes that shape them (Dunster and Dunster 1996).

Restoration, as defined in this document, includes a broad range of actions and measures designed to enable stream corridors to recover dynamic equilibrium and function at a self-sustaining level. The first and most critical step in implementing restoration is to, where possible, halt disturbance activities causing degradation or preventing recovery of the ecosystem (Kauffman et al. 1993). Restoration actions may range from passive approaches that involve removal or attenuation of chronic disturbance activities to active restoration that involves intervention and installation of measures to repair damages to the structure of stream corridors.

Restoration practitioners involved with stream corridors take one of three basic approaches to restoration:

- *Nonintervention and undisturbed recovery:* where the stream corridor is recovering rapidly, and active restoration is unnecessary and even detrimental.
- *Partial intervention for assisted recovery:* where a stream corridor is attempting to recover, but is doing so slowly or uncertainly. In such a case, action may facilitate natural processes already occurring.
- *Substantial intervention for managed recovery:* where recovery of desired functions is beyond the repair capacity of the ecosystem and active restoration measures are needed.

The specific goals of any particular restoration should be defined within the context of the current conditions and disturbances in the watershed,

Streams Have the Capability to Restore Themselves—We must be able to recognize these situations.

"Each stream," says Christopher Hunter, "is a whole greater than the sum of its geologic, climatic, hydrologic, and biologic parts." Those who would save rivers must first see each river whole, as a separate, vital, and unique group of elements and energies that constantly seeks its own dynamic equilibrium (from Nick Lyons, Foreword to Better Trout Habitat: A Guide to Stream Restoration and Management; *Hunter 1991). It is this almost living quality of streams, along with the capability to repair and sustain themselves with the removal of disturbances, that this document must convey to the reader. This document addresses the need within agencies for a comprehensive restoration context, an appreciation of the importance of removing key disturbances to allow streams to restore themselves, and to better determine those circumstances when active intervention in the restoration process is the preferred alternative.*

corridor, and stream. In all likelihood, restoration will not involve returning a system to its pristine or original condition. The goal should be to establish self-sustaining stream functions.

Because this document may be a primary reference on ecological restoration for many users, it is appropriate that more than one definition of restoration be included. The following definition of restoration has been adopted by the Society for Ecological Restoration (SER). "Ecological restoration is the process of assisting the recovery and management of ecological integrity. Ecological integrity includes a critical range of variability in biodiversity, ecological processes, and structures, regional and historical context, and sustainable cultural practices."

Why Is a Stream Corridor Restoration Document Needed?

Interest in restoring stream corridor ecosystems is expanding nationally and internationally. Research is under way and guidelines are being developed for stream corridor restoration in both the public and private sectors. The number of case studies, published papers, technology exchanges, research projects, and symposia on both the technical and process aspects of stream corridor restoration is increasing.

Over the years, many federal agencies have contributed to this growing body of knowledge and have issued manuals and handbooks pertaining in some way to stream restoration. Much of this older literature, however, is significantly different from this document in terms of philosophy and technique. Narrow in scope and focusing on only specific aspects, regions, objectives, or treatments, it may be outdated and not reflective of new restoration techniques and philosophies. The result has been confusion and concern among both government agencies and the public on how to evaluate the need for development and implementation of restoration initiatives.

In response, this document represents an unprecedented cooperative effort by the participating federal agencies to produce a common technical reference on stream corridor restoration.

Recognizing that no two stream corridors and no two restoration initiatives are identical, this technical document broadly addresses the elements of restoration that apply in the majority of situations encountered. The document

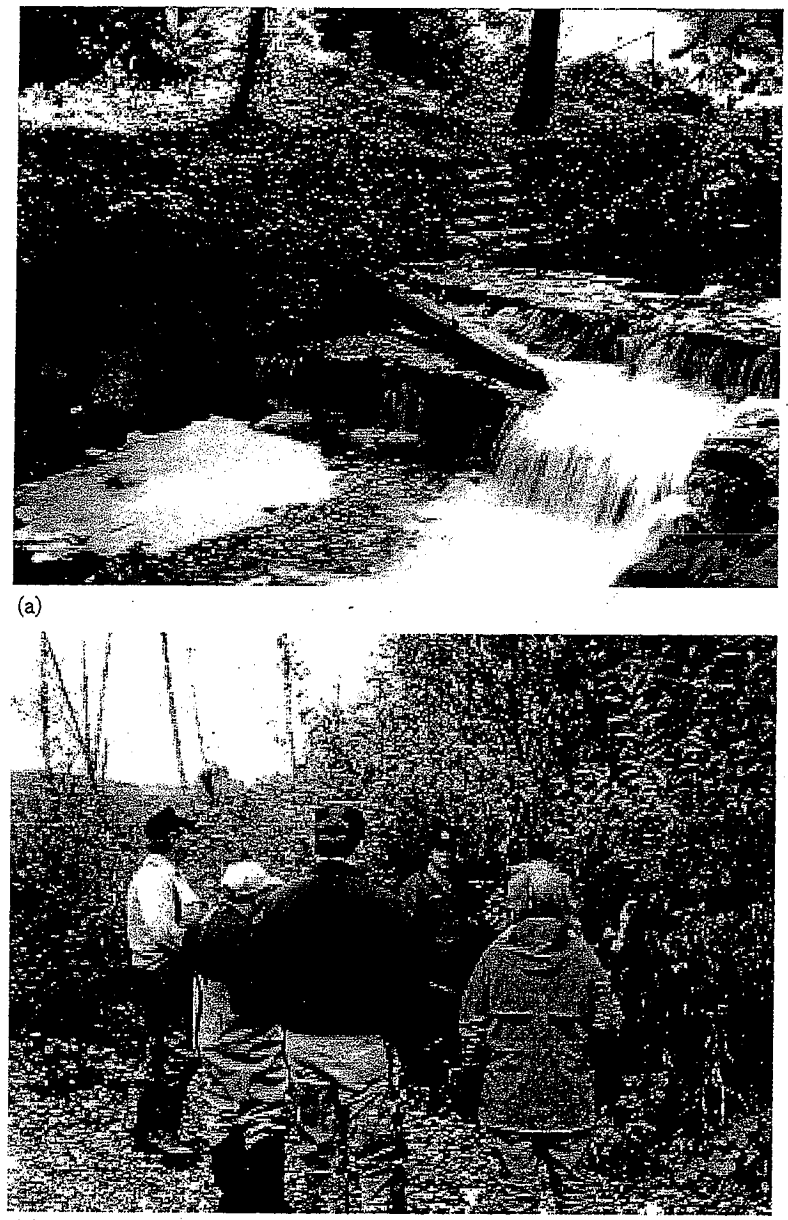
> **It is axiomatic that no restoration can ever be perfect; it is impossible to replicate the biogeochemical and climatological sequence of events over geological time that led to the creation and placement of even one particle of soil, much less to exactly reproduce an entire ecosystem. Therefore, all restorations are exercises in approximation and in the reconstruction of naturalistic rather than natural assemblages of plants and animals with their physical environments.**
>
> *— Berger 1990*

is not a set of guidelines that cover every possible restoration situation, but it does provide a framework in which to plan restoration actions and alternatives.

What Does the Document Cover?

This document takes a more encompassing approach to restoration than most other texts and manuals. It provides broadly applicable guidance for common elements of the restoration process, but also provides alternatives, and references to alternatives, which may be appropriate for site-specific restoration activities. Moreover, the document incorporates and reflects the experiences of the collaborating agencies and provides a common technical reference that can be used to restore systems based on experiences and basic scientific knowledge.

As a general goal, this document promotes the use of ecological processes (physical, chemical, and biological) and minimally intrusive solutions to restore self-sustaining stream corridor func-



(a)

(b)

Fig. I.3: Stream corridor restoration can be applied in both (a) urban and (b) rural settings. *No matter the setting, vegetation and soil characteristics in the corridor differ distinctly from the surrounding uplands.*

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tions. It provides information necessary to develop and select appropriate alternatives and solutions, and to make informed management decisions regarding valuable stream corridors and their watersheds. In addition, the document recognizes the complexity of most stream restoration work and promotes an integrated approach to restoration. It supports close cooperation among all participants in order to achieve a common set of objectives.

The guidance contained in this document is applicable nationwide in both urban and rural settings. The material presented applies to a range of stream types, including intermittent and perennial streams of all sizes, and rivers too small to be navigable by barges. It offers a scientific perspective on restoration work ranging from simple to complex, with the level of detail increasing as the scale moves from the landscape to the stream reach.

Fig. I.4: ***A stream corridor.*** *The document provides an overview of stream corridor structure and functions.*

Note that there are several things that this document is not intended to be.

- It is not a cookbook containing prescribed "recipes" or step-by-step instructions on how to restore a stream corridor.
- While this document refers to issues such as nonpoint source pollution and best management practices, wetlands restoration and delineation, lake and reservoir restoration, and water quality monitoring, it is not meant to focus on these subjects.
- It is not a policy-setting document. No contributing federal agency is strictly bound by its contents. Rather, it suggests and promotes a set of approaches, methods, and techniques applicable to most stream corridor restoration initiatives encountered by agencies and practitioners.
- It is not intended to be an exhaustive research document on the subject of stream corridor restoration. It does provide, however, many references for those desiring a deeper understanding of the principles and theories underlying techniques and issues discussed in general terms.

Who Is the Intended Audience?

The document is intended primarily for interdisciplinary technical and managerial teams and individuals responsible for planning, designing, and implementing stream corridor restoration initiatives. The document may also be useful to others who are working in stream corridors, including contractors, landowners, volunteers, agency staff, and other practitioners.

How Is the Document Organized?

The document is organized to provide an overview of stream corridors, steps in restoration plan development, and guidelines for implementing restoration.

The document has been divided into three principal parts. *Part I* provides background on the fundamental concepts of stream corridor structure, processes, functions, and the effects of disturbance. *Part II* focuses on a general restoration plan development process comprised of several fundamental steps. *Part III* examines the information presented in Parts I and II to consider how it can be applied in a restoration initiative.

Because of the size and complexity of the document, two features are used to assist the reader to maintain a clear orientation within the document. These features will allow the reader to more easily apply the information to specific aspects of a stream corridor restoration initiative. These features are:

- Chapter dividers that include major chapter sections and reader preview and review questions for each chapter. Table I.1 presents a summary of these questions by chapter.
- Short chapter summaries included at the beginning and end of each chapter that explain where the readers have been, where they are in the document, and where they are going.

A special emphasis has been placed on document orientation due to the special mission that the document has to fulfill. The document audience will include readers from many different technical backgrounds and with various levels of training. The orientation features have been included to reinforce the comprehensive and interdisciplinary perspective of stream corridor restoration.

Agencies Contributing to This Document

- *United States Department of Agriculture:*
  - *– Agricultural Research Service*
  - *– Cooperative State Research, Education, and Extension Service*
  - *– Forest Service*
  - *– Natural Resources Conservation Service*
- *United States Department of Commerce:*
  - *– National Oceanic and Atmospheric Administration*
    - *– National Marine Fisheries Service*
- *United States Department of Defense:*
  - *– Army Corps of Engineers*
- *United States Department of Housing and Urban Development*
- *United States Department of the Interior:*
  - *– Bureau of Land Management*
  - *– Bureau of Reclamation*
  - *– Fish and Wildlife Service*
  - *– United States Geological Survey*
  - *– National Park Service*
- *United States Environmental Protection Agency*
- *Federal Emergency Management Agency*
- *Tennessee Valley Authority*

How Is the Document Intended to Be Used?

Use of the document mostly depends on the goals of the reader. To begin with, a quick overview of the material is suggested prior to more thorough reading. A reader seeking only a general understanding of the principles of stream restoration may skip over some of the technical details in the body of the document. Use of document sections, chapters, and headings allows each reader to readily identify whether further, more detailed reading on a subject will serve his or her purposes.

The reader is urged to recognize the interdisciplinary and technical nature of stream restoration. While some technical material may, on the surface, appear irrelevant, it may in fact be highly relevant to a specific part of the process of restoring a stream corridor.

Stream corridor restoration technologies and methodologies are evolving rapidly. Readers are encouraged to add their own notes on restoration and to make the document more relevant to local needs (e.g., a list of suitable native plant species for streambank revegetation).

This document is being published in a notebook form to allow insertion of:

- Updated material that will be made available at the Internet sites printed in the *Preface.*
- Addition of regional or locally relevant materials collected by the reader.

A Note About Units of Measurement

Metric units are commonly used throughout the world, but most data published in the United States are in English units. Although adoption of the metric system is on the increase in the United States—and for many federal agencies this conversion is mandated and being planned for—restorers of stream corridors will continue to use data that are in either metric or English units.

Appendix B contains a table of metric to English unit conversion factors, in case a unit conversion is needed.

Feedback

Readers are encouraged to share their restoration experiences and provide feedback. They can do so by accessing the Stream Corridor Restoration home page on the Internet address printed in the Preface. *Other sources of information may also be found by exploring the cooperating agencies' home pages on the Internet.*

Table I.1

Chapter 1: Overview of Stream Corridors

1.A Physical Structure and Time at Multiple Scales
- *What are the structural components of a stream corridor?*
- *Why are stream corridors of special significance, and why should they be the focus of restoration efforts?*
- *What is the relationship between stream corridors and other landscape units at broader and more local scales?*
- *What scales should be considered for a stream corridor restoration?*

1.B A Lateral View Across the Stream Corridor
- *How is a stream corridor structured from side to side?*
- *How do these elements contribute to stream corridor functions?*
- *What role do these elements play in the life of the stream?*
- *What do we need to know about the lateral elements of a stream corridor to adequately characterize a stream corridor for restoration?*
- *How are the lateral elements of a stream corridor used to define flow patterns of a stream?*

1.C A Longitudinal View Along the Stream Corridor
- *What are the longitudinal structural elements of a stream corridor?*
- *How are these elements used to characterize a stream corridor?*
- *What are some of the basic ecological concepts that can be applied to streams to understand their function and characteristics on a longitudinal scale?*
- *What do we need to know about the longitudinal elements that are important to stream corridor restoration?*

Chapter 2: Stream Corridor Processes, Characteristics, and Functions

2.A Hydrologic and Hydraulic Processes
- *Where does stream flow come from?*
- *What processes affect or are involved with stream flow?*
- *How fast, how much, how deep, how often, and when does water flow?*
- *How is hydrology different in urban stream corridors?*

2.B Geomorphic Processes
- *What factors affect the channel cross section and channel profile?*
- *How are water and sediment related?*
- *Where does sediment come from and how is it transported downstream?*
- *What is an equilibrium channel?*
- *What should a channel look like in cross section and in profile?*
- *How do channel adjustments occur?*
- *What is a floodplain?*
- *Is there an important relationship between a stream and its floodplain?*

2.C Physical and Chemical Characteristics
- *What are the major chemical constituents of water?*
- *What are some important relationships between physical habitat and key chemical parameters?*
- *How are the chemical and physical parameters critical to the aquatic life in a stream corridor?*
- *What are the natural chemical processes in a stream corridor and water column?*
- *How do disturbances in the stream corridor affect the chemical characteristics of stream water?*

Table I.1 (continued)

2.D Biological Community Characteristics

- *What are the important biological components of a stream corridor?*
- *What biological activities and organisms can be found within a stream corridor?*
- *How does the structure of stream corridors support various populations of organisms?*
- *What are the structural features of aquatic systems that contribute to the biological diversity of stream corridors?*
- *What are some important biological processes that occur within a stream corridor?*
- *What role do fish have in stream corridor restoration?*

2.E Functions and Dynamic Equilibrium

- *What are the major ecological functions of stream corridors?*
- *How are these ecological functions maintained over time?*
- *Is a stream corridor stable?*
- *Are these functions related?*
- *How does a stream corridor respond to all the natural forces acting on it (i.e., dynamic equilibrium)?*

Chapter 3: Disturbance Affecting Stream Corridors

3.A Natural Disturbances

- *How does natural disturbance contribute to shaping a local ecology?*
- *Are natural disturbances bad?*
- *How do you describe or define the frequency and magnitude of natural disturbance?*
- *How does an ecosystem respond to natural disturbances?*
- *What are some types of natural disturbances you should anticipate in a stream corridor restoration?*

3.B Human-Induced Disturbances

- *What are some examples of human-induced disturbances at several landscape scales?*
- *What are the effects of some common human-induced disturbances such as dams, channelization, and the introduction of exotic species?*
- *What are some of the effects of land use activities such as agriculture, forestry, mining, grazing, recreation, and urbanization?*

Chapter 4: Getting Organized and Identifying Problems and Opportunities

4.A Getting Organized

- *Why is planning important?*
- *Is an Advisory Group needed?*
- *How is an Advisory Group formed?*
- *Who should be on an Advisory Group?*
- *How can funding be identified and acquired?*
- *How are technical teams established and what are their roles?*
- *What procedures should an Advisory Group follow?*
- *How is communication facilitated among affected stakeholders?*

Table I.1 (continued)

4.B Problem and Opportunity Identification

- *Why is it important to spend resources on the problem ("When everyone already knows what the problem is")?*
- *How can the anthropogenic changes that caused the need for the restoration initiative be altered or removed?*
- *How are data collection and analysis procedures organized?*
- *How are problems affecting the stream corridor identified?*
- *How are reference conditions for the stream corridor determined?*
- *Why are reference conditions needed?*
- *How are existing management activities influencing the stream corridor?*
- *How are problems affecting the stream corridor described?*

Chapter 5: Developing Goals, Objectives, and Restoration Alternatives

5.A Developing Restoration Goals and Objectives

- *How are restoration goals and objectives defined?*
- *How do you describe desired future conditions for the stream corridor and surrounding natural systems?*
- *What is the appropriate spatial scale for the stream corridor restoration?*
- *What institutional or legal issues are likely to be encountered during a restoration?*
- *What are the means to alter or remove the anthropogenic changes that caused the need for the restoration (i.e., passive restoration)?*

5.B Alternative Selection and Design

- *How does a restoration effort target solutions to treat causes of impairment and not just symptoms?*
- *What are important factors to consider when selecting among various restoration alternatives?*
- *What role does spatial scale, economics, and risk play in helping to select the best restoration alternative?*
- *Who makes the decisions?*
- *When is active restoration needed?*
- *When are passive restoration methods appropriate?*

Chapter 6: Implement, Monitor, Evaluate, and Adapt

6.A Restoration Implementation

- *What are the steps that should be followed for successful implementation?*
- *How are boundaries for the restoration defined?*
- *How is adequate funding secured for the duration of the project?*
- *What tools are useful for facilitating implementation?*
- *Why and how are changes made in the restoration plan once implementation has begun?*
- *How are implementation activities organized?*
- *How are roles and responsibilities distributed among restoration participants?*
- *How is a schedule developed for installation of the restoration measures?*
- *What permits and regulations will be necessary before moving forward with restoration measures?*

Table I.1 (continued)

6.B Restoration Monitoring, Evaluation, and Adaptive Management

- *What is the role of monitoring in stream corridor restoration?*
- *When should monitoring begin?*
- *How is a monitoring plan tailored to the specific objectives of a restoration initiative?*
- *Why and how is the success or failure of a restoration effort evaluated?*
- *What are some important considerations in developing a monitoring plan to evaluate the restoration effort?*

Chapter 7: Analysis of Corridor Condition

7.A Hydrologic Processes

- *How does the stream flow and why is this understanding important?*
- *Is streamflow perennial, ephemeral, or intermittent?*
- *What is the discharge, frequency, and duration of extreme high and low flows?*
- *How often does the stream flood?*
- *How does roughness affect flow levels?*
- *What is the discharge most effective in maintaining the stream channel under equilibrium conditions?*
- *How does one determine if equilibrium conditions exist?*
- *What field measurements are necessary?*

7.B Geomorphic Processes

- *How do I inventory geomorphic information on streams and use it to understand and develop physically appropriate restoration plans?*
- *How do I interpret the dominant channel adjustment processes active at the site?*
- *How deep and wide should a stream be?*
- *Is the stream stable?*
- *Are basin-wide adjustments occurring, or is this a local problem?*
- *Are channel banks stable, at-risk, or unstable?*
- *What measurements are necessary?*

7.C Chemical Characteristics

- *How do you measure the condition of the physical and chemical conditions within a stream corridor?*
- *Why is quality assurance an important component of stream corridor analysis activities?*
- *What are some of the water quality models that can be used to evaluate water chemistry data?*

7.D Biological Characteristics

- *What are some important considerations in using biological indicators for analyzing stream corridor conditions?*
- *Which indicators have been used successfully?*
- *What role do habitat surveys play in analyzing the biological condition of the stream corridor?*
- *How do you measure biological diversity in a stream corridor?*
- *What is the role of stream classification systems in analyzing stream corridor conditions?*
- *How can models be used to evaluate the biological condition of a stream corridor?*
- *What are the characteristics of models that have been used to evaluate stream corridor conditions?*

Table I.1 (continued)

Chapter 8: Restoration Design

8.A Valley Form, Connectivity, and Dimension

- *How do you incorporate all the spatial dimensions of the landscape into stream corridor restoration design?*
- *What criteria can be applied to facilitate good design decisions for stream corridor restoration?*

8.B Soil Properties

- *How do soil properties impact the design of restoration activities?*
- *What are the major functions of soils in the stream corridor?*
- *How are important soil characteristics, such as soil microfauna and soil salinity, accounted for in the design process?*

8.C Plant Communities

- *What is the role of vegetative communities in stream corridor restoration?*
- *What functions do vegetative communities fulfill in a stream corridor?*
- *What are some considerations in designing plant community restoration to ensure that all landscape functions are addressed?*
- *What is soil bioengineering and what is its role in stream corridor restoration?*

8.D Habitat Measures

- *What are some specific tools and techniques that can be used to ensure recovery of riparian and terrestrial habitat recovery?*

8.E Stream Channel Restoration

- *When is stream channel reconstruction an appropriate restoration option?*
- *How do you delineate the stream reach to be reconstructed?*
- *How is a stream channel designed and reconstructed?*
- *What are important factors to consider in the design of channel reconstruction (e.g., alignment and average slope, channel dimensions)?*
- *Are there computer models that can assist with the design of channel reconstruction?*

8.F Streambank Restoration

- *When should streambank stabilization be included in a restoration?*
- *How do you determine the performance criteria for streambank treatment, including the methods and materials to be used?*
- *What are some streambank stabilization techniques that can be considered for use?*

8.G Instream Habitat Recovery

- *What are the principal factors controlling the quality of instream habitat?*
- *How do you determine if an instream habitat structure is needed, and what type of structure is most appropriate?*
- *What procedures can be used to restore instream habitat?*
- *What are some examples of instream habitat structures?*
- *What are some important questions to address before designing, selecting, or installing an instream habitat structure?*

8.H Land Use Scenarios

- *What role does land use play in stream corridor degradation and restoration?*
- *What design approaches can be used to address the impacts of various land uses (e.g., dams, agriculture, forestry, grazing, mining, recreation, urbanization)?*
- *What are some disturbances that are often associated with specific land uses?*
- *What restoration measures can be used to mitigate the impacts of various land uses?*
- *What are the potential effects of the restoration measures?*

Chapter 9: Restoration Implementation, Monitoring, and Management

9.A Restoration Implementation

- *What are passive forms of restoration and how are they "implemented"?*
- *What happens after the decision is made to proceed with an active rather than a passive restoration approach?*
- *What type of activities are involved when installing restoration measures?*
- *How can impact on the stream channel and corridor be minimized when installing restoration measures (e.g., water quality, air quality, cultural resources, noise)?*
- *What types of equipment are needed for installing restoration measures?*
- *What are some important considerations regarding construction activities in the stream corridor?*
- *How do you inspect and evaluate the quality and impact of construction activities in the stream corridor?*
- *What types of maintenance measures are necessary to ensure the ongoing success of a restoration?*

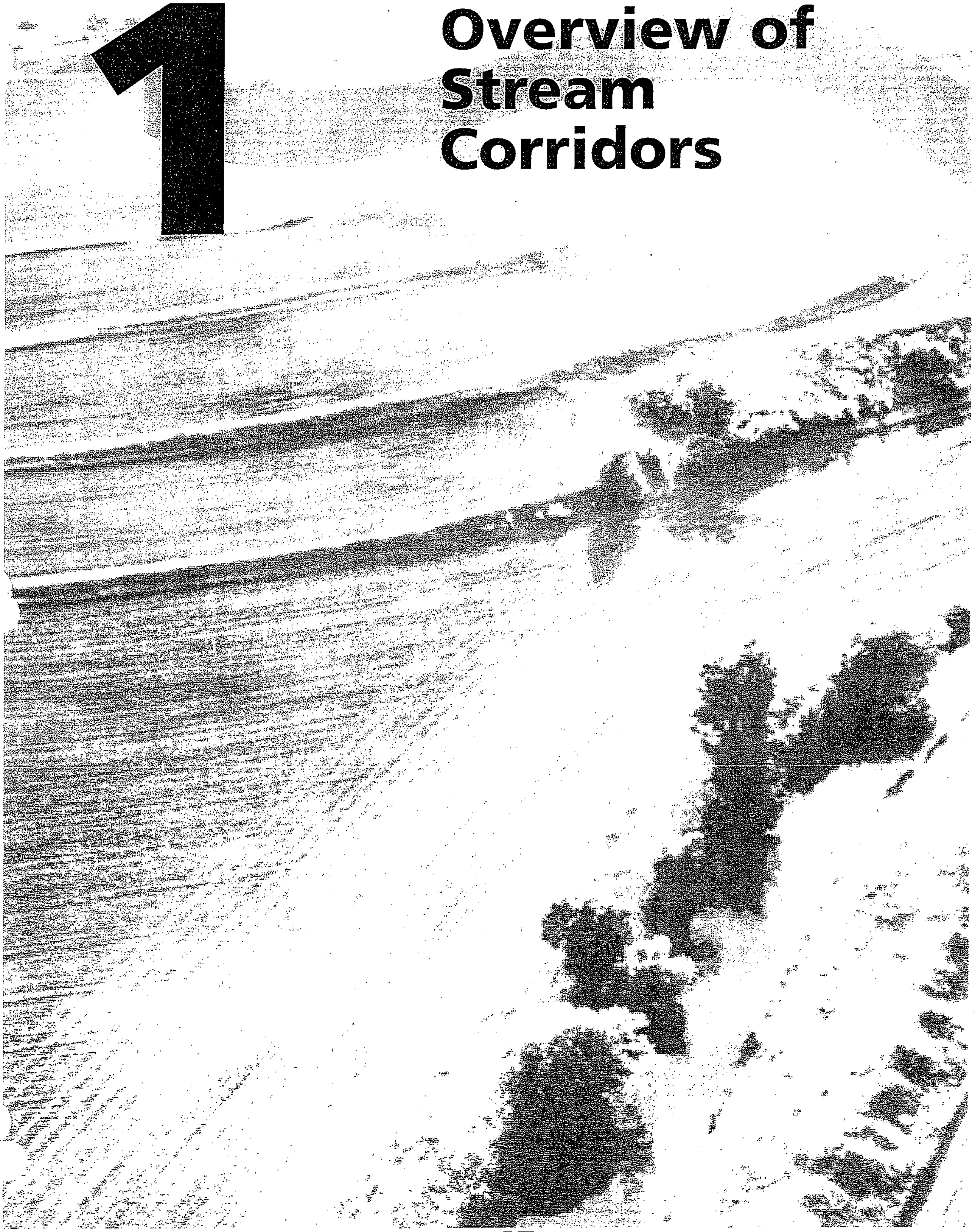
9.B Monitoring Techniques Appropriate for Evaluating Restoration

- *What methods are available for monitoring biological attributes of streams?*
- *What can assessment of biological attributes tell you about the status of the stream restoration?*
- *What physical parameters should be included in a monitoring management plan?*
- *How are the physical aspects of the stream corridor evaluated?*
- *How is a restoration monitoring plan developed, and what issues should be addressed in the plan?*
- *What are the sampling plan design issues that must be addressed to adequately detect trends in stream corridor conditions?*
- *How do you ensure that the monitoring information is properly collected, analyzed, and assessed (i.e., quality assurance plans)?*

9.C Restoration Management

- *What are important management priorities with ongoing activities and resource uses within the stream corridor?*
- *What are some management decisions that can be made to support stream restoration?*
- *What are some example impacts and management options with various types of resource use within the stream corridor (e.g., forest management, grazing, mining, fish and wildlife, urbanization)?*
- *When is restoration complete?*

1 Overview of Stream Corridors



1.A Overview of Structure and Scale

- *What are the structural components of a stream corridor?*
- *Why are stream corridors of special significance, and why should they be the focus of restoration efforts?*
- *What is the relationship between stream corridors and other landscape units at broader and more local scales?*
- *What scales should be considered for a stream corridor restoration?*

1.B Stream Corridor Functions and Dynamic Equilibrium

- *How is a stream corridor structured from side to side?*
- *How do these elements contribute to stream corridor functions?*
- *What role do these elements play in the life of the stream?*
- *What do we need to know about the lateral elements of a stream corridor to adequately characterize a stream corridor for restoration?*
- *How are the lateral elements of a stream corridor used to define flow patterns of a stream?*

1.C A Longitudinal View Along the Stream Corridor

- *What are the longitudinal structural elements of a stream corridor?*
- *How are these elements used to characterize a stream corridor?*
- *What are some of the basic ecological concepts that can be applied to streams to understand their function and characteristics on a longitudinal scale?*
- *What do we need to know about the longitudinal elements that are important to stream corridor restoration?*

1 Overview of Stream Corridors

A stream corridor is an ecosystem that usually consists of three major elements:

- *Stream channel*
- *Floodplain*
- *Transitional upland fringe*

Together they function as dynamic and valued crossroads in the landscape.

***(Figure 1.1)**. Water and other materials, energy, and organisms meet and interact within the stream corridor over space and time. This movement provides critical functions essential for maintaining life such as cycling nutrients, filtering contaminants from runoff, absorbing and gradually releasing floodwaters, maintaining fish and wildlife habitats, recharging ground water, and maintaining stream flows.*

The purpose of this chapter is to define the components of the stream corridor and introduce the concepts of scale and structure. The chapter is divided into three subsections.

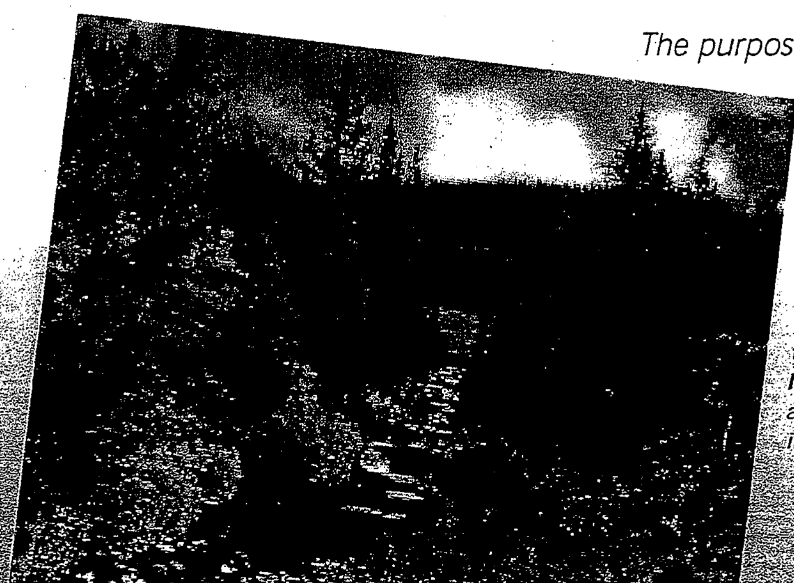


***Figure 1.1: Stream corridors function as dynamic crossroads in the landscape.** Water and other materials, energy, and organisms meet and interact within the corridor.*

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Section 1.A: Physical Structure and Time at Multiple Scales

An important initial task is to identify the spatial and time scales most appropriate for planning and designing restoration. This subsection introduces elements of structure used in landscape ecology and relates them to a hierarchy of spacial scales ranging from broad to local. The importance of integrating time scales into the restoration process is also discussed.

Section 1.B: A Lateral View Across the Stream Corridor

The purpose of this and the following subsection is to introduce the types of structure found within stream corridors. The focus here is on the lateral dimension of structure, which affects the movement of water, materials, energy, and organisms from upland areas into the stream channel.

Section 1.C: A Longitudinal View Along the Stream Corridor

This section takes a longitudinal view of structure, specifically as a stream travels down the valley from headwaters to mouth. It includes discussions of channel form, sediment transport and deposition, and how biological communities have adapted to different stages of the river continuum.

1A Physical Structure and Time at Multiple Scales

A hierarchy of five *spatial scales*, which range from broad to local, is displayed in **Figure 1.2**. Each element within the scales can be viewed as an ecosystem with links to other ecosystems. These linkages are what make an ecosystem's external environment as important to proper functioning as its internal environment (Odum 1989).

Landscapes and stream corridors are ecosystems that occur at different spatial scales. Examining them as ecosystems is useful in explaining the basics of how landscapes, watersheds, stream corridors, and streams function. Many common ecosystem functions involve movement of materials (e.g., sediment and storm water runoff), energy (e.g., heating and cooling of stream waters), and organisms (e.g., movement of mammals, fish schooling, and insect swarming) between the internal and external environments (**Figure 1.3**).

The internal/external movement model becomes more complex when one considers that the external environment of a given ecosystem is a larger ecosystem. A stream ecosystem, for example, has an input/output relationship with the next higher scale, the stream corridor. This scale, in turn, interacts with the landscape scale, and so on up the hierarchy.

Similarly, because each larger-scale ecosystem contains the one beneath it, the structure and functions of the smaller ecosystem are at least part of the structure and functions of the larger. Furthermore, what is not part of the smaller ecosystem might be related to it through input or output relationships with neighboring ecosystems. Investigating relationships between structure and scale is a key first step for planning and designing stream corridor restoration.

Physical Structure

Landscape ecologists use four basic terms to define spatial structure at a particular scale (**Figure 1.4**):

- *Matrix*, the land cover that is dominant and interconnected over the majority of the land surface. Often the matrix is forest or agriculture, but theoretically it can be any land cover type.
- *Patch*, a nonlinear area (polygon) that is less abundant than, and different from, the matrix.
- *Corridor*, a special type of patch that links other patches in the matrix. Typically, a corridor is linear or elongated in shape, such as a stream corridor.
- *Mosaic*, a collection of patches, none of which are dominant enough to be interconnected throughout the landscape.

These simple structural element concepts are repeated at different spatial scales. The size of the area and the spatial resolution of one's observations determine what structural elements one is observing. For example, at the landscape scale one might see a matrix of mature forest with patches of cropland, pasture, clear-cuts, lakes, and wetlands. Looking more closely at a smaller area, one might consider an open woodland to be a series of tree crowns (the patches) against a matrix of grassy ground cover.

On a reach scale, a trout might perceive pools and well-sheltered, cool, pockets of water as preferred patches in a matrix of less desirable shallows and riffles, and the corridor along an undercut streambank might be its only way to travel safely among these habitat patches.

FAST FORWARD

Preview Chapter 2, Section E for a discussion of the six critical functions performed by stream corridor ecosystems.

Landscapes, watersheds, stream corridors, and streams are ecosystems that occur at different spatial scales.

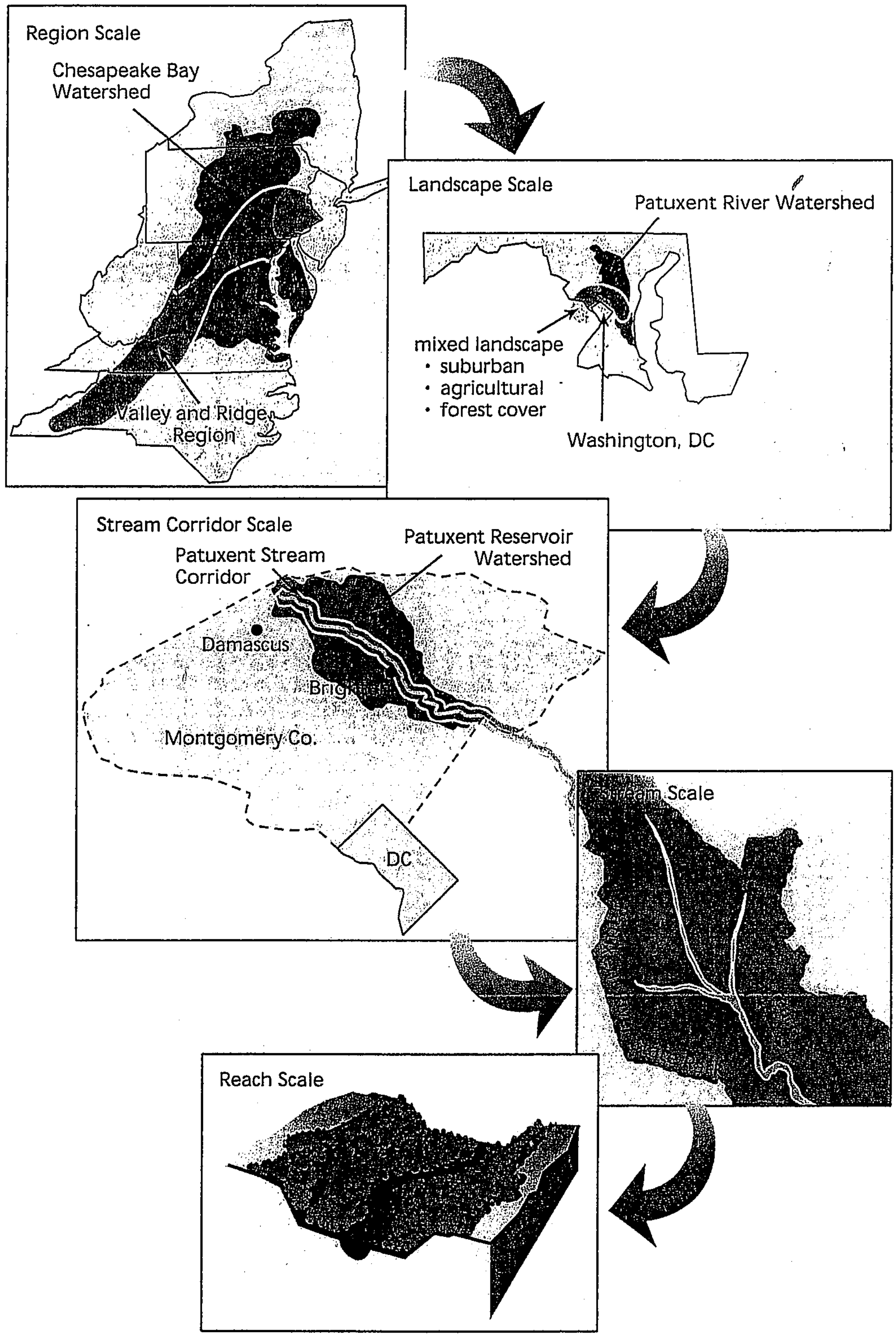

Figure 1.2: Ecosystems at multiple scales.
Stream corridor restoration can occur at any scale, from regional to reach.

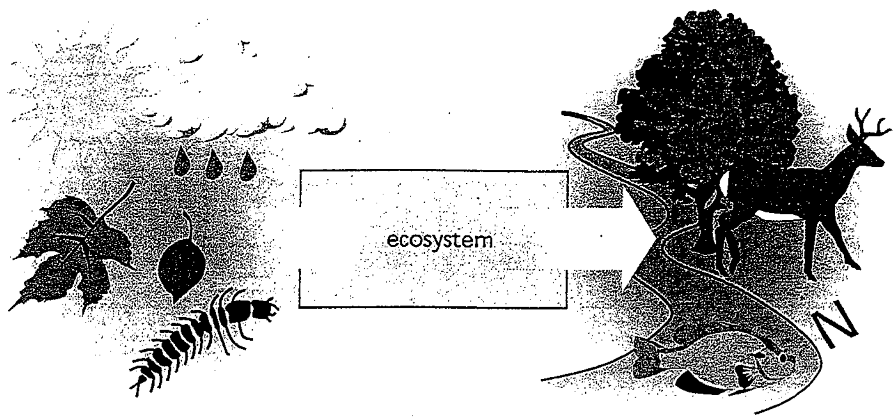

Figure 1.3: ***A simple ecosystem model.*** *Materials, energy, and organisms move from an external input environment, through the ecosystem, and into an external output environment.*

At the other extreme, the coarsest of the imaging satellites that monitor the earth's surface might detect only patches or corridors of tens of square miles in area, and matrices that seem to dominate a whole region. At all levels, the matrix-patch-corridor-mosaic model provides a useful common denominator for describing structure in the environment.

Figure 1.5 displays examples of the matrices, patches, and corridors at broad and local scales. Practitioners should always consider multiple scales when planning and designing restoration.

Structure at Scales Broader Than the Stream Corridor Scale

The landscape scale encompasses the stream corridor scale. In turn, the landscape scale is encompassed by the larger regional scale. Each scale within the hierarchy has its own characteristic structure.

The "watershed scale" is another form of spatial scale that can also encompass the stream corridor. Although watersheds occur at all scales, the term "watershed scale" is commonly used by many practitioners because many functions of the stream corridor are closely tied to drainage patterns. For this reason, the "watershed scale" is included in this discussion.

Landscape ecologists use four basic terms to define spatial structure at a particular scale—matrix, patch, corridor, and mosaic.

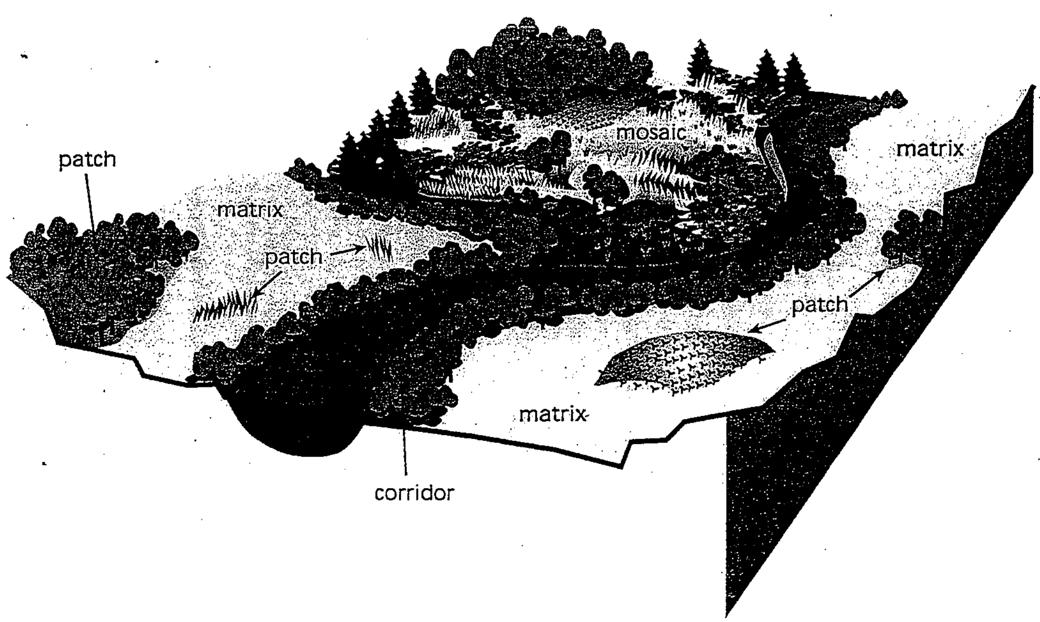

Figure 1.4: ***Spatial structure.*** *Landscapes can be described in terms of matrix, patch, corridor, and mosaic at various scales.*

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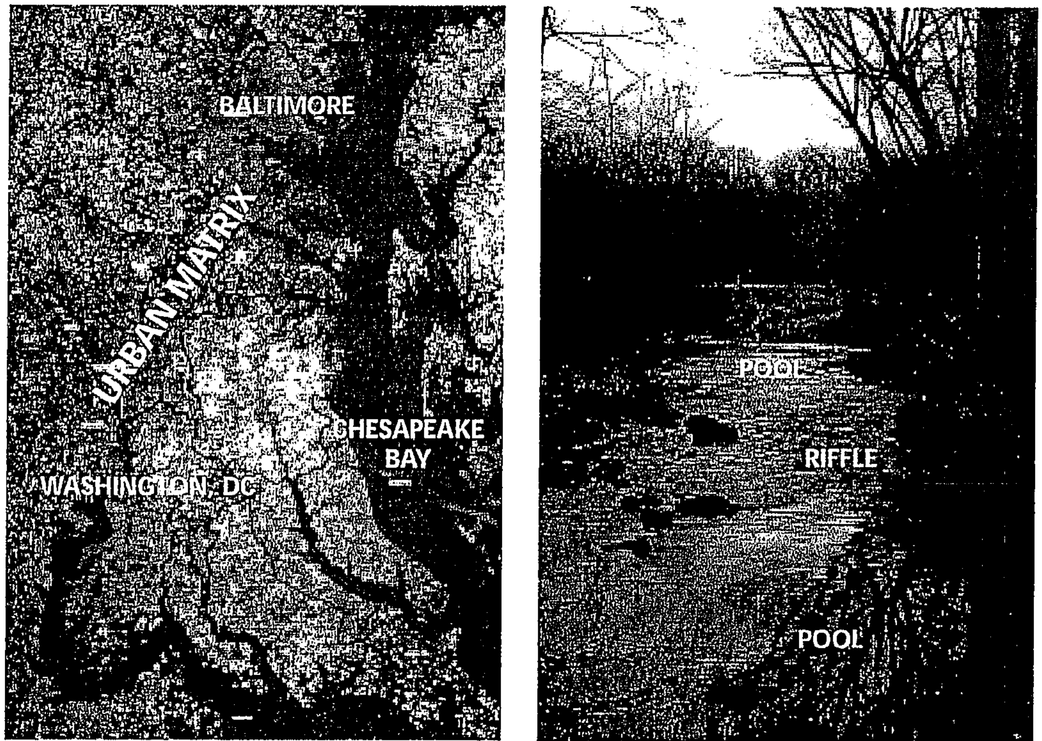


(a) (b)

Figure 1.5: Spatial structure at (a) broad and (b) local scales. Patches, corridors, and matrices are visible at the broad regional scale and the local reach scale.

ractitioners hould always onsider multi- ple scales vhen planning nd designing estoration.

Regional Scale

A *region* is a broad geographical area with a common macroclimate and sphere of human activities and interests (Forman 1995). The spatial elements found at the regional scale are called landscapes. **Figure 1.6** includes an example of the New England region with landscapes defined both by natural cover and by land use.

Matrices in the United States include:

- Deserts and arid grasslands of the arid Southwest.
- Forests of the Appalachian Mountains.
- Agricultural zones of the Midwest.

At the regional scale, patches generally include:

- Major lakes (e.g., the Great Lakes).
- Major wetlands (e.g., the Everglades).
- Major forested areas (e.g., redwood forests in the Pacific Northwest).
- Major metropolitan zones (e.g., the Baltimore-Washington, DC, metropolitan area).
- Major land use areas such as agriculture (e.g., the Corn Belt).

Corridors might include:

- Mountain ranges.
- Major river valleys.
- Interregional development along a major transportation corridor.

Most practitioners of stream corridor restoration do not usually plan and design restoration at the regional scale. The perspective is simply too broad for most projects. Regional scale is introduced here because it encompasses the scale very pertinent to stream corridor restoration—the landscape scale.

Landscape Scale

A *landscape* is a geographic area distinguished by a repeated pattern of components, which include both natural communities like forest patches and wetlands and human-altered areas like croplands and villages. Landscapes can vary in size from a few to several thousand square miles.

At the landscape scale, patches (e.g., wetlands and lakes) and corridors (e.g., stream corridors) are usually described as ecosystems. The matrix is usually identified in terms of the predominant natural vegetation community (e.g., prairie-type, forest-type, and wetland-type) or land-use-dominated ecosystem (e.g., agriculture and urban) (Figure 1.7).

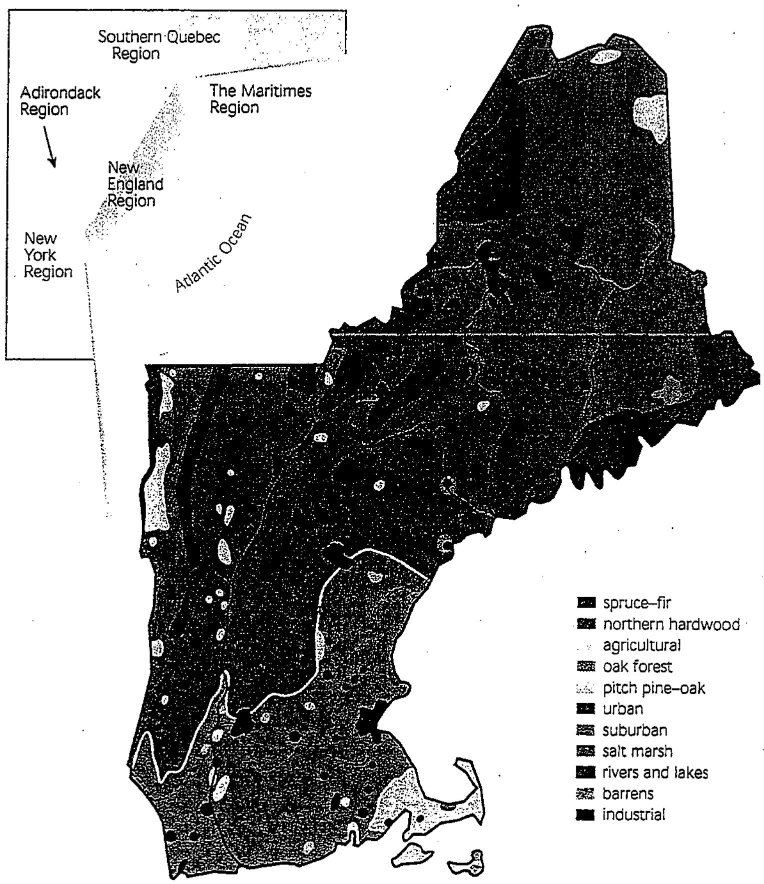
Landscapes differ from one another based on the consistent pattern formed by their structural elements, and the predominant land cover that comprises their patches, corridors, and matrices.

Examples of landscapes in the United States include:

- A highly fragmented east coast mosaic of suburban, forest, and agricultural patches.
- A north-central agricultural matrix with pothole wetlands and forest patches.
- A Sonoran desert matrix with willow-cottonwood corridors.
- A densely forested Pacific Northwest matrix with a pattern of clear-cut patches.

A landscape is a geographic area distinguished by a repeated pattern of components, which include both natural communities like forest patches and wetlands and human-altered areas like croplands and villages.

Figure 1.6: The New England region. *Structure in a region is typically a function of natural cover and land use.*
Source: Forman (1995). Reprinted with the permission of Cambridge University Press.



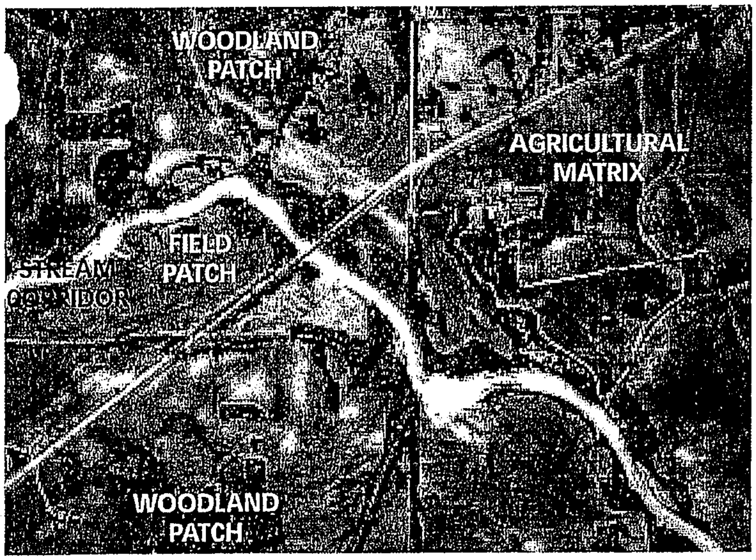


Figure 1.7: Structure at the landscape scale. *Patches and corridors are visible within an agricultural matrix.*

A woodlot within an agricultural matrix and a wetland in an urban matrix are examples of patches at the landscape scale. Corridors at this scale include ridgelines, highways, and the topic of this document—stream corridors.

At the landscape scale it is easy to perceive the stream corridor as an ecosystem with an internal environment and external environment (its surrounding landscape). Corridors play an important role at the landscape scale and at other scales. Recall that a key attribute of ecosystems is the movement of energy, materials, and organisms in, through, and out of the system. Corridors typically serve as a primary pathway for this movement. They connect patches and function as conduits between ecosystems and their external environment. Stream corridors in particular provide a heightened level of functions because of the materials and organisms found in this type of landscape linkage.

A more complete broad scale perspective of the stream corridor is achieved when watershed science is combined with landscape ecology.

Spatial structure, especially in corridors, helps dictate movement in, through, and out of the ecosystem; conversely, this movement also serves to change the structure over time. Spatial structure, as it appears at any one point in time, is therefore the end result of movement that has occurred in the past. Understanding this feedback loop between movement and structure is a key to working with ecosystems in any scale.

"Watershed Scale"

Much of the movement of material, energy, and organisms between the stream corridor and its external environments is dependent on the movement of water. Consequently, the watershed concept is a key factor for planning and designing stream corridor restoration. The term "scale," however, is incorrectly applied to watersheds.

A *watershed* is defined as an area of land that drains water, sediment, and dissolved materials to a common outlet at some point along a stream channel (Dunne and Leopold 1978). Watersheds, therefore, occur at multiple scales. They range from the largest river basins, such as the watersheds of the Mississippi, Missouri, and Columbia, to the watersheds of very small streams that measure only a few acres in size.

The term "watershed scale" (singular) is a misnomer because watersheds occur at a very wide range of scales. This document focuses primarily on the watersheds of small to medium-scale streams and rivers. Watersheds in this size range can contain all or part of a few different landscapes or can be entirely encompassed by a larger landscape.

Ecological structure within watersheds can still be described in matrix, patch, corridor, and mosaic terms, but a discussion of watershed structure is more meaningful if it also focuses on elements such as upper, middle, and lower watershed zones; drainage divides; upper and lower hillslopes; terraces, floodplains, and deltas; and features within the channel. These elements and their related functions are discussed in sections B and C of this chapter.

In short, watersheds and landscapes overlap in size range and are defined by different environmental processes. Whereas the landscape is defined primarily by terrestrial patterns of land cover that may continue across drainage divides to where the consistent pattern ends, the watershed's boundaries are based on the drainage divides themselves. Moreover, the ecological processes occurring in watersheds are more closely linked to the presence and movement of water; therefore as functioning ecosystems, watersheds also differ from landscapes.

The difference between landscape scale and "watershed scale" is precisely why practitioners should consider both when planning and designing stream corridor restoration. For decades the watershed has served as the geographic unit of choice because it requires consideration of hydrologic and geomorphic processes associated with the movement of materials, energy, and organisms into, out of, and through the stream corridor.

The exclusive use of watersheds for the broad-scale perspective of stream corridors, however, ignores the materials, energy, and organisms that move across and through landscapes independent of water drainage. Therefore, a more complete broad-scale perspective of the stream corridor is achieved when watershed science is combined with landscape ecology.

Hydrologic Unit Cataloging and Reach File/National Hydrography Dataset

The USGS developed a national framework for cataloging watersheds of different geographical scales. Each level, or scale, in the hierarchy is designated using the hydrologic unit cataloging (HUC) system. At the national level this system involves an eight-digit code that uniquely identifies four levels of classification.

The largest unit in the USGS HUC system is the water resource region. Regions are designated by the first two digits of the code. The remaining numbers are used to further define subwatersheds within the region down to the smallest scale called the cataloging unit. For example, 10240006 is the hydrologic unit code for the Little Nemaha River in Nebraska. The code is broken down as follows:

10	*Region*
1024	*Subregion*
102400	*Accounting code*
10240006	*Cataloging unit*

There are 21 regions, 222 subregions, 352 accounting units, and 2,150 cataloging units in the United States. The USGS's Hydrologic Unit Map Series documents these hierarchical watershed boundaries for each state. Some state and federal agencies have taken the restoration initiative to subdivide the cataloging unit into even smaller watersheds, extending the HUC code to 11 or 14 digits.

The Reach File/National Hydrography Dataset (RF/NHD) is a computerized database of streams, rivers, and other water bodies in the United States. It is cross-referenced with the HUC system in a geographic information system (GIS) format so users can easily identify both watersheds and the streams contained within their boundaries.

Structure at the Stream Corridor Scale

The stream corridor is a spatial element (a corridor) at the watershed and landscape scales. But as a part of the hierarchy, it has its own set of structural elements (**Figure 1.8**). Riparian (streamside) forest or shrub cover is a common matrix in stream corridors. In other areas, herbaceous vegetation might dominate a stream corridor.

Examples of patches at the stream corridor scale include both natural and human features such as:

- Wetlands.
- Forest, shrubland, or grassland patches.
- Oxbow lakes.
- Residential or commercial development.
- Islands in the channel.
- Passive recreation areas such as picnic grounds.

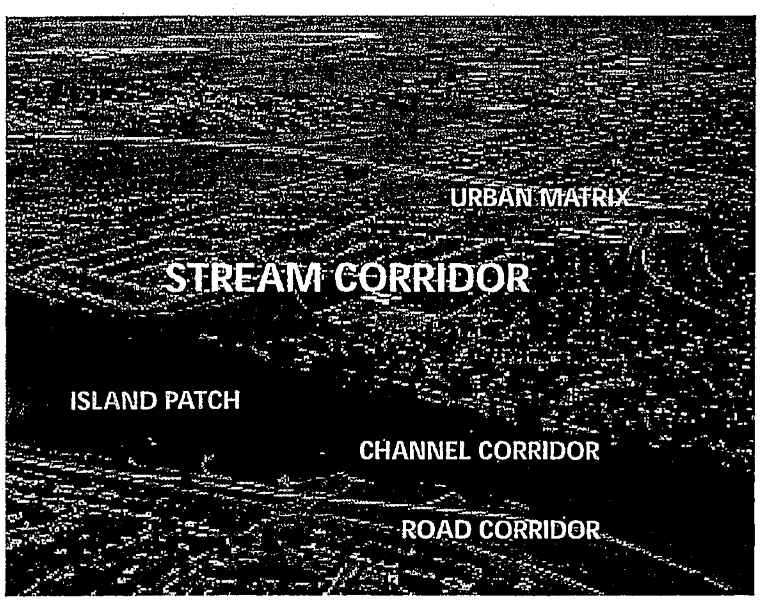


Figure 1.8: Structural elements at a stream corridor scale. *Patches, corridors, and matrix are visible within the stream corridor.*

Corridors at the stream corridor scale include two important elements—the stream channel and the plant community on either side of the stream. Other examples of corridors at this scale might include:

- Streambanks
- Floodplains
- Feeder (tributary) streams
- Trails and roads

Structure Within the Stream Corridor Scale

At the stream scale, patches, corridors, and the background matrix are defined within and near the channel and include elements of the stream itself and its low floodplains (**Figure 1.9**). At the next lower scale, the stream itself is segmented into reaches.

Reaches can be distinguished in a number of ways. Sometimes they are defined by characteristics associated with flow. High-velocity flow with rapids is obviously separable from areas with slower flow and deep, quiet pools. In other instances practitioners find it useful to define reaches based on chemical or biological factors, tributary confluences, or by some human influence that makes one part of a stream different from the next.

Examples of patches at the stream and reach scales might include:

- Riffles and pools
- Woody debris
- Aquatic plant beds
- Islands and point bars

Examples of corridors might include:

- Protected areas beneath overhanging banks.

- The thalweg, the "channel within the channel" that carries water during low-flow conditions.
- Lengths of stream defined by physical, chemical, and biological similarities or differences.
- Lengths of stream defined by human-imposed boundaries such as political borders or breaks in land use or ownership.

Temporal Scale

The final scale concept critical for the planning and design of stream corridor restoration is time.

In a sense, temporal hierarchy parallels spatial hierarchy. Just as global or regional spatial scales are usually too large to be relevant for most restoration initiatives, planning and designing restoration for broad scales of time is not usually practical. Geomorphic or climatic changes, for example, usually occur over centuries to millions of years. The goals of restoration efforts, by comparison, are usually described in time frames of years to decades.

Land use change in the watershed, for example, is one of many factors that can cause disturbances in the stream corridor. It occurs on many time scales, however, from a single year (e.g., crop rotation), to decades (e.g., urbanization), to centuries (e.g., long-term forest management). Thus, it is critical for the practitioner to consider a relevant range of time scales when involving land use issues in restoration planning and design.

Flooding is another natural process that varies both in space and through time. Spring runoff is cyclical and therefore fairly predictable. Large, hurricane-induced floods that inundate lands far beyond the channel are neither cyclical nor predictable, but still should be planned for in restoration designs. Flood specialists rank the extent of floods in temporal terms such as 10-year, 100-year, and 500-year events (10%, 1%, 0.2% chance of recurrence. See Chapter 7 *Flow Frequency Analysis* for more details.). These can serve as guidance for planning and designing restoration when flooding is an issue.

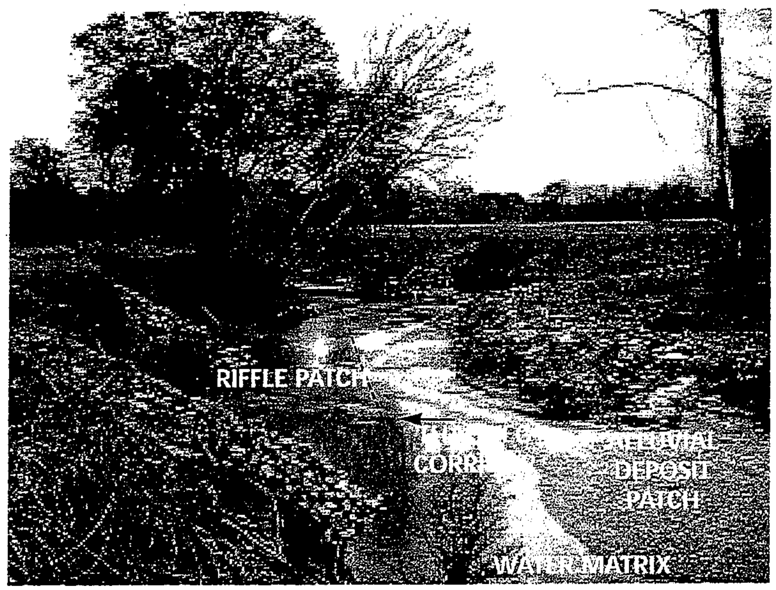


Figure 1.9: Structural elements at a stream scale. *Patches, corridors, and matrix are visible within the stream.*

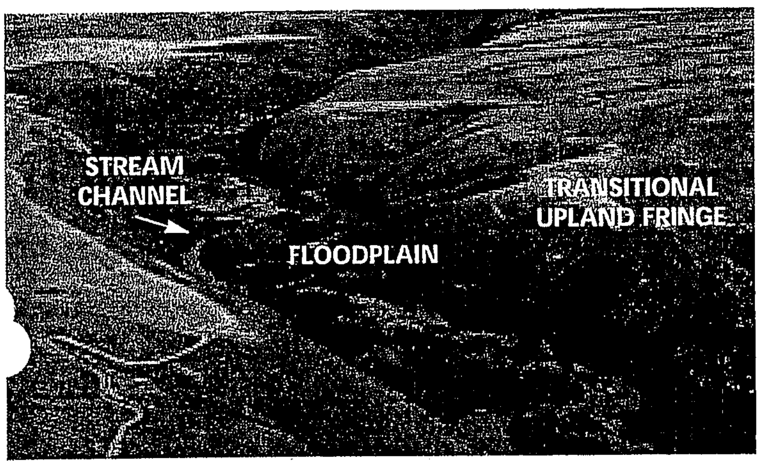
Practitioners of stream corridor restoration may need to simultaneously plan in multiple time scales. If an instream structure is planned, for example, care might be taken that (1) installation does not occur during a critical spawning period (a short-term consideration) and (2) the structure can withstand a 100-year flood (a long-term consideration). The practitioner should never try to freeze conditions as they are, at the completion of the restoration. Stream corridor restoration that works with the dynamic behavior of the stream ecosystem will more likely survive the test of time.

Stream corridor restoration that works with the dynamic behavior of the stream ecosystem will more likely survive the test of time.

1B A Lateral View Across the Stream Corridor

The previous section described how the matrix-patch-corridor-mosaic model can be applied at multiple scales to examine the relationships between the stream corridor and its external environments. This section takes a closer look at physical structure in the stream corridor itself. In particular, this section focuses on the lateral dimension. In cross section, most stream corridors have three major components (Figure 1.10):

- *Stream channel*, a channel with flowing water at least part of the year.
- *Floodplain*, a highly variable area on one or both sides of the stream channel that is inundated by floodwaters at some interval, from frequent to rare.
- *Transitional upland fringe*, a portion of the upland on one or both sides of the floodplain that serves as a transitional zone or edge between the floodplain and the surrounding landscape.



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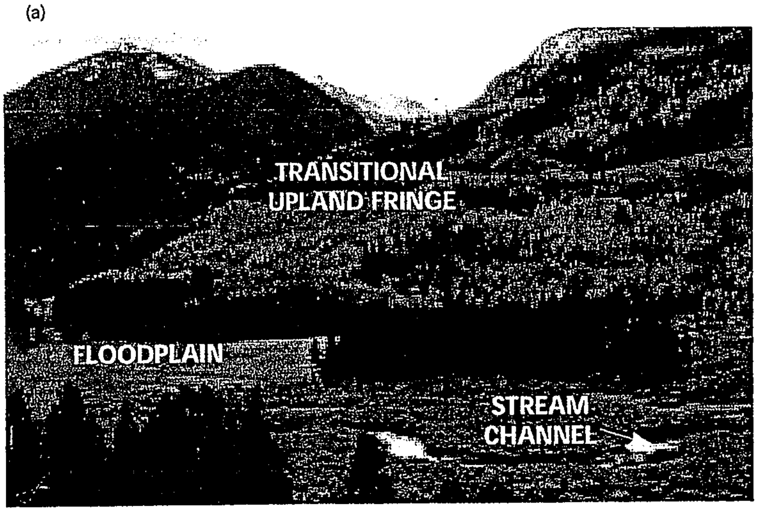

(b)

Figure 1.10: The three major components of a stream corridor in different settings (a) and (b). Even though specific features might differ by region, most stream corridors have a channel, floodplain, and transitional upland fringe.

Some common features found in the river corridor are displayed in **Figure 1.11**. In this example the floodplain is seasonally inundated and includes features such as floodplain forest, emergent marshes and wet meadows. The transitional upland fringe includes an upland forest and a hill prairie. Landforms such as natural levees, are created by processes of erosion and sedimentation, primarily during floods. The various plant communities possess unique moisture tolerances and requirements and consequently occupy distinct landforms.

Each of the three main lateral components is described in the following subsections.

Stream Channel

Nearly all channels are formed, maintained, and altered by the water and sediment they carry. Usually they are gently rounded in shape and roughly parabolic, but form can vary greatly.

Figure 1.12 presents a cross section of a typical stream channel. The sloped bank is called a *scarp*. The deepest part of the channel is called the *thalweg*. The dimensions of a channel cross section define the amount of water that can

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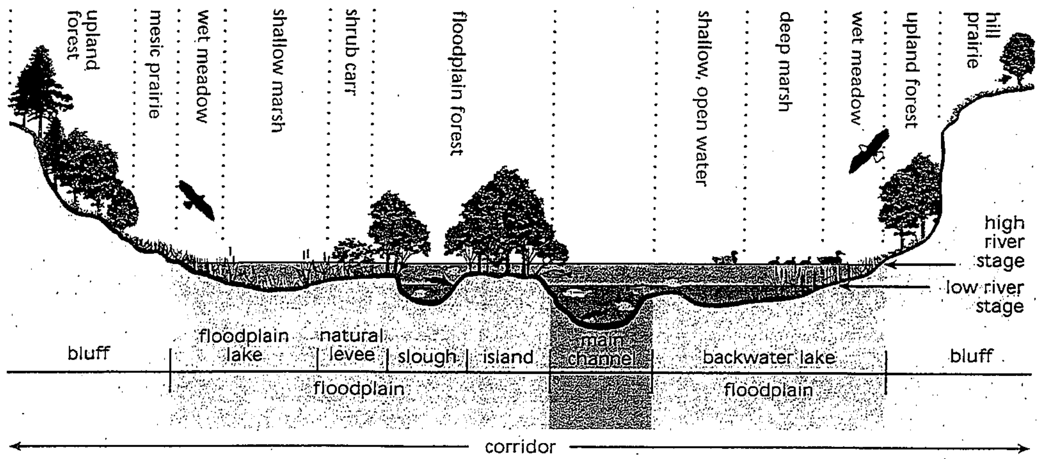


*Figure 1.11: **A cross section of a river corridor.** The three main components of the river corridor can be subdivided by structural features and plant communities. (Vertical scale and channel width are greatly exaggerated.)*

Source: Sparks, Bioscience, vol. 45, p. 170, March 1995. ©1995 American Institute of Biological Science.

pass through without spilling over the banks. Two attributes of the channel are of particular interest to practitioners, channel equilibrium and streamflow.

Lane's Alluvial Channel Equilibrium

Channel equilibirum involves the interplay of four basic factors:

- Sediment discharge (Q_s)
- Sediment particle size (D_{50})
- Streamflow (Q_w)
- Stream slope (S)

Lane (1955) showed this relationship qualitatively as:

$$Q_s \cdot D_{50} \propto Q_w \cdot S$$

This equation is shown here as a balance with sediment load on one weighing pan and streamflow on the other (**Figure 1.13**). The hook holding the sediment pan can slide along the horizontal arm according to sediment size. The hook holding the streamflow side slides according to stream slope.

Channel equilibrium occurs when all four variables are in balance. If a change occurs, the balance will temporarily be tipped and equilibrium lost. If one variable changes, one or more of the other variables must increase or decrease proportionally if equilibrium is to be maintained. For example, if slope is increased and streamflow remains the same, either the sediment load or the size of the particles must also increase. Likewise, if flow is increased (e.g., by an interbasin transfer) and the slope stays the same, sediment load or sediment particle size has to increase to maintain channel equilibrium. A stream seeking a new equilibrium tends to erode more sediment and of larger particle size.

Alluvial streams that are free to adjust to changes in these four variables generally do so and reestablish new equilibrium conditions. Non-alluvial streams such as bedrock or artificial, concrete channels are unable to follow Lane's relationship because of their inability to

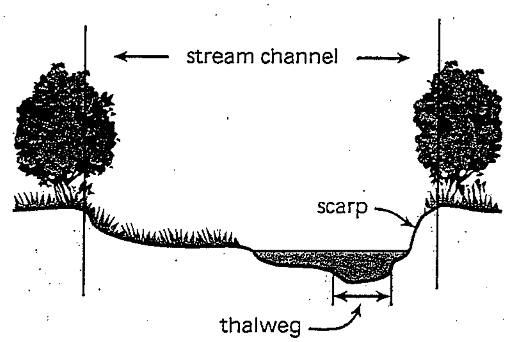


*Figure 1.12: **Cross section of a stream channel.** The scarp is the sloped bank and the thalweg is the lowest part of the channel.*

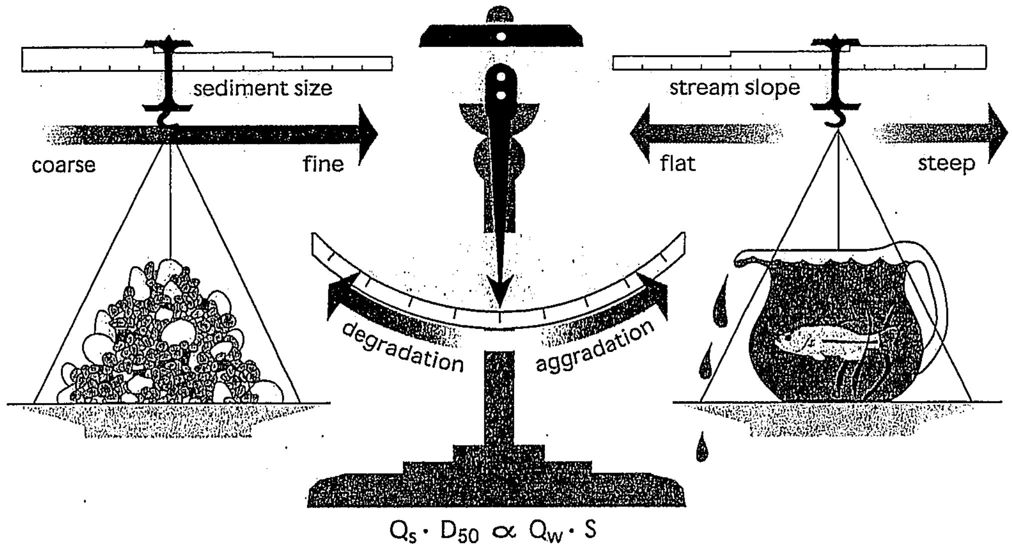


Figure 1.13: ***Factors affecting channel equilibrium.*** *At equilibrium, slope and flow balance the size and quantity of sediment particles the stream moves.*

Source: Rosgen (1996), from Lane, ***Proceedings***, 1955. Published with the permission of American Society of Civil Engineers.

FAST FORWARD

Preview Chapter 2, Section B for more discussion on the stream balance equation. Preview Chapter 7, Section B for nformation on measuring and analyzing these variables and the use of sediment transport equations.

adjust the sediment size and quantity variables.

The stream balance equation is useful for making qualitative predictions concerning channel impacts due to changes in runoff or sediment loads from the watershed. Quantitative predictions, however, require the use of more complex equations.

Sediment transport equations, for example, are used to compare sediment load and energy in the stream. If excess energy is left over after the load is moved, channel adjustment occurs as the stream picks up more load by eroding its banks or scouring its bed. No matter how much complexity is built into these and other equations of this type, however, they all relate back to the basic balance relationships described by Lane.

Streamflow

A distinguishing feature of the channel is streamflow. As part of the water cycle, the ultimate source of all flow is precipitation. The pathways precipitation takes after it falls to earth, however, affect many aspects of streamflow including its quantity, quality, and timing. Practitioners usually find it useful to divide flow into components based on these pathways.

The two basic components are:

- *Stormflow*, precipitation that reaches the channel over a short time frame through overland or underground routes.
- *Baseflow*, precipitation that percolates to the ground water and moves slowly through substrate before reaching the channel. It sustains streamflow during periods of little or no precipitation.

Streamflow at any one time might consist of water from one or both sources. If neither source provides water to the channel, the stream goes dry.

A *storm hydrograph* is a tool used to show how the discharge changes with time (**Figure 1.14**). The portion of the hydrograph that lies to the left of the peak is called the *rising limb*, which shows how long it takes the stream to peak following a precipitation event. The portion of the curve to the right of the peak is called the *recession limb*.

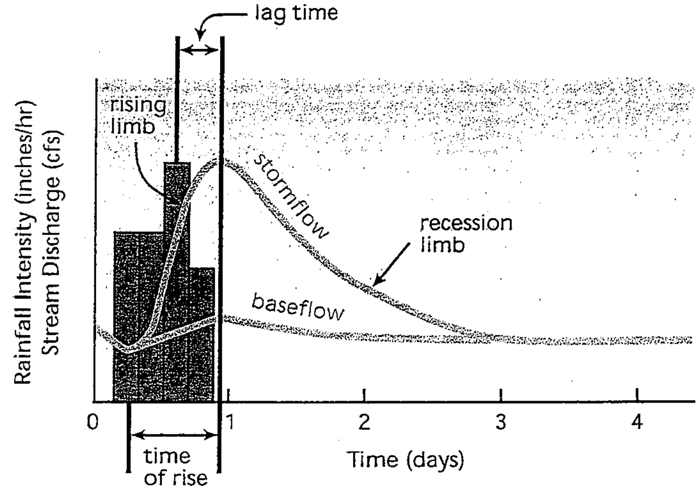


Figure 1.14: A storm hydrograph. *A hydrograph shows how long a stream takes to rise from baseflow to maximum discharge and then return to baseflow conditions.*

Channel and Ground Water Relationships

Interactions between ground water and the channel vary throughout the watershed. In general, the connection is strongest in streams with gravel riverbeds in well-developed alluvial floodplains.

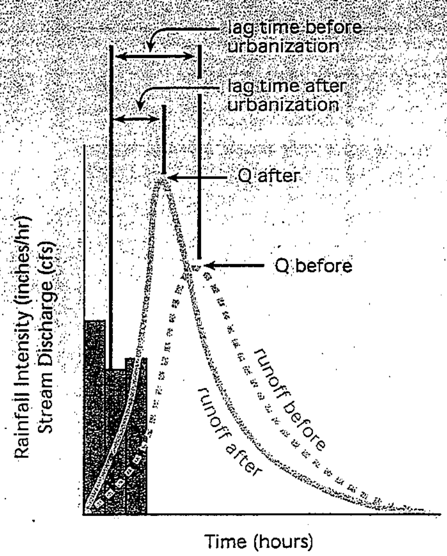


Figure 1.15: A comparison of hydrographs before and after urbanization. *The discharge curve is higher and steeper for urban streams than for natural streams.*

Change in Hydrology After Urbanization

The hydrology of urban streams changes as sites are cleared and natural vegetation is replaced by impervious cover such as rooftops, roadways, parking lots, sidewalks, and driveways. One of the consequences is that more of a stream's annual flow is delivered as storm water runoff rather than baseflow. Depending on the degree of watershed impervious cover, the annual volume of storm water runoff can increase by up to 16 times that for natural areas (Schueler 1995). In addition, since impervious cover prevents rainfall from infiltrating into the soil, less flow is available to recharge ground water. Therefore, during extended periods without rainfall, baseflow levels are often reduced in urban streams (Simmons and Reynolds 1982).

*Storm runoff moves more rapidly over smooth, hard pavement than over natural vegetation. As a result, the rising limbs of storm hydrographs become steeper and higher in urbanizing areas (**Figure 1.15**). Recession limbs also decline more steeply in urban streams.*

Figure 1.16 presents two types of water movement:

- *Influent or "losing" reaches* lose stream water to the aquifer.
- *Effluent or "gaining" reaches* receive discharges from the aquifer.

Practitioners categorize streams based on the balance and timing of the stormflow and baseflow components. There are three main categories:

- *Ephemeral streams* flow only during or immediately after periods of precipitation. They generally flow less than 30 days per year (**Figure 1.17**).
- *Intermittent streams* flow only during certain times of the year. Seasonal flow in an intermittent stream usually lasts longer than 30 days per year.
- *Perennial streams* flow continuously during both wet and dry times. Baseflow is dependably generated from the movement of ground water into the channel.

Discharge Regime

Discharge is the term used to describe the volume of water moving down the channel per unit time (**Figure 1.18**). The basic unit of measurement used in the United States to describe discharge is cubic foot per second (cfs).

Figure 1.17: An ephemeral stream. *Ephemeral streams flow only during or immediately after periods of precipitation.*

Discharge is calculated as:

$$Q = A\,V$$

where:

Q = Discharge (cfs)

A = Area through which the water is flowing in square feet

V = Average velocity in the downstream direction in feet per second

As discussed earlier in this section, streamflow is one of the variables that determine the size and shape of the channel. There are three types of characteristic discharges:

- *Channel-forming (or dominant) discharge.* If the streamflow were held constant at the channel-forming

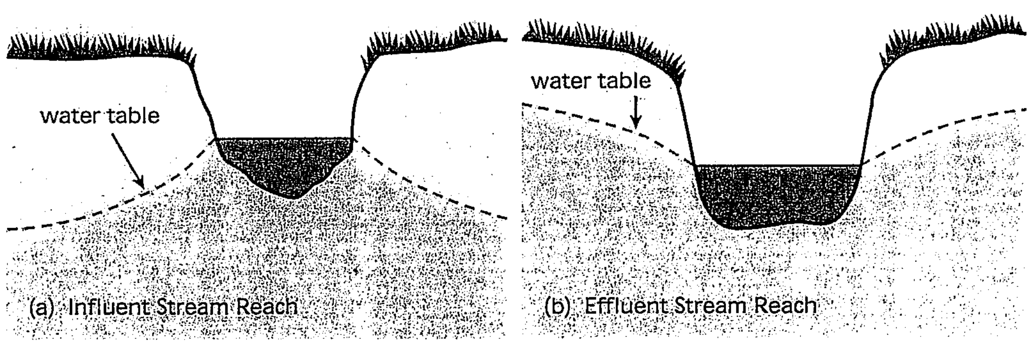
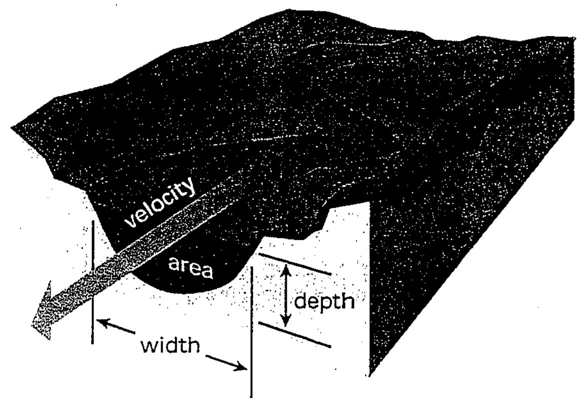


Figure 1.16: Cross sections of (a) influent and (b) effluent stream reaches. *Influent or "losing" reaches lose stream water to the aquifer. Effluent or "gaining" reaches receive discharges from the aquifer.*

discharge, it would result in channel morphology close to the existing channel. However, there is no method for directly calculating channel-forming discharge.

An estimate of channel-forming discharge for a particular stream reach can, with some qualifications, be related to depth, width, and shape of channel. Although channel-forming discharges are strictly applicable only to channels in equilibrium, the concept can be used to select appropriate channel geometry for restoring a disturbed reach.



- *Effective discharge.* The effective discharge is the calculated measure of channel-forming discharge. Computation of effective discharge requires long-term water and sediment measurements, either for the stream in question or for one very similar.

  Since this type of data is not often available for stream restoration sites, modeled or computed data are sometimes substituted. Effective discharge can be computed for either stable or evolving channels.

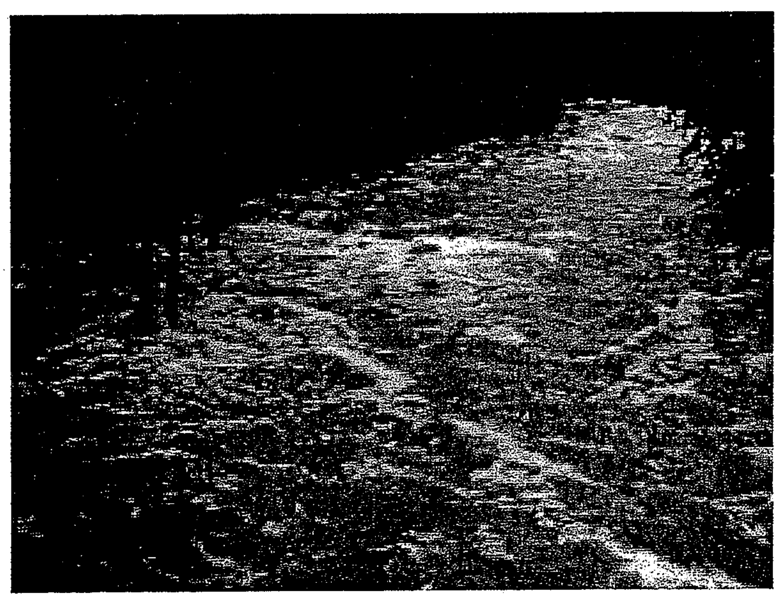
Bankfull discharge. This discharge occurs when water just begins to leave the channel and spread onto the floodplain (Figure 1.19). Bankfull discharge is equivalent to channel-forming (conceptual) and effective (calculated) discharge.

Channel-Forming Discharge

To envision the concept of channel-forming discharge, imagine placing a water hose discharging at constant rate in a freshly tilled garden. Eventually, a small channel will form and reach an equilibrium geometry.

At a larger scale, consider a newly constructed floodwater- retarding reservoir that slowly releases stored floodwater at a constant flow rate. This flow becomes the new channel-forming discharge and will alter channel morphology until the channel reaches equilibrium.

Figure 1.19: Bankfull discharge. This is the flow at which water begins to leave the channel and move onto the floodplain.



Preview Chapter 7, Section B for a discussion of calculating effective discharge. This computation should be performed by a professional with a good background in hydrology, hydraulics, and sediment transport.

Floodplain

The floor of most stream valleys is relatively flat. This is because over time the stream moves back and forth across the valley floor in a process called lateral migration. In addition, periodic flooding causes sediments to move longitudinally and to be deposited on the valley floor near the channel. These two processes continually modify the floodplain.

Through time the channel reworks the entire valley floor. As the channel migrates, it maintains the same average size and shape if conditions upstream remain constant and the channel stays in equilibrium.

Two types of floodplains may be defined (**Figure 1.20**):

- *Hydrologic floodplain*, the land adjacent to the baseflow channel residing below bankfull elevation. It is inundated about two years out of three. Not every stream corridor has a hydrologic floodplain.
- *Topographic floodplain*, the land adjacent to the channel including the hydrologic floodplain and other lands up to an elevation based on the elevation reached by a flood peak of a given frequency (for example, the 100-year floodplain).

Professionals involved with flooding issues define the boundaries of a floodplain in terms of flood frequencies. Thus, 100-year and 500-year floodplains are commonly used in the development of planning and regulation standards.

Flood Storage

The floodplain provides temporary storage space for floodwaters and sediment produced by the watershed. This attribute serves to add to the *lag time* of a flood—the time between the middle of the rainfall event and the runoff peak.

If a stream's capacity for moving water and sediment is diminished, or if the sediment loads produced from the watershed become too great for the stream to transport, flooding will occur more frequently and the valley floor will begin to fill. Valley filling results in the temporary storage of sediment produced by the watershed.

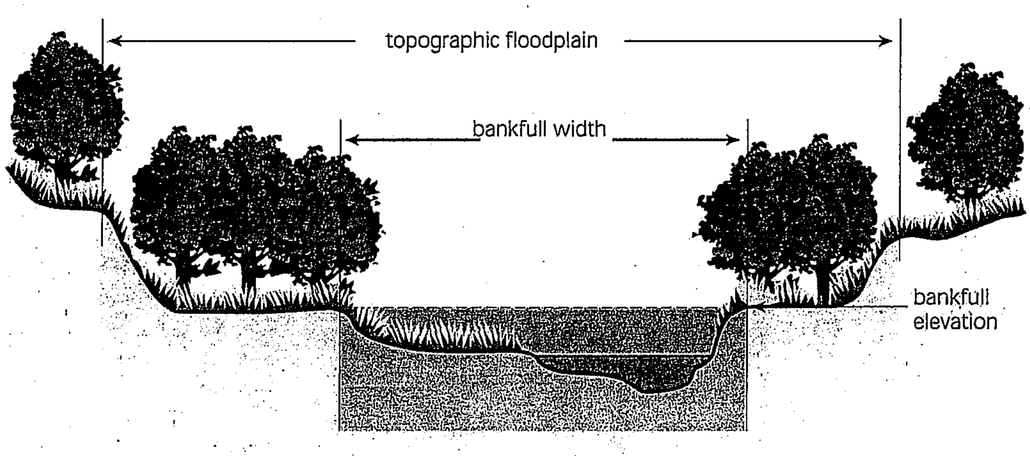


__Figure 1.20: Hydrologic and topographic floodplains.__ The hydrologic floodplain is defined by bankfull elevation. The topographic floodplain includes the hydrologic floodplain and other lands up to a defined elevation.

Landforms and Deposits

Topographic features are formed on the floodplain by the lateral migration of the channel (**Figure 1.21**). These features result in varying soil and moisture conditions and provide a variety of habitat niches that support plant and animal diversity.

Floodplain landforms and deposits include:

- *Meander scroll*, a sediment formation marking former channel locations.
- *Chute*, a new channel formed across the base of a meander. As it grows in size, it carries more of the flow.
- *Oxbow*, a term used to describe the severed meander after a chute is formed.
- *Clay plug*, a soil deposit developed at the intersection of the oxbow and the new main channel.
- *Oxbow lake*, a body of water created after clay plugs the oxbow from the main channel.
- *Natural levees*, formations built up along the bank of some streams that flood. As sediment-laden water spills over the bank, the sudden loss of depth and velocity causes coarser-sized sediment to drop out of suspension and collect along the edge of the stream.
- *Splays*, delta-shaped deposits of coarser sediments that occur when a natural levee is breached. Natural levees and splays can prevent floodwaters from returning to the channel when floodwaters recede.
- *Backswamps*, a term used to describe floodplain wetlands formed by natural levees.

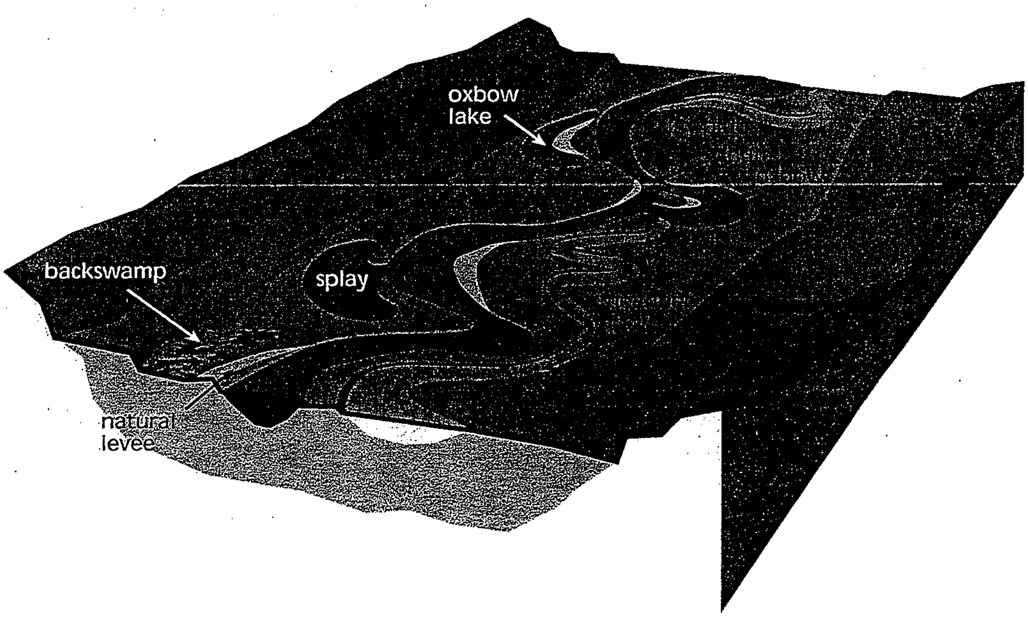


Figure 1.21: Landforms and deposits of a floodplain. *Topographic features on the floodplain caused by meandering streams.*

Transitional Upland Fringe

The transitional upland fringe serves as a transitional zone between the floodplain and surrounding landscape. Thus, its outside boundary is also the outside boundary of the stream corridor itself.

While stream-related hydrologic and geomorphic processes might have formed a portion of the transitional upland fringe in geologic times, they are not responsible for maintaining or altering its present form. Consequently, land use activities have the greatest potential to impact this component of the stream corridor.

There is no typical cross section for this component. Transitional upland fringes can be flat, sloping, or in some cases, nearly vertical (**Figure 1.22**). They can incorporate features such as hillslopes, bluffs, forests, and prairies, often modified by land use. All transitional upland fringes have one common attribute, however: they are distinguishable from the surrounding landscape by their greater connection to the floodplain and stream.

An examination of the floodplain side of the transitional upland fringe often reveals one or more benches. These landforms are called *terraces* (**Figure 1.23**). They are formed in response to new patterns of streamflow, changes in sediment size or load, or changes in watershed base level—the elevation at the watershed outlet.

Terrace formation can be explained using the aforementioned stream balance equation (Figure 1.13). When one or more variables change, equilibrium is lost, and either degradation or aggradation occurs.

Figure 1.24 presents an example of terrace formation by channel incision. Cross section A represents a nonincised channel. Due to changes in streamflow or sediment delivery, equilibrium is lost

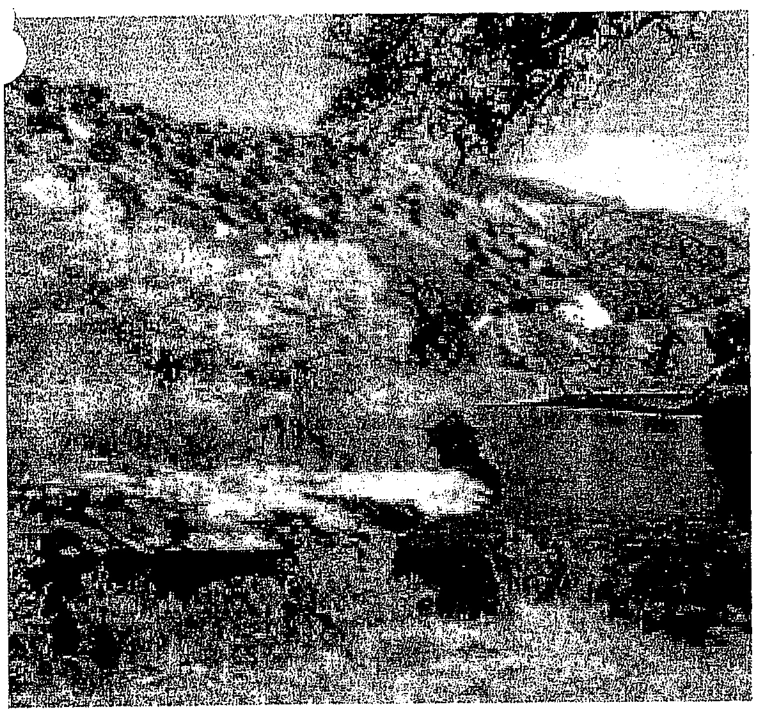


__Figure 1.22: Transitional upland fringe.__ This component of the stream corridor is a transition zone between the floodplain and the surrounding landscape.

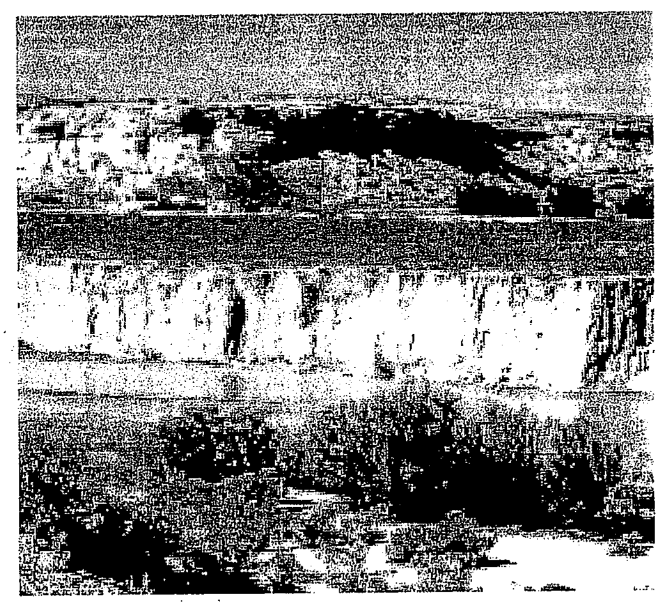


__Figure 1.23: Terraces formed by an incising stream.__ Terraces are formed in response to new patterns of streamflow or sediment load in the watershed.

and the channel degrades and widens. The original floodplain is abandoned and becomes a terrace (cross section B). The widening phase is completed when a floodplain evolves within the widened channel (cross section C).

Geomorphologists often classify landscapes by numbering surfaces from the lowest surface up to the highest surface. Surface 1 in most landscapes is the bottom of the main channel. The next highest surface, Surface 2, is the floodplain. In the case of an incising stream, Surface 3 usually is the most recently formed terrace, Surface 4 the next older terrace, and so on. The numbering system thus reflects the ages of the surfaces. The higher the number, the older the surface.

Boundaries between the numbered surfaces are usually marked by a scarp, or relatively steep surface. The scarp between a terrace and a floodplain is especially important because it helps confine floods to the valley floor. Flooding occurs much less frequently, if at all, on terraces.

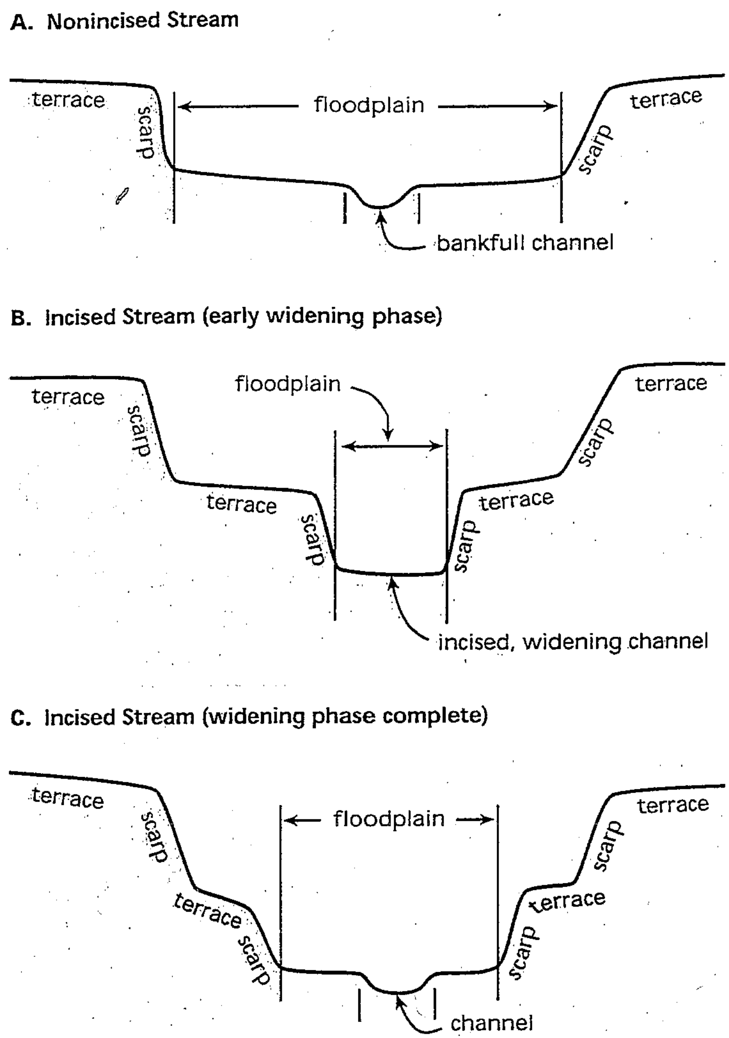


*Figure 1.24: **Terraces in (A) nonincised and (B and C) incised streams.** Terraces are abandoned floodplains, formed through the interplay of incising and floodplain widening.*

Vegetation Across the Stream Corridor

Vegetation is an important and highly variable element in the stream corridor. In some minimally disturbed stream corridors, a series of plant communities might extend uninterrupted across the entire corridor. The distribution of these communities would be based on different hydrologic and soil conditions. In smaller streams the riparian vegetation might even form a canopy and enclose the channel. This and other configuration possibilities are displayed in Figure 1.25.

Plant communities play a significant role in determining stream corridor condition, vulnerability, and potential for (or lack of) restoration. Thus, the type, extent and distribution, soil moisture preferences, elevation, species composition, age, vigor, and rooting depth are all important characteristics that a practitioner must consider when planning and designing stream corridor restoration.

Preview Chapter 2, Section D for more information on plant community characteristics.

Flood-Pulse Concept

Floodplains serve as essential focal points for the growth of many riparian

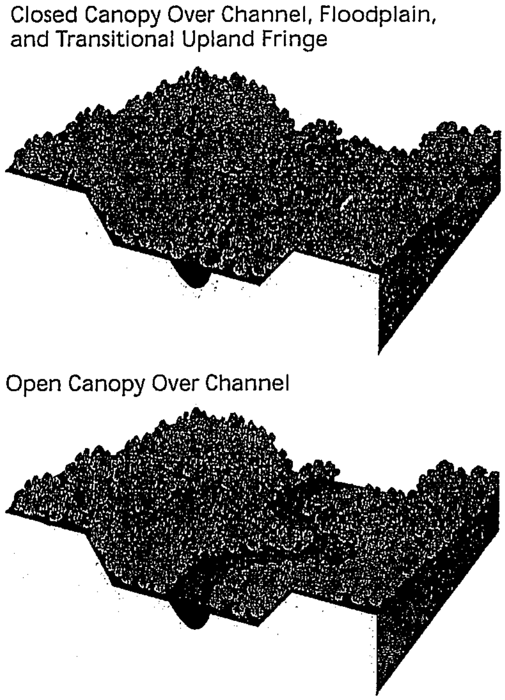


Figure 1.25: Examples of vegetation structure in the stream corridor. *Plant communities play a significant role in determining the condition and vulnerability of the stream corridor.*

plant communities and the wildlife they support. Some riparian plant species such as willows and cottonwoods depend on flooding for regeneration. Flooding also nourishes floodplains with sediments and nutrients and provides habitat for invertebrate communities, amphibians, reptiles, and fish spawning.

The flood-pulse concept was developed to summarize how the dynamic interaction between water and land is exploited by the riverine and floodplain biota (**Figure 1.26**). Applicable primarily on larger rivers, the concept demonstrates that the predictable advance and retraction of water on the floodplain in a natural setting enhances biological productivity and maintains diversity (Bayley 1995).

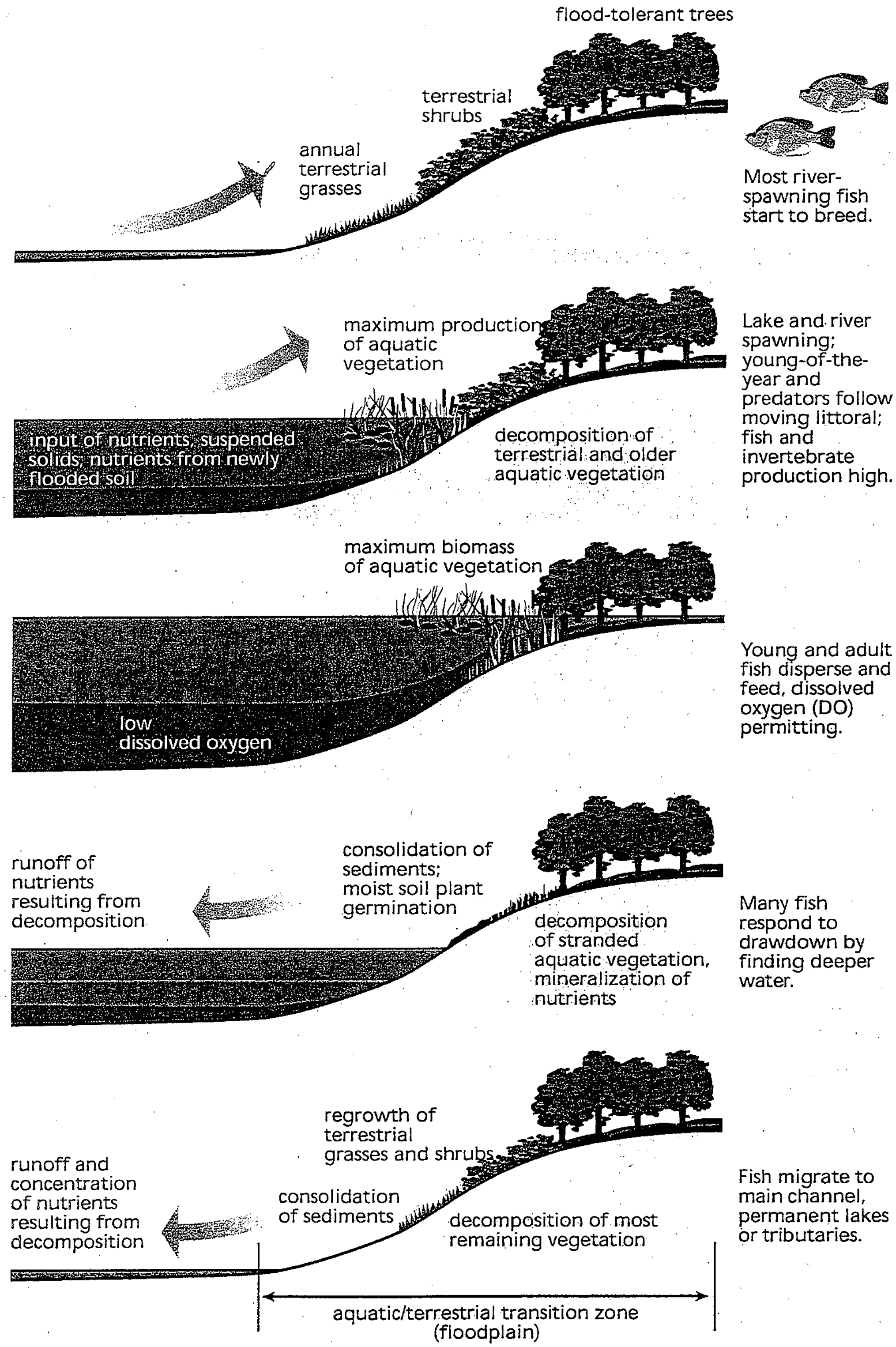


Figure 1.26: Schematic of the flood-pulse concept. *A vertically exaggerated section of a floodplain in five snapshots of an annual hydrological cycle. The left column describes the movement of nutrients. The right column describes typical life history traits of fish.*
Source: Bayley, ***Bioscience***, vol. 45, p.154, March 1995. ©1995 American Institute of Biological Science.

1C A Longitudinal View Along the Stream Corridor

The processes that develop the characteristic structure seen in the lateral view of a stream corridor also influence structure in the longitudinal view. Channel width and depth increase downstream due to increasing drainage area and discharge. Related structural changes also occur in the channel, floodplain, and transitional upland fringe, and in processes such as erosion and deposition. Even among different types of streams, a common sequence of structural changes is observable from headwaters to mouth.

Longitudinal Zones

The overall longitudinal profile of most streams can be roughly divided into three zones (Schumm 1977). Some of the changes in the zones are characterized in **Figures 1.27** and **1.28**.

Zone 1, or headwaters, often has the steepest gradient. Sediment erodes from slopes of the watershed and moves downstream. Zone 2, the transfer zone, receives some of the eroded material. It is usually characterized by wide floodplains and meandering channel patterns. The gradient flattens in Zone 3, the primary depositional zone. Though the figure displays headwaters as mountain streams, these general patterns and changes are also often applicable to watersheds with relatively small topographic relief from the headwaters to mouth. It is important to note that erosion, transfer, and deposition occur in all zones, but the zone concept focuses on the most dominant process.

Watershed Forms

All watersheds share a common definition: a *watershed* is an "area of land that

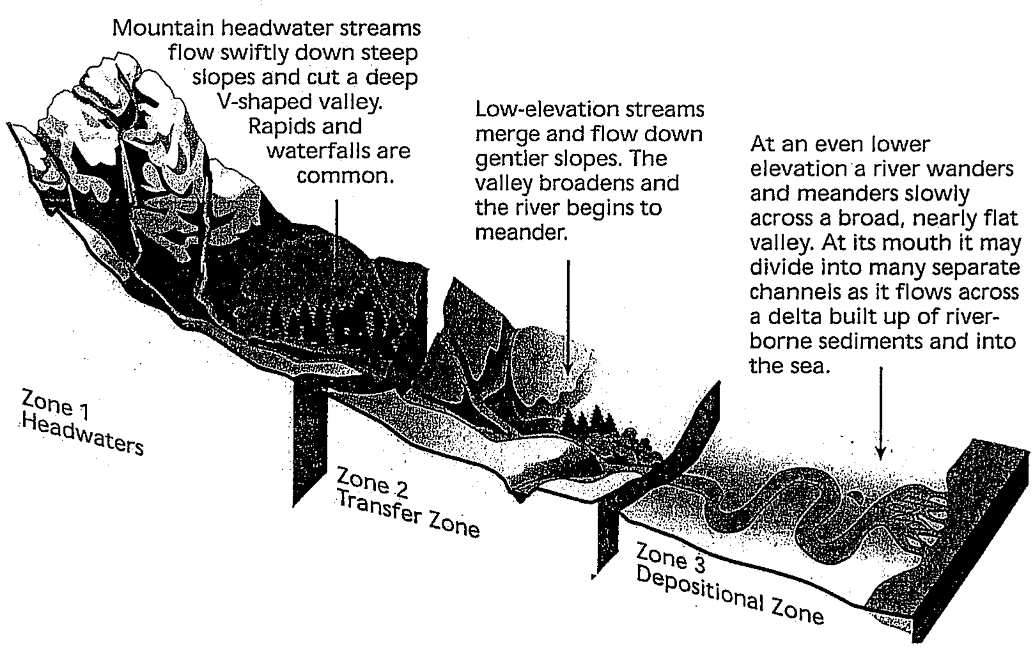


Figure 1.27: Three longitudinal profile zones. *Channel and floodplain characteristics change as rivers travel from headwaters to mouth.*
Source: Miller (1990). ©1990 Wadsworth Publishing Co.

drains water, sediment, and dissolved materials to a common outlet at some point along a stream channel" (Dunne and Leopold 1978). Form varies greatly, however, and is tied to many factors including climatic regime, underlying geology, morphology, soils, and vegetation.

Drainage Patterns

One distinctive aspect of a watershed when observed in planform (map view) is its drainage pattern (Figure 1.29). Drainage patterns are primarily controlled by the overall topography and underlying geologic structure of the watershed.

Stream Ordering

A method of classifying, or ordering, the hierarchy of natural channels within a watershed was developed by Horton (1945). Several modifications of the original stream ordering scheme have

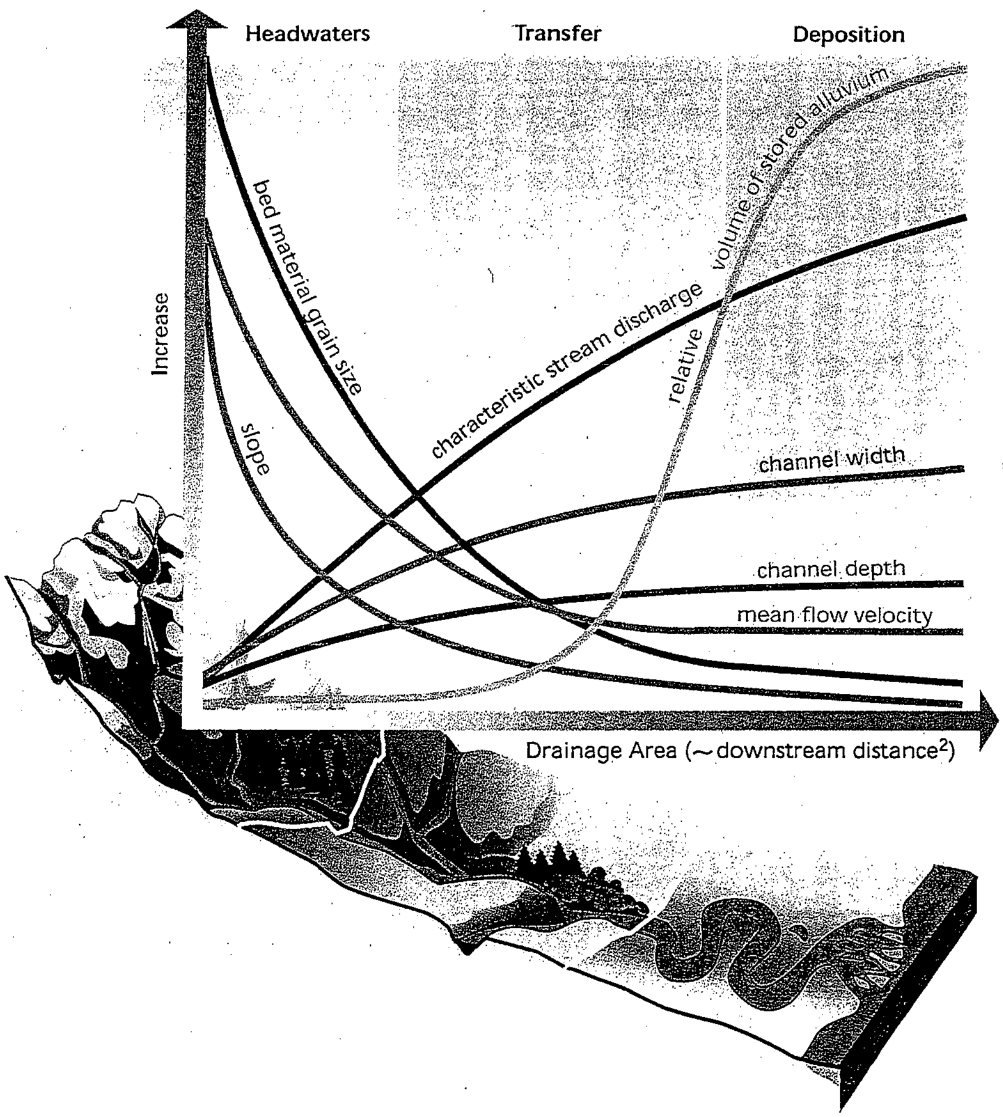


Figure 1.28: ***Changes in the channel in the three zones.*** *Flow, channel size, and sediment characteristics change throughout the longitudinal profile.*

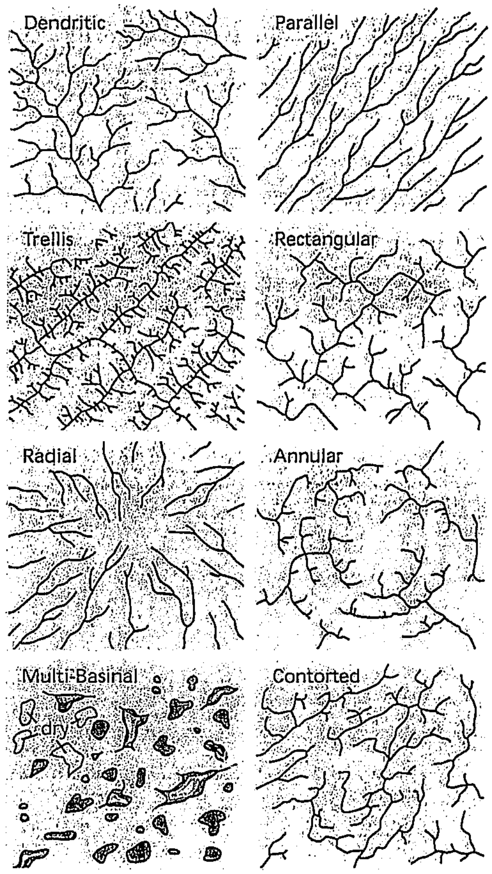


Figure 1.29: Watershed drainage patterns. Patterns are determined by topography and geologic structure.
Source: A.D. Howard, AAPG © 1967, reprinted by permission of the American Association of Petroleum Geologists.

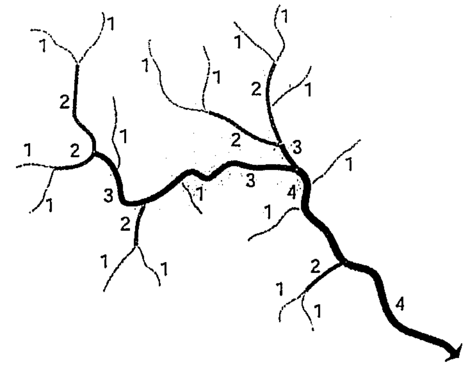


Figure 1.30: Stream ordering in a drainage network. *Stream ordering is a method of classifying the hierarchy of natural channels in a watershed.*

been proposed, but the modified system of Strahler (1957) is probably the most popular today.

Strahler's stream ordering system is portrayed in **Figure 1.30**. The uppermost channels in a drainage network (i.e., headwater channels with no upstream tributaries) are designated as first-order streams down to their first confluence. A second-order stream is formed below the confluence of two first-order channels. Third-order streams are created when two second-order channels join, and so on. Note in the figure that the intersection of a channel with another channel of lower order does not raise the order of the stream below the intersection (e.g., a fourth-order stream intersecting with a second-order stream is still a fourth-order stream below the intersection).

Within a given drainage basin, stream order correlates well with other basin parameters, such as drainage area or channel length. Consequently, knowing what order a stream is can provide clues concerning other characteristics such as which longitudinal zone it resides in and relative channel size and depth.

Channel Form

The form of the channel can change as it moves through the three longitudinal zones. Channel form is typically described by two characteristics—thread (single or multiple) and sinuosity.

Single- and Multiple-Thread Streams

Single-thread (one-channel) streams are most common, but multiple-thread streams occur in some landscapes (**Figure 1.31**). Multiple-thread streams are further categorized as either braided or anastomosed streams.

Three conditions tend to promote the formation of braided streams:

- Erodible banks.
- An abundance of coarse sediment.
- Rapid and frequent variations in discharge.

Braided streams typically get their start when a central sediment bar begins to form in a channel due to reduced streamflow or an increase in sediment load. The central bar causes water to flow into the two smaller cross sections on either side. The smaller cross section results in a higher velocity flow. Given erodible banks, this causes the channels to widen. As they do this, flow velocity decreases, which allows another central bar to form. The process is then repeated and more channels are created.

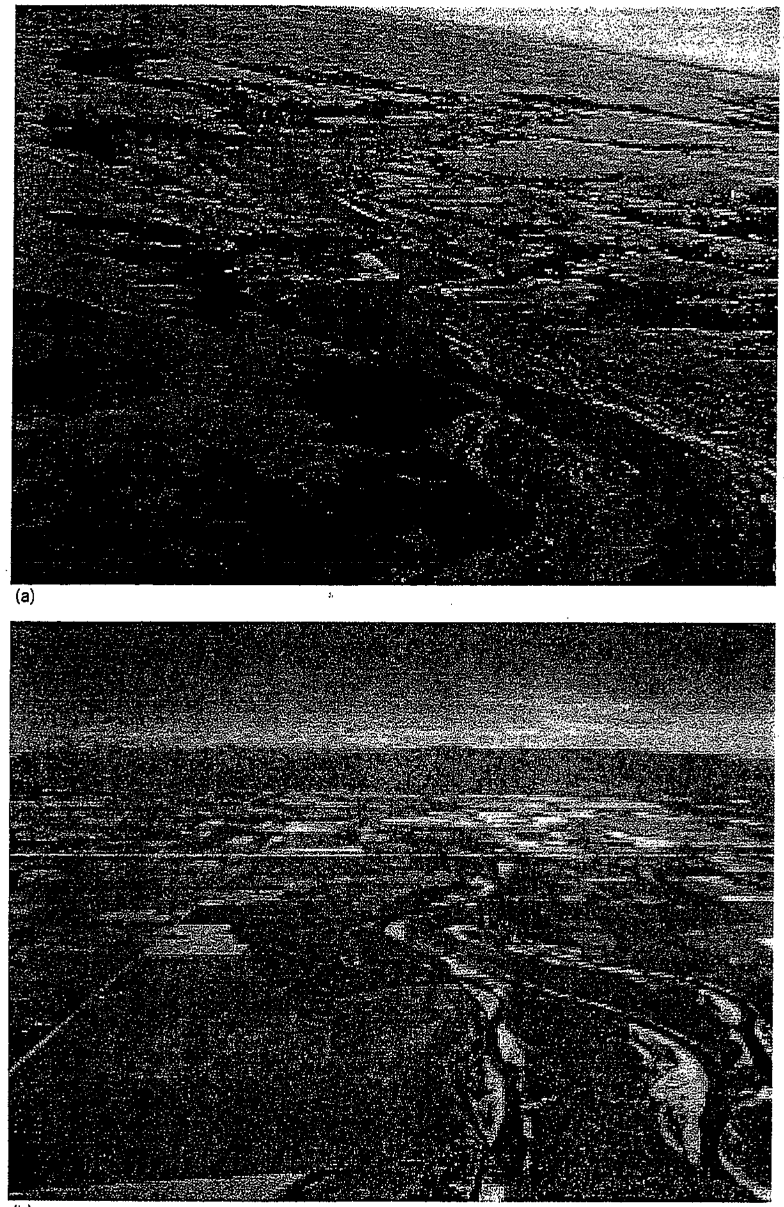
In landscapes where braided streams occur naturally, the plant and animal communities have adapted to frequent and rapid changes in the channel and riparian area. In cases where disturbances trigger the braiding process, however, physical conditions might be too dynamic for many species.

The second, less common category of multiple-thread channels is called *anastomosed streams*. They occur on much flatter gradients than braided streams and have channels that are narrow and deep (as opposed to the wide, shallow channels found in braided streams). Their banks are typically made up of fine, cohesive sediments, making them relatively erosion-resistant.

Anastomosed streams form when the downstream base level rises, causing a rapid buildup of sediment. Since bank materials are not easily erodible, the original single-thread stream breaks up into multiple channels. Streams entering deltas in a lake or bay are often anastomosed. Streams on alluvial fans, in contrast, can be braided or anastomosed.

Sinuosity

Natural channels are rarely straight. Sinuosity is a term indicating the amount of curvature in the channel (**Figure 1.32**). The *sinuosity* of a reach is computed by dividing the channel

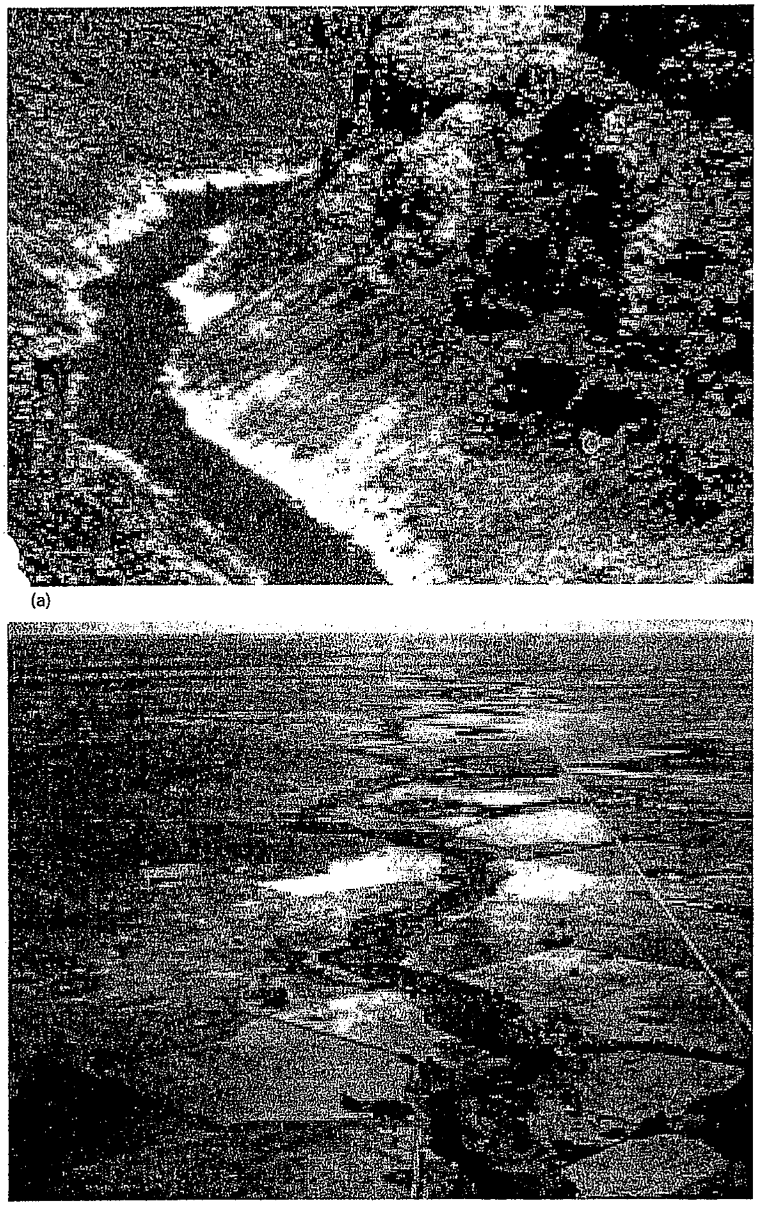


(a) (b)

Figure 1.31: (a) Single-thread and (b) braided streams. *Single-thread streams are most common. Braided streams are uncommon and usually formed in response to erodible banks, an abundance of coarse sediment, and rapid and frequent variations in discharge.*

centerline length by the length of the valley centerline. If the channel length/valley length ratio is more than about 1.3, the stream can be considered meandering in form.

Sinuosity is generally related to the product of discharge and gradient.



(a)

(b)

Figure 1.32: Sinuosity: (a) low and (b) extreme. *Low to moderately sinuous streams are usually found in Zones 1 and 2 of the longitudinal profile. Extremely sinuous streams are more typical of Zone 3.*

Low to moderate levels of sinuosity are typically found in Zones 1 and 2 of the longitudinal profile. Extremely sinuous streams often occur in the broad, flat valleys of Zone 3.

Pools and Riffles

No matter the channel form, most streams share a similar attribute of alternating, regularly spaced, deep and shallow areas called *pools* and *riffles* (Figure 1.33). The pools and riffles are associated with the thalweg, which meanders within the channel. Pools typically form in the thalweg near the outside bank of bends. Riffle areas usually form between two bends at the point where the thalweg crosses over from one side of the channel to the other.

The makeup of the streambed plays a role in determining pool and riffle characteristics. Gravel and cobble-bed streams typically have regularly spaced pools and riffles that help maintain channel stability in a high-energy environment. Coarser sediment particles are found in riffle areas while smaller particles occur in pools. The pool-to-pool or riffle-to-riffle spacing is normally about 5 to 7 times the channel width at bankfull discharge (Leopold et al. 1964).

Sand-bed streams, on the other hand, do not form true riffles since the grain size distribution in the riffle area is similar to that in the pools. However, sand-bed streams do have evenly spaced pools. High-gradient streams also usually have pools but not riffles, but for a different reason. In this case, water moves from pool to pool in a stairstep fashion.

Vegetation Along the Stream Corridor

Vegetation is an important and highly variable element in the longitudinal as well as the lateral view. Floodplains are narrow or nonexistent in Zone 1 of the longitudinal profile; thus flood-dependent or tolerant plant communities tend to be limited in distribution. Upland plant communities, such as forests on moderate to steep slopes in the eastern or northwestern United States, might come close to bordering the stream and create a canopy that leaves little open sky visible from the channel. In other parts of the country, headwaters in flatter terrain may support plant communities dominated by grasses and broad-leaved herbs, shrubs, or planted vegetation.

Despite the variation in plant community type, many headwaters areas provide organic matter from vegetation along with the sediment they export to Zones 2 and 3 downstream. For example, logs and woody debris from headwaters forests are among the most ecologically important features supporting food chains and instream habitat structure in Pacific Northwest rivers from the mountains to the sea (Maser and Sedell 1994).

Zone 2 has a wider and more complex floodplain and larger channel than Zone 1. Plant communities associated with floodplains at different elevations might vary due to differences in soil type, flooding frequency, and soil moisture. Localized differences in erosion and deposition of sediment add complexity and diversity to the types of plant communities that become established.

The lower gradient, larger stream size, and less steep terrain in Zone 2 often attract more agricultural or residential development than in the headwaters zone. This phenomenon frequently counteracts the natural tendency to develop broad and diverse stream corridor plant communities in the middle and lower reaches. This is especially true when land uses involve clearing the native vegetation and narrowing the corridor.

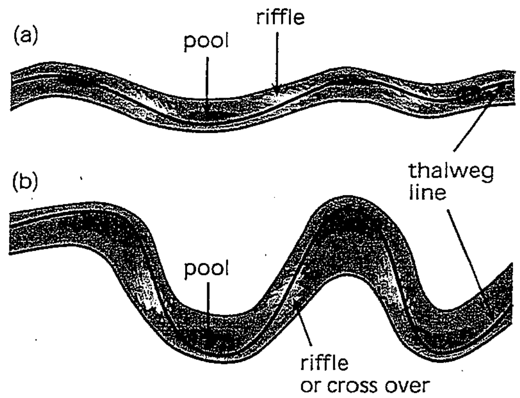


Figure 1.33: Sequence of pools and riffles in (a) straight and (b) sinuous streams. *Pools typically form on the outside bank of bends and riffles in the straight portion of the channel where the thalweg crosses over from one side to the other.*

Often, a native plant community is replaced by a planted vegetation community such as agricultural crops or residential lawns. In such cases, stream processes involving flooding, erosion/deposition, import or export of organic matter and sediment, stream corridor habitat diversity, and water quality characteristics are usually significantly altered.

The lower gradient, increased sediment deposition, broader floodplains, and greater water volume in Zone 3 all set the stage for plant communities different from those found in either upstream zone. Large floodplain wetlands become prevalent because of the generally flatter terrain. Highly productive and diverse biological communities, such as bottomland hardwoods, establish themselves in the deep, rich alluvial soils of the floodplain. The slower flow in the channel also allows emergent marsh vegetation, rooted floating or free-floating plants, and submerged aquatic beds to thrive.

The changing sequence of plant communities along streams from source to mouth is an important source of biodiversity and resiliency to change. Although many, or perhaps most, of a stream corridor's plant communities might be fragmented, a continuous corridor of native plant communities is desirable. Restoring vegetative connectivity in even a portion of a stream will usually improve conditions and increase its beneficial functions.

The River Continuum Concept

The River Continuum Concept is an attempt to generalize and explain longitudinal changes in stream ecosystems (**Figure 1.34**) (Vannote et al. 1980). This conceptual model not only helps to identify connections between the watershed, floodplain, and stream systems, but it also describes how biological communities develop and change from the headwaters to the mouth. The River Continuum Concept can place a site or reach in context within a larger watershed or landscape and thus help practitioners define and focus restoration goals.

The River Continuum Concept hypothesizes that many first- to third-order headwater streams are shaded by the riparian forest canopy. This shading, in turn, limits the growth of algae, periphyton, and other aquatic plants. Since energy cannot be created through photosynthesis (autotrophic production), the aquatic biota in these small streams is dependent on *allochthonous* materials (i.e., materials coming from outside the channel such as leaves and twigs). Biological communities are uniquely adapted to use externally derived organic inputs. Consequently, these headwater streams are considered *heterotrophic* (i.e., dependent on the energy produced in the surrounding watershed). Temperature regimes are also relatively stable due to the influence of ground water recharge, which tends to reduce biological diversity to those species with relatively narrow thermal niches.

Predictable changes occur as one proceeds downstream to fourth-, fifth-, and sixth-order streams. The channel widens, which increases the amount of incident sunlight and average temperatures. Levels of primary production increase in response to increases in light, which shifts many streams to a dependence on *autochthonous* materials (i.e., materials coming from inside the channel), or internal autotrophic production (Minshall 1978).

In addition, smaller, preprocessed organic particles are received from upstream sections, which serves to balance autotrophy and heterotrophy within the stream. Species richness of the invertebrate community increases as a variety of new habitat and food resources appear. Invertebrate functional groups, such as the grazers and collectors, increase in abundance as they adapt to using both autochthonous and allochthonous food resources. Midsized streams also decrease in thermal stability as temperature fluctuations increase, which further tends to increase biotic diversity by increasing the number of thermal niches.

Larger streams and rivers of seventh to twelfth order tend to increase in physical stability, but undergo significant changes in structure and biological function. Larger streams develop increased reliance on primary productivity by

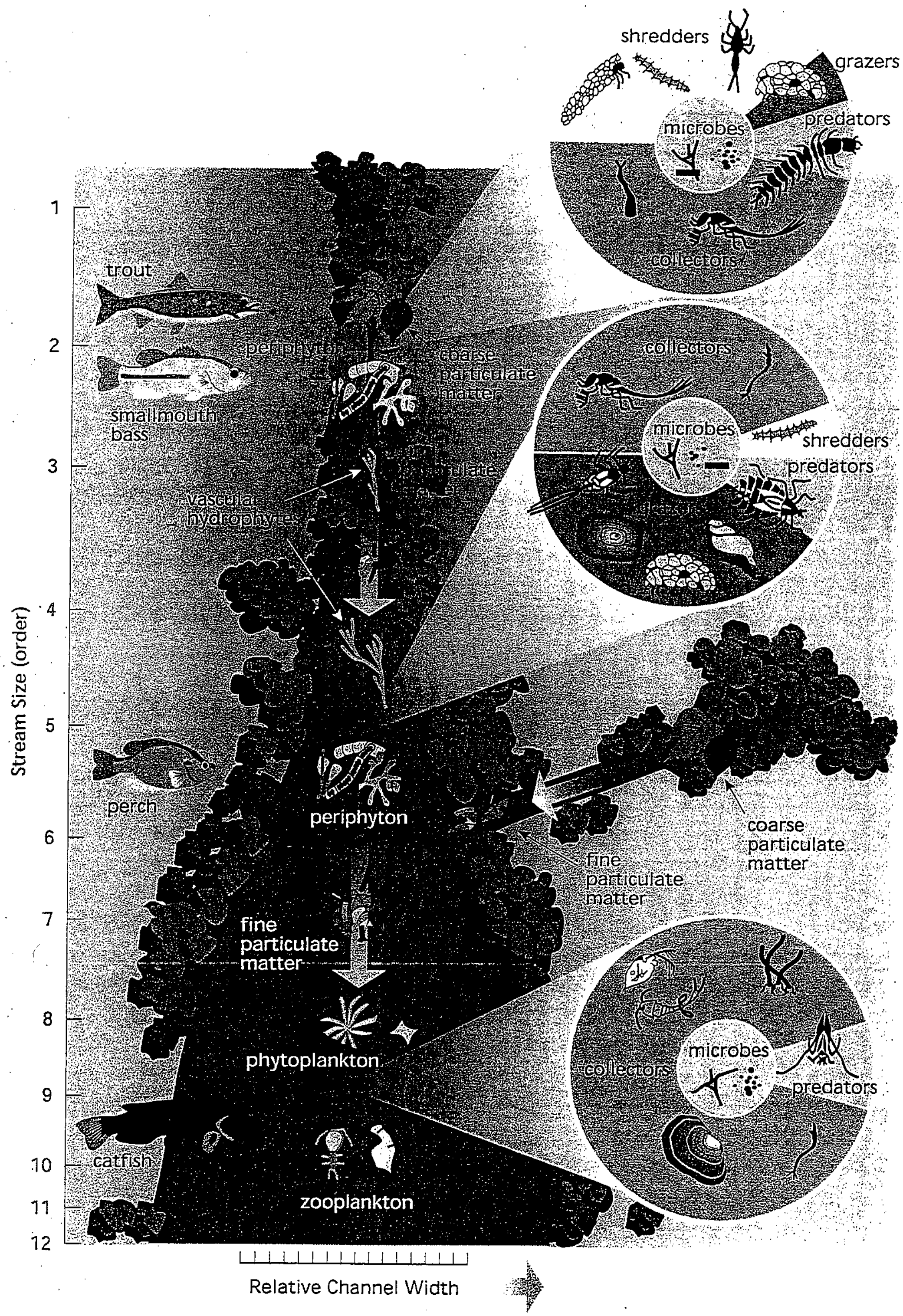


Figure 1.34: The River Continuum Concept. *The concept proposes a relationship between stream size and the progressive shift in structural and functional attributes.*
Source: Vannote et al. (1980). Published with the permission of NRC Research Press.

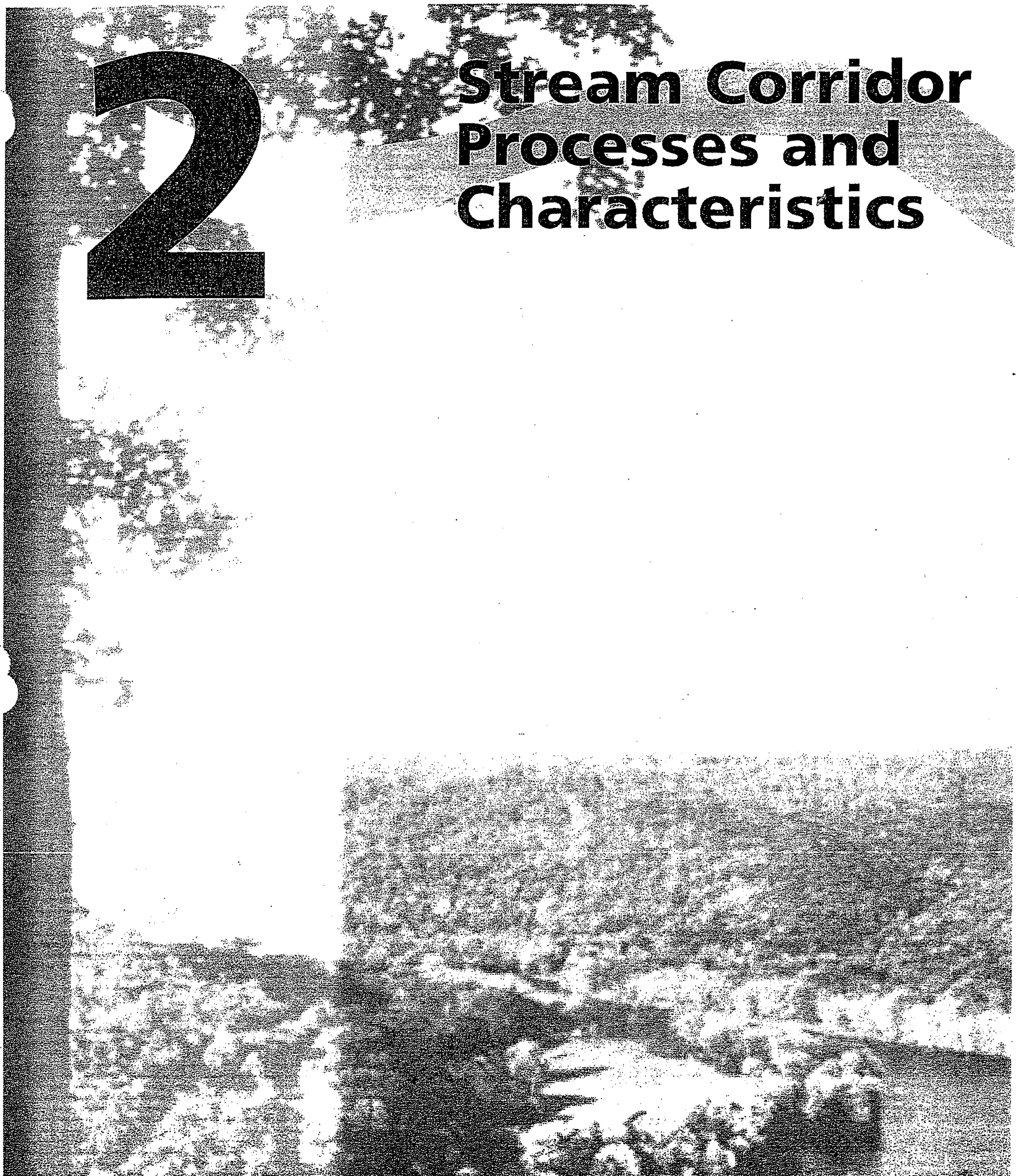
phytoplankton, but continue to receive heavy inputs of dissolved and ultra-fine organic particles from upstream. Invertebrate populations are dominated by fine-particle collectors, including zooplankton. Large streams frequently carry increased loads of clays and fine silts, which increase turbidity, decrease light penetration, and thus increase the significance of heterotrophic processes.

The influence of storm events and thermal fluctuations decrease in frequency and magnitude, which increases the overall physical stability of the stream. This stability increases the strength of biological interactions, such as competition and predation, which tends to eliminate less competitive taxa and thereby reduce species richness.

The fact that the River Continuum Concept applies only to perennial streams is a limitation. Another limitation is that disturbances and their impacts on the river continuum are not addressed by the model. Disturbances can disrupt the connections between the watershed and its streams and the river continuum as well.

The River Continuum Concept has not received universal acceptance due to these and other reasons (Statzner and Higler 1985, Junk et al. 1989). Nevertheless, it has served as a useful conceptual model and stimulated much research since it was first introduced in 1980.

2 Stream Corridor Processes and Characteristics



2.A Hydrologic and Hydraulic Processes

- *Where does stream flow come from?*
- *What processes affect or are involved with stream flow?*
- *How fast, how much, how deep, how often and when does water flow?*
- *How is hydrology different in urban stream corridors?*

2.B Geomorphic Processes

- *What factors affect the channel cross section and channel profile?*
- *How are water and sediment related?*
- *Where does sediment come from and how is it transported downstream?*
- *What is an equilibrium channel?*
- *What should a channel look like in cross section and in profile?*
- *How do channel adjustments occur?*
- *What is a floodplain?*
- *Is there an important relationship between a stream and its floodplain?*

2.C Chemical Processes

- *What are the major chemical constituents of water?*
- *What are some important relationships between physical habitat and key chemical parameters?*
- *How are the chemical and physical parameters critical to the aquatic life in a stream corridor?*
- *What are the natural chemical processes in a stream corridor and water column?*
- *How do disturbances in the stream corridor affect the chemical characteristics of stream water?*

2.D Biological Processes

- *What are the important biological components of a stream corridor?*
- *What biological activities and organisms can be found within a stream corridor?*
- *How does the structure of stream corridors support various populations of organisms?*
- *What are the structural features of aquatic systems that contribute to the biological diversity of stream corridors?*
- *What are some important biological processes that occur within a stream corridor?*
- *What role do fish have in stream corridor restoration?*

2.E Stream Corridor Functions and Dynamic Equilibrium

- *What are the major ecological functions of stream corridors?*
- *How are these ecological functions maintained over time?*
- *Is a stream corridor stable?*
- *Are these functions related?*
- *How does a stream corridor respond to all the natural forces acting on it (i.e., dynamic equilibrium)?*

2 Stream Corridor Processes, Characteristics, and Functions

Chapter 1 provided an overview of stream corridors and the many perspectives from which they should be viewed in terms of scale, equilibrium, and space. Each of these views can be seen as a "snapshot" of different aspects of a stream corridor.

Chapter 2 presents the stream corridor in motion, providing a basic understanding of the different processes that make the stream corridor look and function the way it does. While Chapter 1 presented still images, this chapter provides "film footage" to describe the processes, characteristics, and functions of stream corridors through time.

Section 2.A: Hydrologic and Hydraulic Processes

Understanding how water flows into and through stream corridors is critical to restorations. How fast, how much, how deep, how often, and when water flows are important basic questions that must be answered to

Figure 2.1: A stream corridor in motion. Processes, characteristics, and functions shape stream corridors and make them look the way they do.

make appropriate decisions about stream corridor restoration.

Section 2.B: Geomorphic Processes

This section combines basic hydrologic processes with physical or geomorphic functions and characteristics. Water flows through streams but is affected by the kinds of soils and alluvial features within the channel, in the floodplain, and in the uplands. The amount and kind of sediments carried by a stream largely determines its equilibrium characteristics, including size, shape, and profile. Successful stream corridor restoration, whether active (requiring direct changes) or passive (management and removal of disturbance factors), depends on an understanding of how water and sediment are related to channel form and function and on what processes are involved with channel evolution.

Section 2.C: Physical and Chemical Characteristics

The quality of water in the stream corridor is normally a primary objective of restoration, either to improve it to a desired condition, or to sustain it. Restoration should consider the physical and chemical characteristics that may not be readily apparent but that are nonetheless critical to the functions and processes of stream corridors. Changes in soil or water chemistry to achieve restoration goals usually involve managing or altering elements in the landscape or corridor.

Section 2.D: Biological Community Characteristics

The fish, wildlife, plants, and humans that use, live in, or just visit the stream corridor are key elements to consider in restoration. Typical goals are to restore, create, enhance, or protect habitat to benefit life. It is important to understand how water flows, how sediment is transported, and how geomorphic features and processes evolve; however, a prerequisite to successful restoration is an understanding of the living parts of the system and how the physical and chemical processes affect the stream corridor.

Section 2.E: Functions and Dynamic Equilibrium

The six major functions of stream corridors are: habitat, conduit, barrier, filter, source, and sink. The integrity of a stream corridor ecosystem depends on how well these functions operate. This section discusses these functions and how they relate to dynamic equilibrium.

2A Hydrologic and Hydraulic Processes

The *hydrologic cycle* describes the continuum of the transfer of water from precipitation to surface water and ground water, to storage and runoff, and to the eventual return to the atmosphere by transpiration and evaporation (**Figure 2.2**).

Precipitation returns water to the earth's surface. Although most hydrologic processes are described in terms of rainfall events (or storm events), snowmelt is also an important source of water, especially for rivers that originate in high mountain areas and for continental regions that experience seasonal cycles of snowfall and snowmelt.

The type of precipitation that will occur is generally a factor of humidity and air temperature. Topographic relief and geographic location relative to large water bodies also affect the frequency and type of precipitation. Rainstorms occur more frequently along coastal and low-latitude areas with moderate temperatures and low relief. Snowfalls occur more frequently at high elevations and in mid-latitude areas with colder seasonal temperatures.

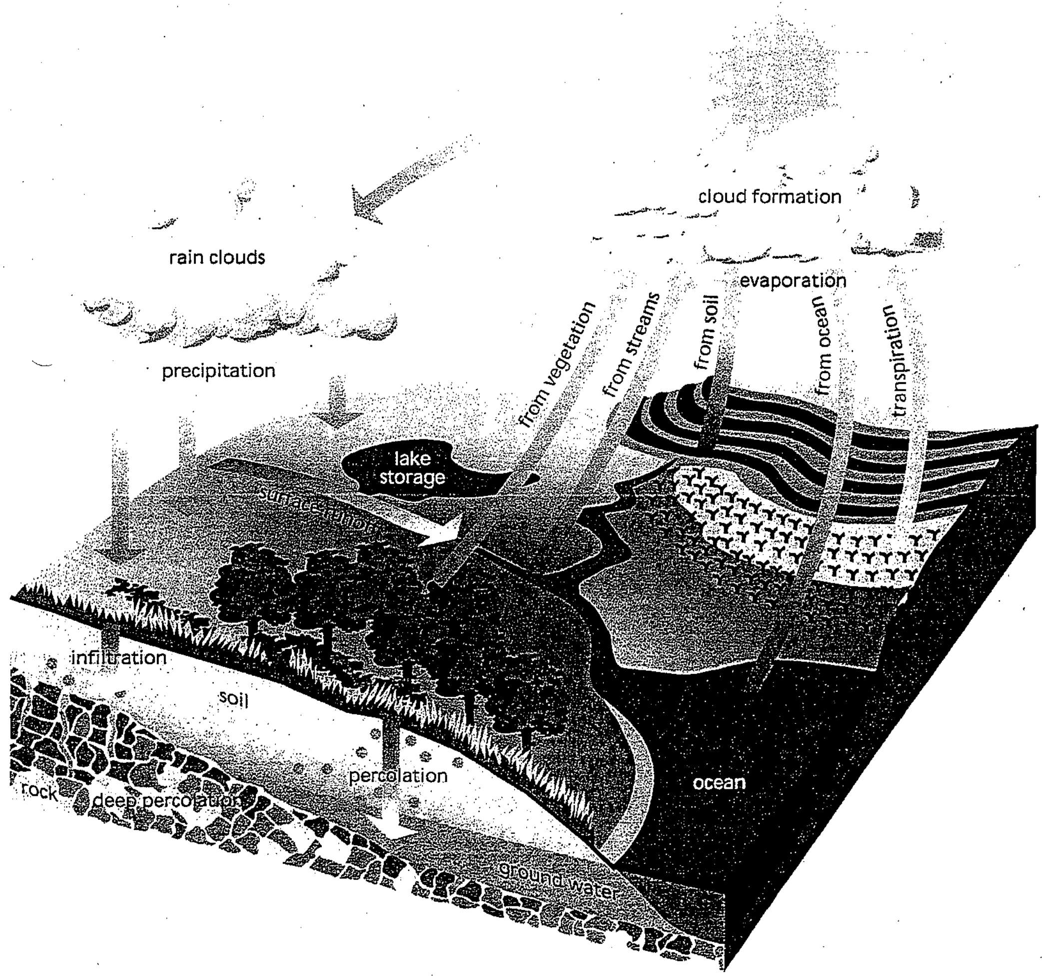


Figure 2.2: ***The hydrologic cycle.*** *The transfer of water from precipitation to surface water and ground water, to storage and runoff, and eventually back to the atmosphere is an ongoing cycle.*

Precipitation can do one of three things once it reaches the earth. It can return to the atmosphere; move into the soil; or run off the earth's surface into a stream, lake, wetland, or other water body. All three pathways play a role in determining how water moves into, across, and down the stream corridor.

This section is divided into two subsections. The first subsection focuses on hydrologic and hydraulic processes in the lateral dimension, namely, the movement of water from the land into the channel. The second subsection concentrates on water as it moves in the longitudinal dimension, specifically as streamflow in the channel.

Hydrologic and Hydraulic Processes Across the Stream Corridor

Key points in the hydrologic cycle serve as organizational headings in this subsection:

- Interception, transpiration, and evapotranspiration.
- Infiltration, soil moisture, and ground water.
- Runoff.

Interception, Transpiration, and Evapotranspiration

More than two-thirds of the precipitation falling over the United States evaporates to the atmosphere rather than being discharged as streamflow to the oceans. This "short-circuiting" of the hydrologic cycle occurs because of the two processes, interception and transpiration.

Interception

A portion of precipitation never reaches the ground because it is intercepted by vegetation and other natural and constructed surfaces. The amount of water intercepted in this manner is determined by the amount of interception storage available on the above-ground surfaces.

In vegetated areas, storage is a function of plant type and the form and density of leaves, branches, and stems (Table 2.1). Factors that affect storage in forested areas include:

- Leaf shape. Conifer needles hold water more efficiently than leaves. On leaf surfaces droplets run together and roll off. Needles, however, keep droplets separated.
- Leaf texture. Rough leaves store more water than smooth leaves.
- Time of year. Leafless periods provide less interception potential in the canopy than growing periods; however, more storage sites are created by leaf litter during this time.
- Vertical and horizontal density. The more layers of vegetation that precipitation must penetrate, the less likely it is to reach the soil.
- Age of the plant community. Some vegetative stands become more dense with age; others become less dense.

The intensity, duration, and frequency of precipitation also affect levels of interception.

Figure 2.3 shows some of the pathways rainfall can take in a forest. Rainfall at

Table 2.1: Percentage of precipitation intercepted for various vegetation types.
Source: Dunne and Leopold 1978.

Vegetative Type	% Precipitation Intercepted
Forests	
Deciduous	13
Coniferous	28
Crops	
Alfalfa	36
Corn	16
Oats	7
Grasses	10–20

the beginning of a storm initially fills interception storage sites in the canopy. As the storm continues, water held in these storage sites is displaced. The displaced water drops to the next lower layer of branches and limbs and fills storage sites there. This process is repeated until displaced water reaches the lowest layer, the leaf litter. At this point, water displaced off the leaf litter either infiltrates the soil or moves downslope as surface runoff.

Antecedent conditions, such as moisture still held in place from previous storms, affect the ability to intercept and store additional water. Evaporation will eventually remove water residing in interception sites. How fast this process occurs depends on climatic conditions that affect the evaporation rate.

Interception is usually insignificant in areas with little or no vegetation. Bare soil or rock has some small impermeable depressions that function as interception storage sites, but typically most of the precipitation either infiltrates the soil or moves downslope as surface runoff. In areas of frozen soil, interception storage sites are typically filled with frozen water. Consequently, additional rainfall is rapidly transformed into surface runoff.

Interception can be significant in large urban areas. Although urban drainage systems are designed to quickly move storm water off impervious surfaces, the urban landscape is rich with storage sites. These include flat rooftops, parking lots, potholes, cracks, and other rough surfaces that can intercept and hold water for eventual evaporation.

Transpiration and Evapotranspiration

Transpiration is the diffusion of water vapor from plant leaves to the atmosphere. Unlike intercepted water, which originates from precipitation, transpired

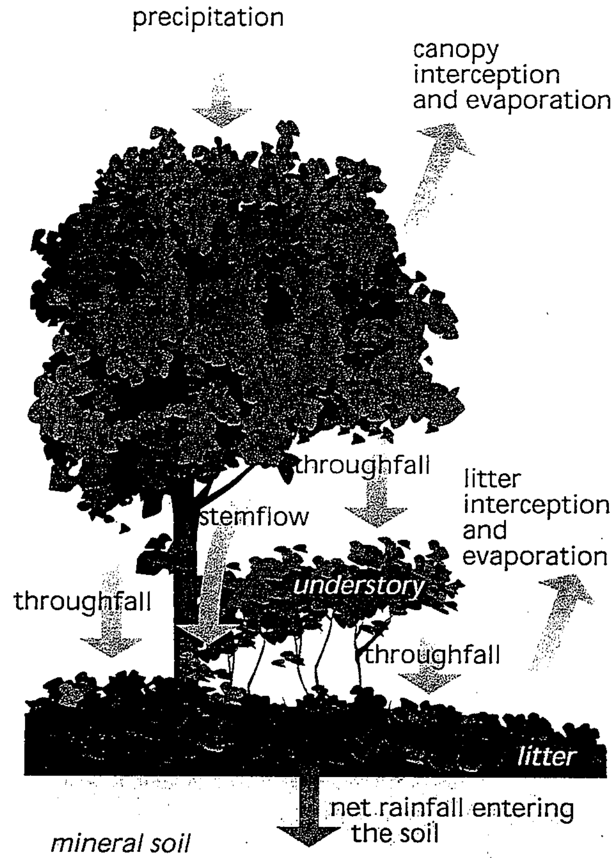


Figure 2.3: Typical pathways for forest rainfall. *A portion of precipitation never reaches the ground because it is intercepted by vegetation and other surfaces.*

water originates from water taken in by roots.

Transpiration from vegetation and evaporation from interception sites and open water surfaces, such as ponds and lakes, are not the only sources of water returned to the atmosphere. Soil moisture also is subject to evaporation. Evaporation of soil moisture is, however, a much slower process due to capillary and osmotic forces that keep the moisture in the soil and the fact that vapor must diffuse upward through soil pores to reach surface air at a lower vapor pressure.

Because it is virtually impossible to separate water loss due to transpiration

Evaporation

Water is subject to evaporation whenever it is exposed to the atmosphere. Basically this process involves:

- *The change of state of water from liquid to vapor*
- *The net transfer of this vapor to the atmosphere*

The process begins when some molecules in the liquid state attain sufficient kinetic energy (primarily from solar energy) to overcome the forces of surface tension and move into the atmosphere. This movement creates a vapor pressure in the atmosphere.

*The net rate of movement is proportional to the difference in vapor pressure between the water surface and the atmosphere above that surface. Once the pressure is equalized, no more evaporation can occur until new air, capable of holding more water vapor, displaces the old saturated air. Evaporation rates therefore vary according to latitude, season, time of day, cloudiness, and wind energy. Mean annual lake evaporation in the United States, for example, varies from 20 inches in Maine and Washington to about 86 inches in the desert Southwest (**Figure 2.4**).*

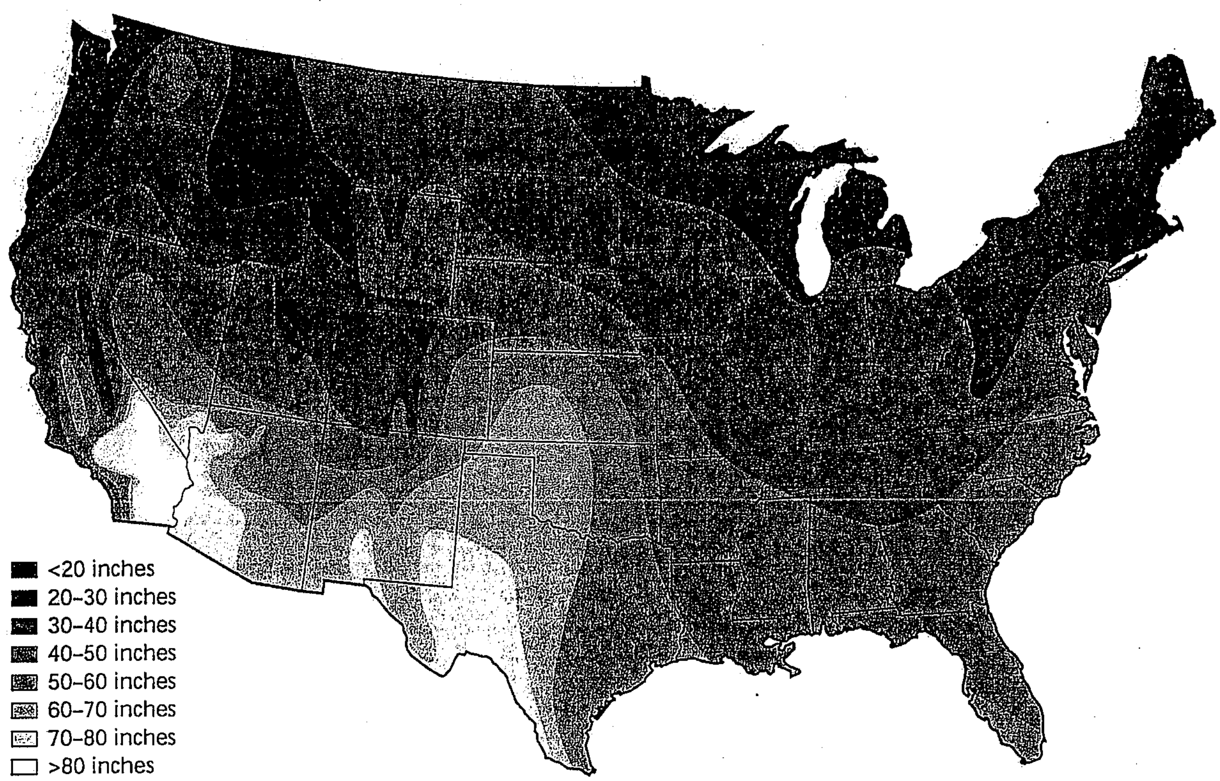


Figure 2.4: Mean annual lake evaporation for the period 1946–1955.
Source: Dunne and Leopold (1978) modified from Kohler et al. (1959).

from water loss due to evaporation, the two processes are commonly combined and labeled *evapotranspiration*. Evapotranspiration can dominate the water balance and can control soil moisture content, ground water recharge, and streamflow.

The following concepts are important when describing evapotranspiration:

- If soil moisture conditions are limiting, the actual rate of evapotranspiration is below its potential rate.
- When vegetation loses water to the atmosphere at a rate unlimited by the supply of water replenishing the roots, its actual rate of evapotranspiration is equal to its potential rate of evapotranspiration.

The amount of precipitation in a region drives both processes, however. Soil types and rooting characteristics also play important roles in determining the actual rate of evapotranspiration.

Infiltration, Soil Moisture, and Ground Water

Precipitation that is not intercepted or flows as surface runoff moves into the soil. Once there, it can be stored in the upper layer or move downward through the soil profile until it reaches an area completely saturated by water called the *phreatic zone*.

Infiltration

Close examination of the soil surface reveals millions of particles of sand, silt, and clay separated by channels of different sizes (**Figure 2.5**). These *macropores* include cracks, "pipes" left by decayed roots and wormholes, and pore spaces between lumps and particles of soil.

Water is drawn into the pores by gravity and capillary action. Gravity is the dominant force for water moving into the largest openings, such as worm or root holes. Capillary action is the domi-

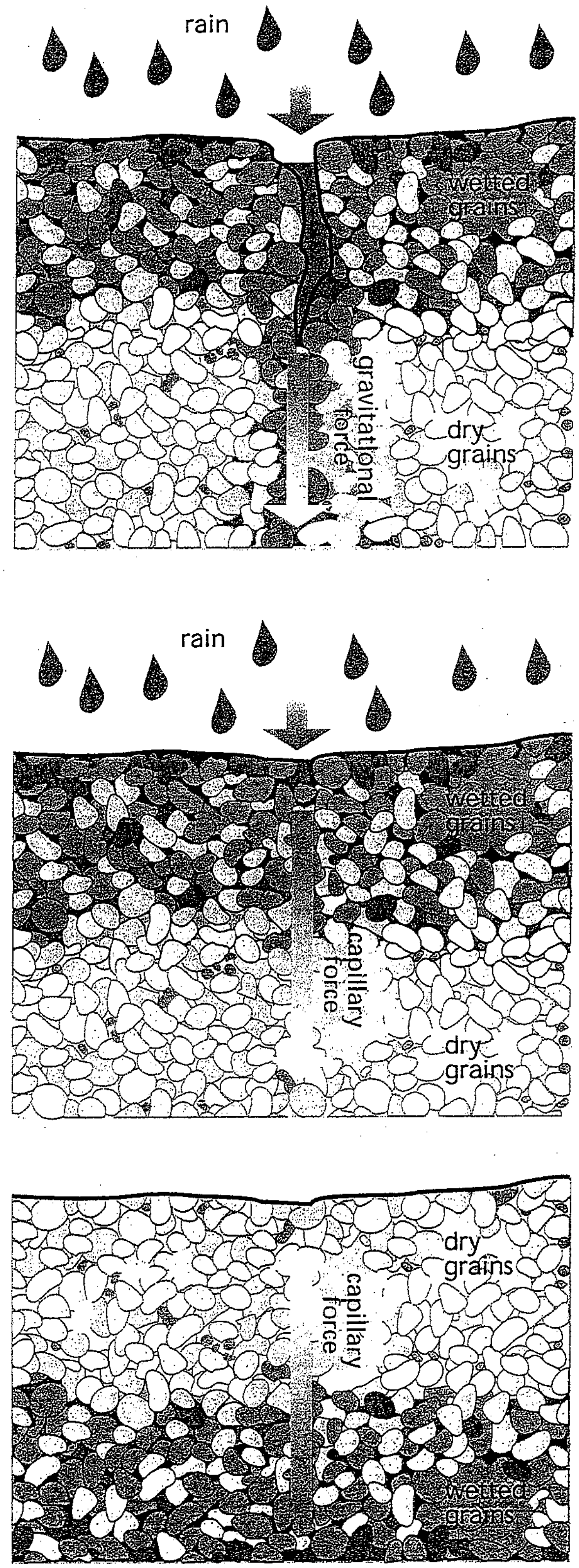


Figure 2.5: Soil profile. Water is drawn into the pores in soil by gravity and capillary action.

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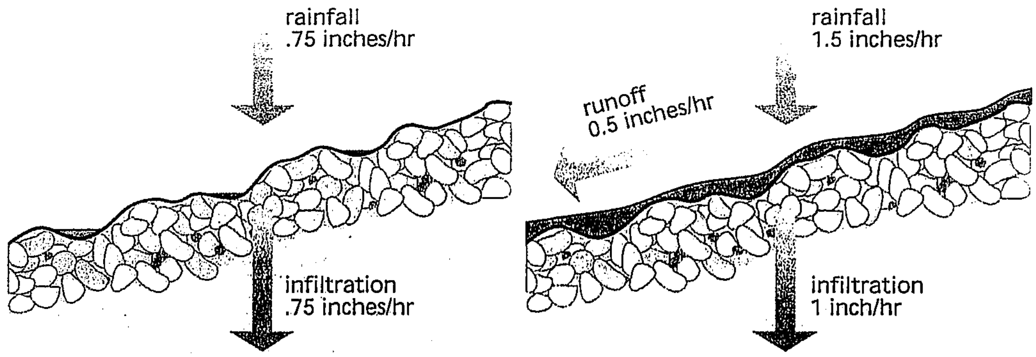


Figure 2.6: Infiltration and runoff. *Surface runoff occurs when rainfall intensity exceeds infiltration capacity.*

nant force for water moving into soils with very fine pores.

The size and density of these pore openings determine the water's rate of entry into the soil. *Porosity* is the term used to describe the percentage of the total soil volume taken up by spaces between soil particles. When all those spaces are filled with water, the soil is said to be saturated.

Soil characteristics such as texture and tilth (looseness) are key factors in determining porosity. Coarse-textured, sandy soils and soils with loose aggregates held together by organic matter or small amounts of clay have large pores and, thus, high porosity. Soils that are tightly packed or clayey have low porosity.

Infiltration is the term used to describe the movement of water into soil pores. The *infiltration rate* is the amount of water that soaks into soil over a given length of time. The maximum rate that water infiltrates a soil is known as the soil's *infiltration capacity.*

If rainfall intensity is less than infiltration capacity, water infiltrates the soil at a rate equal to the rate of rainfall. If the rainfall rate exceeds the infiltration capacity, the excess water either is detained in small depressions on the soil surface or travels downslope as surface runoff (Figure 2.6).

The following factors are important in determining a soil's infiltration rate:

- Ease of entry through the soil surface.
- Storage capacity within the soil.
- Transmission rate through the soil.

Areas with natural vegetative cover and leaf litter usually have high infiltration rates. These features protect the surface soil pore spaces from being plugged by fine soil particles created by raindrop splash. They also provide habitat for worms and other burrowing organisms and provide organic matter that helps bind fine soil particles together. Both of these processes increase porosity and the infiltration rate.

The rate of infiltration is not constant throughout the duration of a storm. The rate is usually high at the beginning of a storm but declines rapidly as gravity-fed storage capacity is filled. A slower, but stabilized, rate of infiltration is reached typically 1 or 2 hours into a storm. Several factors are involved in this stabilization process, including the following:

- Raindrops breaking up soil aggregates and producing finer material, which then blocks pore openings on the surface and reduces the ease of entry.
- Water filling fine pore spaces and reducing storage capacity.
- Wetted clay particles swelling and effectively reducing the diameter of pore spaces, which, in turn, reduces transmission rates.

Soils gradually drain or dry following a storm. However, if another storm occurs before the drying process is completed, there is less storage space for new water. Therefore, antecedent moisture conditions are important when analyzing available storage.

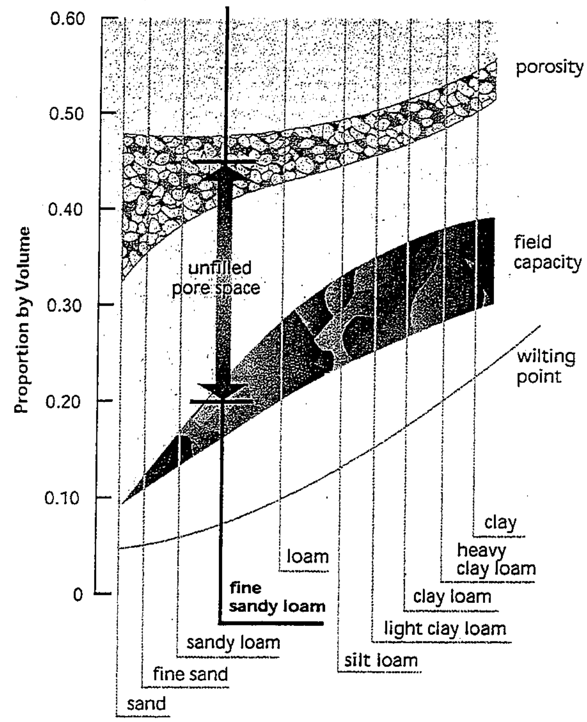


Figure 2.7: Water-holding properties of various soils. Water-holding properties vary by texture. For a fine sandy loam the approximate difference between porosity, 0.45, and field capacity, 0.20, is 0.25, meaning that the unfilled pore space is 0.25 times the soil volume. The difference between field capacity and wilting point is a measure of unfilled pore space.
Source: Dunne and Leopold 1978.

Soil Moisture

After a storm passes, water drains out of upper soils due to gravity. The soil remains moist, however, because some amount of water remains tightly held in fine pores and around particles by surface tension. This condition, called *field capacity*, varies with soil texture. Like porosity, it is expressed as a proportion by volume.

The difference between porosity and field capacity is a measure of unfilled pore space (**Figure 2.7**). Field capacity is an approximate number, however, because gravitation drainage continues in moist soil at a slow rate.

Soil moisture is most important in the context of evapotranspiration. Terrestrial plants depend on water stored in soil. As their roots extract water from progressively finer pores, the moisture content in the soil may fall below the field capacity. If soil moisture is not replenished, the roots eventually reach a point where they cannot create enough suction to extract the tightly held interstitial pore water. The moisture content of the soil at this point, which varies depending on soil characteristics, is called the *permanent wilting point* because plants can no longer withdraw water from the soil at a rate high enough to keep up with the demands of transpiration, causing the plants to wilt.

Deep percolation is the amount of water that passes below the root zone of crops, less any upward movement of water from below the root zone (Jensen et al. 1990).

Ground Water

The size and quantity of pore openings also determines the movement of water within the soil profile. Gravity causes water to move vertically downward. This movement occurs easily through larger pores. As pores reduce in size due to swelling of clay particles or filling of pores, there is a greater resistance to flow. Capillary forces eventually take over and cause water to move in any direction.

Water will continue to move downward until it reaches an area completely saturated with water, the *phreatic zone* or zone of saturation (**Figure 2.8**). The top of the phreatic zone defines the *ground water table* or phreatic surface. Just above the ground water table is an area called the *capillary fringe*, so named because the pores in this area are filled with water held by capillary forces.

In soils with tiny pores, such as clay or silt, the capillary forces are strong. Consequently, the capillary fringe can extend a large distance upward from the water table. In sandstone or soils with large pores, the capillary forces are weak and the fringe narrow.

Between the capillary fringe and the soil surface is the *vadose zone*, or the zone of aeration. It contains air and microbial respiratory gases, capillary water, and water moving downward by gravity to the phreatic zone. *Pellicular water* is the film of ground water that adheres to individual particles above the ground water table. This water is held above the capillary fringe by molecular attraction.

If the phreatic zone provides a consistent supply of water to wells, it is known as an *aquifer*. Good aquifers usually have a large lateral and vertical extent relative to the amount of water withdrawn from wells and high porosity, which allows water to drain easily.

The opposite of an aquifer is an aquitard or confining bed. *Aquitards* or *confining beds* are relatively thin sediment or rock layers that have low permeability. Vertical water movement through an aquitard is severely restricted. If an aquifer has no confining layer overlying it, it is known as an *unconfined aquifer*. A *confined aquifer* is one confined by an aquitard.

The complexity and diversity of aquifers and aquitards result in a multitude of

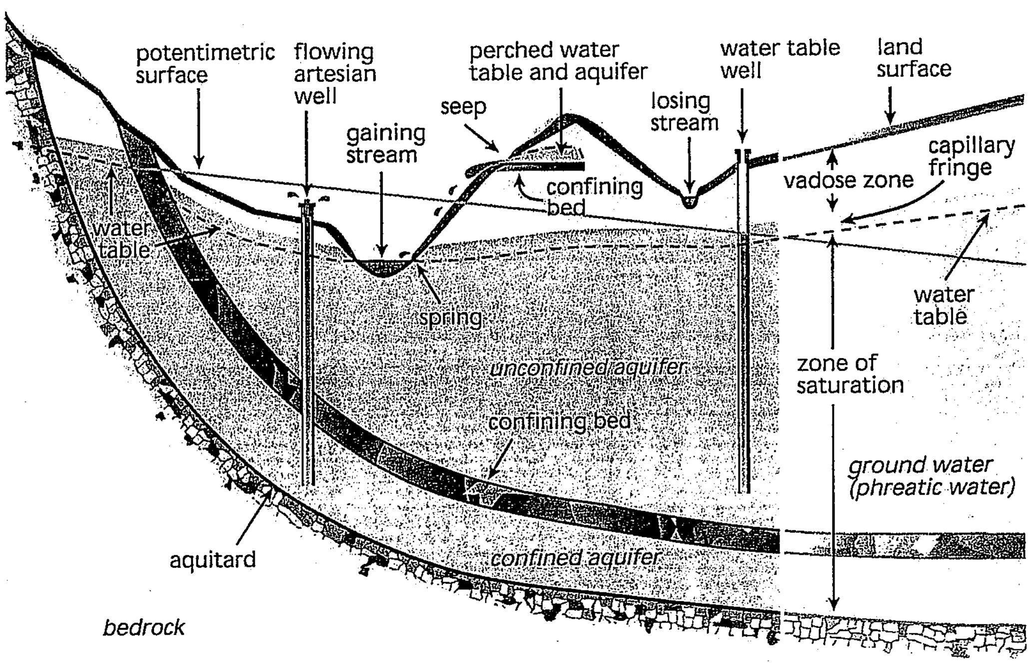


Figure 2.8: Ground water related features and terminology. *Ground water elevation along the stream corridor can vary significantly over short distances, depending on subsurface characteristics.* Source: USGS Water Supply Paper #1988, 1972, Definitions of Selected Ground Water Terms.

underground scenarios. For example, *perched ground water* occurs when a shallow aquitard of limited size prevents water from moving down to the phreatic zone. Water collects above the aquitard and forms a "mini-phreatic zone." In many cases, perched ground water appears only during a storm or during the wet season. Wells tapping perched ground water may experience a shortage of water during the dry season. Perched aquifers can, however, be important local sources of ground water.

Artesian wells are developed in confined aquifers. Because the hydrostatic pressure in confined aquifers is greater than atmospheric pressure, water levels in artesian wells rise to a level where atmospheric pressure equals hydrostatic pressure. If this elevation is above the ground surface, water can flow freely out of the well.

Water also will flow freely where the ground surface intersects a confined aquifer. The *piezometric surface* is the level to which water would rise in wells tapped into confined aquifers if the wells extended indefinitely above the ground surface. Phreatic wells draw water from below the phreatic zone in unconfined aquifers. The water level in a phreatic well is the same as the ground water table.

Practitioners of stream corridor restoration should be concerned with locations where ground water and surface water are exchanged. Areas that freely allow movement of water to the phreatic zone are called *recharge areas*. Areas where the water table meets the soil surface or where stream and ground water emerge are called *springs* or *seeps*.

The volume of ground water and the elevation of the water table fluctuate according to ground water recharge and discharge. Because of the fluctuation of water table elevation, a stream channel can function either as a recharge area (influent or "losing" stream) or a discharge area (effluent or "gaining" stream).

Runoff

When the rate of rainfall or snowmelt exceeds infiltration capacity, excess water collects on the soil surface and travels downslope as runoff. Factors that affect runoff processes include climate, geology, topography, soil characteristics, and vegetation. Average annual runoff in the contiguous United States ranges from less than 1 inch to more than 20 inches (**Figure 2.9**).

Three basic types of runoff are introduced in this subsection (**Figure 2.10**):

- Overland flow
- Subsurface flow
- Saturated overland flow

Each of these runoff types can occur individually or in some combination in the same locale.

Overland Flow

When the rate of precipitation exceeds the rate of infiltration, water collects on the soil surface in small depressions (**Figure 2.11**). The water stored in these spaces is called *depression storage*. It eventually is returned to the atmosphere through evaporation or infiltrates the soil surface.

After depression storage spaces are filled, excess water begins to move downslope as overland flow, either as a shallow sheet of water or as a series of small rivulets or rills. Horton (1933) was the first to describe this process in the literature. The term *Horton overland flow* or Hortonian flow is commonly used.

The sheet of water increases in depth and velocity as it moves downhill. As it travels, some of the overland flow is trapped on the hillside and is called *sur-*

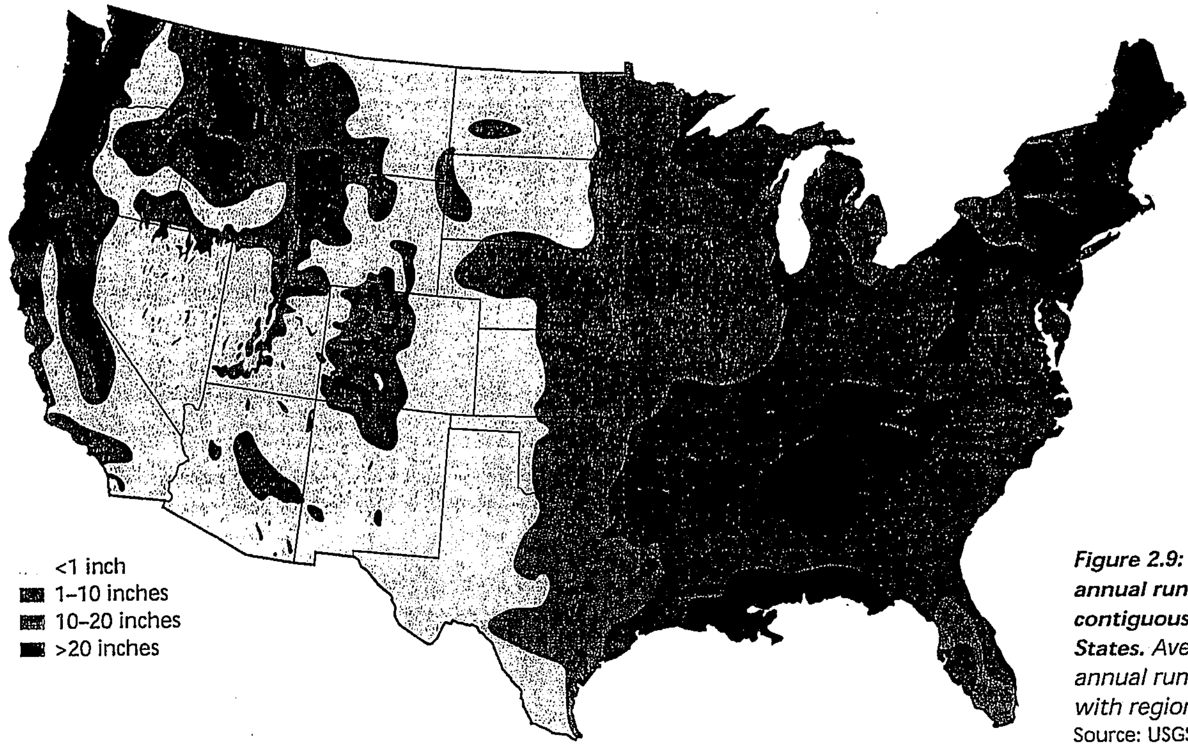


Figure 2.9: Average annual runoff in the contiguous United States. *Average annual runoff varies with regions.*
Source: USGS 1986.

face detention. Unlike depression storage, which evaporates to the atmosphere or enters the soil, surface detention is only temporarily detained from its journey downslope. It eventually runs off into the stream and is still considered part of the total volume of overland flow.

Overland flow typically occurs in urban and suburban settings with paved and impermeable surfaces. Paved areas and soils that have been exposed and compacted by heavy equipment or vehicles are also prime settings for overland flow. It is also common in areas of thin soils with sparse vegetative cover such as in mountainous terrain of arid or semiarid regions.

Subsurface Flow

Once in the soil, water moves in response to differences in hydraulic head (the potential for flow due to the gradient of hydrostatic pressure at different elevations). Given a simplified situation, the water table before a rainstorm has a parabolic surface that slopes toward a stream. Water moves downward and along this slope and into the stream channel. This portion of the flow is the baseflow. The soil below the water table is, of course, saturated. Assuming the hill slope has uniform soil characteristics, the moisture content of surface soils diminishes with distance from the stream.

During a storm, the soil nearest the stream has two important attributes as compared to soil upslope—a higher moisture content and a shorter distance to the water table. These attributes cause the water table to rise more rapidly in response to rainwater infiltration and causes the water table to steepen. Thus a new, storm-generated ground water component is added to baseflow. This new component, called *subsurface flow,* mixes with baseflow and increases ground water discharge to the channel.

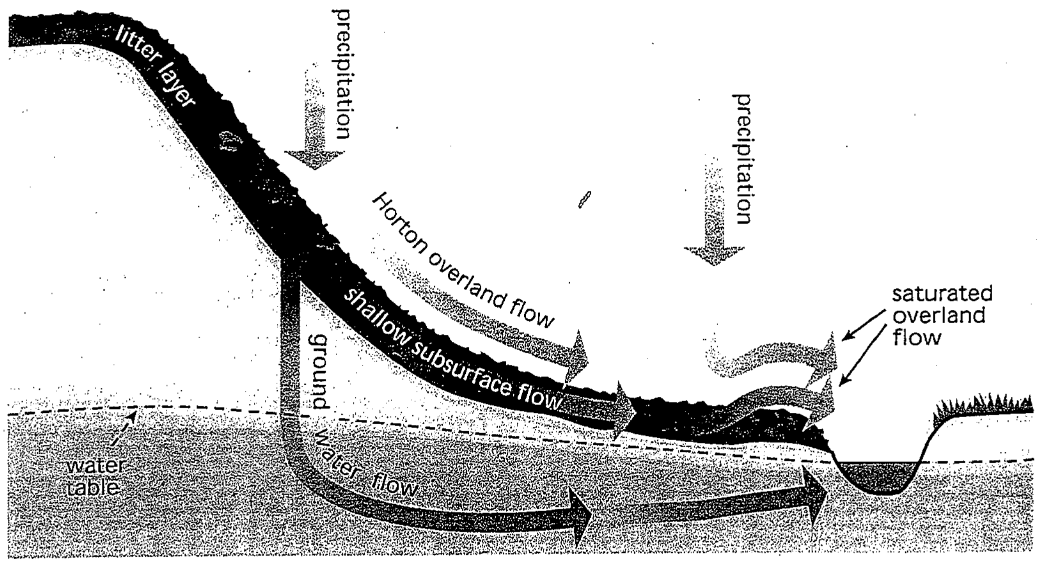


Figure 2.10: ***Flow paths of water over a surface.*** *The portion of precipitation that runs off or infiltrates to the ground water table depends on the soil's permeability rate; surface roughness; and the amount, duration, and intensity of precipitation.*

In some situations, infiltrated storm water does not reach the phreatic zone because of the presence of an aquitard. In this case, subsurface flow does not mix with baseflow, but also discharges water into the channel. The net result, whether mixed or not, is increased channel flow.

Saturated Overland Flow

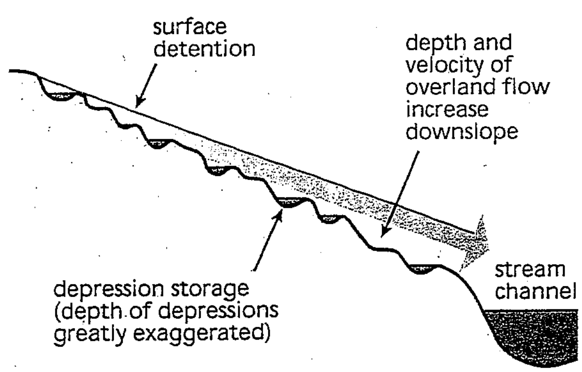
If the storm described above continues, the slope of the water table surface can continue to steepen near the stream. Eventually, it can steepen to the point that the water table rises above the channel elevation. Additionally, ground water can break out of the soil and travel to the stream as overland flow. This type of runoff is termed *quick return flow.*

The soil below the ground water breakout is, of course, saturated. Consequently, the maximum infiltration rate is reached, and all of the rain falling on it flows downslope as overland runoff. The combination of this direct precipitation and quick return flow is called *saturated overland flow.* As the storm progresses, the saturated area expands further up the hillside. Because quick return flow and subsurface flow are so closely linked to overland flow, they are normally considered part of the overall runoff of surface water.

Hydrologic and Hydraulic Processes Along the Stream Corridor

Water flowing in streams is the collection of direct precipitation and water that has moved laterally from the land into the channel. The amount and timing of this lateral movement directly influences

Figure 2.11: Overland flow and depression storage. *Overland moves downslope as an irregular sheet.*
Source: Dunne and Leopold 1978.



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FAST FORWARD

Preview Chapter 7, Section A for more detailed information about flow duration and frequency.

the amount and timing of streamflow, which in turn influences ecological functions in the stream corridor.

Flow Analysis

Flows range from no flow to flood flows in a variety of time scales. On a broad scale, historical climate records reveal occasional persistent periods of wet and dry years. Many rivers in the United States, for example, experienced a decline in flows during the "dust bowl" decade in the 1930s. Another similar decline in flows nationwide occurred in the 1950s. Unfortunately, the length of record regarding wet and dry years is short (in geologic time), making it is difficult to predict broad-scale persistence of wet or dry years.

Seasonal variations of streamflow are more predictable, though somewhat complicated by persistence factors. Because design work requires using historical information (period of record) as a basis for designing for the future, flow information is usually presented in a probability format. Two formats are especially useful for planning and designing stream corridor restoration:

- *Flow duration*, the probability a given streamflow was equaled or exceeded over a period of time.
- *Flow frequency*, the probability a given streamflow will be exceeded (or not exceeded) in a year. (Sometimes this concept is modified and expressed as the average number of years between exceeding [or not exceeding] a given flow.)

Figure 2.12 presents an example of a flow frequency expressed as a series of probability curves. The graph displays months on the x-axis and a range of mean monthly discharges on the y-axis. The curves indicate the probability that the mean monthly discharge will be less than the value indicated by the curve. For example, on about January 1, there is a 90 percent chance that the

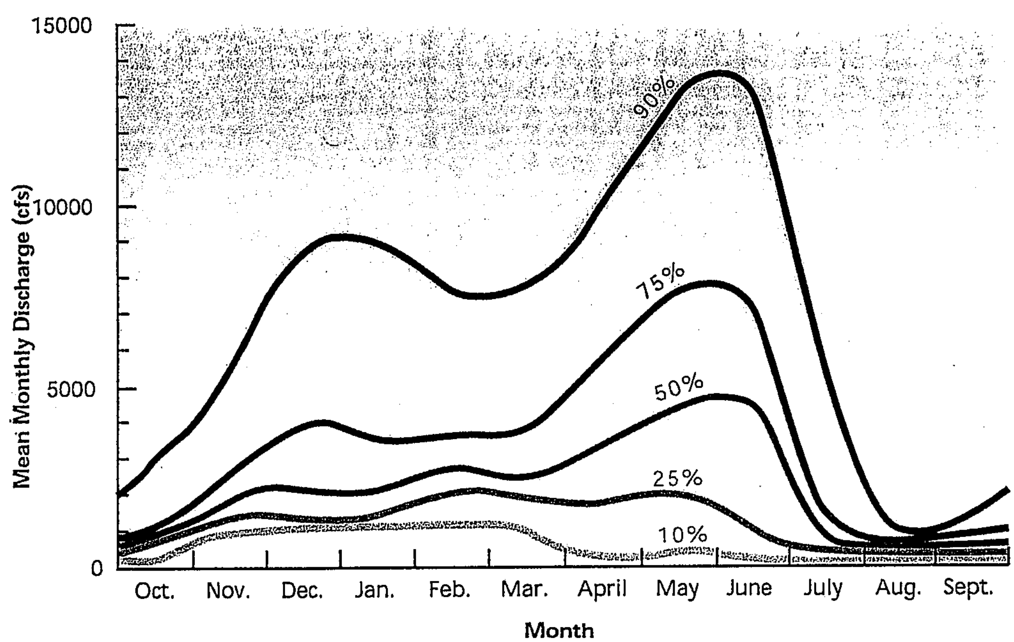


Figure 2.12: An example of monthly probability curves. *Monthly probability that the mean monthly discharge will be less than the values indicated. Yakima River near Parker, Washington. (Data from U.S. Army Corps of Engineers.)*
Source: Dunne and Leopold 1978.

discharge will be less than 9,000 cfs and a 50 percent chance it will be less than 2,000 cfs.

Ecological Impacts of Flow

The variability of streamflow is a primary influence on the biotic and abiotic processes that determine the structure and dynamics of stream ecosystems (Covich 1993). High flows are important not only in terms of sediment transport, but also in terms of reconnecting floodplain wetlands to the channel.

This relationship is important because floodplain wetlands provide spawning and nursery habitat for fish and, later in the year, foraging habitat for waterfowl. Low flows, especially in large rivers, create conditions that allow tributary fauna to disperse, thus maintaining populations of a single species in several locations.

In general, completion of the life cycle of many riverine species requires an array of different habitat types whose temporal availability is determined by the flow regime. Adaptation to this environmental dynamism allows riverine species to persist during periods of droughts and floods that destroy and recreate habitat elements (Poff et al. 1997).

2B Geomorphic Processes

Geomorphology is the study of surface forms of the earth and the processes that developed those forms. The hydrologic processes discussed in the previous section drive the geomorphic processes described in this section. In turn, the geomorphic processes are the primary mechanisms for forming the drainage patterns, channel, floodplain, terraces, and other watershed and stream corridor features discussed in Chapter 1.

Three primary geomorphic processes are involved with flowing water, as follows:

- *Erosion*, the detachment of soil particles.
- *Sediment transport*, the movement of eroded soil particles in flowing water.
- *Sediment deposition*, settling of eroded soil particles to the bottom of a water body or left behind as water leaves. Sediment deposition can be transitory, as in a stream channel from one storm to another, or more or less permanent, as in a larger reservoir.

Since geomorphic processes are so closely related to the movement of water, this section is organized into subsections that mirror the hydrologic processes of surface storm water runoff and streamflow:

- Geomorphic Processes Across the Stream Corridor
- Geomorphic Processes Along the Stream Corridor

Geomorphic Processes Across the Stream Corridor

The occurrence, magnitude, and distribution of erosion processes in watersheds affect the yield of sediment and associated water quality contaminants to the stream corridor.

Soil erosion can occur gradually over a long period, or it can be cyclic or episodic, accelerating during certain seasons or during certain rainstorm events (Figure 2.13). Soil erosion can be caused by human actions or by natural processes. Erosion is not a simple process because soil conditions are continually changing with temperature, moisture content, growth stage and amount of vegetation, and the human manipulation of the soil for development or crop production. **Tables 2.2 and 2.3** show the basic processes that influence soil erosion and the different types of erosion found within the watershed.

Geomorphic Processes Along the Stream Corridor

The channel, floodplain, terraces, and other features in the stream corridor are formed primarily through the erosion, transport, and deposition of sediment by streamflow. This subsection describes the processes involved with transporting sediment loads downstream and how the channel and floodplain adjust and evolve through time.

Sediment Transport

Sediment particles found in the stream channel and floodplain can be categorized according to size. A boulder is the largest particle and clay is the smallest particle. Particle density depends on the size and composition of the particle (i.e., the specific gravity of the mineral content of the particle).

No matter the size, all particles in the channel are subject to being transported downslope or downstream. The size of the largest particle a stream can move under a given set of hydraulic conditions is referred to as *stream competence*. Often, only very high flows are competent to move the largest particles.

Closely related to stream competence is the concept of *tractive stress*, which creates lift and drag forces at the stream boundaries along the bed and banks. Tractive stress, also known as *shear stress*, varies as a function of flow depth and slope. Assuming constant density, shape, and surface roughness, the larger the particle, the greater the amount of tractive stress needed to dislodge it and move it downstream.

The energy that sets sediment particles into motion is derived from the effect of faster water flowing past slower water. This velocity gradient happens because the water in the main body of flow moves faster than water flowing at the boundaries. This is because bound-

Figure 2.13: Raindrop impact. *One of many types of erosion.*

aries are rough and create friction as flow moves over them which, in turn, slows flow.

The momentum of the faster water is transmitted to the slower boundary water. In doing so, the faster water tends to roll up the slower water in a spiral motion. It is this shearing motion, or shear stress, that also moves bed particles in a rolling motion downstream.

Particle movement on the channel bottom begins as a sliding or rolling motion, which transports particles along the streambed in the direction of flow (**Figure 2.14**). Some particles also may move above the bed surface by *saltation*, a skipping motion that occurs when one particle collides with another particle, causing it to bounce upward and then fall back toward the bed.

These rolling, sliding, and skipping motions result in frequent contact of the moving particles with the streambed and characterize the set of moving particles known as *bed load*. The weight of these particles relative to flow velocity causes them essentially to remain in contact with, and to be supported by, the streambed as they move downstream.

Table 2.2: Erosion processes.

Agent	Process
Raindrop impact	Sheet, interill
Surface water runoff	Sheet, interill, rill, ephemeral gully, classic gully
Channelized flow	Rill, ephemeral gully, classic gully, wind, streambank
Gravity	Classic gully, streambank, landslide, mass wasting
Wind	Wind
Ice	Streambank, lake shore
Chemical reactions	Solution, dispersion

Table 2.3: Erosion types vs. physical processes.

	Erosion/Physical Process			
Erosion Type	**Sheet**	**Concentrated Flow**	**Mass Wasting**	**Combination**
Sheet and rill	x	x		
Interill	x			
Rill	x	x		
Wind	x	x		
Ephemeral gully		x		
Classic gully		x	x	
Floodplain scour		x		
Roadside				x
Streambank		x	x	
Streambed		x		
Landslide			x	
Wave/shoreline				x
Urban, construction				x
Surface mine				x
Ice gouging				x

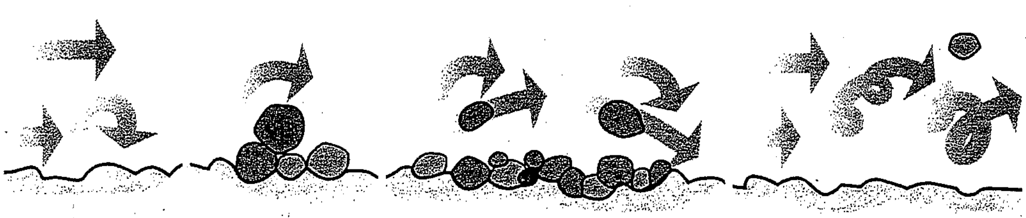


Figure 2.14: Action of water on particles near the streambed. *Processes that transport bed load sediments are a function of flow velocities, particle size, and principles of hydrodynamics.*
Source: *Water in Environmental Planning* by Dunne and Leopold © 1978 by W.H. Freeman and Company. Used with permission.

Wash Load and Bed-Material Load

One way to differentiate the sediment load of a stream is to characterize it based on the immediate source of the sediment in transport. The total sediment load in a stream, at any given time and location, is divided into two parts—wash load and bed-material load. The primary source of wash load is the watershed, including sheet and rill erosion, gully erosion, and upstream streambank erosion. The source of bed material load is primarily the streambed itself, but includes other sources in the watershed.

Wash load is composed of the finest sediment particles in transport. Turbulence holds the wash load in suspension. The concentration of wash load in suspension is essentially independent of hydraulic conditions in the stream and therefore cannot be calculated using measured or estimated hydraulic parameters such as velocity or discharge. Wash load concentration is normally a function of supply; i.e., the stream can carry as much wash load as the watershed and banks can deliver (for sediment concentrations below approximately 3000 parts per million).

Bed-material load is composed of the sediment of size classes found in the streambed. Bed-material load moves along the streambed by rolling, sliding, or jumping, and may be periodically entrained into the flow by turbulence, where it becomes a portion of the suspended load. Bed-material load is hydraulically controlled and can be computed using sediment transport equations discussed in Chapter 8.

Finer-grained particles are more easily carried into suspension by turbulent eddies. These particles are transported within the water column and are therefore called the *suspended load.* Although there may be continuous exchange of sediment between the bed load and suspended load of the river, as long as sufficient turbulence is present. Part of the suspended load may be colloidal clays, which can remain in suspension for very long time periods, depending on the type of clay and water chemistry.

Sediment Transport Terminology

Sediment transport terminology can sometimes be confusing. Because of this confusion, it is important to define some of the more frequently used terms.

- *Sediment load*, the quantity of sediment that is carried past any cross section of a stream in a specified period of time, usually a day or a year. *Sediment discharge*, the mass or volume of sediment passing a stream cross section in a unit of time. Typical units for sediment load are tons, while sediment discharge units are tons per day.
- *Bed-material load*, part of the total sediment discharge that is composed of sediment particles that are the same size as streambed sediment.
- *Wash load*, part of the total sediment load that is comprised of particle sizes finer than those found in the streambed.
- *Bed load*, portion of the total sediment load that moves on or near the streambed by saltation, rolling, or sliding in the bed layer.
- *Suspended bed material load*, portion of the bed material load that is transported in suspension in the water column. The suspended bed material load and the bed load comprise the total bed material load.
- *Suspended sediment discharge* (or *suspended load*), portion of the total sediment load that is transported in suspension by turbulent fluctuations within the body of flowing water.

- *Measured load*, portion of the total sediment load that is obtained by the sampler in the sampling zone.
- *Unmeasured load*, portion of the total sediment load that passes beneath the sampler, both in suspension and on the bed. With typical suspended sediment samplers this is the lower 0.3 to 0.4 feet of the vertical.

The above terms can be combined in a number of ways to give the total sediment load in a stream (**Table 2.4**). However, it is important not to combine terms that are not compatible. For example, the suspended load and the bed material load are not complimentary terms because the suspended load may include a portion of the bed material load, depending on the energy available for transport. The total sediment load is correctly defined by the combination of the following terms:

Total Sediment Load =

Bed Material Load + Wash Load

or

Bed Load + Suspended Load

or

Measured Load + Unmeasured Load

Sediment transport rates can be computed using various equations or models. These are discussed in the *Stream Channel Restoration* section of Chapter 8.

Table 2.4: Sediment load terms.

		Classification System	
		Based on Mechanism of Transport	Based on Particle Size
Total sediment load	Wash load	Suspended load	Wash load
	Suspended bed-material load		Bed-material load
	Bed load	Bed load	

Stream Power

One of the principal geomorphic tasks of a stream is to transport particles out of the watershed (**Figure 2.15**). In this manner, the stream functions as a transporting "machine;" and, as a machine, its rate of doing work can be calculated as the product of available power multiplied by efficiency.

Stream power can be calculated as:

$$\varphi = \gamma Q S$$

Where:

φ = Stream power (foot-lbs/second-foot)

γ = Specific weight of water (lbs/ft^3)

Q = Discharge (ft^3/second)

S = Slope (feet/feet)

Sediment transport rates are directly related to stream power; i.e., slope and discharge. Baseflow that follows the highly sinuous thalweg (the line that marks the deepest points along the stream channel) in a meandering stream generates little stream power; therefore, the stream's ability to move sediment, *sediment-transport capacity*, is limited. At greater depths, the flow follows a straighter course, which increases slope, causing increased sediment transport rates. The stream builds its cross section to obtain depths of flow and channel slopes that generate the sediment-transport capacity needed to maintain the stream channel.

Runoff can vary from a watershed, either due to natural causes or land use practices. These variations may change the size distribution of sediments delivered to the stream from the watershed by preferentially moving particular particle sizes into the stream. It is not uncommon to find a layer of sand on top of a cobble layer. This often happens when accelerated erosion of sandy soils

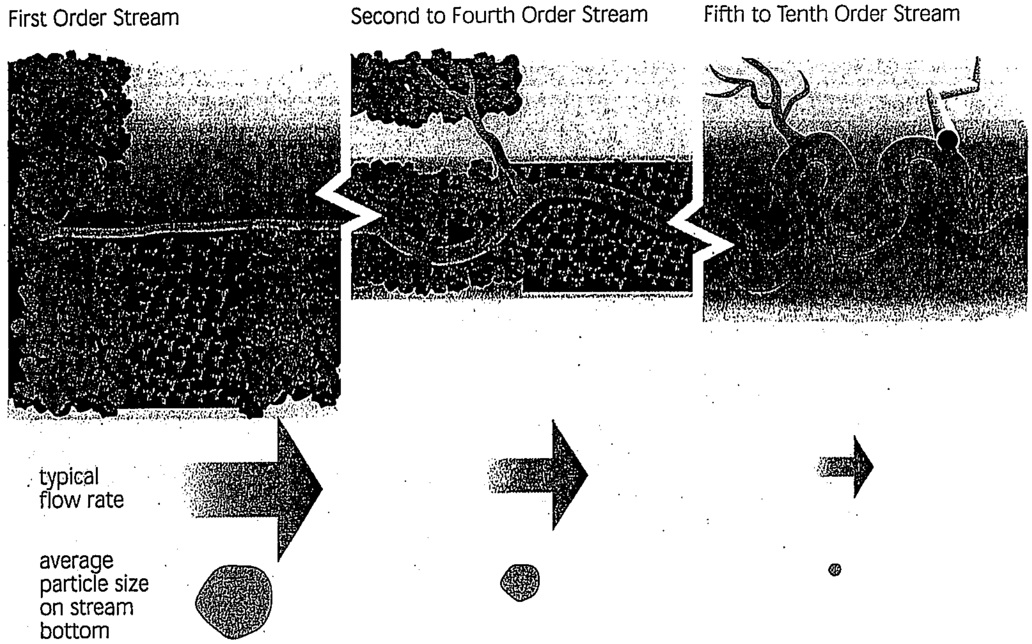


Figure 2.15: ***Particle transport.*** *A stream's total sediment load is the total of all sediment particles moving past a defined cross section over a specified time period. Transport rates vary according to the mechanism of transport.*

occurs in a watershed and the increased load of sand exceeds the transport capacity of the stream during events that move the sand into the channel.

Stream and Floodplain Stability

A question that normally arises when considering any stream restoration action is "Is it stable now and will it be stable after changes are made?" The answer may be likened to asking an opinion on a movie based on only a few frames from the reel. Although we often view streams based on a limited reference with respect to time, it is important that we consider the long-term changes and trends in channel cross section, longitudinal profile, and planform morphology to characterize channel stability.

Achieving channel stability requires that the average tractive stress maintains a stable streambed and streambanks. That is, the distribution of particle sizes in each section of the stream remains in equilibrium (i.e., new particles deposited are the same size and shape as particles displaced by tractive stress).

Yang (1971) adapted the basic theories described by Leopold to explain the longitudinal profile of rivers, the formation of stream networks, riffles, and pools, and river meandering. All these river characteristics and sediment transport are closely related. Yang (1971) developed the theory of average stream fall and the theory of least rate of energy expenditure, based on the entropy concept. These theories state that during the evolution toward an equilibrium condition, a natural stream chooses its course of flow in such a manner that the rate of potential energy expenditure per unit mass of flow along its course is a minimum.

Corridor Adjustments

Stream channels and their floodplains are constantly adjusting to the water and sediment supplied by the watershed. Successful restoration of degraded streams requires an understanding of watershed history, including both natural events and land use practices, and the adjustment processes active in channel evolution.

Channel response to changes in water and sediment yield may occur at differing times and locations, requiring various levels of energy expenditure. Daily changes in streamflow and sediment load result in frequent adjustment of bedforms and roughness in many streams with movable beds. Streams also adjust periodically to extreme high- and low-flow events, as floods not only remove vegetation but create and increase vegetative potential along the stream corridor (e.g., low flow periods allow vegetation incursion into the channel).

Similar levels of adjustment also may be brought about by changes in land use in the stream corridor and the upland watershed. Similarly, long-term changes in runoff or sediment yield from natural causes, such as climate change, wildfire, etc., or human causes, such as cultivation, overgrazing, or rural-to-urban conversions, may lead to long-term adjustments in channel cross section and planform that are frequently described as channel evolution.

Stream channel response to changes in flow and sediment load have been described qualitatively in a number of studies (e.g., Lane 1955, Schumm 1977). As discussed in Chapter 1, one of the earliest relationships proposed for explaining stream behavior was suggested by Lane (1955), who related mean annual streamflow (Q_w) and channel slope (S) to bed-material sediment load (Q_s) and median particle size on the streambed (D_{50}):

$$Q_s \cdot D_{50} \sim Q_w \cdot S$$

Lane's relationship suggests that a channel will be maintained in dynamic equilibrium when changes in sediment load and bed-material size are balanced by changes in streamflow or channel gradient. A change in one of these variables causes changes in one or more of the other variables such that dynamic equilibrium is reestablished.

Preview Section E for a further discussion of dynamic equilibrium.

Additional qualitative relationships have been proposed for interpreting behavior of alluvial channels. Schumm (1977) suggested that width (b), depth (d), and meander wavelength (L) are directly proportional, and that channel gradient (S) is inversely proportional to streamflow (Q_w) in an alluvial channel:

$$Q_w \sim \frac{b, d, L}{S}$$

Schumm (1977) also suggested that width (b), meander wavelength (L), and channel gradient (S) are directly proportional, and that depth (d) and sinuosity (P) are inversely proportional to sediment discharge (Q_s) in alluvial streams:

$$Q_s \sim \frac{b, L, S}{d, P}$$

The above two equations may be rewritten to predict direction of change in channel characteristics, given an increase or decrease in streamflow or sediment discharge:

$$Q_w^+ \sim b^+, d^+, L^+, S^-$$

$$Q_w^- \sim b^-, d^-, L^-, S^+$$

$$Q_s^+ \sim b^+, d^-, L^+, S^+, P^-$$

$$Q_s^- \sim b^-, d^+, L^-, S^-, P^+$$

Combining the four equations above yields additional predictive relationships for concurrent increases or decreases in streamflow and/or sediment discharge:

$$Q_w^+Q_s^+ \sim b^+, d^{+/-}, L^+, S^{+/-}, P^-$$

$$Q_w^-Q_s^- \sim b^-, d^{+/-}, L^-, S^{+/-}, P^+$$

$$Q_w^+Q_s^- \sim b^{+/-}, d^+, L^{+/-}, S^-, P^+$$

$$Q_w^-Q_s^+ \sim b^{+/-}, d^-, L^{+/-}, S^+, P^-$$

Channel Slope

Channel slope, a stream's longitudinal profile, is measured as the difference in elevation between two points in the stream divided by the stream length between the two points. Slope is one of the most critical pieces of design information required when channel modifications are considered. Channel slope directly impacts flow velocity, stream competence, and stream power. Since these attributes drive the geomorphic processes of erosion, sediment transport, and sediment deposition, channel slope becomes a controlling factor in channel shape and pattern.

(See Figs. 1-27 and 1-28)

Most longitudinal profiles of streams are concave upstream. As described previously in the discussion of dynamic equilibrium, streams adjust their profile and pattern to try to minimize the time rate of expenditure of potential energy, or stream power, present in flowing water. The concave upward shape of a stream's profile appears to be due to adjustments a river makes to help minimize stream power in a downstream direction. Yang (1983) applied the theory of minimum stream power to explain why most longitudinal streambed profiles are concave upward. In order to satisfy the theory of minimum stream power, which is a special case of the general theory of minimum energy dissipation rate (Yang and Song 1979), the following equation must be satisfied:

$$\frac{dP}{dx} = \gamma Q \quad \frac{dS}{dx} + S \frac{dQ}{dx} = 0$$

Where:

P = QS = Stream power

x = Longitudinal distance

Q = Water discharge

S = Water surface or energy slope

γ = Specific weight of water

Stream power has been defined as the product of discharge and slope. Since stream discharge typically increases in a downstream direction, slope must decrease in order to minimize stream power. The decrease in slope in a downstream direction results in the concave-up longitudinal profile.

Sinuosity is not a profile feature, but it does affect stream slope. Sinuosity is the stream length between two points on a stream divided by the valley length between the two points. For example, if a stream is 2,200 feet long from point A to point B, and if a valley length distance between those two points is 1,000 feet, that stream has a sinuosity of 2.2. A stream can increase its length by increasing its sinuosity, resulting in a decrease in slope. This impact of sinuosity on channel slope must always be considered if channel reconstruction is part of a proposed restoration.

Pools and Riffles

The longitudinal profile is seldom constant, even over a short reach. Differences in geology, vegetation patterns, or human disturbances can result in flatter and steeper reaches within an overall profile. Riffles occur where the stream bottom is higher relative to streambed elevation immediately upstream or downstream. These relatively deeper areas are considered pools. At normal flow, flow velocities decrease in pool areas, allowing fine grained deposition to occur, and increase atop riffles due to the increased bed slope between the riffle crest and the subsequent pool.

Longitudinal Profile Adjustments

A common example of profile adjustment occurs when a dam is constructed on a stream. The typical response to dam construction is channel degradation downstream and aggradation upstream. However, the specific response is quite complex as can be illustrated by considering Lane's relation. Dams typically reduce peak discharges and sediment supply in the downstream reach. According to Lane's relation, a decrease in discharge (Q) should be offset by an increase in slope, yet the decrease in sediment load (Q_s) should cause a decrease in slope. This response could be further complicated if armoring occurs (D_{50}+), which would also cause an increase in slope. Impacts are not limited to the main channel, but can include aggradation or degradation on tributaries as well. Aggradation often occurs at the mouths of tributaries downstream of dams (and sometimes in the entire channel) due to the reduction of peak-flows on the main stem. Obviously, the ultimate response will be the result of the integration of all these variables.

Channel Cross Sections

Figure 2.16 presents the type of information that should be recorded when collecting stream cross section data. In stable alluvial streams, the high points on each bank represent the top of the bankfull channel.

The importance of the bankfull channel has been established. Channel cross sections need to include enough points to define the channel in relation to a portion of the floodplain on each side. A suggested guide is to include at least one stream width beyond the highest point on each bank for smaller stream corridors and at least enough of the floodplain on larger streams to clearly define its character in relation to the channel.

In meandering streams, the channel cross section should be measured in areas of riffles or crossovers. A riffle or crossover occurs between the apexes of two sequential meanders. The effects of differences in resistance to erosion of soil layers are prominent in the outside bends of meanders, and point bars on the insides of the meanders are constantly adjusting to the water and sediment loads being moved by the stream. The stream's cross section changes much more rapidly and frequently in the meander bends. There is more variability in pool cross sections than in riffle cross sections. The cross section in the crossover or riffle area is more uniform.

Resistance to Flow and Velocity

Channel slope is an important factor in determining streamflow velocity. Flow velocity is used to help predict what discharge a cross section can convey. As discharge increases, either flow velocity, flow area, or both must increase.

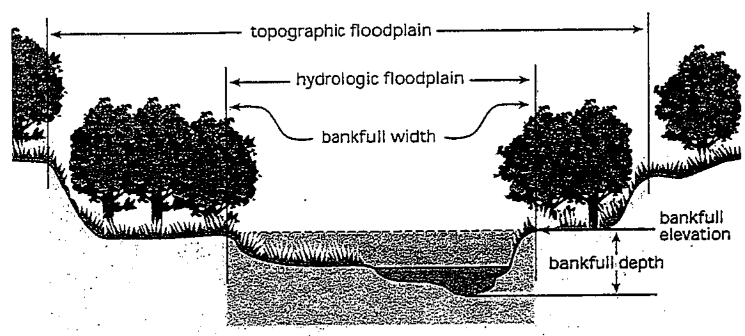


***Figure 2.16:* Channel cross section.** *Information to record when collecting stream cross section data.*

Roughness plays an important r ole in streams. It helps determine the depth or stage of flow in a stream reach. As flow velocity slows in a stream reach due to roughness, the depth of flow has to increase to maintain the volume of flow that entered the upstream end of the reach (a concept known as flow continuity). Typical roughness along the boundaries of the stream includes the following:

- Sediment particles of different sizes.
- Bedforms.
- Bank irregularities.
- The type, amount, and distribution of living and dead vegetation.
- Other obstructions.

Roughness generally increases with increasing particle size. The shape and size of instream sediment deposits, or bedforms, also contribute to roughness.

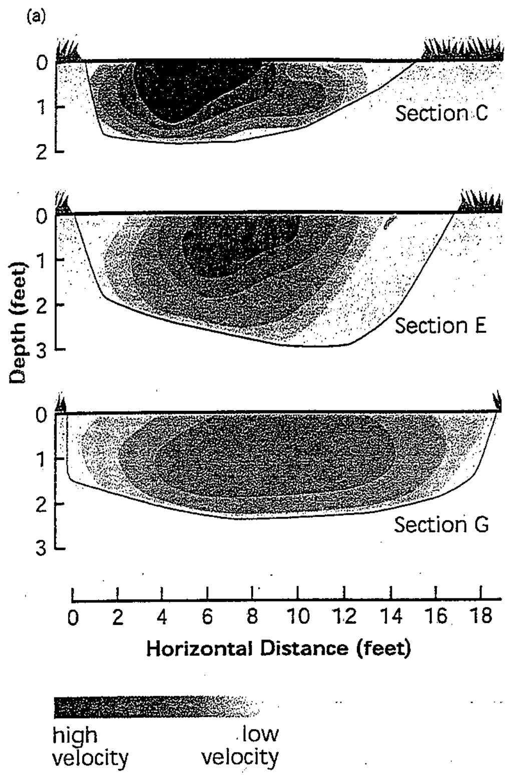
Sand-bottom streams are good examples of how bedform roughness changes with discharge. At very low discharges, the bed of a sand stream may be dominated by ripple bedforms. As flow increases even more, sand dunes may begin to appear on the bed. Each of these bedforms increases the roughness of the stream bottom, which tends to slow velocity.

The depth of flow also increases due to increasing roughness. If discharge continues to increase, a point is reached when the flow velocity mobilizes the sand on the streambed and the entire bed converts again to a planar form. The depth of flow may actually decrease at this point due to the decreased roughness of the bed. If discharge increases further still, antidunes may form. These bedforms create enough friction to again cause the flow depth to increase. The depth of flow for a given discharge in sand-bed streams, therefore, depends on the bedforms present when that discharge occurs.

Vegetation can also contribute to roughness. In streams with boundaries consisting of cohesive soils, vegetation is usually the principal component of roughness. The type and distribution of vegetation in a stream corridor depends on hydrologic and geomorphic processes, but by creating roughness, vegetation can alter these processes and cause changes in a stream's form and pattern.

Meandering streams offer some resistance to flow relative to straight streams. Straight and meandering streams also have different distributions of flow velocity that are affected by the alignment of the stream, as shown in **Figure 2.17**. In straight reaches of a stream, the fastest flow occurs just below the surface near the center of the channel where flow resistance is lowest (see Figure 2.17 (a) Section G). In meanders, velocities are highest at the outside edge due to angular momentum (see Figure 2.17 (b) Section 3). The differences in flow velocity distribution in meandering streams result in both erosion and deposition at the meander bend. Erosion occurs at the outside of bends (cutbanks) from high velocity flows, while the slower velocities at the insides of bends cause deposition on the point bar (which also has been called the *slip-off slope*).

The angular momentum of flow through a meander bend increases the height or *super elevation* at the outside of the bend and sets up a secondary current of flow down the face of the cut bank and across the bottom of the pool toward the inside of the bend. This rotating flow is called *helical flow* and the direction of rotation is illustrated on the diagram on the following page by the arrows at the top and bottom of cross sections 3 and 4 in the figure.



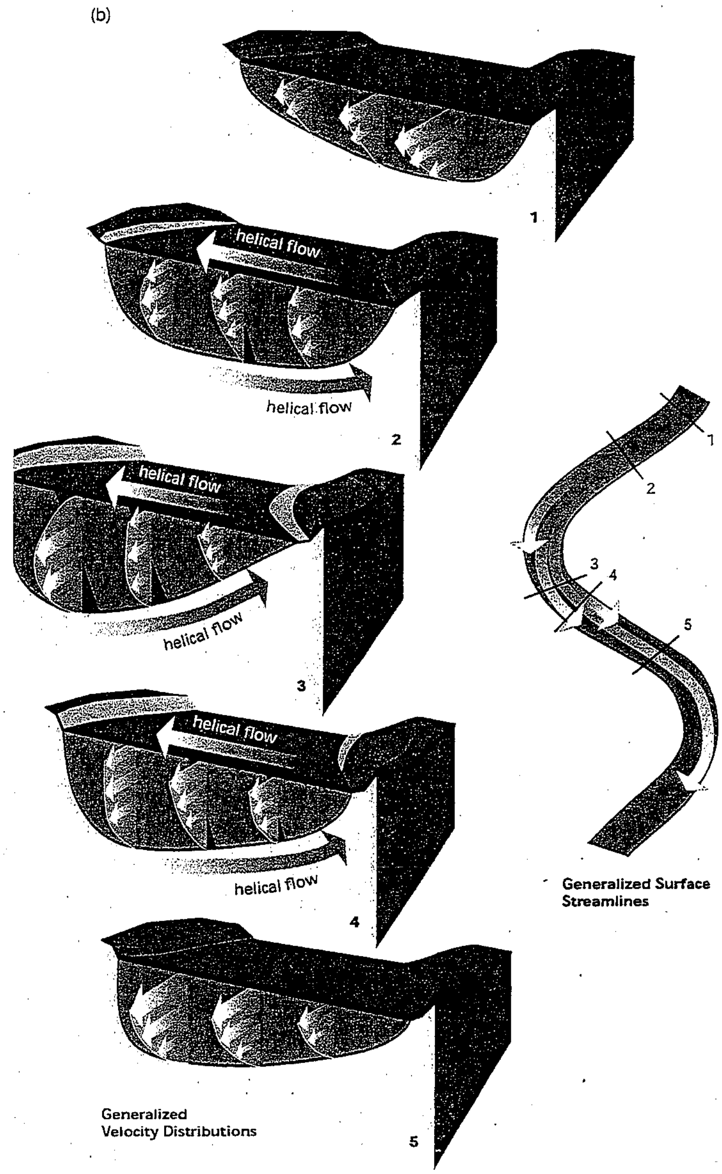


Figure 2.17: Velocity distribution in a (a) straight stream branch and a (b) stream meander. *Stream flow velocities are different through pools and riffles, in straight and curved reaches, across the stream at any point, and at different depths. Velocity distribution also differs dramatically from baseflow conditions through bankfull flows, and flood flows.* Source: Leopold et al. 1964. Published by permission of Dover Publications.

The distribution of flow velocities in straight and meandering streams is important to understand when planning and designing modifications in stream alignment in a stream corridor restoration. Areas of highest velocities generate the most stream power, so where such velocities intersect the stream boundaries indicates where more durable protection may be needed.

As flow moves through a meander, the bottom water and detritus in the pool are rotated to the surface. This rotation is an important mechanism in moving drifting and benthic organisms past predators in pools. Riffle areas are not as deep as pools, so more turbulent flows occur in these shallow zones. The turbulent flow can increase the dissolved oxygen content of the water and may also increase the oxidation and volatilization of some chemical constituents in water.

Another extremely important function of roughness elements is that they create aquatic habitat. As one example, the deepest flow depths usually occur at the base of cutbanks. These scour holes or pools create very different habitat than occurs in the depositional environment of the slip-off slope.

Active Channels and Floodplains

Floodplains are built by two stream processes, lateral and vertical accretion. Lateral accretion is the deposition of sediment on point bars on the insides of bends of the stream. The stream laterally migrates across the floodplain as the outside of the meander bend erodes and the point bar builds with coarse-textured sediment. This naturally occurring process maintains the cross section needed to convey water and sediment from the watershed. Vertical accretion is the deposition of sediment on flooded surfaces. This sediment generally is finer textured than point bar sediments and is considered to be an overbank deposit. Vertical accretion occurs on top of the lateral accretion deposits in the point bars; however, lateral accretion is the dominant process. It typically makes up 60 to 80 percent of the total sediment deposits in floodplains (Leopold et al. 1964). It is apparent that lateral migration of meanders is an important natural process since it plays a critical role in reshaping floodplains.

2C Physical and Chemical Characteristics

The quality of water in the stream corridor might be a primary objective of restoration, either to improve it to a desired condition or to sustain it. Establishing an appropriate flow regime and geomorphology in a stream corridor may do little to ensure a healthy ecosystem if the physical and chemical characteristics of the water are inappropriate. For example, a stream containing high concentrations of toxic materials or in which high temperatures, low dissolved oxygen, or other physical/chemical characteristics are inappropriate cannot support a healthy stream corridor. Conversely, poor condition of the stream corridor—such as lack of riparian shading, poor controls on erosion, or excessive sources of nutrients and oxygen-demanding waste—can result in degradation of the physical and chemical conditions within the stream.

This section briefly surveys some of the key physical and chemical characteristics of flowing waters. Stream water quality is a broad topic on which many books have been written. The focus here is on a few key concepts that are relevant to stream corridor restoration. The reader is referred to other sources (e.g., Thomann and Mueller 1987, Mills et al. 1985) for a more detailed treatment.

As in the previous sections, the physical and chemical characteristics of streams are examined in both the lateral and longitudinal perspectives. The lateral perspective refers to the influence of the watershed on water quality, with particular attention to riparian areas. The longitudinal perspective refers to processes that affect water quality during transport instream.

Physical Characteristics

Sediment

Section 2.B discussed total sediment loads in the context of the evolution of stream form and geomorphology. In addition to its role in shaping stream form, suspended sediment plays an important role in water quality, both in the water column and at the sediment-water interface. In a water quality context, sediment usually refers to soil particles that enter the water column from eroding land. Sediment consists of particles of all sizes, including fine clay particles, silt, and gravel. The term sedimentation is used to describe the deposition of sediment particles in waterbodies.

Although sediment and its transport occur naturally in any stream, changes in sediment load and particle size can have negative impacts (**Figure 2.18**). Fine sediment can severely alter aquatic communities. Sediment may clog and abrade fish gills, suffocate eggs and aquatic insect larvae on the bottom, and fill in the pore space between bottom cobbles where fish lay eggs. Sediment interferes with recreational activities and aesthetic enjoyment at waterbodies by reducing water clarity and filling in waterbodies. Sediment also may carry other pollutants into waterbodies. Nutrients and toxic chemicals may attach to sediment particles on land and ride the particles into surface waters where the pollutants may settle with the sediment or become soluble in the water column.

Studies have shown that fine sediment intrusion can significantly impact the quality of spawning habitat (Cooper 1965, Chapman 1988). Fine sediment intrusion into streambed gravels can reduce permeability and intragravel water velocities, thereby restricting the supply of oxygenated water to developing salmonid embryos and the removal of their metabolic wastes. Excessive fine sediment deposition can effectively smother incubating eggs and entomb alevins and fry. A sediment intrusion model (Alonso et al. 1996) has been developed, verified, and validated to predict the within-redd (spawning area) sediment accumulation and dissolved oxygen status.

Sediment Across the Stream Corridor

Rain erodes and washes soil particles off plowed fields, construction sites, logging sites, urban areas, and strip-mined lands into waterbodies. Eroding streambanks also deposit sediment into waterbodies. In sum, sediment quality in the stream represents the net result of erosion processes in the watershed.

The lateral view of sediment is discussed in more detail in Section 2.B. It is worth noting, however, that from a water quality perspective, interest may focus on specific fractions of the sediment load. For instance, controlling fine sediment load is often of particular concern for restoration of habitat for salmonid fish.

Restoration efforts may be useful for controlling loads of sediment and sediment-associated pollutants from the watershed to streams. These may range from efforts to reduce upland erosion to treatments that reduce sediment delivery through the riparian zone. Design of restoration treatments is covered in Chapter 8.

Figure 2.18: Stream sedimentation. *Although sediment and its transport occur naturally, changes in sediment load and particle size have negative impacts.*

Preview Section D for more detail on the effects of cover on water temperature.

Sediment Along the Stream Corridor

The longitudinal processes affecting sediment transport from a water quality perspective are the same as those discussed from a geomorphic perspective in Section 2.B. As in the lateral perspective, interest from a water quality point of view may be focused on specific sediment size fractions, particularly the fine sediment fraction, because of its effect on water quality, water temperature, habitat, and biota.

Water Temperature

Water temperature is a crucial factor in stream corridor restoration for a number of reasons. First, dissolved oxygen solubility decreases with increasing water temperature, so the stress imposed by oxygen-demanding waste increases with higher temperatures. Second, temperature governs many biochemical and physiological processes in cold-blooded aquatic organisms, and increased temperatures can increase metabolic and reproductive rates throughout the food chain. Third, many aquatic species can tolerate only a limited range of temperatures, and shifting the maximum and minimum temperatures within a stream can have profound effects on species composition. Finally, temperature also affects many abiotic chemical processes, such as reaeration rate, sorption of organic chemicals to particulate matter, and volatilization rates. Temperature increases can lead to increased stress from toxic compounds, for which the dissolved fraction is usually the most bioactive fraction.

Water Temperature Across the Stream Corridor

Water temperature within a stream reach is affected by the temperature of water upstream, processes within the stream reach, and the temperature of influent water. The lateral view addresses the effects of the temperature of influent water.

The most important factor for temperature of influent water within a stream reach is the balance between water arriving via surface and ground water pathways. Water that flows over the land surface to a stream has the opportunity to gain heat through contact with surfaces heated by the sun. In contrast, ground water is usually cooler in summer and tends to reflect average annual temperatures in the watershed. Water flow via shallow ground water pathways may lie between the average annual temperature and ambient temperatures during runoff events.

Both the fraction of runoff arriving via surface pathways and the temperature of surface runoff are strongly affected by the amount of impervious surfaces within a watershed. For example, hot paved surfaces in a watershed can heat surface runoff and significantly increase the temperature of streams that receive the runoff.

Water Temperature Along the Stream Corridor

Water also is subject to thermal loading through direct effects of sunlight on streams. For the purposes of restoration, land use practices that remove overhead cover or that decrease baseflows can increase instream temperatures to levels that exceed critical thermal maxima for fishes (Feminella and Matthews 1984). Maintaining or restoring normal temperature ranges can therefore be an important goal for restoration.

Chemical Constituents

Previous chapters have discussed the physical journey of water as it moves through the hydrologic cycle. Rain percolates to the ground water table or becomes overland flow, streams collect this water and route it toward the ocean, and evapotranspiration occurs throughout the cycle. As water makes this journey, its chemistry changes. While in the air, water equilibrates with atmospheric gases. In shallow soils, it undergoes chemical exchanges with inorganic and organic matter and with soil gases. In ground water, where transit times are longer, there are more opportunities for minerals to dissolve. Similar chemical reactions continue along stream corridors. Everywhere, water interacts with everything it touches—air, rocks, bacteria, plants, and fish—and is affected by human disturbances.

Scientists have been able to define several interdependent cycles for many of the common dissolved constituents in water. Central among these cycles is the behavior of oxygen, carbon, and nutrients, such as nitrogen (N), phosphorus (P), sulfur (S), and smaller amounts of common trace elements.

Iron, for example, is an essential element in the metabolism of animals and plants. Iron in aquatic systems may be present in one of two oxidation states. Ferric iron (Fe^{3+}) is the more oxidized form and is very sparingly soluble in water. The reduced form, ferrous iron (Fe^{2+}), is more soluble by many orders of magnitude. In many aquatic systems, such as lakes for example, iron can cycle from the ferric state to the ferrous state and back again (**Figure 2.19**). The oxidation of ferrous iron followed by the precipitation of ferric iron results in iron coatings on the surfaces of some stream sediments. These coatings, along with organic coatings, play a substantial role in the aquatic chemistry of toxic trace elements and toxic organic chemicals. The chemistry of toxic organic chemicals and metals, along with the cycling and chemistry of oxygen, nitrogen, and phosphorus, will be covered later in this section.

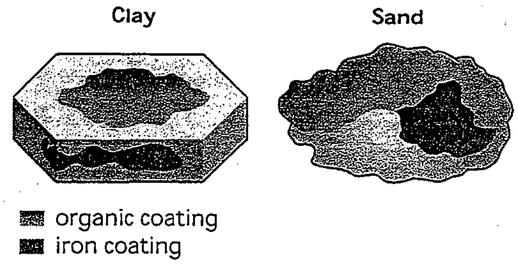


Figure 2.19: ***The organic coatings on suspended sediment from streams.*** *Water chemistry determines whether sediment will carry adsorbed materials or if stream sediments will be coated.*

The total concentration of all dissolved ions in water, also known as salinity, varies widely. Precipitation typically contains only a few parts per thousand (ppt) of dissolved solids, while the salinity of seawater averages about 35 ppt (**Table 2.5**). The concentration of dissolved solids in freshwater may vary from only 10 to 20 mg/L in a pristine mountain stream to several hundred mg/L in many rivers. Concentrations may exceed 1,000 mg/L in arid watersheds. A dissolved solids concentration of less than 500 mg/L is recommended for public drinking water, but this threshold is exceeded in many areas of the country. Some crops (notably fruit trees and beans) are sensitive to even modest salinity, while other crops, such as cotton, barley, and beets, tolerate high concentrations of dissolved solids. Agricultural return water from irrigation may increase salinity in streams, particularly in the west. Recommended salinity limits for livestock vary from 2,860 mg/L for poultry to 12,900 mg/L for adult sheep. Plants, fish, and other aquatic life also vary widely in their adaptation to different concentrations of dissolved solids. Most species have a maximum salinity tolerance, and few can live in very pure water of very low ionic concentration.

ble 2.5: mposition, in milrams per liter, of ain and snow.

	Samples					
Constituent	1	2	3	4	5	6
SiO_2	0.0		1.2	0.3		0.1
Al	.01					
Fe	.00					.015
Ca	.0	.65	1.2	.8	1.41	.075
Mg	.2	.14	.7	1.2		.027
Na	.6	.56	.0	9.4	.42	.220
K	.6	.11	.0	.0		.072
NH_4	.0					
HCO_3	3		7	4		
SO_4	1.6	2.18	.7	7.6	2.14	1.1
Cl	.2	.57	.8	17	.22	
NO_2	.02		.00	.02		
NO_3	.1	.62	.2	.0		
Total dissolved solids	4.8		8.2	38		
pH	5.6		6.4	5.5		4.9

1. Snow, Spooner Summit. U.S. Highway 50, Nevada (east of Lake Tahoe) (Feth, Rogers, and Roberson, 1964).
2. Average composition of rain, August 1962 to July 1963, at 27 points in North Carolina and Virginia (Gambell and Fisher, 1966).
3. Rain, Menlo Park, Calif., 7:00 p.m. Jan. 9 to 8:00 a.m. Jan 10, 1958 (Whitehead and Feth, 1964).
4. Rain, Menlo Park, Calif., 8:00 a.m. to 2:00 p.m. Jan 10, 1958 (Whitehead and Feth, 1964).
5. Average for inland sampling stations in the United States for 1 year. Data from Junge and Werby (1958), as reported by Whitehead and Feth (1964).
6. Average composition of precipitation, Williamson Creek, Snohomish County, Wash., 1973-75. Also reported: As, 0.00045 mg/L; Cu 0.0025 mg/L; Pb, 0.0033 mg/L; Zn, 0.0036 mg/L (Delthier, D.P., 1977, Ph.D. thesis. University of Washington, Seattle).

pH, Alkalinity, and Acidity

Alkalinity, acidity, and buffering capacity are important characteristics of water that affect its suitability for biota and influence chemical reactions. The acidic or basic (alkaline) nature of water is commonly quantified by the negative logarithm of the hydrogen ion concentration, or pH. A pH value of 7 represents a neutral condition; a pH value less than 5 indicates moderately acidic conditions; a pH value greater than 9 indicates moderately alkaline conditions. Many biological processes, such as reproduction, cannot function in acidic or alkaline waters. In particular, aquatic organisms may suffer an osmotic imbalance under sustained exposure to low pH waters. Rapid fluctuations in pH also can stress aquatic organisms. Finally, acidic conditions also can aggravate toxic contamination problems through increased solubility, leading to the release of toxic chemicals stored in stream sediments.

pH, Alkalinity, and Acidity Across the Stream Corridor

The pH of runoff reflects the chemical characteristics of precipitation and the land surface. Except in areas with significant ocean spray, the dominant ion in most precipitation is bicarbonate (HCO_3^-). The bicarbonate ion is produced by carbon dioxide reacting with water:

$$H_2O + CO_2 = H^+ + HCO_3^-$$

This reaction also produces a hydrogen ion (H^+), thus increasing the hydrogen ion concentration and acidity and lowering the pH. Because of the presence of CO_2 in the atmosphere, most rain is naturally slightly acidic, with a pH of about 5.6. Increased acidity in rainfall can be caused by inputs, particularly from burning fossil fuels.

As water moves through soils and rocks, its pH may increase or decrease as additional chemical reactions occur. The carbonate buffering system controls the acidity of most waters. Carbonate buffering results from chemical equilibrium between calcium, carbonate, bicarbonate, carbon dioxide, and hydrogen ions in the water and carbon dioxide in the atmosphere. Buffering causes waters to resist changes in pH (Wetzel 1975). Alkalinity refers to the acid-neutralizing capacity of water and usually refers to those compounds that shift the pH in an alkaline direction (APHA 1995, Wetzel 1975). The amount of buffering is related to the alkalinity and primarily determined by carbonate and bicarbonate concentration, which are introduced into the water from dissolved calcium carbonate (i.e., limestone) and similar minerals present in the watershed. For example, when an acid interacts with limestone, the following dissolution reaction occurs:

$$H^+ + CaCO_3 = Ca^{2+} + HCO_3^-$$

This reaction consumes hydrogen ions, thus raising the pH of the water. Conversely, runoff may acidify when all alkalinity in the water is consumed by acids, a process often attributed to the input of strong mineral acids, such as sulfuric acid, from acid mine drainage, and weak organic acids, such as humic and fulvic acids, which are naturally produced in large quantities in some types of soils, such as those associated with coniferous forests, bogs, and wetlands. In some streams, pH levels can be increased by restoring degraded wetlands that intercept acid inputs, such as acid mine drainage, and help neutralize acidity by converting sulfates from sulfuric acid to insoluble nonacidic metal sulfides that remain trapped in wetland sediments.

pH, Alkalinity, and Acidity Along the Stream Corridor

Within a stream, similar reactions occur between acids in the water, atmospheric CO_2, alkalinity in the water column, and streambed material. An additional characteristic of pH in some poorly buffered waters is high daily variability in pH levels attributable to biological processes that affect the carbonate buffering system. In waters with large standing crops of aquatic plants, uptake of carbon dioxide by plants during photosynthesis removes carbonic acid from the water, which can increase pH by several units. Conversely, pH levels may fall by several units during the night when photosynthesis does not occur and plants give off carbon dioxide. Restoration techniques that decrease instream plant growth through increased shading or reduction in nutrient loads or that increase reaeration also tend to stabilize highly variable pH levels attributable to high rates of photosynthesis.

The pH within streams can have important consequences for toxic materials. High acidity or high alkalinity and oxidizing conditions tend to convert insoluble metal sulfides soluble forms and can increase the concentration of toxic metals. Conversely, high pH can promote ammonia toxicity. Ammonia is present in water in two forms, unionized (NH_3) and ionized (NH_4^+). Of these two forms of ammonia, un-ionized ammonia is relatively highly toxic to aquatic life, while ionized ammonia is relatively negligibly toxic. The proportion of un-ionized ammonia is determined by the pH and temperature of the water (Bowie et al. 1985)—as pH or temperature increases, the proportion of un-ionized ammonia and the toxicity also increase. For example, with a pH of 7 and a temperature of 68°F, only about 0.4 percent of the total ammonia is in the un-ionized form, while at a pH of 8.5 and a temperature of 78°F, 15 percent of the total ammonia is in the un-ionized form, representing 35 times greater potential toxicity to aquatic life.

Dissolved Oxygen

Dissolved oxygen (DO) is a basic requirement for a healthy aquatic ecosystem. Most fish and aquatic insects "breathe" oxygen dissolved in the water column. Some fish and aquatic organisms, such as carp and sludge worms, are adapted to low oxygen conditions, but most sport fish species, such as trout and salmon, suffer if DO concentrations fall below a concentration of 3 to 4 mg/L. Larvae and juvenile fish are more sensitive and require even higher concentrations of DO (USEPA 1997).

Many fish and other aquatic organisms can recover from short periods of low

Preview Section D for more information on DO.

DO in the water. However, prolonged episodes of depressed dissolved oxygen concentrations of 2 mg/L or less can result in "dead" waterbodies. Prolonged exposure to low DO conditions can suffocate adult fish or reduce their reproductive survival by suffocating sensitive eggs and larvae, or can starve fish by killing aquatic insect larvae and other prey. Low DO concentrations also favor anaerobic bacteria that produce the noxious gases or foul odors often associated with polluted waterbodies.

Water absorbs oxygen directly from the atmosphere, and from plants as a result of photosynthesis. The ability of water to hold oxygen is influenced by temperature and salinity. Water loses oxygen primarily by respiration of aquatic plants, animals, and microorganisms. Due to their shallow depth, large surface exposure to air, and constant motion, undisturbed streams generally contain an abundant DO supply. However, external loads of oxygen-demanding wastes or excessive plant growth induced by nutrient loading followed by death and decomposition of vegetative material can deplete oxygen.

Dissolved Oxygen Across the Stream Corridor

Oxygen concentrations in the water column fluctuate under natural conditions, but oxygen can be severely depleted as a result of human activities that introduce large quantities of biodegradable organic materials into surface waters. Excess loading of nutrients also can deplete oxygen when plants within a stream produce large quantities of plant biomass.

Loads of oxygen-demanding waste usually are reported as *biochemical oxygen demand (BOD)*. BOD is a measure of the amount of oxygen required to oxidize organic material in water by biological activity. As such, BOD is an equivalent indicator rather than a true physical or chemical substance. It measures the total concentration of DO that eventually would be demanded as wastewater degrades in a stream.

BOD also is often separated into carbonaceous and nitrogenous components. This is because the two fractions tend to degrade at different rates. Many water quality models for dissolved oxygen require as input estimates of ultimate carbonaceous BOD ($CBOD_u$) and either ultimate nitrogenous BOD ($NBOD_u$) or concentrations of individual nitrogen species.

Oxygen-demanding wastes can be loaded to streams by point source discharges, nonpoint loading, and ground water. BOD loads from major point sources typically are controlled and monitored and thus are relatively easy to analyze. Nonpoint source loads of BOD are much more difficult to analyze. In general, any loading of organic material from a watershed to a stream results in an oxygen demand. Excess loads of organic material may arise from a variety of land use practices, coupled with storm events, erosion, and washoff. Some agricultural activities, particularly large-scale animal operations and improper manure application, can result in significant BOD loads. Land-disturbing activities of silviculture and construction can result in high organic loads through the erosion of organic topsoil. Finally, urban runoff often is loaded with high concentrations of organic materials derived from a variety of sources.

Dissolved Oxygen Along the Stream Corridor

Within a stream, DO content is affected by reaeration from the atmosphere, production of DO by aquatic plants as a by-product of photosynthesis, and consumption of DO in respiration by plants, animals, and, most importantly, microorganisms.

Major processes affecting the DO balance within a stream are summarized in Figure 2.20. This includes the following components:

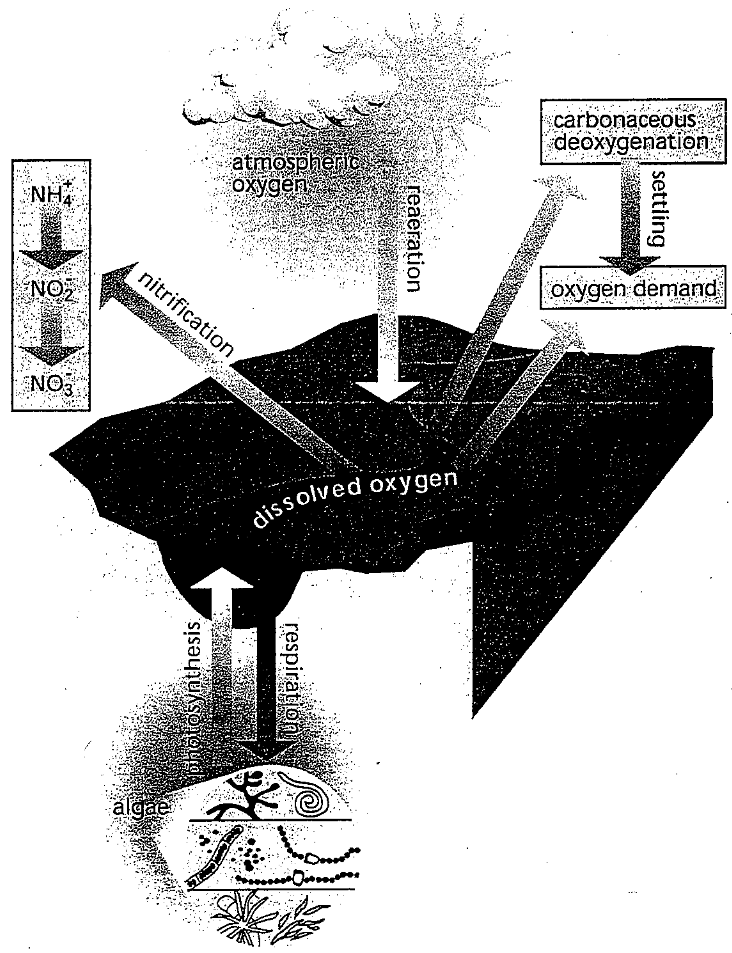
- Carbonaceous deoxygenation
- Nitrogenous deoxygenation (nitrification)
- Reaeration
- Sediment oxygen demand
- Photosynthesis and respiration of plants.

Reaeration is the primary route for introducing oxygen into most waters. Oxygen gas (O_2) constitutes about 21 percent of the atmosphere and readily dissolves in water. The saturation concentration of DO in water is a measure of the maximum amount of oxygen that water can hold at a given temperature. When oxygen exceeds the saturation concentration, it tends to degas to the atmosphere. When oxygen is below the saturation concentration, it tends to diffuse from the atmosphere to water. The saturation concentration of oxygen decreases with temperature according to a complex power function equation (APHA 1995). In addition to temperature, the saturation concentration is affected by water salinity and the atmospheric pressure. As the salinity of water increases, the saturation concentration decreases. As the atmospheric pressure increases the saturation concentration also increases.

Interactions between atmospheric and DO are driven by the partial pressure gradient in the gas phase and the concentration gradient in the liquid phase (Thomann and Mueller 1987). Turbulence and mixing in either phase decrease these gradients and increase reaeration, while a quiescent, stagnant surface or films on the surface reduce reaeration. In general, oxygen transfer in natural waters depends on the following:

- Internal mixing and turbulence due to velocity gradients and fluctuation
- Temperature
- Wind mixing
- Waterfalls, dams, and rapids
- Surface films
- Water column depth.

Figure 2.20: Interrelationship of major kinetic processes for BOD and DO as represented by water quality models. *Complex, interacting physical and chemical processes can sometimes be simplified by models in order to plan a restoration.*



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Stream restoration techniques often take advantage of these relationships, for instance by the installation of artificial cascades to increase reaeration. Many empirical formulations have been developed for estimating stream reaeration rate coefficients; a detailed summary is provided in Bowie et al. (1985).

In addition to reaeration, oxygen is produced instream by aquatic plants. Through photosynthesis, plants capture energy from the sun to fix carbon dioxide into reduced organic matter:

$$6\ CO_2 + 6\ H_2O = C_6H_{12}O_6 + 6\ O_2$$

Note that photosynthesis also produces oxygen. Plants utilize their simple photosynthetic sugars and other nutrients (notably nitrogen [N], phosphorus [P], and sulfur [S] with smaller amounts of several common and trace elements) to operate their metabolism and to build their structures.

Most animal life depends on the release of energy stored by plants in the photosynthetic process. In a reaction that is the reverse of photosynthesis, animals consume plant material or other animals and oxidize the sugars, starches, and proteins to fuel their metabolism and build their own structure. This process is known as respiration and consumes dissolved oxygen. The actual process of respiration involves a series of energy converting oxidation-reduction reactions. Higher animals and many microorganisms depend on sufficient dissolved oxygen as the terminal electron acceptor in these reactions and cannot survive without it. Some microorganisms are able to use other compounds (such as nitrate and sulfate) as electron acceptors in metabolism and can survive in anaerobic (oxygen-depleted) environments.

Detailed information on analysis and modeling of DO and BOD in streams is contained in a number of references (e.g., Thomann and Mueller 1987), and a variety of well-tested computer models are available. Most stream water quality models account for CBOD in the water column separately from NBOD (which is usually represented via direct mass balance of nitrogen species) and *sediment oxygen demand* or *SOD*. SOD represents the oxygen demand of sediment organism respiration and the benthic decomposition of organic material. The demand of oxygen by sediment and benthic organisms can, in some instances, be a significant fraction of the total oxygen demand in a stream. This is particularly true in small streams. The effects may be particularly acute during low-flow and high-temperature conditions, as microbial activity tends to increase with increased temperature.

The presence of toxic pollutants in the water column can indirectly lower oxygen concentrations by killing algae, aquatic weeds, or fish, which provide an abundance of food for oxygen-consuming bacteria. Oxygen depletion also can result from chemical reactions that do not involve bacteria. Some pollutants trigger chemical reactions that place a chemical oxygen demand on receiving waters.

Nutrients

In addition to carbon dioxide and water, aquatic plants (both algae and higher plants) require a variety of other elements to support their bodily structures and metabolism. Just as with terrestrial plants, the most important of these elements are nitrogen and phosphorus. Additional nutrients, such as potassium, iron, selenium, and silica, are needed in smaller amounts and generally are not limiting factors to plant growth. When these chemicals are limited, plant growth may be limited. This is an important consideration in stream management. Plant biomass (either created instream or loaded from the watershed) is necessary to support the food chain. However, excessive growth of algae and other aquatic plants instream can result in nuisance conditions, and the depletion of dissolved oxygen during nonphotosynthetic periods by the respiration of plants and decay of dead plant material can create conditions unfavorable to aquatic life.

Phosphorus in freshwater systems exists in either a particulate phase or a dissolved phase. Both phases include organic and inorganic fractions. The organic particulate phase includes living and dead particulate matter, such as plankton and detritus. Inorganic particulate phosphorus includes phosphorus precipitates and phosphorus adsorbed to particulates. Dissolved organic phosphorus includes organic phosphorus excreted by organisms and colloidal phosphorus compounds. The soluble inorganic phosphate forms $H_2PO_4^-$, HPO_4^{2-}, and PO_4^{3-}, collectively known as *soluble reactive phosphorus (SRP)* are readily available to plants. Some condensed phosphate forms, such as those found in detergents, are inorganic but are not directly available for plant uptake. Aquatic plants require nitrogen and phosphorus in different amounts. For phytoplankton, as an example, cells contain approximately 0.5 to 2.0 µg phosphorus per µg chlorophyll, and 7 to 10 µg nitrogen per µg chlorophyll. From this relationship, it is clear that the ratio of nitrogen and phosphorus required is in the range of 5 to 20 (depending on the characteristics of individual species) to support full utilization of available nutrients and maximize plant growth. When the ratio deviates from this range, plants cannot use the nutrient present in excess amounts. The other nutrient is then said to be the limiting nutrient on plant growth. In streams experiencing excessive nutrient loading, resource managers often seek to control loading of the limiting nutrient at levels that prevent nuisance conditions.

In the aquatic environment, nitrogen can exist in several forms—dissolved nitrogen gas (N_2), ammonia and ammonium ion (NH_3 and NH_4^+), nitrite (NO_2^-), nitrate (NO_3^-), and organic nitrogen as proteinaceous matter or in dissolved or particulate phases. The most important forms of nitrogen in terms of their immediate impacts on water quality are the readily available ammonia ions, nitrites, and nitrates. Because they must be converted to a form more usable by plants, particulate and organic nitrogen are less important in the short term.

It may seem unusual that nitrogen could limit plant growth, given that the atmosphere is about 79 percent nitrogen gas. However, only a few life-forms (for example, certain bacteria and blue-green algae) have the ability to fix nitrogen gas from the atmosphere. Most plants can use nitrogen only if it is available as ammonia (NH_3, commonly present in water as the ionic form ammonium, NH_4^+) or as nitrate (NO_3^-) (**Figure 2.21**). However, in freshwater systems, growth of aquatic plants is more commonly limited by phosphorus than by nitrogen. This limitation occurs because phosphate (PO_4^{3-}) forms insoluble complexes with common constituents in water (Ca^{++} and variable amounts of OH^-, Cl^-, and F^-). Phosphorus also sorbs to iron coatings on clay and other sediment surfaces and is therefore removed from the water column by chemical processes, resulting in the reduced ability of the water body to support plant growth.

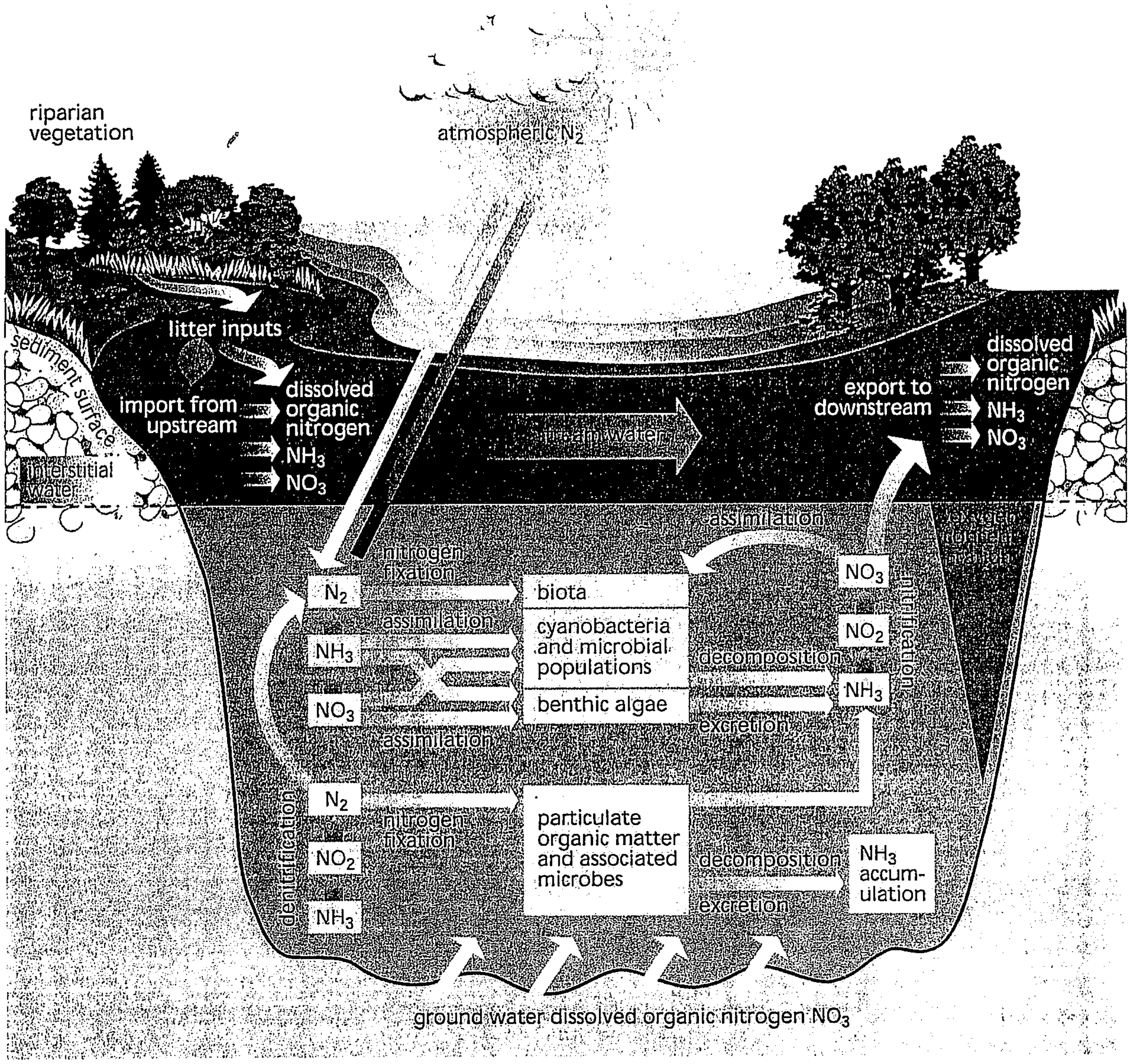


Figure 2.21: Dynamics and transformations of nitrogen in a stream ecosystem. *Nutrient cycling from one form to another occurs with changes in nutrient inputs, as well as temperature and oxygen available.*

Nutrients Across the Stream Corridor

Both nitrogen and phosphorus are delivered to surface waters at an elevated rate as a result of human activities, including point source discharges of treated wastewater and nonpoint sources, such as agriculture and urban development. In many developed watersheds, a major source of nutrients is the direct discharge of treated waste from wastewater treatment plants, as well as combined sewer overflows (CSOs). Such point source discharges are regulated under the National Pollutant Discharge Elimination System (NPDES) and usually are well characterized by monitoring. The NPDES requires permitted dischargers to meet both numeric and narrative water quality standards in streams. While most states do not have numeric standards for nutrients, point source discharges of nutrients are recognized as a factor leading to stream degradation and failure to achieve narrative water quality standards. As a result, increasingly stringent limitations on nutrient concentrations in wastewater treatment plant effluent (particularly phosphorus) have been imposed in many areas.

In many cases the NPDES program has significantly cleaned up rivers and streams; however, many streams still do not meet water quality standards, even with increasingly stringent regulatory standards. Scientists and regulators now understand that the dominant source of nutrients in many streams is from nonpoint sources within the stream's watershed, not from point sources such as wastewater treatment plants. Typical land uses that contribute to the nonpoint contamination of streams are the application of fertilizers to agricultural fields and suburban lawns, the improper handling of animal wastes from livestock operations, and the disposal of human waste in septic systems. Storm runoff from agricultural fields can contribute nutrients to a stream in dissolved forms as well as particulate forms.

Because of its tendency to sorb to sediment particles and organic matter, phosphorus is transported primarily in surface runoff with eroded sediments. Inorganic nitrogen, on the other hand, does not sorb strongly and can be transported in both particulate and dissolved phases in surface runoff. Dissolved inorganic nitrogen also can be transported through the unsaturated zone (interflow) and ground water to waterbodies. **Table 2.6** presents common point and nonpoint sources of nitrogen and phosphorus loading and shows the approximate concentrations delivered. Note that nitrates are naturally occurring in some soils.

Nutrients Along the Stream Corridor

Nitrogen, because it does not sorb strongly to sediment, moves easily between the substrate and the water column and cycles continuously. Aquatic organisms incorporate dissolved and particulate inorganic nitrogen into proteinaceous matter. Dead organisms decompose and nitrogen is released as ammonia ions and then converted to nitrite and nitrate, where the process begins again.

Phosphorus undergoes continuous transformations in a freshwater environment. Some phosphorus will sorb to

Table 2.6: Sources and concentrations of pollutants from common point and nonpoint sources.

Source	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)
Urban runoff[a]	3–10	0.2–1.7
Livestock operations[a]	6–800[b]	4–5
Atmosphere (wet deposition)[a]	0.9	0.015[c]
90% forest[d]	0.06–0.19	0.006–0.012
50% forest[d]	0.18–0.34	0.013–0.015
90% agriculture[d]	0.77–5.04	0.085–0.104
Untreated wastewater[a]	35	10
Treated wastewater[a,e]	30	10

[a] Novotny and Olem (1994).
[b] As organic nitrogen.
[c] Sorbed to airborne particulate.
[d] Omernik (1987).
[e] With secondary treatment.

sediments in the water column or substrate and be removed from circulation. The SRP (usually as orthophosphate) is assimilated by aquatic plants and converted to organic phosphorus. Aquatic plants then may be consumed by detritivores and grazers, which in turn excrete some of the organic phosphorus as SRP. Continuing the cycle, the SRP is rapidly assimilated by aquatic plants.

Toxic Organic Chemicals

Pollutants that cause toxicity in animals or humans are of obvious concern to restoration efforts. *Toxic organic chemicals (TOC)* are synthetic compounds that contain carbon, such as polychlorinated biphenyls (PCBs) and most pesticides and herbicides. Many of these synthesized compounds tend to persist and accumulate in the environment because they do not readily break down in natural ecosystems. Some of the most toxic synthetic organics, DDT and PCBs, have been banned from use in the United States for decades yet continue to cause problems in the aquatic ecosystems of many streams.

Toxic Organic Chemicals Across the Stream Corridor

TOCs may reach a water body via both point and nonpoint sources. Because permitted NPDES point sources must meet water quality standards instream and because of whole effluent toxicity requirements, continuing TOC problems in most streams are due to nonpoint loading, recycling of materials stored in stream and riparian sediments, illegal dumping, or accidental spills. Two important sources of nonpoint loading of organic chemicals are application of pesticides and herbicides in connection with agriculture, silviculture, or suburban lawn care, and runoff from potentially polluted urban and industrial land uses.

The movement of organic chemicals from the watershed land surface to a water body is largely determined by the characteristics of the chemical, as discussed below under the longitudinal perspective. Pollutants that tend to sorb strongly to soil particles are primarily transported with eroded sediment. Controlling sediment delivery from source area land uses is therefore an effective management strategy. Organic chemicals with significant solubility may be transported directly with the flow of water, particularly stormflow from impervious urban surfaces.

Toxic Organic Chemicals Along the Stream Corridor

Among all the elements of the earth, carbon is unique in its ability to form a virtually infinite array of stable covalent bonds with itself: long chains, branches and rings, spiral helixes. Carbon molecules can be so complex that they are able to encode information for the organization of other carbon structures and the regulation of chemical reactions.

The chemical industry has exploited this to produce many useful organic chemicals: plastics, paints and dyes, fuels, pesticides, pharmaceuticals, and other items of modern life. These products and their associated wastes and byproducts can interfere with the health of aquatic ecosystems. Understanding the transport and fate of *synthetic organic compounds (SOC)* in aquatic environments continues to challenge scientists. Only a general overview of the processes that govern the behavior of these chemicals along stream corridors is presented here.

Solubility

It is the nature of the carbon-carbon bond that electrons are distributed relatively uniformly between the bonded atoms. Thus a chained or ringed hydrocarbon is a fairly nonpolar compound.

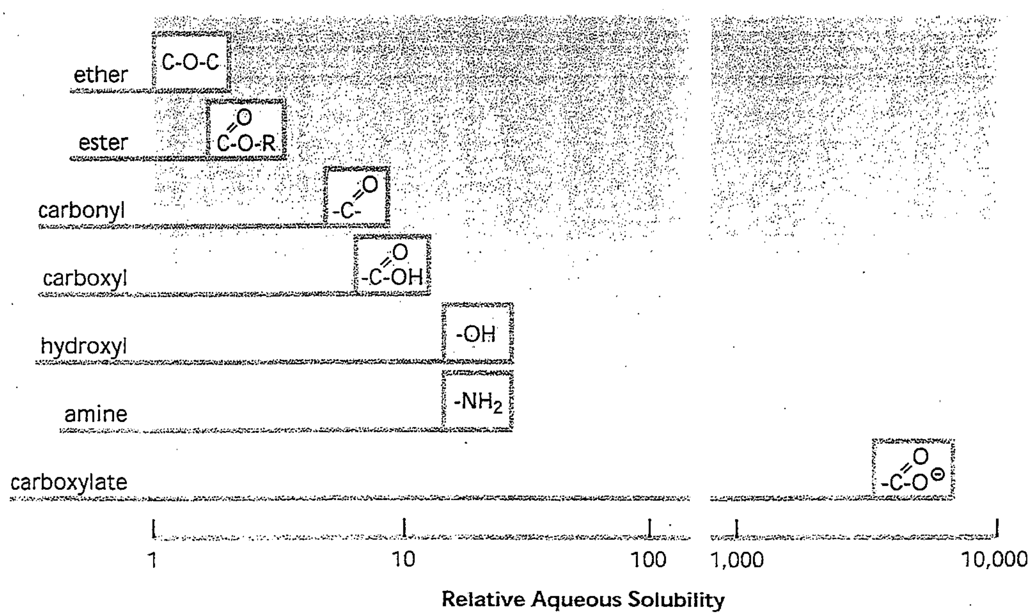
This nonpolar nature is dissimilar to the molecular structure of water, which is a very polar solvent.

On the general principle that "like dissolves like," dissolved constituents in water tend to be polar. Witness, for example, the ionic nature of virtually all inorganic constituents discussed thus far in this chapter. How does an organic compound become dissolved in water? There are several ways. The compound can be relatively small, so it minimizes its disturbance of the polar order of things in aqueous solution. Alternatively, the compound may become more polar by adding polar functional groups (**Figure 2.22**). Alcohols are organic compounds with -OH groups attached; organic acids are organic compounds with attached -COOH groups. These functional groups are highly polar and increase the solubility of any organic compound. Even more solubility in water is gained by ionic functional groups, such as $-COO^-$.

Another way that solubility is enhanced is by increased aromaticity. Aromaticity refers to the delocalized bonding structure of a ringed compound like benzene (**Figure 2.23**). (Indeed, all aromatic compounds can be considered derivatives of benzene.) Because electrons are free to "dance around the ring" of the benzene molecule, benzene and its derivatives are more compatible with the polar nature of water.

A simple example will illustrate the factors enhancing aqueous solubility of organic compounds. Six compounds, each having six carbons, are shown in **Table 2.7**. Hexane is a simple hydrocarbon, an alkane whose solubility is 10 mg/L. Simply by adding a single -OH group, which converts hexane to the alcohol hexanol, solubility is increased to 5,900 mg/L. You can bend hexane into a ringed alkane structure called cyclohexane. Forming the ring makes cyclohexane smaller than hexane and increases its solubility, but only to 55 mg/L. Making the ring aromatic by forming the six-carbon benzene molecule increases solubility all the way to 1,780 mg/L. Adding an -OH to benzene to form a phenol leads to another dra-

Figure 2.22: Relative aqueous solubility of different functional groups. *The solubility of a contaminant in water largely determines the extent to which it will impact water quality.*



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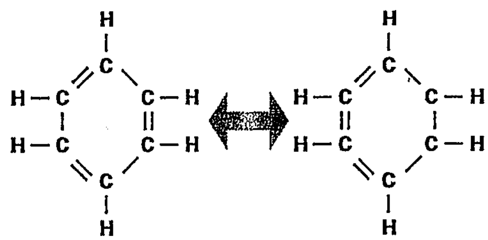

Figure 2.23: Aromatic hydrocarbons. Benzene is soluble in water because of its "aromatic" structure.

matic increase in solubility (to 82,000 mg/L). Adding a chloride atom to the benzene ring diminishes its aromatic character (chloride inhibits the dancing electrons), and thus the solubility of chlorobenzene (448 mg/L) is less than benzene.

Sorption

In the 1940s, a young pharmaceutical industry sought to develop medicines that could be transported in digestive fluids and blood (both of which are essentially aqueous solutions) and could also diffuse across cell membranes (which have, in part, a rather nonpolar character). The industry developed a parameter to quantify the polar versus nonpolar character of potential drugs, and they called that parameter the octanol-water partition coefficient. Basically they put water and octanol (an eight-carbon alcohol) into a vessel, added the organic compound of interest, and shook the combination up. After a period of rest, the water and octanol separate (neither is very soluble in the other), and the concentration of the organic compound can be measured in each phase. The *octanol-water partition coefficient*, or K_{ow}, is defined simply as:

$$K_{ow} = \text{concentration in octanol} / \text{concentration in water}$$

The relation between water solubility and K_{ow} is shown in **Figure 2.24**. Generally we see that very insoluble compounds like DDT and PCBs have very high values of K_{ow}. Alternatively, organic acids and small organic solvents like TCE are relatively soluble and have low K_{ow} values.

The octanol-water partition coefficient has been determined for many compounds and can be useful in understanding the distribution of SOC between water and biota, and between water and sediments. Compounds with high K_{ow} tend to accumulate in fish tissue (**Figure 2.25**). The *sediment-water distribution coefficient*, often expressed as K_d, is defined in a sediment-water mixture at equilibrium as the ratio of the concentration in the sediment to the concentration in the water:

$$K_d = \text{concentration in sediment} / \text{concentration in water}$$

One might ask whether this coefficient is constant for a given SOC. Values of K_d for two polyaromatic hydrocarbons in various soils are shown in **Figure 2.26**. For pyrene (which consists of four benzene rings stuck together), the K_d ratios vary from about 300 to 1500. For phenanthrene (which consists of three benzene rings stuck together), K_d varies from about 10 to 300. Clearly K_d is not a constant value for either compound. But, K_d does appear to bear a relation to the fraction of organic carbon in the various sediments. What appears to be constant is not K_d itself, but the ratio of K_d to the fraction of organic carbon in the sediment. This ratio is referred to as K_{oc}:

Table 2.7: Solubility of six-carbon compounds.

Compound	Solubility
Hexane	10 mg/L
Hexanol	5,900 mg/L
Cyclohexane	55 mg/L
Benzene	1,780 mg/L
Phenol	82,000 mg/L
Chlorobenzene	448 mg/L

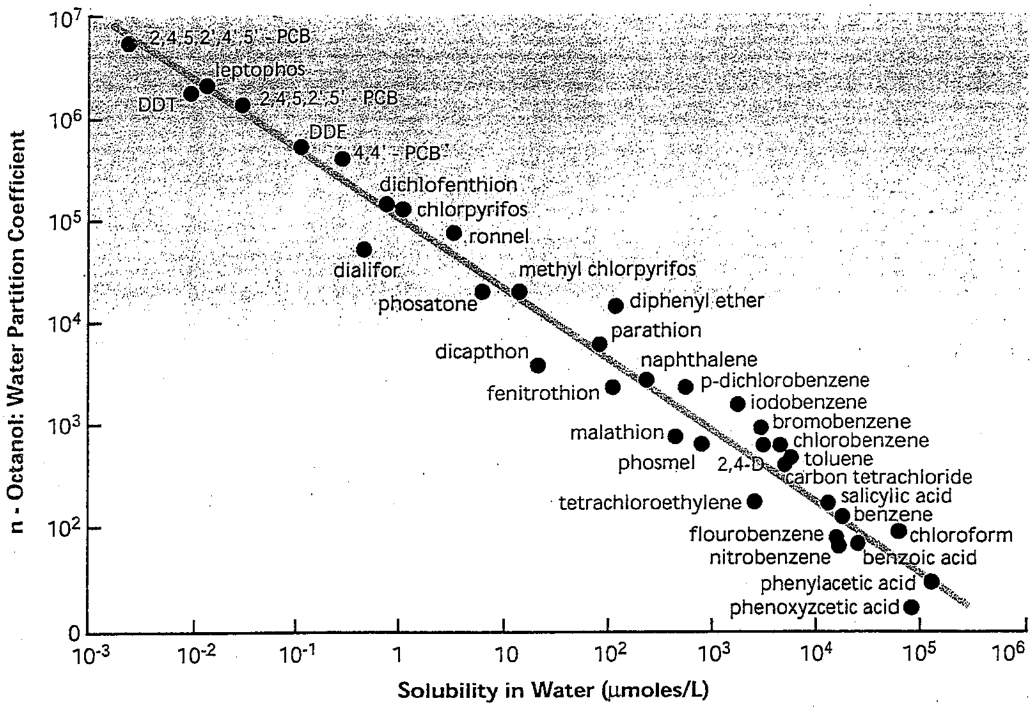

Figure 2.24: Relationship between octanol/H_2O partition coefficient and aqueous solubility. *The relative solubility in water is a substance's "Water Partition Coefficient."*

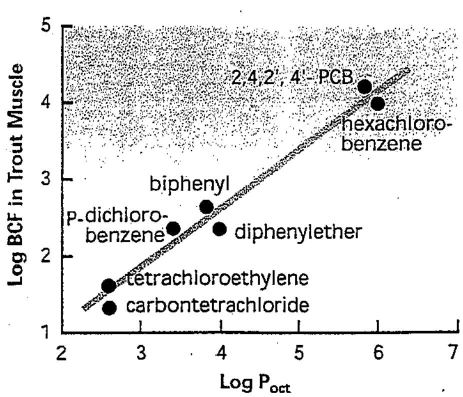

Figure 2.25: Relationship between octanol/ water partition (P_{oct}) coefficient and bioaccumulation factor (BCF) in trout muscle. *Water quality can be inferred by the accumulation of contaminants in fish tissue.*

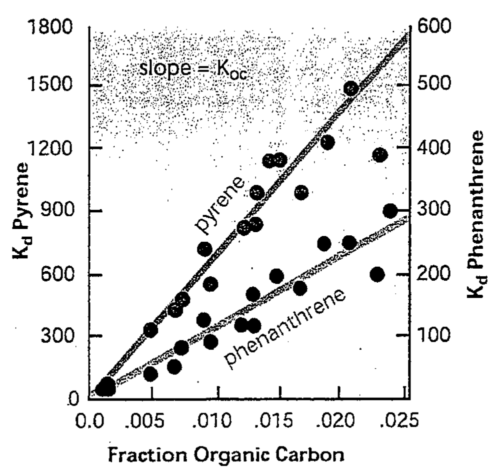

Figure 2.26: Relationship between pyrene, phenanthrene, and fraction organic carbon. *Contaminant concentrations in sediment vs. water (K_d) are related to the amount of organic carbon available.*

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$K_{oc} = K_d$ / fraction of organic carbon in sediment

Various workers have related K_{oc} to K_{ow} and to water solubility (**Table 2.8**).

Using K_{ow}, K_{oc}, and K_d to describe the partitioning of an SOC between water and sediment has shown some utility, but this approach is not applicable to the sorption of all organic molecules in all systems. Sorption of some SOC occurs by hydrogen bonding, such as occurs in cation exchange or metal sorption to sediments (**Figure 2.27**). Sorption is not always reversible; or at least after sorption occurs, desorption may be very slow.

Volatilization

Organic compounds partition from water into air by the process of volatilization. An air-water distribution coefficient, the Henry's Law constant (H), has been defined as the ratio of the concentration of an SOC in air in equilibrium with its concentration in water:

H = SOC concentration in air / SOC concentration in water

"SOC" = synthetic organic compounds

A Henry's Law constant for an SOC can be estimated from the ratio of the compound's vapor pressure to its water solubility. Organic compounds that are inherently volatile (generally low molecular weight solvents) have very high Henry's Law constants. But even compounds with very low vapor pressure can partition into the atmosphere. DDT and PCBs for example, have modest Henry's Law constants because their solubility in water is so low. These SOC also have high K_d values and so may be-

Table 2.8: Regression equations for sediment adsorption coefficients (K_{oc}) for various contaminants.

Equation[a]	No.[b]	r^2[c]	Chemical Classes Represented
$\log K_{oc} = -0.55 \log S + 3.64$ (S in mg/L)	106	0.71	Wide variety, mostly pesticides
$\log K_{oc} = -0.54 \log S + 0.44$ (S in mole fraction)	10	0.94	Mostly aromatic or polynuclear aromatics; two chlorinated
$\log K_{oc} = -0.557 \log S + 4.277$ (S in µ moles/L)[d]	15	0.99	Chlorinated hydrocarbons
$\log K_{oc} = 0.544 \log K_{ow} + 1.377$	45	0.74	Wide variety, mostly pesticides
$\log K_{oc} = 0.937 \log K_{ow} - 0.006$	19	0.95	Aromatics, polynuclear aromatics, triazines, and dinitroaniline herbicides
$\log K_{oc} = 1.00 \log K_{ow} - 0.21$	10	1.00	Mostly aromatic or polynuclear aromatics; two chlorinated
$\log K_{oc} = 0.95 \log K_{ow} + 0.02$	9	e	S-triazines and dinitroaniline herbicides
$\log K_{oc} = 1.029 \log K_{ow} - 0.18$	13	0.91	Variety of insecticides, herbicides, and fungicides
$\log K_{oc} = 0.524 \log K_{ow} + 0.855$[d]	30	0.84	Substituted phenylureas and alkyl-N-phenylcarbamates
$\log K_{oc} = 0.0067 (p - 45N) + 0.237$[d,f]	29	0.69	Aromatic compounds, urea, 1.3.5-triazines, carbamates, and uracils
$\log K_{oc} = 0.681 \log BCF(f) + 1.963$	13	0.76	Wide variety, mostly pesticides
$\log K_{oc} = 0.681 \log BCF(t) + 1.886$	22	0.83	Wide variety, mostly pesticides

[a] K_{oc} = soil (or sediment) adsorption coefficient; S = water solubility; K_{ow} = octanol-water partition coefficient; BCF(f) = bioconcentration factor from flowing-water tests; BCF(t) = bioconcentration factor from model ecosystems; P = parachor; N = number of sites in molecule which can participate in the formation of a hydrogen bond.

[b] No. = number of chemicals used to obtain regression equation.

[c] r^2 = correlation coefficient for regression equation.

[d] Equation originally given in terms of K_{om}. The relationship $K_{om} = K_{oc}/1.724$ was used to rewrite the equation in terms of K_{oc}.

[e] Not available.

[f] Specific chemicals used to obtain regression equation not specified.

come airborne in association with particulate matter.

Degradation

SOC can be transformed into a variety of degradation products. These degradation products may themselves degrade. Ultimate degradation, or mineralization, results in the oxidation of organic carbon to carbon dioxide. Major transformation processes include photolysis, hydrolysis, and oxidation-reduction reactions. The latter are commonly mediated by biological systems.

Photolysis refers to the destruction of a compound by the energy of light. The energy of light varies inversely with its wavelength (**Figure 2.28**). Long-wave light lacks sufficient energy to break chemical bonds. Short wave light (x-rays and gamma rays) is very destructive; fortunately for life on earth, this type of radiation largely is removed by our upper atmosphere. Light near the visible spectrum reaches the earth's surface and can break many of the bonds common in SOC. The fate of organic solvents following volatilization is usually photolysis in the earth's atmosphere. Photolysis also can be important in the degradation of SOC in stream water.

Hydrolysis refers to the splitting of an organic molecule by water. Essentially water enters a polar location on a molecule and inserts itself, with an H^+ going to one part of the parent molecule and an OH^- going to the other. The two parts then separate. A group of SOC called esters are particularly vulnerable to degradation by hydrolysis. Many esters have been produced as pesticides or plasticizers.

Oxidation-reduction reactions are what fuels most metabolism in the biosphere. SOC are generally considered as sources of reduced carbon. In such situations, what is needed for degradation is a metabolic system with the appro-

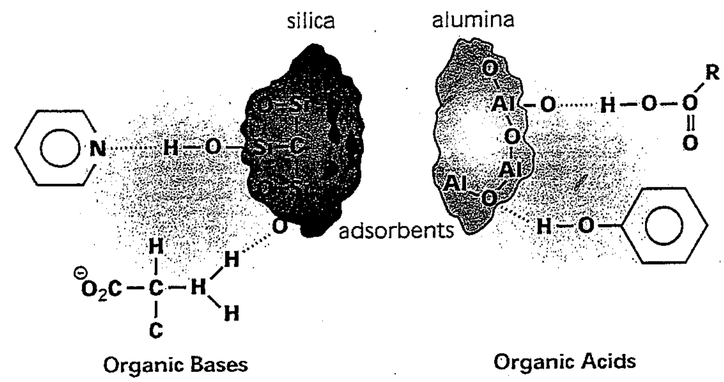
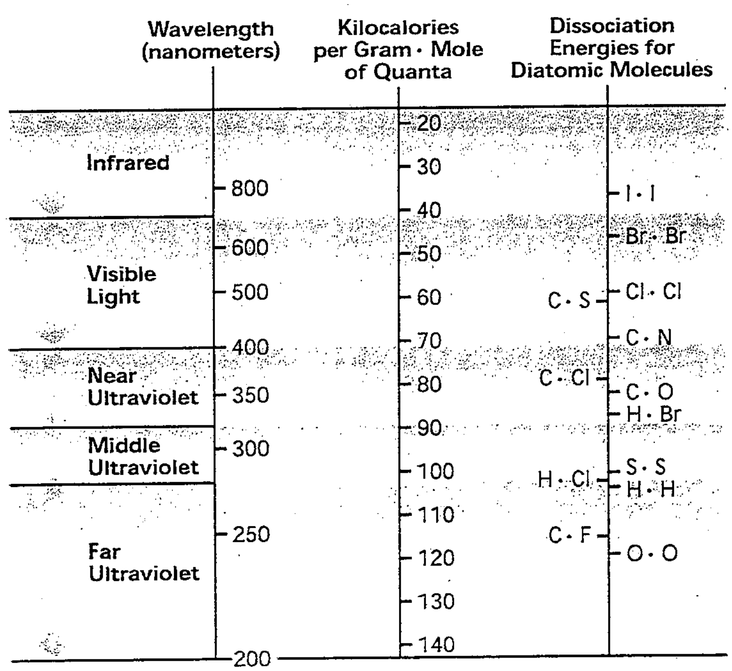


Figure 2.27: Two important types of hydrogen bonding involving natural organic matter and mineral surfaces. *Some contaminants are carried by sediment particles that are sorbed onto their surfaces by chemical bonding.*

Figure 2.28: Energy of electromagnetic radiation compared with some selected bond energies. *Light breaks chemical bonds of some compounds through photolysis.*



priate enzymes for the oxidation of the compound. A sufficient supply of other nutrients and a terminal electron acceptor are also required.

The *principle of microbial infallibility* informally refers to the idea that given a supply of potential food, microbial communities will develop the metabolic capability to use that food for biochemical energy. Not all degradation reactions, however, involve the oxidation of SOC. Some of the most problematic organic contaminants are chlorinated compounds.

Chlorinated SOC do not exist naturally, so microbial systems generally are not adapted for their degradation. Chlorine is an extremely electronegative element. The electronegativity of chlorine refers to its penchant for sucking on electrons. This tendency explains why chloride exists as an anion and why an attached chloride diminishes the solubility of an aromatic ring. Given this character, it is difficult for biological systems to oxidize chlorinated compounds. An initial step in that degradation, therefore, is often reductive dechlorination. The chlorine is removed by reducing the compound (i.e., by giving it electrons). After the chlorines are removed, degradation may proceed along oxidative pathways. The degradation of chlorinated SOC thus may require a sequence of reducing and oxidizing environments, which water may experience as it moves between stream and hyporheic zones.

The overall degradation of SOC often follows complex pathways. Figure 2.29 shows a complex web of metabolic reaction for a single parent pesticide. Hydrolysis, reduction, and oxidation are all involved in the degradation of SOC, and the distribution and behavior of degradation products can be extremely variable in space and time.

Chemical consequences are rarely the immediate goal of most restoration actions. Plans that alter chemical processes and attributes are usually focused on changing the physical and biological characteristics that are vital to the restoration goals.

Toxic Concentrations of Bioavailable Metals

A variety of naturally occurring metals, ranging from arsenic to zinc, have been established to be toxic to various forms of aquatic life when present in sufficient concentrations. The primary mechanisms for water column toxicity of most metals is adsorption at the gill surface. While some studies indicate that particulate metals may contribute to toxicity, perhaps because of factors such as desorption at the gill surface, the dissolved metal concentration most closely approximates the fraction of metal in the water column that is bioavailable. Accordingly, current EPA policy is that dissolved metal concentrations should be used to set and measure compliance with water quality standards (40 CFR 22228-22236, May 4, 1995). For most metals, the dissolved fraction is equivalent to the inorganic ionic fraction. For certain metals, most notably mercury, the dissolved fraction also may include the metal complexed with organic binding agents (e.g., methyl mercury, which can be produced in sediments by methanogenic bacteria, is soluble and highly toxic, and can accumulate through the food chain).

Toxic Concentrations of Bioavailable Metals Across the Stream Corridor

Unlike synthetic organic compounds, toxic metals are naturally occurring. In common with synthetic organics, metals may be loaded to waterbodies from both point and nonpoint sources. Pollutants such as copper, zinc, and lead are often of concern in effluent from wastewater treatment plants but are required under the NPDES program to meet numeric water quality standards.

Many of the toxic metals are present at significant concentrations in most soils but in sorbed nonbioavailable forms. Sediment often introduces significant concentrations of metals such as zinc into waterbodies. It is then a matter of whether instream conditions promote bioavailable dissolved forms of the metal.

Nonpoint sources of metals first reflect the characteristics of watershed soils. In addition, many older industrial areas have soil concentrations of certain metals that are elevated due to past industrial practices. Movement of metals from soil to watershed is largely a function of the erosion and delivery of sediment.

In certain watersheds, a major source of metals loading is provided by acid mine drainage. High acidity increases the solubility of many metals, and mines tend to be in mineral-rich areas. Abandoned mines are therefore a continuing source of toxic metals loading in many streams.

Toxic Concentrations of Bioavailable Metals Along the Stream Corridor

Most metals have a tendency to leave the dissolved phase and attach to suspended particulate matter or form insoluble precipitates. Conditions that partition metals into particulate forms (presence of suspended sediments, dissolved and particulate organic carbon, carbonates, bicarbonates, and other ions that complex metals) reduce potential bioavailability of metals. Also, calcium reduces metal uptake, apparently by competing with metals for active uptake sites on gill membranes. pH is also an important water quality factor in metal bioavailability. In general, metal solubilities are lower at near neutral pH's than in acidic or highly alkaline waters.

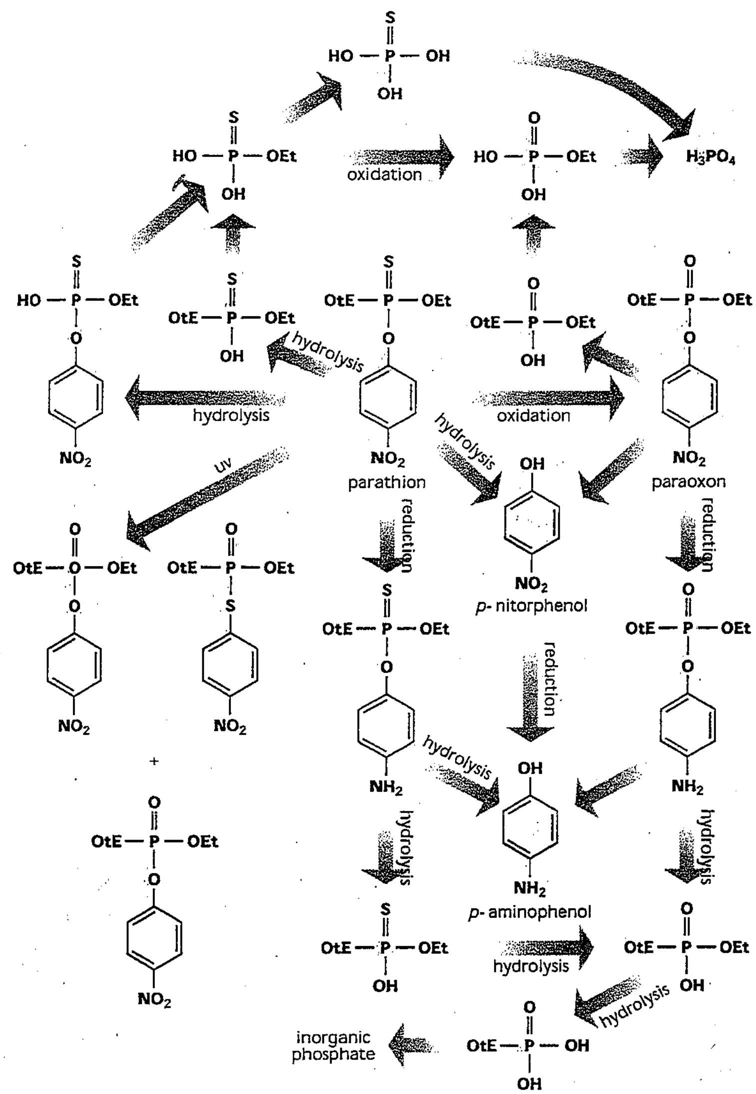


Figure 2.29: Metabolic reactions for a single parent pesticide. *Particles break down through processes of hydrolysis, oxidation, reduction, and photolysis.*

Ecological Functions of Soils

Soil is a living and dynamic resource that supports life. It consists of inorganic mineral particles of differing sizes (clay, silt, and sand), organic matter in various stages of decomposition, numerous species of living organisms, various water soluble ions, and various gases and water. These components each have their own physical and chemical characteristics which can either support or restrict a particular form of life.

Soils can be mineral or organic depending on which material makes up the greater percentage in the soil matrix. Mineral soils develop in materials weathered from rocks while organic soils develop in decayed vegetation. Both soils typically develop horizons or layers that are approximately parallel to the soil surface. The extreme variety of specific niches or conditions soil can create has enabled a large variety of fauna and flora to evolve and live under those conditions.

Soils, particularly riparian and wetland soils, contain and support a very high diversity of flora and fauna both above and below the soil surface. A large variety of specialized organisms can be found below the soil surface, outnumbering those above ground by several orders of magnitude. Generally, organisms seen above ground are higher forms of life such as plants and wildlife. However, at and below ground, the vast majority of life consists of plant roots having the responsibility of supporting the above ground portion of the plant; many insects, mollusks, and fungi living on dead organic matter; and an infinite number of bacteria which can live on a wide variety of energy sources found in soil.

It is important to identify soil boundaries and to understand the differences in soil properties and functions occurring within a stream corridor in order to identify opportunities and limitations for restoration. Floodplain and terrace soils are often areas of dense population and intensive agricultural development due to their flat slopes, proximity to water, and natural fertility. When planning stream corridor restoration initiatives in developed areas, it is important to recognize these alterations and to consider their impacts on goals.

Soils perform vital functions throughout the landscape. One of the most important functions of soil is to provide a physical, chemical, and biological setting for living organisms. Soils support biological activity and diversity for plant and animal productivity. Soils also regulate and partition the flow of water and the storage and cycling of nutrients and other elements in the landscape. They filter, buffer, degrade, immobilize, and detoxify organic and inorganic materials and provide the mechanical support living organisms need. These hydrologic, geomorphic, and biologic functions involve processes that help build and sustain stream corridors.

Soil Microbiology

Organic matter provides the main source of energy for soil microorganisms. Soil organic matter normally makes up 1 to 5 percent of the total weight in a mineral topsoil. It consists of original tissue, partially decomposed tissue, and humus. Soil organisms consume roots and vegetative detritus for energy and to build tissue. As the original organic matter is decomposed and modified by microorganisms, a gelatinous, more resistant compound is formed. This material is called *humus*. It is generally black or brown in color and exists as a colloid, a group of small, insoluble particles suspended in a gel. Small amounts of humus greatly increase a soil's ability to hold water and nutrient ions which enhances plant production. Humus is an indicator of a large and viable population of microorganisms in the soil and it increases the options available for vegetative restoration.

Bacteria play vital roles in the organic transactions that support plant growth. They are responsible for three essential transformations: denitrification, sulfur oxidation, and nitrogen fixation. Microbial reduction of nitrate to nitrite and then to gaseous forms of nitrogen is termed denitrification. A water content of 60 percent generally limits denitrification and the process only occurs at soil temperatures between 5 °C and 75 °C. Other soil properties optimizing the rate of denitrification include a pH between 6 and 8, soil aeration below the biological oxygen demand of the organisms in the soil, sufficient amounts of water-soluble carbon compounds, readily available nitrate in the soil, and the presence of enzymes needed to start the reaction.

Landscape and Topographic Position

Soil properties change with topographic position. Elevation differences generally mark the boundaries of soils and drainage conditions in stream corridors. Different landforms generally have different types of sediment underlying them. Surface and subsurface drainage patterns also vary with landforms.

- *Soils of active channels.* The active channel forms the lowest and usually youngest surfaces in the stream corridor. There is generally no soil developed on these surfaces since the unconsolidated materials forming the stream bottom and banks are constantly being eroded, transported, and redeposited.
- *Soils of active floodplains.* The next highest surface in the stream corridor is the flat, depositional surface of the active floodplain. This surface floods frequently, every 2 out of 3 years, so it receives sediment deposition.
- *Soils of natural levees.* Natural levees are built adjacent to the stream by deposition of coarser, suspended sediment dropping out of overbank flows during floods. A gentle backslope occurs on the floodplain side of the natural levee, so the floodplain becomes lowest at a point far from the river. Parent materials decrease in grain size away from the river due to the decrease in sediment-transport capacity in the slackwater areas.
- *Soils of topographic floodplains.* Slightly higher areas within and outside the active floodplain are defined as the topographic floodplain. They are usually inundated less frequently than the active floodplain, so soils may exhibit more profile development than the younger soils on the active floodplain.
- *Soils of terraces.* Abandoned floodplains, or terraces, are the next highest surfaces in stream corridors. These surfaces rarely flood. Terrace soils, in general, are coarser textured than floodplain soils, are more freely drained, and are separated from stream processes.

Upon close examination, floodplain deposits can reveal historical events of given watersheds. Soil profile development offers clues to the recent and geologic history at a site. Intricate and complex analysis methods such as carbon dating, pollen analysis, ratios of certain isotopes, etc. can be used to piece together an area's history. Cycles of erosion or deposition can at times be linked to catastrophic events like forest fires or periods of high or low precipitation. Historical impacts of civilization, such as extensive agriculture or denudation of forest cover will at times also leave identifiable evidence in soils.

Soil Temperature and Moisture Relationships

Soil temperature and moisture control biological processes occurring in soil. Average and expected precipitation and temperature extremes are critical pieces of information when considering goals for restoration initiatives. The mean annual soil temperature is usually very similar to the mean annual air temperature. Soil temperatures do experience daily, seasonal, and annual fluctuations caused by solar radiation, weather patterns, and climate. Soil temperatures are also affected by aspect, latitude, and elevation.

Soil moisture conditions change seasonally. If changes in vegetation species and composition are being considered as part of a restoration initiative, a graph comparing monthly precipitation and evapotranspiration for the vegetation should be constructed. If the water table and capillary fringe is below the predicted rooting depth, and the graph indicates a deficit in available water, irrigation may be required. If no supplemental water is available, different plant species must be considered.

The soil moisture gradient can decrease from 100 percent to almost zero along the transriparian continuum as one progresses from the stream bottom, across the riparian zone, and into the higher elevations of the adjacent uplands (Johnson and Lowe 1985), which results in vast differences in moisture available to vegetation. This gradient in soil moisture directly influences the characteristics of the ecological communities of the riparian, transitional, and upland zones. These ecological differences result in the presence of two ecotones along the stream corridor—an aquatic-wetland/riparian ecotone and a non-wetland riparian/floodplain ecotone—which increase the edge effect of the riparian zone and, therefore, the biological diversity of the region.

Wetland Soils

Wet or "hydric" soils present special challenges to plant life. Hydric soils are present in wetlands areas, creating such drastic changes in physical and chemical conditions that most species found in uplands cannot survive. Hence the composition of flora and fauna in wetlands are vastly different and unique, especially in wetlands subject to permanent or prolonged saturation or flooding.

Hydric soils are defined as those that are saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions in the upper part. These anaerobic conditions affect the reproduction, growth, and survival of plants. The driving process behind the formation of hydric soils is flooding and/or soil saturation near the surface for prolonged periods (usually more the seven days) during the growing season (Tiner and Veneman 1989).

The following focuses primarily on mineral hydric soil properties, but organic soils such as peat and muck may be present in the stream corridor.

In aerated soil environments, atmospheric oxygen enters surface soils through gas diffusion, as soil pores are mostly filled with air. Aerated soils are found in well drained uplands, and generally all areas having a water table well below the root zone. In saturated soils, pores are filled with water, which diffuse gases very slowly compared to the atmosphere. Only small amounts of oxygen can dissolve in soil moisture, which then disperses into the top few inches of soil. Here, soil microbes quickly deplete all available free oxygen in oxidizing organic residue to carbon dioxide. This reaction produces an anaerobic chemically reducing environment in which oxidized compounds are changed to reduced compounds that are soluble and also toxic to many plants. The rate of diffusion is so slow that oxygenated conditions cannot be reestablished under such circumstances. Similar microbial reactions involving decomposition of organic matter in waterlogged anaerobic environments produce ethylene gas, which is highly toxic to plant roots and has an even stronger effect than a lack of oxygen. After all free oxygen is utilized, anaerobic microbes reduce other chemical constituents of the soil including nitrates, manganese oxides, and iron oxides, creating a further reduced condition in the soil.

Prolonged anaerobic reducing conditions result in the formation of readily visible signs of reduction. The typical gray colors encountered in wet soils are the result of reduced iron, and are known as *gleyed* soils. After iron oxides are depleted, sulfates are reduced to sulfides, producing the rotten egg odor of wet soils. Under extremely waterlogged conditions, carbon dioxide can be reduced to methane. Methane gas, also known as "swamp gas" can be seen at night, as it fluoresces.

Some wetland plants have evolved special mechanisms to compensate for having their roots immersed in anoxic environments. Water lilies, for example, force a gas exchange within the entire plant by closing their stomata during the heat of the day to raise the air pressure within special conductive tissue (aerenchyma). This process tends to introduce atmospheric oxygen deep into the root crown, keeping vital tissues alive. Most emergent wetland plants simply keep their root systems close to the soil surface to avoid anaerobic conditions in deeper strata. This is true of sedges and rushes, for example.

When soils are continually saturated throughout, reactions can occur equally throughout the soil profile as opposed to wet soils where the water level fluctuates. This produces soils with little zonation, and materials tend to be more uniform. Most differences in texture encountered with depth are related to stratification of sediments sorted by size during deposition by flowing water. Clay formation tends to occur in place and little translocation happens within the profile, as essentially no water moves through the soil to transport the particles. Due to the reactivity of wet soils, clay formation tends to progress much faster than in uplands.

Soils which are seasonally saturated or have a fluctuating water table result in distinct horizonation within the profile. As water regularly drains through the profile, it translocates particles and transports soluble ions from one layer to another, or entirely out of the profile. Often, these soils have a thick horizon near the surface which is stripped of all soluble materials including iron; known as a *depleted matrix*. Seasonally saturated soils usually have substantial organic matter accumulated at the surface, nearly black in color. The organics add to the cation exchange capacity of the soil, but base saturation is low due to stripping and overabundance of hydrogen ions. During non-saturated times, organic materials are exposed to atmospheric oxygen, and aerobic decomposition can take place which results in massive liberation of hydrogen ions. Seasonally wet soils also do not retain base metals well, and can release high concentrations of metals in wet cycles following dry periods.

Wet soil indicators will often remain in the soil profile for long periods of time (even after drainage), revealing the historical conditions which prevailed. Examples of such indicators are rust colored iron deposits which at one time were translocated by water in reduced form. Organic carbon distribution from past fluvial deposition cycles or zones of stripped soils resulting from wetland situations are characteristics which are extremely long lived.

Summary

This section provides only a brief overview of the diverse and complex chemistry; nevertheless, two key points should be evident to restoration practitioners:

- *Restoring physical habitat cannot restore biological integrity of a system if there are water quality constraints on the ecosystem.*
- *Restoration activities may interact in a variety of complex ways with water quality, affecting both the delivery and impact of water quality stressors.*

***Table 2.9** shows how a sample selection of common stream restoration and watershed management practices may interact with the water quality parameters described in this section.*

Table 2.9: Potential water quality impacts of selected stream restoration and watershed management practices.

Restoration Activities	Fine Sediment Loads	Water Temperature	Salinity	pH	Dissolved Oxygen	Nutrients	Toxics
Reduction of land-disturbing activities	Decrease	Decrease	Decrease	Increase/ decrease	Increase	Decrease	Decrease
Limit impervious surface area in the watershed	Decrease	Decrease	Negligible effect	Increase	Increase	Decrease	Decrease
Restore riparian vegetation	Decrease	Decrease	Decrease	Decrease	Increase	Decrease	Decrease
Restore wetlands	Decrease	Increase/ decrease	Increase/ decrease	Increase/ decrease	Decrease	Increase	Increase
Stabilize channel and restore under-cut banks	Decrease	Decrease	Decrease	Decrease	Increase	Decrease	Negligible effect
Create drop structures	Increase	Negligible effect	Negligible effect	Increase/ decrease	Increase	Negligible effect	Decrease
Reestablish riffle substrate	Negligible effect	Negligible effect	Negligible effect	Increase/ decrease	Increase	Negligible effect	Negligible effect

2D Biological Community Characteristics

Successful stream restoration is based on an understanding of the relationships among physical, chemical, and biological processes at varying time scales. Often, human activities have accelerated the temporal progression of these processes, resulting in unstable flow patterns and altered biological structure and function of stream corridors. This section discusses the biological structure and functions of stream corridors in relation to geomorphologic, hydrologic, and water quality processes. The interrelations between the watershed and the stream, as well as the cause and effects of disturbances to these interrelationships are also discussed. Indices and approaches for evaluating stream corridor functions are provided in Chapter 7.

Terrestrial Ecosystems

The biological community of a stream corridor is determined by the characteristics of both terrestrial and aquatic ecosystems. Accordingly, the discussion of biological communities in stream corridors begins with a review of terrestrial ecosystems.

Ecological Role of Soil

Terrestrial ecosystems are fundamentally tied to processes within the soil. The ability of a soil to store and cycle nutrients and other elements depends on the properties and microclimate (i.e., moisture and temperature) of the soil, and the soil's community of organisms (Table 2.10). These factors also determine its effectiveness at filtering, buffering, degrading, immobilizing, and detoxifying other organic and inorganic materials.

Terrestrial Vegetation

The ecological integrity of stream corridor ecosystems is directly related to the integrity and ecological characteristics of the plant communities that make up and surround the corridor. These plant communities are a valuable source of energy for the biological communities, provide physical habitat, and moderate solar energy fluxes to and from the surrounding aquatic and terrestrial ecosystems. Given adequate moisture, light, and temperature, the vegetative community grows in an annual cycle of active growth/production, senescence, and relative dormancy. The growth period is subsidized by incidental solar radiation, which drives the photosynthetic process through which inorganic carbon is converted to organic plant materials. A portion of this organic material is stored as above- and below-ground biomass, while a significant fraction of organic matter is lost annually via senescence, fractionation, and leaching to the organic soil layer in the form of leaves, twigs, and decaying roots. This organic fraction, rich in biological activity of microbial flora and microfauna, represents a major storage and cycling pool of available carbon, nitrogen, phosphorus, and other nutrients.

The distribution and characteristics of vegetative communities are determined by climate, water availability, topographic features, and the chemical and physical properties of the soil, including moisture and nutrient content. The characteristics of the plant communities directly influence the diversity and integrity of the faunal communities. Plant communities that cover a large area and that are diverse in their vertical and horizontal structural characteristics can support far more diverse faunal com-

REVERSE

Review Section C for further discussion of the ecological functions of soils.

Animals			
Macro	Subsisting largely on plant materials		
		Small mammals—squirrels, gophers, woodchucks, mice, shrews	
		Insects—springtails, ants, beetles, grubs, etc.	
		Millipedes	
		Sowbugs (woodlice)	
		Mites	
		Slugs and snails	
		Earthworms	
	Largely predatory		
		Moles	
		Insects—many ants, beetles, etc.	
		Mites, in some cases	
		Centipedes	
		Spiders	
Micro	Predatory or parasitic or subsisting on plant residues		
		Nematodes	
		Protozoa	
		Rotifers	
Plants			
Roots of higher plants			
Algae			
		Green	
		Blue-green	
		Diatoms	
Fungi			
		Mushroom fungi	
		Yeasts	
		Molds	
Actinomycetes of many kinds			
Bacteria			
		Aerobic	Autotrophic
			Heterotrophic
		Anaerobic	Autotrophic
			Heterotrophic

Table 2.10: Groups of organisms commonly present in soils.

munities than relatively homogenous plant communities, such as meadows. As a result of the complex spatial and temporal relationships that exist between floral and faunal communities, current ecological characteristics of these communities reflect the recent historical (100 years or less) physical conditions of the landscape.

The quantity of terrestrial vegetation, as well as its species composition, can directly affect stream channel characteristics. Root systems in the streambank can bind bank sediments and moderate erosion processes. Trees and smaller woody debris that fall into the stream can deflect flows and induce erosion at some points and deposition at others. Thus woody debris accumulation can influence pool distribution, organic matter and nutrient retention, and the formation of microhabitats that are important fish and invertebrate aquatic communities.

Streamflow also can be affected by the abundance and distribution of terrestrial vegetation. The short-term effects of removing vegetation can result in an immediate short-term rise in the local water table due to decreased evapotranspiration and additional water entering the stream. Over the longer term, however, after removal of vegetation, the baseflow of streams can decrease and water temperatures can rise, particularly in low-order streams. Also, removal of vegetation can cause changes in soil temperature and structure, resulting in decreased movement of water into and through the soil profile. The loss of surface litter and the gradual loss of organic matter in the soil also contribute to increased surface runoff and decreased infiltration.

In most instances, the functions of vegetation that are most apparent are those that influence fish and wildlife. At the landscape level, the fragmentation of native cover types has been shown to significantly influence wildlife, often favoring opportunistic species over those requiring large blocks of contiguous habitat. In some systems, relatively small breaks in corridor continuity can have significant impacts on animal movement or on the suitability of stream conditions to support certain aquatic species. In others, establishing corridors that are structurally different from native systems or that are inappropriately configured can be equally disruptive. Narrow corridors that are essentially edge habitat may encourage generalist species, nest parasites, and predators, and, where corridors have been established across historic barriers to animal movement, they can disrupt the integrity of regional animal assemblages (Knopf et al. 1988).

Landscape Scale

The ecological characteristics and distribution of plant communities in a watershed influence the movement of water, sediment, nutrients, and wildlife. Stream corridors provide links with other features of the landscape. Links may involve continuous corridors between headwater and valley floor ecosystems or periodic interactions between terrestrial systems. Wildlife use corridors to disperse juveniles, to migrate, and to move between portions of their home range. Corridors of a natural origin are preferred and include streams and rivers, riparian strips, mountain passes, isthmuses, and narrow straits (Payne and Bryant 1995).

It is important to understand the differences between a stream-riparian ecosystem and a river-floodplain ecosystem. Flooding in the stream-riparian ecosystem is brief and unpredictable. The riparian zone supplies nutrients, water, and sediment to the stream channel, and riparian vegetation regulates temperature and light. In the river-floodplain ecosystem, floods are often more predictable and longer lasting, the river channel is the donor of water, sediment, and inorganic nutrients to the floodplain, and the influx of turbid and cooler channel water influences light penetration and temperature of the inundated floodplain.

Stream Corridor Scale

At the stream corridor scale, the composition and regeneration patterns of vegetation are characterized in terms of *horizontal complexity*. Floodplains along unconstrained channels typically are vegetated with a mosaic of plant communities, the composition of which varies in response to available surface and ground water, differential patterns of flooding, fire, and predominant winds, sediment deposition, and opportunities for establishing vegetation.

A broad floodplain of the southern, midwestern, or eastern United States may support dozens of relatively distinct forest communities in a complex mosaic reflecting subtle differences in soil type and flood characteristics (e.g., frequency, depth, and duration). In contrast, while certain western stream systems may support only a few woody species, these systems may be structurally complex due to constant reworking of substrates by the stream, which produces a mosaic of stands of varying ages. The presence of side channels, oxbow lakes, and other topographic variation can be viewed as elements of structural variation at the stream corridor level. Riparian areas along constrained stream channels may consist primarily of upland vegetation organized by processes largely unrelated to stream characteristics, but these areas may have considerable influence on the stream ecosystem.

The River Continuum Concept, as discussed in Chapter 1, is also generally applicable to the vegetative components of the riparian corridor. Riparian vegetation demonstrates both a transriparian gradient (across the valley) and an intra-riparian (longitudinal, elevational) gradient (Johnson and Lowe 1985). In the west, growth of riparian vegetation is increased by the "canyon effect" resulting when cool moist air spills downslope from higher elevations (**Figure 2.30**). This cooler air settles in canyons and creates a more moist microhabitat than occurs on the surrounding slopes. These canyons also serve as water courses. The combination of moist, cooler edaphic and atmospheric conditions is conducive to plant and animal species at lower than normal altitudes, often in disjunct populations or in regions where they would not otherwise occur (Lowe and Shannon 1954).

Plant Communities

The sensitivity of animal communities to vegetative characteristics is well recognized. Numerous animal species are associated with particular plant communities, many require particular developmental stages of those communities (e.g., old-growth), and some depend on particular habitat elements within those communities (e.g., snags). The structure of streamside plant communities also directly affects aquatic organisms by providing inputs of appropriate organic materials to the aquatic food web, by shading the water surface and providing cover along banks, and by influencing instream habitat structure through in-

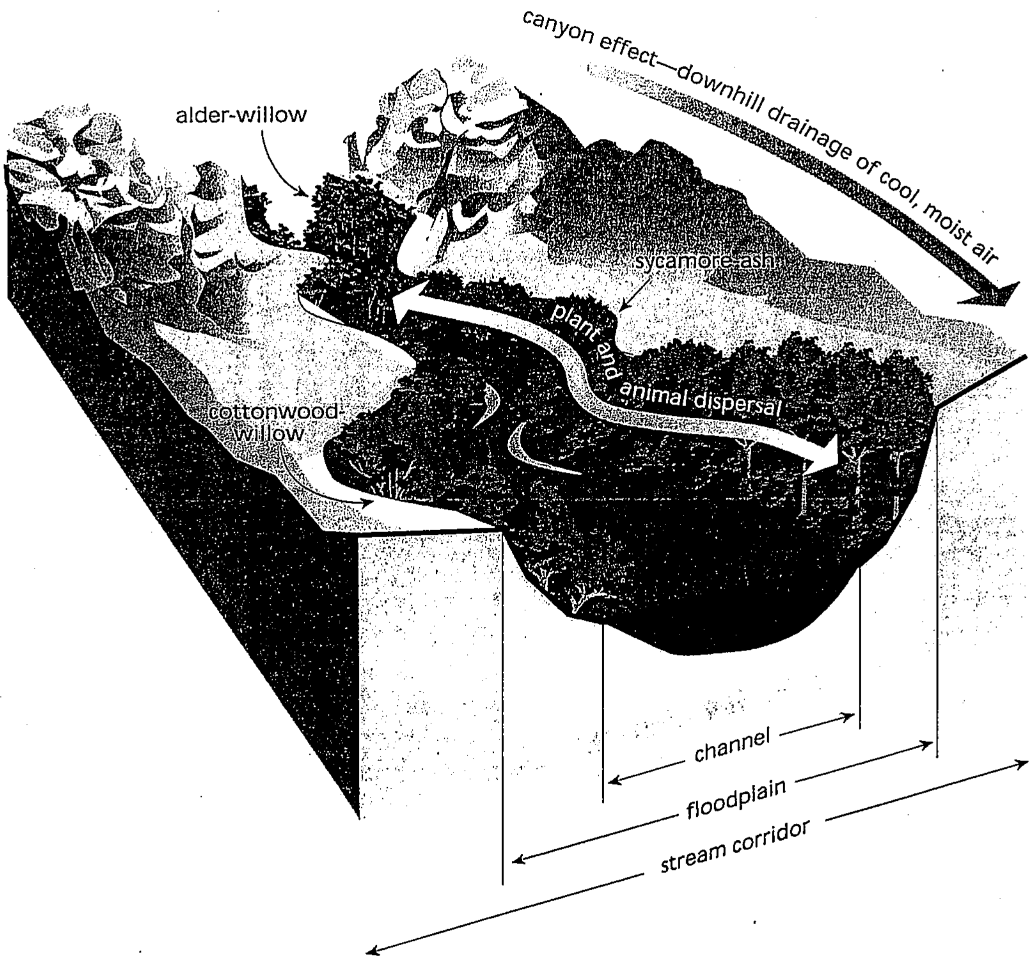


Figure 2.30: Canyon effect. *Cool moist air settles in canyons and creates microhabitat that occurs on surrounding slopes.*

puts of woody debris (Gregory et al. 1991).

Plant communities can be viewed in terms of their internal complexity (Figure 2.31). Complexity may include the number of layers of vegetation and the species comprising each layer; competitive interactions among species; and the presence of detrital components, such as litter, downed wood, and snags. Vegetation may contain tree, sapling, shrub (subtree), vine, and herbaceous subshrub (herb-grass-forb) layers. Microtopographic relief and the ability of water to locally pond also may be regarded as characteristic structural components.

Vertical complexity, described in the concept of diversity of strata or foliage height diversity in ecological literature, was important to studies of avian habitat by Carothers et al. (1974) along the Verde River, a fifth- or sixth-order stream in central Arizona. Findings showed a high correlation between riparian bird species diversity and foliage height diversity of riparian vegetation (Carothers et al. 1974). Short (1985) demonstrated that more structurally diverse vegetative habitats support a greater number of guilds (groups of species with closely related niches in a community) and therefore a larger number of species.

Species and age composition of vegetation structure also can be extremely important. Simple vegetative structure, such as an herbaceous layer without woody overstory or old woody riparian trees without smaller size classes, creates fewer niches for guilds. The fewer guilds there are, the fewer species there are. The quality and vigor of the vegetation can affect the productivity of fruits, seeds, shoots, roots, and other vegetative material, which provide food for wildlife. Poorer vigor can result in less food and fewer consumers (wildlife).

Increasing the patch size (area) of a streamside vegetation type, increasing the number of woody riparian tree size classes, and increasing the number of species and growth forms (herb, shrub, tree) of native riparian-dependent vegetation can increase the number of guilds and the amount of forage, resulting in increased species richness and biomass (numbers). Restoration techniques can change the above factors.

The importance of horizontal complexity within stream corridors to certain animal species also has been well established. The characteristic compositional, structural, and topographic complexity of southern floodplain forests, for example, provides the range of resources and foraging conditions required by many wintering waterfowl to meet particular requirements of their life cycles at the appropriate times (Fredrickson 1978); similar complex relationships have been reported for other vertebrates and invertebrates in floodplain habitats (Wharton et al. 1982). In parts of the arid West, the unique vegetation structure in riparian systems contrasts dra-

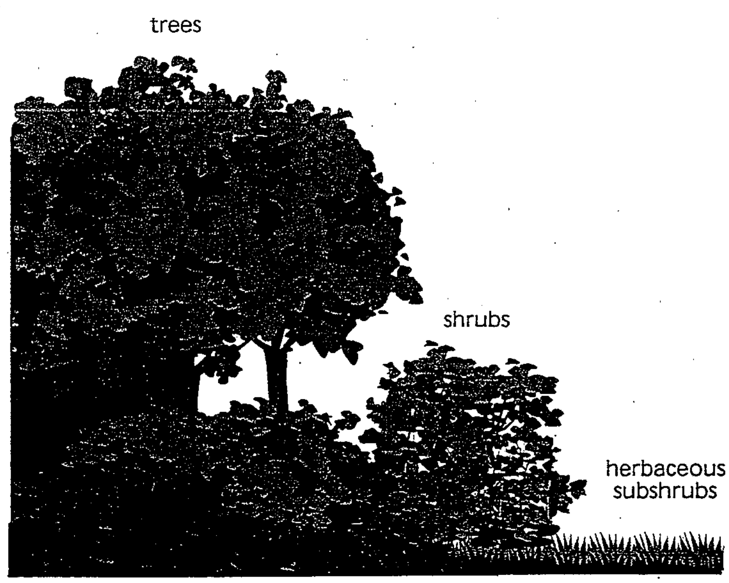


Figure 2.31: Vertical complexity. Complexity may include a number of layers of vegetation.

matically with the surrounding uplands and provides essential habitat for many animals (Knopf et al. 1988). Even within compositionally simple riparian systems, different developmental stages may provide different resources.

Plant communities are distributed on floodplains in relation to flood depth, duration, and frequency, as well as variations in soils and drainage condition. Some plant species, such as cottonwood (*Populus* sp.), willows (*Salix* sp.), and silver maple (*Acer saccharinum*), are adapted to colonization of newly deposited sediments and may require very specific patterns of flood recession during a brief period of seedfall to be successfully established (Morris et al. 1978, Rood and Mahoney 1990). The resultant pattern is one of even-aged tree stands established at different intervals and locations within the active meander belt of the stream. Other species, such as the bald cypress (*Taxodium distichum*), are particularly associated with oxbow lakes formed when streams cut off channel segments, while still others are associated with microtopographic variations within floodplains that reflect the slow migration of a stream channel across the landscape.

Plant communities are dynamic and change over time. The differing regeneration strategies of particular vegetation types lead to characteristic patterns of plant succession following disturbances in which pioneer species well-adapted to bare soil and plentiful light are gradually replaced by longer-lived species that can regenerate under more shaded and protected conditions. New disturbances reset the successional process. Within stream corridors, flooding, channel migration, and, in certain biomes, fire, are usually the dominant natural sources of disturbance. Restoration practitioners should understand patterns of natural succession in a stream corridor and should take advantage of the successional process by planting hardy early-successional species to stabilize an eroding streambank, while planning for the eventual replacement of these species by longer-lived and higher-successional species.

Terrestrial Fauna

Stream corridors are used by wildlife more than any other habitat type (Thomas et al. 1979) and are a major source of water to wildlife populations, especially large mammals. For example, 60 percent of Arizona's wildlife species depend on riparian areas for survival (Ohmart and Anderson 1986). In the Great Basin area of Utah and Nevada, 288 of the 363 identified terrestrial vertebrate species depend on riparian zones (Thomas et al. 1979). Because of their wide suitability for upland and riparian species, midwestern stream corridors associated with prairie grasslands support a wider diversity of wildlife than the associated uplands. Stream corridors play a large role in maintaining biodiversity for all groups of vertebrates.

The faunal composition of a stream corridor is a function of the interaction of food, water, cover, and spatial arrangement (Thomas et al. 1979). These habitat components interact in multiple ways to provide eight habitat features of stream corridors:

- Presence of permanent sources of water.
- High primary productivity and biomass.
- Dramatic spatial and temporal contrasts in cover types and food availability.
- Critical microclimates.
- Horizontal and vertical habitat diversity.

- Maximized edge effect.
- Effective seasonal migration routes.
- High connectivity between vegetated patches.

Stream corridors offer the optimal habitat for many forms of wildlife because of the proximity to a water source and an ecological community that consists primarily of hardwoods in many parts of the country, which provide a source of food, such as nectar, catkins, buds, fruit, and seeds (Harris 1984). Upstream sources of water, nutrients, and energy ultimately benefit downstream locations. In turn, the fish and wildlife return and disperse some of the nutrients and energy to uplands and wetlands during their movements and migrations (Harris 1984).

Water is especially critical to fauna in areas such as the Southwest or Western Prairie regions of the U.S. where stream corridors are the only naturally occurring permanent sources of water on the landscape. These relatively moist environments contribute to the high primary productivity and biomass of the riparian area, which contrasts dramatically with surrounding cover types and food sources. In these areas, stream corridors provide critical microclimates that ameliorate the temperature and moisture extremes of uplands by providing water, shade, evapotranspiration, and cover.

The spatial distribution of vegetation is also a critical factor for wildlife. The linear arrangement of streams results in a maximized edge effect that increases species richness because a species can simultaneously access more than one cover (or habitat) type and exploit the resources of both (Leopold 1933). Edges occur along multiple habitat types including the aquatic, riparian, and upland habitats.

Forested connectors between habitats establish continuity between forested uplands that may be surrounded by unforested areas. These act as feeder lines for dispersal and facilitate repopulation by plants and animals. Thus, connectivity is very important for retaining biodiversity and genetic integrity on a landscape basis.

However, the linear distribution of habitat, or edge effect, is not an effective indicator of habitat quality for all species. Studies in island biogeography, using habitat islands rather than oceanic islands, demonstrate that a larger habitat island supports both a larger population of birds and also a larger number of species (Wilson and Carothers 1979). Although a continuous corridor is most desirable, the next preferable situation is minimal fragmentation, i.e., large plots ("islands") of riparian vegetation with minimal spaces between the large plots.

Reptiles and Amphibians

Nearly all amphibians (salamanders, toads, and frogs) depend on aquatic habitats for reproduction and overwintering. While less restricted by the presence of water, many reptiles are found primarily in stream corridors and riparian habitats. Thirty-six of the 63 reptile and amphibian species found in west-central Arizona were found to use riparian zones. In the Great Basin, 11 of 22 reptile species require or prefer riparian zones (Ohmart and Anderson 1986).

Birds

Birds are the most commonly observed terrestrial wildlife in riparian corridors. Nationally, over 250 species have been reported using riparian areas during some part of the year.

The highest known density of nesting birds in North America occurs in southwestern cottonwood habitats (Carothers and Johnson 1971). Seventy-three percent of the 166 breeding bird species in the Southwest prefer riparian habitats (Johnson et al. 1977).

Bird species richness in midwestern stream corridors reflects the vegetative diversity and width of the corridor. Over half of these breeding birds are species that forage for insects on foliage (vireos, warblers) or species that forage for seeds on the ground (doves, orioles, grosbeaks, sparrows). Next in abundance are insectivorous species that forage on the ground or on trees (thrushes, woodpeckers).

Smith (1977) reported that the distribution of bird species in forested habitats of the Southeast was closely linked to soil moisture. Woodcock (*Scolopax minor*) and snipe (*Gallinago gallinago*), red-shouldered hawks (*Buteo lineatus*), hooded and prothonotary warblers (*Wilsonia citrina, Protonotaria citrea*), and many other passerines in the Southeast prefer the moist ground conditions found in riverside forests and shrublands for feeding. The cypress and mangrove swamps along Florida's waterways harbor many species found almost nowhere else in the Southeast.

Mammals

The combination of cover, water, and food resources in riparian areas make them desirable habitat for large mammals such as mule deer (*Odocoileus hemionus*), white-tailed deer (*Odocoileus virginianus*), moose (*Alces alces*), and elk (*Cervus elaphus*) that can use multiple habitat types. Other mammals depend on riparian areas in some or all of their range. These include otter (*Lutra canadensis*), ringtail (*Bassarisdus astutus*), raccoon (*Procyon lotor*), beaver (*Castor canadensis*), muskrat (*Ondatra zibethicus*), swamp rabbit (*Sylvilagus aquaticus*), short-tailed shrew (*Blarina brevicauda*), and mink (*Mustela vison*).

Riparian areas provide tall dense cover for roosts, water, and abundant prey for a number of bat species, including the little brown bat (*Myotis lucifugus*), big brown bat (*Eptesicus fuscus*), and the pallid bat (*Antrozous pallidus*). Brinson et al. (1981) tabulated results from several studies on mammals in riparian areas of the continental U.S. They concluded that the number of mammal species generally ranges from five to 30, with communities including several furbearers, one or more large mammals, and a few small to medium mammals.

Hoover and Wills (1984) reported 59 species of mammals in cottonwood riparian woodlands of Colorado, second only to pinyon-juniper among eight other forested cover types in the region. Fifty-two of the 68 mammal species found in west-central Arizona in Bureau of Land Management inventories use riparian habitats. Stamp and Ohmart (1979) and Cross (1985) found that riparian areas had a greater diversity and biomass of small mammals than adjacent upland areas.

The contrast between the species diversity and productivity of mammals in the riparian zone and that of the surrounding uplands is especially high in arid and semiarid regions. However, bottomland hardwoods in the eastern U.S. also have exceptionally high habitat values for many mammals. For example, bottomland hardwoods support white-tail deer populations roughly twice as large as equivalent areas of upland forest (Glasgow and Noble 1971).

Stream corridors are themselves influenced by certain animal activities (Forman 1995). For example, beavers build dams that cause ponds to form within a stream channel or in the floodplain. The pond kills much of the existing vegetation, although it does create wetlands and open water areas for fish and migratory waterfowl. If appropriate woody plants in the floodplain are scarce, beavers extend their cutting activities into the uplands and can significantly alter the riparian and stream corridors. Over time, the pond is replaced by a mudflat, which becomes a meadow and eventually gives way to woody successional stages. Beaver often then build a dam at a new spot, and the cycle begins anew with only a spatial displacement.

The sequence of beaver dams along a stream corridor may have major effects on hydrology, sedimentation, and mineral nutrients (Forman 1995). Water from stormflow is held back, thereby affording some measure of flood control. Silts and other fine sediments accumulate in the pond rather than being washed downstream. Wetland areas usually form, and the water table rises upstream of the dam. The ponds combine slow flow, near-constant water levels, and low turbidity that support fish and other aquatic organisms. Birds may use beaver ponds extensively. The wetlands also have a relatively constant water table, unlike the typical fluctuations across a floodplain. Beavers cutting trees diminish the abundance of such species as elm (*Ulmus* spp.) and ash (*Fraxinus* spp.) but enhance the abundance of rapidly sprouting species, such as alder (*Alnus* spp.), willow, and poplar (*Populus* spp.).

Aquatic Ecosystems

Aquatic Habitat

The biological diversity and species abundance in streams depend on the diversity of available habitats. Naturally functioning, stable stream systems promote the diversity and availability of habitats. This is one of the primary reasons stream stability and the restoration of natural functions are always considered in stream corridor restoration activities. A stream's cross-sectional shape and dimensions, its slope and confinement, the grain-size distribution of bed sediments, and even its planform affect aquatic habitat. Under less disturbed situations, a narrow, steep-walled cross section provides less physical area for habitat than a wider cross section with less steep sides, but may provide more biologically rich habitat in deep pools compared to a wider, shallower stream corridor. A steep, confined stream is a high-energy environment that may limit habitat occurrence, diversity, and stability. Many steep, fast flowing streams are coldwater salmonid streams of high value. Unconfined systems flood frequently, which can promote riparian habitat development. Habitat increases with stream sinuosity. Uniform sediment size in a streambed provides less potential habitat diversity than a bed with many grain sizes represented.

Habitat subsystems occur at different scales within a stream system (Frissell et al. 1986) (**Figure 2.32**). The grossest scale, the stream system itself, is measured in thousands of feet, while segments are measured in hundreds of feet and reaches are measured in tens of feet. A reach system includes combinations of debris dams, boulder cascades, rapids, step/pool sequences, pool/riffle sequences, or other types of streambed forms or "structures," each of which could be 10 feet or less in scale. Frissell's smallest scale habitat subsystem includes features that are a foot or less in size. Examples of these *microhabitats* include leaf or stick detritus, sand or silt over cobbles or other coarse material, moss on boulders, or fine gravel patches.

Steep slopes often form a step/pool sequence in streams, especially in cobble, boulder, and bedrock streams. Each step acts as a miniature grade stabilization structure. The steps and pools work

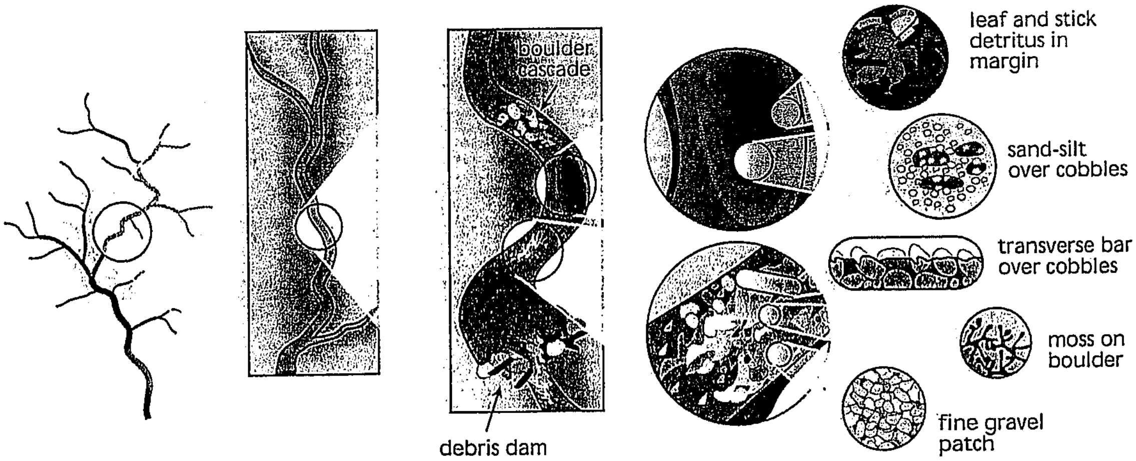


Figure 2.32: Hierarchical organization of a stream system and its habitat subsystems. Approximate linear spatial scale, appropriate to second- or third-order mountain stream.

together to distribute the excess energy available in these steeply sloping systems. They also add diversity to the habitat available. Cobble- and gravel-bottomed streams at less steep slopes form pool/riffle sequences, which also increase habitat diversity. Pools provide space, cover, and nutrition to fish and they provide a place for fish to seek shelter during storms, droughts, and other catastrophic events. Upstream migration of many salmonid species typically involves rapid movements through shallow areas, followed by periods of rest in deeper pools (Spence et al. 1996).

Wetlands

Stream corridor restoration initiatives may include restoration of wetlands such as riverine-type bottomland hardwood systems or riparian wetlands. While wetland restoration is a specific topic better addressed in other references (e.g., Kentula et al. 1992), a general discussion of wetlands is provided here. Stream corridor restoration initiatives should be designed to protect or restore the functions of associated wetlands.

A wetland is an ecosystem that depends on constant or recurrent shallow inundation or saturation at or near the surface of the substrate. The minimum essential characteristics of a wetland are recurrent, sustained inundation or saturation at or near the surface and the presence of physical, chemical, and biological features that reflect recurrent sustained inundation or saturation. Common diagnostic features of wetlands are hydric soils and hydrophytic vegetation. These features will be present except where physicochemical, biotic, or anthropogenic factors have removed them or prevented their development (National Academy of Sciences 1995). Wetlands may occur in streams, riparian areas, and floodplains of the stream corridor. The riparian area or zone may contain both wetlands and non-wetlands.

Wetlands are transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water (Cowardin et al. 1979). For vegetated wetlands, water creates conditions that favor the growth of hydrophytes—plants growing in water or on a substrate that is at least periodically deficient in oxygen as a result of excessive water content (Cowardin et al. 1979) and promotes the development of hydric soils—soils that are saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions in the upper part (National Academy of Sciences 1995).

Wetland functions include fish and wildlife habitat, water storage, sediment trapping, flood damage reduction, water quality improvement/pollution control, and ground water recharge. Wetlands have long been recognized as highly productive habitats for threatened and endangered fish and wildlife species. Wetlands provide habitat for 60 to 70 percent of the animal species federally listed as threatened or endangered (Lohoefner 1997).

The Federal Geographic Data Committee has adopted the U.S. Fish and Wildlife Service's *Classification of Wetlands and Deepwater Habitats of the United States* (Cowardin et al. 1979) as the national standard for wetlands classification. The Service's National Wetlands Inventory (NWI) uses this system to carry out its congressionally mandated role of identifying, classifying, mapping, and digitizing data on wetlands and deepwater habitats. This system, which defines wetlands consistently with the National Academy of Science's reference definition, includes Marine, Estuarine, Riverine, Lacustrine, and Palustrine systems. The NWI has also developed protocols for classifying and mapping riparian habitats in the 22 coterminous western states.

The riverine system under Cowardin's classification includes all wetlands and deepwater habitats contained within a channel except wetlands dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens and habitats with water containing ocean-derived salts in excess of 0.5 parts per thousand (ppt).

It is bounded on the upstream end by uplands and on the downstream end at the interface with tidal wetlands having a concentration of ocean-derived salts that exceeds 0.5 ppt. Riverine wetlands

Riparian Mapping

The riparian zone is a classic example of the maximized value that occurs when two or more habitat types meet. There is little question of the substantial value of riparian habitats in the United States. The Fish and Wildlife Service has developed protocols to classify and map riparian areas in the West in conjunction with the National Wetlands Inventory (NWI). NWI will map riparian areas on a 100 percent user-pay basis. No formal riparian mapping effort has been initiated. The NWI is congressionally mandated to identify, classify, and digitize all wetlands and deepwater habitats in the United States. For purposes of riparian mapping, the NWI has developed a riparian definition that incorporates biological information consistent with many agencies and applies information according to cartographic principles. For NWI mapping and classification purposes, a final definition for riparian has been developed:

Riparian areas are plant communities contiguous to and affected by surface and subsurface hydrological features of perennial or intermittent lotic and lentic water bodies (rivers, streams, lakes, and drainage ways). Riparian areas have one or both of the following characteristics: (1) distinctly different vegetative species than adjacent areas; and (2) species similar to adjacent areas but exhibiting more vigorous or robust growth forms. Riparian areas are usually transitional between wetland and upland.

The definition applies primarily to regions of the lower 48 states in the arid west where the mean annual precipitation is 16 inches or less and the mean annual evaporation exceeds mean annual precipitation. For purposes of this mapping, the riparian system is subdivided into subsystems, classes, subclasses, and dominance types. (USFWS 1997) are bounded perpendicularly on the landward side by upland, the channel bank (including natural and manufactured levees), or by *Palustrine wetlands.* In braided streams, riverine wetlands are bounded by the banks forming the outer limits of the depression within which the braiding occurs.

Vegetated floodplain wetlands of the river corridor are classified as Palustrine under this system. The Palustrine system was developed to group the vegetated wetlands traditionally called by such names as marsh, swamp, bog, fen, and prairie pothole and also includes small, shallow, permanent, or intermittent water bodies often called ponds. Palustrine wetlands may be situated shoreward of lakes, river channels, or estuaries, on river floodplains, in isolated catchments, or on slopes. They also may occur as islands in lakes or rivers. The Palustrine system includes all nontidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses and lichens, and all such wetlands that occur in tidal areas where salinity due to ocean-derived salts is below 0.5 ppt. The Palustrine system is bounded by upland or by any of the other four systems. They may merge with non-wetland riparian habitat where hydrologic conditions cease to support wetland vegetation or may be totally absent where hydrologic conditions do not support wetlands at all (Cowardin et al. 1979).

The *hydrogeomorphic (HGM) approach* is a system that classifies wetlands into similar groups for conducting functional assessments of wetlands. Wetlands are classified based on geomorphology, water source, and hydrodynamics. This allows the focus to be placed on a group of wetlands that function much more similarly than would be the case without classifying them. Reference wetlands are used to develop reference standards against which a wetland is evaluated (Brinson 1995).

Under the HGM approach, riverine wetlands occur in floodplains and riparian corridors associated with stream channels. The dominant water sources are overbank flow or subsurface connections between stream channel and wetlands. Riverine wetlands lose water by surface and subsurface flow returning to the stream channel, ground water recharge, and evapotranspiration. At the extension closest to the headwaters, riverine wetlands often are replaced by slope or depressional wetlands where channel bed and bank disappear, or they may intergrade with poorly drained flats and uplands. Usually forested, they extend downstream to the intergrade with estuarine fringe wetlands. Lateral extent is from the edge of the channel perpendicularly to the edge of the floodplain. In some landscape situations, riverine wetlands may function hydrologically more like slope wetlands, and in headwater streams with little or no floodplain, slope wetlands may lie adjacent to the stream channel (Brinson et al. 1995). **Table 2.11** summarizes functions of riverine wetlands under the HGM approach. The U.S. Fish and Wildlife Service is testing an operational draft set of hydrogeomorphic type descriptors to help bridge the gap between the Cowardin system and the HGM approach (Tiner 1997).

For purposes of regulation under Section 404 of the Clean Water Act, only areas with wetland hydrology, hydrophytic vegetation, and hydric soils are classified as regulated wetlands. As such, they represent a subset of the areas classified as wetlands under the Cowardin system. However, many areas classified as wetlands under the Cowardin system, but not classified as wetlands for purposes of Section 404, are nevertheless subject to regulation because they are part of the Waters of the United States.

Aquatic Vegetation and Fauna

Stream biota are often classified in seven groups—bacteria, algae, macrophytes (higher plants), protists (amoebas, flagellates, ciliates), microinvertebrates (invertebrates less than 0.02 inch in length, such as rotifers, copepods, ostracods, and nematodes), macroinvertebrates (invertebrates greater than 0.02 inch in length, such as mayflies, stoneflies, caddisflies, crayfish, worms, clams, and snails), and vertebrates (fish, amphibians, reptiles, and mammals) (**Figure 2.33**). The discussion of the River Continuum Concept in Chapter 1, provides an overview of the major groups of organisms found in streams and how these assemblages change from higher order to lower order streams.

Undisturbed streams can contain a remarkable number of species. For example, a comprehensive inventory of stream biota in a small German stream, the Breitenbach, found more than 1,300 species in a 1.2-mile reach. Lists of algae, macroinvertebrates, and fish likely to be found at potential restoration sites may be obtained from state or regional inventories. The densities of such stream biota are shown in **Table 2.12**.

Aquatic plants usually consist of algae and mosses attached to permanent stream substrates. Rooted aquatic vegetation may occur where substrates are suitable and high currents do not scour the stream bottom. Luxuriant beds of vascular plants may grow in some areas such as spring-fed streams in Florida where water clarity, substrates, nutrients, and slow water velocities exist. Bedrock or stones that cannot be moved easily by stream currents are often covered by mosses and algae and various forms of

Hydrologic	Dynamic surface water storage
	Long-term surface water storage
	Subsurface storage of water
	Energy dissipation
	Moderation of ground-water flow or discharge
Biogeochemical	Nutrient cycling
	Removal of elements and compounds
	Retention of particulates
	Organic carbon export
Plant habitat	Maintain characteristic plant communities
	Maintain characteristic detrital biomass
Animal habitat	Maintain spatial habitat structure
	Maintain interspersion and connectivity
	Maintain distribution and abundance of invertebrates
	Maintain distribution and abundance of vertebrates

Table 2.11: Functions of riverine wetlands.
Source: Brinson et al. 1995.

micro- and macroinvertebrates (Ruttner 1963). Planktonic plant forms are usually limited but may be present where the watershed contains lakes, ponds, floodplain waters, or slow current areas (Odum 1971).

The benthic invertebrate community of streams may contain a variety of biota, including bacteria, protists, rotifers, bryozoans, worms, crustaceans, aquatic insect larvae, mussels, clams, crayfish, and other forms of invertebrates. Aquatic invertebrates are found in or on a multitude of microhabitats in streams including plants, woody debris, rocks, interstitial spaces of hard substrates, and soft substrates (gravel, sand, and muck). Invertebrate habitats exist at all vertical strata including the water surface, the water column, the bottom surface, and deep within the hyporheic zone.

Unicellular organisms and microinvertebrates are the most numerous biota in streams. However, larger macroinvertebrates are important to community structure because they contribute significantly to a stream's total invertebrate biomass (Morin and Nadon 1991,

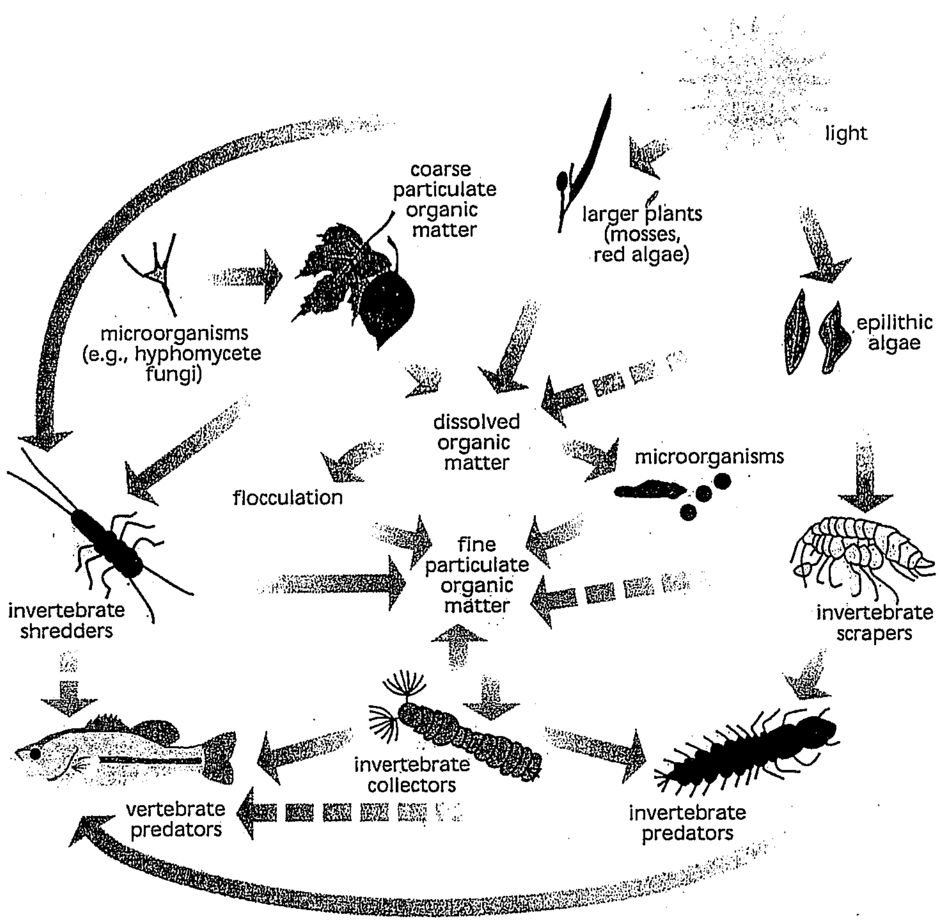


Figure 2.33: Stream 'iota. Food relation- 'ps typically found . streams.

Bourassa and Morin 1995). Furthermore, the larger species often play important roles in determining community composition of other components of the ecosystem. For example, herbivorous feeding activities of caddisfly larvae (Lamberti and Resh 1983), snails (Steinman et al. 1987), and crayfish (Lodge 1991) can have a significant effect on the abundance and taxonomic composition of algae and periphyton in streams. Likewise, macroinvertebrate predators, such as stoneflies, can influence the abundance of other species within the invertebrate community (Peckarsky 1985).

Table 2.12: Ranges of densities commonly observed for selected groups of stream biota.

Biotic Component	Density (Individuals/Square Mile)
Algae	$10^9 - 10^{10}$
Bacteria	$10^{12} - 10^{13}$
Protists	$10^8 - 10^9$
Microinvertebrates	$10^3 - 10^5$
Macroinvertebrates	$10^4 - 10^5$
Vertebrates	$10^0 - 10^2$

Collectively, microorganisms (fungi and bacteria) and benthic invertebrates facilitate the breakdown of organic material, such as leaf litter, that enters the stream from external sources. Some invertebrates (insect larvae and amphipods) act as shredders whose feeding activities break down larger organic leaf litter to smaller particles. Other invertebrates filter smaller organic material from the water (blackfly larvae, some mayfly nymphs, and some caddisfly larvae), scrape material off surfaces (snails, limpets, and some caddisfly and mayfly nymphs), or feed on material deposited on the substrate (dipteran larvae and some mayfly nymphs) (Moss 1988). These feeding activities result in the breakdown of organic matter in addition to the elaboration of invertebrate tissue, which other consumer groups, such as fish, feed on.

Benthic macroinvertebrates, particularly aquatic insect larvae and crustaceans, are widely used as indicators of stream health and condition. Many fish species rely on benthic organisms as a food source either by direct browsing on the benthos or by catching benthic organisms that become dislodged and drift downstream (Walburg 1971).

Fish are ecologically important in stream ecosystems because they are usually the largest vertebrates and often are the apex predator in aquatic systems. The numbers and species composition of fishes in a given stream depends on the geographic location, evolutionary history, and such intrinsic factors as physical habitat (current, depth, substrates, riffle/pool ratio, wood snags, and undercut banks), water quality (temperature, dissolved oxygen, suspended solids, nutrients, and toxic chemicals), and biotic interactions (exploitation, predation, and competition).

There are approximately 700 native freshwater species of fish in North America (Briggs 1986). Fish species richness is highest in the Mississippi River Basin where most of the adaptive radiations have occurred in the United States (Allan 1995). In the Midwest, as many as 50 to 100 species can occur in a local area, although typically only half the species native to a region may be found at any one location (Horwitz 1978). Fish species richness generally declines as one moves westward across the United States, primarily due to extinction during and following the Pleistocene Age (Fausch et al. 1984). For example, 210 species are found west of the Continental Divide, but only 40 of these species are found on both sides of the continent (Minckley and Douglas 1991). The relatively depauperate fauna of the Western United States has been attributed to the isolating mechanisms of tectonic geology. Secondary biological, physical, and chemical factors may further reduce the species richness of a specific community (Minckley and Douglas 1991, Allan 1995).

Fish species assemblages in streams will vary considerably from the headwaters to the outlet due to changes in many hydrologic and geomorphic factors which control temperature, dissolved oxygen, gradient, current velocity, and substrate. Such factors combine to determine the degree of habitat diversity in a given stream segment. Fish species richness tends to increase downstream as gradient decreases and stream size increases. Species richness is generally lowest at small headwater streams due to increased gradient and small stream size, which increases the frequency and severity of environmental fluctuations (Hynes 1970, Matthews and Styron 1980). In addition, the high gradient and decreased links with tributaries reduces the potential for colonization and entry of new species.

Species richness increases in mid-order to lower stream reaches due to increased environmental stability, greater numbers of potential habitats, and increases in numbers of colonization sources or links between major drainages. As one proceeds downstream, pools and runs increase over riffles, allowing for an increase in fine bottom materials and facilitating the growth of macrophytic vegetation. These environments allow for the presence of fishes more tolerant of low oxygen and increased temperatures. Further, the range of body forms increases with the appearance of those species with less fusiform body shapes, which are ecologically adapted to areas typified by decreased water velocities. In higher order streams or large rivers the bottom substrates often are typified by finer sediments; thus herbivores, omnivores, and planktivores may increase in response to the availability of aquatic vegetation and plankton (Bond 1979).

Fish have evolved unique feeding and reproductive strategies to survive in the diverse habitat conditions of North America. Horwitz (1978) examined the structure of fish feeding guilds in 15 U.S. river systems and found that most fish species (33 percent) were benthic insectivores, whereas piscivores (16 percent), herbivores (7 percent), omnivores (6 percent), planktivores (3 percent), and other guilds contained fewer species. However, Allan (1995) indicated that fish frequently change feeding habits across habitats, life stages, and season to adapt to changing physical and biological conditions. Fish in smaller headwater streams tend to be insectivores or specialists, whereas the number of generalists and the range of feeding strategies increases downstream in response to increasing diversity of conditions.

Some fish species are migratory, returning to a particular site over long distances to spawn. Others may exhibit great endurance, migrating upstream against currents and over obstacles such as waterfalls. Many must move between salt water and freshwater, requiring great osmoregulatory ability (McKeown 1984). Species that return from the ocean environment into freshwater streams to spawn are called *anadromous* species.

Species generally may be referred to as cold water or warm water, and gradations between, depending on their temperature requirements (Magnuson et al. 1979). Fish such as salmonids are usually restricted to higher elevations or northern climes typified by colder, highly oxygenated water. These species tend to be specialists, with rather narrow thermal tolerances and rather specific reproductive requirements. For example, salmonids typically spawn by depositing eggs over or within clean gravels which remain oxygenated and silt-free due to upwelling of currents within the interstitial spaces. Reproductive movement and behavior is controlled by subtle thermal changes combined with increasing or decreasing day-length. Salmonid populations, therefore, are highly susceptible to many forms of habitat degradation, including alteration of flows, temperature, and substrate quality.

Numerous fish species in the U.S. are declining in number. Williams and Julien (1989) presented a list of North American fish species that the American Fisheries Society believed should be classified as endangered, threatened, or of special concern. This list contains 364 fish species warranting protection because of their rarity. Habitat loss was the primary cause of depletion for approximately 90 percent of the species listed. This study noted that 77 percent of the fish species listed were found in 25 percent of the states, with the highest concentrations in eight southwestern states. Nehlsen et al. (1991) provided a list of 214 native naturally spawning stocks of depleted Pacific salmon, steelhead, and sea-run cutthroat stocks from California, Oregon, Idaho, and Washington. Reasons cited for the declines were alteration of fish passage and migration due to dams, flow reduction associated with hydropower and agriculture, sedimentation and habitat loss due to logging and agriculture, overfishing, and negative interactions with other fish, including nonnative hatchery salmon and steelhead.

The widespread decline in the numbers of native fish species has led to current widespread interest in restoring the quality and quantity of habitats for fish. Restoration activities have frequently centered on improving local habitats, such as fencing or removing livestock from streams, constructing fish passages, or installing instream physical habitat. However, research has demonstrated that in most of these cases the success has been limited or questionable because the focus was too narrow and did not address restoration of the diverse array of habitat requirements and resources that are needed over the life span of a species.

Stream corridor restoration practitioners and others are now acutely aware that fish require many different habitats over the season and lifespan to fulfill needs for feeding, resting, avoiding predators, and reproducing. For example, Livingstone and Rabeni (1991) determined that juvenile smallmouth bass in the Jacks Fork River of southeastern Missouri fed primarily on small macroinvertebrates in littoral vegetation. Vegetation represented not only a source of food but a refuge from predators and a warmer habitat, factors that can collectively optimize chances for survival and growth (Rabeni and Jacobson 1993). Adult smallmouth bass, however, tended to occupy deeper pool habitats, and the numbers and biomass of adults at various sites were attributed to these specific deep-water habitats (McClendon and Rabeni 1987). Rabeni and Jacobson (1993) suggested that an understanding of these specific habitats, combined with an understanding of the fluvial hydraulics and geomorphology that form and maintain them, are key to developing successful stream restoration initiatives.

The emphasis on fish community restoration is increasing due to many ecological, economic, and recreational factors. In 1996 approximately 35 million Americans older than 16 participated in recreational fishing, resulting in over $36 billion in expenditures (Brouha 1997). Much of this activity is in streams, which justifies stream corridor restoration initiatives.

While fish stocks often receive the greatest public attention, preservation of other aquatic biota may also may be a goal of stream restoration. Freshwater mussels, many species of which are threatened and endangered, are often of particular concern. Mussels are highly sensitive to habitat disturbances and obviously benefit from intact, well-managed stream corridors. The south-central United States has the highest diversity of mussels in the world. Mussel ecology also is intimately linked with fish ecology, as fish function as hosts for mussel larvae (glochidia). Among the major threats they face are dams, which lead to direct habitat loss and fragmentation of remaining habitat, persistent sedimentation, pesticides, and introduced exotic species, such as fish and other mussel species.

Abiotic and Biotic Interrelations in the Aquatic System

Much of the spatial and temporal variability of stream biota reflects variations in both abiotic and biotic factors, including water quality, temperature, streamflow and flow velocity, substrate, the availability of food and nutrients, and predator-prey relationships. These factors influence the growth, survival, and reproduction of aquatic organisms. While these factors are addressed individually below, it is important to remember that they are often interdependent.

Flow Condition

The flow of water from upstream to downstream distinguishes streams from other ecosystems. The spatial and temporal characteristics of streamflow, such as fast versus slow, deep versus shallow, turbulent versus smooth, and flooding versus low flows, are described previously in this chapter. These flow characteristics can affect both micro- and macro-distribution patterns of numerous stream species (Bayley and Li 1992, Reynolds 1992, Ward 1992). Many organisms are sensitive to flow velocity because it represents an important mechanism for delivering food and nutrients yet also may limit the ability of organisms to remain in a stream segment. Some organisms also respond to temporal variations in flow, which can change the physical structure of the stream channel, as well as increase mortality, modify available resources, and disrupt interactions among species (Resh et al. 1988, Bayley and Li 1992).

The flow velocity in streams determines whether planktonic forms can develop and sustain themselves. The slower the currents in a stream, the more closely the composition and configuration of biota at the shore and on the bottom approach those of standing water (Ruttner 1963). High flows are cues for timing migration and spawning of some fishes. High flows also cleanse and sort streambed materials and scour pools. Extreme low flows may limit young fish production because such flows often occur during periods of recruitment and growth (Kohler and Hubert 1993).

Water Temperature

Water temperature can vary markedly within and among stream systems as a function of ambient air temperature, altitude, latitude, origin of the water, and solar radiation (Ward 1985, Sweeney 1993). Temperature governs many biochemical and physiological processes in cold-blooded aquatic organisms because their body temperature is the same as the surrounding water; thus, water temperature has an important role in determining growth, development, and behavioral patterns. Stream insects, for example, often grow and develop more rapidly in warmer portions of a stream or during warmer seasons. Where the thermal differences among sites are significant (e.g., along latitudinal or altitudinal gradients), it is possible for some species to complete two or more generations per year at warmer sites; these same species complete one or fewer generations per year at cooler sites (Sweeney 1984, Ward 1992). Growth rates for algae and fish appear to respond to temperature changes in a similar fashion (Hynes 1970, Reynolds 1992). The relationships between temperature and growth, development, and behavior can be strong enough to affect geographic ranges of some species (**Table 2.13**).

Water temperature is one of the most important factors determining the distribution of fish in freshwater streams, due both to direct impacts and influence on dissolved oxygen concentrations, and is influenced by local conditions, such as shade, depth and current. Many fish species can tolerate only a limited temperature range. Such fish as salmonids and sculpins dominate in cold water streams, whereas such species as largemouth bass, smallmouth bass, suckers, minnows, sunfishes and catfishes may be present in warmer streams (Walburg 1971).

Effects of Cover

For the purposes of restoration, land use practices that remove overhead

Table 2.13: Maximum weekly average temperatures for growth and short term maximum temperatures for selected fish (°F).
Source: Brungs and Jones 1977.

Species	Max. Weekly Average Temp. for Growth (Juveniles)	Max. Temp. for Survival of Short Exposure (Juveniles)	Max. Weekly Average Temp. for Spawning[a]	Max. Temp. for Embryo Spawning[b]
Atlantic salmon	68°F	73°F	41°F	52°F
Bluegill	90°F	95°F	77°F	93°F
Brook trout	66°F	75°F	48°F	55°F
Common carp			70°F	91°F
Channel catfish	90°F	95°F	81°F	84°F[c]
Largemouth bass	90°F	93°F	70°F	81°F[c]
Rainbow trout	66°F	75°F	48°F	55°F
Smallmouth bass	84°F		63°F	73°F[c]
Sockeye salmon	64°F	72°F	50°F	55°F

[a] Optimum or mean of the range of spawning temperatures reported for the species.
[b] Upper temperature for successful incubation and hatching reported for the species.
[c] Upper temperature for spawning.

cover or decrease baseflows can increase instream temperatures to levels that exceed critical thermal maxima for fishes (Feminella and Matthews 1984). Thus, maintenance or restoration of normal temperature regimes can be an important endpoint for stream managers.

Riparian vegetation is an important factor in the attenuation of light and temperature in streams (Cole 1994). Direct sunlight can significantly warm streams, particularly during summer periods of low flow. Under such conditions, streams flowing through forests warm rapidly as they enter deforested areas, but may also cool somewhat when streams reenter the forest. In Pennsylvania (Lynch et al. 1980), average daily stream temperatures that increased 12°C through a clearcut area were substantially moderated after flow through 1,640 feet of forest below the clearcut. They attributed the temperature reduction primarily to inflows of cooler ground water.

A lack of cover also affects stream temperature during the winter. Sweeney (1993) found that, while average daily temperatures were higher in a second-order meadow stream than in a comparable wooded reach from April through October, the reverse was true from November through March. In a review of temperature effects on stream macroinvertebrates common to the Pennsylvania Piedmont, Sweeney (1992) found that temperature changes of 2 to 6 °C usually altered key life-history characteristics of the study species. Riparian forest buffers have been shown to prevent the disruption of natural temperature patterns as well as to mitigate the increases in temperature following deforestation (Brown and Krygier 1970, Brazier and Brown 1973).

The exact buffer width needed for temperature control will vary from site to site depending on such factors as stream orientation, vegetation, and width. Along a smaller, narrow headwater stream, the reestablishment of shrubs, e.g., willows and alders, may provide adequate shade and detritus to restore both the riparian and aquatic ecosystems. The planting and/or reestablishment of large trees, e.g., cottonwoods, willows, sycamores, ash, and walnuts (Lowe 1964), along larger, higher order rivers can improve the segment of the fishery closest to the banks, but has little total effect on light and temperature of wider rivers.

Heat budget models can accurately predict stream and river temperatures (e.g., Beschta 1984, Theurer et al. 1984). Solar radiation is the major factor influencing peak summer water temperatures and shading is critical to the overall temperature regime of streams in small watersheds.

Dissolved Oxygen

Oxygen enters the water by absorption directly from the atmosphere and by plant photosynthesis (Mackenthun 1969). Due to the shallow depth, large surface exposure to air and constant motion, streams generally contain an abundant dissolved oxygen supply even when there is no oxygen production by photosynthesis.

Dissolved oxygen at appropriate concentrations is essential not only to keep aquatic organisms alive but to sustain their reproduction, vigor, and development. Organisms undergo stress at reduced oxygen levels that make them less competitive in sustaining the species (Mackenthun 1969). Dissolved oxygen concentrations of 3.0 mg/L or less have been shown to interfere with fish populations for a number of reasons (Mackenthun 1969, citing several other sources) (**Table 2.14**).

Depletion of dissolved oxygen can result in the death of aquatic organisms, including fish. Fish die when the demand for oxygen by biological and chemical processes exceeds the oxygen input by reaeration and photosynthesis, resulting in fish suffocation. Oxygen depletion usually is associated with slow current, high temperature, extensive growth of rooted aquatic plants, algal blooms, or high concentrations of organic matter (Needham 1969).

Stream communities are susceptible to pollution that reduces the dissolved oxygen supply (Odum 1971). Major factors determining the amount of oxygen found in water are temperature, pressure, abundance of aquatic plants and the amount of natural aeration from contact with the atmosphere (Needham 1969). A level of 5 mg/L of

Table 2.14: Summary of dissolved oxygen concentrations (mg/L) generally associated with effects on fish in salmonid and nonsalmonid waters.
Source: USEPA 1987.

Level of Effect	Salmonid[a]	Nonsalmonid
Early life stages (eggs and fry)		
No production impairment	11 (8)	6.5
Slight production impairment	9 (6)	5.5
Moderate production impairment	8 (5)	5.0
Severe production impairment	7 (4)	4.5
Limit to avoid acute mortality	6 (3)	4.0
Other life stages		
No production impairment	8 (0)	6.0
Slight production impairment	6 (0)	5.0
Moderate production impairment	5 (0)	4.0
Severe production impairment	4 (0)	3.5
Limit to avoid acute mortality	3 (0)	3.0

[a] Values for salmonid early life stages are water column concentrations recommended to achieve the required concentration of dissolved oxygen in the gravel spawning substrate (shown in parentheses).

dissolved oxygen in water is associated with normal activity of most fish (Walburg 1971). Oxygen analyses of good trout streams show dissolved oxygen concentrations that range from 4.5 to 9.5 mg/L (Needham 1969).

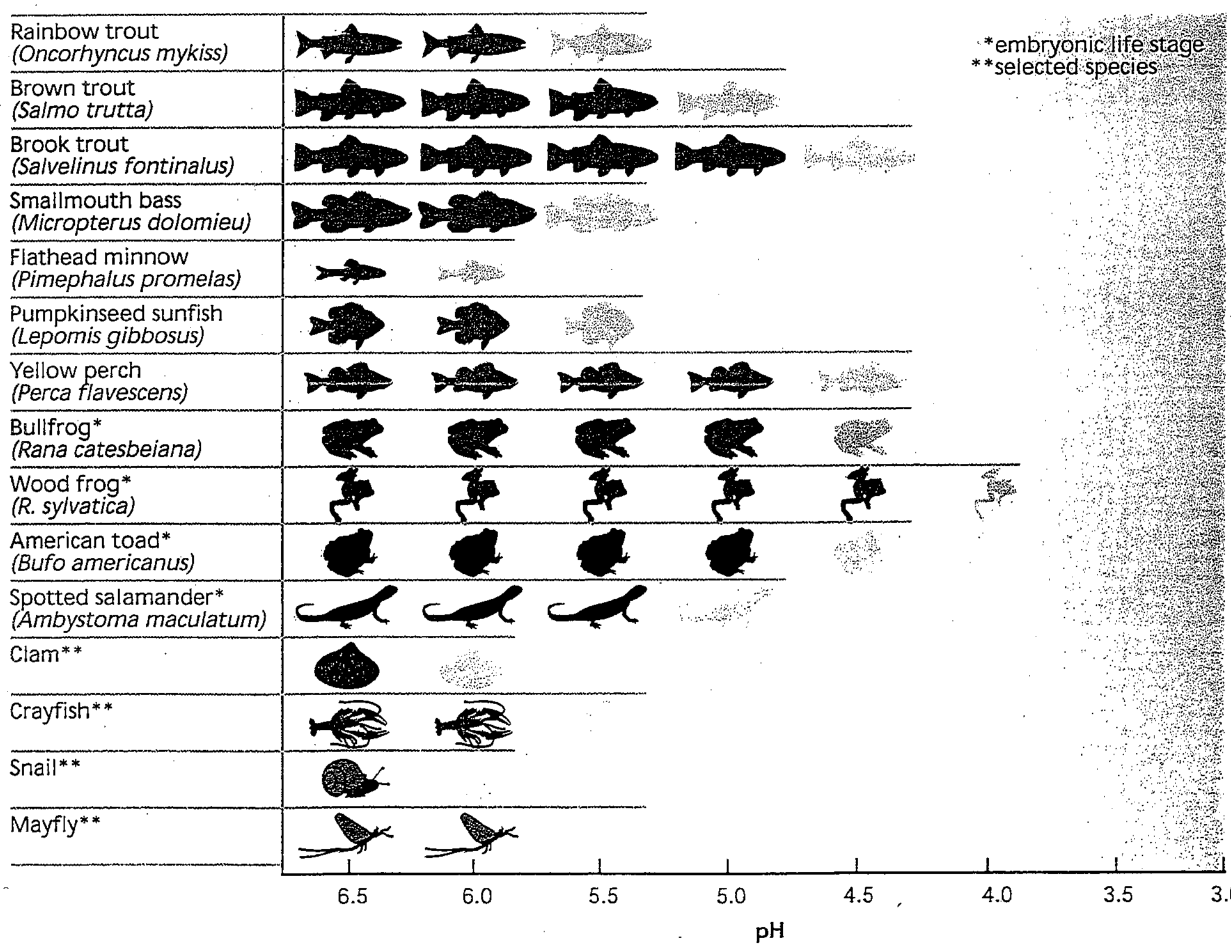
pH

Aquatic organisms from a wide range of taxa exist and thrive in aquatic systems with nearly neutral hydrogen ion activity (pH 7). Deviations, either toward a more basic or acidic environment, increase chronic stress levels and eventually decrease species diversity and abundance (**Figure 2.34**). One of the more widely recognized impacts of changes in pH has been attributed to increased acidity of rainfall in some parts of the United States, especially areas downwind of industrial and urban emissions (Schreiber 1995). Of particular concern are environments that have a reduced capacity to neutralize acid inputs because soils have a limited buffering capacity. Acidic rainfall can be especially harmful to environments such as the Adirondack region of upstate New York, where runoff already tends to be slightly acidic as a result of natural conditions.

Substrate

Stream biota respond to the many abiotic and biotic variables influenced by substrate. For example, differences in

Figure 2.34: Effects of acid rain on some aquatic species. *As acidity increases (and pH decreases) in lakes and streams, some species are lost.*



species composition and abundance can be observed among macroinvertebrate assemblages found in snags, sand, bedrock, and cobble within a single stream reach (Benke et al. 1984, Smock et al. 1985, Huryn and Wallace 1987). This preference for conditions associated with different substrates contributes to patterns observed at larger spatial scales where different macroinvertebrate assemblages are found in coastal, piedmont, and mountain streams (Hackney et al. 1992).

Stream substrates can be viewed in the same functional capacity as soils in the terrestrial system; that is, stream substrates constitute the interface between water and the hyporheic subsurface of the aquatic system. The *hyporheic zone* is the area of substrate which lies below the substrate/water interface, and may range from a layer extending only inches beneath and laterally from the stream channel, to a very large subsurface environment. Alluvial floodplains of the Flathead River, Montana, have a hyporheic zone with significant surface water/ground water interaction which is 2 miles wide and 33 feet deep (Stanford and Ward 1988). Naiman et al. (1994) discussed the extent and connectivity of hyporheic zones around streams in the Pacific Northwest. They hypothesized that as one moves from low-order (small) streams to high-order (large) streams, the degree of hyporheic importance and continuity first increases and then decreases. In small streams, the hyporheic zone is limited to small floodplains, meadows, and stream segments where coarse sediments are deposited over bedrock. The hyporheic zones are generally not continuous. In mid-order channels with more extensive floodplains, the spatial connectivity of the hyporheic zone increases. In large order streams, the spatial extent of the hyporheic zone is usually greatest, but it tends to be highly discontinuous because of features associated with fluvial activities such as oxbow lakes and cutoff channels, and because of complex interactions of local, intermediate, and regional ground water systems (Naiman et al. 1994) (**Figure** 2.35).

Stream substrates are composed of various materials, including clay, sand, gravel, cobbles, boulders, organic matter, and woody debris. Substrates form solid structures that modify surface and interstitial flow patterns, influence the accumulation of organic materials, and provide for production, decomposition, and other processes (Minshall 1984). Sand and silt are generally the least favorable substrates for supporting aquatic organisms and support the fewest species and individuals. Flat or rubble substrates have the highest densities and the most organisms (Odum 1971). As previously described, substrate size, heterogeneity, stability with respect to high and baseflow, and durability vary within streams, depending on particle size, density, and kinetic energy of flow. Inorganic substrates tend to be of larger size upstream than downstream and tend to be larger in riffles than in pools (Leopold et al. 1964). Likewise, the distribution and role of woody debris varies with stream size (Maser and Sedell 1994).

In forested watersheds, and in streams with significant areas of trees in their riparian corridor, large woody debris that falls into the stream can increase the quantity and diversity of substrate and aquatic habitat or range (Bisson et al. 1987, Dolloff et al. 1994). Debris dams trap sediment behind them and often create scour holes immediately downstream. Eroded banks commonly occur at the boundaries of debris blockages.

Organic Material

Metabolic activity within a stream reach depends on autochthonous, allochthonous, and upstream sources of food and nutrients (Minshall et al. 1985). Autochthonous materials, such as algae and aquatic macrophytes, originate within the stream channel, whereas allochthonous materials such as wood, leaves, and dissolved organic carbon, originate outside the stream channel. Upstream materials may be of autochthonous or allochthonous origin and are transported by streamflow to downstream locations. Seasonal flooding provides allochthonous input of organic material to the stream channel and also can significantly increase the rate of decomposition of organic material.

The role of primary productivity of streams can vary depending on geographic location, stream size, and season (Odum 1957, Minshall 1978). The river continuum concept (Vannote et al. 1980) (see *The River Continuum Concept* in section 1.E in Chapter 1) hypothesizes that primary productivity is of minimal importance in shaded headwater streams but increases in significance as stream size increases and riparian vegetation no longer limits the entry of light to stream periphyton. Numerous researchers have demonstrated that primary productivity is of greater importance in certain ecosystems, including streams in grassland and desert ecosystems. Flora of streams can range from diatoms in high mountain streams to dense stands of macrophytes in low gradient streams of the Southeast.

As discussed in Section 2.C, loading of nitrogen and phosphorus to a stream can increase the rate of algae and aquatic plant growth, a process known as *eutrophication*. Decomposition of this excess organic matter can deplete oxygen reserves and result in fish kills and other aesthetic problems in waterbodies.

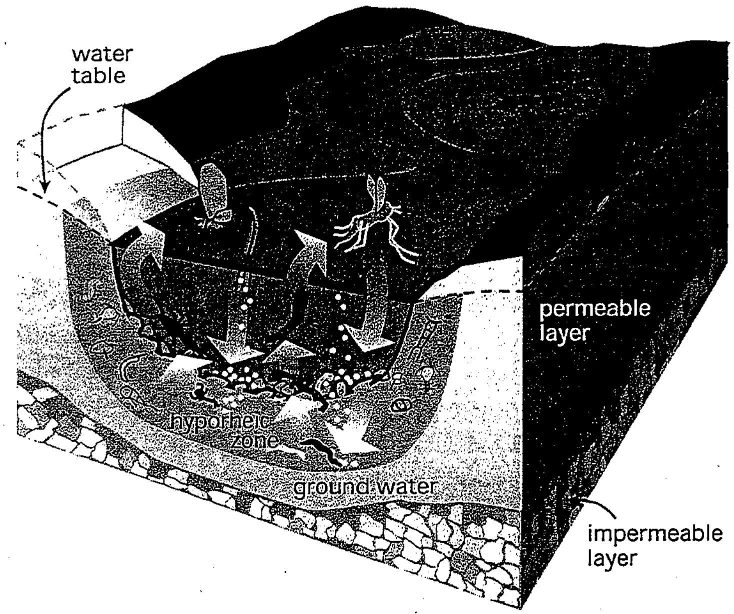


Figure 2.35: Hyporheic zone. *Summary of the different means of migration undergone by members of the stream benthic community.*

Eutrophication in lakes and reservoirs is indirectly measured as standing crops of phytoplankton biomass, usually represented by planktonic chlorophyll a concentration. However, phytoplankton biomass is usually not the dominant portion of plant biomass in smaller streams, due to periods of energetic flow and high substrate to volume ratios that favor the development of periphyton and macrophytes on the stream bottom. Stream eutrophication can result in excessive algal mats and oxygen depletion at times of decreased flows and higher temperatures (**Figure** 2.36). Furthermore, excessive plant growth can occur in streams at apparently low ambient concentrations of nitrogen and phosphorus because the stream currents promote efficient exchange of nutrients and metabolic wastes at the plant cell surface.

Figure 2.36: Stream eutrophication.
Eutrophication can result in oxygen depletion.

In many streams, shading or turbidity limit the light available for algal growth, and biota depend highly on allochthonous organic matter, such as leaves and twigs produced in the surrounding watershed. Once leaves or other allochthonous materials enter the stream, they undergo rapid changes (Cummins 1974). Soluble organic compounds, such as sugars, are removed via leaching. Bacteria and fungi subsequently colonize the leaf materials and metabolize them as a source of carbon. The presence of the microbial biomass increases the protein content of the leaves, which ultimately represents a high quality food resource for shredding invertebrates.

The combination of microbial decomposition and invertebrate shredding/scraping reduces the average particle size of the organic matter, resulting in the loss of carbon both as respired CO_2 and as smaller organic particles transported downstream. These finer particles, lost from one stream segment, become the energy inputs to the downstream portions of the stream. This unidirectional movement of nutrients and organic matter in lotic systems is slowed by the temporary retention, storage, and utilization of nutrients in leaf packs, accumulated debris, invertebrates, and algae.

Organic matter processing has been shown to have nutrient-dependent relationships similar to primary productivity. Decomposition of leaves and other forms of organic matter can be limited by either nitrogen or phosphorus, with predictive N:P ratios being similar to those for growth of algae and periphyton. Leaf decomposition occurs by a sequential combination of microbial decomposition, invertebrate shredding, and physical fractionation. Leaves and organic matter itself are generally low in protein value. However, the colonization of organic matter by bacteria and fungi increases the net content of nitrogen and phosphorus due to the accumulation of proteins and lipids contained in microbial biomass. These compounds are a major nutritive source for aquatic invertebrates. Decaying organic matter represents a major storage component for nutrients in streams, as well as a primary pathway of energy and nutrient transfer within the food web. Ultimately, the efficiency of retention and utilization is reflected at the top of the food web in the form of fish biomass.

Organisms often respond to variations in the availability of autochthonous, allochthonous, and upstream sources. For example, herbivores are relatively more common in streams having open riparian canopies and high algal productivity compared to streams having closed canopies and accumulated leaves as the primary food resource (Minshall et al. 1983). Similar patterns can be observed longitudinally within the same stream (Behmer and Hawkins 1986).

Terrestrial and Aquatic Ecosystem Components for Stream Corridor Restoration

The previous sections presented the biological components and functional processes that shape stream corridors. The terrestrial and aquatic environments were discussed separately for the sake of simplicity and ease of understanding. Unfortunately, this is frequently the same approach taken in environmental restoration initiatives, with efforts placed separately on the uplands, riparian area, or instream channel. The stream corridor must be viewed as a single functioning unit or ecosystem with numerous connections and interactions between components. Successful stream corridor restoration cannot ignore these fundamental relationships.

The structure and functions of vegetation are interrelated at all scales. They are also directly tied to ecosystem dynamics. Particular vegetation types may have characteristic regeneration strategies (e.g., fire, treefall gaps) that maintain those types within the landscape at all times. Similarly, certain topographic settings may be more likely than others to be subject to periodic, dramatic changes in hydrology and related vegetation structure as a result of massive debris jams or occupation by beavers. However, in the context of stream corridor ecosystems, some of the most fundamental dynamic interactions relate to stream flooding and channel migration.

Many ecosystem functions are influenced by the structural characteristics of vegetation. In an undeveloped watershed, the movement of water and other materials is moderated by vegetation and detritus, and nutrients are mobilized and conserved in complex patterns that generally result in balanced interactions between terrestrial and aquatic systems. As the character and distribution of vegetation is altered by removal of biomass, agriculture, livestock grazing, development, and other land uses, and the flow patterns of water, sediment, and nutrients are modified, the interactions among system components become less efficient and effective. These problems can become more pronounced when they are aggravated by introductions of excess nutrients and synthetic toxins, soil disturbances, and similar impacts.

Stream migration and flooding are principal sources of structural and compositional variation within and among plant communities in most undisturbed floodplains (Brinson et al. 1981). Although streams exert a complex influence on plant communities, vegetation directly affects the integrity and characteristics of stream systems. For example, root systems bind bank sediments and moderate erosion processes, and floodplain vegetation slows overbank flows, inducing sediment deposition. Trees and smaller woody debris that fall into the channel deflect flows, inducing erosion at some points and deposition at others, alter pool distribution, the transport of organic material, as well as a number of other processes. The stabilization of streams that are highly interactive with their floodplains can disrupt the fundamental processes controlling the structure and function of stream corridor ecosystems, thereby indirectly affecting the characteristics of the surrounding landscape.

In most instances, the functions of vegetation that are most apparent are those that influence fish and wildlife. At the landscape level, the fragmentation of native cover types has been shown to significantly influence wildlife, often favoring opportunistic species over those requiring large blocks of contiguous habitat. In some systems, relatively small breaks in corridor continuity can have significant impacts on animal movement or on the suitability of stream conditions to support certain aquatic species. In others, establishment of corridors that are structurally different from native systems or inappropriately configured can be equally disruptive. Narrow corridors that are essentially edge habitat may encourage generalist species, nest parasites, and predators, and where corridors have been established across historic barriers to animal movement, they can disrupt the integrity of regional animal assemblages (Knopf et al. 1988).

Some riparian dependent species are linked to streamside riparian areas with fairly contiguous dense tree canopies. Without new trees coming into the population, older trees creating this linked canopy eventually drop out, creating ever smaller patches of habitat. Restoration that influences tree stands so that sufficient recruitment and patch size can be attained will benefit these species. For similar reasons, many riparian-related raptors such as the common black-hawk (*Buteogallus anthracinus*), gray hawk (*Buteo nitidus*), bald eagle (*Haliaeetus leucocephalus*), Cactus ferruginous pygmy-owl (*Glaucidium brasilianum cactorum*), and Cooper's hawk (*Accipiter cooperii*), depend upon various sizes and shapes of woody riparian trees for nesting substrate and roosts. Restoration practices that attain sufficient tree recruitment will greatly benefit these species in the long term, and other species in the short term.

Some aspects related to this subject have been discussed as ecosystem components and functions under other sections. Findings from the earliest studies of the impacts of fragmentation of riparian habitats on breeding birds were published for the Southwest (Carothers and Johnson 1971, Johnson 1971, Carothers et al. 1974). Subsequent studies by other investigators found similar results. Basically, cottonwood-willow gallery forests of the North American Southwest supported the highest concentrations of noncolonial nesting birds for North America. Destruction and fragmentation of these riparian forests reduced species richness and resulted in a nearly straight-line relationship between numbers of nesting pairs/acre and number of mature trees/acre. Later studies demonstrated that riparian areas are equally important as conduits for migrating birds (Johnson and Simpson 1971, Stevens et al. 1977).

When considering restoration of riparian habitats, the condition of adjacent habitats must be considered. Carothers (1979) found that riparian ecosystems, especially the edges, are widely used by nonriparian birds. In addition he found that some riparian birds utilized adjacent nonriparian ecosystems. Carothers et al. (1974) found that smaller breeding species [e.g., warblers and the Western wood pewee (*Contopus sordidulus*)] tended to carry on all activities within the riparian ecosystem during the breeding season. However, larger species (e.g., kingbirds and doves) commonly foraged outside the riparian ecosystem in adjacent habitats. Larger species (e.g., raptors) may forage miles from riparian ecosystems, but still depend on them in critical ways (Lee et al. 1989).

Because of more mesic conditions created by the canyon effect, canyons and their attendant riparian vegetation serve as corridors for short-range movements of animals along elevational gradients (e.g., between summer and winter ranges). Long-range movements that occur along riparian zones throughout North America include migration of birds and bats. Riparian zones also serve as stopover habitat for migrating birds (Stevens et al. 1977). Woody vegetation is generally important, not only to most riparian ecosystems, but also to adjacent aquatic and even upland ecosystems. However, it is important to establish clear management objectives before attempting habitat modification.

Restoring all of a given ecosystem to its "pristine condition" may be impossible, especially if upstream conditions have been heavily modified, such as by a dam or other water diversion project. Even if complete restoration is a possibility, it may not accomplish or complement the restoration goals.

For example, encroachment of woody vegetation in the channel below several dams in the Platte River Valley in Nebraska has greatly decreased the amount of important wet meadow habitat. This area has been declared critical habitat for the whooping crane (*Grus americana*) (Aronson and Ellis 1979), for piping plover, and for the interior least tern. It is also an important staging area for up to 500,000 sandhill cranes (*Grus canadensis*) from late February to late April and supports 150 to 250 bald eagles (*Haliaeetus leucocephalus*). Numerous other important species using the area include the peregrine falcon (*Falco peregrinus*), Canada goose (*Branta canadensis*), mallard (*Anas platyrhynchos*), numerous other waterfowl, and raptors (USFWS 1981). Thus, managers here are confronted with means of reducing riparian groves in favor of wet meadows.

2E Functions and Dynamic Equilibrium

Throughout the past two chapters, this document has covered stream corridor structure and the physical, chemical, and biological processes occurring in stream corridors. This information shows how stream corridors function as ecosystems, and consequently, how these characteristic structural features and processes must be understood in order to enable stream corridor functions to be effectively restored. In fact, reestablishing structure or restoring a particular physical or biological process is not the only thing that restoration seeks to achieve. Restoration aims to reestablish valued functions. Focusing on ecological functions gives the restoration effort its best chance to recreate a self-sustaining system. This property of sustainability is what separates a functionally sound stream, that freely provides its many benefits to people and the natural environment, from an impaired watercourse that cannot sustain its valued functions and may remain a costly, long-term maintenance burden.

Section 1.A of Chapter 1 emphasized matrix, patch, corridor and mosaic as the most basic building blocks of physical structure at local to regional scales. Ecological functions, too, can be summarized as a set of basic, common themes that recur in an infinite variety of settings. These six critical functions are *habitat, conduit, filter, barrier, source,* and *sink* (Figure 2.37).

In this section, the processes and structural descriptions of the past two chapters are revisited in terms of these critical ecological functions.

Two attributes are particularly important to the operation of stream corridor functions:

Habitat—*the spatial structure of the environment which allows species to live, reproduce, feed, and move.*

Barrier—*the stoppage of materials, energy, and organisms.*

Conduit—*the ability of the system to transport materials, energy, and organisms.*

Filter—*the selective penetration of materials, energy, and organisms.*

Source—*a setting where the output of materials, energy, and organisms exceeds input.*

Sink—*a setting where the input of water, energy, organisms and materials exceeds output.*

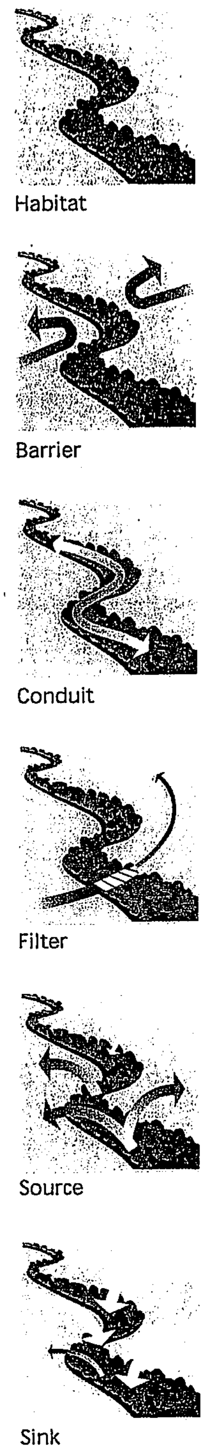


Figure 2.37: Critical ecosystem functions. Six functions can be summarized as a set of basic, common themes recurring in a variety of settings.

- *Connectivity*—This is a measure of how spatially continuous a corridor or a matrix is (Forman and Godron 1986). This attribute is affected by gaps or breaks in the corridor and between the corridor and adjacent land uses (**Figure 2.38**). A stream corridor with a high degree of connectivity among its natural communities promotes valuable functions including transport of materials and energy and movement of flora and fauna.
- *Width*—In stream corridors, this refers to the distance across the stream and its zone of adjacent vegetation cover. Factors affecting width are edges, community composition, environmental gradients, and disturbance effects of adjacent ecosystems, including those with human activity. Example measures of width include average dimension and variance, number of narrows, and varying habitat requirements (Dramstad et al. 1996).

Width and connectivity interact throughout the length of a stream corridor. Corridor width varies along the length of the stream and may have gaps. Gaps across the corridor interrupt and reduce connectivity. Evaluating connectivity and width can provide some of the most valuable insight for designing restoration actions that mitigate disturbances.

The following subsections discuss each of the functions and general relationship to connectivity and width. The final subsection discusses dynamic equilibrium and its relevance to stream corridor restoration.

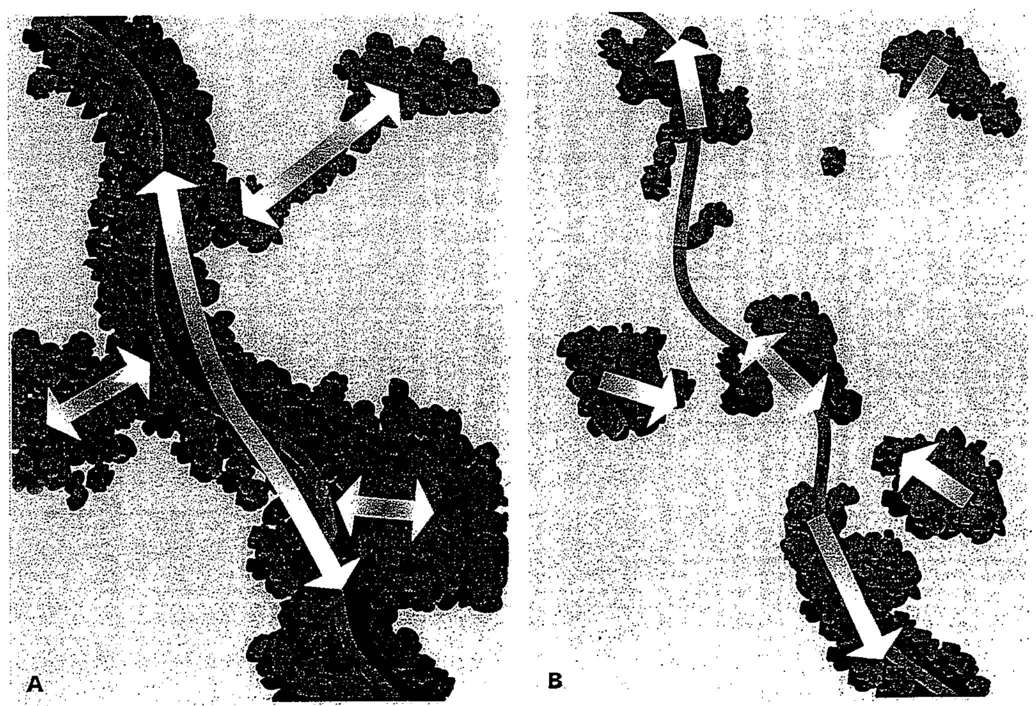
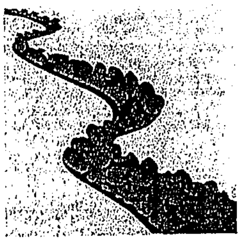


Figure 2.38: Landscapes with (A) high and (B) low degrees of connectivity. *A connected landscape structure generally has higher levels of functions than a fragmented landscape.*

Habitat Functions



Habitat is a term used to describe an area where plants or animals (including people) normally live, grow, feed, reproduce, and otherwise exist for any portion of their life cycle. Habitats provide organisms or communities of organisms with the necessary elements of life, such as space, food, water, and shelter.

Under suitable conditions often provided by stream corridors, many species can use the corridor to live, find food and water, reproduce, and establish viable populations. Some measures of a stable biological community are population size, number of species, and genetic variation, which fluctuate within expected limits over time. To varying degrees, stream corridors constructively influence these measures. The corridor's value as habitat is increased by the fact that corridors often connect many small habitat patches and thereby create larger, more complex habitats with larger wildlife populations and higher biodiversity.

Habitat functions differ at various scales, and an appreciation of the scales at which different habitat functions occur will help a restoration initiative succeed. The evaluation of habitat at larger scales, for example, may make note of a biotic community's size, composition, connectivity, and shape.

At the landscape scale, the concepts of matrix, patches, mosaics and corridors are often involved in describing habitat over large areas. Stream corridors and major river valleys together can provide substantial habitat. North American flyways include examples of stream and river corridor habitat exploited by migratory birds at landscape to regional scales.

Stream corridors, and other types of naturally vegetated corridors as well, can provide migrating forest and riparian species with their preferred resting and feeding habitats during migration stopovers. Large mammals such as black bear are known to require large, contiguous wild terrain as home range, and in many parts of the country broad stream corridors are crucial to linking smaller patches into sufficiently large territories.

Habitat functions within watersheds may be examined from a somewhat different perspective. Habitat types and patterns within the watershed are significant, as are patterns of connectivity to adjoining watersheds. The vegetation of the stream corridor in upper reaches of watersheds sometimes has become disconnected from that of adjacent watersheds and corridors beyond the divide. When terrestrial or semiaquatic stream corridor communities are connected at their headwaters, these connections will usually help provide suitable alternative habitats beyond the watershed.

Assessing habitat function at the stream corridor and smaller scales can also be viewed in terms of patches and corridors, but in finer detail than in landscapes and watersheds. It is also at local scales that transitions among the various habitats within the corridor can become more important. Stream corridors often include two general types of habitat structure: interior and edge habitat. Habitat diversity is increased by a corridor that includes both edge and interior conditions, although for most streams, corridor width is insufficient to provide

Edge and Interior Habitat

Two important habitat characteristics are edges and interior (**Figure 2.39**) Edges are critical lines of interaction between different ecosystems. Interior habitats are generally more stable, sheltered environments where the ecosystem may remain relatively the same for prolonged periods. Edge habitat is exposed to highly variable environmental gradients. The result is a different species composition and abundance than observed interior habitat. Edges are important as filters of disturbance to interior habitat. Edges can also be diverse areas with a large variety of flora and fauna.

Edges and interiors are scale-independent concepts. Larger mammals known as interior forest species may need to be miles from the forest edge to find desired habitat, while an insect or amphibian may be sensitive to the edges and interiors of the microhabitat under a rotted log. The edges and interiors of a stream corridor, therefore, depend upon the species being considered. As elongated, narrow ecosystems that include land/water interfaces and often include natural/human-made boundaries as well at the upland fringe, stream corridors have an abundance of edges and these have a pronounced effect on their biota.

Edges and interiors are each preferred by different sets of plant and animal species, and it is inappropriate to consider edges or interiors as consistently "bad" or "good" habitat characteristics. It may be desirable to maintain or increase edge in some circumstances, or favor interior habitats in others. Generally speaking, however, human activity tends to increase edge and decrease interior, so more often it is restoring or protecting interior that merits specific management action.

Edge habitat at the stream corridor boundary typically has higher inputs of solar energy, precipitation, wind energy, and other influences from the adjacent ecosystems. The difference in environmental gradients at the stream corridor's edge results in a diversified plant and animal community interacting with adjacent ecosystems. The effect of edge is more pronounced when the amount of interior habitat is minimal.

Interior habitat occurs further from the perimeter of the element. Interior is typified by more stable environmental inputs than those found at the edge of an ecosystem. Sunlight, rainfall, and wind effects are less intense in the interior. Many sensitive or rare species depend upon a less-disturbed environment for their survival. They are therefore tolerant of only "interior" habitat conditions. The distance from the perimeter required to create these interior conditions is dependent upon the species' requirements.

Interior plants and animals differ considerably from those that prefer or tolerate the edge's variability. With an abundance of edge, stream corridors often have mostly edge species. Because large ecosystems and wide corridors are becoming increasingly fragmented in modern landscapes, however, interior species are often rare and hence are targets for restoration. The habitat requirements of interior species (with respect to distance from edge are a useful guide in restoring larger stream corridors to provide a diversity of habitat types and sustainable communities.

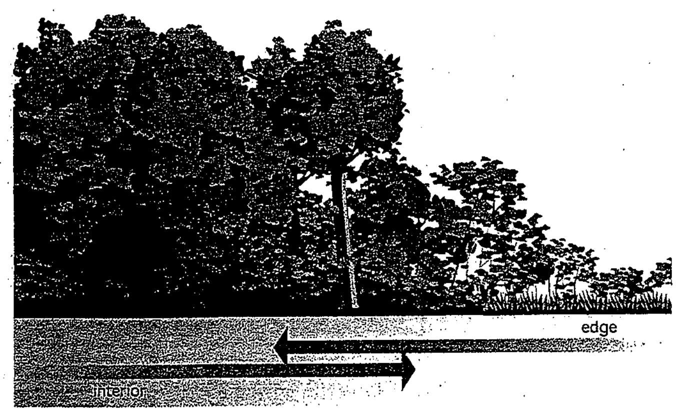


Figure 2.39: Edge and interior habitat of a woodlot. Interior plants and animals differ considerably from those that prefer or tolerate the edge's variability.

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much interior habitat for larger vertebrates such as forest interior bird species. For this reason, increasing interior habitat is sometimes a watershed scale restoration objective.

Habitat functions at the corridor scale are strongly influenced by connectivity and width. Greater connectivity and increased width along and across a stream corridor generally increases its value as habitat. Stream valley morphology and environmental gradients (such as gradual changes in soil wetness, solar radiation, and precipitation) can cause changes in plant and animal communities. More species generally find suitable habitat conditions in a wide, contiguous, and diverse assortment of native plant communities within the stream corridor than in a narrow, homogeneous or highly fragmented corridor.

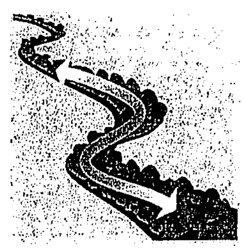
When applied strictly to stream channels, however, this might not be true. Some narrow and deeply incised streams, for example, provide thermal conditions that are critical for endangered salmonids.

Habitat conditions within a corridor vary according to factors such as climate and microclimate, elevation, topography, soils, hydrology, vegetation, and human uses. In terms of planning restoration measures, corridor width is especially important for wildlife. When planning for maintenance of a given wildlife species, for example, the dimension and shape of the corridor must be wide enough to include enough suitable habitat that this species can populate the stream corridor. Corridors that are too narrow may provide as much of a barrier to some species' movement as would a complete gap in the corridor.

On local scales, large woody debris that becomes lodged in the stream channel can create morphological changes to the stream and adjacent streambanks. Pools may be formed downstream from a log that has fallen across a stream and both upstream and downstream flow characteristics are altered. The structure formed by large woody debris in a stream improves aquatic habitat for most fish and invertebrate species.

Riparian forests, in addition to their edge and interior habitats, may offer vertical habitat diversity in their canopy, subcanopy, shrub and herb layers. And within the channel itself, riffles, pools, glides, rapids and backwaters all provide different habitat conditions in both the water column and the streambed. These examples, all described in terms of physical structure, illustrate once again the strong linkage between structure and habitat function.

Conduit Function



The conduit function is the ability to serve as a flow pathway for energy, materials, and organisms. A stream corridor is above all a conduit that was formed by and for collecting and transporting water and sediment. In addition, many other types of materials and biota move throughout the system.

The stream corridor can function as a conduit laterally, as well as longitudinally, with movement by organisms and materials in any number of directions. Materials or animals may further move across the stream corridor, from one side to another. Birds or small mammals, for example, may cross a stream with a closed canopy by moving through its vegetation. Organic debris and nutrients may fall from higher to lower floodplains and into the stream within corridors, affecting the food supply for stream invertebrates and fishes.

Moving material is important because it impacts the hydrology, habitat, and structure of the stream as well as the terrestrial habitat and connections in the floodplain and uplands. The structural attributes of connectivity and width also influence the conduit function.

For migratory or highly mobile wildlife, corridors serve as habitat and conduit simultaneously. Corridors in combination with other suitable habitats, for example, make it possible for songbirds to move from wintering habitat in the neo-tropics to northern, summer habitats. Many species of birds can only fly for limited distances before they must rest and refuel. For stream corridors to function effectively as conduits for these birds, they must be sufficiently connected and be wide enough to provide required migratory habitat.

Stream corridors are also conduits for the movement of energy, which occurs in many forms. The gravity-driven energy of stream flow continually sculpts and modifies the landscape. The corridor modifies heat and energy from sunlight as it remains cooler in spring and summer and warmer in the fall. Stream valleys are effective airsheds, moving cool air from higher to lower elevations in the evening. The highly productive plant communities of a corridor accumulate energy as living plant material, and export large amounts in the form of leaf fall or detritus. The high levels of primary productivity, nutrient flow, and leaf litter fall also fuel increased decomposition in the corridor, allowing new transformations of energy and materials. At its outlet, a stream's outputs to the next larger water body (e.g., increased water volume, higher temperature, sediments, nutrients, and organisms) are in part the excesses of energy from its own system.

One of the best known and studied examples of aquatic species movement and interaction with the watershed is the migration of salmon upstream for spawning. After maturing in the ocean, the fish are dependent on access to their upstream spawning grounds. In the case of Pacific salmon species, the stream corridor is dependent upon the resultant biomass and nutrient input of abundant spawning and dying adults into the upper reaches of stream systems during spawning. Thus, connectivity is often critical for aquatic species transport, and in turn, nutrient transport upstream from ocean waters to stream headwaters.

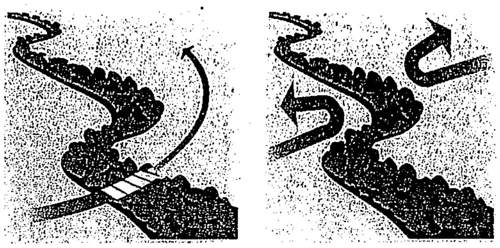
Streams are also conduits for distribution of plants and their establishment in new areas (Malanson 1993). Flowing water may transport and deposit seeds over considerable distances. In flood stage, mature plants may be uprooted, relocated, and redeposited alive in new locations. Wildlife also help redistribute plants by ingesting and transporting seeds throughout different parts of the corridor.

Sediment (bed load or suspended load) is also transported through the stream. Alluvial streams are dependent on the continual supply and transport of sediment, but many of their fish and invertebrates can also be harmed by too much fine sediment. When conditions are altered, a stream may become either starved of sediment or choked with sediment down-gradient. Streams lacking appropriate amounts of sediment attempt to reestablish equilibrium through downcutting, bank erosion, and channel erosion. An appropriately structured stream corridor will optimize timing and supply of sediment to the stream to improve sediment transport functions.

Local areas in the corridor are dependent on the flow of materials from one point to another. In the salmonid example, the local upland area adjacent to spawning grounds is dependent upon the nutrient transfer from the biomass of the fish into other terrestrial wildlife and off into the uplands. The local structure of the streambed and aquatic ecosystem are dependent upon the sediment and woody material from upstream and upslope to create a self-regulating and stable channel.

Stream corridor width is important where the upland is frequently a supplier of much of the natural load of sediment and biomass into the stream. A wide, contiguous corridor acts as a large conduit, allowing flow laterally and longitudinally along the corridor. Conduit functions are often more limited in narrow or fragmented corridors.

Filter and Barrier Functions



Stream corridors may serve as barriers that prevent movement or filters that allow selective penetration of energy, materials and organisms. In many ways, the entire stream corridor serves beneficially as a filter or barrier that reduces water pollution, minimizes sediment transport, and often provides a natural boundary to land uses, plant communities, and some less mobile wildlife species.

Materials, energy, and organisms which moved into and through the stream corridor may be filtered by structural attributes of the corridor. Attributes affecting barrier and filter functions include connectivity (gap frequency) and corridor width (**Figure 2.40**). Elements which are moving along a stream corridor edge may also be selectively filtered as they enter the stream corridor. In these circumstances it is the shape of the edge, whether it is straight or convoluted, which has the greatest effect on filtering functions. Still, it is most often movement perpendicular to the stream corridor which is most effectively filtered or halted.

Materials may be transported, filtered, or stopped altogether depending upon the width and connectedness of a stream corridor. Material movement across landscapes toward large river valleys may be intercepted and filtered by stream corridors. Attributes such as the structure of native plant communities can physically affect the amount of runoff entering a stream system through uptake, absorption, and interruption. Vegetation in the corridor can filter out much of the overland flow of nutrients, sediment, and water.

Siltation in larger streams can be reduced through a network of stream corridors functioning to filter excessive sediment. Stream corridors filter many of the upland materials from moving unimpeded across the landscape. Ground water and surface water flows are filtered by plant parts below and above ground. Chemical elements are intercepted by flora and fauna within stream corridors. A wider corridor provides more effective filtering, and a contiguous corridor functions as a filter along its entire length.

Breaks in a stream corridor can sometimes have the effect of funneling damaging processes into that area. For example, a gap in contiguous vegetation along a stream corridor can reduce the filtering function by focusing increased runoff into the area, leading to erosion,

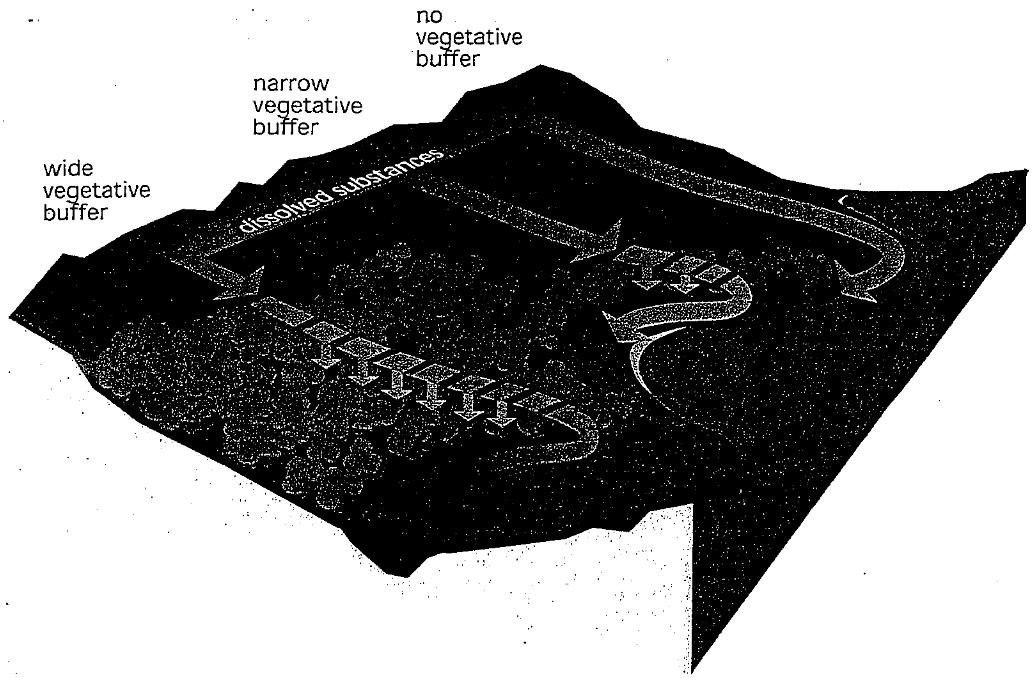
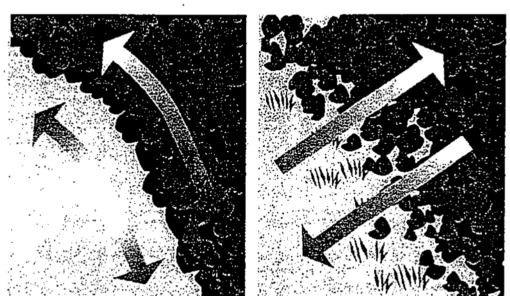


Figure 2.40: The width of the vegetation buffer influences filter and barrier functions. *Dissolved substances, such as nitrogen, phosphorus, and other nutrients, entering a vegetated stream corridor are restricted from entering the channel by friction, root absorption, clay, and soil organic matter.*
Adapted from* Ecology of Greenways: Design and Function of Linear Conservation Areas. *Edited by Smith and Hellmund. © University of Minnesota Press 1993.

gullying, and the free flow of sediments and nutrients into the stream.

Edges at the boundaries of stream corridors begin the process of filtering. Abrupt edges concentrate initial filtering functions into a narrow area. A gradual edge increases filtering and spreads it across a wider ecological gradient (Figure 2.41).

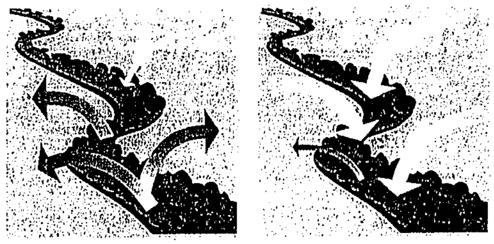
Movement parallel to the corridor is affected by coves and lobes of an uneven corridor's edge. These act as barriers or filters for materials flowing into the corridor. Individual plants may selectively capture materials such as wind-borne sediment, carbon, or propagules as they pass through a convoluted edge. Herbivores traveling along a boundary edge, for example, may stop to rest and selectively feed in a sheltered nook. The wind blows a few seeds into the corridor, and those suited to the conditions of the corridor may germinate and establish a population. The lobes have acted as a selective filter collecting some seeds at the edge and allowing other species to interact at the boundary (Forman 1995).



(a) (b)

Figure 2.41: Edges can be (a) abrupt or (b) gradual. *Abrupt edges, usually caused by disturbances, tend to discourage movement between ecosystems and promote movement along the boundary. Gradual edges usually occur in natural settings, are more diverse, and encourage movement between ecosystems.*

Source and Sink Functions



Sources provide organisms, energy or materials to the surrounding landscape. Areas that function as sinks absorb organisms, energy, or materials from the surrounding landscape. Influent and effluent reaches, discussed in Section 1.B of Chapter 1, are classic examples of sources and sinks. The influent or "losing" reach is a source of water to the aquifer, and the effluent or "gaining" reach is a sink for ground water.

Stream corridors or features within them can act as a source or a sink of environmental materials. Some stream corridors act as both, depending on the time of year or location in the corridor. Streambanks most often act as a source, for example, of sediment to the stream. At times, however, they can function as sinks while flooding deposits new sediments there. At the landscape scale, corridors are connectors to various other patches of habitats in the landscape and as such they are sources and conduits of genetic material throughout the landscape.

n constantly hanging ecosystems ike stream cor- idors, stability s the ability of a system to ersist within a range of con- ditions. This henomenon s referred to as *dynamic* equilibrium.

Stream corridors can also act as a sink for storage of surface water, ground water, nutrients, energy, and sediment allowing for materials to be temporarily fixed in the corridor. Dissolved substances, such as nitrogen, phosphorus, and other nutrients, entering a vegetated stream corridor are restricted from entering the channel by friction, root absorption, clay, and soil organic matter. Although these functions of source and sink are conceptually understood, they lack a suitable body of research and practical application guidelines.

Forman (1995) offers three source and sink functions resulting from floodplain vegetation:

- Decreased downstream flooding through floodwater moderation and/or uptake
- Containment of sediments and other materials during flood stage
- Source of soil organic matter and water-borne organic matter

Biotic and genetic source/sink relationships can be complex. Interior forest birds are vulnerable to nest parasitism by cowbirds when they try to nest in too small a forest patch. For these species, small forest patches can be considered sinks that reduce their population numbers and genetic diversity by causing failed reproduction. Large forest patches with sufficient interior habitat, in comparison, support successful reproduction and serve as sources of more individuals and new genetic combinations.

Dynamic Equilibrium

The first two chapters of this document have emphasized that, although stream corridors display consistent patterns in their structure, processes, and functions, these patterns change naturally and constantly, even in the absence of human disturbance. Despite frequent change, streams and their corridors exhibit a dynamic form of stability. In constantly changing ecosystems like stream corridors, stability is the ability of a system to persist within a range of conditions. This phenomenon is referred to as *dynamic equilibrium.*

The maintenance of dynamic equilibrium requires that a series of self-correcting mechanisms be active in the stream corridor ecosystem. These mechanisms allow the ecosystem to control external stresses or disturbances within a certain range of responses thereby maintaining a self-sustaining condition. The threshold levels associated with these ranges are difficult to identify and quantify. If they are exceeded, the system can become unstable. Corridors may then undergo a series of adjustments to achieve a new steady state condition, but usually after a long period of time has elapsed.

Many stream systems can accommodate fairly significant disturbances and still return to functional condition in a reasonable time frame, once the source of the disturbance is controlled or removed. Passive restoration is based on this tendency of ecosystems to heal themselves when external stresses are removed. Often the removal of stress and the time to recover naturally are an economical and effective restoration strategy. When significant disturbance and alteration has occurred, however, a stream corridor may require several decades to restore itself. Even then, the recovered system may be a very different type of stream that, although at equilibrium again, is of severely diminished ecological value in comparison with its previous potential. When restoration practitioners' analysis indicates lengthy recovery time or dubious recovery potential for a stream, they may decide to use active restoration techniques to reestablish a more functional channel form, corridor structure, and biological community in a much shorter time frame. The main benefit of an active restoration approach is regaining functionality more quickly, but the biggest challenge is to plan, design, and implement correctly to reestablish the desired state of dynamic equilibrium.

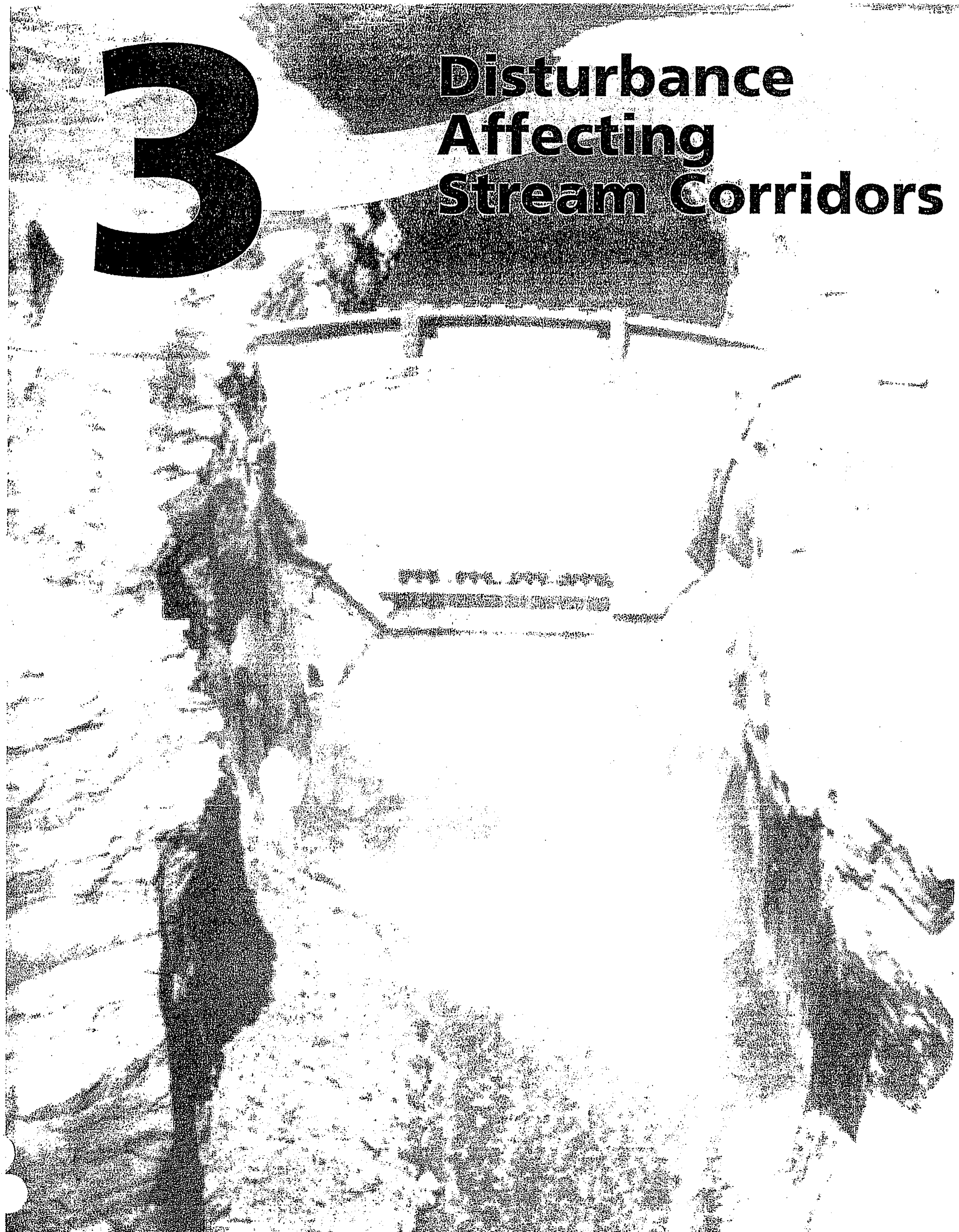
This new equilibrium condition, however, may not be the same that existed prior to the initial occurrence of the disturbance. In addition, disturbances can often stress the system beyond its natural ability to recover. In these instances restoration is needed to remove the cause of the disturbance or stress (passive) or to repair damages to the structure and functions of the stream corridor ecosystem (active).

Stability, Disturbance, and Recovery

Stability, as a characteristic of ecosystems, combines the concepts of resistance, resilience, and recovery. Resistance is the ability to maintain original form and functions. Resilience is the rate at which a system returns to a stable condition after a disturbance. Recovery is the degree to which a system returns to its original condition after a disturbance. Natural systems have developed ways of coping with disturbance, in order to produce recovery and stability. Human activities often superimpose additional disturbances which may exceed the recovery capability of a natural system. The fact that change occurs, however, does not always mean a system is unstable or in poor condition.

The term mosaic stability is used to denote the stability of a larger system within which local changes still take place. Mosaic stability, or the lack thereof, illustrates the importance of the landscape perspective in making site-specific decisions. For example, in a rapidly urbanizing landscape, a riparian system denuded by a 100-year flood may represent a harmful break in already diminished habitat that splits and isolates populations of a rare amphibian species. In contrast, the same riparian system undergoing flooding in a less-developed landscape may not be a geographic barrier to the amphibian, but merely the mosaic of constantly shifting suitable and unsuitable habitats in an unconfined, naturally functioning stream. The latter landscape with mosaic stability is not likely to need restoration while the former landscape without mosaic stability is likely to need it urgently. Successful restoration of any stream corridor requires an understanding of these key underlying concepts.

3 Disturbance Affecting Stream Corridors



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3.A Natural Disturbances

- How does natural disturbance contribute to shaping a local ecology?
- Are natural disturbances bad?
- How do you describe or define the frequency and magnitude of natural disturbance?
- How does an ecosystem respond to natural disturbances?
- What are some types of natural disturbances you should anticipate in a stream corridor restoration?

3.B Human-Induced Disturbances

- What are some examples of human-induced disturbances at several landscape scales?
- What are the effects of some common human-induced disturbances such as dams, channelization, and the introduction of exotic species?
- What are some of the effects of land use activities such as agriculture, forestry, mining, grazing, recreation, and urbanization?

3 Disturbance Affecting Stream Corridors

*Disturbances that bring changes to stream corridors and associated ecosystems are natural events or human-induced activities that occur separately or simultaneously (**Figure 3.1**). Either individually or in combination, disturbances place stresses on the stream corridor that have the potential to alter its structure and impair its ability to perform key ecological functions. The true impact of these disturbances can best be understood by how they affect the ecosystem structure, processes, and functions introduced in Chapters 1 and 2.*

A disturbance occurring within or adjacent to a corridor typically produces a causal chain of effects, which may permanently alter one or more characteristics of a stable system. A view of this chain is illustrated in Figure 3.2 *(Wesche 1985). This view can be applied in many stream corridor restoration initiatives with the ideal goal of moving back as far as feasible on the cause-effect chain to plan and select restoration alternatives*

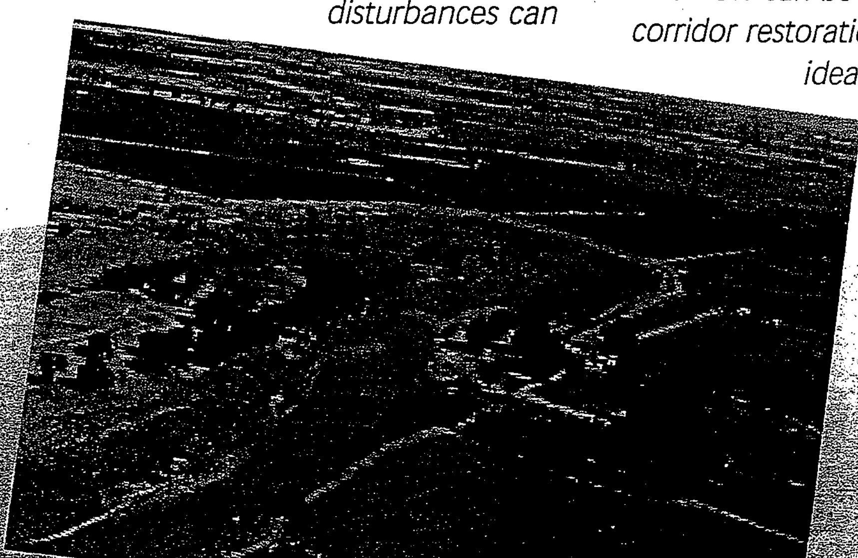

Figure 3.1: Disturbance in the stream corridor. *Both natural and human-induced disturbances result in changes to stream corridors.*

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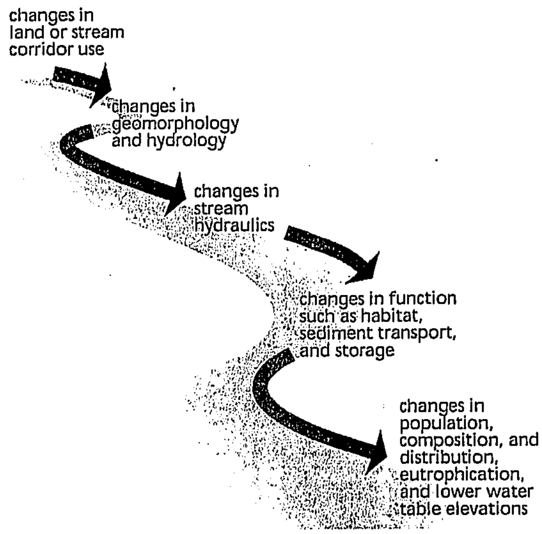

Figure 3.2: Chain of events due to disturbance. *Disturbance to a stream corridor system typically results in a causal chain of alterations to stream corridor structure and functions.*

(Armour and Williamson 1988). Otherwise, chosen alternatives may merely treat symptoms rather than the source of the problem.

Using this broad goal along with the thoughtful use of a responsive evaluation and design process will greatly reduce the need for trial-and-error experiences and enhance the opportunities for successful restoration. Passive restoration, as the critical first option to pursue, will result.

Disturbances can occur anywhere within the stream corridor and associated ecosystems and can vary in terms of frequency, duration, and intensity. A single disturbance event may trigger a variety of disturbances that differ in frequency, duration, intensity, and location. Each of these subsequent forms of direct or indirect disturbance should be addressed in restoration planning and design for successful results.

This chapter focuses on understanding how various disturbances affect the stream corridor and associated ecosystems. We can better determine what actions are needed to restore stream corridor structure and functions by understanding the evolution of what disturbances are stressing the system, and how the system responds to those stresses.

Section 3.A: Natural Disturbances

This section introduces natural disturbances as a multitude of potential events that cover a broad range of temporal and spatial scales. Often the agents of natural regeneration and restoration, natural disturbances are presented briefly as part of the dynamic system and evolutionary process at work in stream corridors.

Section 3.B: Human-Induced Disturbances

Traditionally the use and management of stream corridors have focused on the health and safety or material wealth of society. Human-induced forms of disturbances and resulting effects on the ecological structure and functions of stream corridors are, therefore, common. This section briefly describes some of these major disturbance activities and their potential effects.

Changes on Broad Temporal and Spatial Scales

Disturbance occurs within variations of scale and time. Changes brought about by land use, for example, may occur within a single year at the stream or reach scale (crop rotation), a decade within the corridor or stream scale (urbanization), and even over decades within the landscape or corridor scale (long-term forest management). Wildlife populations, such as monarch butterfly populations, may fluctuate wildly from year to year in a given locality while remaining nationally stable over several decades. Geomorphic or climatic changes may occur over hundreds to thousands of years, while weather changes daily.

Tectonics alter landscapes over periods of hundreds to millions of years, typically beyond the limits of human observance. Tectonics involves mountain-building forces like folding and faulting or earthquakes that modify the elevation of the earth's surface and change the slope of the land. In response to such changes, a stream typically will modify its cross section or its planform. Climatic changes, in contrast, have been historically and even geologically recorded. The quantity, timing, and distribution of precipitation often causes major changes in the patterns of vegetation, soils, and runoff in a landscape. Stream corridors subsequently change as runoff and sediment loads vary.

3A Natural Disturbances

Floods, hurricanes, tornadoes, fire, lightning, volcanic eruptions, earthquakes, insects and disease, landslides, temperature extremes, and drought are among the many natural events that disturb structure and functions in the stream corridor (**Figure 3.3**). How ecosystems respond to these disturbances varies according to their relative stability, resistance, and resilience. In many instances they recover with little or no need for supplemental restoration work.

Natural disturbances are sometimes agents of regeneration and restoration. Certain species of riparian plants, for example, have adapted their life cycles to include the occurrence of destructive, high-energy disturbances, such as alternating floods and drought.

In general, riparian vegetation is resilient. A flood that destroys a mature cottonwood gallery forest also commonly creates nursery conditions necessary for the establishment of a new forest (Brady et al. 1985), thereby increasing the resilience and degree of recovery of the riparian system.

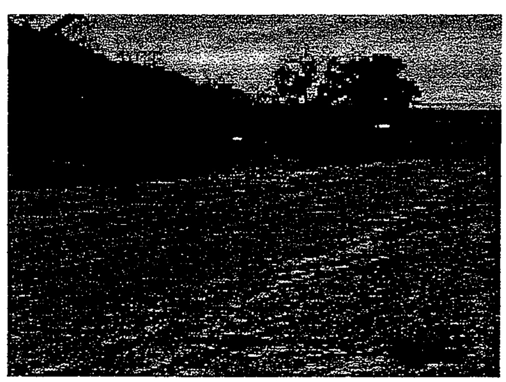

Figure 3.3: Drought—one of many types of natural disturbance. *How a stream corridor responds to disturbances depends on its relative stability, resistance, and resilience.*

Ecosystem Resilience in Eastern Upland Forests

*Eastern upland forest systems, dominated by stands of beech/maple, have adapted to many types of natural disturbances by evolving attributes such as high biomass and deep, established root systems (**Figure 3.4**). Consequently, they are relatively unperturbed by drought or other natural disturbances that occur at regular intervals. Even when unexpected severe stress such as fire or insect damage occurs, the impact is usually only on a local scale and therefore insignificant in the persistence of the community as a whole.*

Resilience of the Eastern Upland Forest can be disrupted, however, by widespread effects such as acid rain and indiscriminate logging and associated road building. These and other disturbances have the potential to severely alter lighting conditions, soil moisture, soil nutrients, soil temperature, and other factors critical for persistence of the beech/maple forest. Recovery of an eastern "climax" system after a widespread disturbance might take more than 150 years.

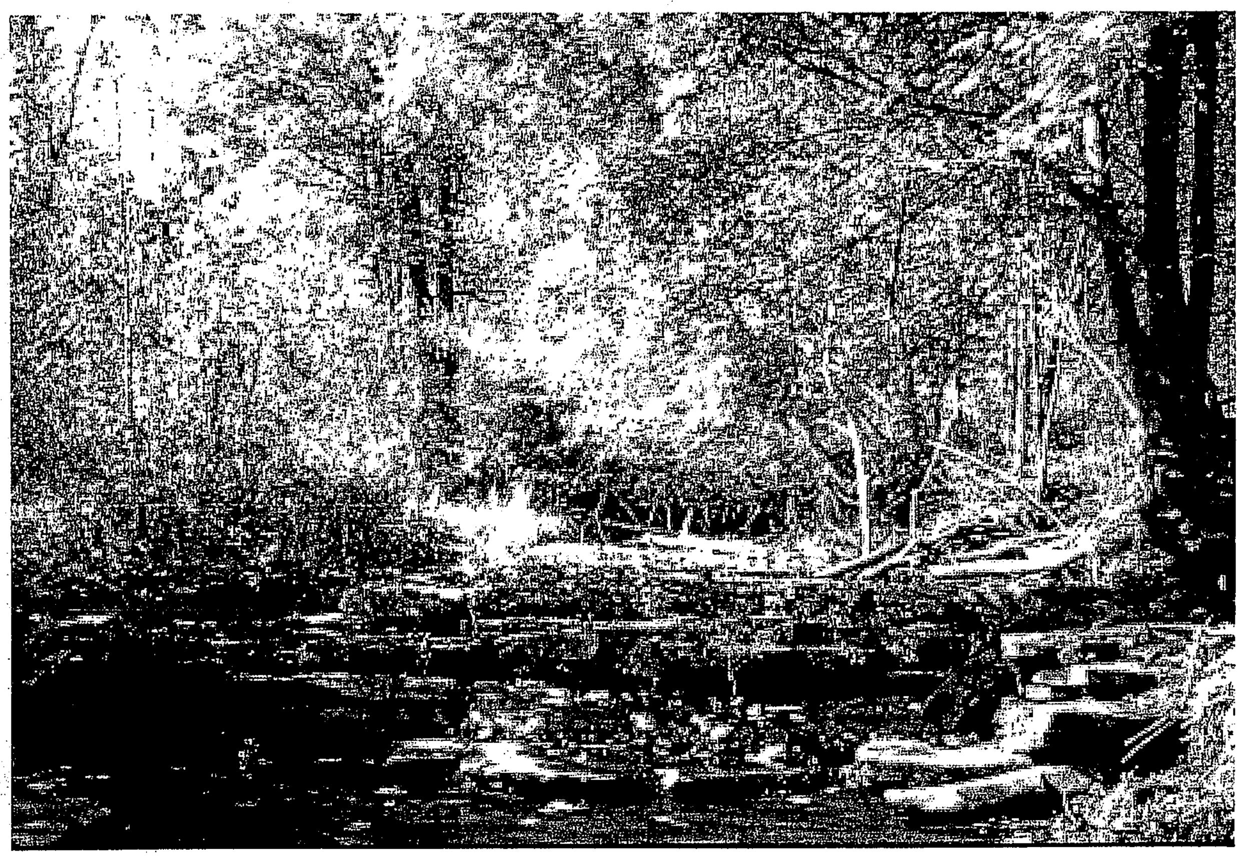

***Figure 3.4: Eastern upland forest system.** The beech/maple-dominated system is resistent to many natural forms of stress due to high biomass; deep, established root systems; and other adaptations.*

CASE STUDY Before the Next Flood

Recently the process of recovery from major flood events has taken on a new dimension. Environmental easements, land acquisition, and relocation of vulnerable structures have become more prominent tools to assist recovery and reduce long-term flood vulnerability. In addition to meeting the needs of disaster victims, these actions can also be effective in achieving stream corridor restoration. Local interest in and support for stream corridor restoration may be high after a large flood event, when the floodwaters recede and the extent of property damage can be fully assessed. At this point, public recognition of the costly and repetitive nature of flooding can provide the impetus needed for communities and individuals to seek better solutions. Advanced planning on a systemwide basis facilitates identification of areas most suited to levee setback, land acquisition, and relocation.

*The city of Arnold, Missouri, is located about 20 miles southwest of St. Louis at the confluence of the Meramec and Mississippi Rivers. When the Mississippi River overflows its banks, the city of Arnold experiences backwater conditions—river water is forced back into the Meramec River, causing flooding along the Meramec and smaller tributaries to the Meramec. The floodplains of the Mississippi, Meramec, and local tributaries have been extensively developed. This development has decreased the natural function of the floodplain. In 1991 Arnold adopted a floodplain management plan that included, but was not limited to, a greenway to supplement the floodplain of the Mississippi River, an acquisition and relocation program to facilitate creation of the greenway, regulations to guide future development and ensure its consistency with the floodplain management objectives, and a watershed management plan. The 1993 floods devastated Arnold (**Figure 3.5**). More than $2 million was spent on federal disaster assistance to individuals, and the city's acquisition program spent $7.3 million in property buyouts. Although not as severe as the 1993 floods, the 1995 floods were the fourth largest in Arnold's history. Because of the relocation and other floodplain management efforts, federal assistance to individuals totaled less than $40,000. As the city of Arnold demonstrated, having a local floodplain management plan in place before a flood makes it easier to take advantage of the mitigation opportunities after a severe flood.*

Across the Midwest, the 1993 floods resulted in record losses with over 55,000 homes flooded. Total damage estimates ranged between $12 billion and $16 billion. About half of the damage was to residences, businesses, public facilities, and transportation infrastructure. The Federal Emergency Management Agency and the U.S. Department of Housing and Urban Development were able to make considerably more funding available for acquisition, relocation, and raising the elevation of properties than had been available in the past. The U.S. Fish and Wildlife Service and state agencies were also able to acquire property easements along the rivers. As a result, losses from the 1995 floods in the same areas were reduced and the avoided losses will continue into the future. In addition to reducing the potential for future flood damages, the acquisition of property in floodplains and the subsequent conversion of that property into open space provides an opportunity for the return of the natural functions of stream corridors.

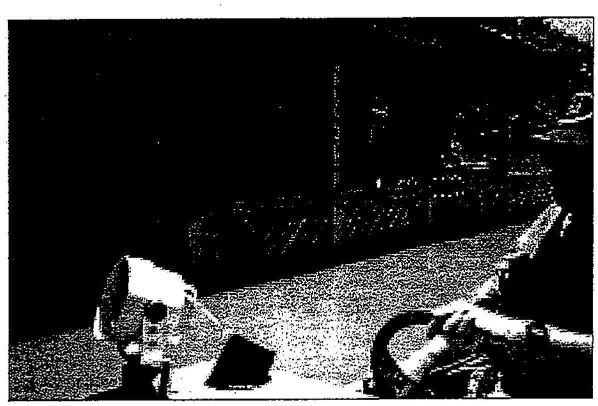

Figure 3.5: Flooding in Arnold, Missouri (1983).

3B Human-Induced Disturbances

Human-induced disturbances brought about by land use activities undoubtedly have the greatest potential for introducing enduring changes to the ecological structure and functions of stream corridors (**Figure 3.6**). Chemically defined disturbance effects, for example, can be introduced through many activities including agriculture (pesticides and nutrients), urban activities (municipal and industrial waste contaminants), and mining (acid mine drainage and heavy metals).

> **luman-induced disturbances rought about y land use ctivities undoubtedly have he greatest otential for ntroducing enduring changes o the ecologial structure nd functions f stream corridors.**

They have the potential to disturb natural chemical cycles in streams, and thus to degrade water quality. Chemical disturbances from agriculture are usually widespread, nonpoint sources. Municipal and industrial waste contaminants are typically point sources and often chronic in duration. Secondary effects, such as agricultural chemicals attached to sediments and increased soil salinity, frequently occur as a result of physical activities (irrigation or heavy application of herbicide). In these cases, it is better to control the physical activity at its source than to treat the symptoms within a stream corridor.

Biologically defined disturbance effects occur within species (competition, cannibalism, etc.) and among species (competition, predation, etc.). These are natural interactions that are important determinants of population size and community organization in many ecosystems. Biological disturbances due to improper grazing management or recreational activities are frequently encountered. The introduction of exotic flora and fauna species can introduce widespread, intense, and continuous stress on native biological communities.

Physical disturbance effects occur at any scale from landscape and stream corridor to stream and reach, where they can cause impacts locally or at locations far removed from the site of origin. Activities such as flood control, forest management, road building and maintenance, agricultural tillage, and irrigation, as well as urban encroachment, can have dramatic effects on the geomorphology and hydrology of a watershed and the stream corridor morphology within it. By altering the structure of plant communities and soils, these and other activities can affect the infiltration and movement of water, thereby altering the timing and magnitude of runoff events. These disturbances also occur at the reach scale and cause changes that can be addressed in stream corridor restoration. The modification of stream hydraulics, for example, directly affects the system,

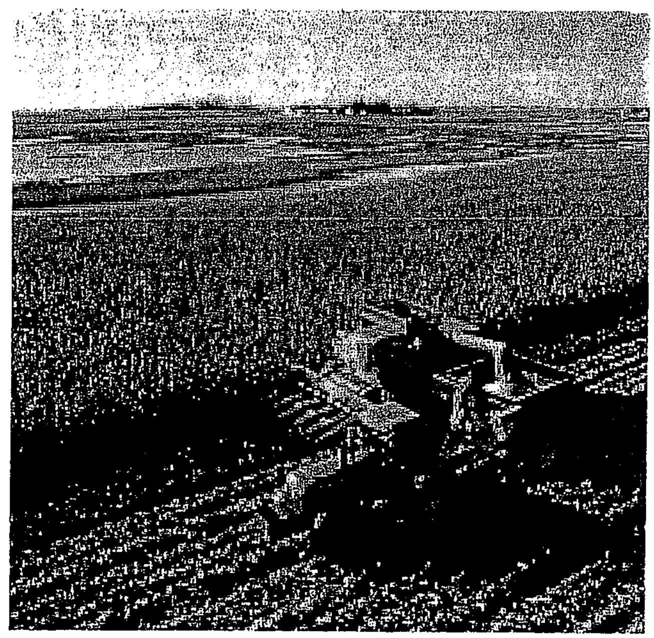

Figure 3.6: Agricultural activity. *Land use activities can cause extensive physical, biological, or chemical disturbances in a watershed and stream corridor.*

causing an increase in the intensity of disturbances caused by floods.

This section is divided into two subsections. Common disturbances are discussed first, followed by land use activities.

Common Disturbances

Dams, channelization, and the introduction of exotic species represent forms of disturbance found in many if not all of the land uses discussed later in this chapter. Therefore, they are presented as separate discussions in advance of more specific land use activities that potentially introduce disturbance. Many societal benefits are derived from these land use changes. This document, however, focuses on their potential for disturbance and subsequent restoration of stream corridors.

Figure 3.7: An impoundment dam. Dams range widely in size and purpose, and in their effects on stream corridors.

Dams

Ranging from small temporary structures constructed of stream sediment to huge multipurpose structures, dams can have profound and varying impacts on stream corridors (**Figure 3.7**). The extent and impact largely depend on the purposes of the dam and its size in relation to stream flow.

Changes in discharges from dams can cause downstream effects. Hydropower dam discharges may vary widely on a hourly and daily basis in response to peaking power needs and affect the downstream morphology. The rate of change in the discharge can be a significant factor increasing streambank erosion and subsequent loss of riparian habitat. Dams release water that differs from that received. Flowing streams can slow and change into slack water pools, sometimes becoming lacustrine environments. A water supply dam can decrease instream flows, which alters the stream corridor morphology, plant communities, and habitat or can augment flows, which also results in alterations to the stream corridor.

Dams affect resident and migratory organisms in stream channels. The disruption of flow blocks or slows the passage and migration of aquatic organisms, which in turn affects food chains associated with stream corridor functions (**Figure 3.8**). Without high flows, silt is not washed from the gravel beds on which many aquatic species rely for spawning. Upstream fish movement may be blocked by relatively small structures. Downstream movement may be slowed or stopped by the dam or its reservoir. As a stream current dissipates in a reservoir, smolts of anadromous fish may lose a sense of downstream direction or might be subject to more predation, altered water chemistry, and other effects.

Dams also affect species by altering water quality. Relatively constant flows can create constant temperatures, which affect those species dependent on temperature variations for reproduction or maturation. In places where irrigation water is stored, unnaturally low flows can occur and warm more easily and hold less oxygen, which can cause stress or death in aquatic organisms. Likewise, large storage pools keep water cool, and released water can result in significantly cooler temperatures downstream to which native fish might not be adapted.

Dams also disrupt the flow of sediment and organic materials (Ward and Standford 1979). This is particularly evident with the largest dams, whereas dams which are typically low in elevation and have small pools modify natural flood and transport cycles only slightly. As stream flow slackens, the load of suspended sediment decreases and sediment drops out of the stream to the reservoir bottom. Organic material suspended in the sediment, which provides vital nutrients for downstream food webs, also drops out and is lost to the stream ecosystem.

When suspended sediment load is decreased, scouring of the downstream streambed and banks may occur until the equilibrium bed load is reestablished. Scouring lowers the streambed and erodes streambanks and riparian zones, vital habitat for many species. Without new sources of sediment, sandbars alongside and within streams are eventually lost, along with the habitats and species they support. Additionally, as the stream channel becomes incised, the water table underlying the riparian zone also lowers. Thus, channel incision can lead to adverse changes in the composition of vegetative communities within the stream corridor.

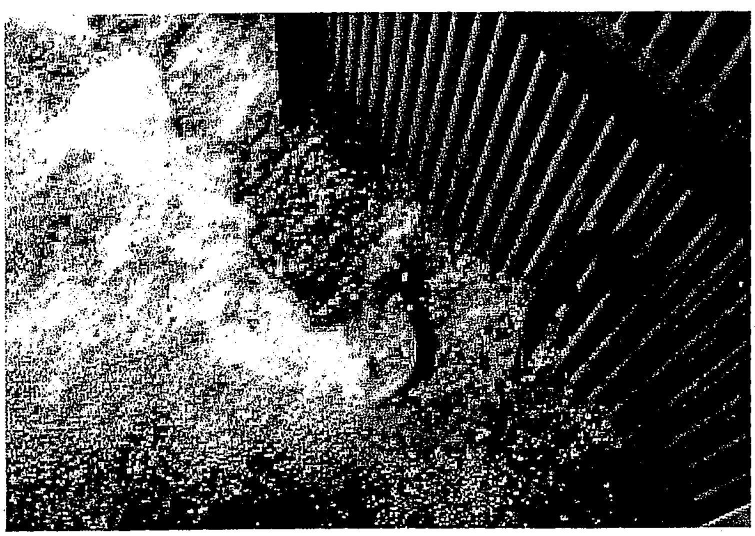

Figure 3.8: Biological effects of dams. Dams can prevent the migration of anadromous fish and other aquatic organisms.

Conversely, when dams are constructed and operated to reduce flood damages, the lack of large flood events can result in channel aggradation and the narrowing and infilling of secondary channels (Collier et al. 1996).

Channelization and Diversions

Like dams, channelization and diversions cause changes to stream corridors. Stream channelization and diversions can disrupt riffle and pool complexes needed at different times in the life cycle of certain aquatic organisms. The flood conveyance benefits of channelization and diversions are often offset by ecological losses resulting from increased stream velocities and reduced habitat diversity. Instream modifications such as uniform cross section and armoring result in less habitat for organisms living in or on stream sediments (**Figure 3.10**). Habitat is also lost when large woody debris, which frequently supports a high density of aquatic macroinvertebrates, is removed (Bisson et al. 1987, Sweeney 1992).

The impacts of diversions on the stream corridor depend on the timing and amount of water diverted, as well as the location, design, and operation

CASE STUDY The Glen Canyon Dam Spiked Flow Experiment

The Colorado River watershed is a 242,000-square-mile mosaic of mountains, deserts, and canyons. The watershed begins at over 14,000 feet in the Rocky Mountains and ends at the Sea of Cortez. Many native species require very specific environments and ecosystem processes to survive. Before settlement of the Colorado River watershed, the basin's rivers and streams were characterized by a large stochastic variability in the annual and seasonal flow levels. This was representative of the highly variable levels of moisture and runoff. This hydrologic variability was a key factor in the evolution of the basin's ecosystems.

Settlement and subsequent development and management of the waters of the Colorado River system detrimentally affected the ecological processes. Today over 40 dams and diversion structures control the river system and result in extensive fragmentation of the watershed and riverine ecosystem. Watershed development, in addition to the dams, has also resulted in modifications to the hydrology and the sediment input.

*Historically, flood flows moved nutrients into the ecosystem, carved the canyons, and redistributed sand from the river bottom creating sandbars and backwaters where fish could breed and grow. In 1963, the closure of Glen Canyon Dam, about 15 miles upstream of the Grand Canyon, permanently altered these processes (**Figure 3.9**). In the spring of 1996 the Bureau of Reclamation ran the first controlled release of water from Glen Canyon Dam to test and study the ability to use "spike flows" for redistribution of sediment (sand) from the river bottom to the river's margins in eddy zones. The primary objective of the controlled release of large flows was to restore portions of the ecological equation by mimicking the annual floods which used to occur in the Grand Canyon.*

Flow releases of 45,000 cfs were maintained for one week. The results were mixed. The flood heightened and slightly widened existing sandbars. It built scores of new camping beaches and provided additional protection for archeological sites threatened with loss from erosion. The spike flow also liberated large quantities of vital nutrients. It created 20 percent more backwater areas for spawning native fish. No endangered species were significantly harmed, nor was the trout fishery immediately below Glen Canyon Dam harmed. The flow was not, however, strong enough to flush some nonnative species (e.g., tamarisk) from the system as had been hoped. One important finding was that most of the ecological effects were realized during the first 48 hours of the week-long high-flow conditions.

The Bureau of Reclamation is continuing to monitor the effects of the spike flow. The effects of the restorative flood are not permanent. New beaches and sandbars will continue to erode. An adaptive management approach will help guide future decisions about spike flows and management of flows to better balance the competing needs for hydropower, flood protection, and preservation of the Grand Canyon ecosystem. It might be that short spike flows are ecologically more acceptable. Changing flow releases provides another tool that, if properly used, can help restore ecological processes that are essential for maintaining ecosystem health and biodiversity.

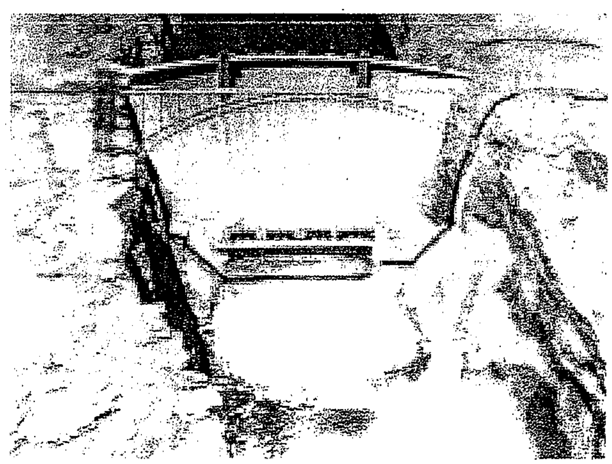

Figure 3.9: Glen Canyon Dam. *The Glen Canyon Dam permanently altered downstream functions and ecology.*

of the diversion structure or its pumps (Figure 3.11). The effects of diversions on stream flows are similar to those addressed for dams. The effects of levees depend on siting considerations, design, and maintenance practices.

'lood damage eduction measures encompass a wide variety of trategies, ome of which night not be ompatible vith goals of tream corridor estoration.

Earthen diversion channels leak, and the water lost for irrigation may create wetlands. Leakage may support a vegetative corridor approaching that of a simple riparian community, or it can facilitate spread of exotic species, such as tamarisk (*Tamarisk chinensis*). Diversions can also trap fish, resulting in diminished spawning, lowered health of species, and death of fish.

Flood damage reduction measures encompass a wide variety of strategies, some of which might not be compatible with goals of stream corridor restoration. Floodwalls and levees can increase the velocity of the stream and elevate flood heights by constraining high flows of the river to a narrow band. When floodwalls are set farther back from streams, they can define the stream corridor and for some or all of the natural functions of the floodplain, including temporary flood storage.

Figure 3.10: Stream channelization. *Instream modifications, such as uniform cross section and armoring, result in ecological decline.*

Levees juxtaposed to streams tend to replace riparian vegetation. The loss or diminishment of the tree overstory and other riparian vegetation results in the changes in shading, temperature, and nutrients discussed earlier.

Introduction of Exotic Species

Stream corridors naturally evolve in an environment of fluctuating flows and seasonal rhythms. Native species adapted to such conditions might not survive without them. For stream corridors that have naturally evolved in an environment of spring floods and low winter and summer flows, the diminution of such patterns can result in the creation of a new succession of plants and animals and the decline of native species. In the West, nonnative species like tamarisk can invade altered stream corridors and result in creation of a habitat with lower stability. The native fauna might not secure the same survival benefits from this altered condition because they did not evolve with tamarisk and are not adapted to using it.

The introduction of exotic species, whether intentional or not, can cause disruptions such as predation, hybridization, and the introduction of diseases. Nonnative species compete with native species for moisture, nutrients, sunlight, and space and can adversely influence establishment rates for new plantings, foods, and habitat. In some cases, exotic plant species can even detract from the recreational value of streams by creating a dense, impenetrable thicket along the streambank. Well-known examples of the effects of exotic species introduction include the planned introduction of kudzu and the inadvertent introduction of the zebra mussel. Both species have imposed widespread, intense, and continuous stress on native biological communities. Tamarisk (also known as salt cedar) is perhaps the most renowned exotic in North America. It is an aggressive, exotic colonizer in the West due to its high rate of seed production and ability to withstand long periods of inundation.

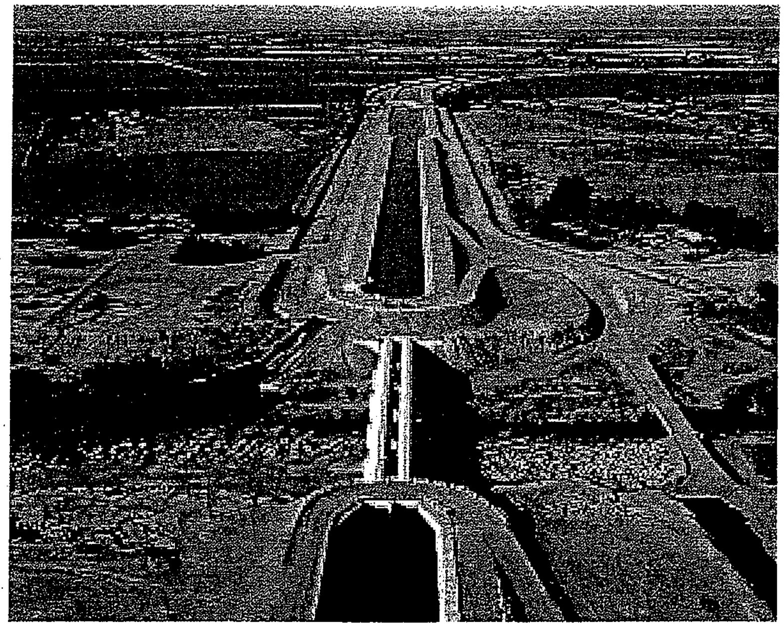

Figure 3.11: Stream diversion. Diversions are built to provide water for numerous purposes, including agriculture, industry, and drinking water supplies.

Exotic Species in the West

Exotic animals are a common problem in many areas of the West. "Wild" burros wander up and down many desert washes and stream corridors. Their destructive foraging is often evident in sensitive riparian areas. Additionally, species such as bullfrogs, not native to most of the West, have been introduced in many waters (**Figure 3.12**). *Without the normal checks and balances found in their native habitat in the eastern United States, bullfrogs reproduce prodigiously and prey on numerous native amphibians, reptiles, fish, and small mammals.*

Figure 3.12: Bullfrog. *Without the normal checks and balances found in the eastern United States, bullfrogs in the West have reproduced prodigiously.*
Source: C. Zabawa.

CASE STUDY

Salt Cedar Control at Bosque del Apache National Wildlife Refuge, New Mexico

The exotic salt cedar (Tamarix chinensis) *has become the predominant woody species along many of the stream corridors in the Southwest. The wide distribution of this species can be attributed to its ability to tolerate a wide range of environmental factors and its adaptability to new stream conditions accelerated by human activities (e.g., summer flooding or no flooding, reduced or altered water tables, high salinity from agricultural tail water, and high levels of sediment downstream from grazed watersheds). Salt cedar is particularly abundant on regulated rivers. Its ability to rapidly dominate riparian habitat results in exclusion of cottonwood, willow, and many other native riparian species..*

Salt cedar control is an integral part of riparian restoration and enhancement at Bosque del Apache National Wildlife Refuge on the Rio Grande in central New Mexico. Diverse mosaics of native cottonwood/black willow (Populus fremontii/Salix nigra) *forests, screw bean mesquite* (Prosobis pubescens) *brushlands, and saltgrass* (Distichlis *sp.*) *meadows have been affected by this invasive exotic. The degree of infestation varies widely throughout the refuge, ranging from isolated plants to extensive monocultures totaling thousands of acres. For the past 10 years, the refuge has experimented with mechanical and herbicide programs for feasible control of salt cedar.*

*The refuge has experimented with several techniques in controlling large salt cedar monocultures prior to native plant establishment. Herbicide/broadcast burn and mechanical techniques have been employed on three 150-acre units on the refuge (**Figure 3.13**). Initially, the strategy for control was aerial application of a low-toxicity herbicide, at 2 quarts/acre in the late summer, followed by a broadcast prescribed burn a year later. This control method appeared effective; however, extensive resprouting following the burn indicated the herbicide might not have had time to kill the plant prior to the burning.*

Mechanical control using heavy equipment was another option. Root plowing and raking have long been used as a technique for salt cedar control. A plow is pulled by a bulldozer, severing salt cedar root crowns from the remaining root mass about 12 to 18 inches below the ground surface, followed by root raking, which pulls the root crowns from the ground for later stacking.

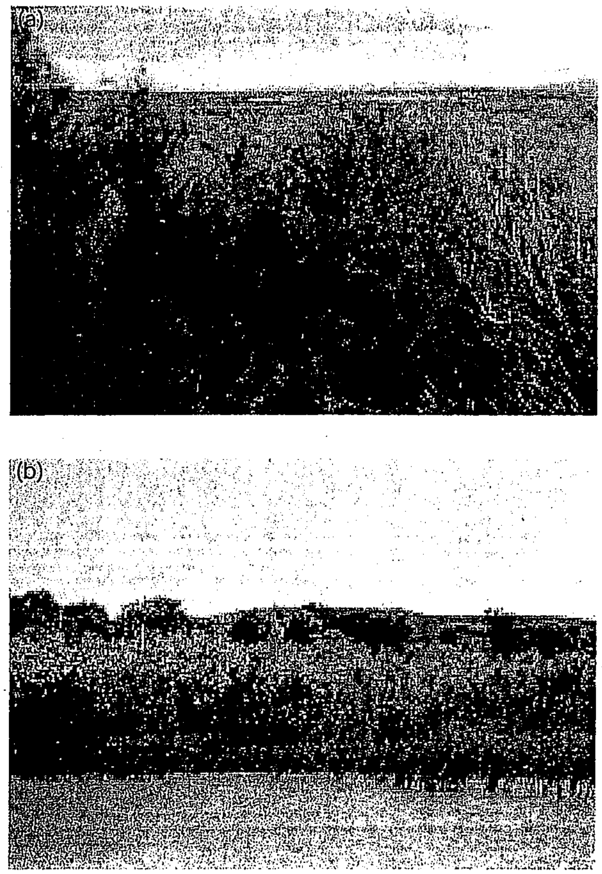

Figure 3.13: Salt cedar site (a) before and (b) after treatment. *Combinations of burning, chemical treatment, and mechanical control techniques can be used to control salt cedar, giving native vegetation an opportunity to colonize and establish.*

There are advantages and disadvantages with each technique (**Table 3.1**). Cost-effectiveness is the distinct advantage of an herbicide/burn control program. Costs can be low if resprouting is minor and burning removes much of the aerial vegetation. Because an herbicide/burn program is potentially cost-effective, this technique is again being experimented with at the refuge. Costs are being further reduced by combining the original herbicide with a less expensive herbicide. A delay of 2 years prior to broadcast burning is expected to dramatically reduce resprouting, allowing time for the herbicide to effectively move throughout the entire plant. Disadvantages of herbicide application include restrictions regarding application near water bodies and impacts on native vegetation remnants within salt cedar monocultures.

Advantages of mechanical control include proven effectiveness and more thorough site preparation for revegetation. Disadvantages include significant site disturbance, equipment breakdowns/delays, and lower effectiveness in tighter clay soils. Both methods require skill in equipment operation, whether applying herbicide aerially or operating heavy equipment.

Other salt cedar infestations on the refuge are relatively minor, consisting of small groups of plants or scattered individual plants. Nonetheless, these patches are aggressively controlled to prevent spread. Heavy equipment requires working space and is generally restricted to sites of 1 acre and larger. For these smaller areas, front end loaders have been filled with "stinger bars," which remove individual plant root crowns much like a root plow. For areas of less than 1 acre, spot herbicide applications are made using a 1 percent solution from a small sprayer. To date, approximately 1,000 acres of salt cedar have been controlled, with over 500 acres effectively restored to native riparian vegetative communities. A combination of techniques in the control of salt cedar has proven effective and will continue to be used in the future.

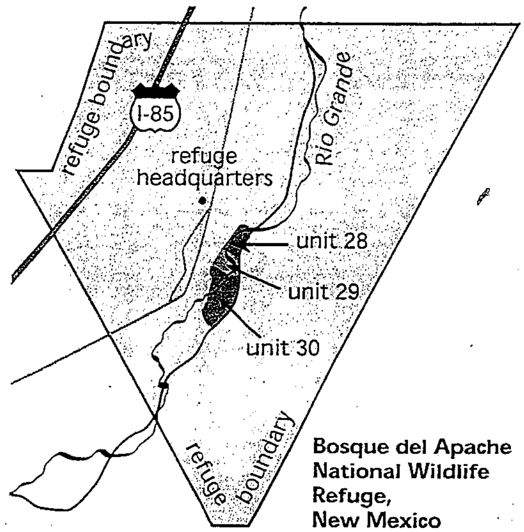

Table 3.1: Salt cedar control techniques at Bosque del Apache.

Unit	Herbicide	Broadcast Burn	Root Plow	Root Rake	Pile Burn	% Control
28	x	x	x			88%
29	x	x	x	x	x	90%
30			x	x	x	99%

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Land Use Activities

Agriculture

According to the 1992 Natural Resources Inventory (USDA-NRCS 1992), cultivated and noncultivated cropland make up approximately 382 million acres of the roughly 1.9 billion acres existing in the contiguous United States, Hawaii, Puerto Rico, and the U.S. Virgin Islands (excludes Alaska). The conversion of undisturbed land to agricultural production has often disrupted the previously existing state of dynamic equilibrium. Introduced at the landscape, watershed, stream corridor, stream, and reach scales, agricultural activities have generally resulted in encroachment on stream corridors with significant changes to the structure and mix of functions usually found in stable systems (**Figure 3.14**).

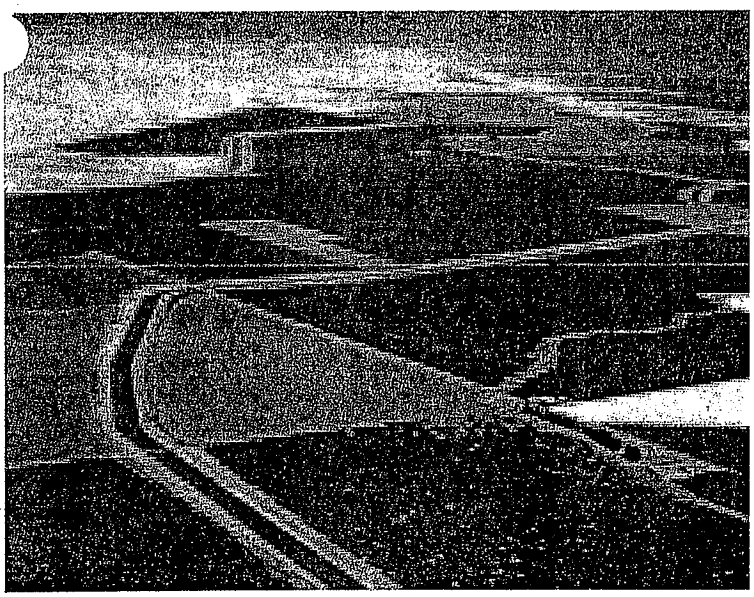


Figure 3.14: Agriculture fragments natural ecosystems. *Cultivated and noncultivated cropland make up approximately 382 million acres of the roughly 1.9 billion acres existing in the contiguous United States, Hawaii, Puerto Rico, and the U.S. Virgin Islands (excludes Alaska).*

Vegetative Clearing

One of the most obvious disturbances from agriculture involves the removal of native, riparian, and upland vegetation. Producers often crop as much productive land as possible to enhance economic returns; therefore, vegetation is sacrificed to increase arable acres.

As the composition and distribution of vegetation are altered, the interactions between structure and function become fragmented. Vegetative removal from streambanks, floodplains, and uplands often conflicts with the hydrologic and geomorphic functions of stream corridors. These disturbances can result in sheet and rill as well as gully erosion, reduced infiltration, increased upland surface runoff and transport of contaminants, increased streambank erosion, unstable stream channels, and impaired habitat.

Instream Modifications

Flood-control structures and channel modifications implemented to protect agricultural systems further disrupt the geomorphic and hydrologic characteristics of stream corridors and associated uplands. For agricultural purposes, streams are often straightened or moved to "square-up" fields for more efficient production and reconstructed to a new profile and geometric cross section to accommodate increased runoff. Stream corridors are also often modified to enhance conditions for single purposes such as fish habitat, or to manage conditions such as localized streambank erosion. Some of the potential effects caused by these changes are impaired upland or floodplain surface and subsurface flow; increased water temperature, turbidity, and pH; incised channels; lower ground water elevations; streambank failure; and loss of habitat for aquatic and terrestrial species.

Soil Exposure and Compaction

Tillage and soil compaction interfere with soil's capacity to partition and regulate the flow of water in the landscape, increase surface runoff, and decrease the water-holding capacity of soils. Increases in the rate and volume of throughflow in the upper soil layers are frequent. Tillage also often aids in the development of a *hard pan*, a layer of increased soil density and decreased permeability that restricts the movement of water into the subsurface.

The resulting changes in surface and ground water flow often initiate incised channels and effects similar to those discussed previously for instream modifications.

Irrigation and Drainage

Diverting surface water for irrigation and depleting aquifers have brought about major changes in stream corridors. Aquifers have been a desired source of water for agriculture because ground water is usually high-quality and historically abundant and is a more reliable source than rivers, lakes, and reservoirs (**Figure 3.15**). Underground water supplies have diminished at an alarming rate in the United States, with ground water levels reported to be dropping an estimated foot or more a year under 45 percent of the ground water-irrigated cropland (Dickason 1988).

Agricultural drainage, which allows the conversion of wetland soils to agricultural production, lowers the water table. Tile drainage systems concentrate ground water discharge to a point source, in contrast to a diffuse source of seeps and springs in more natural discharges. Subsurface tile drainage systems, constructed waterways, and drainage ditches constitute a landscape scale network of disturbances. These practices have eliminated or fragmented habitat and natural filtration systems needed to slow and purify runoff. The results are often a compressed and exaggerated hydrograph.

Figure 3.15: Central pivot irrigation systems use ground water sources. *Reliance on aquifers for irrigation has brought about major changes in ground water supply, as well as the landscape.*

Sediment and Contaminants

Disturbance of soil associated with agriculture generates runoff polluted with sediment, a major nonpoint source pollutant in the nation. Pesticides and nutrients (mainly nitrogen, phosphorous, and potassium) applied during the growing season can leach into ground water or flow in surface water to stream corridors, either dissolved or adsorbed to soil particles. Applied aerially, these same chemicals can drift into the stream corridor. Improper storage and application of animal waste from concentrated animal production facilities are potential sources of chemical and bacterial contaminants to stream corridors.

Soil salinity is a naturally occurring phenomenon found most often in floodplains and other low-lying areas of wet soils, lakes, or shallow water tables. Dissolved salts in surface and ground water entering these areas become concentrated in the shallow ground water and the soils as evapotranspiration removes water. Agricultural activities in such landscapes can increase the rate of soil salinization by changing vegetation patterns or by applying irrigation water without adequate drainage. In the arid and semiarid areas of the West, irrigation can import salts into a drainage basin. Since crops do not use up the salts, they accumulate in the soil. Salinity levels greater than 4 millimhos/cm can alter soil structure, promote waterlogging, cause salt toxicity in plants, and decrease the ability of plants to take up water.

Drainage and Streambank Erosion

Many wetlands have been drained to increase the acres of arable land. The drainage area of the Blue Earth River in the glaciated areas of west-central Minnesota, for example, has almost doubled due to extensive tile drainage of depressional areas that formerly stored surface runoff. Studies to identify sources of sediment in this watershed have been made, and as a result, farmers have complied with reduced tillage and increased crop residue recommendations to help decrease the suspended sediment load in the river. Testing, however, indicates the sediment problem has not been solved. Some individuals have suggested that streambank erosion, not erosion on agricultural lands, might be the source of the sediment. Streambank erosion is more likely to be the result of drainage and subsequent changes to runoff patterns in the watershed.

Forestry

Three general activities associated with forestry operations can affect stream corridors—tree removal, activities necessary to transport the harvested timber, and preparation of the harvest site for regeneration.

Removal of Trees

Forest thinning includes the removal of either mature trees or immature trees to provide more growth capability for the remaining trees. Final harvest removes mature trees, either singularly or in groups. Both activities reduce vegetative cover.

Tree removal decreases the quantity of nutrients in the watershed since approximately one-half of the nutrients in trees are in the trunks. Instream nutrient levels can increase if large limbs fall into streams during harvesting and decompose. Conversely, when tree cover is removed, there is a short-term increase in nutrient release followed by long-term reduction in nutrient levels.

Removal of trees can affect the quality, quantity, and timing of stream flows for the same reasons that vegetative clearing for agriculture does. If trees are removed from a large portion of a watershed, flow quantity can increase accordingly. The overall effect depends on the quantity of trees removed and their proximity to the stream corridor (**Figure 3.16**). Increases in flood peaks can occur if vegetation in the area closest to the stream is removed. Long-term loss of riparian vegetation can result in bank erosion and channel widening, increasing the width/depth ratio (Hartman et al. 1987, Oliver and Hinckley 1987, Shields et al. 1994). Water temperature can increase during summer and decrease in winter by removal of shade trees in riparian areas. Allowing large limbs to fall into a stream and divert stream flow may alter flow patterns and cause bank or bed erosion.

Removal of trees can reduce availability of cavities for wildlife use and otherwise alter biological systems, particularly if a large percentage of the tree cover is removed. Loss of habitat for fish, invertebrates, aquatic mammals, amphibians, birds, and reptiles can occur.

Transportation of Products

Forest roads are constructed to move loaded logs from the landing to higher-quality roads and then to a manufacturing facility. Mechanical means to move logs to a loading area (landing) produce "skid trails." Stream crossings are necessary along some skid trails and most forest road systems and are especially sensitive areas.

Removal of topsoil, soil compaction, and disturbance by equipment and log skidding can result in long-term loss of productivity, decreased porosity, decreased soil infiltration, and increased runoff and erosion. Spills of petroleum products can contaminate soils. Trails, roads, and landings can intercept ground water flow and cause it to become surface runoff.

Soil disturbance by logging equipment can have direct physical impact on habitat for a wide variety of amphibians, mammals, fish, birds, and reptiles, as well as physically harm wildlife. Loss of cover, food, and other needs can be critical. Sediment can clog fish habitat, widen streams, and accelerate streambank erosion.

Site Preparation

Preparing the harvested area for the next generation of desired trees typically includes some use of prescribed fire or other methods to prepare a seed bed and reduce competition from unwanted species.

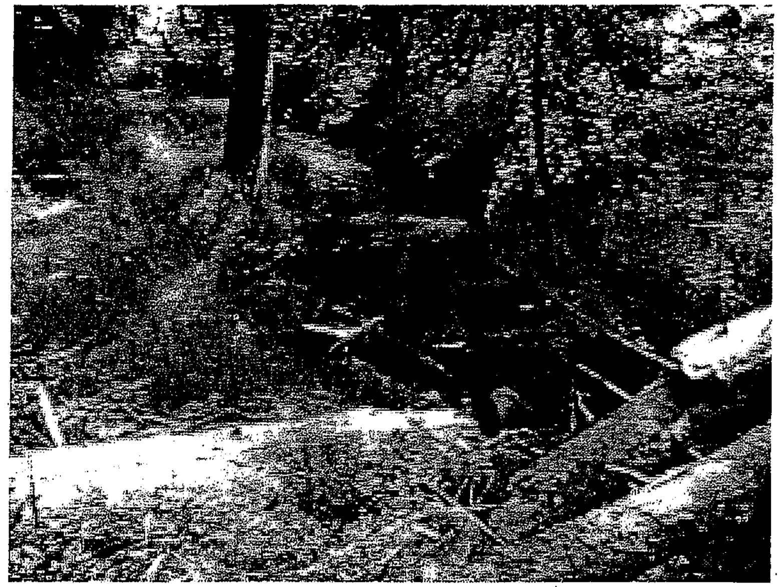


Figure 3.16: Riparian forest. *Streamside forest cover serves many important functions such as stabilizing streambanks and moderating diurnal stream temperatures.*

Mechanical methods that completely remove competing species can cause severe compaction, particularly in wet soils. This compaction reduces infiltration and increases runoff and erosion. Moving logging debris into piles or windrows can remove important nutrients from the soil. Depending on the methods used, significant soil can be removed from the site and stacked with piled debris, further reducing site productivity.

Intense prescribed fire can volatilize important nutrients, while less intense fire can mobilize nutrients for rapid plant uptake and growth. Use of fire can also release nutrients to the stream in unacceptable quantities.

Mechanical methods that cause significant compaction or decrease infiltration can increase runoff and therefore the amount of water entering the stream system. Severe mechanical disturbance can result in significant erosion and sedimentation. Conversely, less disruptive mechanical means can increase organic matter in the soil surface and increase infiltration. Each method has advantages and disadvantages.

Direct harm can occur to wildlife by mechanical means or fire. Loss of habitat can occur if site preparation physically removes most competing vegetation. Loss of diversity can result from efforts to strongly limit competition with desired timber species. Careless use of mechanical equipment can directly damage streambanks and cause erosion.

Domestic Livestock Grazing

Grazing of domestic livestock, primarily cattle and sheep, is commonplace across the nation. Stream corridors are particularly attractive to livestock for many reasons. They are generally highly productive, providing ample forage. Water is close at hand, shade is available to cool the area, and slopes are gentle, generally less than 35 percent in most areas. Unless carefully managed, livestock can overuse these areas and cause significant disturbance (Figure 3.17). For purposes of the following discussion, cattle grazing provides the focus, although sheep, goats, and other less common species also can have particular effects that might be different from those discussed. It is important to note that the effects discussed result from poorly managed grazing systems.

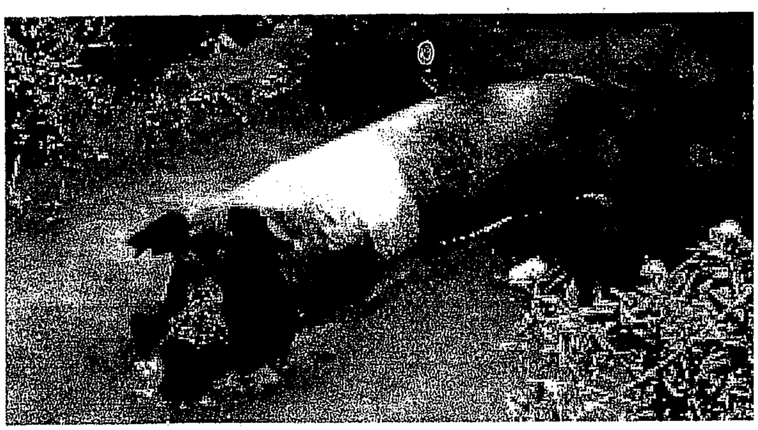


Figure 3.17: Livestock in stream. *Use of stream corridors by domestic livestock can result in extensive physical disturbance and bacteriological contamination.*

The primary impacts that result from grazing of domestic livestock are the loss of vegetative cover due to its consumption or trampling and streambank erosion from the presence of livestock (Table 3.2).

Loss of Vegetative Cover

Reduced vegetative cover can increase soil compaction and decrease the depth of and productivity of topsoil. Reduced cover of mid-story and overstory plants decreases shade and increases water temperatures, although this effect diminishes as stream width increases. Sediment from upland or streambank erosion can reduce water quality through increases in turbidity and attached chemicals. Where animal concentrations are large, fecal material can increase nutrient loads above standards and introduce bacteria and pathogens, although this is uncommon. Dissolved oxygen reductions can result from high temperature and nutrient-rich waters.

Extensive loss of ground cover in the watershed and stream corridor can decrease infiltration and increase runoff, leading to higher flood peaks and additional runoff volume. Where reduced cover increases overland flow and prevents infiltration, additional water may flow more rapidly into stream channels so that flow peaks come earlier rather than later in the runoff cycle, producing a more "flashy" stream system. Reductions in baseflow and increases in stormflow can result in a formerly perennial stream becoming intermittent or ephemeral.

Table 3.2: Livestock impacts on stream corridors.

Impact
Decreased plant vigor
Decreased biomass
Alteration of species composition and diversity
Reduction or elimination of woody species
Elevated surface runoff
Erosion and sediment delivery to streams
Streambank erosion and failure
Channel instability
Increased width to depth ratios
Degradation of aquatic species
Water quality degradation

References: Ames (1977); Knopf and Cannon (1982); Hansen et al. (1995); Kauffman and Kreuger (1984); Brooks et al. (1991); Platts (1979); MacDonald et al. (1991).

Increased sedimentation of channels can reduce channel capacity, increasing width/depth ratios, forcing water into streambanks, and inducing bank erosion. This leads to channel instability, causing other adjustments in the system. Similarly, excessive water reaching the system without additional sediment may cause channel degradation as increased stream energy erodes channel bottoms, incising the channel.

Physical Impacts from Livestock Presence

Trampling, trailing, and similar activities of livestock physically impact stream corridors. Impacts on soils are particularly dependent on soil moisture content, with compaction presenting a major concern. Effects vary markedly by soil type and moisture content. Very dry soils are seldom affected, while very wet soils may also be resistant to compaction. Moist soils are typically more subject to compaction damage. Very wet soils may be easily displaced, however. Adjusting grazing use to periods where soil moisture will minimize impacts will prevent many problems.

Compaction of soils by grazing animals can cause increased soil bulk density, reduced infiltration, and increased runoff. Loss of capillarity reduces the ability of water to move vertically and laterally in the soil profile. Reduced soil moisture content can reduce site capacity for riparian-dependent plant species and favor drier upland species.

Trailing can break down streambanks, causing bank failure and increasing sedimentation. Excessive trailing can result in gully formation and eventual channel extension and migration.

Unmanaged grazing can significantly change stream geomorphology. Bank instability and increased sedimentation can cause channel widening and increases in the width/depth ratio. Increased meandering may result, causing further instability. Erosion of fine materials into the system can change channel bottom composition and alter sediment transport relationships.

Excessive livestock use can cause breakage or other physical damage to streamside vegetation. Loss of bank-holding species and undercut banks can reduce habitat for fish and other aquatic species. Excessive sedimentation can result in filling of stream gravels with fine sediments, reducing the survival of some fish eggs and newly hatched fish due to lack of oxygen. Excessive stream temperatures can be detrimental to many critical fish species, as well as amphibians. Loss of preferred cover reduces habitat for riparian-dependent species, particularly birds.

Mining

Exploration, extraction, processing, and transportation of coal, minerals, sand and gravel, and other materials has had and continues to have a profound effect on stream corridors across the nation (**Figure 3.18**). Both surface mining and subsurface mining damage stream corridors. Surface mining methods include strip mining, open-pit operations, dredging, placer mining, and hydraulic mining. Although several of these methods are no longer commonly practiced today, many streams throughout the United States remain in a degraded condition as a result of mining activities that, in some cases, occurred more than a century ago. Such mining activity frequently resulted in total destruction of the stream corridor. In some cases today, mining operations still disturb most or all of entire watersheds.

Figure 3.18: Results of surface mining. *Many streams remain in a degraded condition as a result of mining activities.*

Vegetative Clearing

Mining can often remove large areas of vegetation at the mine site, transportation facilities, processing plant, tailings piles, and related activities. Reduced shade can increase water temperatures enough to harm aquatic species.

Loss of cover vegetation, poor-quality water, changes in food availability, disruption of migration patterns, and similar difficulties can have serious effects on terrestrial wildlife. Species composition may change significantly with a shift to more tolerant species. Numbers will likely drop as well. Mining holds few positive benefits for most wildlife species.

Soil Disturbance

Transportation, staging, loading, processing, and similar activities cause extensive changes to soils including loss of topsoils and soil compaction. Direct displacement for construction of facilities reduces the number of productive soil acres in the watershed. Covering of soil by materials such as tailings piles further reduces the acreage of productive soils. These activities decrease infiltration, increase runoff, accelerate erosion, and increase sedimentation.

Altered Hydrology

Changes to hydrologic conditions due to mining activity are extensive. Surface mining is, perhaps, the only land use with a greater capacity to change the hydrologic regime of a stream than urbanization. Increased runoff and decreased surface roughness will cause peaks earlier in the hydrograph with steeper rising and falling limbs. Once-perennial streams may become intermittent or ephemeral as baseflow decreases.

Changes in the quantity of water leaving a watershed are directly proportional to the amount of impervious surface or reduced infiltration in a watershed. Loss of topsoils, soil compaction, loss of vegetation, and related actions will decrease infiltration, increase runoff, increase stormflow, and decrease baseflows. Total water leaving the watershed may increase due to reduced in-soil storage.

Stream geomorphology can change dramatically, depending on the mining method used. Floating dredges and hydraulic mining with high-pressure hoses earlier in the century completely altered streamcourses. In many places virtually no trace of the original stream character exists today. Flow may run completely out of view into piles of mine tailings. Once-meandering streams may now be straight, gullied channels. Less extreme mining methods can also significantly alter stream form and function through steepening or lowering the gradient, adding high sediment loads, adding excessive water to the system, or removing water from the system.

Contaminants

Water and soils are contaminated by *acid mine drainage* (AMD) and the materials used in mining. AMD, formed from the oxidation of sulfide minerals like pyrite, is widespread. Many hard rock mines are located in iron sulfide deposits. Upon exposure to water and air, such deposits undergo sulfide oxidation with attendant release of iron, toxic metals (lead, copper, zinc), and excessive acidity. Mercury was often used to separate gold from the ore; therefore, mercury was also lost into streams. Present-day miners using suction dredges often find considerable quantities of mercury still resident in streambeds. Current heap-leaching methods use cyanide to extract gold from low-quality ores. This poses a special risk if operations are not carefully managed.

Toxic runoff or precipitates can kill streamside vegetation or can cause a shift to species more tolerant of mining conditions. This affects habitat required by many species for cover, food, and reproduction.

Floating dredges and hydraulic mining with high-pressure hoses earlier in the century completely altered streamcourses.

Aquatic habitat suffers from several factors. Acid mine drainage can coat stream bottoms with iron precipitates, thereby affecting the habitat for bottom-dwelling and feeding organisms. AMD also adds sulfuric acid to the water, killing aquatic life. The low pH alone can be toxic, and most metals exhibit higher solubility and more bioavailability under acidic conditions. Precipitates coating the stream bottom can eliminate places for egg survival. Fish that do hatch may face hostile stream conditions due to poor water quality, loss of cover, and limited food base.

Recreation

The amount of impact caused by recreation depends on soil type, vegetation cover, topography, and intensity of use. Various forms of foot and vehicular traffic associated with recreational activities can damage riparian vegetation and soil structure. All-terrain vehicles, for example, can cause increased erosion and habitat reduction. At locations heavily used by hikers and tourists, reduced infiltration due to soil compaction and subsequent surface runoff can result in increased sediment loading to the stream (Cole and Marion 1988). Widening of the stream channel can occur where hiking trails cross the stream or where intensive use destroys bank vegetation (**Figure 3.19**).

In areas where the stream can support recreational boating, the system is vulnerable to additional impacts (**Figure**

__Figure 3.19: Trail sign.__ Recreational hiking can cause soil compaction and increased surface runoff.

3.20). Propeller wash and water displacement can disrupt and resuspend bottom sediments, increase bank erosion, and disorient or injure sensitive aquatic species. In addition, waste discharges or accidental spills from boats or loading facilities can contribute pollutants to the system (NRC 1992).

Both concentrated and dispersed recreational use of stream corridors can cause disturbance and ecological change. Camping, hunting, fishing, boating, and other forms of recreation can cause serious disturbances to bird colonies. Ecological damage primarily results from the need for access for the recreational user. A pool in the stream might be the attraction for a swimmer or fisherman, whereas a low streambank might provide an access point for boaters. In either case, a trail often develops along the shortest or easiest route to the point of access on the stream. Additional impact may be a function of the mode of access to the stream: motorcycles and horses cause far more damage to vegetation and trails than do pedestrians.

Urbanization

Urbanization in watersheds poses special challenges to the stream restoration practitioner. Recent research has shown that streams in urban watersheds have a character fundamentally different from that of streams in forested, rural, or even agricultural watersheds. The amount of impervious cover in the watershed can be used as an indicator to predict how severe these differences can be. In many regions of the country, as little as 10 percent watershed impervious cover has been linked to stream degradation, with the degradation becoming more severe as impervious cover increases (Schueler 1995).

Impervious cover directly influences urban streams by dramatically increasing surface runoff during storm events (Figure 3.21). Depending on the degree of watershed impervious cover, the

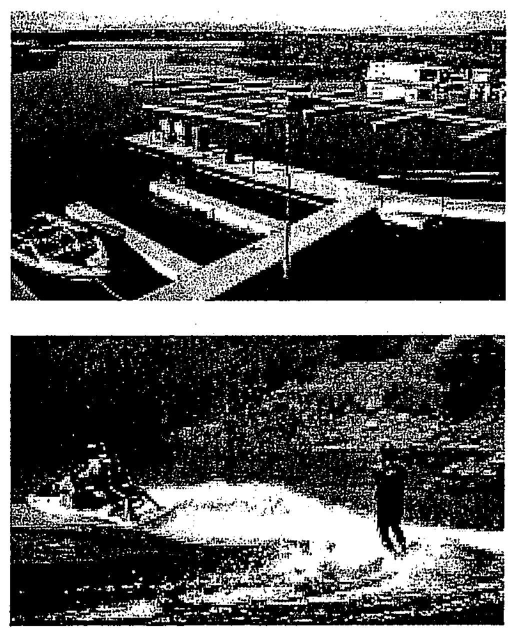


__Figure 3.20: Recreational boating.__ Propeller wash and accidental spills can degrade stream conditions.

annual volume of storm water runoff can increase by 2 to 16 times its predevelopment rate, with proportional reductions in ground water recharge (Schueler 1995).

The unique character of urban streams often requires unique restoration strategies for the stream corridor. For example, the practitioner must seriously consider the degree of upland development that has occurred or is projected to occur. In most projects, it is advisable or even necessary to investigate whether upstream detention or retention can be provided within the watershed to at least partially restore the predevelopment hydrologic regime.

Some of the key changes in urban streams that merit special attention from the stream restoration practitioner are discussed in the following subsections.

Altered Hydrology

The peak discharge associated with the bankfull flow (i.e., the 1.5- to 2-year return storm) increases sharply in magnitude in urban streams. In addition, channels experience more bankfull flood events each year and are exposed to critical erosive velocities for longer

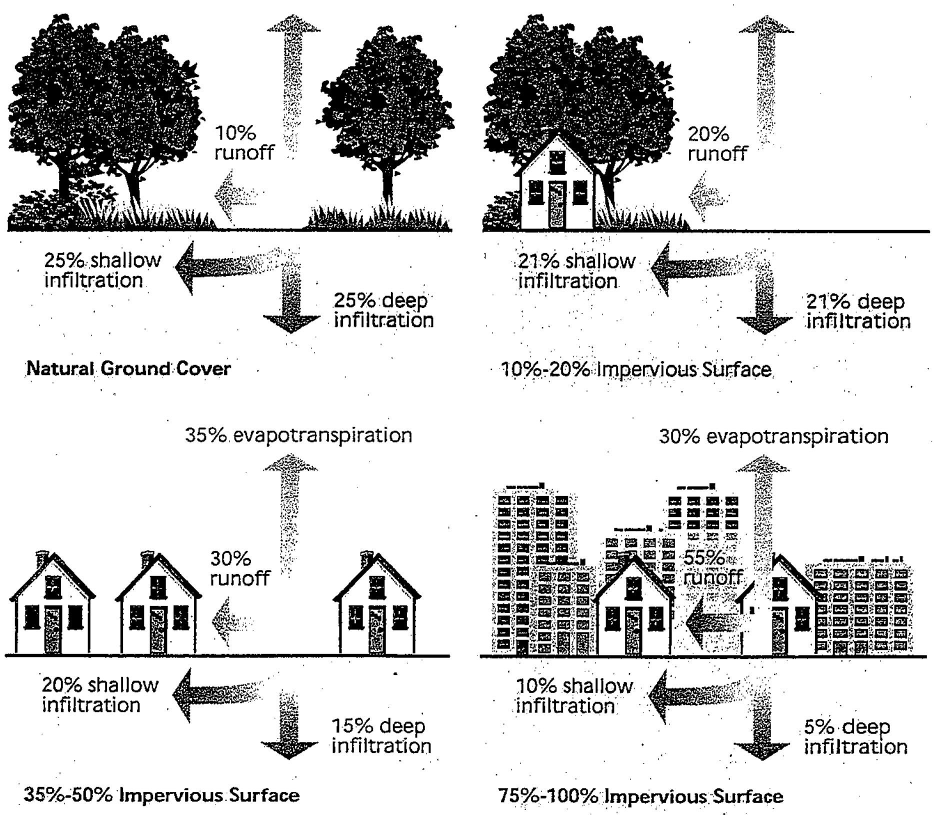


Figure 3.21: Relationship between impervious cover and surface runoff. *Impervious cover in a watershed results in increased surface runoff. As little as 10 percent impervious cover in a watershed can result in stream degradation.*

intervals (Hollis 1975, Macrae 1996, Booth and Jackson 1997).

Since impervious cover prevents rainfall from infiltrating into the soil, less flow is available to recharge ground water. Consequently, during extended periods without rainfall, baseflow levels are often reduced in urban streams (Simmons and Reynolds 1982).

Altered Channels

The hydrologic regime that had defined the geometry of the predevelopment stream channel irreversibly changes toward higher flow rates on a more frequent basis. The higher flow events of urban streams are capable of performing more "effective work" in moving sediment than they had done before (Wolman 1964).

The customary response of urban streams is to increase their cross-sectional area to accommodate the higher flows. This is done by streambed downcutting or streambank widening, or a combination of both. Urban stream channels often enlarge their cross-sectional areas by a factor of 2 to 5, depending on the degree of impervious cover in the upland watershed and the age of development (Arnold et al. 1982, Gregory et al. 1992, and Macrae 1996).

Stream channels react to urbanization not only by adjusting their widths and depths, but also by changing their gradients and meanders (Riley 1998).

Urban stream channels are also extensively modified in an effort to protect adjacent property from streambank erosion or flooding (**Figure 3.22**). Headwater streams are frequently enclosed within storm drains, while others are channelized, lined, or armored by heavy stone. Another modification unique to urban streams is the installation of sanitary sewers underneath or parallel to the stream channel.

The wetted perimeter of a stream is the proportion of the total cross-sectional area of the channel that is covered by flowing water during dry-weather periods. It is an important indicator of habitat degradation in urban streams. Given that urban streams develop a larger channel cross section at the same time that their baseflow rates decline, it necessarily follows that the wetted perimeter will become smaller. Thus, for many urban streams, this results in a very shallow, low-flow channel that wanders across a very wide streambed, often changing its lateral position in response to storms.

Sedimentation and Contaminants

The prodigious rate of channel erosion in urban streams, coupled with sediment erosion from active construction sites, increases sediment discharge to urban streams. Researchers have documented that channel erosion constitutes as much as 75 percent the total sediment budget of urban streams (Crawford and Lenat 1989, Trimble 1997). Urban streams also tend to have a higher sediment discharge than

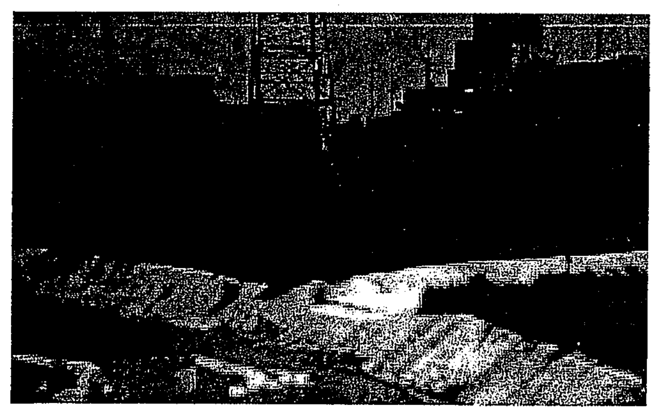


Figure 3.22: Urban stream channel modifications. *Channel armoring often prevents streams from accommodating hydrologic changes that result from urbanization.*

nonurban streams, at least during the initial period of active channel enlargement.

The water quality of urban streams during storm events is consistently poor. Urban storm water runoff contains moderate to high concentrations of sediment, carbon, nutrients, trace metals, hydrocarbons, chlorides, and bacteria (Schueler 1987) (**Figure 3.23**). Although considerable debate exists as to whether storm water pollutant concentrations are actually toxic to aquatic organisms, researchers agree that pollutants deposited in streambeds exert undesirable impacts on stream communities.

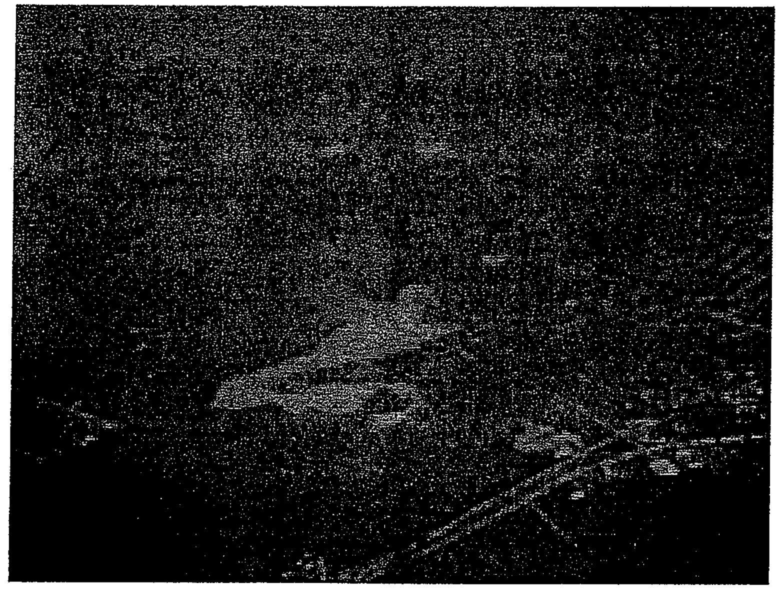


Figure 3.23: Water quality in urban streams. *Surface runoff carries numerous pollutants to urban streams, resulting in consistently poor water quality.*
Source: C. Zabawa.

Habitat and Aquatic Life

Urban streams are routinely scored as having poor instream habitat quality, regardless of the specific metric or method employed. Habitat degradation is often exemplified by loss of pool and riffle structure, embedding of streambed sediments, shallow depths of flow, eroding and unstable banks, and frequent streambed turnover.

Large woody debris (LWD) is an important structural component of many low-order streams systems, creating complex habitat structure and generally making the stream more retentive. In urban streams, the quantity of LWD found in stream channels is reduced due to the loss of riparian forest cover, storm washout, and channel maintenance practices (Booth et al. 1996, May et al. 1997).

Many forms of urban development are linear in nature (e.g., roads, sewers, and pipelines) and cross stream channels. The number of stream crossings increases directly in proportion to impervious cover (May et al. 1997), and many crossings can become partial or total barriers to upstream fish migration, particularly if the streambed erodes below the fixed elevation of a culvert or a pipeline.

The important role that riparian forests play in stream ecology is often diminished in urban watersheds since tree cover is often partially or totally removed along the stream as a consequence of development (May et al. 1997) (**Figure 3.24**). Even when stream buffers are reserved, encroachment often reduces their effective width and native species are supplanted by exotic trees, vines, and ground covers.

The impervious surfaces, ponds, and poor riparian cover in urban watersheds can increase mean summer stream temperatures by 2 to 10 degrees Fahrenheit (Galli 1991). Since temperature plays a central role in the rate and timing of biotic and abiotic reactions in stream, such increases have an adverse impact on streams. In some regions, summer stream warming can irreversibly shift a cold-water stream to

Figure 3.24: Stream corridor encroachment. Stream ecology is disturbed when riparian forests are removed for development.

a cool-water or even warm-water stream, with deleterious effects on salmonoids and other temperature-sensitive organisms.

Urban streams are typified by fair to poor fish and macroinvertebrate diversity, even at relatively low levels of watershed impervious cover or population density (Schueler 1995, Shaver et al. 1995, Couch 1997, May et al. 1997). The ability to restore predevelopment fish assemblages or aquatic diversity is constrained by a host of factors—irreversible changes in carbon supply, temperature, hydrology, lack of instream habitat structure, and barriers that limit natural recolonization.

Summary of Potential Effects of Land Use Activities

Table 3.3 presents a summary of the disturbance activities associated with major land uses and their potential for changing stream corridor functions. Many of the potential effects of disturbance are cumulative or synergistic. Restoration might not remove all disturbance factors; however, addressing one or two disturbance activities can dramatically reduce the impact of those remaining. Simple changes in management, such as the use of conservation buffer strips in cropland or managed livestock access to riparian areas, can substantially overcome undesired cumulative effects or synergistic interactions.

Table 3.3: Potential effects of major land use activities.

Potential Effects	Vegetative Clearing	Channelization	Streambank Armoring	Streambed Disturbance	Withdrawal of Water	Dams	Levees	Soil Exposure or Compaction	Irrigation and Drainage	Contaminants	Hard Surfacing	Overgrazing	Roads and Railroads	Trails	Exotic Species	Utility Crossings	Reduction of Floodplain	Dredging for Mineral Extract.	Land Grading	Bridges	Woody Debris Removal	Piped Discharge/Cont. Outlets
	Disturbance Activities																					
Homogenization of landscape elements	■	■	▒	▒	▒	▒	▒	▒	■	▒	▒	■	▒	▒	■	▒	■	■	■	▒	▒	▒
Point source pollution	▒	▒	▒	▒	▒	■	▒	▒	▒	■	■	■	■	▒	▒	■	▒	■	▒	▒	▒	■
Nonpoint source pollution	■	■	▒	■	▒	▒	■	▒	■	■	■	■	■	■	▒	■	▒	■	■	▒	■	■
Dense compacted soil	■	▒	■	▒	▒	■	■	■	▒	▒	■	■	■	■	▒	■	■	■	■	▒	▒	▒
Increased upland surface runoff	■	▒	▒	▒	▒	▒	▒	■	■	▒	■	■	■	■	▒	▒	▒	▒	■	▒	▒	▒
Increased sheetflow w/surface erosion rill and gully flow	■	▒	▒	▒	▒	▒	▒	■	■	▒	■	■	■	■	▒	▒	▒	▒	■	▒	▒	▒
Increased levels of fine sediment and contaminants in stream corridor	■	■	▒	■	▒	■	■	■	■	■	■	■	■	■	▒	■	■	■	■	■	■	■
Increased soil salinity	▒	▒	▒	▒	■	▒	▒	▒	■	■	■	▒	■	▒	▒	▒	▒	▒	▒	▒	▒	▒
Increased peak flood elevation	■	■	▒	▒	▒	■	■	■	■	▒	■	■	■	▒	▒	▒	■	▒	▒	▒	▒	■
Increased flood energy	■	■	■	■	▒	▒	■	■	■	▒	■	■	■	▒	▒	▒	■	▒	▒	▒	■	■
Decreased infiltration of surface runoff	■	▒	■	▒	▒	▒	▒	■	■	▒	■	■	■	■	▒	▒	▒	▒	■	▒	▒	■
Decreased interflow and subsurface flow	■	■	■	▒	▒	▒	▒	■	▒	■	▒	▒	▒	▒	▒	▒	▒	▒	■	▒	▒	■
Reduced ground water recharge and aquifer volumes	■	▒	▒	▒	■	■	■	■	■	▒	■	■	■	▒	▒	▒	■	■	▒	▒	■	■
Increased depth to ground water	■	■	▒	▒	■	■	■	■	■	▒	■	■	■	▒	▒	▒	■	■	■	▒	▒	▒
Decreased ground water inflow to stream	■	■	■	▒	■	▒	■	■	■	▒	■	■	■	▒	▒	▒	■	■	■	▒	▒	■
Increased flow velocities	■	■	■	■	▒	■	■	■	■	▒	■	■	■	▒	▒	▒	■	■	■	▒	■	■
Reduced stream meander	▒	■	■	■	▒	■	■	▒	▒	▒	■	▒	▒	▒	▒	▒	■	▒	■	▒	■	■
Increased or decreased stream stability	■	■	■	■	■	■	■	■	▒	▒	■	■	■	▒	▒	▒	■	■	■	■	■	■
Increased stream migration	■	▒	▒	■	▒	▒	▒	■	▒	▒	■	■	■	▒	▒	▒	■	■	▒	▒	■	■
Channel widening and downcutting	■	■	■	■	■	■	■	▒	▒	▒	■	■	■	▒	▒	▒	■	■	▒	■	■	■
Increased stream gradient and reduced energy dissipation	▒	■	■	■	■	■	■	▒	▒	▒	▒	▒	▒	▒	▒	▒	■	■	▒	▒	■	■
Increased or decreased flow frequency	■	▒	▒	▒	■	■	■	■	■	▒	■	■	■	▒	▒	▒	■	▒	■	▒	▒	■
Reduced flow duration	■	■	■	■	■	▒	■	■	■	▒	■	■	■	▒	▒	▒	■	▒	▒	▒	■	■
Decreased capacity of floodplain and upland to accumulate, store, and filter materials and energy	■	▒	▒	▒	▒	▒	■	■	■	■	■	■	■	■	▒	▒	■	■	■	▒	■	■
Increased levels of sediment and contaminants reaching stream	■	■	■	■	▒	▒	▒	▒	■	■	■	■	■	▒	▒	■	▒	■	■	■	■	■
Decreased capacity of stream to accumulate and store or filter materials and energy	▒	■	■	■	▒	▒	■	▒	▒	■	▒	▒	▒	▒	▒	▒	▒	■	▒	▒	■	■
Reduced stream capacity to assimilate nutrients/pesticides	■	■	■	■	■	■	■	■	■	■	■	■	▒	▒	▒	▒	■	■	▒	▒	■	■
Confined stream channel w/little opportunity for habitat development	▒	■	■	■	▒	▒	■	▒	▒	▒	▒	▒	▒	▒	▒	▒	■	▒	▒	▒	▒	▒

■ Activity has potential for direct impact.

▒ Activity has potential for indirect impact.

Table 3.3: Potential effects of major land use activities (continued)

Potential Effects	Vegetative Clearing	Channelization	Streambank Armoring	Streambed Disturbance	Withdrawal of Water	Dams	Levees	Soil Exposure or Compaction	Irrigation and Drainage	Contaminants	Hard Surfacing	Overgrazing	Roads and Railroads	Trails	Exotic Species	Utility Crossings	Reduction of Floodplain	Dredging for Mineral Extract.	Land Grading	Bridges	Woody Debris Removal	Piped Discharge/Cont.Outlets
Increased streambank erosion and channel scour	■	■	▒	■	▒	■	■	■	▒	▒	▒	■	▒	▒	▒	▒	▒	■	▒	▒	■	■
Increased bank failure	■	■	▒	■	■	■	■	■	▒	▒	▒	■	▒	▒	▒	▒	▒	■	▒	▒	■	■
Loss of instream organic matter and related decomposition	■	■	■	■	▒	■	■	▒	▒	▒	▒	■	▒	▒	▒	▒	■	■	▒	▒	■	▒
Increased instream sediment, salinity, and turbidity	■	■	▒	■	▒	■	■	▒	■	■	■	■	■	■	▒	■	■	■	■	▒	■	■
Increased instream nutrient enrichment, siltation, and contaminants leading to eutrophication	■	▒	▒	■	▒	■	■	■	■	■	■	■	■	▒	▒	■	■	■	▒	▒	■	■
Highly fragmented stream corridor with reduced linear distribution of habitat and edge effect	■	■	■	▒	■	■	▒	▒	▒	▒	■	■	▒	▒	▒	▒	■	■	■	■	■	▒
Loss of edge and interior habitat	■	■	■	■	▒	▒	■	▒	▒	▒	■	■	■	▒	■	▒	■	■	■	▒	■	▒
Decreased connectivity and width within the corridor and to associated ecosystems	■	■	■	■	▒	■	■	▒	▒	▒	■	■	■	■	■	■	■	■	■	■	▒	▒
Decreased movement of flora and fauna species for seasonal migration, dispersal, and population	■	■	■	■	■	■	■	▒	▒	▒	■	■	■	■	■	■	■	■	■	■	▒	▒
Increase of opportunistic species, predators, and parasites	■	■	■	▒	▒	■	■	▒	▒	■	▒	■	▒	■	■	■	▒	▒	▒	▒	■	■
Increased exposure to solar radiation, weather, and temperature extremes	■	■	■	■	■	▒	■	■	▒	▒	■	■	■	■	▒	■	■	■	■	▒	■	▒
Magnified temperature and moisture extremes throughout the corridor	■	▒	▒	▒	▒	▒	■	■	▒	▒	■	■	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒
Loss of riparian vegetation	■	■	■	■	■	■	■	■	▒	▒	▒	■	■	■	■	■	■	■	▒	■	■	▒
Decreased source of instream shade, detritus, food, and cover	■	■	■	■	■	▒	■	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	■	▒	▒	■	▒
Loss of vegetative composition, structure, and height diversity	■	■	■	▒	■	▒	■	▒	■	▒	■	■	■	▒	■	▒	■	■	▒	▒	▒	▒
Increased water temperature	■	■	■	■	■	■	■	▒	▒	▒	■	■	▒	▒	▒	▒	■	■	▒	▒	■	▒
Impaired aquatic habitat diversity	■	■	■	■	■	■	■	▒	■	■	■	■	▒	▒	■	▒	■	■	▒	▒	■	■
Reduced invertebrate population in stream	■	■	■	■	■	■	■	▒	■	■	■	■	▒	▒	■	▒	■	■	▒	▒	■	■
Loss of associated wetland function including water storage, sediment trapping, recharge, and habitat	▒	■	▒	■	■	■	■	▒	■	▒	■	■	■	▒	■	▒	■	■	■	▒	▒	▒
Reduced instream oxygen concentration	■	■	■	■	■	■	■	▒	▒	▒	■	■	▒	▒	▒	▒	■	■	▒	▒	■	■
Invasion of exotic species	■	■	■	■	■	▒	■	▒	▒	▒	▒	■	▒	▒	■	▒	■	▒	▒	▒	▒	■
Reduced gene pool of native species for dispersal and colonization	■	■	■	■	■	▒	■	▒	▒	▒	▒	■	▒	▒	■	▒	■	▒	▒	▒	■	▒
Reduced species diversity and biomass	■	■	■	■	■	▒	■	■	■	▒	■	■	▒	▒	■	▒	■	▒	▒	▒	■	▒

Disturbance Activities

■ Activity has potential for direct impact. ▒ Activity has potential for indirect impact.

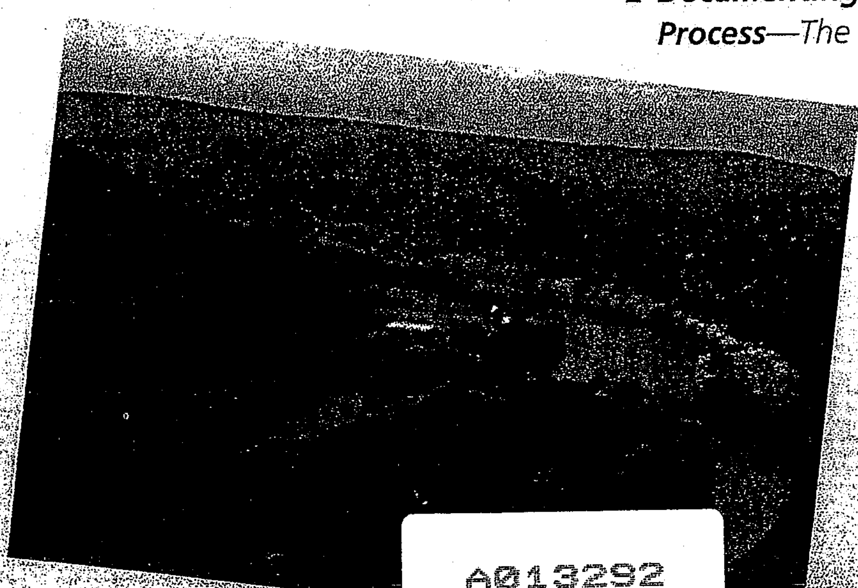
Part II

Developing A Restoration Plan

Developing a Stream Corridor Restoration Plan

A well conceived and developed stream corridor restoration plan is critical to any restoration effort. The restoration plan establishes a framework for documenting the processes, forms, and functions operating within the corridor, identifying disturbances that disrupt or eliminate those functions, and planning and implementing restoration activities. The restoration plan essentially serves as the cornerstone of the restoration effort by achieving several key functions.

- ***Problem Solving Framework****—The restoration plan establishes a framework for addressing critical stream corridor restoration issues, problems, and needs. As such, it prevents disjointed decision-making and facilitates the organization of restoration activities.*
- ***Documenting the Results of the Process****—The restoration plan serves as a record of all subsequent activities by outlining the restoration process. As a result, the plan enables*



the transfer of "lessons learned" to other groups undertaking restoration efforts and helps legitimize the restoration process.

- **Communication and Outreach**—The restoration plan serves to communicate the elements of the corridor restoration process to the public and other interested parties. It also serves an important symbolic function in that it represents the common vision of multiple partners.

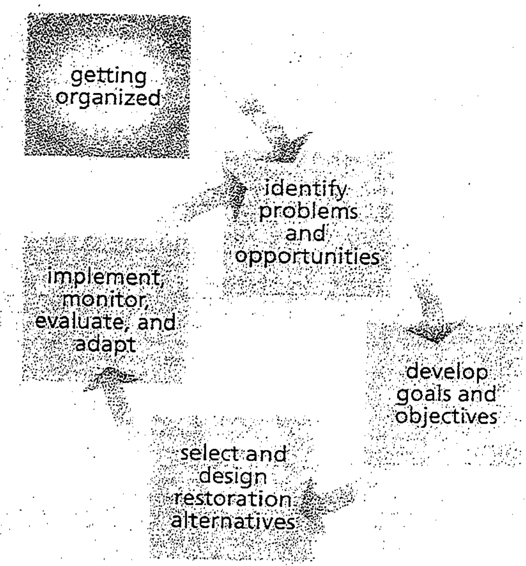
The overall objective of the restoration plan will differ depending on local needs and objectives. Each corridor restoration initiative has unique ecological, social, and economic conditions that dictate activities to meet specific needs and changing circumstances. Despite these differences, the restoration plan should emphasize the ecological integrity of the stream corridor.

The restoration plan should emphasize the maintenance and restoration of the ecological integrity and the dynamic stability of the stream corridor by focusing on multiple scales, functions, and values.

A Note About Scope

Although the concepts presented in these chapters are appropriate for all restoration initiatives, the organizational structure can be simplified for smaller restorations.

Not all restorations are complex or costly. Some may be as simple as a slight change in the way that resources are managed in and along the stream corridor involving only minor costs. Other restoration initiatives, however, may require substantial funds because of the complexity and extent of the measures needed to achieve the planned restoration goals.



The Stream Corridor Restoration Plan Development Process

In recognition of the diversity of restoration plan objectives, Part II of the document focuses on identifying and explaining a general restoration plan development process that each initiative should follow. This process is characterized as a decision-making process composed of several steps (see illustration). These fundamental steps include: getting organized; identifying problems and opportunities; developing goals and objectives; selecting and designing restoration alternatives; and implementation, monitoring, evaluation, and adaptation.

Each of these steps can be integrated into any program- or agency-specific restoration planning process. In addition, these steps

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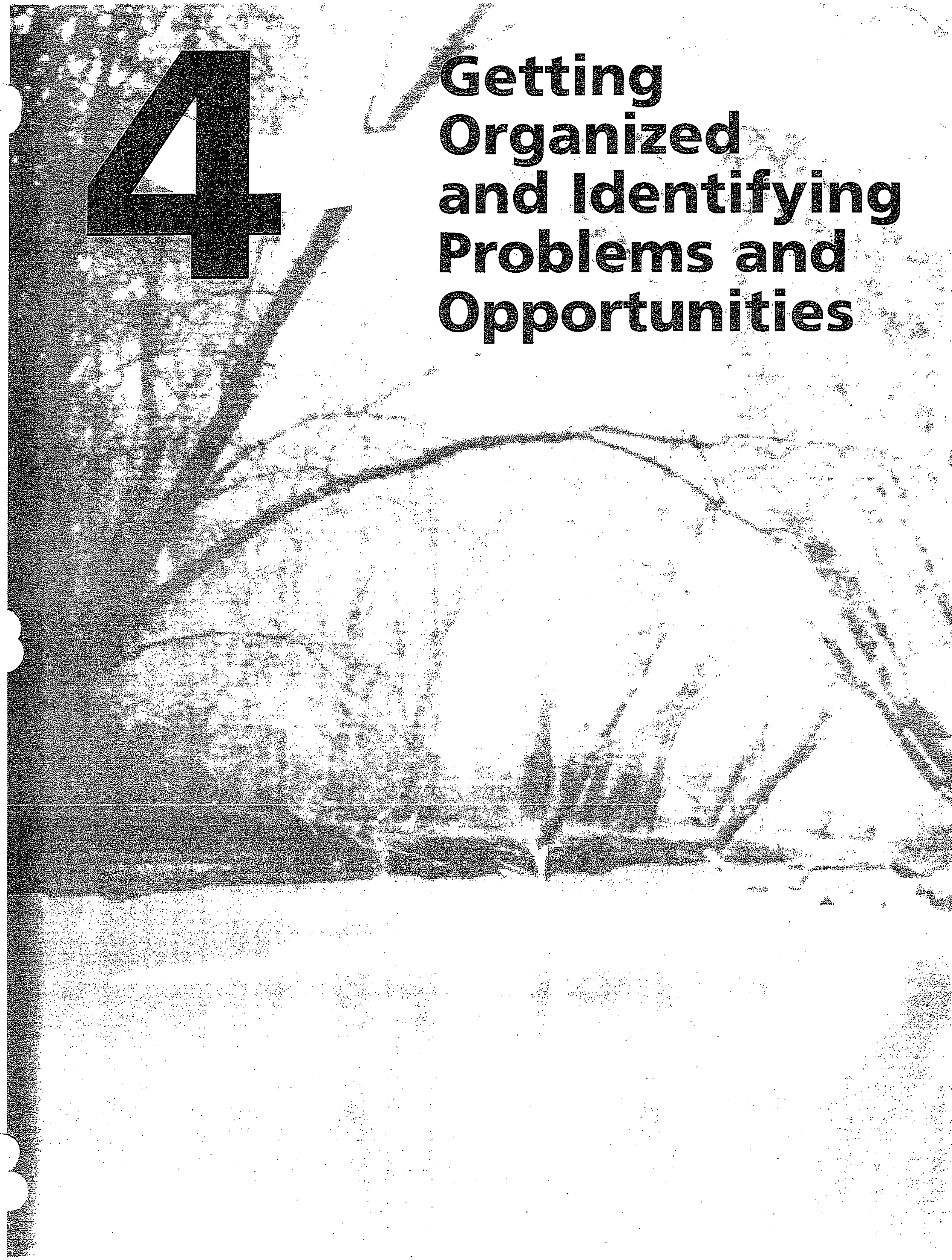
should not be viewed as sequential, but iterative in nature. Many of the fundamental steps may be repeated or may occur simultaneously. In addition, the process, which is based on the philosophy of adaptive management, should be flexible enough to adjust management actions and directions in light of new information about the corridor and about progress toward restoration objectives.

Part II consists of three chapters and is organized in accordance with the fundamental steps of the restoration plan development process.

- ***Chapter 4** introduces the first two steps of plan development. The first portion of the chapter focuses on the basics of getting organized and presents key steps that should be undertaken to initiate the restoration process. The remainder of the chapter centers on problem/opportunity identification and introduces the basics of stream corridor condition analysis and problem assessment.*
- ***Chapter 5** presents information concerning how restoration goals and objectives are identified and how alternatives are designed and selected.*
- ***Chapter 6** concludes with a discussion of implementation of restoration as well as monitoring and evaluation.*



4 Getting Organized and Identifying Problems and Opportunities

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4.A Getting Organized

- *Why is planning important?*
- *Is an Advisory Group needed?*
- *How is an Advisory Group formed?*
- *Who should be on an Advisory Group?*
- *How can funding be identified and acquired?*
- *How are technical teams established and what are their roles?*
- *What procedures should an Advisory Group follow?*
- *How is communication facilitated among affected stakeholders?*

4.B Problem and Opportunity Identification

- *Why is it important to spend resources on the problem ("When everyone already knows what the problem is")?*
- *How can the anthropogenic changes that caused the need for the restoration initiative be altered or removed?*
- *How are data collection and analysis procedures organized?*
- *How are problems affecting the stream corridor identified?*
- *How are reference conditions for the stream corridor determined?*
- *Why are reference conditions needed?*
- *How are existing management activities influencing the stream corridor?*
- *How are problems affecting the stream corridor described?*

4 Getting Organized and Identifying Problems and Opportunities

The impetus for a restoration initiative may come from several sources. The realization that a problem or opportunity exists in a stream corridor may warrant community action and any number of interested groups, and individuals may be actively involved in recognizing the situation and initiating the restoration effort. Federal or state agencies may be designated to undertake a corridor restoration effort as a result of a legislative mandate or an internal agency directive. Citizen groups or groups with special cultural or economic interests in the corridor (e.g., native tribes, sport fishermen) may also initiate a restoration effort. Still others might undertake stream corridor restoration as part of a broad-based cooperative initiative that draws from various funding sources and addresses a diversity of interests and objectives.

Accompanying the recognition of the situation and initiation of the restoration effort is the initial proposal of "the solution." This almost instantaneous leap from problem/opportunity recognition to the identification of the initial "solution" occurs during the formative stage of nearly every initiative involving water and multiple landowners. This instantaneous leap might not always address the true causes of the problem or identified opportunity and therefore might not result in a *successful restoration initiative. Projects that come through a logical process of plan development tend to be more successful.*

Regardless of the origins of the restoration initiative or the introduction of the proposed "solution," it is essential that the focus of the leadership for the restoration planning process be at the local level; i.e., the people who are pushing for action, who own the land, who are affected, who might benefit, who can make decisions, or who can lead. With this local leadership in place, a logical, iterative restoration plan development process can be undertaken. Often, this approach will involve going back to the identification of the problem or opportunity and realizing that the situation is not as simple as initially perceived and needs further definition and refinement.

This chapter concentrates on the two initial steps of stream corridor restoration plan development—getting organized and problem/opportunity identification. The chapter is divided into two sections and includes a discussion of the core components of each of these initial steps.

Section 4.A: Getting Organized

This section outlines some of the organizational considerations that should be taken into account when conducting stream corridor restoration.

Section 4.B: Problem and Opportunity Identification

Once some of the organizational logistics have been settled, the disturbances affecting the stream corridor ecosystem and the resulting problems/opportunities need to be identified. Section B outlines the core components of the problem/opportunity identification process. One of the most common mistakes made in planning restorations is the failure to characterize the nature of the problems to be solved and when, where, and exactly how they affect the stream corridor.

4A Getting Organized

This section presents the key components of organizing and initiating the development of a stream corridor restoration plan and establishing a planning and management framework to facilitate communication among all involved and interested parties. Ensuring the involvement of all partners and beginning to secure their commitment to the project is a central aspect of "getting organized" and undertaking a restoration initiative. (See Chapter 6 for detailed information on securing commitments.) It is often helpful to identify a common motivation for taking action and also to develop a rough outline of restoration goals. In addition, defining the scale of the corridor restoration initiative is important. Often the issues to be addressed require that restoration be considered on a watershed or whole-reach basis, rather than by an individual jurisdiction or one or two landholders.

Setting Boundaries

Geographical boundaries provide a spatial context for technical assessment and a sense of place for organizing community-based involvement. An established set of project boundaries streamlines the process of gathering, organizing, and depicting information for decision making.

When boundaries are selected, the area should reflect relevant ecological processes. The boundaries may also reflect the various scales at which ecological processes influence stream corridors (see Chapter 5, *Identifying Scale Considerations*). For example, matters affecting the conservation of biodiversity tend to play out at broader, more regional scales. On the other hand, the quality of drinking water is usually more of a basin-specific or local-scale issue.

In setting boundaries, two other factors are equally as important. One is the nature of human-induced disturbance, including the magnitude of its impact on stream corridors. The other factor is the social organization of people, including where opportunities for action are distributed across the landscape.

The challenge of establishing useful boundaries is met by conceptually superimposing the three selection factors. One effective way of starting this process is through the identification, by public forum or other free and open means, of a stream reach or aquatic resource area that is particularly valued by the community. The scoping process would continue by having resource managers or landowners define the geographical area that contributes to both the function and condition of the valued site or sites. Those boundaries

FAST FORWARD

REVERSE

Review Chapter 1. Preview Chapter 5's Identifying Scale Considerations.

Core Components of Getting Organized

- *Setting boundaries*
- *Forming an advisory group*
- *Establishing technical teams*
- *Identifying funding sources*
- *Establishing points of contact and a decision structure*
- *Facilitating involvement and information sharing among participants*
- *Documenting the process*

would then be further adjusted to reflect community interests and goals.

Forming an Advisory Group

Central to the development of a stream corridor restoration plan is the formation of an *advisory group* (Figure 4.1). An advisory group is defined as a collection of key participants, including private citizens, public interest groups, economic interests, public officials, and any other groups or individuals who are interested in or might be affected by the restoration initiative. Grassroots citizen groups comprise multiple interests that hopefully share a stated common concern for environmental conservation. Such broad-based participation helps ensure that self-interest or agency agendas do not drive the process from the top down. Local citizens should be enlisted and informed to the extent that their values and preferences drive decision making with technical guidance from agency participants.

orming an advisory group is n effective nd efficient vay to plan nd manage he restoration effort, although not all estoration decision makers vill choose to establish one.

Figure 4.1: ***Advisory group meeting.*** *The advisory group, composed of a variety of community interests, plays an active role in advising the decision maker(s) throughout the restoration process.*
Source: S. Ratcliffe. Reprinted by permission.

The advisory group generally meets for the following purposes:

- Carrying out restoration planning activities.
- Coordinating plan implementation.
- Identifying the public's interest in the restoration effort.
- Making diverse viewpoints and objectives known to decision makers.
- Ensuring that local values are taken into account during the restoration process.

The point to remember is that the true role of the advisory group is to advise the *decision maker* or *sponsor*—the agency(s), organization(s), or individual(s) leading and initiating the restoration effort—on the development of the restoration plan and execution of restoration activities. Although the advisory group will play an active planning and coordinating role, it will not make the final decisions. As a result, it is important that all members of the advisory group understand the issues, develop practical and well thought-out recommendations, and achieve consensus in support of their recommendations.

Typically, it is the responsibility of the decision maker(s) to identify and organize the members of the advisory group. Critical to this process is the identification of the key participants. Participants can be identified by making announcements to the news media, writing to interested organizations, making public appearances, or directly contacting potential partners.

The exact number of groups or individuals that will compose the advisory group is difficult to determine and is usually situation-specific. In general, it is important that the group not be so small that it is not representative of all interests. Exclusion of certain community interests can undermine the legitimacy of or even halt the restoration initiative. Conversely, a large group might include so many interests that organization and consensus building become unmanageable. Include a balance of representative interests such as the following:

- Private citizens
- Public interest groups
- Public officials
- Economic interests

It is important to note that while forming an advisory group is an effective and efficient way to plan and manage the restoration effort, not all restoration decision makers will choose to establish one. There might be cases where a landowner or small group of landowners elect to take on all of the responsibilities of the advisory group in addition to playing a leadership or decision-making role.

Regardless of the number of individuals involved, it is important for all project participants (and funders) to note at this early stage that the usual duration of projects is 2 to 3 years. There are no guarantees that every project will be a success, and in some cases a project may fail simply due to lack of time to allow nature to "heal itself" and restoration methods to take effect. All participants must be reminded up front to set realistic expectations for the project and for themselves.

Establishing Technical Teams

Planning and implementing restoration work requires a high level of knowledge, skill, and ability, as well as professional judgment. Often, the advisory group will find it necessary to establish special technical teams, or subcommittees, to provide more information on a particular issue or subject.

In general, interdisciplinary technical teams should be organized to draw upon the knowledge and skills of different agencies, organizations, and individuals. These teams can provide continuity as well as important information and insight from varied disciplines, experiences, and backgrounds.

The expertise of an experienced multidisciplinary team is essential. No single text, manual, or training course can provide the technical background and judgment needed to plan, design, and implement stream corridor restoration. A team with a broad technical background is needed and should include expertise in both engineering and biological disciplines, particularly in aquatic and terrestrial ecology, hydrology, hydraulics, geomorphology, and sediment transport.

Team members should represent interagency, public, and private interests and include major partners, especially if they are sharing costs or work on the restoration initiative. Team makeup is based on the type of task the team is assembled to undertake. Members of the technical teams can also be members of the advisory committee or even the decision-making body.

Some of the technical teams that could be formed to assist in the restoration initiative will have responsibilities such as these:

- Soliciting financial support for the restoration work.
- Coordinating public outreach.
- Providing scientific support for the restoration work. This support may encompass anything from conducting the baseline condition analysis to designing and implementing restoration measures and monitoring.

CASE STUDY

Lower Missouri River Coordinated Resource Management Efforts in Northeast Montana

The Lower Missouri River Coordinated Resource Management (CRM) Council is an outgrowth of the Lower Fort Peck Missouri River Development Group, which was formed in September 1990 as a result of an irrigation and rural development meeting held in Poplar, Montana. The meeting was held to determine the degree of interest in economic and irrigation development along the Missouri River below Fort Peck Dam.

A major blockade to development seemed to be the erosion problems along the river. The Roosevelt County Conservation District and other local leaders decided that before developing irrigation along the river, streambank erosion needed to be addressed.

*The large fluctuation of the water being released from Missouri River dams is causing changes in the downstream river dynamics, channel, and streambanks. Before the dams, the river carried a sediment load based on the time of the year and flow event. Under natural conditions, a river system matures and tries to be in equilibrium by transporting and depositing sediment. Today, below the dams, the water is much cleaner because the sediment has settled behind the dams (**Figure 4.2**). The clean water releases have changed the river system from what it was prior to the dams. The clean water now picks up sediment in the river and attacks the streambanks, while trying to reach equilibrium. These probable causes and a river system out of equilibrium could be part of the cause of the river erosion.*

***Figure 4.2: Lower Missouri River.** Water released from dams is causing downstream erosion.*

Leaders in the group are politically active, traveling to Washington, D.C., and meeting with congressional delegates and the US Army Corps of Engineers (USACE) to secure funding to address streambank erosion. As a result of the trips to Washington, $3 million was appropriated and transferred to the USACE for streambank erosion abatement. However, efforts to agree on a mutually beneficial solution continued to delay the progress. The USACE had completed an economic analysis of the area, and the only viable alternative it could offer was sloughing easements. This would do little to save the valuable soils along the Missouri River.

The group seemed to be at a stalemate. In July 1994, then Chief of the Natural Resources Conservation Service (NRCS), Paul Johnson, met with the members of the Lower Fort Peck Missouri River Development Group, local landowners, surrounding Conservation District members, NRCS field office staff, and Bill Miller, Project Manager for the Omaha District of the USACE, at an erosion site along the Missouri River. After sharing of ideas and information, Chief Johnson suggested that a Coordinated Resource Management (CRM) group be formed to resolve the sensitive issues surrounding the erosion and other problems of the river. He instructed local and state NRCS staff to provide technical assistance to the CRM group. The group followed Chief Johnson's idea, and the Lower Missouri River CRM Council was formed. This has helped those involved in solving the problems to overcome many of the stumbling blocks with which they were being confronted. Some of these successes include:

- *Through the CRM Council the $3 million transferred to the USACE was used to try some new innovative erosion solutions on a site in Montana and one in North Dakota. The group helped the USACE to select the site. NRCS assisted in the design and implementation. For the first time in this area, materials such as hay bales, willow cuttings, and log revetments were used.*
- *An interagency meeting and tour of erosion sites was sponsored by the CRM Council in September of 1996. In addition to local producers, CRM Council members, NRCS state and national staff, USACE staff, researchers from the USDA Agricultural Research Service (ARS) National Sedimentation Laboratory of Oxford, Mississippi, attended the session. The group agreed that the erosion problem needed to be studied further. The NRCS, USACE, and ARS have been doing studies on the River System below Fort Peck Dam since the 1996 meeting. A final report on the research is planned for summer of 1998.*
- *The CRM Council has been surveying producers along the river to determine what they perceive to be their major problems. This helps the group to stay in tune with current problems.*
- *The CRM Council contracted with a group of Montana State University senior students from the Film and TV Curriculum to develop an informational video about the Missouri River and its resources. This project has been completed, and the video will be used to show legislators and others what the problems and resources along the river are.*

The group has been successful because of the CRM process. The process takes much effort by all involved, but it does work.

CASE STUDY

Watershed Planning Through a Coordinated Resource Management Planning Process

The American River watershed, located in the Sierra Nevada Mountains of California, comprises 963 square miles. It is an important source of water for the region. The watershed also supports a diversity of habitats from grassland at lower elevations, transitioning to chaparral and to hardwood forest, and eventually to coniferous forest at upper elevations. In addition, the watershed is a recreational and tourist destination for the adjacent foothill communities like the greater Sacramento metropolitan area and the San Francisco Bay area.

Urban development is rapidly expanding in the watershed, particularly at lower elevations. This additional development is challenging environmental managers in the watershed and stressing the natural resources of the area. In 1996, the Placer County Resource Conservation District (PCRCD) spearheaded a multi-interest effort to address watershed concerns within the American River watershed. Due to the range of issues to be addressed, they sought to involve representatives from various municipalities, environmental and recreational groups, fire districts, ranchers, and state and federal agencies. The group established a broad goal "to enhance forest health and the overall condition of the watershed," as well as a set of specific goals that include the following:

- *Actively involve the community and be responsive to its needs.*
- *Optimize citizen initiative to manage fuels on private property to enhance forest and watershed.*
- *Restore hydrologic and vegetative characteristics of altered meadows and riparian areas.*
- *Create and sustain diverse habitats supporting diverse species.*
- *Ensure adequate ground cover to prevent siltation of waterways.*
- *Reduce erosion from roads and improvements.*
- *Prevent and correct pollution discharges before they adversely affect water quality.*
- *Reduce excessive growths of fire-dependent brush species.*
- *Increase water retention and water yield of the watershed.*
- *Optimize and sustain native freshwater species.*

Because of past conflicts and competing interests among members of the group, a Memorandum of Understanding (MOU) was prepared to develop a cooperative framework within which the various experts and interest groups could participate in natural resource management of the watershed. The signatories jointly committed to find common ground from which to work. The first step was to establish "future desired conditions" that will meet the needs of all the signatories as well as the local landowners and the public.

By including all of the signatories in the prioritization of implementation actions, PCRCD continues to keep the watershed planning process moving forward. In addition, PCRCD has encouraged the development of a small core group of landowners, agency representatives, and environmental organizations to determine how specific actions will be implemented. Several projects that incorporate holistic ecosystem management and land stewardship principles to achieve measurable improvements within the watershed are already under way.

- Investigating sensitive legal, economic, or cultural issues that might influence the restoration effort.
- Facilitating the restoration planning, design, and implementation process outlined in this document.

It is important to note that technical expertise often plays an important role in the success of restoration work. For example, a restoration initiative might involve resource management or land use considerations that are controversial or involve complex cultural and social issues. An initiative might address issues like western grazing practices or water rights and require the restriction of certain activities, such as timber or mineral extraction, certain farming and grazing practices, or recreation (**Figure 4.3**). In these cases, involving persons who have the appropriate expertise on regulatory programs, as well as social, political, and legal issues, can prevent derailment of the restoration effort.

Perhaps the most important benefit of establishing technical teams, however, is that the advisory group and decision makers will have the necessary information to develop restoration objectives. The advisory group will be able to integrate the knowledge gained from the analysis of what is affecting stream corridor structure and functions with the information on the social, political, and economic factors operative within the stream corridor. Essentially, the advisory group will be able to help define a thorough set of restoration objectives.

Identifying Funding Sources

Identifying funding sources is often an early and vital step toward an effective stream restoration initiative. The funding needed may be minimal or substantial, and it may come from a variety of sources. Funding may come from state or federal sources that have recognized the need for restoration due to the efforts of local citizens' groups. Funding may come from counties or any entity that has taxing authority. Philanthropic organizations, nongovernmental organizations, landowners' associations, and voluntary contributions are other funding sources. Regardless of the source of funds, the funding agent (sponsor) will almost certainly influence restoration decisions or act as the leader and decision maker in the restoration effort.

Interdisciplinary Nature of Stream Corridor Restoration

The complex nature of stream corridor restoration requires that any restoration initiative be approached from an interdisciplinary perspective. Specialists from a variety of disciplines are needed to provide both the advisory group and sponsor with valuable insight on scientific, social, political, and economic issues that might affect the restoration effort. The following is a list of some of the professionals who can provide important input for this interdisciplinary effort:

- *Foresters*
- *Legal consultants*
- *Botanists*
- *Microbiologists*
- *Engineers*
- *Hydrologists*
- *Economists*
- *Geomorphologists*
- *Archaeologists*
- *Sociologists*
- *Soil scientists*
- *Rangeland specialists*
- *Landscape architects*
- *Fish and wildlife biologists*
- *Public involvement specialists*
- *Real estate experts*
- *Ecologists*
- *Native Americans and Tribal Leaders*

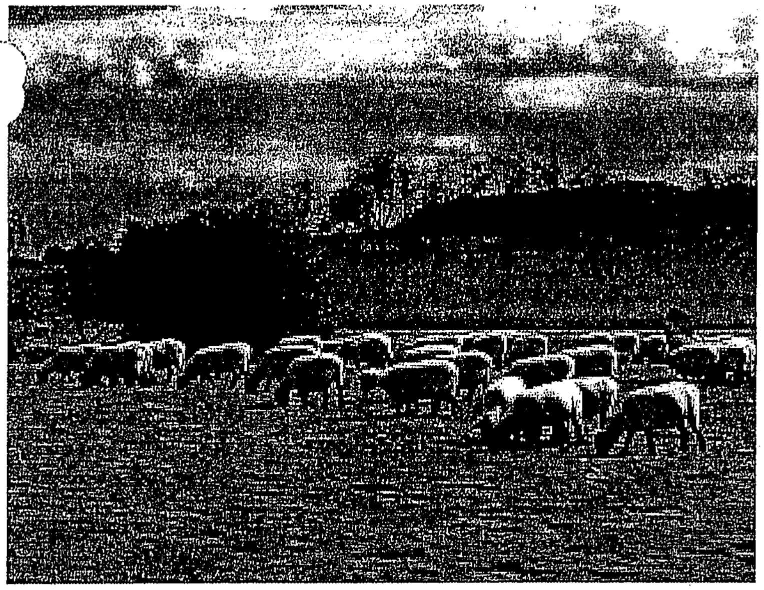


Figure 4.3: Livestock grazing. Technical teams can be helpful in addressing controversial and complex issues that have the potential to influence the acceptance and success of a restoration initiative.

Establishing a Decision Structure and Points of Contact

Once the advisory group and relevant technical teams have been formed, it is important to develop a decision-making structure (**Figure 4.4**) and to establish clear points of contact.

As noted earlier, the advisory group will play an active planning and coordinating role, but it will not make the final decisions. The primary decision-making authority should reside in the hands of the stakeholders. The advisory group, however, will play a strong role by providing recommendations and informing the decision maker(s) of various restoration options and the opinions of the various participants.

It is important to note that the decision maker, as well as the advisory group, may be composed of a collection of interests and organizations. Consequently, both entities should establish some basic protocols to facilitate decision making and communication. Within each group some of the following rules of thumb might be helpful:

- Select officers
- Establish ground rules
- Establish a planning budget
- Appoint technical teams

In conjunction with establishing a decision structure, the sponsor, advisory group, and relevant subcommittees need to establish points of contact. These points of contact should be people who are accessible and possess strong outreach and communication skills. Points of contact play an important role in the restoration process by facilitating communication among the various groups and partners.

Facilitating Involvement and Information Sharing Among Participants

It is important that every effort be made to include all interested parties throughout the duration of the restoration process. Solicit input from participants and keep all interested parties informed of the plan development, including uncertainties associated with a particular solution, approach, or management prescription and what must be involved in modifying and adapting them as the need arises. In other words, it is important to operate under the principles of both information giving and information receiving.

Receiving Input from Restoration Participants

In terms of information receiving, a special effort should be made to directly contact landowners, resource users, and other interested parties to ask them to participate in the planning process. Typically, these groups or indi-

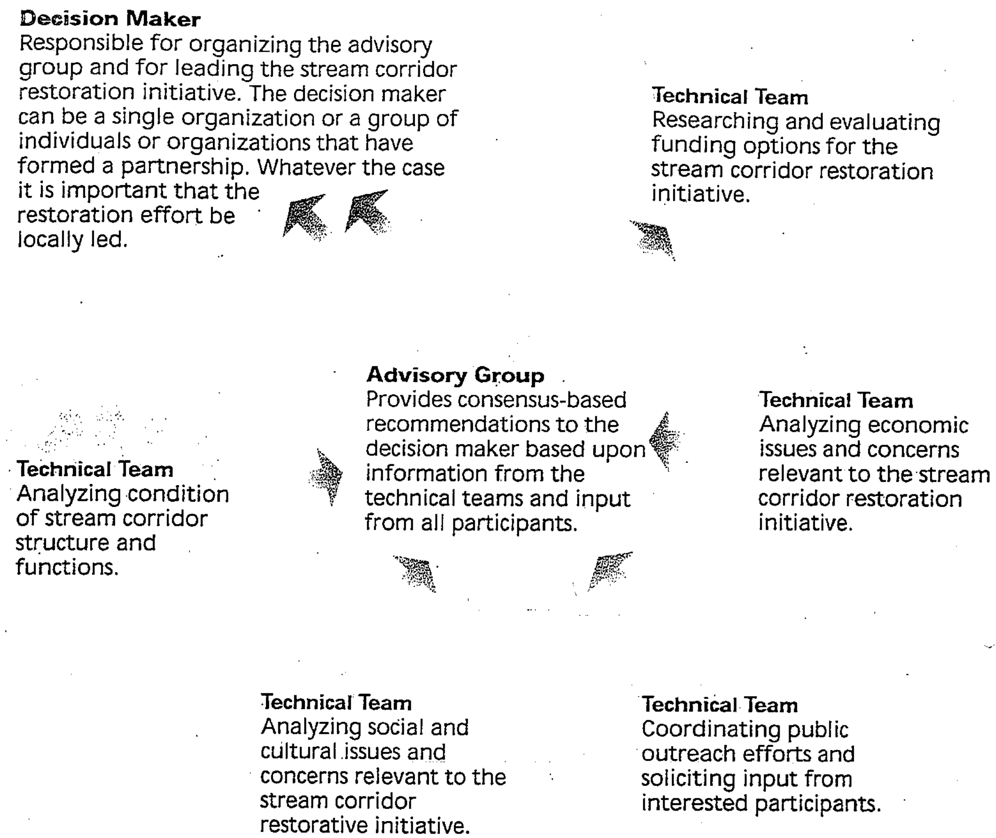


Figure 4.4: Flow of communication. *Restoration plan development requires a decision structure that streamlines communication between the decision maker, the advisory group, and the various technical teams.*

viduals will have some personal interest in the condition of the stream corridor and associated ecosystems in their region. A failure to provide them the opportunity to review and comment on stream corridor restoration plans will often result in objections later in the process.

Private landowners, in particular, often have the greatest personal stake in the restoration work. As part of the restoration effort it might be necessary for private landowners to place some of their assets at increased risk, make them more available for public use, or reduce the economic return they provide (e.g., restricting grazing in riparian areas or increasing buffer widths between agricultural fields and drainage channels). Thus, it is in the best interest of the restoration initiative to include these persons as decision makers.

A variety of public outreach tools can be useful in soliciting input from participants. Some of the most common mechanisms include public meetings, workshops, and surveys. *Tools for Facilitating Participant Involvement and Information Sharing During the Restoration Process*, provides a more complete list of potential outreach options.

Informing Participants Throughout the Restoration Process

In addition to actively seeking input from participants, it is important that the sponsor(s) and the advisory group regularly inform the public of the status of the restoration effort. The restoration initiative can also be viewed as a strong educational resource for the entire community. Some effective ways to communicate this information and to provide educational opportunities include newsletters, fact sheets, seminars, and brochures. A more complete list of potential outreach tools is provided in the box *Tools for Facilitating Participant Involvement and Information Sharing During the Restoration Process.*

It is important to note that the educational opportunities associated with information giving can help support restoration initiatives. For example, in cases that require the implementation of costly management prescriptions, outreach tools can be effective in improving landowner awareness of ways in which risks and losses can be offset, such as incentive programs (e.g., Conservation Reserve Program) or cost-sharing projects (e.g., Section 319 of the Clean Water Act). In these cases, the most effective approach might be for the representative landowners serving on the decision-making team to be responsible for conducting this outreach to their constituents.

In addition, educational outreach can also be viewed as an opportunity to demonstrate the anticipated benefits of restoration work, on both regional and local levels. One of the most effective ways to accomplish this is with periodic public field days involving visits to the restoration corridor, as well as pilot demonstration sites, model farms, and similar examples of restoration actions planned.

Finally, wherever possible, information on the effectiveness and lessons learned from restoration work should be made available to persons interested in carrying out restoration work elsewhere. Most large restoration initiatives will require relatively detailed documentation of design and performance, but this information is usually not widely distributed. Summaries of restoration experiences can be published in any of a variety of technical journals, newsletters, bulletins, Internet Web sites, or other media and can be valuable to the success of future restoration initiatives.

Tools for Facilitating Participant Involvement and Information Sharing During the Restoration Process

Tools for Receiving Input

- *Public Hearings*
- *Task Forces*
- *Training Seminars*
- *Surveys*
- *Focus Groups*
- *Workshops*
- *Interviews*
- *Review Groups*
- *Referendums*
- *Phone-in Radio Programs*
- *Internet Web Sites*

Tools for Informing Participants

- *Public Meetings*
- *Internet Web Sites*
- *Fact Sheets*
- *News Releases*
- *Newsletters*
- *Brochures*
- *Radio or TV Programs or Announcements*
- *Telephone Hotlines*
- *Report Summaries*
- Federal Register

Selecting Tools for Facilitating Information Sharing and Participant Involvement

Although a variety of outreach tools can be used to inform participants and solicit input, attention should be paid to selecting the best tool at the most appropriate time. In making this selection, it is helpful to consider the stage of the restoration process as well as the outreach objectives.

For example, if a restoration initiative is in the early planning stages, providing community members with background information through a newsletter or news release might be effective in bringing interested parties to the table and in generating support for the initiative (Figures 4.5 and 4.6). Conversely, once the planning process is well under way and restoration alternatives are being selected, a public hearing may be a useful mechanism for receiving input on the desirability of the various options under consideration (Figure 4.7).


CBF NEWS

Oyster Plan Falls Short on Conservation

Rockfish Rebound Affirms Management Controls

Figure 4.5: Chesapeake Bay Foundation newsletter. *Newsletters can be an effective way to communicate the status of restoration efforts to the community.*

Some additional factors that should be taken into account in selecting outreach tools include the following:

- Strengths and weaknesses of individual techniques.
- Cost, time, and personnel required for implementation.
- Receptivity of the community.

Again, no matter what tools are selected, it is important to make an effort to solicit input from participants as well as to keep all interested parties informed of plan developments. The Interagency Ecosystem Management Task Force (1995) provides the following suggestion for a combination of techniques that can be used to facilitate participant involvement and information sharing:

- Regular newsletters or information sheets apprising people of plans and progress.
- Regularly scheduled meetings of landowner and citizen groups.
- Public hearings.
- Field trips and workdays on project sites for volunteers and interested parties.

In addition, the innovative communication possibilities afforded by the Internet and the World Wide Web cannot be ignored.

FAST FORWARD

Preview Chapter 6's Developing a Monitoring Plan.

Documenting the Process

The final element of getting organized involves the documentation of the various activities being undertaken as part of the stream corridor restoration effort. Although the restoration plan, when completed, will ultimately document the results of the restoration process, it is also important to keep track of activities as they occur.

An effective way to identify important restoration issues and activities as well as keep track of those activities is through the use of a "restoration checklist" (National Research Council, 1992). The checklist can be maintained by the advisory group or sponsor and used to engage project stakeholders and to inform them of the progress of restoration efforts. The checklist can serve as an effective guide through the remaining components of restoration plan development and project implementation. In addition, a draft version of *Developing a Monitoring Plan* (see Chapter 6) should be prepared as part of planning data collection.

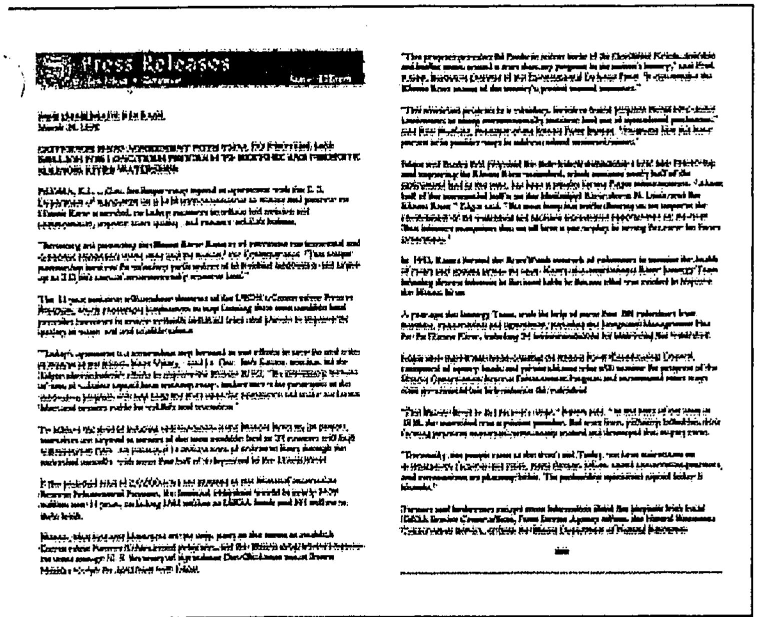

Press Releases

Figure 4.6: Regional restoration news releases. *A news release is an effective tool for informing the community of the planning of the restoration initiative.*
Source: State of Illinois.

Figure 4.7: Local public hearing. *Public hearings are a good way to solicit public input on restoration options.*
Source: S. Ratcliffe. Reprinted by permission.

Restoration Checklist (Adapted from National Research Council 1992)

During Planning...

- ❑ Have all potential participants been informed of the restoration initiative?
- ❑ Has an advisory committee been established?
- ❑ Have funding sources been identified?
- ❑ Has a decision structure been developed and points of contact identified?
- ❑ Have steps been taken to ensure that participants are included in the restoration processes?
- ❑ Has the problem that requires treatment been investigated and defined?
- ❑ Has consensus been reached on the mission of the restoration initiative?
- ❑ Have restoration goals and objectives been identified by all participants in the restoration effort?
- ❑ Has the restoration been planned with adequate scope and expertise?
- ❑ Has the restoration plan had an annual or mid-course correction point in line with adaptive management procedures?
- ❑ Have the indicators of stream corridor structure and function been directly and appropriately linked to the restoration objectives?
- ❑ Have adequate monitoring, surveillance, management, and maintenance programs been specified as an integral part of the restoration plan? Have monitoring costs and operational details been integrated so that results will be available to serve as input in improving techniques used in the restoration work?
- ❑ Has an appropriate reference system (or systems) been selected from which to extract target values of performance indicators for comparison in conducting the evaluation of the restoration initiative?
- ❑ Have sufficient baseline data been collected over a suitable period of time on the stream corridor and associated ecosystems to facilitate before-and-after treatment comparisons?
- ❑ Have critical restoration procedures been tested on a small experimental scale to minimize the risks of failure?
- ❑ Has the length of a monitoring program been established that is sufficiently long to determine whether the restoration work is effective?
- ❑ Have risk and uncertainty been adequately considered in planning?
- ❑ Have alternative designs been formulated?
- ❑ Have cost-effectiveness and incremental cost of alternatives been evaluated?

During Project Implementation and Management...

- ❑ Based on the monitoring result, are the anticipated intermediate objectives being achieved? If not, are appropriate steps being taken to correct the problem(s)?
- ❑ Do the objectives or performance indicators need to be modified? If so, what changes might be required in the monitoring program?
- ❑ Is the monitoring program adequate?

During Postrestoration...

- ❑ To what extent were restoration plan objectives achieved?
- ❑ How similar in structure and function is the restored corridor ecosystem to the reference ecosystem?
- ❑ To what extent is the restored corridor self-sustaining (or will be), and what are the maintenance requirements?
- ❑ If all stream corridor structure and functions were not restored, have the critical structure and functions been restored?
- ❑ How long did the restoration initiative take?
- ❑ What lessons have been learned from this effort?
- ❑ Have those lessons been shared with interested parties to maximize the potential for technology transfer?
- ❑ What was the final cost, in net present value terms, of the restoration work?
- ❑ What were the ecological, economic, and social benefits realized by the restoration initiative?
- ❑ How cost-effective was the restoration initiative?
- ❑ Would another approach to restoration have produced desirable results at lower cost?

4B Problem and Opportunity Identification

Preview Chapter 7's Data Collection and Analysis Methods sections.

Development of stream corridor restoration objectives is preceded by an analysis of resource conditions in the corridor. It is also preceded by the formulation of a problem/opportunity statement that identifies conditions to be improved through and benefit from restoration activities. Although problem/opportunity identification can be very difficult, in terms of measurable stream corridor conditions, it is the single most important step in the development of the restoration plan and in the restoration process. This section focuses on the six steps of the problem/opportunity identification process that are critical to any stream corridor restoration initiative.

The Six Steps of the Problem/ Opportunity Identification Process

1. *Data collection and analysis*
2. *Definition of existing stream corridor conditions (structure and function) and causes of disturbance*
3. *Comparison of existing conditions to desired conditions or a reference condition*
4. *Analysis of the causes (disturbances) of altered or impaired stream corridor conditions*
5. *Determination of how management practices might be affecting stream corridor structure and functions*
6. *Development of problem and opportunity statements*

Data Collection and Analysis

Data collection and analysis are important to all aspects of decision making and are conducted throughout the duration of the restoration process. The same data and analytic techniques are often applied to, and are important components of, problem/opportunity identification; goal formulation; alternative selection; and design, implementation, and monitoring. Data collection and analysis, however, begin with problem/opportunity identification. They are integral to defining existing stream corridor and reference conditions, identifying causes of impairment, and developing problem/opportunity statements. Data collection and analysis should be viewed as the first step in this process.

Data Collection

Data collection should begin with a technical team, in consultation with the advisory group and the decision maker, identifying potential data needs based on technical and institutional requirements. The perspective of the public should then be solicited from participants or through public input forums. Data targeted for collection should generally provide information on both the historical and baseline conditions of stream corridor structure and functions, as well as the social, cultural, and economic conditions of the corridor and the larger watershed.

Data are collected with the help of a variety of techniques, including remote sensing, historical maps and photographs, and actual resource inventory using standardized on-site field techniques, evaluation models, and other recognized and widely accepted methodologies. Community mapping (drawing areas of importance to the community or individuals) is becoming a popular method of involving the public and children in restoration initiatives. This technique can solicit information not accessible to traditional survey or data collection techniques and it also makes the data collection process accessible to the public. Additional data collection and analysis methods are discussed in Part III, Chapter 7.

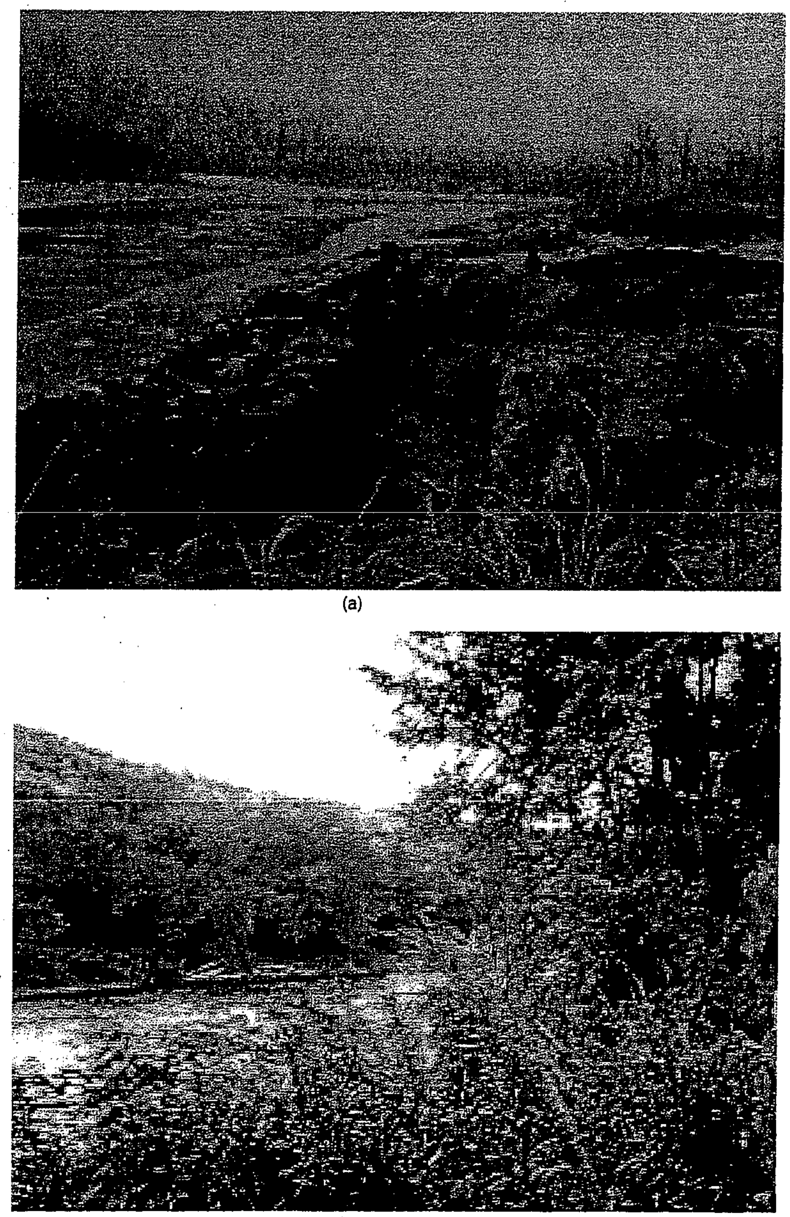
Collecting Baseline Data

Restoration work should not be attempted without having knowledge of existing stream corridor conditions. In fact, it is impossible to determine goals and objectives without this basic information. As a result, it is important to collect and analyze information that provides an accurate account of existing conditions. Due to the dynamic nature of hydrologic systems, a range of conditions need to be monitored. Ultimately, these *baseline data* will provide a point from which to compare and measure future changes.

Baseline data consist of the existing structure and functions of the stream corridor and surrounding ecosystems across scales, as well as the associated disturbance factors. These data, when compared to a desired reference condition (derived from either existing conditions elsewhere in the corridor or historical conditions), are important in determining cumulative effects on the stream corridor's structure and functions (i.e., hydrologic, geomorphic, habitat, etc.). Baseline data collection efforts should include information needed to determine associated problems and opportunities to be addressed in later design and implementation stages of the restoration process.

Collecting Historical Data

As described in earlier chapters, stream corridors change over time in response to ongoing natural or human-induced processes and disturbances. It is important to identify historical conditions and activities to understand the present stream corridor condition (**Figure 4.8**).



(a)

(b)

Figure 4.8: The Winooski River (a) in the 1930s and (b) at the same location in the 1990s. *Using photographs is one way to identify the historical condition of the corridor.*

Part of collecting *historical data* is collecting background information on the requirements of the species and ecosystems of concern. Historical data should also include processes that occurred at the site. The historic description may also be used to establish target conditions, or the reference condition, for restoration. Often the goal of restoration will not be to return a corridor to a pristine, or pre-European settlement, condition. However, by understanding this condition, valuable knowledge is gained for making decisions on restoring and sustaining a state of dynamic equilibrium.

In terms of gathering historical data, emphasis should be placed on understanding changes in land use, channel planform, cover type, and other physical conditions. Historical data, such as maps and photographs, should be reviewed and long-time residents interviewed to determine changes to the stream corridor and associated ecosystems. Major human-induced or natural disturbances, such as land clearing, floods, fires, and channelization, should also be considered. These data will be critical in understanding present conditions, identifying a reference condition, and determining future trends.

Collecting Social, Cultural, and Economic Data

In addition to physical, chemical, and biological data, it is also important to gather data on the social, cultural, and economic conditions in the area. These data more often than not will drive the overall restoration effort, delimit its scale, determine its citizen and landowner acceptance, determine ability to coordinate and communicate, and generally decide overall stability and capability to maintain and manage. In addition, these data are likely to be of most interest to participants and should be collected with their assistance to avoid derailment or alteration of the restoration effort due to misconceptions and misinformation.

Properly designed surveys of social attitudes, values, and perceptions can also be valuable tools both to assess the changes needed to accomplish the restoration goals and to determine changes in these intangible values over time, throughout the planning process, and after implementation.

Prioritizing Data Collection

Although data on both the historical and baseline conditions related to ecosystem structure and functions and social, cultural, and economic values are important, it is not always practical to collect all of the available information. Budgets and technical limitations often place constraints on the amount and types of data that can be collected. It is therefore important for the technical team, advisory group, and decision maker to prioritize the data needed.

At a minimum, the data necessary to explain the mechanisms or processes that affect stream corridor conditions need to be collected. To illustrate the challenges of data prioritization, consider the example of identifying data for assessing habitat functions. Potential habitat data could include items such as the extent of impacted fish, wildlife, and other biota; ecological aspects; biological characteristics of soils and water; vegetation (both native and nonnative); and relationships among ecological considerations (**Figure 4.9**). Depending on the scope of the restoration plan, however, data for all of these elements might not be necessary to successfully accomplish restoration. This holds especially true for smaller restoration efforts in limited stream reaches.

An effective way to prioritize data collection is through a scoping process designed to determine those data which are critical to decision making. The scoping process identifies significant concerns by institutional recognition (laws, policies, rules, and regulations), public recognition (public concern and local perceptions), or technical recognition (standards, criteria, and procedures).

Data Analysis

Data analysis, like data collection, plays an important role in all elements of problem identification as well as other aspects of the restoration process. Data analysis techniques range from qualitative evaluations using professional judgment to elaborate computer models.

The scope and complexity of the restoration effort, along with the budget, will influence the type of analytical techniques selected. A wealth of techniques are discussed in the literature and various manuals and will not be listed in this document. Part I, however, provides examples of the types of processes and functions that need to be analyzed. In addition, Part III discusses some analytical techniques used for condition analysis and restoration design, offers some analytic methodologies, and provides additional references.

Existing Stream Corridor Structure, Functions, and Disturbances

The second step in problem identification and analysis is determining which stream corridor conditions best characterize the existing situation. Corridor structure, functions, and associated disturbances used to describe the existing condition of the stream corridor will be determined on a case-by-case basis. Just as human health is indexed by such parameters as blood pressure and body temperature, the condition of a stream corridor must be indexed by an appropriate suite of measurable attributes.

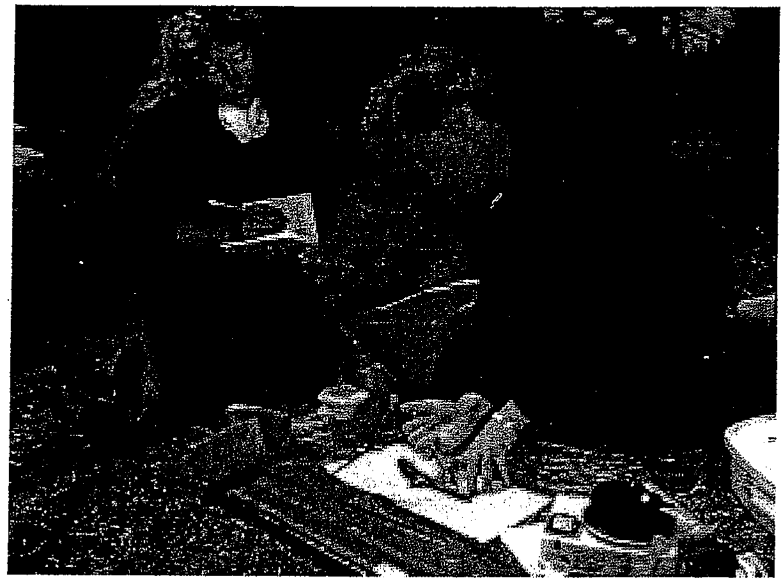


Figure 4.9: Characterizing stream corridor conditions. *Data collection and analysis are important components of problem identification.*

There are no hard-and-fast rules about which attributes are most useful in characterizing the condition of stream corridor structure and functions. However, as a starting point, consideration should be given to describing present conditions associated with the following eight components of the corridor:

- Hydrology
- Erosion and sediment yield
- Floodplain/riparian vegetation
- Channel processes
- Connectivity
- Water quality
- Aquatic and riparian species and critical habitats
- Corridor dimension

Since the ultimate goal is to establish restoration objectives in terms of the structure and functions of the stream corridor, it is useful to characterize those attributes which either measure or index the eventual attainment of the desired ecological condition. Some measurable attributes that might be useful for describing the above components of a stream corridor are listed in the box *Measurable Attributes for Describing Conditions in the Stream Corridor*. Detailed guidance for quantifying many of the following attributes is either described or referenced elsewhere in this document.

Existing vs. Desired Structure and Functions: The Reference Condition

The third step in problem identification and analysis is to define the conditions within which the stream corridor problems and opportunities will be defined and restoration objectives established. It is helpful to describe how the present baseline conditions of the stream corridor compare to a *reference condition* that represents, as closely as possible, the desired outcome of restoration (**Figure 4.10**). The reference condition might be similar to what the stream corridor would have been like had it remained relatively stable. It might represent a condition less ideal than the pristine, but substantially improved from the present condition. Developing a set of reference conditions might not be an easy task, but it is essential to conducting a good problem/opportunity analysis.

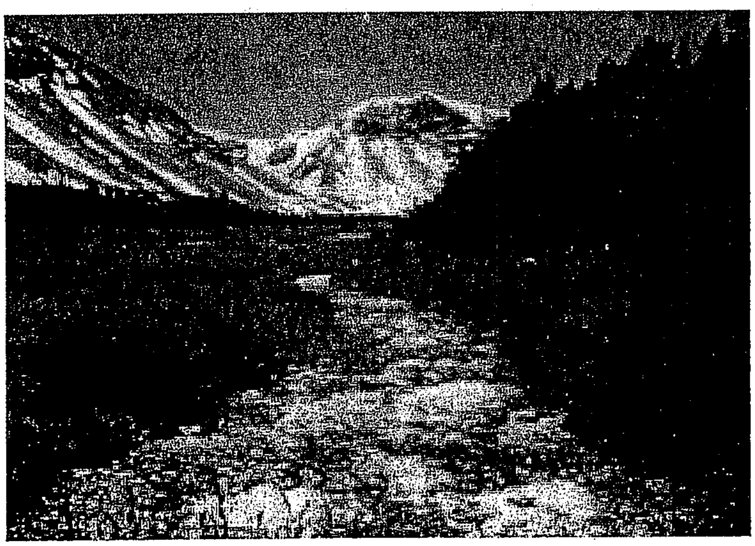


Figure 4.10: Example reference condition in the western United States. *A reference condition may be similar to what the corridor would have been like in a state of relative "dynamic equilibrium."*

Several information sources can be very helpful in defining the reference condition. Published literature might provide information for developing reference conditions. Hydrologic data can often be used to describe natural flow and sediment regimes, and regional hydraulic geometry relations may define reference conditions for channel dimensions, pattern, and profile. Published soil surveys contain soil map-unit descriptions and interpretations reflecting long-term ecological conditions that may be suitable for reference. Species lists of plants and animals (both historical and present) and literature on species habitat needs provide information on distribution of organisms, both by habitat characteristics and by geographic range.

In most cases, however, reference conditions are developed by comparison with *reference reaches* or sites believed to be indicative of the natural potential of the stream corridor. The *reference site* might be the predisturbance condition of the stream to be restored, where such conditions are established by examining relic areas (enclosures, preserves), historical photos, survey notes, and/or other descriptive accounts. Similarly, reference conditions may be developed from nearby stream corridors in similar physiographic settings if those streams are minimally impacted by natural and human-caused disturbances.

Measurable Attributes for Describing Conditions in the Stream Corridor

Hydrology

- *total (annual) discharge*
- *seasonal (monthly) discharge*
- *peak flows*
- *minimum flows*
- *annual flow durations*
- *rainfall records*
- *size and shape of the watershed*

Erosion and Sediment Yield

- *watershed cover and soil health*
- *dominant erosion processes*
- *rates of surface erosion and mass wasting*
- *sediment delivery ratios*
- *channel erosion processes and rates*
- *sediment transport functions*

Floodplain/Riparian Vegetation

- *community type*
- *type distribution*
- *surface cover*
- *canopy*
- *community dynamics and succession*
- *recruitment/reproduction*
- *connectivity*

Channel Processes

- *flow characteristics*
- *channel dimensions, shape, profile, and pattern*
- *substrate composition*
- *floodplain connectivity*
- *evidence of entrenchment and/or deposition*
- *lateral (bank) erosion*
- *floodplain scour*
- *channel avulsions/realignments*
- *meander and braiding processes*
- *depositional features*
- *scour-fill processes*
- *sediment transport class (suspended, bedload)*

Water Quality

- *color*
- *temperature, dissolved oxygen (BOD, COD, and TOC)*
- *suspended sediment*
- *present chemical condition*
- *present macroinvertebrate condition*

Aquatic and Riparian Species and Critical Habitats

- *aquatic species of concern and associated habitats*
- *riparian species of concern and associated habitats*
- *native vs. introduced species*
- *threatened or endangered species*
- *benthic, macroinvertebrate, or vertebrate indicator species*

Corridor Dimension

- *plan view maps*
- *topographic maps*
- *width*
- *linearity, etc.*

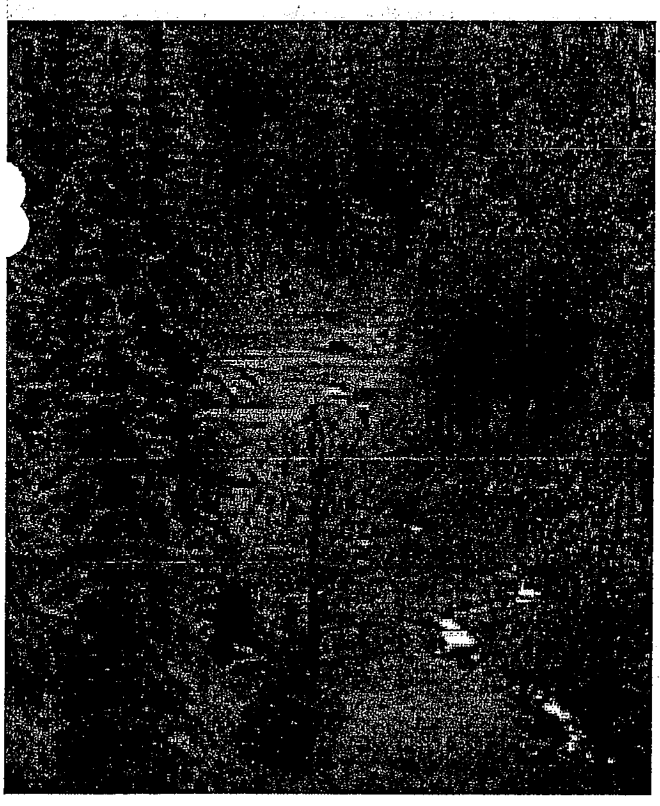
The Condition Continuum

Preview Chapter 7's PFC section.

*One helpful way to conceptualize the relationship between the current and reference conditions is to think of stream corridor conditions as occurring on a "condition continuum." At one end of this continuum, conditions may be categorized as being natural, pristine, or unimpaired by human activities. A headwater wilderness stream could exist near this end of the continuum (**Figure 4.11**). At the other end of the continuum, stream corridor conditions may be considered severely altered or impaired. Streams at this end of the continuum could be totally "trashed" streams or completely channelized water conduits.*

In concept, present conditions in the stream corridor exist somewhere along this condition continuum. The condition objective for stream restoration from an ecological perspective should be as close to the dynamic equilibrium as possible. It should be noted, however, that once other important considerations, such as political, economic, and social values, are introduced during the establishment of restoration goals and objectives, the target may shift to restoring the stream to some condition that lies between the present situation and dynamic equilibrium.

The proper functioning condition (PFC) concept is used as a minimum target in western riparian areas and can be the basis on which to plan additional enhancements (Pritchard et al. 1993, rev. 1995).



(a)

(b)

***Figure 4.11: Condition continuum.** The condition continuum runs from (a) untouched by humans to (b) severely impaired.*
Source: L. Goldman.

Causes of Altered or Impaired Conditions

Conditions that provide the impetus for stream corridor restoration activities include degraded stream channel conditions and degraded habitat. A thorough analysis of the cause or causes of these alterations or impairments is fundamental to identifying management opportunities and constraints and to defining realistic and attainable restoration objectives.

As discussed in Chapter 3, for every stream corridor structural attribute and function that is altered or impaired, there may be a causal chain of events responsible for the impairment. As a result, when conducting a problem analysis, it is useful to consider factors that affect stream corridor ecological condition at different levels or scales:

- Landscape
- Stream corridor and reach

Landscape Factors Affecting Stream Corridor Condition

When analyzing landscape-scale factors that contribute to existing stream corridor conditions, disturbances that result in changes in water and sediment delivery to the stream and in sources of contamination should be considered. In alluvial stream corridors, for example, anything that changes the historical balance between delivery of sediment to the channel and sediment-transport capacity of the stream will elicit a change in channel conditions. When sediment deliveries increase relative to sediment-transport capacities, stream aggradation usually occurs; when sediment-transport capacities increase relative to sediment delivery, stream incision usually occurs. How the channel responds to changes in flow and sediment regime depends on the magnitude of change in runoff and sediment and the type of sediment load being transported by the stream—suspended sediment or bedload.

The analysis of watershed effects on channels is aided by the use of standard hydrologic, hydraulic, and sediment transport tools. Depending on the available data, results may range from highly precise to quantitative. Altered flow regimes, for example, might be readily discernible if the stream has a long-term gauge record. Otherwise, numerical runoff modeling techniques might be needed to place an approximate magnitude on the

Common Impaired or Degraded Stream Corridor Conditions

The following list provides some examples of impaired stream corridor conditions. A more complete list of these effects is provided in Chapter 3.

- *Stream aggradation—filling (rise in bed elevation over time)*
- *Stream degradation—incision (drop in bed elevation over time)*
- *Streambank erosion*
- *Impaired aquatic habitat*
- *Impaired riparian habitat*
- *Impaired terrestrial habitat*
- *Loss of gene pool of native species*
- *Increased peak flood elevation*
- *Increased bank failure*
- *Lower water table levels*
- *Increase of fine sediment in the corridor*
- *Decrease of species diversity*
- *Impaired water quality*
- *Altered hydrology*

Accelerated Bank Erosion: The Importance of Understanding a Causal Chain of Events

*To illustrate the concept of a causal chain of events, consider the problem of accelerated bank erosion (**Figure 4.12**). Often the cause of accelerated bank erosion might be attributed to increases in peak runoff or sediment delivery to a stream when a surrounding watershed is undergoing land use changes; to the loss of bank vegetation, which also increases the vulnerability of the bank to erosion; or to structures in the stream (e.g., bridge abutments) that redirect the water flow into the bank. In this case, determining that bank erosion has increased relative to some reference rate is central to the identification of an impaired condition. In addition, understanding the cause or causes of the increased erosion is a key step in effective problem analysis. It is critical to the solution of the problem that this understanding be factored into the development of restoration objectives and management alternatives.*

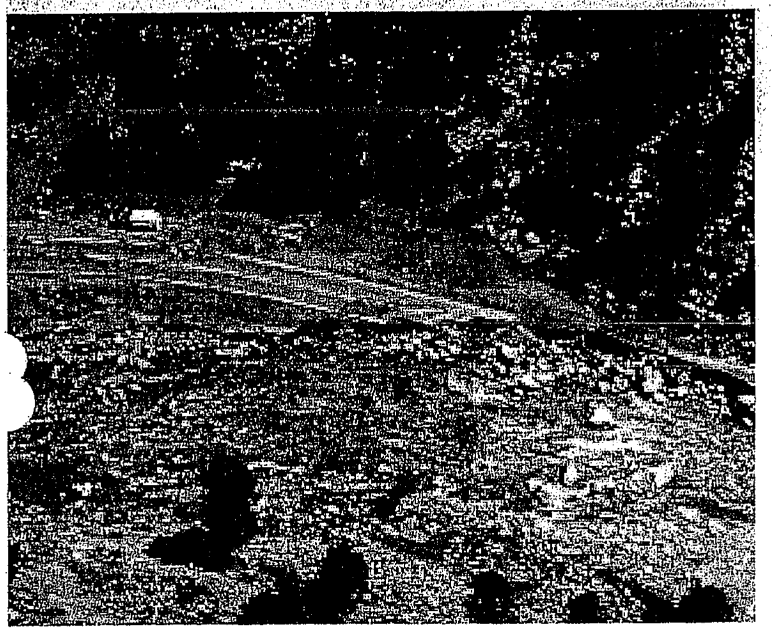


***Figure 4.12: Bank erosion.** The cause(s) of bank erosion should be identified.*

change in peak flows resulting from a change in land use conditions. Water developments such as storage reservoirs and diversions also must be factored into an analysis of altered watershed hydrology (**Figure 4.13**).

The effects of altered land use on sediment delivery to streams may be assessed using various analytical and empirical tools. These are discussed in Chapters 7 and 8. However, these tools should be used with some caution unless they have been verified and calibrated with actual instream sediment sampling data or measured reservoir sedimentation rates.

The stream channel itself might provide some clues as to whether it is experiencing an increase or decrease in sediment delivery from the watershed relative to sediment-transport capacity. Special attention should be paid to channel capacities and depositional features such as sand or gravel bars. If flooding seems to be more frequent, it might be an indication that aggradation is occurring. Conversely, if there is evidence of channel entrenchment, such as exposed bridge pier or abutment footings, degradation is occurring. Similarly, if the number and size of gravel bars are significantly different from what is evident in historical photos, for example, the difference might be an indication that either aggradation or erosion has been enhanced. Care is needed when using the channel to interpret possible changes in watershed conditions since similar channel symptoms can also be caused by changes in conditions within the stream corridor itself or by natural variation of the hydrograph.

Stream Corridor and Reach Factors Affecting Stream Corridor Conditions

In addition to watershed factors affecting stream corridor conditions, it is important to consider disturbances at the stream corridor and reach scales. In general, stream corridor structural attributes and functions are greatly affected by several important categories of activities if they occur within the corridor. Chapter 3 explores these in more detail; the following are some of the activities that commonly impact corridor structure and function.

- Activities that alter or remove streambank and riparian vegetation (e.g., grazing, agriculture, logging, and urbanization), resulting in changes in the stability of streambanks, runoff and transport of contaminants, water quality, or habitat characteristics of riparian zones (**Figure 4.14**).
- Activities that physically alter the morphology of channels, banks, and riparian zones, resulting in effects such as the displacement of aquatic and riparian habitat and the disruption of the flow of energy and materials (e.g., channelization, levee construction, gravel mining, and access trails).
- Instream modifications that alter channel shape and dimensions, flow hydraulics, sediment-transport characteristics, aquatic habitat, and water quality (e.g., dams and grade stabilization measures, bank riprap, logs, bridge piers, and habitat "enhancement" measures) (**Figure 4.15**). In the case of logs, it might be the loss of such structures rather than their addition that alters flow hydraulics and channel structure.

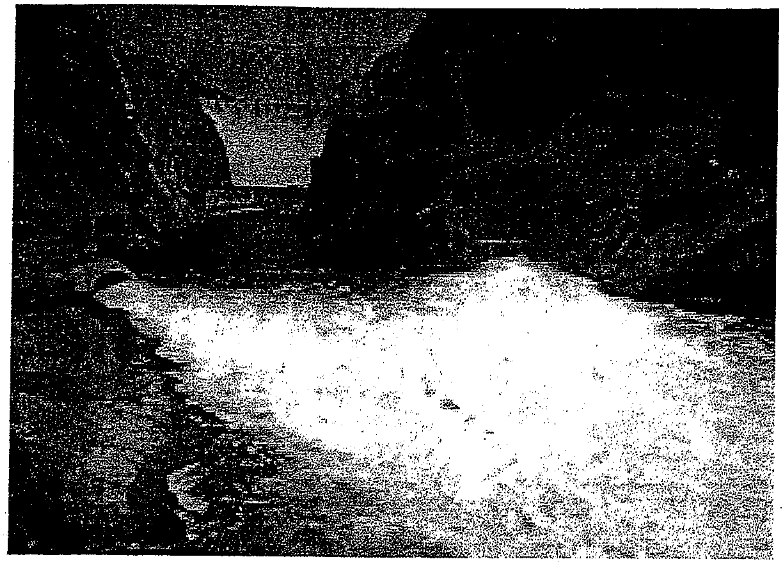


Figure 4.13: Water releases below a dam. *Altering the flow regime of river below Hoover Dam altered the stream condition.*

Altered riparian vegetation and physical modification of channels and floodplains are primary causes of impaired stream corridor structure and functions because their effects are both profound and direct. Addressing the causes of these changes might offer the best, most feasible opportunities for restoring stream corridors. However, the altered vegetation and physical modifications also may create some of the most significant challenges for stream corridor restoration by constraining the number or type of possible solutions.

FAST FORWARD

Preview Chapters 7 and 8, Analytical and Empirical Tools section.

It is important to remember that there are no simple analytical methods available for analyzing relationships

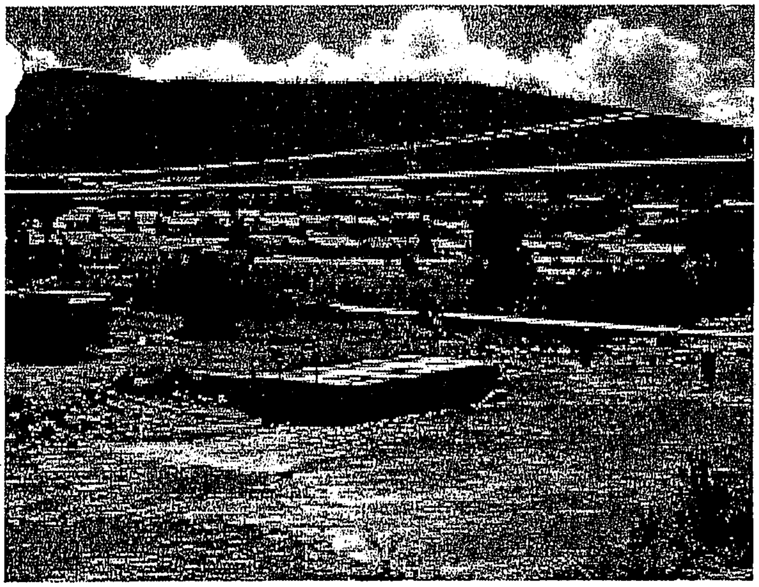


Figure 4.14: Residential development. Urbanization can severely impair conditions critical for riparian vegetation by increasing impervious surfaces.

between activities or events potentially disturbing the stream corridor and the structure and functions defining the corridor. However, there are modes by which stream corridor activities and structures can affect ecological conditions that involve both direct and indirect impacts. The box *Examples of How Activities Occurring Within the Corridor Can Affect Structure and Functions* provides some examples of the modes by which activities can affect stream corridor structure and functions.

Preview Chapter 7's Quantitative Tools section.

In conducting the problem analysis, it is important to investigate the various modes of ecological interaction at the reach and system scales. The analysis might need to be subjective and deductive, in which case use of an interdisciplinary team is essential. In other cases, the analysis might be enhanced by application of available hydrologic, hydraulic, sedimentation, water quality, or habitat models.

Whatever the situation, it is likely that the analysis will require site-specific application of ecological principles aided by a few quantitative tools. It will rarely be possible to determine causative factors for resource impairment using uninterpreted results from off-the-shelf analytical models. Part III, Chapter 7, contains a detailed discussion of some of the quantitative tools available to assist in the analysis of the resource conditions within the stream corridor ecosystem.

Determination of Management Influence on Stream Corridor Conditions

Once the conditions have been identified and the causes of those conditions described, the key remaining question is whether the causative factors are a function of and responsive to management. Specific management factors that contribute to impairment might or might not have been identified with the causes of impairment previously identified.

Figure 4.15: Riparian vegetation and structure. The loss of logs in a stream alters flow hydraulics and channel structure.

To illustrate, consider again the example of increased bank erosion. An initial analysis of impaired conditions might identify causes such as land uses in the watershed that are yielding higher flows and sediment loads, loss of streambank vegetation, or redirection of flow from instream modifications. None of these, however, identify the role of management influences. For example, if higher water and sediment yields are a function of improper grazing management, the problem might be mitigated simply by altering grazing practices.

The ability to identify management influences becomes critical when identifying alternatives for restoration. Description of past management influences may prevent the repetition of previous mistakes and should facilitate prediction of future system response for evaluating alternatives. Recognition of management influences also is important for predicting the effectiveness of mitigation and the feasibility of specific treatments. Identifying the role of management is a key consideration when evaluating the ability of the stream corridor to heal itself (e.g., without management, with management, with management plus additional treatments). The identification of past management, both in the watershed and in the stream corridor, and its influence on those factors causing impairment will therefore help to sharpen the focus of the restoration effort.

Localized Impacts Affecting the Stream Corridor

Spatial considerations in stream corridor restoration are usually discussed at the landscape, corridor, and stream scales (e.g., connections to other systems, minimum widths, or maximum edge concerns). However, the critical failures in corridor systems can often occur at the reach scale, where a single break in continuity or other weakness can have a domino effect on the entire corridor. Just as uncontrolled watershed degradation can doom stream corridor restoration effectiveness, so can specific sites where critical problems exist that can prevent the whole corridor from functioning effectively.

Examples of weaknesses or problems at the reach scale that might affect the whole corridor are wide-ranging. Barriers to fish passage, lack of appropriate shade and resultant loss of water temperature moderation, breaks in terrestrial migration lands, or narrow points that make some animals particularly vulnerable to predators can often alter conditions elsewhere in the corridor. In addition, other sites might be direct or indirect source areas for problems, such as headcuts or rapidly eroding banks that contribute excessive sediment to the stream and instability to the system, or locations with populations of noxious exotic plant species that can spread to other parts of the corridor system. Some site-specific land use problems can also have critical impacts on corridor integrity, including chronic damage from grazing livestock, irrigation water returns, and uncontrolled storm water outflows.

Problem or Opportunity Statements for Stream Corridor Restoration

The final step in the process of problem/opportunity identification and analysis is development of concise statements to drive the restoration effort. *Problem/opportunity statements* not only serve as a general focus for the restoration effort but also become the basis for developing specific restoration objectives. Moreover, they form the basis for determining success or failure of the restoration initiative. Problem/opportunity statements are therefore critical for design of a relevant monitoring approach.

Examples of How Activities Occurring Within the Corridor Can Affect Structure and Functions

- *Direct disturbance or displacement of aquatic and/or riparian species or habitats*
- *Indirect disturbance associated with altered stream hydraulics and sediment transport capacity*
- *Indirect disturbance associated with altered channel and riparian zone sedimentation dynamics*
- *Indirect disturbance associated with altered surface water-ground water exchanges*
- *Indirect disturbance associated with chemical discharges and altered water quality*

For maximum effectiveness, these statements should usually have the following two characteristics:

- They describe impaired stream corridor conditions that are explicitly stated in measurable units and can be related to specific processes within the stream corridor.
- They describe deviation from the desired reference condition (dynamic equilibrium) or proper functioning condition for each impaired condition.

CASE STUDY Bluewater Creek

The watershed analysis and subsequent treatments performed at Bluewater Creek, New Mexico, demonstrate successful watershed and stream corridor restoration. Although most of the work has taken place on federal land, the intermixing of private lands and the values and needs of the varied publics concerned with the watershed make it a valuable case study. The project, begun in 1984, has a record of progress and improved land management. The watershed received the 1997 Chief's Stewardship Award from the Chief of the Forest Service and continues to host numerous studies and research projects.

Located in the Zuni mountains of north-central New Mexico, Bluewater Creek drains a 52,042-acre watershed that enters Bluewater Lake, a 2,350-acre reservoir in the East Rio San Jose watershed. Bluewater Creek and Lake provide the only opportunity to fish for trout and other coldwater species and offer a unique opportunity for water-based recreation in an otherwise arid part of New Mexico.

The watershed has a lengthy history of complex land uses. Between 1890 and 1940, extensive logging using narrow-gauge railroad technology cut over much of the watershed. Extensive grazing of livestock, uncontrolled fires, and some mining activity also occurred. Following logging by private enterprises, large portions of the watershed were sold to the USDA Forest Service in the early 1940s. Grazing, some logging, extensive roading, and increased recreational use continued in the watershed. The Mt. Taylor Ranger District of the Cibola National Forest now manages 86 percent of the watershed, with significant private holdings (12.5 percent) and limited parcels owned by the state of New Mexico and Native Americans.

In the early 1980s, local citizens worked with the Soil Conservation Service (now Natural Resources Conservation Service) to begin a Resource Conservation and Development (RC&D) project to protect water quality in the stream and lake as well as limit lake sedimentation harming irrigation and recreation opportunities. Although the RC&D project did not develop, the Forest Service, as the major land manager in the watershed, conducted a thorough analysis on the lands it managed and implemented a restoration initiative and monitoring that continue to this day.

The effort has been based on five goals: (1) reduce flood peaks and prolong baseflows, (2) reduce soil loss and resultant downstream channel and lake sedimentation, (3) increase fish and wildlife productivity, (4) improve timber and range productivity, and (5) demonstrate proper watershed analysis and treatment methods. Also important is close adherence to a variety of legal requirements to preserve the environmental and cultural values of the watershed, particularly addressing the needs of threatened, endangered, and sensitive plant and animal species; preserving the rich cultural history of the area; and complying with requirements of the Clean Water Act.

*For analysis purposes, the watershed was divided into 13 subwatersheds and further stratified based on vegetation, geology, and slope. Analysis of data gathered measuring ground cover transects and channel analysis from August 1984 through July 1985 resulted in eight major conclusions: (1) areas forested with mixed conifer and ponderosa pine species were generally able to handle rainfall and snowmelt runoff; (2) excessive peak flows, as well as normal flows continually undercut steep channel banks, causing large volumes of bank material to enter the stream and lake system; (3) most perennial and intermittent channels were lacking the riparian vegetation they needed to maintain streambank integrity; (4) most watersheds had an excessive number of roads (**Figure 4.16**); (5) trails caused by livestock, particularly cattle, concentrate runoff into small streams and erodible areas; (6) several key watersheds suffered from livestock overuse and improper grazing management systems; (7) some instances of timber management practices were exacerbating watershed problems;*

Figure 4.16: Vehicle traffic through wet meadow in Bluewater Creek, NM. *(May 1984.) Such traffic compacts and damages soil, changes flow patterns, and induces gully erosion.*

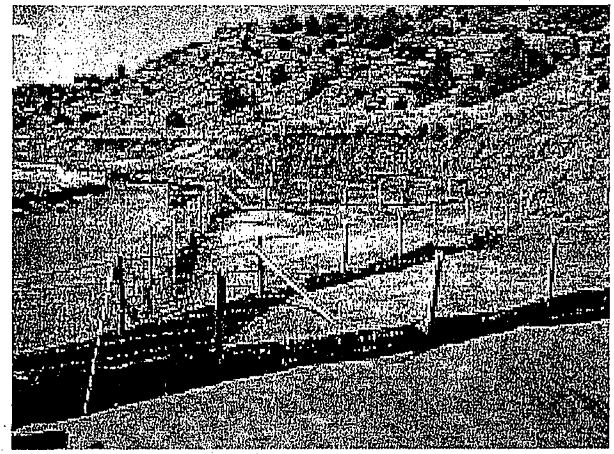


Figure 4.17: Recently installed treatment. *(April 1987.) Porous fence revetment designed to reduce bank failure.*

Figure 4.18: Porous fence revetment aided by bank sloping. *(August 1987.) The photo shows initial revegetation during first growing season following treatment installation.*

and (8) excessive runoff in some subwatersheds continued to degrade the main channel.

*Based on the conclusions of the analysis, a broad range of treatments were prescribed and implemented. Some were active (e.g., construction of particular works or projects); others were more passive (e.g., adjustments to grazing strategies). Channel treatments such as small dams, gully headcut control structures, grade control structures, porous fence revetments (**Figures 4.17, 4.18, and 4.19**), and channel crossings (**Figure 4.20**) were used to affect flow regimes, channel stability, and water quality. Riparian plantings, riparian pastures, and beaver management programs were also established, and meander reestablishment and channel relocation were conducted. Land treatments, such as the establishment of best management practices (BMPs) for livestock, timber, roads, and fish and wildlife, were developed to prevent soil loss and maintain site productivity.*

In a few cases, land and channel treatments were implemented simultaneously (e.g., livestock drift fences and seasonal area closures). Additional attention was paid to improved road management practices, and unnecessary roads were closed.

Results of the project have largely met its goals, and the watershed is more productive and enjoyable for a broad range of goods, services, and values. Although one weakness of the project was the lack of a carefully designed monitoring and

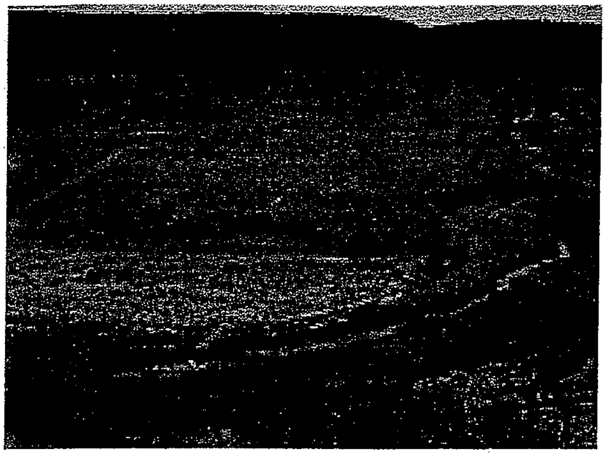


Figure 4.19: Porous fence revetments after two growing seasons. *(September 1988.) Vegetation is noticeably established over first growing season.*

Figure 4.20: Multiple elevated culvert array at crossing of wet meadow. *(June 1997.) The culvert spreads flow and decreases erosion energy, captures sediment upstream, reduces flood peaks, and prolongs baseflows.*

evaluation plan, observers generally agree that the completed treatments continue to perform their designed function, while additional treatments add to the success of the project.

Most of the small in-channel structures are functioning as designed. The meander reestablishment has lengthened the channel and decreased gradient in a critical reach. The channel relocation project has just completed its first year, and initial results are promising. Beaver have established themselves along the main channel of Bluewater Creek, providing significant habitat for fish and wildlife, as their ponds capture sediment and moderate flood peaks. The watershed now provides a more varied and robust population of fish and wildlife species. Changes in road management have yielded significant results. Road closures have removed traffic from sensitive areas, and reconstruction of two key roads has reduced sediment damages to the stream. Special attention to road crossings of wet meadows has begun to rehabilitate scores of acres dewatered by improper crossings. Range management techniques (e.g., combined allotments, improved fencing, and more modern grazing strategies) are improving watershed condition. A limited timber management program on the federal property has had beneficial impacts on the watershed, but significant timber harvest on private lands provided a cause for concern, particularly regarding compliance with Clean Water Act best management practices.

The local citizens who use the watershed have benefited from the improved conditions. Recreation use continues to climb.

Problem/Opportunity Statements

Problem/Opportunity statements should follow directly from the analysis of existing and reference stream corridor conditions. These statements can be viewed as an articulation of some of the potential benefits that can be realized through restoration of the structure and functions of the stream corridor. For example, problem statements might focus on the impaired structural attributes and functions needing attention, while associated opportunities might focus on reintroduction of native species that were previously eliminated from the system. Problem/Opportunity statements can also focus on the economic benefits of a proposed restoration initiative. By identifying such economic benefits to local landowners, it may be possible to increase the number of private citizens participating in the planning process.

Example problem statement:

Statement	Component
Coarse sediment	Geomorphic Input
from past	Time Frame
mass wasting	Watershed Process
in unit 3	Hillslope Unit Locator
associated with clearcut logging	Activity
on unstable slopes is	Conditions and Modifiers
reducing pools	Channel Effects
on segments 1 and 2	Locator
and degrading summer rearing habitat.	Resource Effects

Example opportunity statements:

- *To prevent streambank erosion and sediment damage and provide quality streamside vegetation through bioengineering techniques—Four Mile Run, Virginia.*
- *To protect approximately 750 linear feet of Sligo Creek through the construction of a parallel pipe system for storm water discharge control—Sligo Creek, Maryland.*
- *To enhance the creek through reconstruction of instream habitat (e.g., pools and riffles)—Pipers Creek, Washington.*
- *To reintroduce nongame fish and salamanders in conjunction with implementing several stream restoration techniques and eliminating point source discharges—Berkeley Campus Creek, California.*

Example statements adapted from Center for Watershed Protection 1995.

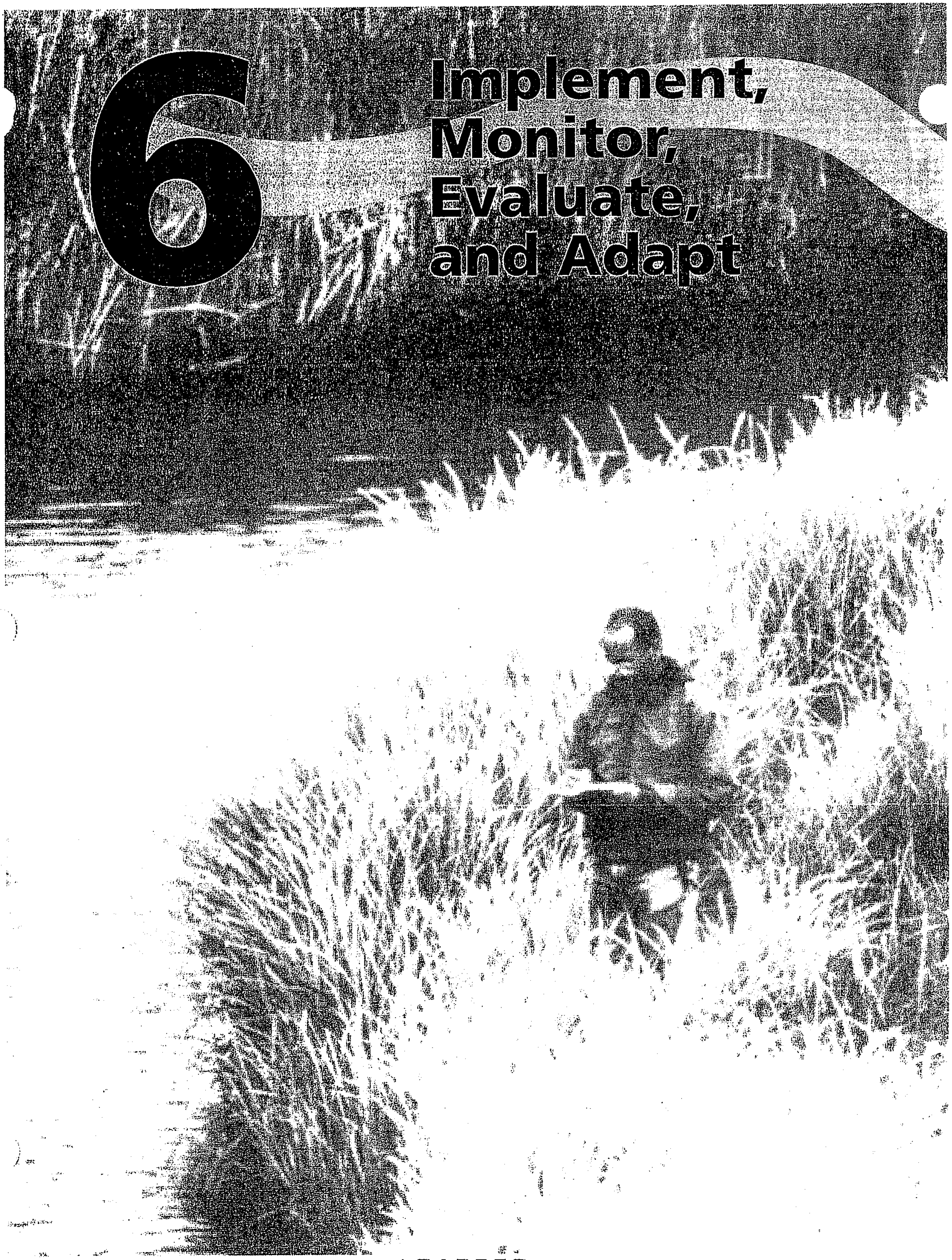
5.A Developing Restoration Goals and Objectives

- *How are restoration goals and objectives defined?*
- *How do you describe desired future conditions for the stream corridor and surrounding natural systems?*
- *What is the appropriate spatial scale for the stream corridor restoration?*
- *What institutional or legal issues are likely to be encountered during a restoration?*
- *What are the means to alter or remove the anthropogenic changes that caused the need for the restoration (i.e., passive restoration)?*

5.B Alternative Selection and Design

- *How does a restoration effort target solutions to treat causes of impairment and not just symptoms?*
- *What are important factors to consider when selecting among various restoration alternatives?*
- *What role does spatial scale, economics, and risk play in helping to select the best restoration alternative?*
- *Who makes the decisions?*
- *When is active restoration needed?*
- *When are passive restoration methods appropriate?Chapter 6: Implement, Monitor, Evaluate, and Adapt*

6 Implement, Monitor, Evaluate, and Adapt



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6.A Restoration Implementation

- *What are the steps that should be followed for successful implementation?*
- *How are boundaries for the restoration defined?*
- *How is adequate funding secured for the duration of the project?*
- *What tools are useful for facilitating implementation?*
- *Why and how are changes made in the restoration plan once implementation has begun?*
- *How are implementation activities organized?*
- *How are roles and responsibilities distributed among restoration participants?*
- *How is a schedule developed for installation of the restoration measures?*
- *What permits and regulations will be necessary before moving forward with restoration measures?*

6.B Restoration Monitoring, Evaluation, and Adaptive Management

- *What is the role of monitoring in stream corridor restoration?*
- *When should monitoring begin?*
- *How is a monitoring plan tailored to the specific objectives of a restoration initiative?*
- *Why and how is the success or failure of a restoration effort evaluated?*
- *What are some important considerations in developing a monitoring plan to evaluate the restoration effort?*

6 Implementing, Monitoring, Evaluating, and Adapting

The development of restoration goals and objectives and the formulation and selection of restoration alternatives does not mark the end of the restoration plan development process. Successful stream corridor restoration requires careful consideration of how the restoration design will be implemented, monitored, and evaluated. In addition, it requires a commitment to long-term planning and management that facilitates adaptation and adjustment in light of changing ecological, social, and economic factors.

This chapter focuses on the final stages of restoration plan development. It presents the basics of restoration implementation, monitoring, evaluation, and management within a planning context. Specifically, the administrative and planning elements associated with these activities are discussed in detail. This chapter is intended to set the stage for the technical or "how to" discussion of restoration implementation, monitoring, maintenance, and management presented in Chapter 9. The present chapter is divided into two main sections.

Section 6.A: Restoration Implementation

The first section examines the basics of restoration implementation. It includes a discussion of all aspects relevant to carrying out the design, including funding, *incentives, division of responsibilities, and the actual implementation process.*

Section 6.B: Restoration Monitoring, Evaluation, and Adaptive Management

Once the basic design is executed, the monitoring, evaluation, and adaptation process begins. This section explores some of the basic considerations that need to be addressed in examining and evaluating the success of the restoration initiative. In addition, it emphasizes the importance of making adjustments to the restoration design based on information received during the monitoring and evaluation process. Note especially that the plan development process can be reiterated if conditions in or affecting the stream corridor change or if perceptions or goals change due to social, economic, or legal developments.

6A Restoration Implementation

Implementation is a critical component of the stream corridor restoration process. It includes all the activities necessary to execute the restoration design and achieve restoration goals and objectives. Although implementation is typically considered the "doing," not the "planning," successful restoration implementation demands a high level of advance scheduling and foresight that constitutes planning by any measure.

Securing Funding for Restoration Implementation

An essential component of any stream corridor restoration initiative is the availability of funds to implement the restoration design. As discussed in Chapter 4, identifying potential funding sources should be one of the first priorities of the advisory group and decision maker. By the time the restoration initiative reaches the implementation stage, however, the initial identification of sources should be translated into tangible resource allocations. In other words, all needed funding should be secured so that restoration implementation can be initiated. It is important to remember that financing might ultimately come from several sources. All benefactors, both public and private, should be identified and appropriate cost-sharing arrangements should be developed.

An important element of securing funding for restoration is linking the available resources to the specific activities that will be part of implementation. Specifically, it should be the responsibility of the restoration planners to categorize the various activities that will be part of the restoration, determine how much each activity will cost to implement, and determine how much funding is available for each activity. In performing this analysis it should be noted that funding need not be thought of exclusively in terms of available "cash." Often many of the activities that are part of the restoration effort can be completed with the work of the staff of a participating agency or other organization.

Securing Funding for Anacostia Restoration Initiatives

The Anacostia Watershed Restoration Committee annually seeks funding for many restoration initiatives. In FY91, more than 50 projects were funded by over a dozen local, state, and federal agencies. Funding sources are matched with appropriate watershed projects. In about half a dozen cases, special funding came from federal agencies like the Corps of Engineers, USDA, and EPA. The overwhelming majority of projects, however, involved a skillful coordination of existing sources of support from state and local governmental programs combined with additional help from nongovernmental organizations such as Trout Unlimited and from other citizen volunteers. The signatory agencies (e.g., the District of Columbia, Prince George's and Montgomery Counties, and the state of Maryland) fund most of the storm water retrofit, monitoring, and demonstration projects, as well as public participation activities.

*A key element in maximizing resources from existing programs is the organization of special technical assistance teams for priority subwatersheds (**Figure 6.1**). Subwatershed Action Plan (SWAP) coordinators carry out public education and outreach efforts, and they also assist in comparing the management needs of their subwatersheds with activities of local government. Because many of the problems in the Anacostia relate to urban storm water runoff, many infrastructure projects can have a bearing on restoration needs. When such infrastructure projects are identified, SWAP coordinators try to coordinate with the project sponsor and involve the sponsor in the Anacostia program. If possible, the SWAP coordinator attempts to integrate the retrofit and management objectives of the program and the project.*

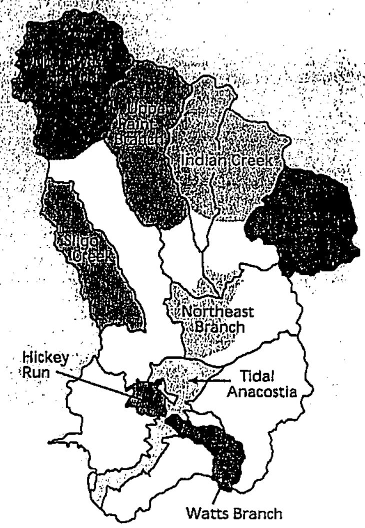


Figure 6.1: Anacostia Basin. *Nine priority subwatersheds compose the Anacostia Basin.* Source: MWCOG 1997. Reprinted permission.

It is important to note that there might be insufficient funding to carry out all of the activities outlined in the stream corridor restoration design. In this situation, planners should recognize that this is, in fact, a common occurrence and that restoration should proceed. An effort should be made, however, to prioritize restoration activities, execute them as effectively and efficiently as possible, and document success. Typically, if the restoration initiative is demonstrated as producing positive results and benefits, additional funding can be acquired.

Identifying Tools to Facilitate Restoration Implementation

In addition to securing funding, it is important to identify the various tools and mechanisms available to facilitate the implementation of the restoration design. Tools available to the stream corridor restoration practitioner include a mix of both nonregulatory or incentive-based mechanisms and regulatory mechanisms. The *Tools for Facilitating the Implementation of Stream Corridor Restoration Measures* box contains a list and description of some of these tools.

As discussed in Chapter 4, the use of incentives can be effective in obtaining participation from private landowners

REVERSE

Review Chapter 4's conservation easement section.

Important Components of Restoration Implementation

- Securing Funding for Restoration Implementation
- Identifying Tools to Facilitate Implementation
- Dividing Implementation Responsibilities
- Installing Restoration Measures

in the corridor and in gaining their support for the restoration initiative (**Figure 6.2**). Incentive programs involving cost shares, tax advantages, or technical assistance can encourage private landowners to implement restoration measures on their property, even if the results of these practices are not directly beneficial to the owner.

In addition to incentives, regulatory approaches are an important option for stream corridor restoration. Regulatory programs can be simple, direct, and easy to enforce. They can be effectively used to control land use and various land use activities.

Figure 6.2: Landowner participation. Restoration on private lands can be facilitated by landowners.

Deciding which tool, or combination of tools, is most appropriate for the restoration initiative is not an easy endeavor. The following is a list of some important tips that should be kept in mind when selecting among these tools (USEPA 1995a).

- Without targeted and effective education programs, technical assistance and cost sharing alone will not ensure implementation.
- Enforcement programs can also be costly because of the necessary inspections and personnel needed to make them effective.
- The most successful efforts appear to use a mix of both regulatory and incentive-based approaches. An effective combination might include variable cost-share rates, market-based incentives, and regulatory backup coupled with support services (governmental and private) to keep controls maintained and properly functioning.

Dividing Implementation Responsibilities

With funding in place and restoration tools and activities identified, the focus should shift to dividing the responsibilities of restoration implementation among the participants. This process involves identifying all the relevant players, assigning responsibilities, and securing commitments.

Identifying the Players

The identification of the individuals and organizations that will be responsible for implementing the design is

Tools for Facilitating the Implementation of Stream Corridor Restoration Measures

Education	*Programs that target the key audience involved with or affected by the restoration initiative to elicit awareness and support. Programs can include technical information as well as information on the benefits and costs of selected measures.*
Technical Assistance	*One-to-one interaction between professionals and the interested citizen or landowner. Includes provision of recommendations and technical assistance about restoration measures specific to a stream corridor or reach.*
Tax Advantages	*Benefits that can be provided through state and local taxing authorities or by a change in the federal taxing system that rewards those who implement certain restoration measures.*
Cost-share to Individuals	*Direct payment to individuals for installation of specific restoration measures. Most effective where the cost-share rate is high enough to elicit widespread participation.*
Cross-compliance Among Existing Programs	*A type of quasi-regulatory incentive/disincentive that conditions benefits received on meeting certain requirements or performing in a certain way. Currently in effect through the 1985, 1990, and 1996 Farm Bills.*
Direct Purchase of Stream Corridors or of Lands Causing the Greatest Problems	*Direct purchase of special areas for preservation or community-owned greenbelts in urban areas. Costs of direct purchase are usually high, but the results can be very effective. Sometimes used to obtain access to critical areas whose owners are unwilling to implement restoration measures.*
Nonregulatory Site Inspections	*Periodic site visits by staff of local, state, or federal agencies can be a powerful incentive for voluntary implementation of restoration measures.*
Peers	*Simple social acceptance by one's peers or members of the surrounding community, which can provide the impetus for an individual landowner to implement restoration measures. For example, if a community values the use of certain agricultural best management practices (BMPs), producers in those communities are more likely to install them.*

Tools for Facilitating the Implementation of Stream Corridor Restoration Measures (continued)

Direct Regulation of Land Use and Production Activities	*Regulatory programs that are simple, direct, and easy to enforce. Such programs can regulate land uses in the corridor (through zoning ordinances) or the kind and extent of activities permitted, or they can set performance standards for a land activity (such as retention of the first inch of runoff from urban property in the corridor).*
Easements	*Conservation easements on private property are excellent tools for implementing parts of a stream corridor restoration plan (see more detailed discussion in following box). Flowage easements may be a critical component in order to design, construct, and maintain structures and flow conditions.*
Donations	*In some instances, private landowners may be willing, or may be provided economic or tax incentives, to donate land to help implement a restoration initiative.*
Financing	*Normally, a restoration initiative will require multiple sources of funds, and no single funding source may be sufficient. Non-monetary resources may also be instrumental in successfully implementing a restoration initiative.*

essential to successful stream corridor restoration. Since the restoration partners are identified early in the planning process, at this point the focus should be on "reviewing" the list of participants and identifying the ones who are most interested in the implementation phase. Although some new players might emerge, most of the participants interested in the implementation phase will already have been involved in some aspect of the restoration effort (**Figure 6.4**). Typically, partners will change their participation as the process shifts from "evaluating" to "doing."

The decision maker(s), with assistance from the advisory group, should identify the key partners that will be actively involved in the implementation process.

Assigning Responsibilities

To ensure the effective allocation of responsibilities among the various participants, the decision maker(s) and advisory group should rely on a special interdisciplinary technical team. Specifically, the technical team should oversee and manage the implementation process as well as coordinate the work of other participants, such as contractors and volunteers, involved with restoration implementation. The following are some of the responsibilities of the major participants involved in the implementation process.

Conservation Easements

Conservation easements are an effective stream corridor management tool on private property regardless of whether the stream reach supports high biodiversity or the stream corridor would benefit from active restoration in conjunction with a modification of adjacent land use activities (**Figure 6.3**). *Through a conservation easement, landowners receive financial compensation for giving up or modifying some of their development rights while the easement holder acquires the right to enforce restrictions on the use of the property.*

Specific details of a conservation easement are developed on a case-by-case basis. Only those activities which may be considered incompatible with stream corridor management objectives may be restricted. The value of a conservation easement is typically estimated as the difference between the values of the underlying land with and without the restrictions imposed by the conservation easement. Government agencies or nonprofit organizations must compensate landowners for the rights they are giving up, but not to exceed more than the results are worth to society. The fair market values of the land before and after an easement is established are based on the "highest and best" uses of the land with and without the restrictions imposed by the easement. Once a conservation easement is established, it becomes part of the title on the property, and any stipulations of the conservation easement are retained when the property is sold. Conservation easements may be established indefinitely or for 25 to 30 years.

Conservation easements may be established with federal agencies, such as the U.S. Fish and Wildlife Service or the Natural Resources Conservation Service, with state agencies, or through nonprofit organizations like The Nature Conservancy or Public Land Trusts. It is often beneficial for federal, state, or local governments to establish conservation easements in partnership with nonprofit organizations. These organizations can assist public agencies in acquiring and conveying easements more efficiently since they are able to act quickly, take advantage of tax incentives, and mobilize local knowledge and support.

Conservation easements are beneficial to all parties involved. The landowners benefit by receiving financial compensation for giving up the rights to certain land use activities, enhancing the quality of the natural resources present on their property, and, when applicable, eliminating problems associated with human use in difficult areas. The quality of the land will also increase as a result of providing increased fish and wildlife habitat, improving water quality by filtering and attenuating sediments and chemicals, reducing flooding, recharging ground water, and protecting or restoring biological diversity. Conservation easements are also beneficial to public resource agencies because, in addition to the public benefit of improved quality of the stream corridor's natural resources, they provide an opportunity for public agencies to influence resource use without incurring the political costs of regulation or the full financial costs of outright land acquisition.

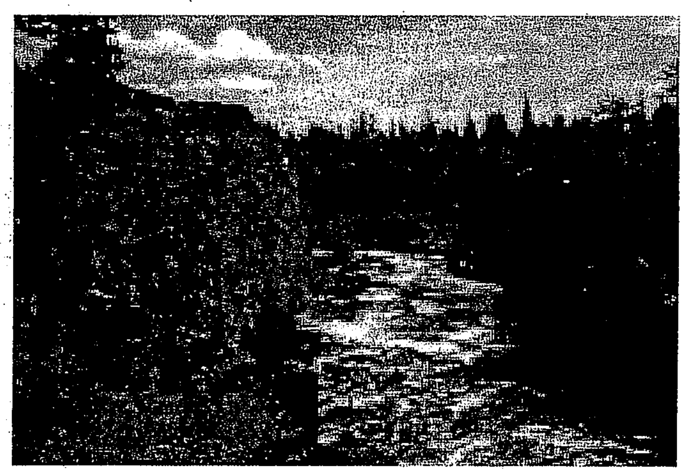


Figure 6.3: Conservation easement.
Conservation easements are an effective tool for protecting valuable areas of the stream corridor.

Review Chapter 4's Organizational Consideration Section.

Interdisciplinary Technical Team

As noted above, the interdisciplinary technical team is responsible for overseeing and coordinating restoration implementation and will assign implementation responsibilities. Before identifying roles, however, the technical team should establish some organizational ground rules. *Some Important Organizational Considerations for Successful Teamwork* reviews some of the important logistical issues that need to be addressed by the team. Organizational considerations are also addressed in Chapter 4.

In addition to establishing ground rules, the technical team should appoint a single project manager. This person must be knowledgeable about the structure, function, and condition of the stream corridor; the various elements of the restoration design; and the policies and missions of the various co-operating agencies, citizen groups, and local governments. When consensus-based decisions are not possible due to time limitations, the project manager must be able to make quick and informed decisions relevant to restoration implementation.

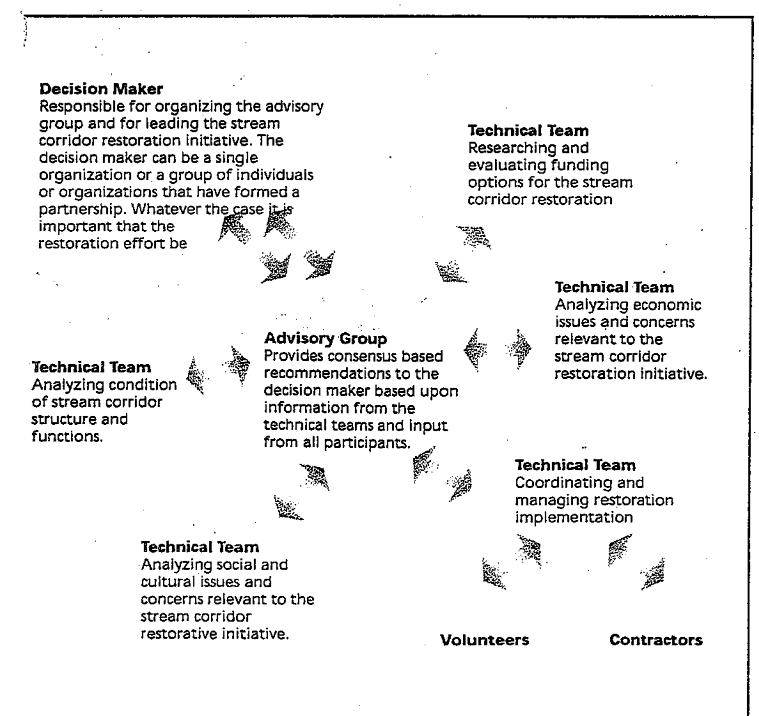


Figure 6.4: Communication flow. This depicts a possible scenario in which volunteers and contractors may become actively involved.

Once the organizational issues have been taken care of, the technical team can begin to address its coordination and management responsibilities. In general, the technical team must grapple with several major management issues during the implementation process. The following are some of the major questions that are essential to successful management:

- How much time is required to implement the restoration?
- Which tasks are critical to meeting the schedule?
- What resources are necessary to complete the restoration?
- Who will perform the various restoration activities?
- Is the implementation team adequately staffed?
- Are adequate lines of communication and responsibility established?
- Are all competing and potentially damaging interests and concerns adequately represented, understood, and addressed?

Volunteers

Volunteers can be very effective in assisting with stream corridor restoration (Figure 6.5). Numerous activities that are part of the restoration implementation process are suitable for volunteer labor. For example, soil bioengineering and other uses of plants to stabilize slopes are labor-intensive. Two crews of at least two people each are needed for all but the largest installations—one crew at the harvest location and the

Some Important Organizational Considerations for Successful Teamwork

Meeting Mechanics	■ *How often will the team meet?* ■ *Where?* ■ *What will the agenda include?* ■ *How do members get items on the agenda?* ■ *Who will take minutes?* ■ *How will minutes be distributed?* ■ *Who will facilitate the meetings?*
Team Decision Making	■ *How will the team make decisions (vote, consensus, advise only)?* ■ *What decisions must be deferred to higher authorities?*
Problem Solving	■ *How will problems be addressed?* ■ *How will disagreements be resolved?* ■ *What steps will be taken in the event of an impasse?*
Communication and Information	■ *What additional information does the team need to function?* ■ *How will necessary information be shared among team members, and by whom?* ■ *Who handles public relations?*
Leadership Support	■ *What is needed from supervisors and/or managers to ensure project success?*

other at the implementation site. However, a high level of skill or experience is often not required except for the crew leader, and training can commonly occur on the job. Restoration installations involving plant materials are therefore particularly suitable for youth, Job Corps, or volunteer forces.

It should be noted that the use of volunteers is not without some cost. Equipment, transportation, meals, insurance, and training might all be required, and each carries a real dollar need that must be met by the project budget or by a separate agency sponsoring the volunteer effort. However, those

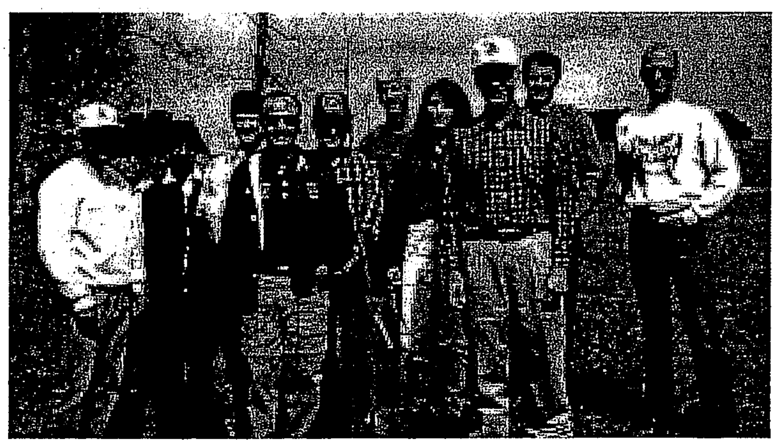


Figure 6.5: Volunteer team. *Volunteers can perform important functions during the restoration implementation process.*

costs are still but a fraction of what would otherwise be needed for nonvolunteer forces.

Contractors

Contractors typically have responsibilities in the implementation of the restoration design. In fact, many restoration efforts require contracting due to the staff limitations of participating agencies, organizations, and landowners.

Contractors can assist in performing some of the tasks involved in implementing restoration design. Specifically, they can be hired to perform various tasks such as channel modification, installation of instream structures, and bank revegetation (**Figure 6.6**). All tasks performed by the contractor should be specified in the scope of the contract and should be subject to frequent and periodic inspection to ensure that they are completed within the proper specifications.

Figure 6.6: Contractor team. *Contractors can assist in performing tasks that might be involved in restoration such as installing bank stabilization measures.*
Source: Robin Sotir and Associates.

Although the contract will outline the role the contractor is to perform, it might be helpful for the technical team (or a member of the technical team) to meet with the contractor to establish a clear understanding of the respective roles and responsibilities. This preinstallation meeting might also be used to formally determine the frequency and mechanisms for reporting the progress of any installation activities. On the next page is a checklist of issues that are helpful in determining some of the roles and responsibilities associated with using contractors to perform restoration-related activities.

Securing Commitments

The final element of the division of responsibilities is securing commitments from the organizations and individuals that have agreed to assist in the implementation process. Two types of commitments are particularly important to ensuring the success of stream corridor restoration implementation (USEPA 1995):

- Commitments from public agencies, private organizations, individuals, and others who will fund and implement programs that involve restoration activities.
- Commitments from public agencies, private organizations, individuals, and others who will actually install the restoration measures.

One tool that can be used to help secure a commitment is a Memorandum of Understanding (MOU). An MOU is an agreement between two or more parties that is placed in writing. Essentially, by documenting what each party specifically agrees to, defining ambiguous concepts or terms, and outlining a conflict resolution process in the event of

Some Issues That Should Be Considered in Addressing Contractor Roles and Responsibilities

- *What constitutes successful completion of the contract obligations by the contractor?*
- *What is the planned order of work and necessary scheduling?*
- *Who is responsible for permitting?*
- *Where are utilities located and what are the related concerns?*
- *What is the relationship between the prime contractor and subcontractors? (In general, the chain of communication should always pass through the prime contractor, and the prime contractor's representative is always present on site. Normally, clients reserve the right to approve or reject individual subcontractors.)*
- *What records and reports will be needed to provide necessary documentation (forms, required job site postings, etc.)?*
- *What arrangements are needed for traffic control?*
- *What specific environmental concerns are present on the site? Who has permit responsibility, both for obtaining and for compliance?*

misunderstandings, an MOU serves to formalize commitments, avoid disappointment, and minimize potential conflict.

A second tool that can be effective is public accountability. As emphasized earlier, the restoration process should be an "open process" that is accessible to the interested public. Once written commitments have been made and announced, a series of periodic public meetings can be scheduled for the purpose of providing updates on the attainment of the various restoration activities being performed. In this way, participants in the restoration effort can be held accountable.

Installing Restoration Measures

A final element of stream corridor restoration implementation is the initiation of management and/or installation of restoration measures in accordance with the restoration design (**Figure 6.7**). If the plan involves construction, implementation responsibilities are often given to a private contractor. As a result, the contractor is required to perform a variety of restoration implementation activities, which can include large-scale actions like channel reconfiguration as well as small-scale actions like bank revegetation.

Whatever the scale of the restoration action, the process itself typically involves several stages. These stages generally include site preparation, site clearing, site construction, and site inspection. Each stage must be carefully executed to ensure successful installation of restoration measures. (See Chapter 9 for a more detailed explanation of this process.)

In addition to careful execution of the installation process, it is important that all actions be preceded by careful plan-

FAST FORWARD
Preview Chapter 9's restoration measures section.

Review Chapter 5's permit section.

ning. Such preinstallation planning is essential to achieve the desired restoration objectives and to avoid adverse environmental, social, and economic impacts that could result. The following is a discussion of some of the major steps that should be taken to ensure successful implementation of restoration-related installation actions.

Determining the Schedule

Scheduling is a very important and highly developed component of implementation planning and management. For large-scale installation actions, scheduling is now almost always executed with the assistance of a computer-based software program. Even for small actions, however, the principles of scheduling are worth following.

Figure 6.7: Installation of erosion control fabric. *Installing measures can be considered a "midpoint" in restoration and not the completion. Preceding installation is the necessary planning, with monitoring and adaptive management subsequent to the installation.*

Table 6.1: Examples of permit requirements for restoration activities.

Local/State				
Permits Required			**Activities Covered**	**Administered By**
Varies thresholds and definitions vary by state			e.g., clearing/grading, sensitive/critical areas, water quality, aquatic access	Local grading, planning, or building departments; various state departments
Federal				
Permits Required			**Activities Covered**	**Administered By**
Section 10, Rivers and Harbors Act of 1849			Building of any structure in the channel or along the banks of navigable waters of the U.S. that changes the course, condition, location, or capacity	U.S. Army Corps of Engineers
Section 404, Federal Clean Water Act	Letters of permission		Minor or routine work with minimum impacts	U.S. Army Corps of Engineers
	Nationwide permits	3	Repair, rehabilitation, or replacement of structures destroyed by storms, fire, or floods in past 2 years	
		13	Bank stabilization less than 500 feet in length solely for erosion protection	
		26	Filling of up to 1 acre of a non-tidal wetland or less than 500 linear feet of non-tidal stream that is either isolated from other surface waters or upstream of the point in a drainage network where the average annual flow is less than 5cfs	
		27	Restoration of natural wetland hydrology, vegetation, and function to altered and degraded non-tidal wetlands, and restoration of natural functions of riparian areas on private lands, provided a wetland restoration or creation agreement has been developed	
	Regional permits		Small projects with insignificant environmental impacts	
	Individual permits		Proposed filling or excavation that causes severe impacts, but for which no practical alternative exists; may require an environmental assessment	
Section 401, Federal Clean Water Act			Water quality certification	State agencies
Section 402, Federal Clean Water Act National Pollutant Discharge Elimination System (NPDES)			Point source discharges, as well as nonpoint pollution discharges	State agencies
Endangered Species Act Incidental Take Permit			Otherwise lawful activities that may take listed species	U.S. Fish and Wildlife Service

For tasks that are part of the actual installation work, scheduling is most efficiently done by the contractor actually charged with doing the work. All supporting activities, both before and during installation, must be carefully scheduled as well and should be the responsibility of the project manager.

Obtaining the Necessary Permits

Restoration installation actions conducted in or in contact with streams, wetlands, and other water bodies are subject to various federal, state, and local regulatory programs and requirements. At the federal level, a number of these are aimed at protecting natural resources values and the integrity of the nation's water resources. As discussed in Chapter 5, most of these require the issuance of permits by local, state, and federal agencies.

If the action will be conducted or assistance provided by a federal agency, the agency is required to comply with federal legislation, including the National Environmental Policy Act; sections 401, 402, and 404 of the Clean Water Act; the Endangered Species Act; Section 10 of the Rivers and Harbors Act of 1899; executive orders for floodplain management and wetland protection; and possibly other federal mandates depending on the areas that would be affected (see **Table 6.1**).

For example, under the Endangered Species Act, federal agencies must ensure that actions they take will not jeopardize the continued existence of listed threatened or endangered species or destroy or adversely modify their critical habitats (**Figure 6.8**). Where an action would jeopardize a species, reasonable and prudent alternatives must be implemented to avoid jeopardy. In addition, for federal agencies, an incidental take statement is required in

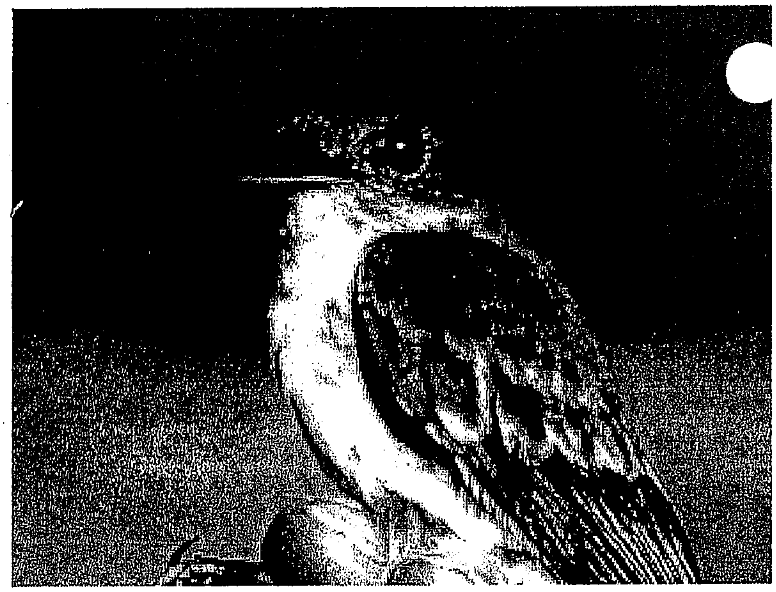
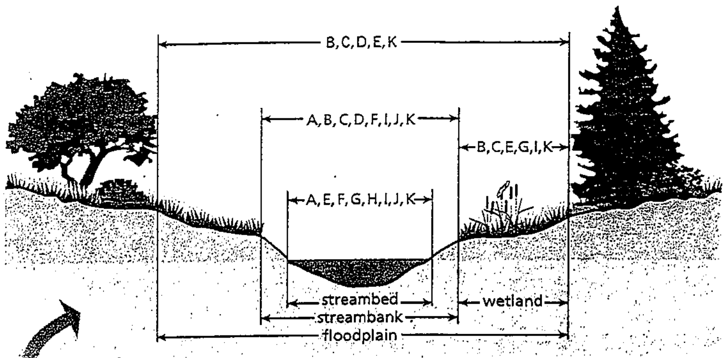


Figure 6.8: Southwestern willow flycatcher. *Prior to initiating implementation activities, permits may be needed to ensure the protection of certain species such as the Southwestern willow flycatcher.*

those instances where there will be a "taking" of species associated with the federal action. For non-federal activities that might result in "taking" of a listed species, an incidental take permit is required.

Any work in floodplains delineated for the National Flood Insurance Program might also require participating communities to adhere to local ordinances and obtain special permits.

If the activity will affect lands such as historic sites, archaeological sites and remains, parklands, National Wildlife Refuges, floodplains, or other federal lands, meeting requirements under a number of federal, state, or local laws might be necessary. Familiarity with the likely requirements associated with the activities to be conducted and early contact with permitting authorities will help to minimize delays. Local grading, planning, or building departments are



Using this diagram, determine where your activity will occur. The letters refer to the permits listed below.

	Permit	Government Agency
A	Montana Stream Protection Act (124)	Montana Fish, Wildlife & Parks
B	Storm Water Discharge General Permits	Department of Environmental Quality
C	Streamside Management Zone Law	Department of Natural Resources & Conservation
D	Montana Floodplain and Floodway Management Act	Department of Natural Resources & Conservation
E	Short-term Exemption from Montana's Surface Water Quality Standards (3A)	Department of Environmental Quality
F	Montana Natural Streambed and Land Preservation Act (310)	Montana Association of Conservation Districts and Department of Natural Resources & Conservation
G	Montana Land-use License or Easement on Navigable Waters	Department of Natural Resources & Conservation/ Special Uses
H	Montana Water Use Act	Department of Natural Resources & Conservation
I	Federal Clean Water Act (Section 404)	U.S. Army Corps of Engineers
J	Federal Rivers and Harbors Act (Section 10)	U.S. Army Corps of Engineers
K	Other laws that may apply depending upon your location & activity	various agencies

Figure 6.9: Example of permits necessary for working in and around streams in Montana. *The number of permits required for an aquatic restoration effort may appear daunting but they are all necessary.*
Source: MDEQ 1996. Reprinted by permission.

usually the best place to begin the permit application process. They should be approached as soon as a conceptual outline of the project has been developed. At such a preapplication meeting, the project manager should bring such basic design information as the following:

- A site map or plan.
- A simple description of the restoration measures to be installed.
- Property ownership of the site and potential access route(s).
- Preferred month and year of implementation.

Whether or not that local agency claims jurisdiction over the particular activity, its staff will normally be aware of state and federal requirements that might be applicable. Local permit requirements vary from place to place and change periodically, so it is best to contact the appropriate agency for the most current information. In addition, different jurisdictions handle the designation of sensitive or critical areas differently. Work that occurs in the vicinity of a stream or wetland might or might not be subject to state or local permit requirements unique to aquatic environments. In addition, state and local agencies might regulate other aspects of a project as well.

The sheer number of permits required for an aquatic restoration effort might appear daunting, but much of the required information and many of the remedial measures are the same for all. **Figure 6.9** shows an example of how Montana's permitting requirements mesh with those at the federal level.

Holding Preinstallation Conferences

Preinstallation conferences should be conducted on site between the project manager and supervisor, crew foreman, and contractor(s) as appropriate. The purpose is to establish a clear understanding of the respective roles and responsibilities, and to formally determine the frequency and mechanisms for reporting the progress of the work. In a typical situation, the agency reviews consultant work, provides guidance in the interpretation of internal agency documents or guidelines, and takes a lead or at least supporting role in acquiring permits and satisfying the requirements imposed by regulatory agencies. An additional conference with any inspectors should be held with all affected contractors and field supervisors to avoid potential misunderstandings. Volunteers and noncontractor personnel should also be involved if they are critical to implementation.

At particularly sensitive sites, the need to avoid installation-related damage should be valued at least as highly as the need to complete the planned implementation actions as designed. An on-site meeting, if appropriate to the timing of installation and the seasonality of storms, can avoid many of the emergency problems that might otherwise be encountered in the future. At a minimum, the project manager or on-site superintendent and the local inspector(s) for the permitting jurisdiction(s) should attend. Other people with relevant knowledge and responsibility could also include the grading contractor's superintendent, the civil engineer or landscape architect responsible for the erosion and sediment control plans, a soil scientist or geologist, a biologist, and the plan checker(s) from the permitting jurisdiction(s) (**Figure 6.10**).

The meeting should ensure that all aspects of the plans are understood by the field supervisors, that the key actions and most sensitive areas of the site are recognized, that the sequence and schedule of implementing control measures are agreed upon, and that the mechanism for emergency response is clear. Any changes to the erosion and sediment control plan should be noted on the plan documents for future reference. Final copies of plans and permits should be obtained, and particular attention should be paid to changes that might have been recorded on submitted and approved plan copies, but not transferred to archived or contractor copies.

Involving Property Owners

If possible, the project manager should contact and meet with neighbors affected by the work, including those with site ownership, those granting access and other easements, and others nearby who might endure potential noise or dust impacts.

Securing Site Access

Obtaining right of entry onto private property can be a problematic and time-consuming part of restoration (**Figure 6.11**). Several types of access agreements with differing rights and obligations are available:

- *Right of entry* is the right to pass over the property for a specific purpose for a limited period of time. In many cases, if landowners are involved from the beginning, they will be aware of the need to enter private property. Various types of easements can accomplish this goal.

Figure 6.10: On-site meeting. *Many problems that might otherwise be encountered can be avoided by appropriately timed on-site meetings.*

- *Implementation easement* defines the location, time period, and purpose for which the property can be used during implementation.
- *Access easement* provides for permanent access across and on private property for maintenance and monitoring of a project. The geographic limits and allowable activities are specified.
- *Drainage easement* allows for the implementation and permanent maintenance of a drainage facility at a particular site. Usually, the property owner has free use of the property for any nonconflicting activities.
- *Fee acquisition* is the outright purchase of the property. It is the most secure, but most expensive, alternative. Normally, it is unnecessary unless the project is so extensive that all other potential activities on the property will be precluded.

In many cases little or no money may be exchanged in return for the easement because the landowner receives substantial property improvements, such as stabilized streambanks, improved appearance, better fisheries, and permanent stream access and stream crossings. In some instances, however, the proposed implementation is in direct conflict with existing or planned uses, and the purchase of an easement must be anticipated.

Locating Existing Utilities

Since most restoration efforts have a lower possibility of encountering utilities than other earthwork activities, special measures might not be necessary. If utilities are present, however, certain principles should be remembered (King 1987).

First, field location and highly visible markings are mandatory; utility atlases are notoriously incomplete or inaccu-

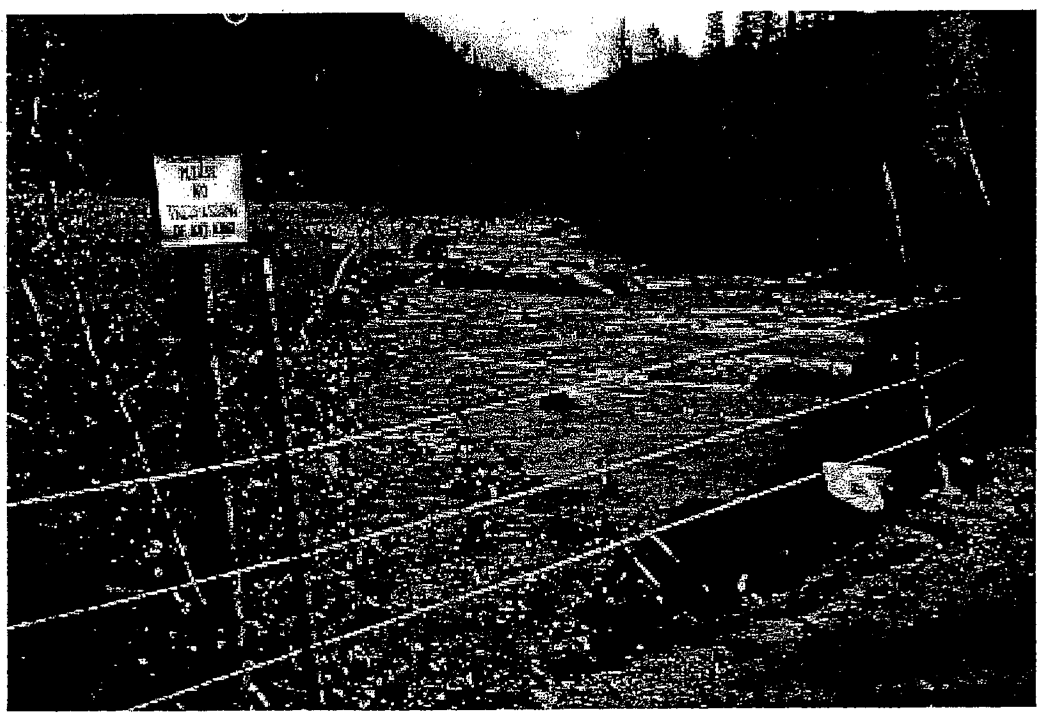


Figure 6.11: Site access. *In certain areas, access agreements, such as a right of entry or implementation easement, might have to be obtained to install restoration measures.*

rate. Utilities have a particular size and shape, not just a location, which might affect the nature or extent of adjacent implementation. They also require continuous support by the adjacent soil or temporary restraining structures. Rights-of-way might also create constraints during and after implementation. Even though all potential conflicts between utilities and the proposed implementation should be resolved during implementation planning, field discovery of unanticipated problems occurs frequently. Resolution comes only with the active involvement of the utility companies themselves, and the project manager should not hesitate to bring them on site as soon as a conflict is recognized.

Characteristics of Successful Implementation

- *Central responsibility in one person*
- *Thorough understanding of planning and design documents*
- *Familiarity with the site and its biological and physical framework*
- *Knowledge of laws and regulations*
- *Understanding of environmental control plans*
- *Communication among all parties involved in the project action*

Confirming Sources and Ensuring Material Standards

First, the project manager must determine the final sources of any required fill dirt and then arrange a pickup and/or delivery schedule. The project manager should also confirm the sources of nursery and donor sites for plant materials. Note, however, that delaying the initial identification of these sources until the time of site preparation almost guarantees that the project will suffer unexpected delays. In addition, it is important to double check with suppliers that all materials scheduled for delivery or pickup will meet the specified requirements. Early attention to this detail will avoid delays imposed by the rejection of substandard materials.

Characteristics of Successful Implementation

As was discussed earlier, successful restoration requires the efficient and effective execution of several core implementation activities, such as installing restoration measures, assigning responsibilities, identifying incentives, and securing funding. The Winooski River Case Study is a good example. Cutting across these core activities, however, are a few key concepts that can be considered characteristics of successful restoration implementation efforts.

Central Responsibility in One Person

Most restoration efforts are a product of teamwork, involving specialists from such disparate disciplines as biology, geology, engineering, landscape architecture, and others. Yet the value of a single identifiable person with final responsibility cannot be overemphasized. This project manager ignores the recommendations and concerns of the project team only at his or her peril. Rapid decisions, particularly during implementation, must nonetheless often be made. Rarely are financial resources available to keep all members of the design team on site during implementation, and even if some members are present, the time needed to achieve a consensus is simply not available.

CASE STUDY

Successful Implementation: The Winooski River Watershed Project, Vermont

In the late 1930s, an extensive watershed restoration effort known as "Project Vermont" was implemented in the Lower Winooski River Watershed, Chittenden County, Vermont. The project encompassed the lower 111 square miles (including 340 farms) of the 1,076-square-mile Winooski River Watershed.

*The Winooski River Watershed sustained severe damage from major floods during the 1920s and 1930s. In addition, overgrazing, poor soil conservation practices on cropland areas, encroachment to the streambanks, and forest clear-cutting also led to excessive erosion (**Figure 6.12**). Annual iceflows and jams during snowmelt runoff further exacerbated riverbank erosion. Throughout the watershed, both water and wind erosion were prevalent. In addition to problems in the low-lying areas, there were many environmental problems to address on the uplands. The soil organic matter was depleted in some areas, cropland had low productivity, pastures were frequently overgrazed, cover for wildlife was sparse, and forest areas had been clear-cut in many areas. In some cases, this newly cleared land was subject to grazing, which created additional problems.*

***Figure 6.12: Brushmattress and plantings after spring runoff in March 1938.** Note pole jetties. Brushmatting involves applying a layer of brush fastened down with live stakes and wire.*

The Soil Conservation Service (SCS) joined with the University of Vermont (UVM) and local landowners to formulate a comprehensive, low-input approach to restoring and protecting the watershed. One hundred eighty-nine farmers participated in developing conservation plans for their farms, which covered approximatey 57 square miles. Other cooperators applied practices to another 38-square-mile area. Their approach relied heavily on plantings or a combination of plantings and mechanical techniques to overcome losses of both land and vegetated buffer along the river corridor, and in the uplands to make agricultural land sustainable and to restore deteriorating forestland.

The measures, many of which were experimental at the time, were installed from 1938 to 1941 primarily by landowners. Landowners provided extensive labor and, occasionally, heavy equipment for earthmoving and transportation and placement of materials too heavy for laborers. SCS provided interdisciplinary (e.g., agronomy, biology, forestry, soil conservation, soil science, and engineering) technical assistance in the planning, design, and installation. UVM provided extensive educational services for marketing and operation and maintenance.

In the stream corridor, a variety of measures were implemented along 17 percent of the 33 river miles to control bank losses, restore buffers, and heal overbank floodflow channels. They included the following:

- *Livestock Exclusion: Heavy-use areas were fenced back 15 feet from the top of the bank on straight reaches, 200 feet or wider on the outsides of curves, and 200 feet wide in flood overflow entrance and exit sections.*
- *Plantings and Soil Bioengineering Bank Stabilization: Where the main current was not directed toward the treatment, streambanks were sloped back and planted with more than*

600,000 cuttings and 70,000 plants, primarily willow. Brushmattresses, which involved applying a layer of brush fastened down with live stakes and wire, were used to protect the bank until plantings could be made and established. Where streamflow was directed toward the bank, rock riprap was embedded at the toe up to 2 or more feet above the normal water line. Other toe protection techniques, such as pile jetties, were used.

- *Structures: In reaches where nearshore water was deep (up to 14 feet) and bank voiding was occurring, whole tree deflectors were used to trap sediment and rebuild the voided section. Trees with butt diameters of 2 to 3 feet were placed longitudinally along the riverbank with branches intact and with butts and tops slightly overlapped. The butts were cabled to wooden piles driven 8 to 10 feet into the bank. The slope above the normal waterline was brush-matted and planted.*
- *Log pile check dams were constructed at the entrances of flood overflow channels and filled with one-person-size rocks for ballast. These served as barriers to overbank flow along channels sculpted by previous floods. They were installed in conjunction with extensive buffer plantings, and in some cases, whole tree barricades, that were laced down parallel to the river along the top of the denuded bank.*
- *At overbank locations where flow threatened buffer plantings, log cribs were inset parallel to the bank and filled with rock. Various tree species were planted as a 200-foot or wider buffer behind the cribs. The cribs provided protection needed until the trees became well established.*

In the watershed, the conservation plans provided for comprehensive management for sustainable farming, grazing, forestry, and wildlife. The cropland practices included contour strips, contour tillage, cover crops, crop and pasture rotation, grass and legume plantings, diversions, grassed waterways, log culvert crossings, contour furrows in pastures, livestock fencing, planting of hedgerows, field border plantings, reforestation, and sustainable forest practices.

***Figure 6.13: Same site (Figure 6.12) in April 1995. Note remnants of old jetties and heavy bank cover.** Restoration measures are continuing to function well, more than 55 years after installation.*

Wildlife habitat improvement practices provided connectivity among the cropland, pasture, and forest areas; hedgerow plantings as travelways, food sources, and cover; livestock exclusion areas to encourage understory herbaceous growth for cover and food sources; snags for small mammals and birds; and slash pile shelters as cover for rabbits and grouse.

One reason for this historic project's usefulness to modern environmental managers is the extensive documentation, including photos, maps, and detailed observations and records, available for many of the sites. Complete aerial photography is available from before, during, and after implementation. More than 600 photos provide a chronology of the measures, and three successive studies (Edminster and Atkinson 1949, Kasvinsky 1968, Ryan and Short 1995) document the performance of the project.

*The restoration measures implemented are continuing to function well today, more than 55 years after installation. Tree plantings along the corridor have matured to diameters as great as 45 inches and heights exceeding 100 feet (**Figure 6.13**). The wooded river corridor averages 50 feet wider than it did in the 1930s. Some of the measures have failed, however, including all plantings without toe protection. Lack of maintenance and long-term follow-up also resulted in the failure of restoration efforts at several sites.*

CASE STUDY

The Winooski River Watershed Project
(continued)

Although the Winooski project was experimental in the 1930s, many of its elements were highly successful:

- *Recognition of the importance of landscape relationships and an emphasis on comprehensive treatment of the entire watershed rather than isolated, individual problem areas.*
- *Using an interdisciplinary technical team for planning and implementation.*
- *Strong landowner participation.*
- *Empowerment of landowners to carry out the restoration measures using low-cost approaches (often using materials from the farm).*
- *Fostering the use of experimental methods that are now recognized as viable biotechnical approaches.*

The success of restoration efforts depends more on having a competent project manager than on any other factor. The ideal project manager should be skilled in leadership, scheduling, budgeting, technical issues, human relationships, communicating, negotiating, and customer relations. Most will find this a daunting list of attributes, but an honest evaluation of a manager's shortcomings before restoration is under way might permit a complementary support team to assist the one who most commonly guides restoration to completion.

Thorough Understanding of Planning and Design Materials

Orchestrating the implementation of all but the simplest restoration efforts requires the integration of labor, equipment, and supplies, all within a context determined by requirements of both the natural system and the legal system. Designs must be adequate and based on a foundation of sound physical and biological principles, tempered with the experience of past efforts, both successful and unsuccessful. Schedules must anticipate the duration of specific implementation tasks, the lead time necessary to prepare for those tasks, and the consequences of inevitable delays. A manager who has little familiarity with the planning and design effort can neither execute the implementation plans efficiently nor adjust those plans in the face of unanticipated conditions. A certain amount of flexibility is key. Often specific techniques are tied to specific building material, for example. Adjustments are often made according to what is available.

Familiarity With the Reach

Existing site conditions are seldom as they appear on a set of engineering plans. Variability in landform and vegetation, surface water and ground water flow, and changing site conditions during the interval between initial design and final implementation are all inevitable. There is no substitute for familiarity with the site that extends beyond what is shown on the plans, so that implementation-period "surprises" are kept to a minimum (Figure 6.14). Similarly, when such surprises do occur,

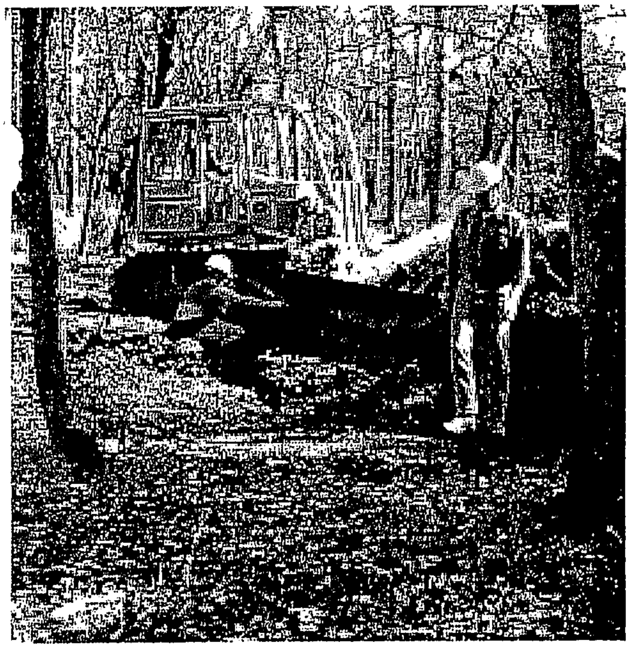


Figure 6.14: Workers installing a silt fence. *Familiarity with on-site conditions is critical to successful implementation of restoration measures.*

a sound response must be based on the project manager's understanding of both the restoration goals and the likely behavior of the natural system.

Knowledge of Laws and Regulations

Site work in and around aquatic features is one of the most heavily regulated types of implementation in the United States (**Figure 6.15**). Restrictions on equipment use, season of the year, distance from the water's edge, and types of material are common in regulations from the local to the federal level. Not appreciating those regulations can easily delay implementation by a year or more, particularly if narrow seasonal windows are missed. The cost of a project can also multiply if required measures or mitigation are discovered late in the design or implementation process.

Understanding of Environmental Control Plans

A project in which a designed restoration measure is installed but the ecological structure and function of an area are destroyed is no success. The designer must create a workable plan for minimizing environmental degradation, but the best of plans can fail in the field through careless implementation.

Communication Among All Parties Involved in the Action

Despite the emphasis here on a single responsible project manager, the success of a project depends on regular, frequent, and open communication among all parties involved in implementation—manager, technical support people, contractor, crews, inspectors, and decision maker(s). No restoration effort proceeds exactly according to plans, and not every contingency can be predicted ahead of time. But well-established lines of communication can overcome most complications that arise.

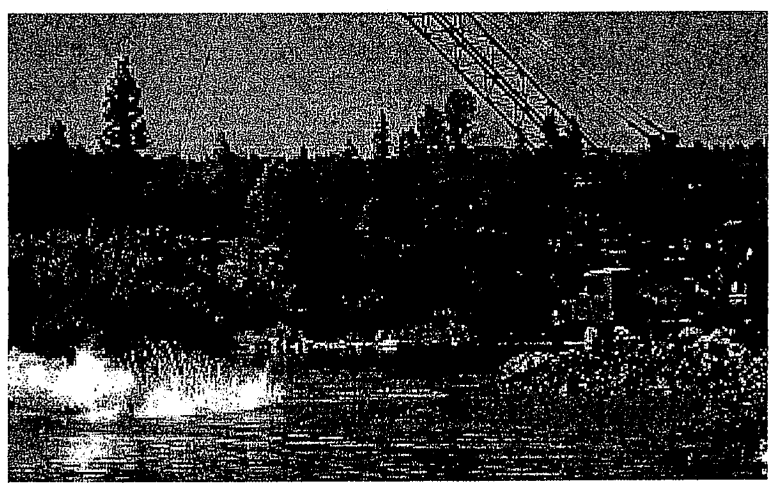


Figure 6.15: Instream construction activity. *Site work in and around aquatic features is one of the most heavily regulated types of activity in the United States and should not be attempted without a sound knowledge of the relevant laws and regulations.*

6B Restoration Monitoring, Evaluation, and Adaptive Management

FAST FORWARD

Preview Chapter 9's restoration monitoring management section.

The restoration effort is not considered complete once the design has been implemented. Monitoring, evaluation, and adaptive management are essential components that must be undertaken to ensure the success of stream corridor restoration. Each is carried out at a different level depending on the size and scope of the design.

Monitoring includes both pre- and post-restoration monitoring, as well as monitoring during actual implementation. All are essential to determining the success of the restoration design and require a complete picture or understanding of the structure and functions of the stream corridor. Monitoring provides needed information, documents chronological and other aspects of restoration succession, and provides lessons learned to be used in similar future efforts (Landin 1995).

Directly linked to monitoring are restoration evaluation and adaptive management. Using the information obtained from the monitoring process, the restoration effort should be evaluated to ensure it is functioning as planned and achieving the restoration goals and objectives. Even with the best plans, designs, and implementation, the evaluation will often result in the identification of some unforeseen problems and require midcourse correction either during or shortly following implementation. Most restoration efforts will require some level of oversight and on-site adaptive management.

This section examines some of the basics of restoration monitoring, evaluation, and adaptive management. A more detailed discussion on the technical aspects of restoration monitoring management is provided in Chapter 9 of this document.

Monitoring as Part of Stream Corridor Restoration Initiative

Restoration monitoring should be guided by predetermined criteria and checklists and allow for the recording of results in regular monitoring reports. The technical analyses in a monitoring report should reflect restoration objectives and should identify and discuss options to address deficiencies. For example, the report might include data summaries that indicate that forest understory conditions are not as structurally complex as expected in a particular management unit, that this finding has negative consequences for certain wildlife species, and that a program of canopy tree thinning is recommended to rectify the problem. The recommendation should be accompanied by an estimate of costs associated with the proposed action, a proposed schedule, and identification of possible conflicts with other restoration objectives.

Restoration Monitoring, Evaluation, and Adaptive Management

Restoration Monitoring

- *Progress Toward Objectives*
- *Regional Resource Priorities and Trends*
- *Watershed Activities*

Restoration Evaluation

- *Reasons to Evaluate Restoration Efforts*
- *A Conceptual Framework for Evaluation*

Monitoring plans should be conceived during the planning phase when the goals and performance criteria are developed for the restoration effort. Baseline studies required to provide more information on the site, to develop restoration goals, and to refine the monitoring plan often are conducted during the planning phase and can be considered the initial phase of the monitoring plan. Baseline information can form a very useful data set on prerestoration conditions against which performance of the system can be evaluated.

Monitoring during the implementation phase is done primarily to ensure that the restoration plans are correctly carried out and that the natural habitats surrounding the site are not unduly damaged.

Actual performance monitoring of the completed plan is done later in the assessment phase (**Figure 6.16**). Management of the system includes both management of the monitoring plan and application of the results to make midcourse corrections.

Finally, results are disseminated to inform interested parties of the progress of the system toward the intended goals.

Goals of a Restoration Monitoring Plan

- *Assess the performance of the restoration initiative relative to the project goals.*
- *Provide information that can be used to improve the performance of the restoration actions.*
- *Provide information about the restoration initiative in general.*

Figure 6.16: Monitoring of revegetation efforts. *Monitoring the results of revegetation efforts is a critical part of restoring riparian zones along highly eroded channels.*

Components of a Monitoring Plan

Based on a thorough review of freshwater monitoring plans, some of which had been in place for over 30 years, the National Research Council (NRC) recommended the following factors to ensure a sound monitoring plan (NRC 1990):

- Clear, meaningful monitoring plan goals and objectives that provide the basis for scientific investigation.
- Appropriate allocation of resources for data collection, management, synthesis, interpretation, and analysis.
- Quality assurance procedures and peer review.
- Supportive research beyond the primary objectives of the plan.
- Flexible plans that allow modifications where changes in conditions or new information suggests the need.
- Useful and accessible monitoring information available to all interested parties.

The box, *Developing a Monitoring Plan*, shows the monitoring steps throughout the planning and implementation of a restoration. Each step is discussed in this chapter.

When to Develop the Monitoring Plan

The monitoring plan should be developed in conjunction with planning for the restoration. Once the goals and objectives have been established in the planning phase, the condition of the system must be considered.

Baseline monitoring enables planners to identify goals and objectives and provides a basis for assessing the performance of the completed restoration. Monitoring therefore begins with the determination of baseline conditions and continues through the planning and implementation of the restoration plan.

Developing a Monitoring Plan

Step 1: Define the Restoration Vision, Goals, and Objectives

The goals set for the restoration drive the monitoring plan design. Above all, it is important to do the following:

- Make goals as simple and unambiguous as possible.
- Relate goals directly to the vision for the restoration.
- Set goals that can be measured or assessed in the plan.

Developing Performance Criteria Involves:

- *Linking criteria to restoration goals.*
- *Linking criteria to the actual measurement parameters.*
- *Specifying the bounds or limit values for the criteria.*

Step 2: Develop the Conceptual Model

A conceptual model is a useful tool for developing linkages between planned goals and parameters that can be used to assess performance. In fact, a conceptual model is a useful tool throughout the planning process. The model forces persons planning the restoration to identify direct and indirect connections among the physical, chemical, and biological components of the ecosystem, as well as the principal components on which to focus restoration and monitoring efforts.

Baseline studies might be necessary to meet the following needs:

- To define existing conditions without any actions.
- To identify actions required to restore the system to desired functions and values.
- To help design the restoration actions.
- To help design the monitoring plan.

Step 3: Choose Performance Criteria

Link Performance to Goals

A link between the performance of the system and the planned goals is critical. If the goals are stated in a clear manner and can be reworded as a set of testable hypotheses, performance criteria can be developed. *Performance criteria* are standards by which to evaluate measurable or otherwise observable aspects of the restored system and thereby indicate the progress of the system toward meeting the planned goals. The closer the tie between goals and performance criteria, the better the ability to judge the success of the restoration efforts.

Developing a Monitoring Plan

A. Planning

Step 1: Define the restoration, vision, goals, and objectives

Step 2: Develop the conceptual model

Step 3: Choose performance criteria

- Link performance to goals
- Develop the criteria
- Identify reference sites

Step 4: Choose monitoring parameters and methods

- Choose efficient monitoring parameters
- Review watershed activities
- Choose methods for sampling design, sampling, and sample handling/processing
- Conduct sociological surveys
- Rely on instream organisms for evidence of project success
- Minimize the necessary measurements of performance
- Incorporate supplemental parameters

Step 5: Estimate cost

- Cost for developing the monitoring plan itself
- Quality assurance
- Data management
- Field sampling program
- Laboratory sample analysis
- Data analysis and interpretation
- Report preparation
- Presentation of results

Step 6: Categorize the types of data

Step 7: Determine the level of effort and duration of monitoring

- Incorporate landscape ecology
- Determine timing, frequency, and duration of sampling
- Develop statistical framework
- Choose the sampling level

B. Implementing and Managing

- Manager must have a vision for the life of the monitoring plan
- Roles and responsibilities must be clearly defined
- Enact quality assurance procedures
- Interpret the results
- Manage the data
- Provide for contracts

C. Responding to the Monitoring Results

- No action
- Maintenance
- Adding, abandoning, or decommissioning plan elements
- Modification of project goals
- Adaptive management
- Documentation and reporting
- Dissemination of results

Primary Functions of Reference Sites

- *Can be used as models for developing restoration actions for a site.*
- *Provide a target to judge success or failure.*
- *Provide a control system by which environmental effects, unrelated to the restoration action, can be assessed.*

Develop the Criteria

The primary reason for implementing the monitoring plan must be kept in mind: to assess progress and to indicate the steps required to fix a system or a component of the system that is not successful.

Criteria are usually developed through an iterative process that involves listing measures of performance relative to goals and refining them to arrive at the most efficient and relevant set of criteria.

Identify Reference Sites

A reference site or sites should be monitored along with the restored site. Although pre- and post-implementation comparisons of the system are useful in documenting effects, the level of success can be judged only relative to reference systems.

Step 4: Choose Monitoring Parameters and Methods

Monitoring should include an overall assessment of the condition and development of the stream corridor relative to projected trends or "target" conditions. In some cases, this assessment may involve technical analyses of stream flow data, channel and bank condition, bedload measurements, and comparisons of periodic aerial photography to determine whether stream migration and debris storage and transport are within the range of equilibrium conditions. Monitoring may also include forest inventories, range condition assessments, evaluations of fish and wildlife habitat or populations, and measurements of fire fuel loading. In small rural or urban "greenbelt" projects, more general qualitative characterization of corridor integrity and quality might be sufficient.

Numerous monitoring programs and techniques have been developed for particular types of resources, different regions, and specific management questions. For example, general stream survey techniques are described by Harrelson et al. (1994), while a regional programmatic approach for monitoring streams in the context of forest management practices in the Northwest is described in Schuett-Hames et al. (1993). Similarly, monitoring of fish and wildlife habitat quality and availability can be approached from various avenues, ranging from direct sampling of animal populations to application of the habitat evaluation procedures developed and used by the U.S. Fish and Wildlife Service (1980a). Techniques specific to riparian zone monitoring are given by Platts et al. (1987).

Basic Questions to Ask When Selecting Methods for Monitoring

- *Does the method efficiently provide accurate data?*
- *Does the method provide reasonable and replicable data?*
- *Is the method feasible within time and cost constraints?*

Choose Efficient Monitoring Parameters

There are two critical steps in choosing efficient monitoring parameters. The first is to identify parameters to monitor. A scientifically based, relatively easily measured set of parameters that provide direct feedback on success or failure of restoration actions are identified. The NRC (1992) has recommended that at least three parameters should be selected and that they include physical, hydrological, and ecological measures. The second step is to select regional and system-specific parameters. Criteria development must be based on a thorough knowledge of the system under consideration.

Those responsible for resources in the stream corridor must be aware of changing watershed and regional resource priorities. The appropriate place to consider the implications of regional needs is in the context of periodic reevaluation of restoration objectives, which is a function of the monitoring process. Therefore, an annual monitoring report should include recognition of ongoing or proposed initiatives (e.g., changes in regulations, emphasis on restoration of specific fish populations, endangered species listings) that might influence priorities in the restored corridor. Awareness of larger regional programs may produce opportunities to secure funding to support management of the corridor.

Review Watershed Activities

The condition of the watershed controls the potential to restore and maintain ecological functions in the stream corridor. As discussed in Chapter 3, changes in land use and/or hydrology can profoundly alter basic stream interactions with the floodplain, inputs of sediment and nutrients to the system, and fish and wildlife habitat quality. Therefore, it is important that stream corridor monitoring include periodic review of watershed cover and land use, including proposed changes (**Figure 6.17**).

Figure 6.17: Urban sprawl. *Understanding changes in watershed land uses, such as increased urbanization, is an important aspect of restoration monitoring.*
Source: C. Zabawa.

Patterns of water movement through and within the stream corridor are basic considerations in developing objectives, design features, and management programs. Proposals to increase impervious surfaces, develop storm water management systems, or construct flood protection projects that reduce floodplain storage potential and increase surface and ground water consumption are all of legitimate concern to the integrity of the stream corridor. Stream corridor managers should be aware of such proposals and provide relevant input to the planning process. As changes are implemented, their probable influence on the corridor should be considered in periodic reevaluation of objectives and maintenance and management plans.

In rural settings, the corridor managers should be alert to land use changes in agricultural areas (**Figure 6.18**). Conversions between crop and pasture lands might require verification that fencing and drainage practices are consistent with agreed-upon BMPs or renegotiation of those agreements. Similarly, in wildland areas, major watershed management actions (timber har-

REVERSE

Review Chapter 3's land use and hydrology Sections.

vests, prescribed burn programs) should be evaluated to ensure that stream corridors are adequately considered.

Increasing development and urbanization may reduce the ability of the stream corridor to support a wide variety of fish and wildlife species and, at the same time, generate additional pressure for recreational uses. Awareness of development and population growth trends will allow a rational, rather than reactive, adjustment of corridor management and restoration objectives. Proposals for specific implementation activities, such as roads, bridges, or storm water detention facilities, within or near the stream corridor should be scrutinized so that concerns can be considered before authorization of the implementation.

Choose Methods for Sampling Design, Sampling, and Sample Handling and Processing

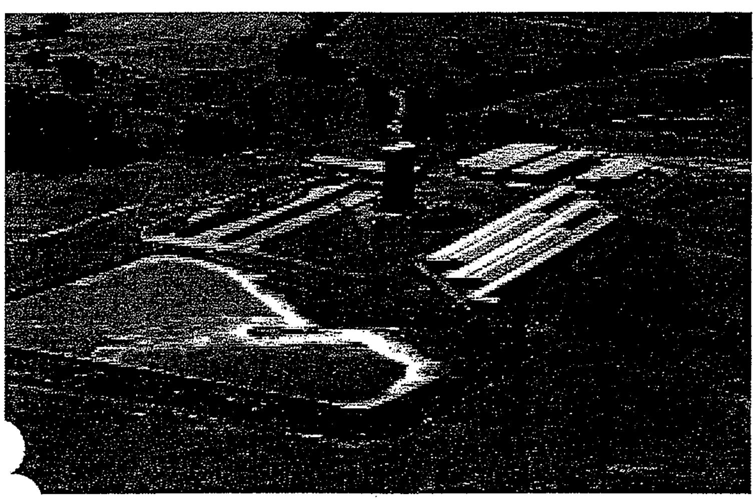
Parameters that might be included in a restoration monitoring plan are well established in the scientific literature. Any methods used for sampling a particular parameter should have a documented protocol (e.g., Loeb and Spacie 1994).

Conduct Sociological Surveys

Scientifically designed surveys can be used to determine changes in social attitudes, values, and perceptions from prerestoration planning through implementation phases. Such surveys may complement physical, chemical, and biological parameters that are normally considered in a monitoring plan. Sociological surveys can reveal important shifts in the ways a community perceives the success of a restoration effort.

Rely on Instream Organisms for Evidence of Project Success

The restoration evaluation should usually focus on aquatic organisms and instream conditions as the "judge and jury" for evaluating restoration success. Instream physical, chemical, and biological conditions integrate the other factors within the stream corridor. Instream biota, however, have shown sensitivity to complex problems not as well detected by chemical or physical indicators alone in state water quality monitoring programs. For instance, in comparing chemical and biological criteria, the state of Ohio found that biological criteria detected an impairment in 49.8 percent of the situations where no impairment was evident with chemical criteria alone. Agreement between chemical and biological criteria was evident in 47.3 percent of the cases, while chemical criteria detected an impairment in only 2.8 percent of the cases where biological criteria indicated attainment (Ohio EPA 1990). As a result, Ohio's Surface Water Monitoring and Assessment Program has recognized that biological criteria must play a key role in defining water quality standards and in evaluating and monitoring standards attainment if the goal to restore and maintain the physical, chemical, and biological integrity of Ohio's waters is to be met.



igure 6.18: onfinement farm. *ractitioners monitoring stream corridor restoration in ural areas should be ware of changes in gricultural land use.*

Minimize the Necessary Measurements of Performance

A holistic perspective is needed when monitoring restoration performance. Still, monitoring should focus narrowly on the fewest possible measurements or indicators that most efficiently demonstrate the overall condition of the stream corridor system and the success of the restoration effort. Costs and the ability to develop statistically sound data may quickly get out of hand unless the evaluation measures chosen are narrowly focused, are limited in number, and incorporate existing data and work wherever appropriate.

Existing data from state and federal agencies, community monitoring programs, educational institutions, research projects, and sportsmen's and other groups should be considered when planning for restoration evaluation. For example, turbidity data are generally more common than sediment data. If one of the objectives of a restoration effort is to reduce sediment concentrations, turbidity may provide a suitable surrogate measurement of sediment at little or no expense to restoration planners. Table 6.2 provides some other examples of restoration objectives linked to specific performance evaluation tools and measures.

Incorporate Supplemental Parameters

Although the focus of the monitoring plan is on parameters that relate directly to assessment of performance, data on other parameters are often useful and may add considerably to interpretation of the results. For example, stream flow should be monitored if water temperature is a concern.

Step 5: Estimate Cost

Various project components must be considered when developing a cost estimate. These cost components include:

General Objectives	Potential Evaluation Tools and Criteria
Channel capacity and stability	Channel cross sections
	Flood-stage surveys
	Width-to-depth ratio
	Rates of bank or bed erosion
	Longitudinal profile
	Aerial photography interpretation
Improve aquatic habitat	Water depths
	Water velocities
	Percent overhang, cover, shading
	Pool/riffle composition
	Stream temperature
	Bed material composition
	Population assessments for fish, invertebrates, macrophytes
Improve riparian habitat	Percent vegetative cover
	Species density
	Size distribution
	Age class distribution
	Plantings survival
	Reproductive vigor
	Bird and wildlife use
	Aerial photography
Improve water quality	Temperature
	pH
	Dissolved oxygen
	Conductivity
	Nitrogen
	Phosphorus
	Herbicides/pesticides
	Turbidity/opacity
	Suspended/floating matter
	Trash loading
	Odor
Recreation and community involvement	Visual resource improvement based on landscape control point surveys
	Recreational use surveys
	Community participation in management

Table 6.2: Environmental management.
Source: Kondolf and Micheli 1995.

- *Monitoring plan.* Development of a monitoring plan is an important and often ignored component of a monitoring cost assessment. The plan should determine monitoring goals, acceptable and unacceptable results, and potential contingencies for addressing unacceptable results (Figure 6.19). The plan should specify responsibilities of participants.
- *Quality assurance (QA).* The monitoring plan should include an indepen-

dent review to ensure that the plan meets the restoration goals, the data quality objectives, and the expectations of the restoration manager. The major cost component of quality assurance is labor.

- *Data management.* Monitoring plans should have data management specifications that start with sample tracking (i.e., that define the protocols and procedures) and conclude with the final archiving of the information. Major costs include staff labor time for data management, data entry, database maintenance, computer time, and data audits.
- *Field sampling plan.* Sampling may range from the very simple, such as photo monitoring, wildlife observation, and behavioral observation (e.g., feeding, resting, movement), to the more complex, such as nutrient and contaminant measurement, water quality parameter measurement, plankton group measurement, productivity measurement in water column and substrate surface, macrophyte or vegetation sampling, and hydrological monitoring. The cost components for a complex plan may include the following:
  - Restoration management and field staff labor.
  - Subcontracts for specific field sampling or measurement activities (including costs of managing and overseeing the subcontracted activities).
  - Mobilization and demobilization costs.
  - Purchase, rental, or lease of equipment.
  - Supplies.

Figure 6.19: Monitoring. *It is important to develop a framework for the monitoring protocol and a plan for monitoring evaluation.*

  - Travel.
  - Shipping.
- *Laboratory sample analysis.* Laboratory analyses can range from simple tests of water chemistry parameters such as turbidity, to highly complex and expensive tests, such as organic contaminant analyses and toxicity assays. The cost components of laboratory sample analysis are usually estimated in terms of dollars per sample.
- *Data analysis and interpretation.* Analysis and interpretation require the expertise of trained personnel and may include database management, which can be conducted by a data management specialist if the data are complex or by a technician or restoration manager if they are relatively straightforward.

- *Report preparation.* One of the final steps in the monitoring plan is to prepare a report outlining the restoration action, monitoring goals, methods, and findings. These documents are meant to serve as interpretative reports, synthesizing the field and lab data analysis results. These reports are typically prepared by a research scientist with the aid of a research assistant. Report production costs depend on the type and quality of reports requested.
- *Presentation of results.* Though not often considered a critical component of a monitoring plan, presentation of plan results should be considered, including costs for labor and travel.

Step 6: Categorize the Types of Data

Several types of data gathered as part of the monitoring plan may be useful in developing the plan or may provide additional information on the performance of the system. The restoration manager should also be aware of available information that is not part of the monitoring plan but could be useful. Consultation with agency personnel, local universities and consultants, citizen environmental groups (e.g., Audubon chapters), and landowners in the area can reveal important information.

Step 7: Determine the Level of Effort and Duration

How much monitoring is required? The answer to this question is dependent on the goals and performance criteria for the restoration as well as on the type of ecological system being restored. A monitoring plan does not need to be complex and expensive to be effective.

Incorporate Landscape Ecology

The restoration size or scale affects the complexity of the monitoring required. As heterogeneity increases, the problem of effectively sampling the entire system becomes more complex. Consideration must be given to the potential effect on the restoration success of such things as road noise, dogs, dune buggies, air pollution, waterborne contamination, stream flow diversions, human trampling, grazing animals, and myriad other elements (**Figure 6.20**).

Types of Data Important to Various Phases of the Restoration

- *Restoration Planning*
  - *Develop baseline data at the site.*
- *Implementation of Restoration Plan*
  - *Monitor implementation activities.*
  - *Collect as-built or as-implemented information.*
- *Postimplementation*
  - *Collect performance data.*
  - *Conduct other studies as needed.*

Determine Timing, Frequency, and Duration of Sampling

The monitoring plan should be carried out according to a systematic schedule. The plan should include a start date, the time of the year during which field studies should take place, the frequency of field studies, and the end date for the plan. Timing, frequency, and duration are dependent on the aspects of system type and complexity, controversy, and uncertainty.

- *Timing.* The monitoring plan should be designed prior to conducting any baseline studies. A problem often encountered with this initial sampling is seasonality. Implementation may be completed in midwinter, when vegetation and other conditions are not as relevant to the performance criteria and goals of the restoration, which might focus on midsummer conditions.

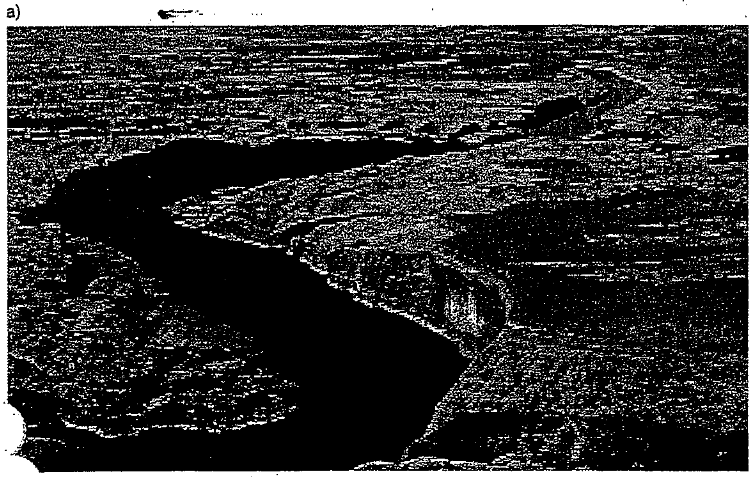
  The field studies should be carried out during an appropriate time of the year. The driving consideration is the performance criteria. Because weather varies from year to year, it is wise to "bracket" the season with the sampling. For example, sampling temperature four times during the midsummer may be better than a single sampling in the middle of the season. Sampling can be performed either by concentrating all tasks during a single site visit or by carrying out one task or a similar set of tasks at several sites in a single day.

- *Frequency.* Frequency of sampling refers to the period of time between samplings. In general, "new" systems change rapidly and should be monitored more often than older systems. As a system becomes established, it is generally less vulnerable to disturbances. Hence, monitoring can be less frequent. An example of this is annual monitoring of a marsh for the first 3 years, followed by monitoring at intervals of 2 to 5 years for the duration of the planned restoration or until the system stabilizes.

- *Duration.* The monitoring plan should extend long enough to provide reasonable assurances either that the system has met its performance criteria or that it will or will not likely meet the criteria. A restored system should be reasonably self-maintaining after a certain period of time. Fluctuations on an annual basis in some parameters of the system will occur even in the most stable mature systems. It is important for the plan to extend to a point somewhere after the period of most rapid change and into the period of stabilization of the system.

igure 6.20: Streams the (a) western d (b) eastern nited States. *The vide variability of tream structure and unction among different regions of the country makes standardized restoration evaluation difficult.*

a)



(b)

Develop a Statistical Framework

The monitoring study design needs to include consideration of statistical issues, including the location of sample collection, the number of replicate samples to collect, the sample size, and others. Decisions should be made based on an understanding of the accuracy and precision required for the data (**Figure 6.21**). The ultimate use of the data must be kept in mind when developing the sampling plan. It is useful to frequently ask, "Will this sampling method give us the answers we need for planning?" and "Will we be able to determine the success or performance of the restoration?"

Monitoring can consist of many different methods and can occur at varying locations, times, and intensities, depending on the conditions to be monitored. The costs or expenditures of time and resources also vary accordingly. The challenge is to design the monitoring plan to provide, in a cost-efficient and timely manner, accurate information to provide the rationale for decisions made throughout the planning process, and during and after implementation to assess success.

The accuracy of the data to define environmental conditions is of paramount concern, but the acceptable precision of the data can vary, depending on the target of concern. For example, if the amount of pesticides in surface water is a concern, it is much cheaper to assay for the presence of groups of pesticides than to test for specific ones. Also, if overall water quality conditions are needed, seasonal sampling of biological indicators may act as a surrogate for long-term sampling of specific chemical parameters.

Choose the Sampling Level

The appropriate level of sampling or the number of replicates under any particular field or laboratory sampling effort depends on the information required and the level of accuracy needed. Quantity and quality of information desired is in turn dependent in part on the expenditures necessary to carry out the identified components of the sampling plan.

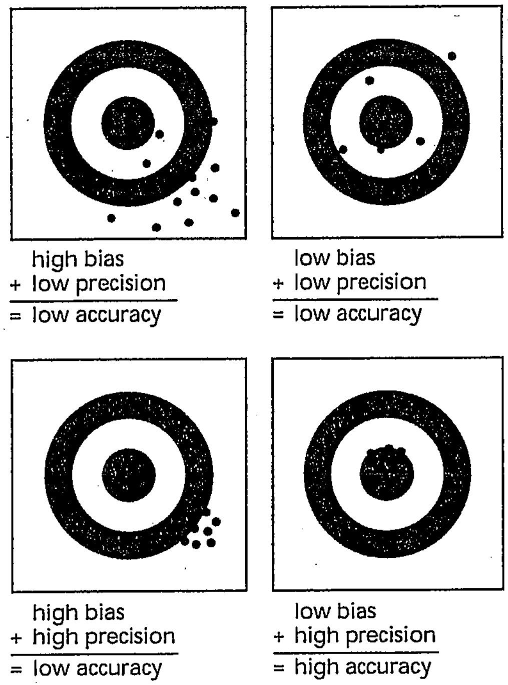


Figure 6.21: Patterns of shots at a target. *Monitoring design decisions should be made based on an understanding of the accuracy and precision required of the data.*
Source: Gilbert 1987 after Jessen 1978.

Implementing and Managing the Monitoring Plan

Management of the monitoring plan is perhaps the least appreciated but one of the most important components of restoration. Because monitoring continues well after implementation activities, there is a natural tendency for the plan to lose momentum, for the data to accumulate with little analysis, and for little documentation and dissemination of the information to occur. This section presents methods for preventing or minimizing these problems.

Envisioning the Plan

The restoration manager must have a vision of the life (i.e., duration) of the monitoring plan and must see how the plan fits into the broader topic of restoration as a viable tool for meeting the goals of participating agencies, organizations, and sponsors.

Determining Roles

Carrying out the monitoring plan is usually the responsibility of the restoration sponsor. However, responsibility should be established clearly in writing during the development of the restoration because this responsibility can last for a decade or more.

Ensuring Quality

The restoration manager should consider data quality as a high priority in the monitoring plan. Scientifically defensible data require that at least minimal quality assurance procedures be in place.

Interpreting Results

Results of the monitoring plan should be interpreted with objectivity, completeness, and relevance to the restoration objectives. The restoration manager and the local sponsor may share responsibility in interpreting the results generated by the monitoring plan. The roles of the restoration manager and local sponsor need to be determined before any data-gathering effort begins. Both parties should seek appropriate technical expertise as needed.

Managing Data

Data should be stored in a systematic and logical manner that facilitates analysis and presentation. Development of the monitoring plan should address the types of graphs and tables that will be used to summarize the results of the monitoring plan. Most monitoring data sets can be organized to allow direct graphing of the data using database or spreadsheet software.

Managing Contracts

One of the most difficult aspects of managing a monitoring plan can be management of the contracts required to conduct the plan. Most restoration requires that at least some of the work be contracted to a consultant or another agency. Because monitoring plans are frequently carried out on a seasonal basis, timing is important.

Restoration Evaluation

Directly linked to monitoring is the evaluation of the success of the restoration effort. Restoration evaluation is intended to determine whether restoration is achieving the specific goals identified during planning, namely, whether the stream corridor has reestablished and will continue to maintain the conditions desired.

Approaches to evaluation most often emphasize biological features, physical attributes, or both. The primary tool of evaluation is monitoring indicators of stream corridor structure, function, and condition that were chosen because they best estimate the degree to which restoration goals were met.

Evaluation may target certain aquatic species or communities as biological indicators of whether specific water quality or habitat conditions have been restored. Or, for example, evaluation may focus on the physical traits of the channel or riparian zone that were intentionally modified by project implementation (**Figure 6.22**). In any case, the job is not finished unless the condition and function of the modified stream corridor are assessed and adjustments, if necessary, are made. The time frame for evaluating restoration success can vary from months to years, depending on the speed of the stream system's response to the treatment applied. Therefore, performance evaluation often means a commitment to evaluate restoration long after it was implemented.

Reasons to Evaluate Restoration Efforts

The evaluation of stream corridor restoration is a key step that is often omitted. Kondolf and Micheli (1995) indicate that despite increased commitment to stream restoration, postrestoration evaluations have generally been neglected. In one study in Great Britain, only 5 of almost 100 river conservation enhancement projects had postimplementation appraisal reports (Holmes 1991).

Why do practitioners of restoration sometimes leave out the final evaluation process? One probable reason is that evaluation takes time and money and is often seen as expendable excess in a proposed restoration effort when it is misunderstood. It appears that the final restoration evaluation is sometimes abandoned so the remaining time and money can be spent on the restoration itself. Although an understandable temptation, this is not an acceptable course of action for most restoration efforts, and collectively the lack of evaluation slows the development and improvement of successful restoration techniques.

Protecting the Restoration Investment

Stream corridor restoration can be extremely costly and represent substantial financial losses if it fails to work properly. Monitoring during and after the restoration is one way to detect problems before they become prohibitively complex or expensive to correct.

Restoration may involve a commitment of resources from multiple agencies,

Figure 6.22: Instream modifications. *Restoration evaluation may focus on the physical traits of the channel that were intentionally modified during project implementation such as the riffles pictured.*

Review Chapter 5's goals and objectives section.

groups, and individuals to achieve a variety of objectives within a stream corridor. All participants have made an investment in reaching their own goals. Reaching consensus on restoration goals is a process that keeps these participants aware of each others' aims. Evaluating restoration success should maintain the existing group awareness and keep participants involved in helping to protect their own investment.

Helping to Advance Restoration Knowledge for Future Applications

Restoration actions are relatively new and evolving and have the risk of failure that is inherent in efforts with limited experience or history. Restoration practitioners should share their experiences and increase the overall knowledge of restoration practices—those that work and those that do not. Shared experience is essential to our limited knowledge base for future restoration.

Maintaining Accountability to Restoration Supporters

The coalition of forces that make a restoration effort possible can include a wide variety of interest groups, active participants, funding sources, and political backers, and all deserve to know the outcome of what they have supported. Sometimes, restoration monitoring may be strongly recommended or required by regulation or as a condition of restoration funding. For example, the USEPA has listed an evaluation and reporting plan in guidance for grants involving restoration practices to reduce nonpoint source pollution. Requirements notwithstanding, it is worthwhile to provide the restoration effort's key financial supporters and participants with a final evaluation. Other benefits such as enhancing public relations or gaining good examples of restoration successes and publishable case histories, can also stem from well-designed, well-executed evaluations.

Acting on the Results

Identified goals and objectives, as discussed in Chapter 5, should be very clear and specific concerning the resulting on-site conditions desired. However, large or complex restoration efforts are sometimes likely to involve a wide range of goals. Restoration evaluations are needed to determine whether the restoration effort is meeting and will continue to meet specific goals identified during planning, to allow for mid-

Reasons to Prepare Written Documentation for the Monitoring Plan

- *Demonstrates that the monitoring plan is "happening."*
- *Demonstrates that the restoration meets the design specifications and performance criteria.*
- *Assists in discussions with others about the restoration.*
- *Documents details that may otherwise be forgotten.*
- *Provides valuable information to new participants.*
- *Informs decision makers.*

course adjustments, and to report on any unanticipated benefits or problems as a result of the program.

The results from a monitoring plan are an important tool for assessing the progress of a restoration and informing restoration decision makers about the potential need for action.

Alternative Actions

Because restoration involves natural systems, unexpected consequences of restoration activities can occur. The four basic options available are as follows:

- *No action.* If the restoration is generally progressing as expected or if progress is slower than expected but will probably meet restoration goals within a reasonable amount of time, no action is appropriate.
- *Maintenance.* Physical actions might be required to keep restoration development on course toward its goals.
- *Adding, abandoning, or decommissioning plan elements.* Significant changes in parts of the implemented restoration plan might be needed. These entail revisiting the overall plan, as well as considering changes in the design of individual elements.
- *Modification of restoration goals.* Monitoring might indicate that the restoration is not progressing toward the original goals, but is progressing toward a system that has other highly desirable functions. In this case, the participants might decide that the most cost-effective action would be to modify the restoration goals rather than to make extensive physical changes to meet the original goals for the restoration.

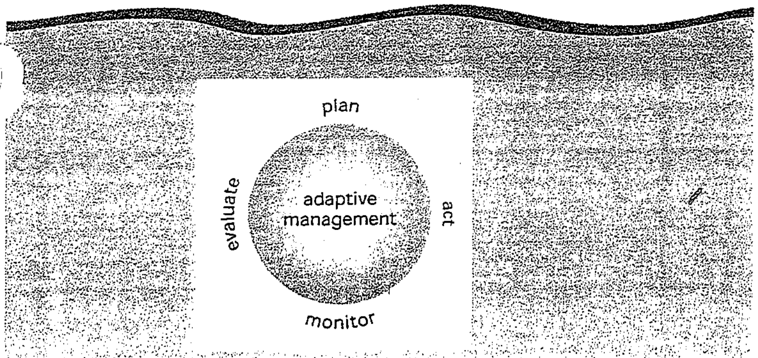
Adaptive Management

The expectations created during the decision to proceed with restoration might not always influence the outcome, but they are certainly capable of influencing the opinions of participants and clients concerning the outcome. The first fundamental rule, then, is to set proper expectations for the restoration effort. If the techniques to be used are experimental, have some risk of failure, or are likely to need midcourse corrections, these facts need to be made clear. One effective way to set reasonable expectations from the beginning is to acknowledge uncertainty, evaluation of performance, and adjustments as part of the game plan.

Adaptive management is not "adjustment management" but a way of establishing hypotheses early in the planning, then treating the restoration process as an experiment to test the hypotheses.

Adaptive management involves adjusting management direction as new information becomes available (**Figure 6.23**). It requires willingness to experiment scientifically and prudently, and to accept occasional failures (Interagency Ecosystem Management Task Force 1995). Since restoration is a new science with substantial uncertainty, adaptive management to incorporate new midcourse information should be expected. Moreover, through adaptive management specific problems can be focused on and corrected.

It is recognized that restoration is uncertain. Therefore, it is prudent to allow for contingencies to address problems during or after restoration implementation. The progress of the system should be assessed annually. At that time, deci-



- Modify plans using monitoring, technical, and social feedback
- Track restoration policy, programs, and individual projects as feedback for further restoration policy and program redesign
- Restoration initiatives: recommend annual assessments
  - use monitoring data and other data/expertise
  - midcourse corrections or alternative actions
  - link reporting/monitoring schedules for midcourse corrections
- Manager may contract some/all monitoring, but periodically must visit sites, review reports, discuss with contractors.

Figure 6.23: Adaptive management. *Adjusting management direction as new information becomes available requires a willingness to experiment and accept occassional failures.*

sions can be made regarding any midcourse corrections or other alternative actions, including modification of goals. The annual assessments would use monitoring data and might require additional data or expertise from outside the restoration team. Because the overall idea is to make the restoration "work," while not expending large amounts of funds to adhere to inflexible and unrealistic goals, decisions would be made regarding the physical actions that might be needed versus alterations in restoration goals.

Restoration participants must remain willing to acknowledge failures and to learn from them. Kondolf (1995) emphasizes that even if restoration fails, it provides valuable experimental results that can help in the design of future efforts. Repeatedly, a cultural reluctance to admit failure perpetuates the same mistakes instead of educating others about pitfalls that might affect their efforts, too. Accepting failure reiterates the importance of setting appropriate expectations. Participants should all acknowledge that failure is one of the possible outcomes of restoration. Should failure occur, they should resist the natural temptation to bury their disappointment and instead help others to learn from their experience.

Documenting and Reporting

The monitoring report should also include a systematic review of changes in resource management priorities and watershed conditions along with a discussion of the possible implications for restoration measures and objectives. The review should be wide-ranging, including observations and concerns that might not require immediate attention but should be documented to ensure continuity in case of turnover in personnel. The monitoring report should alert project managers to proposed developments or regulation changes that could affect the restoration effort, so that feedback can be provided and stream corridor concerns can be considered during planning for the proposed developments.

Documentation and reporting of the progress and development of the restoration provide written evidence that the restoration manager can use for a variety of purposes. Three simple concepts are common among the best-documented restorations:

- A single file that was the repository of all restoration information was developed.
- The events and tasks of the restoration were recorded chronologically in a systematic manner.
- Well-written documents (i.e., planning and monitoring documents) were produced and distributed widely enough to become part of the general regional or national awareness of the restoration.

Main sections in a general format for a monitoring report should include title page, summary or abstract, introduction, site description, methods, results, discussion, conclusions, recommendations, acknowledgments, and literature cited.

Dissemination of the Results

Recipients of the report and other monitoring information should include all interested parties (e.g., all state and federal agencies involved in a permit action). In addition, complete files should be maintained. The audience can include beach-goers, birders, fishers, developers, industry representatives, engineers, government environmental managers, politicians, and scientists. The recipient list and schedule for delivery of the reports should be developed by the restoration manager. If appropriate, a meeting with interested parties should be held to present the results of the monitoring effort and to discuss the future of the restoration. Large, complex, and expensive restorations might have wide appeal and interest, and meetings on these restorations will require more planning. Presentations should be tailored to the audience to provide the information in the clearest and most relevant form.

Planning for Feedback During Restoration Implementation

A sound quality control/quality assurance component of the restoration plan incorporates the means to measure and control the quality of an activity so that it meets expectations (USEPA 1995a). Especially in restoration efforts that involve substantial earthmoving and other major structural modifications, risk of unintentional damage to water quality or aquatic biota exists. Midcourse monitoring should be part of the plan, both to guard against unexpected additional damage and to detect positive improvements (**Figure 6.24**).

Making a Commitment to the Time Frame Needed to Judge Success

The time required for system recovery should be considered in determining the frequency of monitoring.

- Data on fractions of an hour might be needed to characterize streamflow.

Figure 6.24: Streambank failure. *Midcourse monitoring will guard against unexpected damages.*

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- Hourly data might be needed for water temperature and water quality.
- Weekly data might be appropriate to show changes in the growth rate of aquatic organisms.
- Monthly or quarterly data might be necessary to investigate annual cycles.
- Annual measures might be adequate to show the stability of streambanks.
- Organisms with long life spans, such as paddlefish or trees, might need to be assessed only on the order of decades (Figure 6.25).

The time of day for measurement should also be considered. It might be most appropriate to measure dissolved oxygen at dawn, whereas temperature might be measured most appropriately in the mid- to late afternoon. Migrations or climatic patterns might require that studies be conducted during specific months or seasons. For example, restoration efforts expected to result in increased baseflow might require studies only in late summer and early fall.

The expected time for recovery of the stream corridor could involve years or decades, which should be addressed in the duration of the study and its evaluation. Moreover, if the purpose of restoration is to maintain natural floodplain functions during a 10-year flood event, it might take years for such an event to occur and allow a meaningful evaluation of performance.

Some efforts have been made to integrate short- and long-term performance monitoring requirements into overall design. Bryant (1995) recently presented the techniques of a pulsed monitoring strategy involving a series of

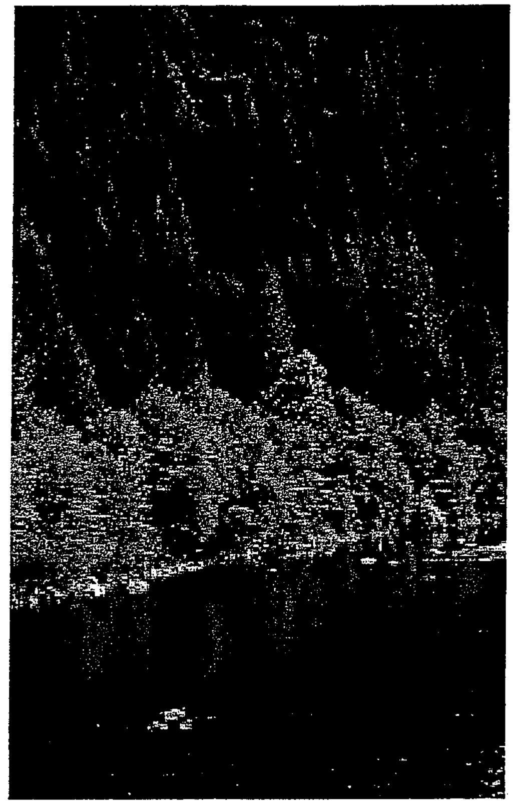


Figure 6.25: Revegetated streambank. *Monitoring and evaluation must take into account the differences in life spans among organisms. Tree growth along the streambank will be evaluated on a much longer time scale than other restoration results.*

short-term, high-intensity studies separated by longer periods of low-intensity data collection. MacDonald et al. (1991) have described several different types of monitoring by frequency, duration, and intensity.

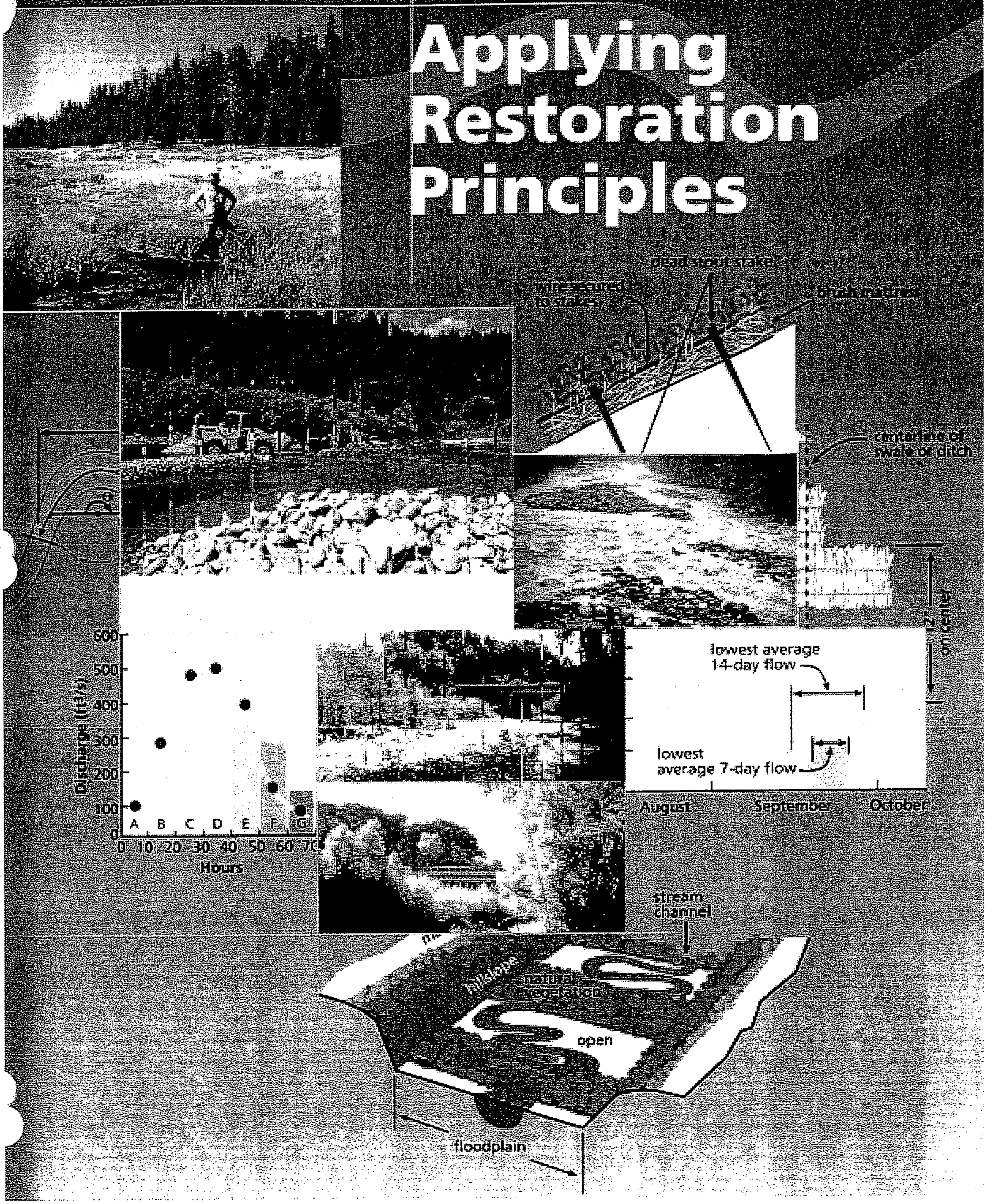
Evaluating Changes in the Sources of Stress as Well as in the System Itself

Restoration might be necessary because of stress currently affecting the stream corridor or because of damage in the past. It is critical to know whether the sources of stress are still present or are absent, and to incorporate treatment of the sources of stress as part of the restoration approach. In fact, some practitioners will not enter into a restoration effort that does not include reducing or eliminating the source of negative impacts because simply improving the stream itself will likely result in only temporary enhancements.

The beginning steps of ecological risk assessment are largely designed around characterization of an ecosystem's valued features, characterization of the stressors degrading the ecosystem, identification of the routes of exposure of the ecosystem to the stressors, and description of ecological effects that might result. If these factors are documented for restoration during its design and execution, it should be clear how evaluating performance should address each factor after completion. Has the source of stress, or its route of exposure, been diminished or eliminated? Are the negative ecological effects reversed or no longer present?

Part III

Applying Restoration Principles

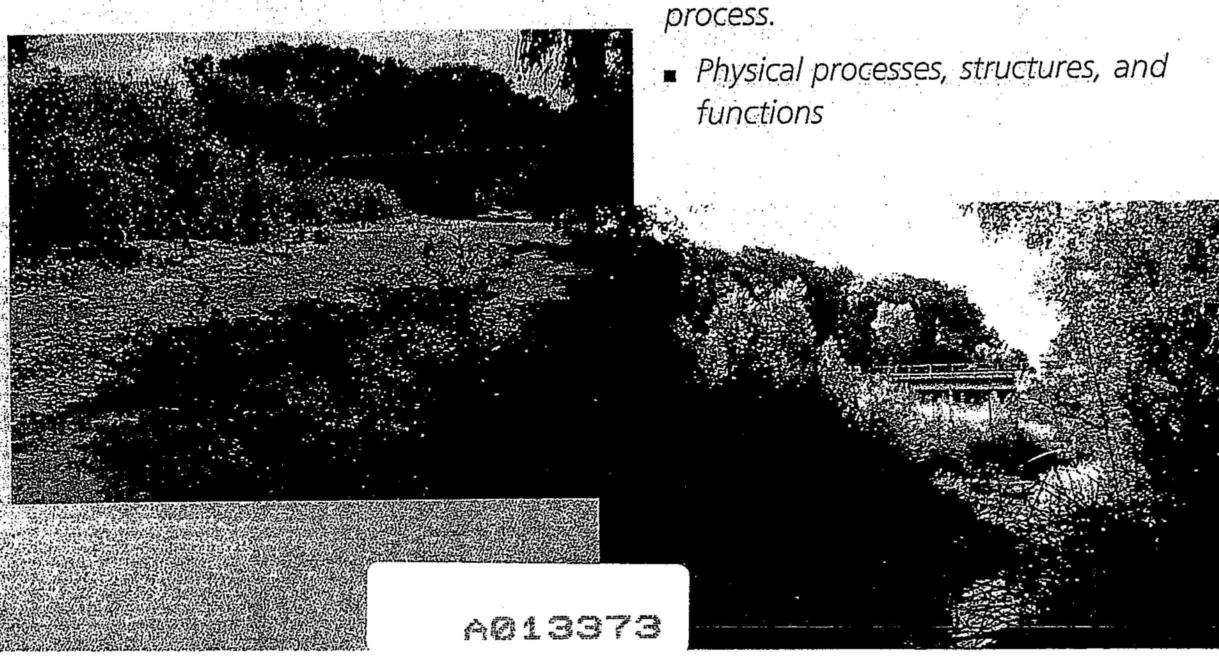


Applying Restoration Principles

Stream corridor functions are recognizable and definable for the smallest study area as well as for eco-regional levels. Because a corridor functions at all scales, the principles of restoration should be applied using those appropriate to the scale of concern.

Part III of this document is the "how to" section. The understanding gained in Part I and developed into a restoration plan in Part II is applied. Part III shows how condition analysis and design can lead to restoring corridor structure and the habitat, conduit, filter/barrier, source, and sink functions.

- ***Chapter 7*** *discusses the measurement and analysis of corridor condition. The analysis is broken down by scale and process.*
  - *Physical processes, structures, and functions*



- *Geomorphic and hydrological*
- *Water chemistry*
- *Biological analysis*

This breakdown allows the generation of a "picture" of stream corridor conditions that comes into clearer focus as one descends in scale from maps and aerial photographs to the streambed.

- ***Chapter 8*** *contains design guidance and techniques to restore stream corridor structure and functions. It is not, however, a cookbook of prescribed solutions.*
- ***Chapter 9*** *deals with construction topics that can occur after the stream corridor restoration design is complete and required permits are obtained. Careful construction and field inspection are necessary to ensure that the corridor is not degraded by construction activities. At the end of successful restoration, the stream must be managed, maintained, and monitored to ensure goals and objectives are being met.*

7 Analysis of Corridor Condition

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7.A Hydrologic and Hydraulic Processes

- *How does the stream flow and why is this understanding important?*
- *Is streamflow perennial, ephemeral or intermittent?*
- *What is the discharge, frequency and duration of extreme high and low flows?*
- *How often does the stream flood?*
- *How does roughness affect flow levels?*
- *What is the discharge most effective in maintaining the stream channel under equilibrium conditions?*
- *How does one determine if equilibrium conditions exist?*
- *What field measurements are necessary?*

7.B Geomorphic Processes

- *How do I inventory geomorphic information on streams and use it to understand and develop physically appropriate restoration plans?*
- *How do I interpret the dominant channel adjustment processes active at the site?*
- *How deep and wide should a stream be?*
- *Is the stream stable?*
- *Are basin-wide adjustments occurring, or is this a local problem?*
- *Are channel banks stable, at-risk, or unstable?*
- *What measurements are necessary?*

7.C Chemical Processes

- *How do you measure the condition of the physical and chemical conditions within a stream corridor?*
- *Why is quality assurance an important component of stream corridor analysis activities?*
- *What are some of the water quality models that can be used to evaluate water chemistry data?*

7.D Biological Characteristics

- *What are some important considerations in using biological indicators for analyzing stream corridor conditions?*
- *Which indicators have been used successfully?*
- *What role do habitat surveys play in analyzing the biological condition of the stream corridor?*
- *How do you measure biological diversity in a stream corridor?*
- *What is the role of stream classification systems in analyzing stream corridor conditions?*
- *How can models be used to evaluate the biological condition of a stream corridor?*
- *What are the characteristics of models that have been used to evaluate stream corridor conditions?*

7 Analysis of Corridor Condition

Section 7.A: Hydrologic Processes

Understanding how water flows into and through stream corridors is critical to developing restoration initiatives. How fast, how much, how deep, how often, and when water flows are important basic questions that must be answered in order to make appropriate decisions about the implementation of a stream corridor's restoration.

Section 7.B: Geomorphic Processes

This section combines the basic hydrologic processes with the physical or geomorphic functions and characteristics. Water flows through streams but is affected by the kinds of soils and alluvial features within the channel, in the floodplain, and in the uplands. The amount and kind of sediments carried by a stream is largely a determinant of its equilibrium characteristics, including size, shape, and profile. Successful implementation of the stream corridor restoration, whether active (requiring direct intervention) or passive, (removing only disturbance factors), depends on an understanding of how water and sediment are related to channel form and function, and on what processes are involved with channel evolution.

Section 7.C: Chemical Characteristics

The quality of water in the stream corridor is normally a primary objective of restoration, either to improve it to a desired condition, or to sustain it. Restoration initiatives should consider the physical and chemical characteristics that may not be readily apparent but that are nonetheless critical to the functions and processes of stream corridors. Chemical manipulation of specific characteristics usually involves the management or alteration of elements in the landscape or corridor.

Section 7.D: Biological Characteristics

The fish, wildlife, plants, and human beings that use, live in, or just visit the stream corridor are key elements to consider, not only in terms of increasing populations or species diversity, but also in terms of usually being one of the primary goals of the restoration effort. A thorough understanding of how water flows, how sediment is transported, and how geomorphic features and processes evolve is important. However, a prerequisite to successful restoration is an understanding of the living parts of the system and how the physical and chemical processes affect the stream corridor.

Flow Analysis

Restoring stream structure and function requires knowledge of flow characteristics. At a minimum, it is helpful to know whether the stream is perennial, intermittent, or ephemeral, and the relative contributions of baseflow and stormflow in the annual runoff. It might also be helpful to know whether streamflow is derived primarily from rainfall, snowmelt, or a combination of the two.

Other desirable information includes the relative frequency and duration of extreme high and low flows for the site and the duration of certain stream flow levels. High and low flow extremes usually are described with a statistical procedure called a frequency analysis, and the amount of time that various flow levels are present is usually described with a flow duration curve.

Finally, it is often desirable to estimate the channel-forming or dominant discharge for a stream (i.e., the discharge that is most effective in shaping and maintaining the natural stream channel). *Channel-forming* or *dominant discharge* is used for design when the restoration includes channel reconstruction.

Estimates of streamflow characteristics needed for restoration can be obtained from stream gauge data. Procedures for determining flow duration characteristics and the magnitude and frequency of floods and low flows at gauged sites are described in this section. The procedures are illustrated using daily mean flows and annual peak flows (the maximum discharge for each year) for the Scott River near Fort Jones, a 653-square-mile watershed in northern California.

Most stream corridor restoration initiatives are on streams or reaches that lack systematic stream gauge data. Therefore, estimates of flow duration and the frequency of extreme high and low flows must be based on indirect methods from regional hydrologic analysis. Several methods are available for indirect estimation of mean annual flow and flood characteristics; however, few methods have been developed for estimating low flows and general flow duration characteristics.

Users are cautioned that statistical analyses using historical streamflow data need to account for watershed changes that might have occurred during the period of record. Many basins in the United States have experienced substantial urbanization and development; construction of upstream reservoirs, dams, and storm water management structures; and construction of levees or channel modifications. These features have a direct impact on the statistical analyses of the data for peak flows, and for low flows and flow duration curves in some instances. Depending on basin modifications and the analyses to be performed, this could require substantial time and effort.

Flow Duration

The amount of time certain flow levels exist in the stream is represented by a *flow duration curve* which depicts the percentage of time a given streamflow was equaled or exceeded over a given period. Flow duration curves are usually based on daily streamflow (a record containing the average flow for each day) and describe the flow characteristics of a stream throughout a range of discharges without regard to the sequence of occurrence. A flow duration curve is the cumulative histogram of the set of all daily flows. The construction of flow duration curves is described by Searcy (1959), who recommends defining the cumulative histogram of streamflow by using 25 to 35 well-distributed class intervals of streamflow data.

Figure 7.1 is a flow duration curve that was defined using 34 class intervals and software documented by Lumb et al. (1990). The numerical output is provided in the accompanying table.

The curve shows that a daily mean flow of 1,100 cubic feet per second (cfs) is exceeded about 20 percent of the time or by about 20 percent of the observed daily flows. The long-term mean daily flow (the average flow for the period of record) for this watershed was determined to be 623 cfs. The duration curve shows that this flow is exceeded about 38 percent of the time.

For over half the states, the USGS has published reports for estimating flow duration percentiles and low flows at ungauged locations. Estimating flow duration characteristics at ungauged sites usually is attempted by adjusting data from a nearby stream gauge in a hydrologically similar basin. Flow duration characteristics from the stream gauge record are expressed per unit area of drainage basin at the gauge (i.e., in cfs/mi^2) and are multiplied by the drainage area of the ungauged site to estimate flow duration characteristics there. The accuracy of such a procedure is directly related to the similarity of the two sites. Generally, the drainage area at the stream gauge and ungauged sites should be fairly similar, and streamflow characteristics should be similar for both sites. Additionally, mean basin elevation and physiography should be similar for both sites. Such a procedure does not work well and should not be attempted in stream systems dominated by local convective storm runoff or where land uses vary significantly between the gauged and ungauged basins.

Flow Frequency Analysis

The frequency of floods and low flows for gauged sites is determined by analyzing an annual time series of maximum or minimum flow values (a chronological list of the largest or smallest flow that occurred each year). Although previously described in Chapter 1, *flow frequency* is redefined here because of its relevance to the sections that follow. Flow frequency is defined as the probability or percent chance of a given flow's being exceeded or not exceeded in any given year. Flow frequency is often expressed in terms of *recurrence interval* or the average number of years between exceeding or not exceeding the given flows. For example, a given flood flow that has a 100-year recurrence interval is expected to be exceeded, on average, only once in any 100-year period; that is, in any given year, the annual flood flow has a 1 percent chance or 0.01 probability of exceeding the 100-year flood. The exceedance probability, p, and the recurrence interval, T, are related in that one is the reciprocal of the other (i.e., $T = 1/p$). Statistical procedures for determining the frequency of floods and low flows at gauged sites follow.

As mentioned earlier, most stream corridor restoration initiatives are on streams or reaches lacking systematic stream gauge data; therefore, estimates of flow duration characteristics and the frequency of extreme high and extreme low flows must be based on indirect methods from regional hydrologic analysis.

Flood Frequency Analysis

Guidelines for determining the frequency of floods at a particular location using streamflow records are documented by the Hydrology Subcommittee of the Interagency Advisory Committee on Water Data (IACWD 1982, Bulletin 17B). The guidelines described in Bulletin 17B are used by all federal agencies in planning activities involving water and related land resources. Bulletin 17B recommends fitting the Pearson Type III frequency distribution to the logarithms of the annual peak flows using sample statistics (mean, standard deviation, and skew) to estimate the distribution parameters. Procedures for outlier detection and adjustment, adjustment for historical data, development of generalized skew, and weighting of station and generalized skews are provided. The station skew is computed from the observed peak flows, and the generalized skew is a regional estimate determined from estimates at several long-term stations in the region. The US Army Corps of Engineers also has produced a user's manual for *flood frequency analysis* (Report CPD-13, 1994) that can aid in determining flood frequency distribution parameters. NRCS has also produced a manual (*National Engineering Handbook*, Section 4, Chapter 18) that can also be used in determining flood frequency distribution (USDA-SCS 1983).

Throughout the United States, flood frequency estimates for USGS gauging stations have been correlated with certain climatic and basin characteristics. The result is a set of regression equations that can be used to estimate flood magnitude for various return periods in ungauged basins (Jennings et al. 1994). Reports outlining these equations often are prepared for state highway departments to help them size culverts and rural road bridge openings.

Estimates of the frequency of peak flows at ungauged sites may be made by using these regional regression equa-

River Basin	a	b
Southeastern PA	61	0.82
Upper Salmon River, ID	36	0.68
Upper Green River, WY	28	0.69
San Francisco Bay Region, CA	53	0.93

$Q_{bf} = aA^b$

Figure 7.1: Flow duration curve and associated data tables. *Data for the Scott River, near Fort Jones, CA, 1951–1980, show that a flow of 1,100 cubic feet per second (cfs) is exceeded about 20 percent of the time.* Source: Lumb et al. (1990).

Sources of Daily Mean Discharge and Other Data from USGS Stream Gauges

Daily Mean Streamflow

Daily mean streamflow data needed for defining flow duration curves are published on a water-year (October 1 to September 30) basis for each state by the U.S. Geological Survey (USGS) in the report series Water Resources Data. The data collected and published by the USGS are archived in the National Water Information System (NWIS).

The USGS currently provides access to streamflow data by means of the Internet. The USGS URL address for access to streamflow data is http://water.usgs.gov. Approximately 400,000 station years of historical daily mean flows for about 18,500 stations are available through this source. The USGS data for the entire United States are also available from commercial vendors on two CD-ROMs, one for the eastern and one for the western half of the country (e.g., CD-ROMs for DOS can be obtained from Earth Info, and CD-ROMs for Windows can be obtained from Hydrosphere Data Products. Both companies are located in Boulder, Colorado.)

In addition to the daily mean flows, summary statistics are also published for active streamflow stations in the USGS annual Water Resources Data reports. Among the summary statistics are the daily mean flows that are exceeded 10, 50, and 90 percent of the time of record. These durations are computed by ranking the observed daily mean flows from $q_{(1)}$ *to* $q_{(n \cdot 365)}$ *where n is the number of years of record,* $q_{(1)}$ *is the largest observation, and* $q_{(365 \cdot n)}$ *is the smallest observation. The ranked list is called a set of ordered observations. The* $q_{(i)}$ *that are exceeded 10, 50, and 90 percent of the time are then determined. Flow duration percentiles (quantiles) for gauged sites are also published by USGS in reports on low flow frequency and other streamflow statistics (e.g., Atkins and Pearman 1994, Zalants 1991, Telis 1991, and Ries 1994).*

Peak Flow

Annual peak flow data needed for flood frequency analysis are also published by the USGS, archived in NWIS, and available through the internet at the URL address provided above. Flood frequency estimates at gauged sites are routinely published by USGS as part of cooperative studies with state agencies to develop regional regression equations for ungauged watersheds. Jennings et al. (1994) provide a nationwide summary of the current USGS reports that summarize flood frequency estimates at gauged sites as well as regression equations for estimating flood peak flows for ungauged watersheds. Annual and partial-duration (peaks-above-threshold) peak flow data for all USGS gauges can be obtained on one CD-ROM from commercial vendors.

tions, provided that the gauged and ungauged sites have similar climatic and physiographic characteristics.

Frequently the user needs only such limited information as mean annual precipitation, drainage area, storage in lakes and wetlands, land use, major soil types, stream gradients, and a topographic map to calculate flood magnitudes at a site. Again, the accuracy of the procedure is directly related to the hydrologic similarity of the two sites.

Similarly, in many locations, flood frequency estimates from USGS gauging stations have been correlated with certain channel geometry characteristics. These correlations produce a set of regression equations relating some channel feature, usually active channel width, to flood magnitudes for various return periods. A review of these equations is provided by Wharton (1995). Again, the standard errors of the estimate might be large.

Regardless of the procedure or source of information chosen for obtaining flood frequency information, estimates for the 1.5, 2, 5, 10, 25, and (record permitting) 50 and 100-year flood events may be plotted on standard log-probability paper, and a smooth curve may be drawn between the points. (Note that these are flood events with probabilities of 67, 50, 20, 10, 4, 2, and 1 percent, respectively.) This plot becomes the flood frequency relationship for the restoration site under consideration. It provides the background information for determining the frequency of inundation of surfaces and vegetation communities along the channel.

Low-Flow Frequency Analysis

Guidelines for *low-flow frequency analysis* are not as standardized as those for flood frequency analysis. No single frequency distribution or curve-fitting method has been generally accepted.

Flood Frequency Estimates

Flood frequency estimates also may be generated using precipitation data and applicable watershed runoff models such as HEC-1, TR-20, and TR-55. The precipitation record for various return-period storm events is used by the watershed model to generate a runoff hydrograph and peak flow for that event. The modeled rainfall may be from historical data or from an assumed time distribution of precipitation (e.g., a 2-year, 24-hour rainfall event). This method of generating flood frequency estimates assumes the return period of the runoff event equals the return period of the precipitation event (e.g., a 2-year rainfall event will generate a 2-year peak flow). The validity of this assumption depends on antecedent moisture conditions, basin size, and a number of other factors.

Vogel and Kroll (1989) provide a summary of the limited number of studies that have evaluated frequency distributions and fitting methods for low flows. The methodology used by USGS and USEPA is described below.

The hypothetical daily hydrograph shown in **Figure 7.2** is typical of many areas of the United States where the annual minimum flows occur in late summer and early fall. The climatic year (April 1 to March 31) rather than the water year is used in low-flow analyses so that the entire low-flow period is contained within one year.

Data used in low-flow frequency analyses are typically the annual minimum average flow for a specified number of consecutive days. The annual minimum 7- and 14-day low flows are illustrated in Figure 7.2. For example, the annual minimum 7-day flow is the annual minimum value of running 7-day means.

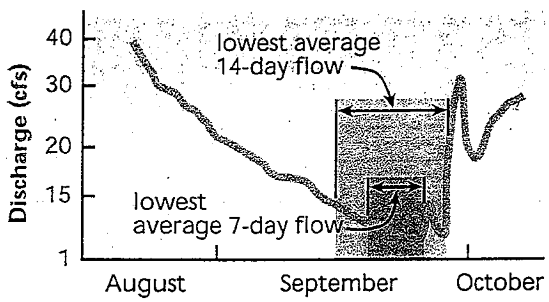

Figure 7.2: ***Annual hydrograph displaying low flows.*** *The daily mean flows on the lowest part of the annual hydrograph are averaged to give the 7-day and 14-day low flows for that year.*

USGS and USEPA recommend using the Pearson Type III distribution to the logarithms of annual minimum d-day low flows to obtain the flow with a nonexceedance probability p (or recurrence interval T = 1/p). The Pearson Type III low-flow estimates are computed from the following equation:

$$X_{d,T} = M_d - K_T S_d$$

where:

$X_{d,T}$ = the logarithm of the annual minimum d-day low flow for which the flow is not exceeded in 1 of T years or which has a probability of p = 1/T of not being exceeded in any given year

M_d = the mean of the logarithms of annual minimum d-day low flows

S_d = the standard deviation of the logarithms of the annual minimum d-day low flows

K_T = the Pearson Type III frequency factor

The desired quantile, $Q_{d,T}$, can be obtained by taking the antilogarithm of the equation.

The 7-day, 10-year low flow ($Q_{7,10}$) is used by about half of the regulatory agencies in the United States for managing water quality in receiving waters (USEPA 1986, Riggs et al. 1980). Low flows for other durations and frequencies are used in some states.

Computer software for performing low-flow analyses using a record of daily mean flows is documented by Hutchison (1975) and Lumb et al. (1990). An example of a low-flow frequency curve for the annual minimum 7-day low flow is given in **Figure 7.3** for Scott River near Fort Jones, California, for the same period (1951 to 1980) used in the flood frequency analyses above.

From Figure 7.3, one can determine that the $Q_{7,10}$ is about 20 cfs, which is comparable to the 99th percentile (daily mean flow exceeded 99 percent of the time) of the flow duration curve (Figure 7.1). This comparison is consistent with findings of Fennessey and Vogel (1990), who concluded that the $Q_{7,10}$ from 23 rivers in Massachusetts was approximately equal to the 99th flow duration percentile. The USGS routinely publishes low flow estimates at gauged sites (Zalants 1991, Telis 1991, Atkins and Pearman 1994).

Following are discussions of different ways to look at the flows that tend to form and maintain streams. Restorations that include alterations of flows or changes in the dimensions of the stream must include engineering analyses as described in Chapter 8.

Channel-forming Flow

The *channel-forming* or *dominant discharge* is a theoretical discharge that if constantly maintained in an alluvial stream over a long period of time would produce the same channel geometry that is produced by the long-term natural hydrograph. Channel-forming discharge is the most commonly used single independent variable that is found to govern channel shape and form. Using a channel-forming discharge to design channel geometry is

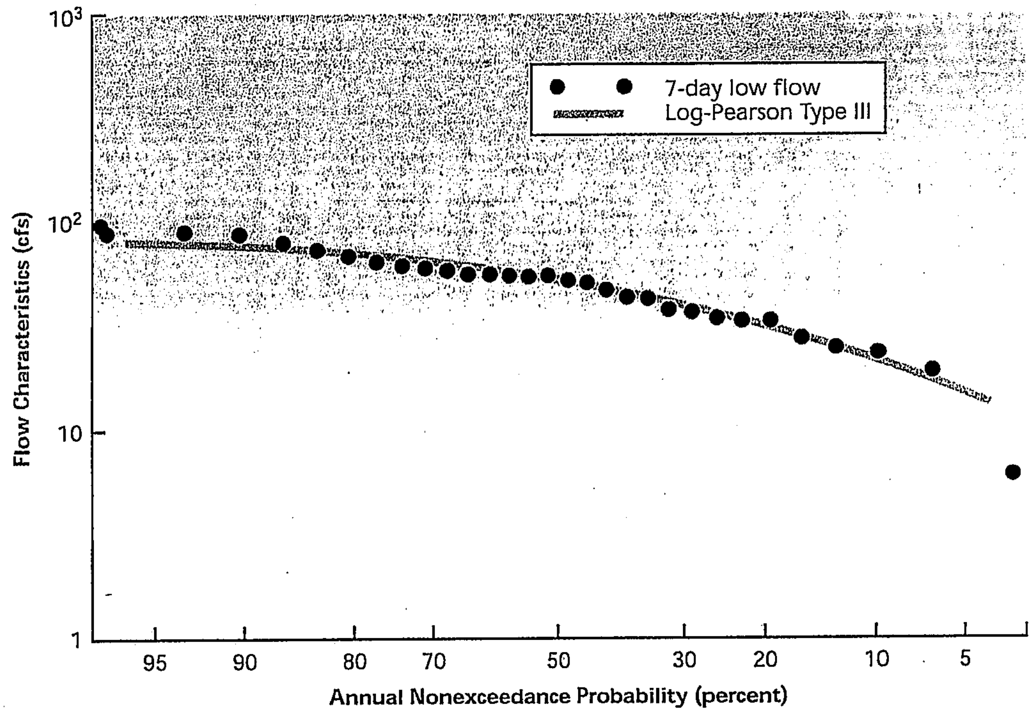

Figure 7.3: Annual minimum 7-day low flow frequency curve. The $Q_{7,10}$ on this graph is about 20 cfs. The annual minimum value of 7-day running means for this gauge is about 10 percent.

not a universally accepted technique, although most river engineers and scientists agree that the concept has merit, at least for perennial (humid and temperate) and perhaps ephemeral (semiarid) rivers. For arid channels, where runoff is generated by localized high-intensity storms and the absence of vegetation ensures that the channel will adjust to each major flood event, the channel-forming discharge concept is generally not applicable.

Natural alluvial rivers experience a wide range of discharges and may adjust their geometry to flow events of different magnitudes by mobilizing either bed or bank sediments. Although Wolman and Miller (1960) noted that "it is logical to assume that the channel shape is affected by a range of flows rather than a single discharge," they concurred with the view put forward earlier by civil engineers working on "regime theory" that the channel-forming or dominant discharge is the steady flow that produces the same gross channel shapes and dimensions as the natural sequence of events (Inglis 1949). Wolman and Miller (1960) defined "moderate frequency" as events occurring "at least once each year or two and in many cases several or more times per year." They also considered the sediment load transported by a given flow as a percentage of the total amount of sediment carried by the river during the period of record. Their results, for a variety of American rivers located in different climatic and physiographic regions, showed that the greater part (that is, 50 percent or more) of the total sediment load was carried by moderate flows rather than catastrophic floods. Ninety percent of the load was carried by events with a return period of less than 5 years. The precise form of the cumulative curve actually depends on factors such as the predominant mode of transport (bed load, suspended load, or mixed load) and the flow variability, which is influenced by the size and hydrologic characteristics of the watershed. Small watersheds generally experience a wider range of flows than large watersheds, and this tends to increase the proportion of sediment load carried by infrequent events. Thorough reviews of arguments about the conceptual basis of channel-forming discharge theory can be found in textbooks by Richards (1982), Knighton (1984), and Summerfield (1991).

Researchers have used various discharge levels to represent the channel-forming discharge. The most common are (1) bankfull discharge, (2) a specific discharge recurrence interval from the annual peak or partial duration frequency curves, and (3) effective discharge. These approaches are frequently used and can produce a good approximation of the channel-forming discharge in many situations; however, as discussed in the following paragraphs, considerable uncertainties are involved in all three of these approaches. Many practitioners are using specific approaches to determine channel-forming discharge and the response of stream corridors. Bibliographic information on these methods is available later in the document.

Because of the spatial variability within a given geographical region, the response of any particular stream corridor within the region can differ from that expected for the region as a whole. This is especially critical for streams draining small, ungauged drainage areas. Therefore, the expected channel-forming discharge of ungauged areas should be estimated by more than one alternative method, hopefully leading to consistent estimates.

Bankfull Discharge

The *bankfull discharge* is the discharge that fills a stable alluvial channel up to the elevation of the active floodplain. In many natural channels, this is the discharge that just fills the cross section without overtopping the banks, hence the term "bankfull." This discharge is considered to have morphological significance because it represents the breakpoint between the processes of channel formation and floodplain formation. In stable alluvial channels, bankfull discharge corresponds closely with effective discharge and channel-forming discharge.

The stage vs. discharge or rating curve presented in **Figure 7.4** was developed for a hypothetical stream by computing the discharge for different water surface elevations or stages. Since discharges greater than bankfull spread across the active floodplain, stage increases more gradually with increasing discharge above bankfull than below bankfull, when flows are confined to the channel. Another method for determining the bankfull stage and discharge is to determine the minimum value on a plot relating water surface elevation to the ratio of surface width to area. The frequency of the bankfull discharge can be determined from a frequency distribution plot like Figure 7.1.

Bankfull stage can also be identified from field indicators of the elevation of the active floodplain. The corresponding bankfull discharge is then determined from a stage vs. discharge relationship.

Field Indicators of Bankfull Discharge

Various field indicators can be used for estimating the elevation of the stage associated with bankfull flow. Although the first flat depositional surface is often used, the identification of depositional surfaces in the field can be difficult and misleading and, at the very least, requires trained, experienced field personnel. After an elevation is selected as the bankfull, the stage vs. discharge curve can be computed to determine the magnitude of the discharge corresponding to that elevation.

The above relationships seldom work in incised streams. In an incised stream, the top of the bank might be a terrace (an abandoned floodplain), and indicators of the active floodplain might be found well below the existing top of bank. In this situation, the elevation of the channel-forming discharge will be well below the top of the bank. In addition, the difference between the ordinary use of the term "bankfull" and the geomorphic use of the term can cause major communication problems.

Field identification of bankfull elevation can be difficult (Williams 1978), but is usually based on a minimum width/depth ratio (Wolman 1955), together with the recognition of some discontinuity in the nature of the channel banks such as a change in its sedimentary or vegetative characteristics. Others have defined bankfull discharge as follows:

- Nixon (1959) defined the bankfull stage as the highest elevation of a river that can be contained within the channel without spilling water on the river floodplain or washlands.
- Wolman and Leopold (1957) defined bankfull stage as the elevation of the active floodplain.
- Woodyer (1968) suggested bankfull stage as the elevation of the middle bench of rivers having several overflow surfaces.
- Pickup and Warner (1976) defined bankfull stage as the elevation at which the width/depth ratio becomes a minimum.

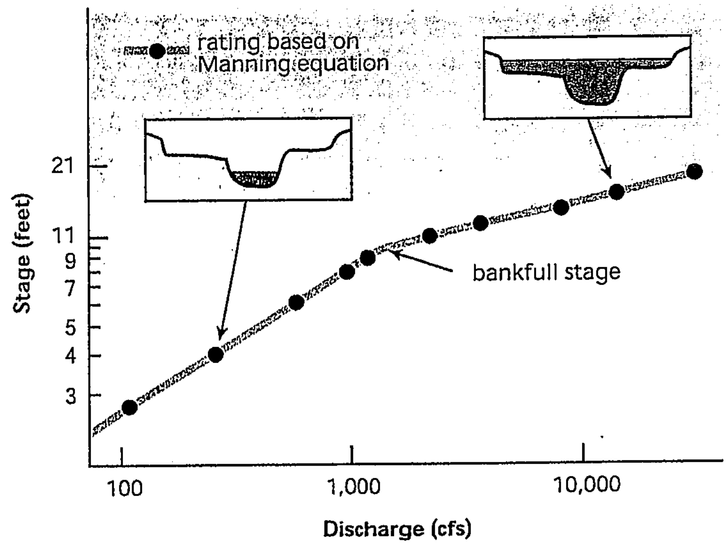

Figure 7.4: Determination of bankfull stage from a rating curve. *The discharge that corresponds to the elevation of the first flat depositional surface is the bankfull discharge.*

Bankfull stage has also been defined using morphologic factors, as follows:

- Schumm (1960) defined bankfull stage as the height of the lower limit of perennial vegetation, primarily trees.
- Similarly, Leopold (1994) states that bankfull stage is indicated by a change in vegetation, such as herbs, grasses, and shrubs.
- Finally, the bankfull stage is also defined as the average elevation of the highest surface of the channel bars (Wolman and Leopold 1957).

The field identification of bankfull stage indicators is often difficult and subjective and should be performed in stream reaches that are stable and alluvial (Knighton 1984). Additional guidelines are reviewed by Wharton (1995). In unstable streams, bankfull indicators are often missing, embryonic, or difficult to determine.

Direct determination of the discharge at bankfull stage is possible if a stream gauge is located near the reach of interest. Otherwise, discharge must be calculated using applicable hydraulic resistance equations and, preferably, standard hydraulic backwater techniques. This approach typically requires that an estimation of channel roughness be made, which adds to the uncertainty associated with calculated bankfull discharge.

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Because of its convenience, bankfull discharge is widely used to represent channel-forming discharge. There is no universally accepted definition of bankfull stage or discharge that can be consistently applied, has general application, and integrates the processes that create the bankfull dimensions of the river. The reader is cautioned that the indicators used to define the bankfull condition must be spelled out each time a bankfull discharge is used in a project plan or design.

Determining Channel-Forming Discharge from Recurrence Interval

To avoid some of the problems related to field determination of bankfull stage, the *channel-forming discharge* is often assumed to be represented by a specific *recurrence interval* discharge. Some researchers consider this representative discharge to be equivalent to the bankfull discharge. Note that "bankfull discharge" is used synonymously with "channel-forming discharge" in this document. The earliest estimate for channel-forming discharge was the mean annual flow (Leopold and Maddock 1953). Wolman and Leopold (1957) suggested that the channel-forming discharge has a recurrence interval of 1 to 2 years. Dury (1973) concluded that the channel-forming discharge is approximately 97 percent of the 1.58-year discharge or the most probable annual flood. Hey (1975) showed that for three British gravel-bed rivers, the 1.5-year flow in an annual maximum series passed through the scatter of bankfull discharges measured along the course of the rivers. Richards (1982) suggested that in a partial duration series bankfull discharge equals the most probable annual flood, which has a 1 year return period. Leopold (1994) stated that most investigations have concluded that the bankfull discharge recurrence intervals ranged from 1.0 to 2.5 years. Pickup and Warner (1976) determined bankfull recurrence intervals ranged from 4 to 10 years on the annual series.

However, there are many instances where the bankfull discharge does not fall within this range. For example, Williams (1978) determined that approximately 75 percent of 51 streams that he analyzed appeared to have recurrence intervals for the bankfull discharge of between 1.03 and 5.0 years. Williams used the elevation of the active floodplain or the valley flat, if no active floodplain was defined at a station, as the elevation of the bankfull surface in his analyses. He did not establish whether these streams were in equilibrium, so the validity of using the top of the streambank as the bankfull elevation is in question, especially for those stations with valley flats. This might explain the wide range (1.02 to 200 years) he reported for bankfull discharge return intervals for streams with valley flats as opposed to active floodplains. The range in return intervals for 19 of the 28 streams with active floodplains was from 1.01 to 32 years. Nine of the 28 streams had bankfull discharge recurrence intervals of less than 1.0 year. It should be noted that only 3 of those 28 streams had bankfull discharge recurrence intervals greater than 4.8 years. About one-third of the active floodplain stations had bankfull discharges near the 1.5-year recurrence interval.

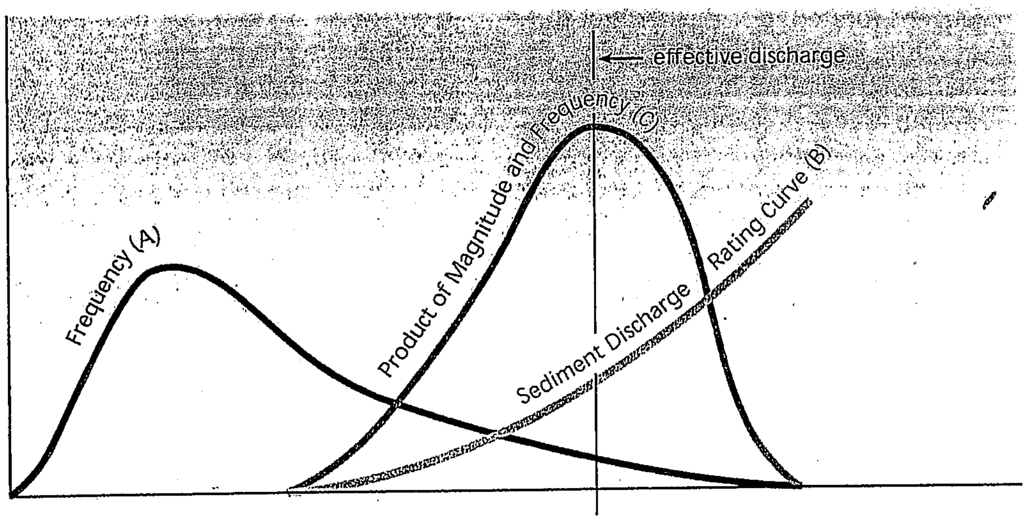

Figure 7.5: Effective discharge determination from sediment rating and flow duration curves. *The peak of curve C marks the discharge that is most effective in transporting sediment.*
Source: Wolman and Miller (1960).

Although the assumption that the channel-forming flow has a recurrence interval of 1 to 3 years is sufficient for reconnaissance-level studies, it should not be used for design until verified through inspection of reference reaches, data collection, and analysis. This is especially true in highly modified streams such as in urban or mined areas, as well as ephemeral streams in arid and semiarid areas.

Effective Discharge

The *effective discharge* is defined as the increment of discharge that transports the largest fraction of the sediment load over a period of years (Andrews 1980). The effective discharge incorporates the principle prescribed by Wolman and Miller (1960) that the channel-forming discharge is a function of both the magnitude of the event and its frequency of occurrence. An advantage of using the effective discharge is that it is a calculated rather than field-determined value. The effective discharge is calculated by numerically integrating the flow duration curve (A) and the sediment transport rating curve (B). A graphical representation of the relationship between sediment transport, frequency of the transport, and the effective discharge is shown in Figure 7.5. The peak of curve C marks the discharge that is most effective in transporting sediment and, therefore, does the most work in forming the channel.

For stable alluvial streams, effective discharge has been shown to be highly correlated with bankfull discharge. Of the various discharges related to channel morphology (i.e., dominant, bankfull, and effective discharges), effective discharge is the only one that can be computed directly. The effective discharge has morphological significance since it is the discharge that transports the bulk of the sediment.

The effective discharge represents the single flow increment that is responsible for transporting the most sediment over some time period. However, there is a range of flows on either side of the effective discharge that also carry a significant portion of the total annual sediment load.

Biedenharn and Thorne (1994) used a graphical relationship between the

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cumulative percentage of sediment transported and the water discharge to define a range of effective discharges responsible for the majority of the sediment transport on the Lower Mississippi River. They found that approximately 70 percent of the total sediment was moved in a range of flows between 500,000 cfs and 1,200,000 cfs, which corresponds to the flow that is equaled or exceeded 40 percent of the time and 3 percent of the time, respectively. Thorne et al. (1996) used a similar approach to define the range of effective discharges on the Brahmaputra River.

A standard procedure should be used for the determination of the effective discharge to ensure that the results for different sites can be compared. To be practical, it must either be based on readily available gauging station data or require only limited additional information and computational procedures.

The basic components required for calculation of effective discharge are (1) flow duration data and (2) sediment load as a function of water discharge. The method most commonly adopted for determining the effective discharge is to calculate the total bed material sediment load (tons) transported by each flow increment over a period of time by multiplying the frequency of occurrence for the flow increment (number of days) by the sediment load (tons/day) transported by that flow level. The flow increment with the largest product is the effective discharge. Although this approach has the merit of simplicity, the accuracy of the estimate of the effective discharge is clearly dependent on the calculation procedure adopted.

Values of mean daily discharges are usually used to compute the flow duration curve, as discussed above and presented in Figure 7.1. However, on flashy streams, mean daily values can underestimate the influence of the high flows, and, therefore, it might be necessary to reduce the discharge averaging period from 24 hours (mean daily) to 1 hour, or perhaps 15 minutes.

A *sediment rating curve* must be developed to determine the effective discharge. (See the *Sediment Yield and Delivery* section in Chapter 8 for more details.) The bed material load should be used in the calculation of the effective discharge. This sediment load can be determined from measured data or computed using an appropriate sediment transport equation. If measured suspended sediment data are used, the wash load should be subtracted and only the suspended bed material portion of the suspended load used. If the bed load is a significant portion of the load, it should be calculated using an appropriate sediment transport function and added to the suspended bed material load to provide an estimate of the total bed material load. If bed load measurements are available, these data can be used.

Design Discharge and Ecological Function

Although a channel-forming or dominant discharge is important for design, it is often not sufficient for channel restoration initiatives. An assessment of a wider range of discharges might be necessary to ensure that the functional objectives of the project are met. For example, a restoration initiative targeting low-flow habitat conditions must consider the physical conditions in the channel during low flows.

Determination of effective discharge using flow and sediment data is further discussed by Wolman and Miller (1960) and Carling (1988).

Determining Channel-Forming Discharge from Other Watershed Variables

When neither time nor resources permit field determination of bankfull discharge or data are unavailable to calculate the effective discharge, indirect methods based on *regional hydrologic analysis* may be used (Ponce 1989). In its simplest form, regional analysis entails regression techniques to develop empirical relationships applicable to homogeneous hydrologic regions. For example, some workers have used watershed areas as surrogates for discharge (Brookes 1987, Madej 1982, Newbury and Gaboury 1993). Regional relationships of drainage area with bankfull discharge can provide good starting points for selecting the channel-forming discharge.

Within hydrologically homogeneous regions where runoff varies with contributing area, runoff is proportional to watershed drainage area. Dunne and Leopold (1978) and Leopold (1994) developed average curves relating bankfull discharge to drainage area for widely separated regions of the United States. For example, relationships between bankfull discharge and drainage area for Brandywine Creek in Pennsylvania and the upper Green River basin in Wyoming are shown in the **Figure 7.6.**

Two important points are immediately apparent from Figure 7.6. First, humid regions that have sustained, widely distributed storms yield higher bankfull discharges per unit of drainage area than semiarid regions where storms of high intensity are usually localized. Second, bankfull discharge is correlated with drainage area, and the general relationship can be represented by functions of the form:

$$Q_{bf} = aA^b$$

where Q_{bf} is the bankfull discharge in cfs, A is the drainage area in square miles, and a and b are regression coefficients and exponents given in **Table 7.1.**

Establishing similar parametric relationships for other rivers of interest is useful because the upstream area draining into a stream corridor can be easily determined from either maps or digital terrain analysis tools. Once the area is determined, an estimate of the expected bankfull discharge for the corridor can be made from the above equation.

Regional Relationship Between Bankfull and Mean Annual Discharge

Because the mean annual flow for each stream gauge operated by the USGS is readily available, it is useful to establish regional relationships between bankfull and mean annual discharges so that one can be estimated whenever the other is available. This information can be compared to the bankfull discharge estimated for any given ungauged site within a U.S. region. ***The user is cautioned, however, that regional curve values have a high degree of error and can vary significantly for specific sites or reaches to be restored.***

Mean Annual Flow

Another frequently used surrogate for channel-forming discharge in empirical regression equations is the *mean annual flow.* The mean annual flow, Q_m, is equivalent to the constant discharge that would yield the same volume of water in a water year as the sum of all continuously measured discharges. Just as in the case of bankfull discharge, Q_m varies proportionally with drainage area within hydrologically homogeneous

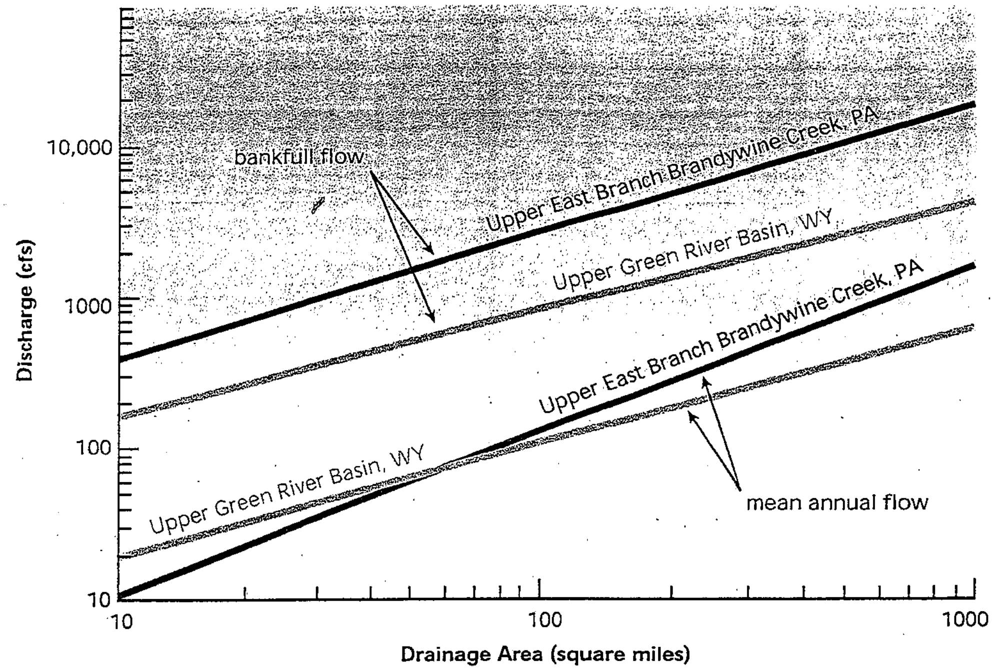


Figure 7.6: Regional relationships for bankfull and mean annual discharge as a function of drainage area. *The mean annual flow is normally less than the bankfull flow.*
Source: Dunne and Leopold 1978.

Table 7.1: Functional parameters used in regional estimates of bankfull discharge. *In column a are regression coefficients and in column b are exponents that can be used in the bankfull discharge equation.*
Source: Dunne and Leopold 1978.

River Basin	a	b
Southeastern PA	61	0.82
Upper Salmon River, ID	36	0.68
Upper Green River, WY	28	0.69
San Francisco Bay Region, CA	53	0.93

$Q_{bf} = aA^b$

basins. Given that both Q_{bf} and Q_m exhibit a similar functional dependence on A, a consistent proportionality is to be expected between these discharge measures within the same region. In fact, Leopold (1994) gives the following average values of the ratio Q_{bf}/Q_m for three widely separated regions of the United States: 29.4 for 21 stations in the Coast Range of California, 7.1 for 20 stations in the Front Range of Colorado, and 8.3 for 13 stations in the Eastern United States.

Stage vs. Discharge Relationships

Surveys of stream channel cross sections are useful for analyzing channel form, function, and processes. Use of survey data to construct relationships among streamflow, channel geometry, and various hydraulic characteristics provides information that serves a variety of applications. Although stage-discharge curves often can be computed from such cross section data, users should be cautioned to verify their computations with direct discharge measurements whenever possible.

Information on stream channel geometry and hydraulic characteristics is useful for channel design, riparian area restoration, and instream structure placement. Ideally, once a channel-forming discharge is defined, the channel is designed to contain that flow and higher flows are allowed to spread over the floodplain. Such periodic flooding is extremely important for the formation of channel macrofeatures, such as point bars and meander bends, and for establishing certain kinds of riparian vegetation. A cross section analysis also may help in optimal design and placement of items such as culverts and fish habitat structures.

Additionally, knowledge of the relationships between discharge and channel geometry and hydraulics is useful for reconstructing the conditions associated with a particular flow rate. For example, in many channel stability analyses, it is customary to relate movement of bed materials to some measure of stream power or average bed shear stress. If the relationships between discharge and certain hydraulic variables (e.g., mean depth and water surface slope) are known, it is possible to estimate stream power and average bed shear as a function of discharge. A cross section analysis therefore makes it possible to estimate conditions of substrate movement at various levels of streamflow.

Continuity Equation

Discharge at a cross section is computed using the simplified form of the *continuity equation*:

$$Q = AV$$

where:

Q = discharge

A = cross sectional area of the flow

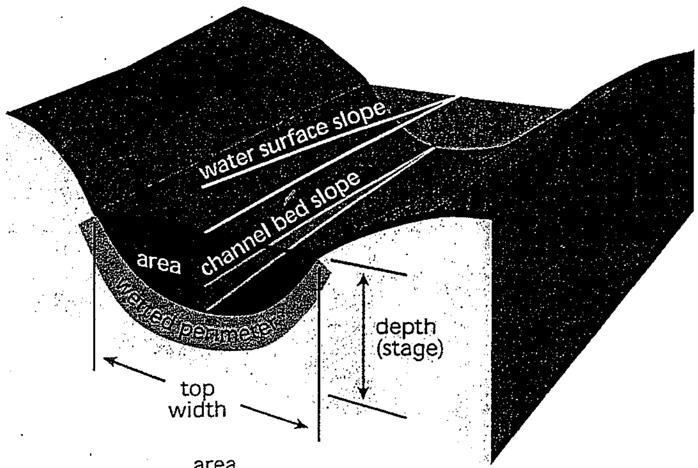
V = average velocity in the downstream direction

Computing the cross-sectional area is a geometry problem. The area of interest is bounded by the channel cross section and the water surface elevation (stage) (**Figure 7.7**). In addition to cross-sectional area, the top width, wetted perimeter, mean depth, and hydraulic radius are computed for selected stages (Figure 7.7).

Uniform flow equations may be used for estimating mean velocity as a function of cross section hydraulic parameters.

Manning's Equation

Manning's equation was developed for conditions of uniform flow in which the water surface profile and energy grade line are parallel to the streambed, and the area, hydraulic radius, and average depth remain constant throughout the reach. The energy grade line is a theoretical line whose elevation above the streambed is the sum of the water surface elevation and a term that represents the kinetic energy of the flow (Chow 1959). The slope of the energy grade line represents the rate at which energy is dissipated through turbulence and boundary friction. When the water surface slope and the energy grade line



$$\text{mean depth} = \frac{\text{area}}{\text{top width}}$$

$$\text{hydraulic radius} = \frac{\text{area}}{\text{wetted perimeter}}$$

Figure 7.7: ***Hydraulic parameters.*** *Streams have specific cross-sectional and longitudinal profile characteristics.*

parallel the streambed, the slope of the energy grade line is assumed to equal the water surface slope. When the slope of the energy grade line is known, various resistance formulas allow computing mean cross-sectional velocity.

The importance of Manning's equation in stream restoration is that it provides the basis for computing differences in flow velocities and elevations due to differences in hydraulic roughness. Note that the flow characteristics can be altered to meet the goals of the restoration either by direct intervention or by changing the vegetation and roughness of the stream. Manning's equation is also useful in determining bankfull discharge for bankfull stage.

Manning's equation is also used to calculate energy losses in natural channels with gradually varied flow. In this case, calculations proceed from one cross section to the next, and unique hydraulic parameters are calculated at each cross section. Computer models, such as HEC-2, perform these calculations and are widely used analytical tools.

Manning's equation for mean velocity, V (in feet per second or meters per second), is given as:

$$V = \frac{k}{n} R^{2/3} S^{1/2}$$

where:

k = 1.486 for English units (1 for metric units)

n = Manning's roughness coefficient

R = hydraulic radius (feet or meters)

S = energy slope (water surface slope).

Manning's roughness coefficient may be thought of as an index of the features of channel roughness that contribute to the dissipation of stream energy. **Table 7.2** shows a range of n values for various boundary materials and conditions.

Two methods are presented for estimating Manning's roughness coefficient for natural channels:

- Direct solution of Manning's equation for n.
- Comparison with computed n values for other channels.

Each method has its own limitations and advantages.

Direct Solution for Determining Manning's n

Even slightly nonuniform flow can be difficult to find in natural channels. The method of direct solution for Manning's n does not require perfectly uniform flow. Manning n values are computed for a reach in which multiple cross sections, water surface elevations, and at least one discharge have been measured. A series of water surface profiles are then computed with different n values, and the computed profile that matches the measured profile is deemed to have an n value that most nearly represents the roughness of that stream reach at the specific discharge.

Table 7.2: Manning roughness coefficients for various boundaries.
Source: Ven te Chow 1964.

Boundary	Manning Roughness, *n* Coefficient
Smooth concrete	0.012
Ordinary concrete lining	0.013
Vitrified clay	0.015
Shot concrete, untroweled, and earth channels in best condition	0.017
Straight unlined earth canals in good condition	0.020
Rivers and earth canals in fair condition—some growth	0.025
Winding natural streams and canals in poor condition—considerable moss growth	0.035
Mountain streams with rocky beds and rivers with variable sections and some vegetation along banks	0.040-0.050
Alluvial channels, sand bed, no vegetation	
1. Lower regime	
Ripples	0.017-0.028
Dunes	0.018-0.035
2. Washed-out dunes or transition	0.014-0.024
3. Upper regime	
Plane bed	0.011-0.015
Standing waves	0.012-0.016
Antidunes	0.012-0.020

Using Manning's n Measured at Other Channels

The second method for estimating n values involves comparing the reach to a similar reach for which Manning's n has already been computed. This procedure is probably the quickest and most commonly used for estimating Manning's n. It usually involves using values from a table or comparing the study reach with photographs of natural channels. Tables of Manning's n values for a variety of natural and artificial channels are common in the literature on hydrology (Chow 1959, Van Havereen 1986) (Table 7.2). Photographs of stream reaches with computed n values have been compiled by Chow (1959) and Barnes (1967). Estimates should be made for several stages, and the relationship between n and stage should be defined for the range of flows of interest.

When the roughness coefficient is estimated from table values, the chosen n value (n_b) is considered a base value that may need to be adjusted for additional resistance features. Several publications provide procedures for adjusting base values of n to account for channel irregularities, vegetation, obstructions, and sinuosity (Chow 1959, Benson and Dalrymple 1967, Arcement and Schneider 1984, Parsons and Hudson 1985).

The most common procedure uses the following formula, proposed by Cowan (1959) to estimate the value of n:

$$n = (n_b + n_1 + n_2 + n_3 + n_4)\ m$$

where

n_b = base value of n for a straight, uniform, smooth channel in natural materials

n_1 = correction for the effect of surface irregularities

Uniform Flow

Under conditions of constant width, depth, area, and velocity, the water surface slope and energy grade line approach the slope of the streambed, producing a condition known as uniform flow. One feature of uniform flow is that the streamlines are parallel and straight (Roberson and Crowe 1996). Perfectly uniform flow is rarely realized in natural channels, but the condition is approached in some reaches where the geometry of the channel cross section is relatively constant throughout the reach.

*Conditions that tend to disrupt uniform flow include bends in the stream course; changes in cross-sectional geometry; obstructions to flow caused by large roughness elements, such as channel bars, large boulders, and woody debris; or other features that cause convergence, divergence, acceleration, or deceleration of flow (**Figure 7.8**). Resistance equations may also be used to evaluate these nonuniform flow conditions (gradually varied flow); however, energy-transition considerations (backwater calculations) must then be factored into the analysis. This requires the use of multiple-transect models (e.g., HEC-2 and WSP2; HEC-2 is a water surface profile computer program developed by the U.S. Army Corps of Engineers, Hydrologic Engineering Center, in Davis, California; WSP2 is a similar program developed by the USDA Natural Resources Conservation Service.)*

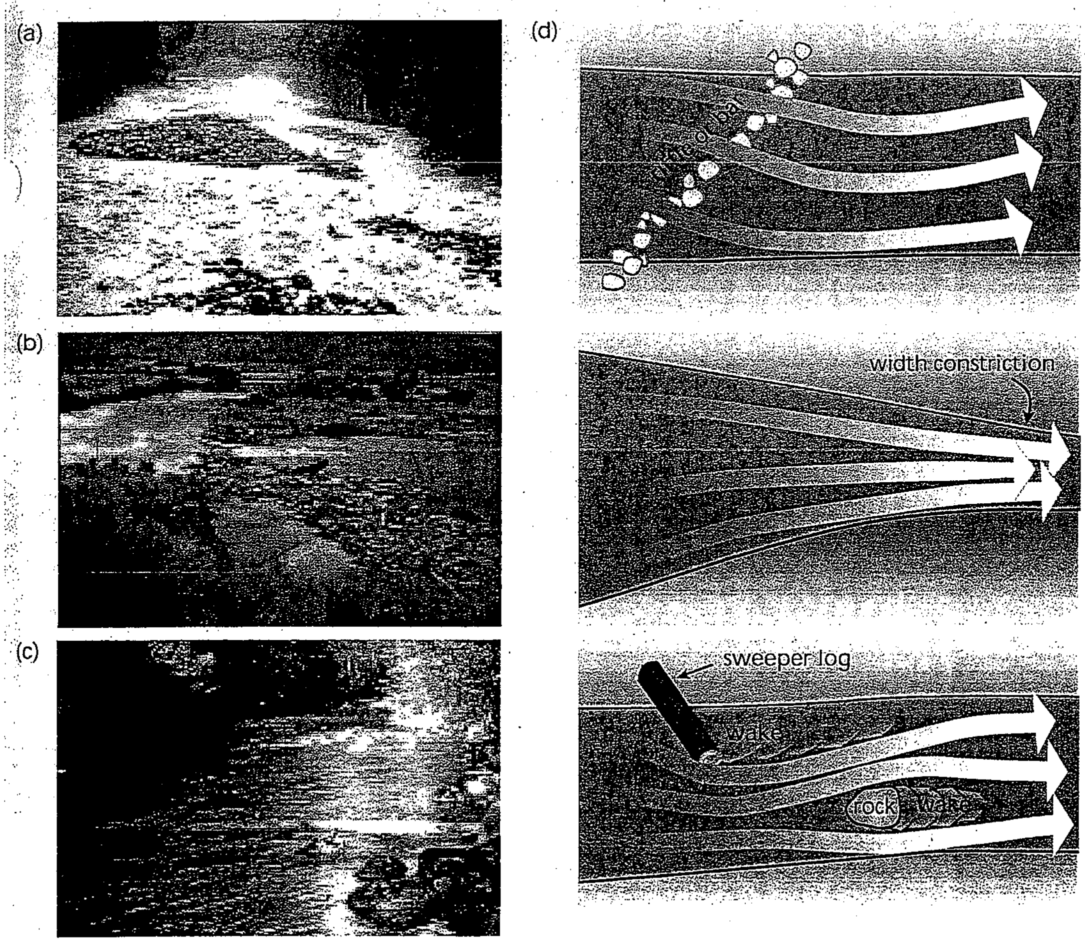


Figure 7.8: Streamflow paths for channels with constrictions or obstructions. *(a) Riffle or bar, Nisqually, Washington.* Source: J. McShane. *(b) Stream width restriction. (c) Sweeper log. (d) Stream lines through a reach.*

n_2 = correction for variations in cross section size and shape

n_3 = correction for obstructions

n_4 = correction for vegetation and flow conditions

m = correction for degree of channel meandering

Table 7.3 is taken from Aldridge and Garrett (1973) and may be used to estimate each of the above correction factors to produce a final estimated n.

Energy Equation

The *energy equation* is used to calculate changes in water-surface elevation between two relatively similar cross sections. A simplified version of this equation is:

$$z_1 + d_1 + V_1^2/2g = z_2 + d_2 + V_2^2/2g + h_e$$

where:

z = minimum elevation of streambed

d = maximum depth of flow

V = average velocity

g = acceleration of gravity

h_e = energy loss between the two sections

Subscript 1 indicates that the variable is at the upstream cross section, and subscript 2 indicates that the variable is at the downstream cross section.

This simplified equation is applicable when hydraulic conditions between the two cross sections are relatively similar (gradually varied flow) and the channel slope is small (less than 0.18).

Energy losses between the two cross sections occur due to channel boundary roughness and other factors described above. These roughnesses may be represented by a Manning's roughness coefficient, n, and then energy losses can be computed using the Manning equation.

Manning's n in Relation to Channel Bedforms

Just as Manning's n may vary significantly with changes in stage (water level), channel irregularities, obstructions, vegetation, sinuosity, and bed-material size distribution, n may also vary with bedforms in the channel. The hydraulics of sand and mobile-bed channels produce changes in bedforms as the velocity, stream power, and Froude number increase with discharge. The Froude number is a dimensionless number that represents the ratio of inertial forces to gravitational force. As velocity and stream power increase, bedforms evolve from ripples to dunes, to washed-out dunes, to plane bed, to antidunes, to chutes and pools. A stationary plane bed, ripples, and dunes occur when the Froude number (long wave equation) is less than 1 (subcritical flow); washed-out dunes occur at a Froude number equal to 1 (critical flow); and a plane bed in motion, antidunes, and chutes and pools occur at a Froude number greater than 1 (supercritical flow). Manning's n attains maximum values when dune bedforms are present, and minimum values when ripples and plane bedforms are present (Parsons and Hudson 1985).

$$h_e = L\ [Qn/kAR^{2/3}]^2$$

where:

L = distance between cross sections

Q = discharge

n = Manning's roughness coefficient

A = channel cross-sectional area

R = hydraulic radius (Area/wetted perimeter)

k = 1 (SI units)

k = 1.486 (ft-lb-sec units)

Computer models (such as HEC-2 and others) are available to perform these calculations for more complex cross-sectional shapes, including floodplains, and for cases where roughness varies laterally across the cross section (USACE 1991).

Table 7.3: "n" value adjustments.
Source: Aldridge and Garrett (1973).

	Channel Conditions	n Value Adjustment[1]	Example
Degree of irregularity (n_1)	Smooth	0.000	Compares to the smoothest channel attainable in a given bed material.
	Minor	0.001-0.005	Compares to carefully dredged channels in good condition but having slightly eroded or scoured side slopes.
	Moderate	0.006-0.010	Compares to dredged channels having moderate to considerable bed roughness and moderately sloughed or eroded side slopes.
	Severe	0.011-0.020	Badly sloughed or scalloped banks of natural streams; badly eroded or sloughed sides of canals or drainage channels; unshaped, jagged, and irregular surfaces of channels in rock.
Variation in channel cross section (n_2)	Gradual	0.000	Size and shape of channel cross sections change gradually.
	Alternating occasionally	0.001-0.005	Large and small cross sections alternate occasionally, or the main flow occasionally shifts from side to side owing to changes in cross-sectional shape.
	Alternating frequently	0.010-0.015	Large and small cross sections alternate frequently, or the main flow frequently shifts from side to side owing to changes in cross-sectional shape.
Effect of obstruction (n_3)	Negligible	0.000-0.004	A few scattered obstructions, which include debris deposits, stumps, exposed roots, logs, piers, or isolated boulders, that occupy less than 5 percent of the cross-sectional area.
	Minor	0.005-0.015	Obstructions occupy less than 15 percent of the cross-sectional area and the spacing between obstructions is such that the sphere of influence around one obstruction does not extend to the sphere of influence around another obstruction. Smaller adjustments are used for curved smooth-surfaced objects than are used for sharp-edged angular objects.
	Appreciable	0.020-0.030	Obstructions occupy from 15 to 20 percent of the cross-sectional area or the space between obstructions is small enough to cause the effects of several obstructions to be additive, thereby blocking an equivalent part of a cross section.
	Severe	0.040-0.050	Obstructions occupy more than 50 percent of the cross-sectional area or the space between obstructions is small enough to cause turbulence across most of the cross section.
Amount of vegetation (n_4)	Small	0.002-0.010	Dense growths of flexible turf grass, such as Bermuda, or weeds growing where the average depth of flow is at least two times the height of the vegetation; supple tree seedlings such as willow, cottonwood, arrowweed, or saltcedar growing where the average depth of flow is at least three times the height of the vegetation.
	Medium	0.010-0.025	Turf grass growing where the average depth of flow is from one to two times the height of the vegetation; moderately dense stemmy grass, weeds, or tree seedlings growing where the average depth of the flow is from two to three times the height of the vegetation; brushy, moderately dense vegetation, similar to 1- to 2-year-old willow trees in the dormant season, growing along the banks and no significant vegetation along the channel bottoms where the hydraulic radius exceeds 2 feet.
	Large	0.025-0.050	Turf grass growing where the average depth of flow is about equal to the height of vegetation; 8- to 10-year-old willow or cottonwood trees intergrown with some weeds and brush (none of the vegetation in foliage) where the hydraulic radius exceeds 2 feet; bushy willows about 1 year old intergrown with some weeds along side slopes (all vegetation in full foliage) and no significant vegetation along channel bottoms where the hydraulic radius is greater than 2 feet.
	Very Large	0.050-0.100	Turf grass growing where the average depth of flow is less than half the height of the vegetation; bushy willow trees about 1 year old intergrown with weeds along side slopes (all vegetation in full foliage) or dense cattails growing along channel bottom; trees intergrown with weeds and brush (all vegetation in full foliage).
Degree of meandering[1] (adjustment values apply to flow confined in the channel and do not apply where downvalley flow crosses meanders) (m)	Minor	1.00	Ratio of the channel length to valley length is 1.0 to 1.2.
	Appreciable	1.15	Ratio of the channel length to valley length is 1.2 to 1.5.
	Severe	1.30	Ratio of the channel length to valley length is greater than 1.5.

[1] Adjustments for degree of irregularity, variations in cross section, effect of obstructions, and vegetation are added to the base n value before multiplying by the adjustment for meander.

Backwater Effects

Straight channel reaches with perfectly uniform flow are rare in nature and, in most cases, may only be approached to varying degrees. If a reach with constant cross-sectional area and shape is not available, a slightly contracting reach is acceptable, provided there is no significant backwater effect from the constriction. Backwater occurs where the stage vs. discharge relationship is controlled by the geometry downstream of the area of interest (e.g., a high riffle controls conditions in the upstream pool at low flow). Manning's equation assumes uniform flow conditions. Manning's equation used with a single cross section, therefore, will not produce an accurate stage vs. discharge relationship in backwater areas. In addition, expanding reaches also should be avoided since there are additional energy losses associated with channel expansions. When no channel reaches are available that meet or approach the condition of uniform flow, it might be necessary to use multitransect models (e.g., HEC-2) to analyze cross section hydraulics. If there are elevation restrictions corresponding to given flows (e.g., flood control requirements), the water surface profile for the entire reach is needed and use of a multitransect (backwater) model is required.

Analyzing Composite and Compound Cross Sections

Natural channel cross sections are rarely perfectly uniform, and it may be necessary to analyze hydraulics for very irregular cross sections (compound channel). Streams frequently have overflow channels on one or both sides that carry water only during unusually high flows. Overflow channels and overbank areas, which may also carry out-of-bank flows at various flood stages, usually have hydraulic properties significantly different from those of the main channel. These areas are usually treated as separate subchannels, and the discharge computed for each of these subsections is added to the main channel to compute total discharge. This procedure ignores lateral momentum losses, which could cause n values to be underestimated.

A composite cross section has roughness that varies laterally across the section, but the mean velocity can still be computed by a uniform flow equation without subdividing the section. For example, a stream may have heavily vegetated banks, a coarse cobble bed at its lowest elevations, and a sand bar vegetated with small annual willow sprouts.

A standard hydraulics text or reference (such as Chow 1959, Henderson 1986, USACE 1991, etc.) should be consulted for methods of computing a composite n value for varying conditions across a section and for varying depths of flow.

Reach Selection

The intended use of the cross section analysis plays a large role in locating the reach and cross sections. Cross sections can be located in either a short critical reach where hydraulic characteristics change or in a reach that is considered representative of some larger area. The reach most sensitive to change or most likely to meet (or fail to meet) some important condition may be considered a critical reach. A representative reach typifies a definable extent of the channel system and is used to describe that portion of the system (Parsons and Hudson 1985).

Once a reach has been selected, the channel cross sections should be measured at locations considered most suitable for meeting the uniform flow requirements of Manning's equation. The uniform flow requirement is approached by siting cross sections where channel width, depth, and cross-sectional flow area remain relatively constant within the reach, and the water surface slope and energy grade line approach the slope of the streambed. For this reason, marked changes in channel geometry and discontinuities in the flow (steps, falls, and hydraulic jumps) should be avoided. Generally, sections should be located where it appears the streamlines are parallel to the bank and each other within the selected reach. If uniform flow conditions cannot be met and backwater computations are required, defining cross sections located at changes in channel geometry is essential.

Field Procedures

The basic information to be collected in the reach selected for analysis is a survey of the channel cross sections and water surface slope, a measurement of bed-material particle size distribution, and a discharge measurement. The U.S. Forest Service has produced an illustrated guide to field techniques for stream channel reference sites (Harrelson et al. 1994) that is a good reference for conducting field surveys.

Standard Step Backwater Computation

Many computer programs (e.g., HEC-2) are available to compute water surface profiles. The standard step method of Chow (1959, p. 265) can be used to determine the water surface elevation (depth) at the upstream end of the reach by iterative approximations. This method uses trial water surface elevations to determine the elevation that satisfies the energy and Manning equations written for the end sections of the reach. In using this method, cross sections should be selected so that velocities increase or decrease continuously throughout the reach (USACE 1991).

Survey of Cross Section and Water Surface Slope

The cross section is established perpendicular to the flow line, and the points across the section are surveyed relative to a known or arbitrarily established benchmark elevation. The distance/elevation paired data associated with each point on the section may be obtained by sag tape, rod-and-level survey, hydrographic surveys, or other methods.

Water surface slope is also required for a cross section analysis. The survey of water surface slope is somewhat more complicated than the cross section survey in that the slope of the water surface at the location of the section (e.g., pool, run, or riffle) must be distinguished from the more constant slope of the entire reach. (See Grant et al. 1990 for a detailed discussion on recognition and characteristics of channel units.) Water surface slope in individual channel reaches may vary significantly with changes in stage and discharge.

For this reason, when water surface slopes are surveyed in the field, the low-water slope may be approximated by the change in elevation over the individual channel unit where the cross section is located, approximately 1 to 5 channel widths in length, while the high-water slope is obtained by measuring the change in elevation over a much longer reach of channel, usually at least 15 to 20 channel widths in length.

Bed Material Particle Size Distribution

Computing mean velocity with resistance equations based on relative roughness, such as the ones suggested by Thorne and Zevenbergen (1985), requires an evaluation of the particle size distribution of the bed material of the stream. For streams with no significant channel armor and bed material finer than medium gravel, bed material samplers developed by the Federal Interagency Sedimentation Project (FISP 1986) may be used to obtain a representative sample of the streambed, which is then passed through a set of standard sieves to determine percent by weight of particles of various sizes. The cumulative percent of material finer than a given size may then be determined.

Particle size data are usually reported in terms of d_i, where i represents some nominal percentile of the distribution and d_i represents the particle size, usually expressed in millimeters, at which i percent of the total sample by weight is finer. For example, 84 percent of the total sample would be finer than the d_{84} particle size. For additional guidance on bed material sampling in sand-bed streams, refer to Ashmore et al. (1988).

For estimating velocity in steep mountain rivers with substrate much coarser than the medium-gravel limitation of FISP samplers, a *pebble count*, in which at least 100 bed material particles are manually collected from the streambed and measured, is used to measure surface particle size (Wolman 1954). At each sample point along a cross section, a particle is retrieved from the bed, and the intermediate axis (not the longest or shortest axis) is measured. The measurements are tabulated as to number of particles occurring within predetermined size intervals, and the percentage of the total number in each interval is then determined. Again, the percentage in each interval is accumulated to give a particle size distribution, and the particle size data are reported as described above. Additional guidance for bed material sampling in coarse-bed streams is provided in Yuzyk (1986). If an armor layer or pavement is present, standard techniques may be employed to characterize bed sediments, as described by Hey and Thorne (1986).

Discharge Measurement

If several discharge measurements can be made over a wide range of flows, relationships among stage, discharge, and other hydraulic parameters may be developed directly. If only one discharge measurement is obtained, it likely will occur during low water and will be useful for defining the lower end of the rating table. If two measurements can be made, it is desirable to have a low-water measurement and a high-water measurement to define both ends of the rating table and to establish the relationship between Manning's n and stage. If high water cannot be measured directly, it may be necessary to estimate the high-water n (see the discussion earlier in the chapter).

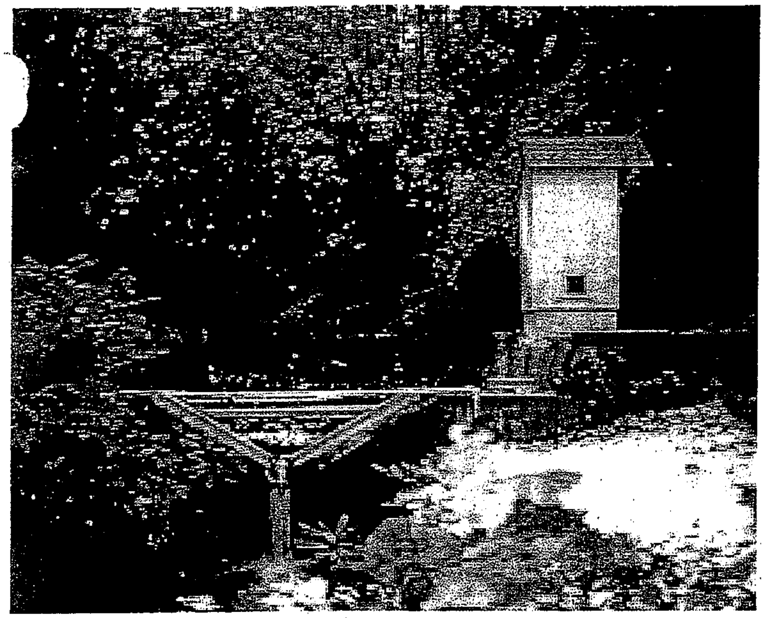


Figure 7.9: ***Station measuring discharge.*** *Permanent stations provide measurements for a wide range of flow, but the necessary measurements can be made in other ways.* Source: C. Zabawa.

The Bureau of Reclamation *Water Measurement Manual* (USDI-BOR 1997) is an excellent source of information for measuring channel and stream discharge (**Figure 7.9**). Buchanan and Somers (1969) and Rantz et al. (1982) also provide in-depth discussions of discharge measurement techniques. When equipment is functioning properly and standard procedures are followed correctly, it is possible to measure streamflow to within 5 percent of the true value. The USGS considers a "good" measurement of discharge to account for plus or minus 5 percent and an "excellent" discharge measurement to be within plus or minus 3 percent of the true value.

7.B Geomorphic Processes

In planning a project along a river or stream, awareness of the fundamentals of fluvial geomorphology and channel processes allows the investigator to see the relationship between form and process in the landscape. The detailed study of the fluvial geomorphic processes in a channel system is often referred to as a *geomorphic assessment*. The geomorphic assessment provides the process-based framework to define past and present watershed dynamics, develop integrated solutions, and assess the consequences of restoration activities. A geomorphic assessment generally includes data collection, field investigations, and channel stability assessments. It forms the foundation for analysis and design and is therefore an essential first step in the design process, whether planning the treatment of a single reach or attempting to develop a comprehensive plan for an entire watershed.

Stream Classification

The use of any *stream classification* system is an attempt to simplify what are complex relationships between streams and their watersheds.

Although classification can be used as a communications tool and as part of the overall restoration planning process, the use of a classification system is not required to assess, analyze, and design stream restoration initiatives. The design of a restoration does, however, require site-specific engineering analyses and biological criteria, which are covered in more detail in Chapter 8.

Restoration designs range from simple to complex, depending on whether "no action," only management techniques, direct manipulation, or combinations of these approaches are used. Complete stream corridor restoration designs require an interdisciplinary approach as discussed in Chapter 4. A poorly designed restoration might be difficult to repair and can lead to more extensive problems.

More recent attempts to develop a comprehensive stream classification system have focused on morphological forms and processes of channels and valley bottoms, and drainage networks. Classification systems might be categorized as systems based on sediment transport processes and systems based on channel response to perturbation.

Stream classification methods are related to fundamental variables and processes that form streams. Streams are classified as either alluvial or non-alluvial. An *alluvial stream* is free to adjust its dimensions, such as width, depth, and slope, in response to changes in watershed sediment discharge. The bed and banks of an alluvial stream are composed of material transported by the river under present flow conditions. Conversely, a *non-alluvial* river, like a bedrock-controlled channel, is not free to adjust. Other conditions, such as a high mountain stream flowing in very coarse glacially deposited materials or streams which are significantly controlled by fallen timber, would suggest a non-alluvial system.

Streams may also be classified as either perennial, intermittent, or ephemeral, as discussed in Chapter 1. A perennial stream is one that has flow at all times. An intermittent stream has the potential for continued flow, but at times the entire flow is absorbed by the bed material. This may be seasonal in nature. An ephemeral stream has flow only following a rainfall event. When carrying flow, intermittent and ephemeral streams both have characteristics very similar to those of perennial streams.

Advantages of Stream Classification Systems

The following are some advantages of stream classification systems:

- Classification systems promote communication among persons trained in different resource disciplines.
- They also enable extrapolation of inventory data collected on a few channels of each stream class to a much larger number of channels over a broader geographical area.
- Classification helps the restoration practitioner consider the landscape context and determine the expected range of variability for parameters related to channel size, shape, and pattern and composition of bed and bank materials.
- Stream classification also enables the practitioner to interpret the channel-forming or dominant processes active at the site, providing a base on which to begin the process of designing restoration.
- Classified reference reaches can be used as the stable or desired form of the restoration.
- A classification system is also very useful in providing an important cross-check to verify if the selected design values for width/depth ratio, sinuosity, etc., are within a reasonable range for the stream type being restored.

Limitations of Stream Classification Systems

All stream classification systems have limitations that are inherent to their approaches, data requirements, and range of applicabilities. They should be used cautiously and only for establishing some of the baseline conditions on which to base initial restoration planning. Standard design techniques should never be replaced by stream classification alone.

Some limitations of classification systems are as follows:

- Determination of bankfull or channel-forming flow depth may be difficult or inaccurate. Field indicators are often subtle or missing and are not valid if the stream is not stable and alluvial.
- The dynamic condition of the stream is not indicated in most classification systems. The knowledge of whether the stream is stable, aggrading, or degrading or is approaching a critical geomorphic threshold is important for a successful restoration initiative.
- River response to a perturbation or restoration action is normally not determined from the classification system alone.
- Biological health of a stream is usually not directly determined through a stream classification system.
- A classification system alone should not be used for determining the type, location, and purpose of restoration activities. These are determined through the planning steps in Part II and the design process in Chapter 8.

When the results of stream classification will be used for planning or design, the field data collection should be performed or directed by persons with experience and training in hydrology, hydraulics, terrestrial and aquatic ecology, sediment transport, and river mechanics. Field data collected by personnel with only limited formal training may not be reliable, particularly in the field determination of bankfull indicators and the assessment of channel instability trends.

Stream Classification Systems

Stream Order

Designation of *stream order*, using the Strahler (1957) method, described in Chapter 1, is dependent on the scale of maps used to identify first-order streams. It is difficult to make direct comparisons of the morphological characteristics of two river basins obtained from topographic maps of different scales. However, the basic morphological relationships defined by Horton (1945) and Yang (1971) are valid for a given river basin regardless of maps used, as shown in the case study of the Rogue River Basin (Yang and Stall 1971, 1973).

Horton (1945) developed some basic empirical stream morphology relations, i.e., Horton's law of stream order, stream slope, and stream length. These show that the relationships between stream order, average stream length, and slope are straight lines on semilog paper.

Yang (1971) derived his theory of average stream fall based on an analogy with thermodynamic principles. The theory states that the ratio of average fall (change in bed elevation) between any two stream orders in a given river basin is unity. These theoretical results were supported by data from 14 river basins in the United States with an average fall ratio of 0.995. The Rogue River basin data were used by Yang and Stall (1973) to demonstrate the relationships between average stream length, slope, fall, and number of streams.

Stream order is used in the *River Continuum Concept* (Vannote et al. 1980), described in Chapter 1, to distinguish different levels of biological activity. However, stream order is of little help to planners and designers looking for clues to restore hydrologic and geomorphic functions to stream corridors.

Schumm

Other classification schemes combine morphological criteria with dominant modes of sediment transport. Schumm (1977) identified straight, meandering, and braided channels and related both channel pattern and stability to modes of sediment transport (**Figure 7.10**).

Schumm recognized relatively stable straight and meandering channels, with predominantly suspended sediment load and cohesive bank materials. On the other end of the spectrum are relatively unstable braided streams characterized by predominantly bedload sediment transport and wide, sandy channels with noncohesive bank materials. The intermediate condition is generally represented by meandering mixed-load channels.

Montgomery and Buffington

Schumm's classification system primarily applies to alluvial channels; Montgomery and Buffington (1993) have proposed a similar classification system for alluvial, colluvial, and bedrock streams in the Pacific Northwest that addresses channel response to sediment inputs throughout the drainage network. Montgomery and Buffington recognize six classes of alluvial channels cascade, step-pool, plane-bed, riffle-pool, regime, and braided (**Figure 7.11**).

The stream types are differentiated on the basis of channel response to sediment inputs, with steeper channels (cascade and step-pool) maintaining their morphology while transmitting increased sediment loads, and low-gradient channels (regime and pool-riffle) responding to increased sediment through morphological adjustments. In general, steep channels act as sediment-delivery conduits connecting zones of sediment production with low-gradient response channels.

Rosgen Stream Classification System

One comprehensive stream classification system in common use is based on morphological characteristics described by Rosgen (1996) (**Figure 7.12**). The Rosgen system uses six morphological measurements for classifying a stream reach entrenchment, width/depth ratio, sinuosity, number of channels, slope, and bedmaterial particle size. These criteria are used to define eight major stream classes with about 100 individual stream types.

Rosgen uses the bankfull discharge to represent the stream-forming discharge or channel-forming flow. Bankfull discharge is needed to use this classification system because all of the morphological relationships are related to this flow condition: width and depth of flow are measured at the bankfull elevation, for example.

Except for entrenchment and width/depth ratio (both of which depend on a determination of bankfull depth), the parameters used are relatively straightforward measurements. The problems in determining bankfull depth were discussed earlier in Chapter 1. The width/depth ratio is taken at bankfull stage and is the ratio of top width to mean depth for the bankfull channel. Sinuosity is the ratio of stream length to valley length or, alternatively, valley slope to stream slope. The bed material particle size used in the classification is the dominant bed surface particle size, determined in the field by a pebble-count procedure (Wolman 1954) or as modified for sand and smaller sizes. Stream slope is measured over a channel reach of at least 20 widths in length.

Entrenchment describes the relationship between a stream and its valley and is defined as the vertical containment of the stream and the degree to

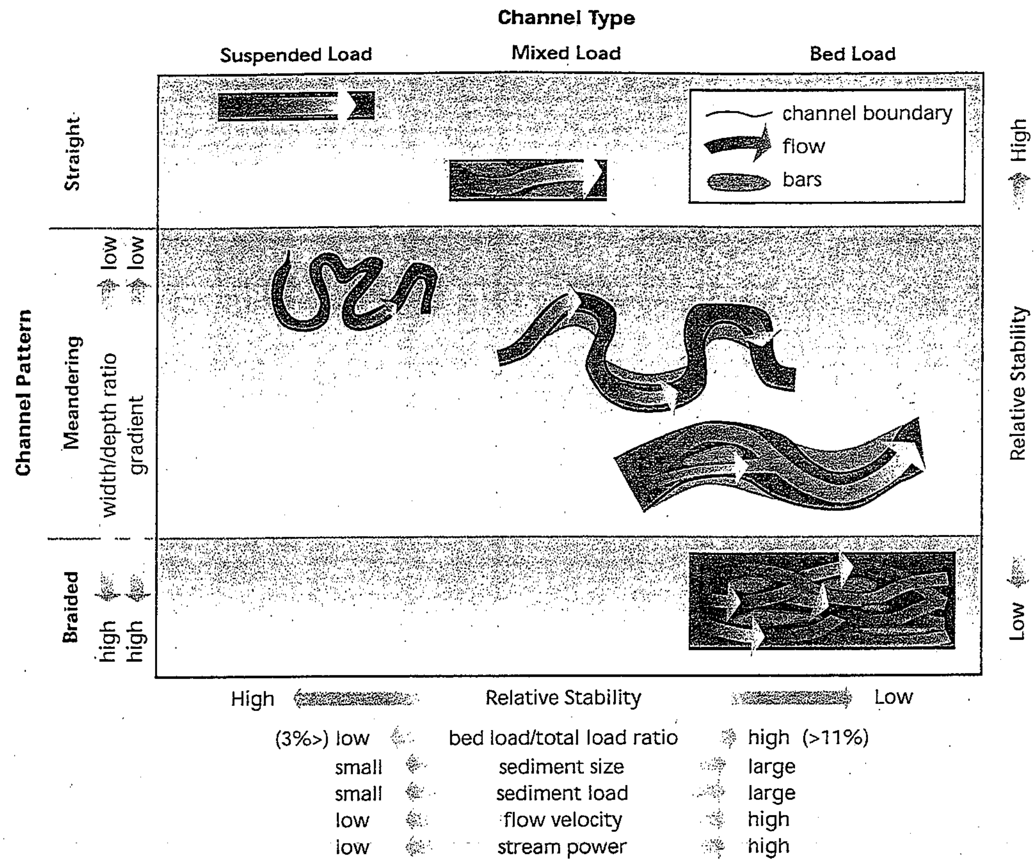


Figure 7.10: Classification of alluvial channels. *Schumms classification system relates channel stability to kind of sediment load and channel type.*

Source: Schumm, The Fluvial System. © 1977. Reprinted by permission of John Wiley and Sons, Inc.

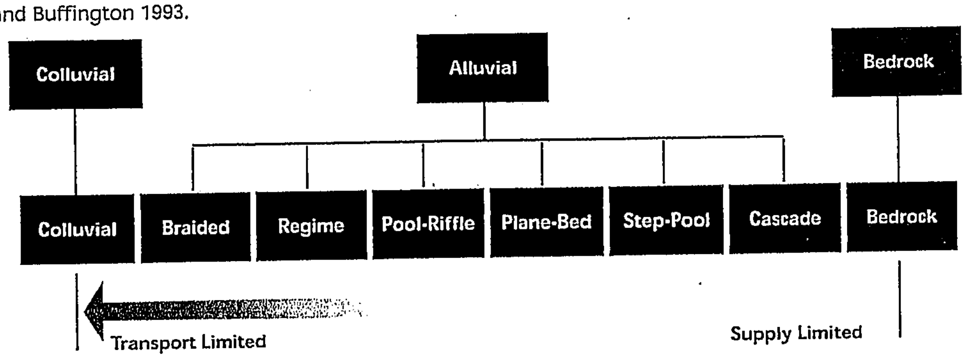
which it is incised in the valley floor. It is, therefore, a measure of how accessible a floodplain is to the stream. The entrenchment ratio used in the Rosgen classification system is the flood-prone width of the valley divided by the bankfull width of the channel. Flood-prone width is determined by doubling the maximum depth in the bankfull channel and measuring the width of the valley at that elevation. If the flood-prone width is greater than 2.2 times the bankfull width, the stream is considered to be slightly entrenched or confined and the stream has ready access to its floodplain. A stream is classified as entrenched if its flood-prone width is less than 1.4 times the bankfull width.

A sample worksheet for collecting data and classifying a stream using the Rosgen system is shown in **Figure 7.13**. A field book for collecting reference reach information is available (Leopold et al. 1997).

Channel Evolution Models

Conceptual *models of channel evolution* describe the sequence of changes a stream undergoes after certain kinds of disturbances. The changes can include increases or decreases in the width/depth ratio of the channel and also involve alterations in the floodplain. The sequence of changes is somewhat predictable, so it is important that the current stage of evolution be identified so appropriate actions can be planned.

Figure 7.11: Suggested stream classification system for Pacific Northwest. Included are classifications for nonalluvial streams.
Source: Montgomery and Buffington 1993.



	Braided	Regime	Pool-Riffle	Plane-Bed	Step-Pool	Cascade	Bedrock	Colluvial
Typical Bed Material	Variable	Sand	Gravel	Gravel, cobble	Cobble, boulder	Boulder	N/A	Variable
Bedform Pattern	Laterally oscillary	Multi-layered	Laterally oscillary	None	Vertically oscillary	None		Variable
Reach Type	Response	Response	Response	Response	Transport	Transport	Transport	Source
Dominant Roughness Elements	Bedforms (bars, pools)	Sinuosity, bedforms (dunes, ripples, bars) banks	Bedforms (bars, pools), grains, LWD, sinuosity, banks	Grains, banks	Bedforms (steps, pools), grains, LWD, banks	Grains, banks	Boundaries (bed & banks)	Grains, LWD
Dominant Sediment Sources	Fluvial, bank failure, debris flow	Fluvial, bank failure, inactive channel	Fluvial, bank failure, inactive channel, debris flows	Fluvial, bank failure, debris flow	Fluvial, hillslope, debris flow	Fluvial, hillslope, debris flow	Fluvial, hillslope, debris flow	Hillslope, debris flow
Sediment Storage Elements	Overbank, bedforms	Overbank, bedforms, inactive channel	Overbank, bedforms, inactive channel	Overbank, inactive channel	Bedforms	Lee & stoss sides of flow obstructions		Bed
Typical Slope (m/m)	S < 0.03	S < 0.001	0.001 < S and S < 0.02	0.01 < S and S < 0.03	0.03 < S and S < 0.08	0.08 < S and S < 0.30	Variable	S > 0.20
Typical Confinement	Unconfined	Unconfined	Unconfined	Variable	Confined	Confined	Confined	Confined
Pool Spacing (Channel Widths)	Variable	5 to 7	5 to 7	none	1 to 4	< 1	Variable	Variable

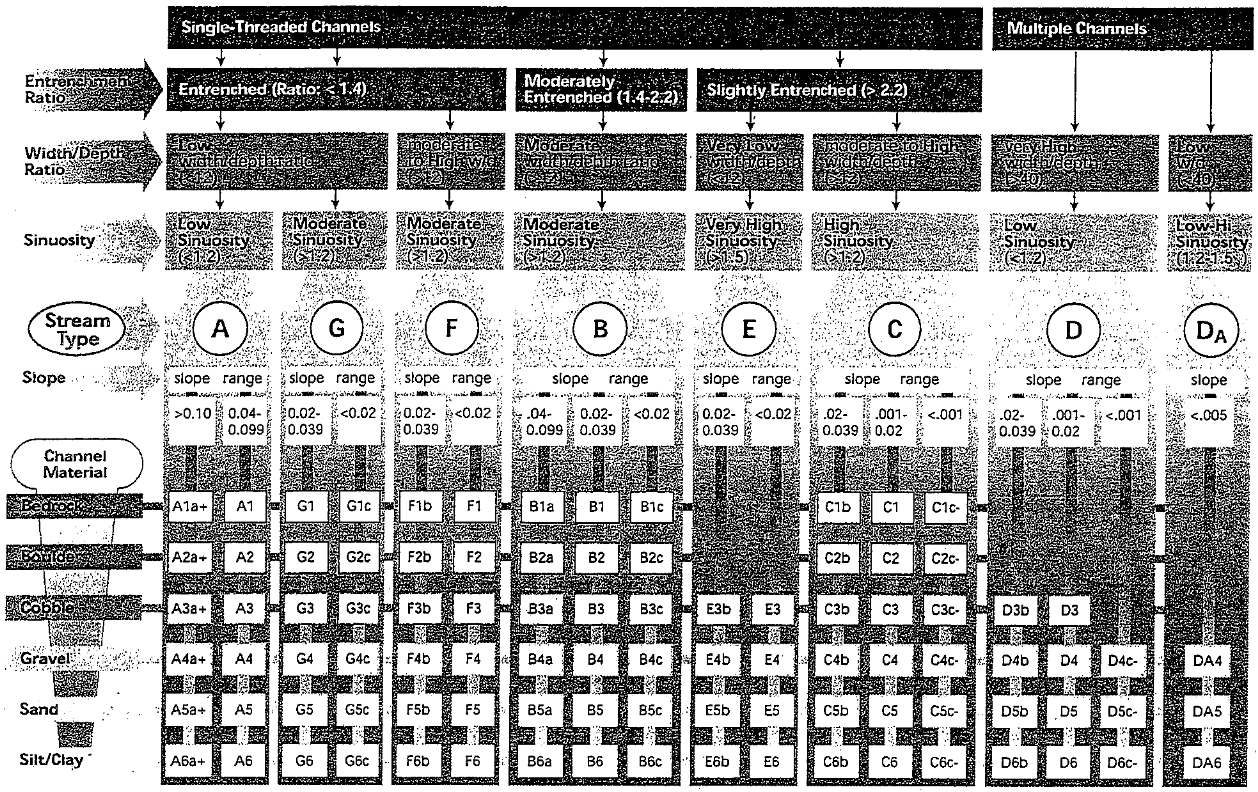


__Figure 7.12: Rosgen's stream channel classification system (Level II).__ This classification system includes a recognition of specific characteristics of channel morphology and the relationship between the stream and its floodplain.
Source: Rosgen 1996. Published by permission of Wildland Hydrology.

Schumm et al. (1984), Harvey and Watson (1986), and Simon (1989) have proposed similar channel evolution models due to bank collapse based on a "space-for-time" substitution, whereby downstream conditions are interpreted as preceding (in time) the immediate location of interest and upstream conditions are interpreted as following (in time) the immediate location of interest. Thus, a reach in the middle of the watershed that previously looked like the channel upstream will evolve to look like the channel downstream.

Downs (1995) reviews a number of classification schemes for interpreting channel processes of lateral and vertical adjustment (i.e., aggradation, degradation, bend migration, and bar formation). When these adjustment processes are placed in a specific order of occurrence, a channel evolution model (CEM) is developed. Although a number of CEMs have been suggested, two models (Schumm et al. 1984 and Simon 1989, 1995) have gained wide acceptance as being generally applicable for channels with cohesive banks.

Both models begin with a predisturbance condition, in which the channel is well vegetated and has frequent interaction with its floodplain. Following a perturbation in the system (e.g., channelization or change in land use), degradation occurs, usually as a result of excess stream power in the disturbed reach. Channel degradation eventually leads to oversteepening of the banks, and when critical bank heights are exceeded, bank failures and mass wasting (the episodic

A013408

STREAM CLASSIFICATION WORKSHEET

Party:________________ Date:________________
State:________________ County:________________
Stream: ________________________________

Bankfull Measurements: Lat/Long ________________
Width __________ Depth __________ W/D __________

Sinuosity (Stream Length/Valley Length) or (Valley Slope/Channel Slope):
Strm. Length ____________ Valley Slope ____________
Valley Length ____________ Channel Slope ____________
Sinuosity $\frac{S_L}{V_L}$ ____________ Sinuosity $\frac{V_S}{C_S}$ ____________

Entrenchment Ratio (Floodprone Width/Bankfull Width):
Floodprone width is water level at 2x maximum depth in bankfull cross-section, or width of intermediate floodplain (10-50 yr. event)
Bankfull Width ____________ Floodprone Width ____________
Entrenchment Ratio ____________
Slight = 2.2+ Moderate + 1.41-2.2 Entrenched = 1.0-1.4

Dominant Channel Soils:
Bed Material __________ Left Bank __________ Right Bank __________
Description of Soil Profiles (from base of bank to top)
Left: ________________________________
Right: ________________________________

Riparian Vegetation:
Left Bank: ____________ Right Bank ____________
% Total Area (Mass) L __________ R __________
% Total Ht w/Roots L __________ R __________
Ratio of Actual Bank Height to Bankfull Height ____________

Bank Slope (Horizontal to Vertical): L __________ R __________

STREAM TYPE __________ Remarks ____________________

PEBBLE COUNT	Site________														
Metric (mm)	English (inches)	Particle	Count	Tot #	% Tot	% Cum	Count	Tot #	% Tot	% Cum	Count	Tot #	% Tot	% Cum
<.062	<.002	Silt/Clay												
.062-0.25	.002-.01	Fine Sand												
0.25-.5	.01-.02	Med Sand												
.5-1.0	.02-.04	Coarse Sand												
1.0-2.0	.04-.08	Vy Coarse Sand												
2-8	.08-.32	Fine Gravel												
8-16	.32-.63	Med Gravel												
16-32	.63-1.26	Coarse Gravel												
32-64	1.26-2.51	Vy Coarse Gravel												
64-128	2.51-5.0	Small Cobbles												
128-256	5.0-10.1	Large Cobbles												
256-512	10.1-20.2	Sm Boulders												
512-1024	20.2-40.3	Med Boulders												
1024-2048	40.3-80.6	Lg Boulders												
2048-4096	80.6-161	Vy Lg Boulders												

Figure 7.13: Example of stream classification worksheet used with Rosgen methods.
Source: NRCS 1994 (worksheet) and Rosgen 1996 (pebble count). Published by permission of Wildland Hydrology.

downslope movement of soil and rock) lead to channel widening. As channel widening and mass wasting proceed upstream, an aggradation phase follows in which a new low-flow channel begins to form in the sediment deposits. Upper banks may continue to be unstable at this time. The final stage of evolution is the development of a channel within the deposited alluvium with dimensions and capacity similar to those of the predisturbance channel (Downs 1995). The new channel is usually lower than the predisturbance channel, and the old floodplain now functions primarily as a terrace.

Once streambanks become high, either by downcutting or by sediment deposition on the floodplain, they begin to fail due to a combination of erosion at the base of the banks and mass wasting. The channel continues to widen until flow depths do not reach the depths required to move the sloughed bank materials. Sloughed materials at the base of the banks may begin to be colonized by vegetation. This added roughness helps increase deposition at the base of the banks, and a new small-capacity channel begins to form between the stabilized sediment deposits. The final stage of channel evolution results in a new bankfull channel and active floodplain at a new lower elevation. The original floodplain has been abandoned due to channel incision or excessive sediment deposition and is now termed a terrace.

Schumm et al. (1984) applied the basic concepts of channel evolution to the problem of unstable channelized streams in Mississippi. Simon (1989) built on Schumm's work in a study of channelized streams in Tennessee. Simon's CEM consisted of six stages (**Figure 7.14**). Both models use the cross section, longitudinal profile, and geomorphic processes to distinguish stages of evolution. Both models were developed for landscapes dominated by streams with cohesive banks. However, the same physical processes of evolution can occur in streams with noncohesive banks but not necessarily in the same well-defined stages.

Table 7.4 and **Figure 7.15** show the processes at work in each of Simon's stages.

Advantages of Channel Evolution Models

CEMs are useful in stream corridor restoration in the following ways (Note: Stages are from Simon's 1989 six-stage CEM):

- CEMs help to establish the direction of current trends in disturbed or constructed channels. For example, if a reach of stream is classified as being in Stage IV of evolution (Figure 7.14), more stable reaches should occur downstream and unstable reaches should occur upstream. Once downcutting or incision occurs in a stream (Stage III), the headcut will advance upstream until it reaches a resistant soil layer, the drainage area becomes too small to generate erosive runoff, or the slope flattens to the point that the stream cannot generate enough energy to downcut. Stages IV to VI will follow the headcut upstream.
- CEMs can help to prioritize restoration activities if modification is planned. By stabilizing a reach of stream in early Stage III with grade control measures, the potential degradation of that reach and upstream reaches can be prevented. It also takes less intensive efforts to successfully restore stream reaches in Stages V and VI than to restore those in Stages III and IV.

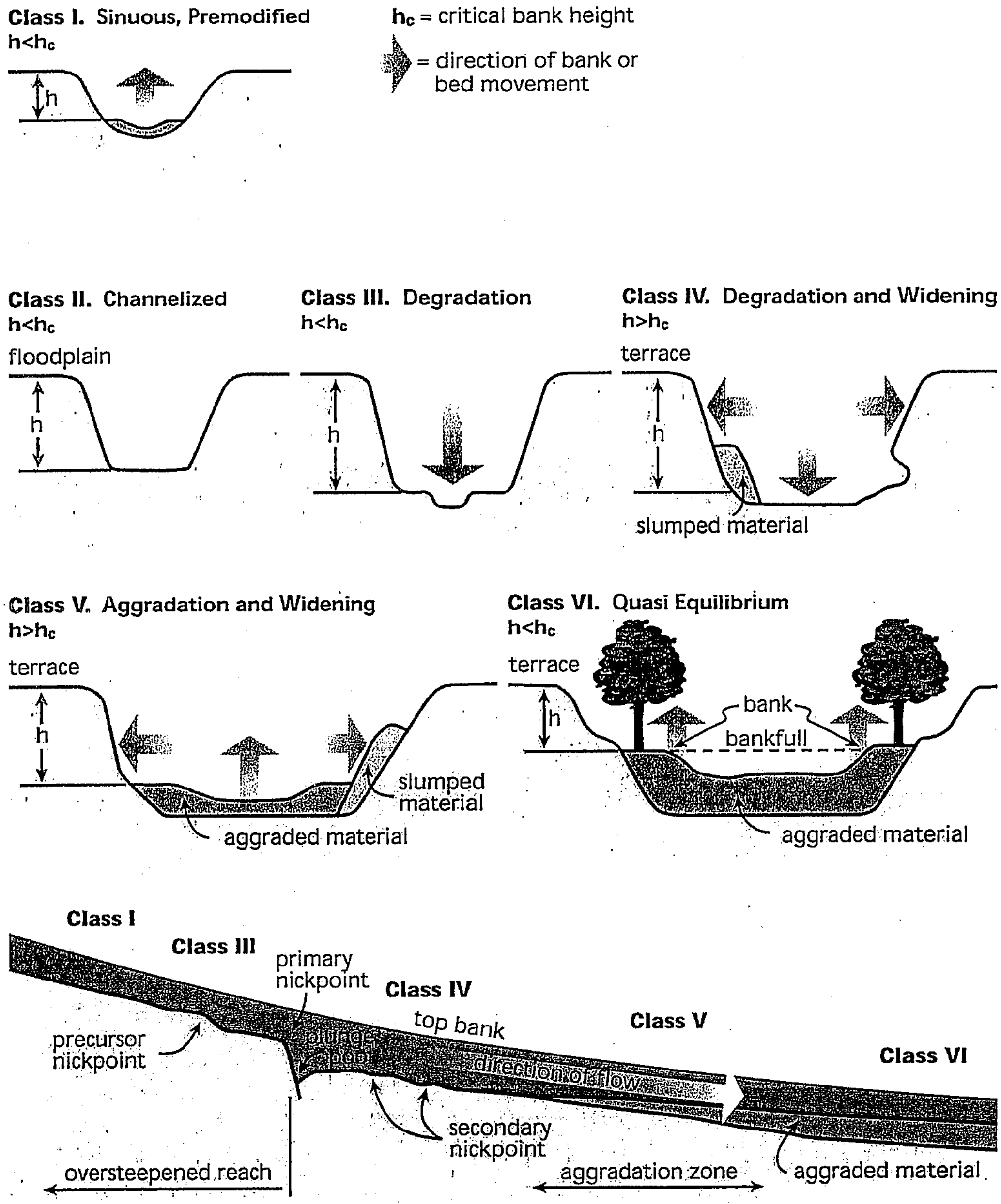


Figure 7.14: Channel evolution model. *A disturbed or unstable stream is in varying stages of disequilibrium along its length or profile. A channel evolution model theoretically may help predict future upstream or downstream changes in habitat and stream morphology.*
Source: Simon 1989, USACE 1990.

- CEMs can help match solutions to the problems. Downcutting in Stage III occurs due to the greater capacity of the stream created by construction, or earlier incision, in Stage II. The downcutting in Stage III requires treatments such as grade control aimed at modifying the factors causing the bottom instability. Bank stability problems are dominant in Stages IV and V, so the approaches to stabilization required are different from those for Stage III. Stages I and VI typically require only maintenance activities.

- CEMs can help provide goals or models for restoration. Reaches of streams in Stages I and VI are graded streams, and their profile, form, and pattern can be used as models for restoring unstable reaches.

Limitations of Channel Evolution Models

The chief limitations in using CEMs for stream restoration are as follows:

- Future changes in base level elevations and watershed water and sediment yield are not considered when predicting channel response.
- Multiple adjustments by the stream simultaneously are difficult to predict.

Table 7.4: Dominant hillslope and instream processes, characteristic cross section shape and bedforms, and condition of vegetation in the various stages of channel evolution.
Source: Simon 1989.

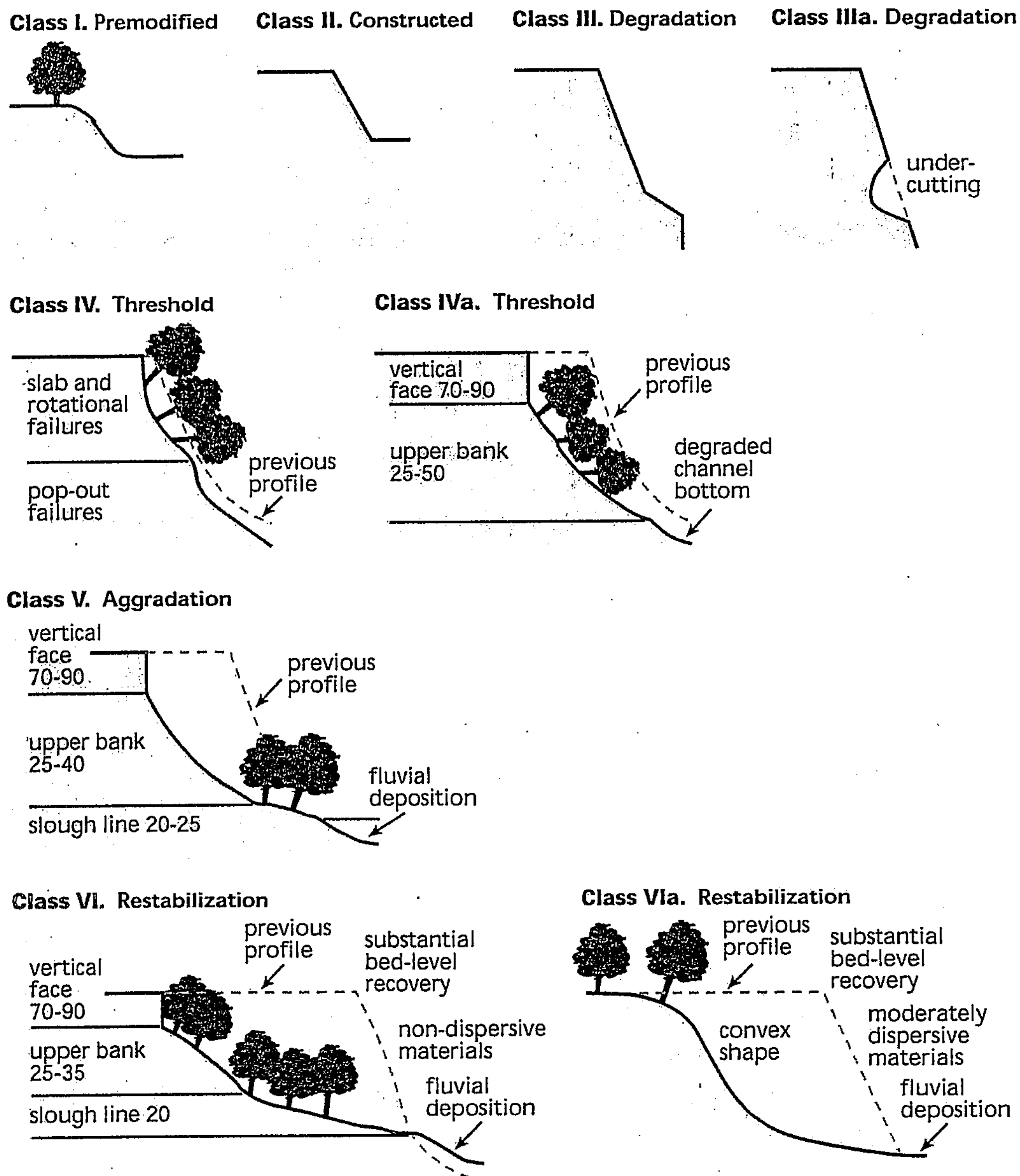
Class No.	Class Name	Dominant Processes: Fluvial	Dominant Processes: Hillslope	Characteristic Forms	Geobotanical Evidence
I	Premodified	Sediment transport - mild aggradation; basal erosion on outside bends; deposition on inside bends.		Stable, alternate channel bars; convex top-bank shape; flow line high relative to top bank; channel straight or meandering.	Vegetated banks to flow line.
II	Constructed			Trapezoidal cross section; linear bank surfaces; flow line lower relative to top bank.	Removal of vegetation.
III	Degradation	Degradation; basal erosion on banks.	Pop-out failures.	Heightening and steepening of banks; alternate bars eroded; flow line lower relative to top bank.	Riparian vegetation high relative to flow line and may lean toward channel.
IV	Threshold	Degradation; basal erosion on banks.	Slab, rotational and pop-out failures.	Large scallops and bank retreat; vertical face and upper-bank surfaces; failure blocks on upper bank; some reduction in bank angles; flow line very low relative to top bank.	Riparian vegetation high relative to flow line and may lean toward channel.
V	Aggradation	Aggradation; development of meandering thalweg; initial deposition of alternate bars; reworking of failed material on lower banks.	Slab, rotational and pop-out failures; low-angle slides of previously failed material.	Large scallops and bank retreat; vertical face, upper bank, and slough line; flattening of bank angles; flow line low relative to top bank; development of new floodplain.	Tilted and fallen riparian vegetation; reestablishing vegetation on slough line; deposition of material above root collars of slough line vegetation.
VI	Restabilization	Aggradation; further development of meandering thalweg; further deposition of alternate bars; reworking of failed material; some basal erosion on outside bends deposition of flood-plain and bank surfaces.	Low-angle slides; some pop-out failures near flow line.	Stable, alternate channel bars; convex-short vertical face on top bank; flattening of bank angles; development of new floodplain; flow line high relative to top bank.	Reestablishing vegetation extends up slough line and upper bank; deposition of material above root collars of slough-line and upper-bank vegetation; some vegetation establishing on bars.

Applications of Geomorphic Analysis

Stream classification systems and channel evolution models may be used together in resource inventories and analysis to characterize and group streams. Although many classification systems are based on morphological parameters, and channel evolution models are based on adjustment processes, the two approaches to stream characterization complement each other. Both indicate the present condition of a stream reach under investigation, but characterization of additional reaches upstream and downstream of the investigation area can provide an understanding of the overall trend of the stream.

Stream classification systems and channel evolution models also provide in-

Figure 7.15: Simon's channel evolution stages related to streambank shape. *The cross-sectional shape of the streambank may be a good indicator of its evolutionary stage.*
Source: Simon 1989. Published by permission of the American Water Resources Association.



sights as to the type of stability problems occurring within the stream corridor and potential opportunities for restoration. Gullied stream channels are downcutting, so grade stabilization is required before time and money are spent on bank stabilization or floodplain restoration. Similarly, incised channels with lateral instabilities are in the initial stages of widening, a process that often must be accommodated before equilibrium conditions can be attained. Although most argue that channel widening must be accommodated to restore incised channels, in some cases not allowing the stream to widen might be preferred, depending on the value and priority placed on adjacent land use and structures within the corridor.

On the other hand, incised streams that have widened enough for a new inner channel and floodplain to begin forming are excellent candidates for vegetation management since these streams are already tending toward renewed stability and establishing riparian vegetation can accelerate the process.

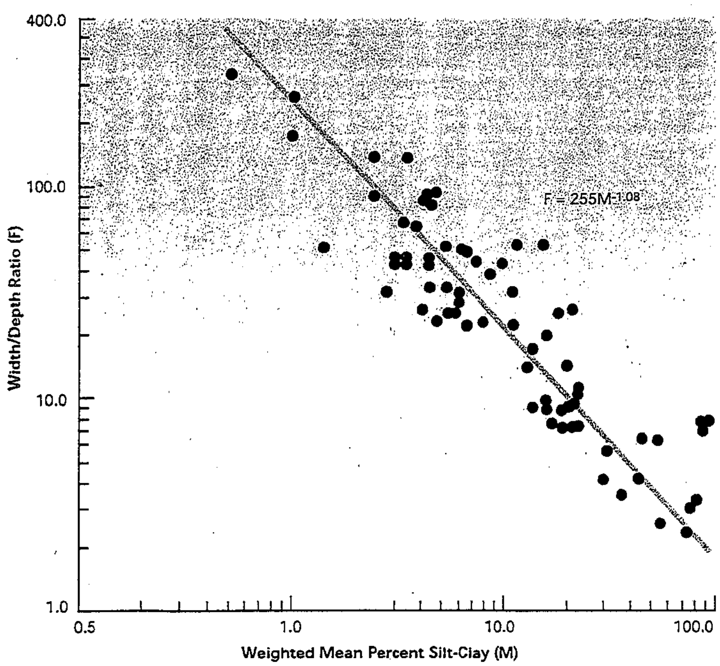


Figure 7.16: Schumm's F versus M relationship. *Data for aggrading streams generally plot above or to the right of the line. Degrading or incising streams plot below the line.*
Source: Schumm 1960.

Both the stream classification and the stage of channel evolution inventories can serve as the foundation for assessing systemwide stability. Channel width/depth ratio (F) at mean annual discharge and the percent of silt and clay in the channel boundary (M) are useful diagnostics for determining systemwide adjustments. These variables can be plotted on Schumm's (1960) curve of width/depth ratio versus percent silt-clay ($F = 255M^{-1.08}$) to assess stability (**Figure 7.16**). Schumm's width/depth ratio is the top width of the bankfull channel and the deepest depth in the bankfull channel cross section. The term "M" is defined by the relationship

$$M = [(S_c W) + (S_b 2D)] / (W + 2D)$$

where

S_c = percentage of silt and clay in the bed material

S_b = percentage of silt and clay in the bank material

W = channel width

D = channel depth

Data from aggrading streams generally plot above the line of best fit, whereas data for degrading streams plot below the line. Schumm's graph could also be used as a guide in selecting an appropriate width/depth ratio for an incised or recently disturbed channel.

Finally, classification systems and evolution models can help guide the selection of restoration treatments. As mentioned above, there is little opportunity for successfully establishing streambank vegetation in streams with vertical and horizontal instability. The banks of such streams are subject to deep-seated slope failures that are not usually prevented even by mature woody vegetation. Conversely, establishing and managing perennial grasses and woody vegetation is critical to protecting streams that are already functioning properly.

Proper Functioning Condition (PFC)

The Bureau of Land Management (BLM) has developed guidelines and procedures to rapidly assess whether a stream riparian area is functioning properly in terms of its hydrology, landform/soils, channel characteristics, and vegetation (Prichard et al. 1993, rev. 1995). This assessment, commonly called PFC, is useful as a baseline analysis of stream condition and physical function, and it can also be useful in watershed analysis.

It is essential to do a thorough analysis of the stream corridor and watershed conditions prior to development of restoration plans and selection of restoration approaches to be used. There are many cases where selection of the wrong approach has led to complete failure of stream restoration efforts and the waste of costs of restoration. In many cases, particularly in wildland situations, restoration through natural processes and control of land uses is the preferred and most cost-effective method. If hydrologic conditions are rapidly changing in a drainage, no restoration might be the wisest course until equilibrium is restored.

Identifying streams and drainages where riparian areas along streams are not in proper functioning condition, and those at risk of losing function, is an important first step in restoration analysis. Physical conditions in riparian zones are excellent indicators of what is happening in a stream or the drainage above.

With the results of PFC analysis, it is possible to begin to determine stream corridor and watershed restoration needs and priorities. PFC results may also be used to identify where gathering more detailed information is needed and where additional data are not needed.

PFC is a methodology for assessing the physical functioning of a riparian-wetland area. It provides information critical to determining the "health" of a riparian ecosystem. PFC considers both abiotic and biotic components as they relate to the physical functioning of riparian areas, but it does not consider the biotic component as it relates to habitat requirements. For habitat analysis, other techniques must be employed.

The PFC procedure is currently a standard baseline assessment for stream/riparian surveys for the BLM, and PFC is beginning to be used by the U.S. Forest Service in the West. This technique is not a substitute for inventory or monitoring protocols designed to yield detailed information on the habitat or populations of plants or animals dependent on the riparian-stream ecosystem.

PFC is a useful tool for watershed analysis. Although the assessment is conducted on a stream reach basis, the ratings can be aggregated and analyzed at the watershed scale. PFC, along with other watershed and habitat condition information, provides a good picture of watershed "health" and causal factors affecting watershed "health." Use of PFC will help to identify watershed-scale problems and suggest management remedies.

The following are definitions of proper function as set forth in TR 1737-9:

- *Proper Functioning Condition* Riparian-wetland areas are functioning properly when adequate vegetation, landform, or large woody debris is present to:

1. Dissipate stream energy associated with high waterflows, thereby reducing erosion and improving water quality.
2. Filter sediment, capture bedload, and aid floodplain development.
3. Improve floodwater retention and ground water storage.
4. Develop root masses that stabilize streambanks against cutting action.
5. Develop diverse ponding and channel characteristics to provide the habitat and the water depth, duration, and temperature necessary for fish production, waterfowl breeding, and other uses.
6. Support greater biodiversity.

- *Functional-at Risk* Riparian-wetland areas that are in functional condition, but an existing soil, water, or vegetation attribute makes them susceptible to degradation.
- *Nonfunctional* Riparian-wetland areas that clearly are not providing adequate vegetation, landform, or large debris to dissipate stream energy associated with high flow and thus are not reducing erosion, improving water quality, or performing other functions as listed above under the definition of proper function. The absence of certain physical attributes, such as absence of a floodplain where one should be, is an indicator of nonfunctioning conditions.

Assessing functionality with the PFC technique involves procedures for determining a riparian-wetland area's capability and potential, and comparing that potential with current conditions.

Although the PFC procedure defines streams without floodplains (when a floodplain would normally be present) as nonfunctional, many streams that lose their floodplains through incision or encroachment still retain ecological functions. The importance of a floodplain needs to be assessed in view of the site-specific aquatic and riparian community.

When using the PFC technique, it is important not to equate "proper function" with "desired condition." Proper function is intended to describe the state in which the stream channel and associated riparian areas are in a relatively stable and self-sustaining condition. Properly functioning streams can be expected to withstand intermediate flood events (e.g., 25- to 30-year flood events) without substantial damage to existing values. However, proper functioning condition will often develop well before riparian succession provides shrub habitat for nesting birds. Put another way, proper functioning condition is a prerequisite to a variety of desired conditions.

Although based on sound science, the PFC field technique is not quantitative. An advantage of this approach is that it is less time-consuming than other techniques because measurements are not required. The procedure is performed by an interdisciplinary team and involves completing a checklist evaluating 17 factors dealing with hydrology, vegetation, and erosional/depositional characteristics. Training in the technique is required, but the technique is not difficult to learn. With training, the functional determinations resulting from surveys are reproducible to a high degree.

Other advantages of the PFC technique are that it provides an easy-to-understand "language" for discussing stream conditions with a variety of agencies and publics, PFC training is readily available, and there is growing interagency acceptance of the technique.

Hydraulic Geometry: Streams in Cross Section

Stream corridor restoration initiatives frequently involve partial or total reconstruction of channels that have been severely degraded. Channel reconstruction design requires criteria for channel size and alignment. The following material presents an overview of *hydraulic geometry theory* and provides some sample hydraulic geometry relationships for relating bankfull dimensions to bankfull discharge. Correlations between certain planform dimensions (e.g., meander characteristics) of stable alluvial stream channels to bankfull discharge and channel width also are discussed.

Hydraulic geometry theory is based on the concept that a river system tends to develop in a way that produces an approximate equilibrium between the channel and the in-flowing water and sediment (Leopold and Maddock 1953). The theory typically relates an independent or driving variable, such as drainage area or discharge, to dependent variables such as width, depth, slope, and velocity. Hydraulic geometry relations are sometimes stratified according to bed material size or other factors. These relationships are empirically derived, and their development requires a relatively large amount of data.

Figure 7.17 presents hydraulic geometry relations based on the mean annual discharge rather than the bankfull discharge. Similar hydraulic geometry relationships can be determined for a watershed of interest by measuring channel parameters at numerous cross sections and plotting them against a discharge. Such plots can be used with care for planning and preliminary design. The use of hydraulic geometry relationships alone for final design is not recommended.

Careful attention to defining stable channel conditions, channel-forming discharge, and streambed and bank characteristics are required in the data collection effort. The primary role of discharge in determining channel cross sections has been clearly demonstrated, but there is a lack of consensus about which secondary factors such as sediment loads, bank materials, and vegetation are significant, particularly with respect to width. Hydraulic geometry relationships that do not explicitly consider sediment transport are applicable mainly to channels with relatively low bed-material loads (USACE 1994).

Hydraulic geometry relations can be developed for a specific river, watershed, or for streams with similar physiographic characteristics. Data scatter is expected about the developed curves even in the same river reach. The more dissimilar the stream and watershed characteristics are, the greater the expected data scatter is. It is important to recognize that this scatter represents a valid range of stable channel configurations due to variables such as geology, vegetation, land use, sediment load and gradation, and runoff characteristics.

Figures 7.18 and 7.19 show hydraulic geometry curves developed for the upper Salmon River watershed in Idaho (Emmett 1975). The scatter of data for stable reaches in the watershed indicates that for a drainage area of 10 square miles, the bankfull discharge could reasonably range from 100 to 250 cfs and the bankfull width could reasonably range from 10 to 35 feet. These relations were developed for a relatively homogeneous watershed, yet there is still quite a bit of natural variation in the data. This illustrates the importance of viewing the data used to develop any curve (not just the curve itself), along with statistical parameters such as R^2 values and confidence limits. (Refer to a text on statistics for additional information.)

Given the natural variation related to stream and watershed characteristics, the preferred source of data for a hydraulic geometry relationship would be the restoration initiative reach. This choice may be untenable due to channel instability. The second preferred choice is the project watershed, although care must be taken to ensure that data are acquired for portions of the watershed with physiographic conditions similar to those of the project reach.

Statistically, channel-forming discharge is a more reliable independent variable for hydraulic geometry relations than drainage area. This is because the magnitude of the channel forming discharge is the driving force that creates the observed channel geometry, and drainage

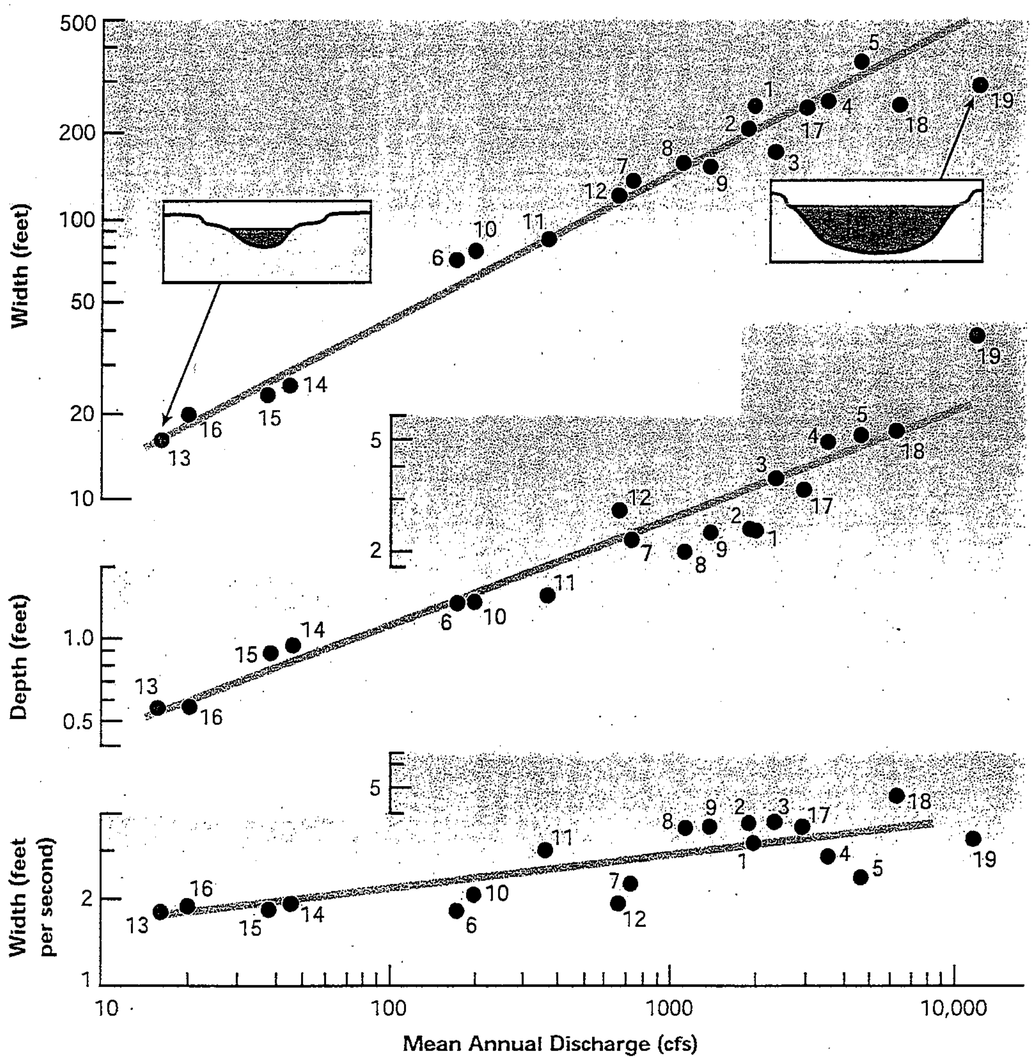


Figure 7.17: Channel morphology related to average annual discharge. *Width, depth, and velocity in relation to mean annual discharge as discharge increases downstream on 19 rivers in Wyoming and Montana.*
Source: Leopold and Maddock 1953.

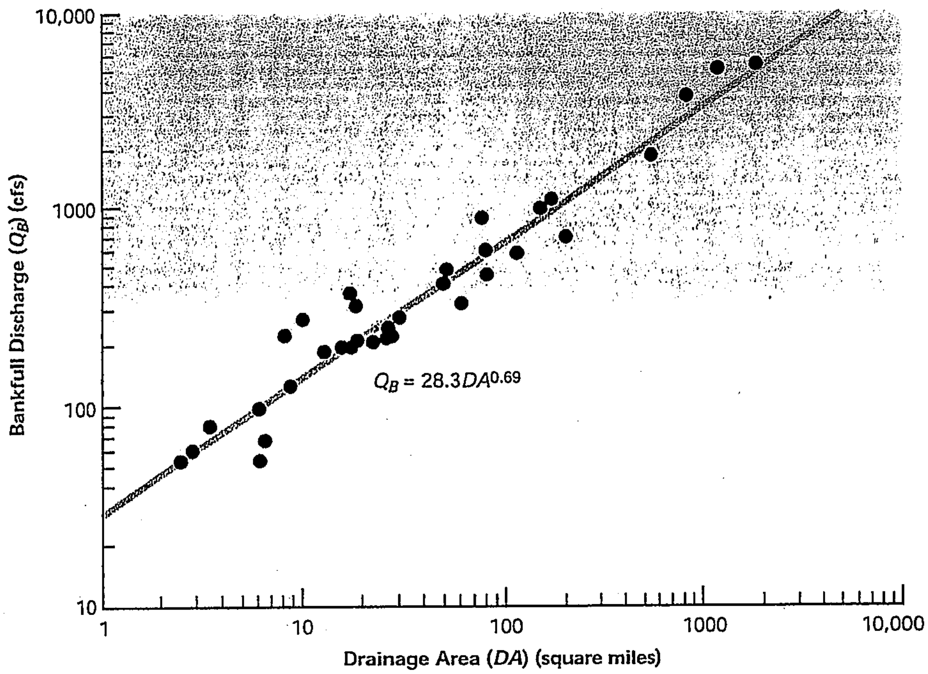


Figure 7.18: Bankfull discharge versus drainage area—Upper Salmon River area. *Curves based on measured data such as this can be valuable tools for designing restorations (Emmett 1975).*

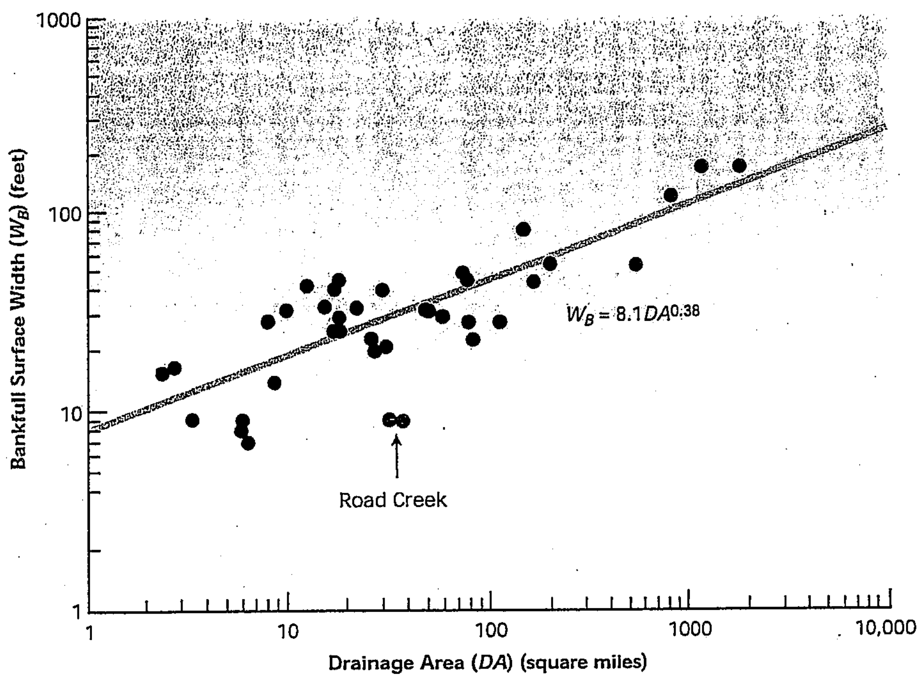


Figure 7.19: Bankfull surface width versus drainage area—Upper Salmon River area. *Local variations in bankfull width may be significant. Road Creek widths are narrower because of lower precipitation.*

Regime Theory and Hydraulic Geometry

Regime theory was developed about a century ago by British engineers working on irrigation canals in what is now India and Pakistan. Canals that required little maintenance were said to be "in regime," meaning that they conveyed the imposed water and sediment loads in a state of dynamic equilibrium, with width, depth, and slope varying about some long-term average. These engineers developed empirical formulas linking low-maintenance canal geometry and design discharge by fitting data from relatively straight canals carrying near-constant discharges (Blench 1957, 1969; Simons and Albertson 1963). Since few streams will be restored to look and act as canals, the regime relationships are not presented here.

About 50 years later, hydraulic geometry formulas similar to regime relationships were developed by geomorphologists studying stable, natural rivers. These rivers, of course, were not straight and had varying discharges. A sample of these hydraulic geometry relationship is presented in the table on the following page. In general, these formulas take the form:

$$w = k_1 Q^{k_2} D_{50}^{k_3}$$

$$D = k_4 Q^{k_5} D_{50}^{k_6}$$

$$S = k_7 Q^{k_8} D_{50}^{k_9}$$

where w and D are reach average width and depth in feet, S is the reach average slope, D_{50} is the median bed sediment size in millimeters, and Q is the bankfull discharge in cubic feet per second. These formulas are most reliable for width, less reliable for depth, and least reliable for slope.

area is merely a surrogate for discharge. Typically, channel-forming discharge correlates best with channel width. Correlations with depth are somewhat less reliable. Correlations with slope and velocity are the least reliable.

Hydraulic Geometry and Stability Assessment

The use of hydraulic geometry relations to assess the stability of a given channel reach requires two things. First, the watershed and stream channel characteristics of the reach in question must be the same as (or similar to) the data set used to develop the hydraulic geometry relations. Second, the reasonable scatter of the data in the hydraulic geometry relations must be known. If the data for a specific reach fall outside the reasonable scatter of data for stable reaches in a similar watershed, there is reason to believe that the reach in question may be unstable. This is only an indicator, since variability in other factors (geology, land use, vegetation, etc.) may cause a given reach to plot high or low on a curve. For instance, in Figure 7.17, the data points from the Road Creek subbasin plot well below the line (narrower bankfull surface width) because the precipitation in this subbasin is lower. These reaches are not unstable; they have developed smaller channel widths in response to lower discharges (as one would expect).

In summary, the use of hydraulic geometry relations requires that the actual data be plotted and the statistical coefficients known. Hydraulic geometry relations can be used as a preliminary guide to indicate stability or instability in stream reaches, but these indications should be checked using other techniques due to the wide natural variability of the data (see Chapter 8 for more information on assessment of channel stability).

Regional Curves

Dunne and Leopold (1978) looked at similar relationships from numerous watersheds and published *regional curves* relating bankfull channel dimensions to drainage area (**Figure 7.20**). Using these curves, the width and depth of the bankfull channel can be approximated once the drainage area of a watershed within one of these regions is known. Obviously, more curves such as these are needed for regions that experience different topographic, geologic, and hydrologic regimes; therefore, additional regional relationships should be developed for specific areas of interest. Several hydraulic geometry formulas are presented in **Table 7.5**.

Regional curves should be used only as indicators to help identify the channel geometry at a restoration initiative site

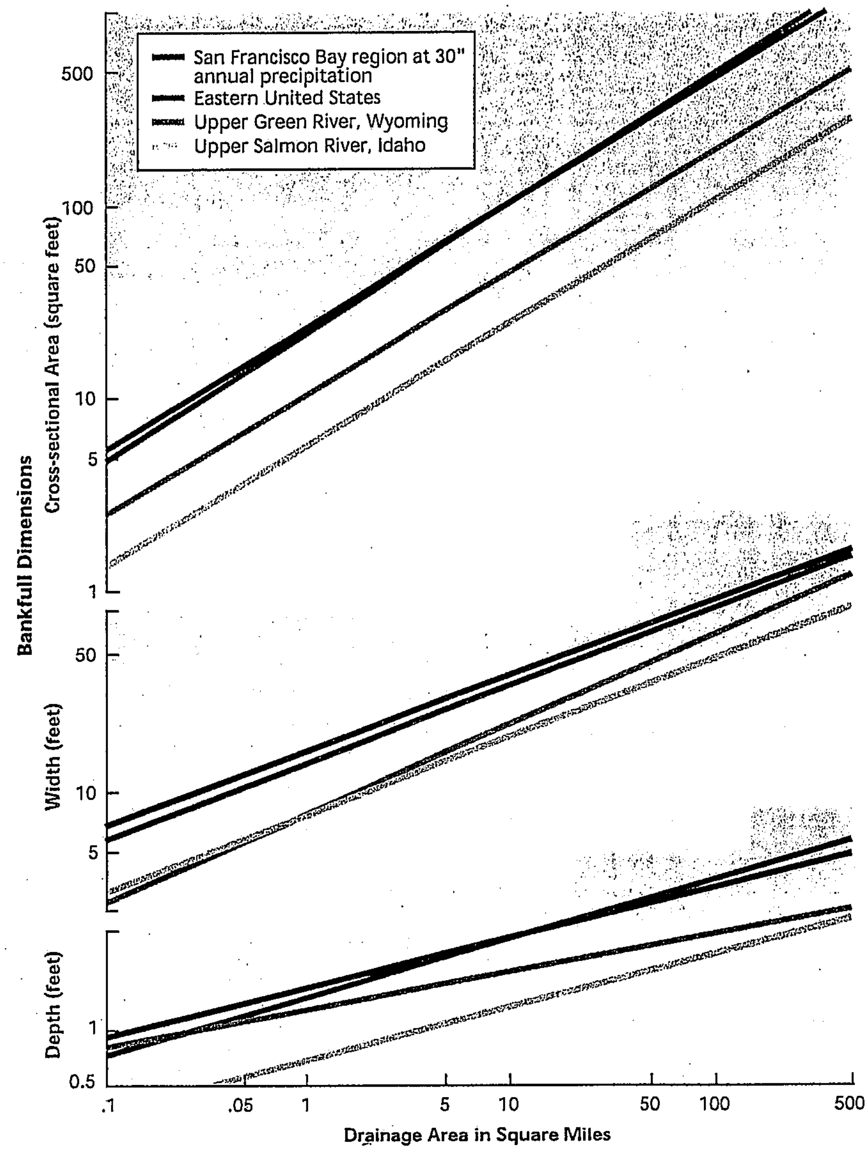


***Figure 7.20:* Regional curves for bankfull channel dimensions versus drainage area.** *Curves showing channel dimensions relating to drainage area for a region of the country can be useful in determining departure from normal conditions. The use of such curves must be tempered with an understanding of the limitations of the specific data that produced the curves.*
Source: Dunne and Leopold 1978.

Table 7.5: Limits of data sets used to derive regime formulas.
Source: Hey 1988, 1990.

Reference	Data Source	Median Bed Material Size (mm)	Banks	Discharge (ft^3/s)	Sediment Concentration (ppm)	Slope	Bedforms
Lacey 1958	Indian canals	0.1 to 0.4	Cohesive to slightly cohesive	100 to 10,000	< 500		
Blench 1969	Indian canals	0.1 to 0.6	Cohesive	1 to 100,000	< 30[1]	Not specified	Ripples to dunes
Simons and Albertson 1963	U.S. and Indian canals	0.318 to 0.465	Sand	100 to 400	< 500	.000135 to .000388	Ripples to dunes
		0.06 to 0.46	Cohesive	5 to 88,300	< 500	.000059 to .00034	Ripples to dunes
		Cohesive, 0.029 to 0.36	Cohesive	137 to 510	< 500	.000063 to .000114	Plane
Nixon 1959	U.K. rivers	gravel		700 to 18,050	Not measured		
Kellerhals 1967	U.S., Canadian, and Swiss rivers of low sinuousity, and lab	7 to 265	Noncohesive	1.1 to 70,600	Negligible	.00017 to .0131	Plane
Bray 1982	Sinuous Canadian rivers	1.9 to 145		194 to 138,400	Mobile bed	.00022 to .015	
Parker 1982	Single channel Canadian rivers		Little cohesion	353 to 211,900			
Hey and Thorne 1986	Meandering U.K. rivers	14 to 176		138 to 14,970	Q_S computed to range up to 114	.0011 to .021	

[1] Blench (1969) provides adjustment factors for sediment concentrations between 30 and 100 ppm.

because of the large degree of natural variation in most data sets. Published hydraulic geometry relationships usually are based on stable, single-thread alluvial channels. Channel geometry-discharge relationships are more complex for multithread channels.

Exponents and coefficients for hydraulic geometry formulas are usually determined from data sets for a specific stream or watershed. The relatively small range of variation of the exponents k_2, k_5, and k_8 is impressive, considering the wide range of situations represented. Extremes for the data sets used to generate the hydraulic geometry formulas are given in **Tables 7.6 and 7.7**. Because formula coefficients vary, applying a given set of hydraulic geometry relationships should be limited to channels similar to the calibration sites. This principle severely limits applying the Lacey, Blench, and Simons and Albertson formulas in channel restoration work since these curves were developed using canal data. Additionally, hydraulic geometry relationships developed for pristine or largely undeveloped watersheds should not be applied to urban watersheds.

As shown in Table 7.5, hydraulic geometry relationships for gravel-bed rivers are far more numerous than those for sand-bed rivers. Gravel-bed relationships have been adjusted for bank soil characteristics and vegetation, whereas sand-bed formulas have been modified to include bank silt-clay content (Schumm 1977). Parker (1982) argues in favor of regime-type relationships based on dimensionless variables. Accordingly, the original form of the Parker formula was based on dimensionless variables.

Table 7.6: Coefficients for selected hydraulic geometry formulas.

Author	Year	Data	Domain	k_1	k_2	k_3	k_4	k_5	k_6	k_7	k_8	k_9
Nixon	1959	U.K. rivers	Gravel-bed rivers		0.5		0.545	0.33		$1.258n^{2b}$	-0.11	
Leopold et al.	1964	Midwestern U.S.		1.65	0.5			0.4			-0.49	
		Ephemeral streams in semiarid U.S.			0.5			0.3			-0.95	
Kellerhals	1967	Field (U.S., Canada, and Switzerland) and laboratory	Gravel-bed rivers with paved beds and small bed material concentration	1.8	0.5		0.33	0.4	-0.12^{a}	0.00062	-0.4	0.92^{a}
Schumm	1977	U.S. (Great Plains) and Australia (Riverine Plains of New South Wales)	Sand-bed rivers with properties shown in Table 6	$37k_1$*	0.38		$0.6k_4$*	0.29	-0.12^{a}	$0.01136k_7$*	-0.32	
Bray	1982	Canadian rivers	Gravel-bed rivers	3.1	0.53	-0.07	0.304	0.33	-0.03	0.00033	-0.33	0.59
Parker	1982	Single-channel Alberta rivers	Gravel-bed rivers, banks with little cohesion	6.06	0.444	-0.11	0.161	0.401	-0.0025	0.00127	-0.394	0.985
Hay and Thorne	1986	U.K. rivers	Gravel-bed rivers with:									
			Grassy banks with no trees or shrubs	2.39	0.5		0.41	0.37	-0.11	$0.00296k_7$**	-0.43	-0.09
			1-5% tree/shrub cover	1.84	0.5		0.41	0.37	-0.11	$0.00296k_7$**	-0.43	-0.09
			Greater than 5-50% tree/shrub cover	1.51	0.5		0.41	0.37	-0.11	$0.00296k_7$**	-0.43	-0.09
			Greater than 50% shrub cover or incised flood plain	1.29	0.5		0.41	0.37	-0.11	$0.00296k_7$**	-0.43	-0.09

[a] Bed material size in Kellerhals equation is D_{90}.
[b] n = Manning n.
k_1* = $M^{-0.39}$, where M is the percent of bank materials finer than 0.074 mm. The discharge used in this equation is mean annual rather than bankfull.
k_4* = $M^{0.432}$, where M is the percent of bank materials finer than 0.074 mm. The discharge used in this equation is mean annual rather than bankfull.
k_7* = $M^{-0.36}$, where M is the percent of bank materials finer than 0.074 mm. The discharge used in this equation is mean annual rather than bankfull.
k_7** = $D_{54}^{0.84} Q_x^{0.10}$, where Q_x = bed material transport rate in kg s^{-1} at water discharge Q, and D_{54} refers to bed material and is in mm.

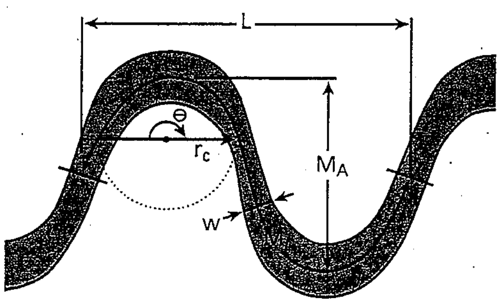
Planform and Meander Geometry: Stream Channel Patterns

Meander geometry variables are shown in **Figure 7.21**. Channel planform parameters may be measured in the field or from aerial photographs and may be compared with published relationships, such as those identified in the box. Developing regional relationships or coefficients specific to the site of interest is, however, preferable to using published relationships that may span wide ranges in value. **Figure 7.22** shows some planform geometry relations by Leopold (1994). Meander geometries that do not fall within the range of predicted relationships may indicate stream instability and deserve attention in restoration design.

Table 7.7: Meander geometry equations.
Source: Williams 1986.

Equation Number	Equation	Applicable Range
Interrelations between meander features		
2	$L_m = 1.25L_b$	$18.0 \le L_b \le 43{,}600$ ft
3	$L_m = 1.63B$	$12.1 \le B \le 44{,}900$ ft
4	$L_m = 4.53R_c$	$8.5 \le R_c \le 11{,}800$ ft
5	$L_b = 0.8L_m$	$26 \le L_m \le 54{,}100$ ft
6	$L_b = 1.29B$	$12.1 \le B \le 32{,}800$ ft
7	$L_b = 3.77R_c$	$8.5 \le R_c \le 11{,}800$ ft
8	$B = 0.61L_m$	$26 \le L_m \le 76{,}100$ ft
9	$B = 0.78L_b$	$18.0 \le L_b \le 43{,}600$ ft
10	$B = 2.88R_c$	$8.5 \le R_c \le 11{,}800$ ft
11	$R_c = 0.22L_m$	$33 \le L_m \le 54{,}100$ ft
12	$R_c = 0.26L_b$	$22.3 \le L_b \le 43{,}600$ ft
13	$R_c = 0.35B$	$16 \le B \le 32{,}800$ ft
Relations of channel size to meander features		
14	$A = 0.0094L_m^{1.53}$	$33 \le L_m \le 76{,}100$ ft
15	$A = 0.0149L_b^{1.53}$	$20 \le L_b \le 43{,}600$ ft
16	$A = 0.021B^{1.53}$	$16 \le B \le 38{,}100$ ft
17	$A = 0.117R_c^{1.53}$	$7 \le R_c \le 11{,}800$ ft
18	$W = 0.019L_m^{0.89}$	$26 \le L_m \le 76{,}100$ ft
19	$W = 0.026L_b^{0.89}$	$16 \le L_b \le 43{,}600$ ft
20	$W = 0.031B^{0.89}$	$10 \le B \le 44{,}900$ ft
21	$W = 0.81R_c^{0.89}$	$8.5 \le R_c \le 11{,}800$ ft
22	$D = 0.040L_m^{0.66}$	$33 \le L_m \le 76{,}100$ ft
23	$D = 0.054L_b^{0.66}$	$23 \le L_b \le 43{,}600$ ft
24	$D = 0.055B^{0.66}$	$16 \le B \le 38{,}100$ ft
25	$D = 0.127R_c^{0.66}$	$8.5 \le R_c \le 11{,}800$ ft
Relations of meander features to channel size		
26	$L_m = 21A^{0.65}$	$0.43 \le A \le 225{,}000$ ft
27	$L_b = 15A^{0.65}$	$0.43 \le A \le 225{,}000$ ft
28	$B = 13A^{0.65}$	$0.43 \le A \le 225{,}000$ ft
29	$R_c = 4.1A^{0.65}$	$0.43 \le A \le 225{,}000$ ft
30	$L_m = 6.5W^{1.12}$	$4.9 \le W \le 13{,}000$ ft
31	$L_b = 4.4W^{1.12}$	$4.9 \le W \le 7{,}000$ ft
32	$B = 3.7W^{1.12}$	$4.9 \le W \le 13{,}000$ ft
33	$R_c = 1.3W^{1.12}$	$4.9 \le W \le 7{,}000$ ft
34	$L_m = 129D^{1.52}$	$0.10 \le D \le 59$ ft
35	$L_b = 86D^{1.52}$	$0.10 \le D \le 57.7$ ft
36	$B = 80D^{1.52}$	$0.10 \le D \le 59$ ft
37	$R_c = 23D^{1.52}$	$0.10 \le D \le 57.7$ ft
Relations between channel width, channel depth, and channel sinuosity		
38	$W = 12.5D^{1.45}$	$0.10 \le D \le 59$ ft
39	$D = 0.17W^{0.89}$	$4.92 \le W \le 13{,}000$ ft
40	$W = 73D^{1.23}K^{-2.35}$	$0.10 \le D \le 59$ ft and $1.20 \le K \le 2.60$
41	$D = 0.15W^{0.50}K^{1.48}$	$4.9 \le W \le 13{,}000$ ft and $1.20 \le K \le 2.60$

Derived empirical equations for river-meander and channel-size features.
A = bankfull cross-sectional area.
W = bankfull width.
D = bankfull mean depth.
L_m = meander wavelength.
L_b = along-channel bend length.
B = meander belt width.
R_c = loop radius of curvature.
K = channel sinuosity.



L meander wavelength
M_L meander arc length
w average width at bankfull discharge
M_A meander amplitude
r_c radius of curvature
θ arc angle

Figure 7.21: Meander geometry variables.
Adapted from Williams 1986.

Stream System Dynamics

Stream management and restoration require knowledge of the complex interactions between watershed and stream processes, boundary sediments, and bank and floodplain vegetation. Identifying the causes of channel instability or potential instability and having knowledge of the magnitude and distribution of channel adjustment processes are important for the following:

- Estimating future channel changes.
- Developing appropriate mitigation measures.
- Protecting the stream corridor.

Meander Geometry Formulas

Reviews of meander geometry formulas are provided by Nunnally and Shields (1985 Table 3) and Chitale (1973). Ackers and Charlton (1970) developed a typical formula that relates meander wavelength and bankfull discharge, Q (cfs), using laboratory data and checking against field data from a wide range of stream sizes.

$$L = 38Q^{0.467}$$

There is considerable scatter about this regression line; examination of the plotted data is recommended. Other formulas, such as this one by Schumm (1977), also incorporate bed sediment size or the fraction of silt-clay in the channel perimeter:

$$L = 1890Q_m^{0.34} / M^{0.74}$$

where Q_m is average discharge (cfs) and M is the percentage of silt-clay in the perimeter of the channel. These types of relationships are most powerful when developed from regional data sets with conditions that are typical of the area being restored. Radius of curvature, r, is generally between 1.5 and 4.5 times the channel width, w, and more commonly between 2w and 3w, while meander amplitude is 0.5 to 1.5 times the meander wavelength, L (USACE 1994). Empirical (Apmann 1972, Nanson and Hickin 1983) and analytical (Begin 1981) results indicate that lateral migration rates are greatest for bends with radii of curvature between 2w and 4w.

Adjustment processes that affect entire fluvial systems often include channel incision (lowering of the channel bed with time), aggradation (raising of the channel bed with time), planform geometry changes, channel widening or narrowing, and changes in the magnitude and type of sediment loads. These processes differ from localized processes, such as scour and fill, which can be limited in magnitude and extent.

In contrast, the processes of channel incision and aggradation can affect long reaches of a stream or whole stream systems. Long-term adjustment processes, such as incision, aggradation, and channel widening, can exacerbate local scour problems. Whether streambed erosion occurs due to local scour or channel incision, sufficient bed level lowering can lead to bank instability and to changes in channel planform.

It is often difficult to differentiate between local and systemwide processes without extending the investigation upstream and downstream of the site in question. This is because channels migrate over time and space and so may affect previously undisturbed reaches. For example, erosion at a logjam initially may be attributed to the deflection of flows caused by the woody debris blocking the channel. However, the appearance of large amounts of woody debris may indicate upstream channel degradation related to instability of larger scope.

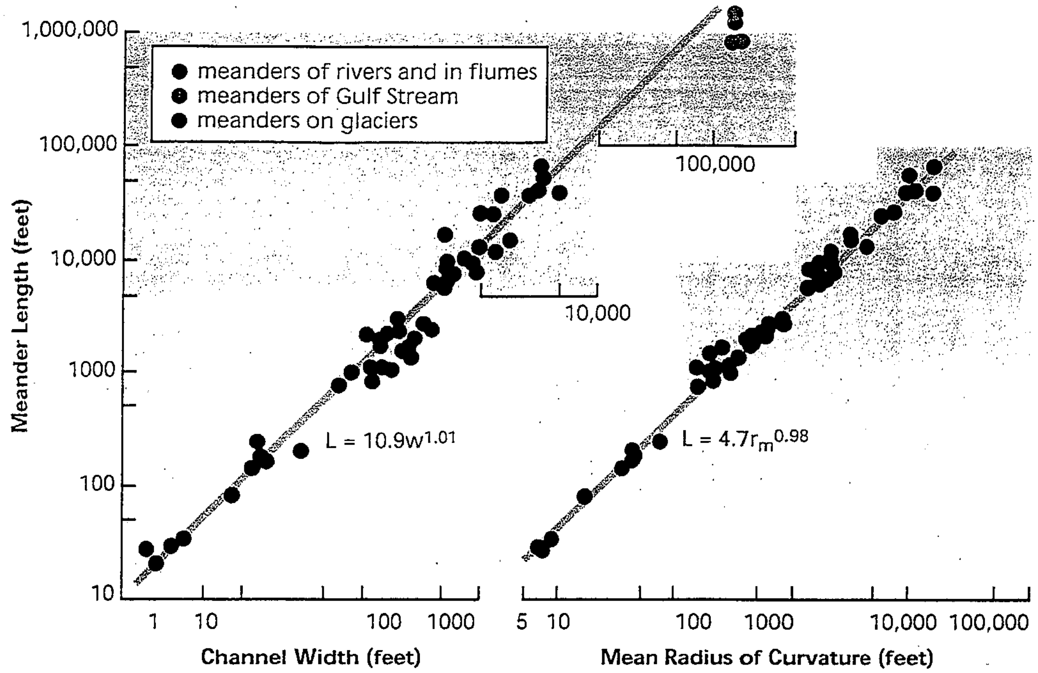


Figure 7.22: Planform geometry relationships. *Meander geometries that do not plot close to the predicted relationship may indicate stream instability.*
Source: Leopold 1994.

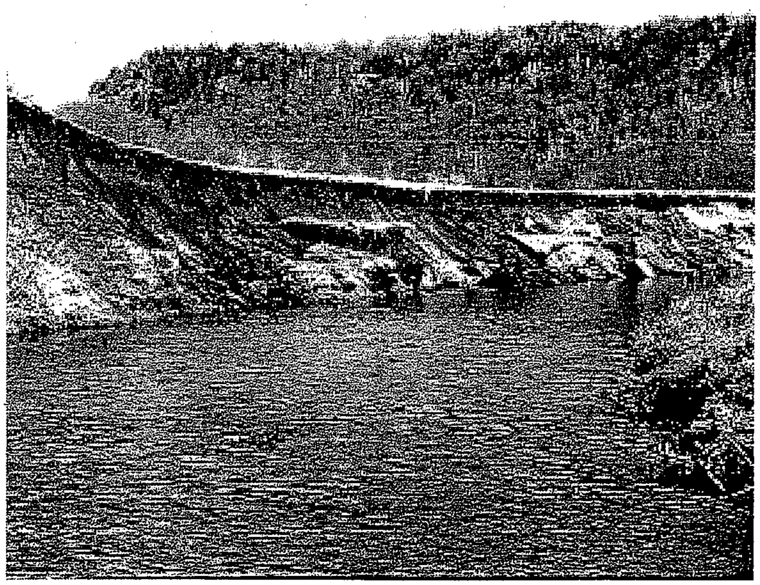


Figure 7.23: Bank instability. *Determining if instability is localized or systemwide is imperative to establish a correct path of action.*

Determining Stream Instability: Is It Local or Systemwide?

Stage of channel evolution is the primary diagnostic variable for differentiating between local and systemwide channel stability problems in a disturbed stream or constructed channel. During basinwide adjustments, stage of channel evolution usually varies systematically with distance upstream. Downstream sites might be characterized by aggradation and the waning stages of widening, whereas upstream sites might be characterized (in progressive upstream order) by widening and mild degradation, then degradation, and if the investigation is extended far enough upstream, the stable, predisturbed condition (Figure 7.23). This sequence of stages can be used to reveal systemwide instabilities. Stream classification can be applied in a similar manner to natural streams. The sequence of stream types can reveal systemwide instabilities.

Restoration measures often fail, not as the result of inadequate structural design, but rather because of the failure of the designers to incorporate the existing and future channel morphology into the design. For this reason, it is important for the designer to have some general understanding of stream processes to ensure that the selected restoration measures will work in harmony with the existing and future river conditions. This will allow the designer to assess whether the conditions at a particular site are due to local instability processes or are the result of some systemwide instability that may be affecting the entire watershed.

Systemwide Instability

The equilibrium of a stream system can be disrupted by various factors. Once this occurs, the stream will attempt to regain equilibrium by making adjustments in the dependent variables. These adjustments in the context of physical processes are generally reflected in aggradation, degradation, or changes in planform characteristics (meander wavelength, sinuosity, etc.). Depending on the magnitude of the change and the basin characteristics (bed and bank materials, hydrology, geologic or man-made controls, sediment sources, etc.), these adjustments can propagate throughout the entire watershed and even into neighboring systems. For this reason, this type of disruption of the equilibrium condition is referred to as system instability. If system instability is occurring or expected to occur, it is imperative that the restoration initiative address these problems before any bank stabilization or instream habitat development is considered.

Local Instability

Local instability refers to erosion and deposition processes that are not symptomatic of a disequilibrium condition in the watershed (i.e., system instability). Perhaps the most common form of local instability is bank erosion along the concave bank in a meander bend that is occurring as part of the natural meander process. Local instability can also occur in isolated locations as the result of channel constriction, flow obstructions (ice, debris, structures, etc.), or geotechnical instability. Local instability problems are amenable to local bank protection. Local instability can also exist in channels where severe system instability exists. In these situations, the local instability problems will probably be accelerated due to the system instability, and a more comprehensive treatment plan will be necessary.

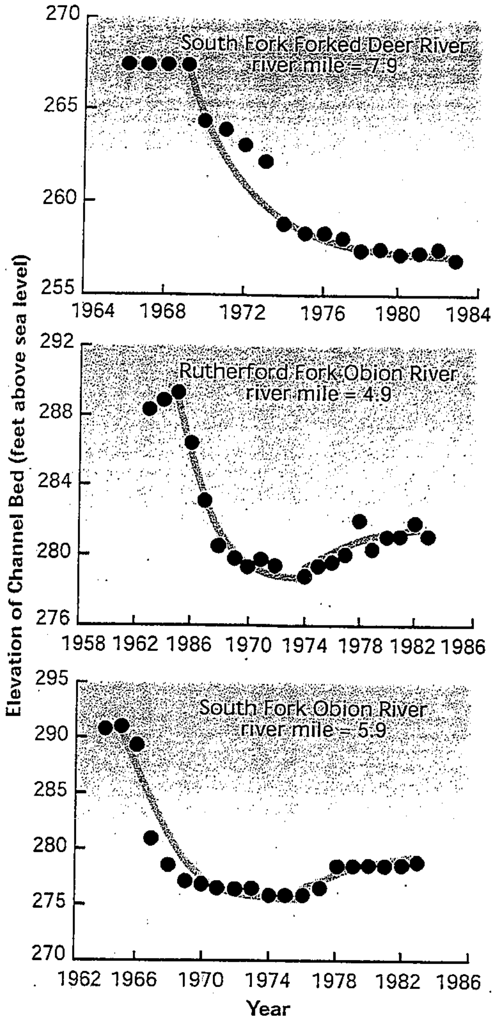
Caution must be exercised if only local treatments on one site are implemented. If the upstream reach is stable and the downstream reach is unstable, a systemwide problem may again be indicated. The instability may continue moving upstream unless the root cause of the instability at the watershed level is removed or channel stabilization at and downstream of the site is implemented.

Local channel instabilities often can be attributed to redirection of flow caused by debris, structures, or the approach angle from upstream. During moderate and high flows, obstructions often result in vortices and secondary-flow cells that accelerate impacts on channel boundaries, causing local bed scour, erosion of bank toes, and ultimately bank failures. A general constriction of the channel cross section from debris accumulation or a bridge causes a backwater condition upstream, with acceleration of the flow and scour through the constriction.

Bed Stability

In unstable channels, the relationship between bed elevation and time (years)

Figure 7.24: ***Changes in bed elevations over time.*** *Plotting river bed elevations at a point along the river over time can indicate whether a major phase of channel incision is ongoing or has passed.*



can be described by nonlinear functions, where change in response to a disturbance occurs rapidly at first and then slows and becomes asymptotic with time (**Figure 7.24**). Plotting bed elevations against time permits evaluating bed-level adjustment and indicates whether a major phase of channel incision has passed or is ongoing. Various mathematical forms of this function have been used to characterize bed-level adjustment at a site and to predict future bed elevations. This method also can provide valuable information on trends of channel stability at gauged locations where abundant data from discharge measurements are available.

Specific Gauge Analysis

Perhaps one of the most useful tools available to the river engineer or geomorphologist for assessing the historical stability of a river system is the specific gauge record. A specific gauge record is a graph of stage for a specific discharge at a particular stream gauging location plotted against time (Blench 1969). A channel is considered to be in equilibrium if the specific gauge record shows no consistent increasing or decreasing trends over time, while an increasing or decreasing trend is indicative of an aggradational or degradational condition, respectively. An example of a specific gauge record is shown in **Figure 7.25.**

The first step in a specific gauge analysis is to establish the stage vs. discharge relationship at the gauge for the period of record being analyzed. A rating curve is developed for each year in the period of record. A regression curve is then fitted to the data and plotted on the scatter plot. Once the rating curves have been developed, the discharges to be used in the specific gauge record must be selected. This selection depends largely on the objectives of the study. It is usually advisable to select discharges that encompass the entire range of observed flows. A plot is then developed showing the stage for the given flow plotted against time.

Specific gauge records are an excellent tool for assessing the historical stability at a specific location. However, specific gauge records indicate only the conditions in the vicinity of the particular gauging station and do not necessarily reflect river response farther upstream or downstream of the gauge. Therefore, even though the specific gauge record is one of the most valuable tools used by river engineers, it should be coupled with other assessment techniques to

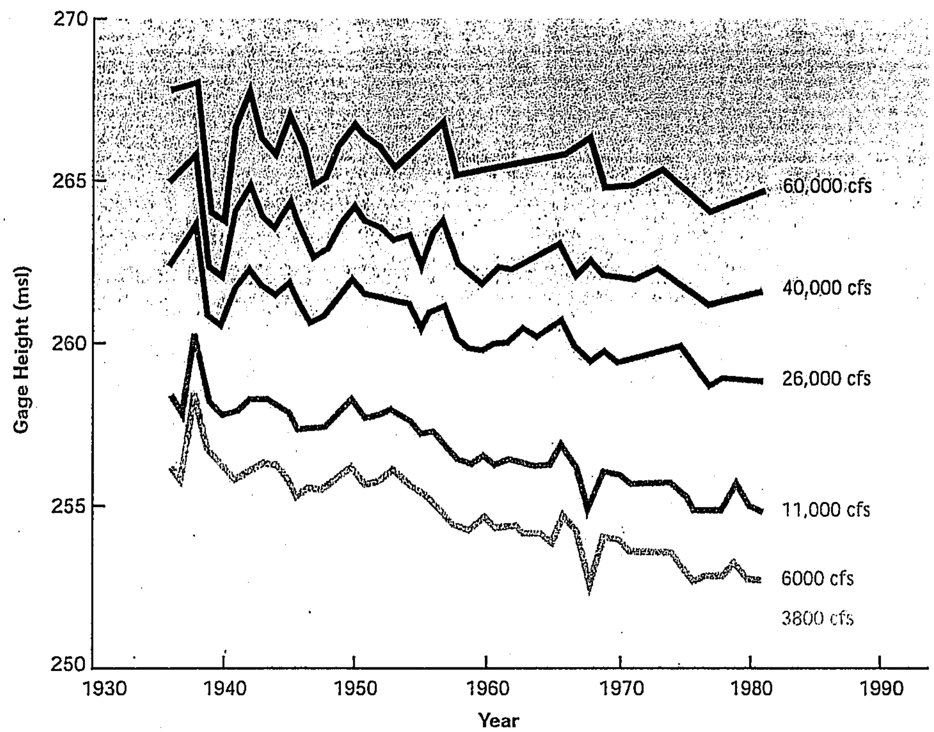


Figure 7.25: Specific gauge plot for Red River at Index, Arkansas. *Select discharges from the gauge data that represent the range of flows.* Source: Biedenharn et al. 1997.

assess reach conditions or to make predictions about the ultimate response on a river.

Comparative Surveys and Mapping

One of the best methods for directly assessing channel changes is to compare channel surveys (thalweg and cross section).

Thalweg surveys are taken along the channel at the lowest point in the cross section. Comparison of several thalweg surveys taken at different points in time allows the engineer or geomorphologist to chart the change in the bed elevation through time (**Figure** 7.26).

Certain limitations should be considered when comparing surveys on a river system. When comparing thalweg profiles, it is often difficult, especially on larger streams, to determine any distinct trends of aggradation or degradation if there are large scour holes, particularly in bendways. The existence of very deep local scour holes may completely obscure temporal variations in the thalweg. This problem can sometimes be overcome by eliminating the pool sections and focusing only on the crossing locations, thereby allowing aggradational or degradational trends to be more easily observed.

Although thalweg profiles are a useful tool, it must be recognized that they reflect only the behavior of the channel bed and do not provide information about the channel as a whole. For this reason it is usually advisable to study changes in the cross-sectional geometry. Cross-sectional geometry refers to width, depth, area, wetted perimeter, hydraulic radius, and channel conveyance at a specific cross section.

If channel cross sections are surveyed at permanent monumented range locations, the cross-sectional geometry at different times can be compared

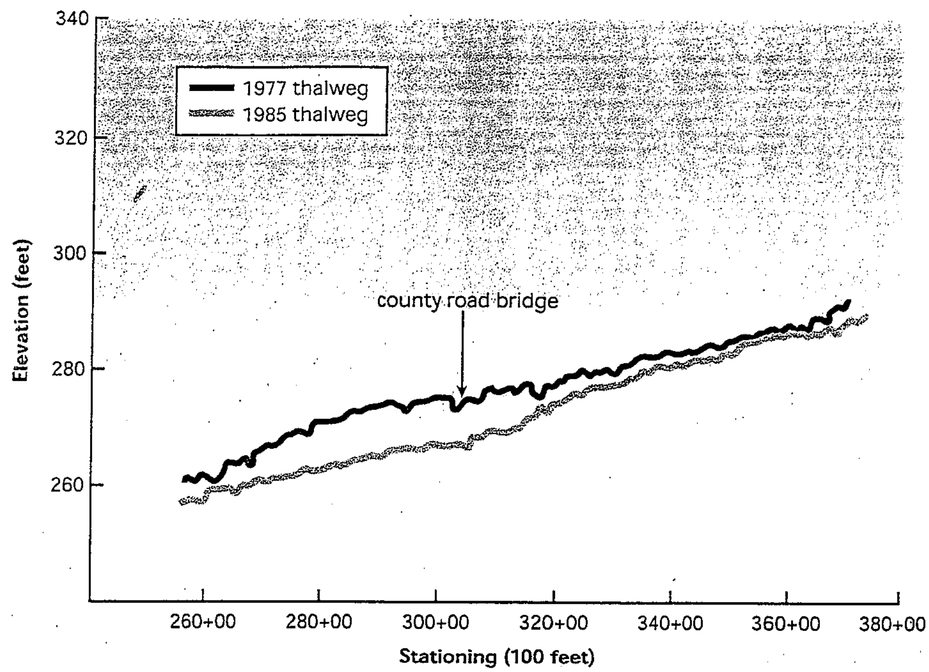


Figure 7.26: Comparative thalweg profiles. *Changes in bed elevation over the length of a stream can indicate areas of transition and reaches where more information is needed.* Source: Biedenharn et al., USACE 1997.

directly. The cross section plots for each range at the various times can be overlaid and compared. It is seldom the case, however, that the cross sections are located in the exact same place year after year. Because of these problems, it is often advisable to compare reach-average values of the cross-sectional geometry parameters. This requires the study area to be divided into distinct reaches based on geomorphic characteristics. Next, the cross-sectional parameters are calculated at each cross section and then averaged for the entire reach. Then the reach-average values can be compared for each survey. Cross-sectional variability between bends (pools) and crossings (riffles) can obscure temporal trends, so it is often preferable to use only cross sections from crossing reaches when analyzing long-term trends of channel change.

Comparison of time-sequential maps can provide insight into the planform instability of the channel. Rates and magnitude of channel migration (bank caving), locations of natural and man-made cutoffs, and spatial and temporal changes in channel width and planform geometry can be determined from maps. With these types of data, channel response to imposed conditions can be documented and used to substantiate predictions of future channel response to a proposed alteration. Planform data can be obtained from aerial photos, maps, or field investigations.

Regression Functions for Degradation

Two mathematical functions have been used to describe bed level adjustments with time. Both may be used to predict channel response to a disturbance, subject to the caution statements below. The first is a power function (Simon 1989a):

$$E = a\, t^b$$

where E = elevation of the channel bed, in feet; a = coefficient, determined by regression, representing the premodified elevation of the channel bed, in feet; t = time since beginning of adjustment process, in years, where $t_0 = 1.0$ (year prior to onset of the adjustment process); and b = dimensionless exponent, determined by regression and indicative of the nonlinear rate of channel bed change (negative for degradation and positive for aggradation).

The second function is a dimensionless form of an exponential equation (Simon 1992):

$$z / z_0 = a + b\, e^{(-k\, t)}$$

where

- z = the elevation of the channel bed (at time t)
- z_0 = the elevation of the channel bed at t_0
- a = the dimensionless coefficient, determined by regression and equal to the dimensionless elevation (z/z_0) when the equation becomes asymptotic, a>1 = aggradation, a<1 = degradation
- b = the dimensionless coefficient, determined by regression and equal to the total change in the dimensionless elevation (z/z_0) when the equation becomes asymptotic
- k = the coefficient determined by regression, indicative of the rate of change on the channel bed per unit time
- t = the time since the year prior to the onset of the adjustment process, in years (t_0=0)

Future elevations of the channel bed can, therefore, be estimated by fitting the equations to bed elevations and by solving for the period of interest. Either equation provides acceptable results, depending on the statistical significance of the fitted relation. Statistical significance of the fitted curves improves with additional data. Degradation and aggradation curves for the same site are fit separately. For degrading sites, the equations will provide projected minimum channel elevations when the value of t becomes large and, by subtracting this result from the floodplain elevation, projected maximum bank heights. A range of bed adjustment trends can be estimated by using different starting dates in the equations when the initial timing of bed level change is unknown. Use of the equations, however, may be limited in some areas because of a lack of survey data.

Regression Functions for Aggradation

Once the minimum bed elevation has been obtained, that elevation can be used as the starting elevation at a new t_0 for the secondary aggradation phase that occurs during channel widening (see discussion of channel evolution above). Secondary aggradation occurs at a site after degradation reduces channel gradient and stream power to such an extent that sediment loads delivered from degrading reaches upstream can no longer be transported (Simon 1989a). Coefficient values for Simon's power function for estimating secondary aggradation can be obtained either from interpolating existing data or from estimating their values as about 60 percent less than the corresponding value obtained for the degradation phase.

The variation of the regression coefficients a and b with longitudinal distance along the channel can be used as an empirical model of bed level adjustment providing there are data from enough sites. Examples using both equations are provided for the Obion River system, West Tennessee (**Figure 7.27**). Estimates of bed-level change with time for unsurveyed sites can be obtained using interpolated coefficient a values and t_0. For channels downstream from dams without significant tributary sediment inputs, the shape of the a-value curve would be similar but inverted; maximum amounts of degradation (minimum a values) occur immediately downstream of the dam and attenuate nonlinearly with distance farther downstream.

Caution: If one of the above mathematical functions is used to predict future bed elevations, the assumption is made that no new disturbances have occurred to trigger a new phase of channel change. Downstream channelization, construction of a reservoir, formation of a large woody debris jam that blocks the channel, or even a major flood are examples of disturbances that can trigger a new period of rapid change.

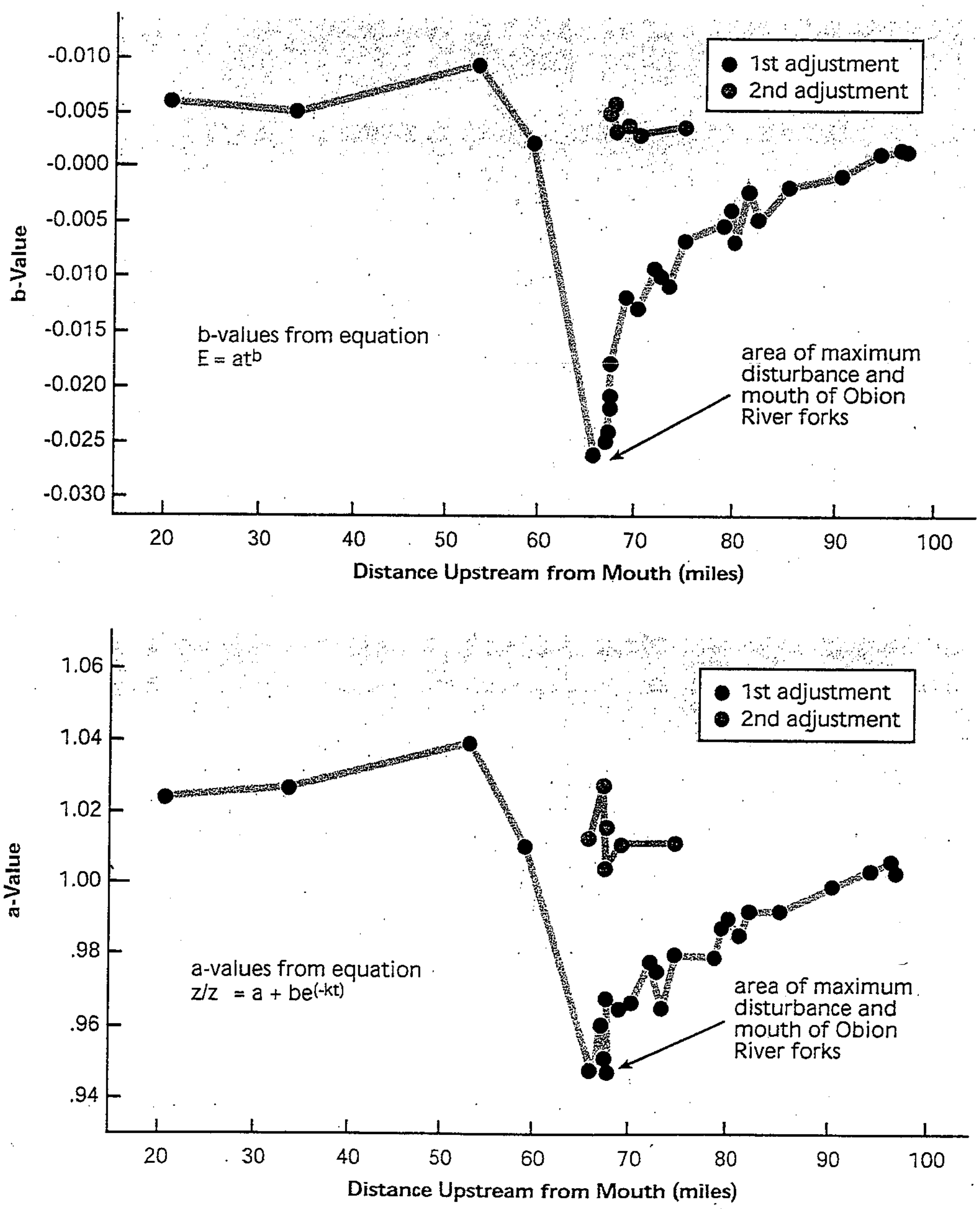


Figure 7.27: Coefficient a and b values for regression functions for estimating bed level adjustment versus longitudinal distance along stream. *Future bed elevations can be estimated by using empirical equations.*
Source: Simon 1989, 92.

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The investigator is cautioned that the use of regression functions to compute aggradation and degradation is an empirical approach that might be appropriate for providing insight into the degradational and aggradational processes during the initial planning phases of a project. However, this procedure does not consider the balance between supply and transport of water and sediment and, therefore, is not acceptable for the detailed design of restoration features.

Sediment Transport Processes

This document does not provide comprehensive coverage of sedimentation processes and analyses critical to stream restoration. These processes include erosion, entrainment, transport, deposition, and compaction. Refer to standard texts and reference on sediment, including Vanoni (1975), Simons and Senturk (1977), Chang (1988), Richards (1982), and USACE (1989a).

Numerical Analyses and Models to Predict Aggradation and Degradation

Numerical analyses and models such as HEC-6 are used to predict aggradation and degradation (incision) in stream channels, as discussed in Chapter 8.

Bank Stability

Streambanks can be eroded by moving water removing soil particles or by collapse. Collapse or mass failure occurs when the strength of bank materials is too low to resist gravity forces. Banks that are collapsing or about to collapse are referred to as being geotechnically unstable (**Figure 7.28**). The physical properties of bank materials should be described to aid characterization of potential stability problems and identification of dominant mechanisms of bank instability.

The level of intensity of geotechnical investigations varies in planning and design. During planning, enough information must be collected to determine the feasibility of alternatives being considered. For example, qualitative descriptions of bank stratigraphy obtained during planning may be all that is required for identifying dominant modes of failure in a study reach. Thorne (1992) describes stream reconnaissance procedures particularly for recording streambank data.

Qualitative Assessment of Bank Stability

Natural streambanks frequently are composed of distinct layers reflecting the depositional history of the bank materials. Each individual sediment layer can have physical properties quite different from those of other layers. The bank profile therefore will respond according to the physical properties of each layer. Since the stability of stream-

Figure 7.28: Bank erosion by undercutting. *Removal of toe slope support leads to instability requiring geotechnical solutions.*

banks with respect to failures due to gravity depends on the geometry of the bank profile and the physical properties of the bank materials, dominant failure mechanisms tend to be closely associated with characteristic stratigraphy or succession of layers (Figure 7.29).

A steep bank consisting of uniform layers of cohesive or cemented soils generally develops tension cracks at the top of the bank parallel to the bank alignment. Slab failures occur when the weight of the soil exceeds the strength of the grain-to-grain contacts within the soil. As clay content or cementing agent decreases, the slope of the bank decreases; vertical failure planes become more flat and planar failure surfaces develop. Rotational failures occur when the bank soils are predominantly cohesive. Block-type failures occur when a weak soil layer is eroded away and the layers above the weak layer lose structural support.

The gravity failure processes described in Figure 7.29 usually occur after the banks have been saturated due to precipitation or high stream stages. The water adds weight to the soil and reduces grain-to-grain contacts and cohesion forces while increasing the pore pressure. Pore pressure occurs when soil water in the pore spaces is under pressure from overlying soil and water. Pore pressure therefore is internal to the soil mass. When a stream is full, the flowing

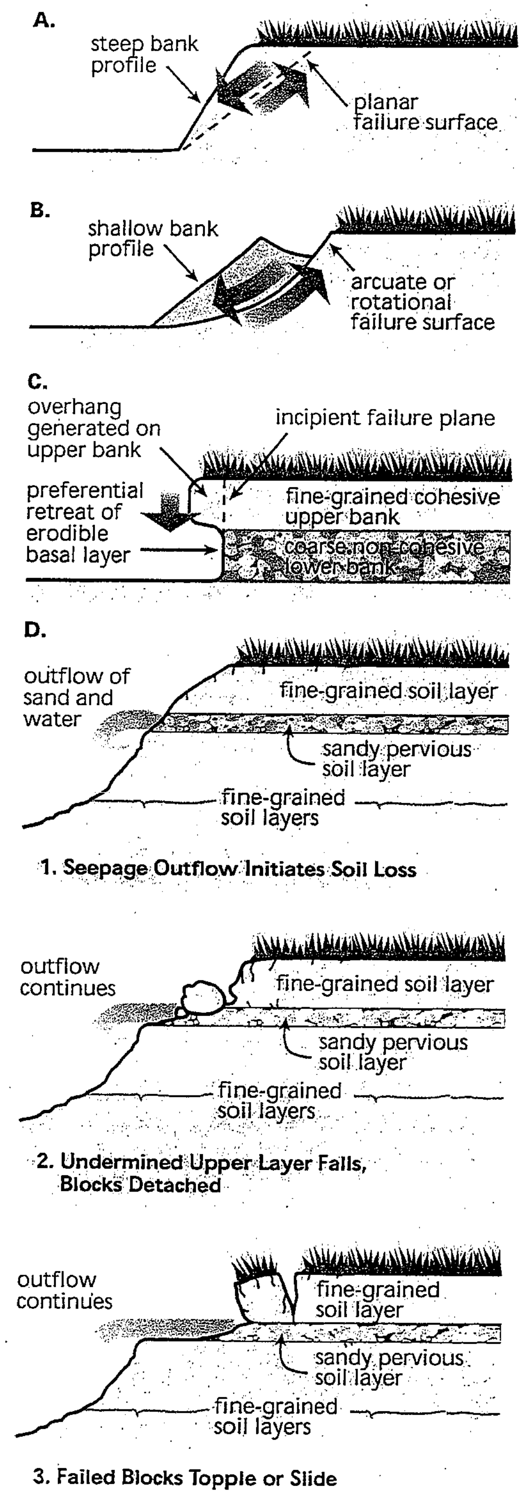

Figure 7.29: Relationship of dominant bank failure mechanisms and associated stratigraphics. *(a) Uniform bank undergoing planar type failure (b) Uniform shallow bank undergoing rotational type failure (c) Cohesive upper bank, noncohesive lower bank leads to cantilever type failure mechanism (d) Complex bank stratigraphy may lead to piping or sapping type failures.*

Source: Hagerty 1991. In *Journal of Hydraulic Engineering*. Vol. 117 Number 8. Reproduced by permission of ASCE.

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water provides some support to the streambanks. When the stream level drops, the internal pore pressure pushes out from within and increases the potential for bank failure.

The last situation described in Figure 7.29 involves ground water sapping or piping. Sapping or piping is the erosion of soil particles beneath the surface by flowing ground water. Dirty or sediment-laden seepage from a streambank indicates ground water sapping or piping is occurring. Soil layers above the areas of ground water piping eventually will collapse after enough soil particles have been removed from the support layer.

Quantitative Assessment of Bank Stability

When restoration design requires more quantitative information on soil properties, additional detailed data need to be collected (**Figure 7.30**). Values of cohesion, friction angle, and unit weight of the bank material need to be quantified. Because of spatial variability, careful sampling and testing programs are required to minimize the amount of data required to correctly characterize the average physical properties of individual layers or to determine a bulk average statistic for an entire bank.

Care must be taken to characterize soil properties not only at the time of measurement but also for the "worst case" conditions at which failure is expected (Thorne et al. 1981). Unit weight, cohesion, and friction angle vary as a function of moisture content. It usually is not possible to directly measure bank materials under worst-case conditions, due to the hazardous nature of unstable sites under such conditions. A qualified geotechnical or soil mechanics engineer should estimate these operational strength parameters.

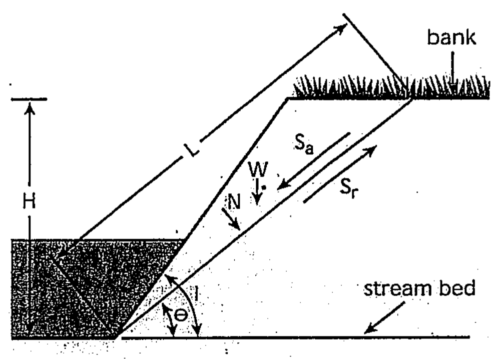
Quantitative analysis of bank instabilities is considered in terms of force and resistance. The shear strength of the bank material represents the resistance of the boundary to erosion by gravity. Shear strength is composed of cohesive strength and frictional strength. For the case of a planar failure of unit length, the Coulomb equation is applicable

$$S_r = c + (N - \mu) \tan \phi$$

where S_r = shear strength, in pounds per square foot; c = cohesion, in pounds per square foot; N = normal stress, in pounds per square foot; μ = pore pressure, in pounds per square foot; and ϕ = friction angle, in degrees.Also:

$$N = W \cos \theta$$

where W = weight of the failure block, in pounds per square foot; and θ = angle of the failure plane, in degrees.



Explanation

H = bank height
L = failure plane length
c = cohesion
ϕ = friction angle
γ = bulk unit weight
W = weight of failure block
(c, ϕ, γ, W: soil properties)
I = bank angle
S_a = $W\sin\theta$ (driving force)
S_r = $cL + N\tan\phi$ (resisting force)
N = $W\cos\theta$
θ = $(0.5I = 0.5\phi)$ (failure plane angle)

for the critical case $S_a = S_r$ and:

$$H_c = \frac{4c \sin I \cos \phi}{\gamma (1 - \cos [I - \phi])}$$

Figure 7.30: Forces acting on a channel bank assuming there is zero pore-water pressure. *Bank stability analyses relate strength of bank materials to bank height and angles, and to moisture conditions.*

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The gravitational force acting on the bank is:

$$S_a = W \sin \theta$$

Factors that decrease the erosional resistance (S_r), such as excess pore pressure from saturation and the development of vertical tension cracks, favor bank instabilities. Similarly, increases in bank height (due to channel incision) and bank angle (due to undercutting) favor bank failure by increasing the gravitational force component. In contrast, vegetated banks generally are drier and provide improved bank drainage, which enhances bank stability. Plant roots provide tensile strength to the soil resulting in reinforced earth that resists mass failure, at least to the depth of roots (Yang 1996).

Bank Instability and Channel Widening

Channel widening is often caused by increases in bank height beyond the critical conditions of the bank material. Simon and Hupp (1992) show that there is a positive correlation between the amount of bed level lowering by degradation and amounts of channel widening. The adjustment of channel width by mass-wasting processes represents an important mechanism of channel adjustment and energy dissipation in alluvial streams, occurring at rates covering several orders of magnitude, up to hundreds of feet per year (Simon 1994).

Present and future bank stability may be analyzed using the following procedure:

- Measure the current channel geometry and shear strength of the channel banks.
- Estimate the future channel geometries and model worst-case pore pressure conditions and average shear strength characteristics.

For fine-grained soils, cohesion and friction angle data can be obtained from standard laboratory testing (triaxial shear or unconfined compression tests) or by in situ testing with a borehole shear test device (Handy and Fox 1967, Lutteneger and Hallberg 1981, Thorne et al. 1981, Simon and Hupp 1992). For coarse-grained, cohesionless soils, estimates of friction angles can be obtained from reference manuals. By combining these data with estimates of future bed elevations, relative bank stability can be assessed using bank stability charts.

Bank Stability Charts

To produce bank stability charts such as the one following, a stability number (N_s) representing a simplification of the bank (slope) stability equations is used. The stability number is a function of the bank-material friction angle (ϕ) and the bank angle (i) and is obtained from a stability chart developed by Chen (1975) (**Figure 7.31**) or from Lohnes and Handy (1968):

$$N_s = (4 \sin i \cos \phi) / [1 - \cos (i - \phi)]$$

The critical bank height H_c, where driving force S_a = resisting force S_r for a given shear strength and bank geometry is then calculated (Carson and Kirkby 1972):

$$H_c = N_s (c / \gamma)$$

where c =cohesion, in pounds per square foot, and γ = bulk unit weight of soil in pounds per cubic foot.

Equations are solved for a range of bank angles using average or ambient soil moisture conditions to produce the upper line "Ambient field conditions, unsaturated." Critical bank height for worst-case conditions (saturated banks and rapid decline in river stage) are obtained by solving the equations, assuming that ϕ and the frictional component of shear strength goes to 0.0 (Lutton

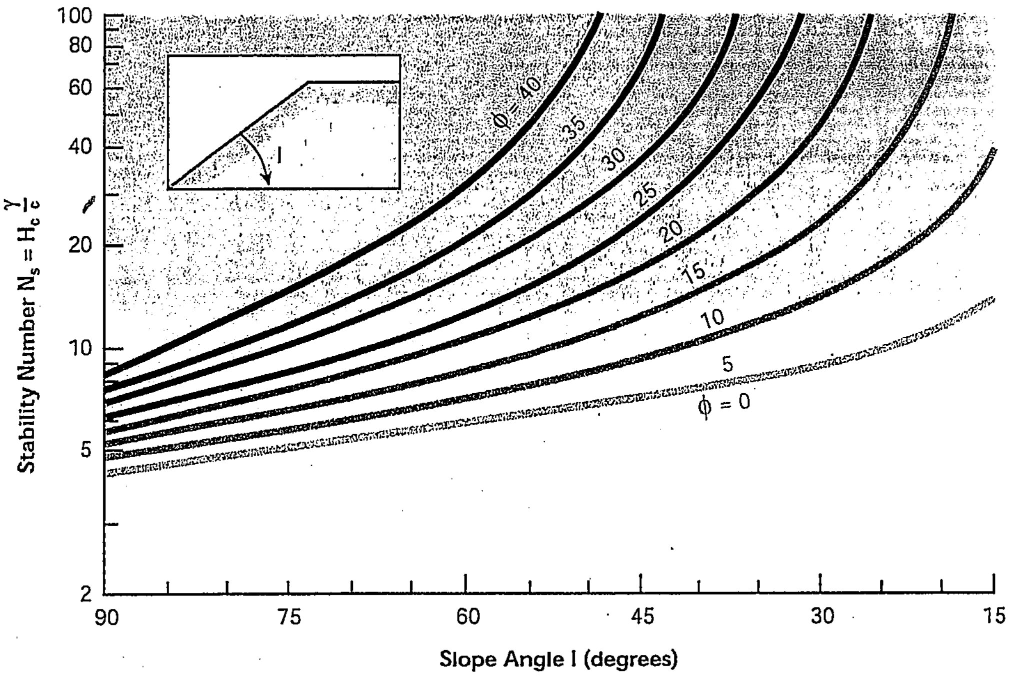

Figure 7.31: Stability number (N_s) as a function of bank angle (i) for a failure surface passing through the bank toe. Critical bank height for worst-case condition can be computed.
Source: Chen 1975.

1974) and by using a saturated bulk-unit weight. These results are represented by the lower line, "saturated conditions."

The frequency of bank failure for the three stability classes (unstable, at-risk, and stable) is subjective and is based primarily on empirical field data (**Figure 7.32**). An unstable channel bank can be expected to fail at least annually and possibly after each major stormflow in which the channel banks are saturated, assuming that there is at least one major stormflow in a given year. At-risk conditions translate to a bank failure every 2 to 5 years, again assuming that there is a major flow event to saturate the banks and to erode toe material. Stable banks by definition do not fail by mass wasting processes. However, channel banks on the outside of meander bends may experience erosion of the bank toe, leading to oversteepening of the bank profile and eventually to bank caving episodes.

Generalizations about critical bank heights (H_c) and angles can be made with knowledge of the variability in cohesive strengths. Five categories of mean cohesive strength of channel banks are identified in **Figure 7.33**. Critical bank heights above the mean low-water level and saturated conditions were used to construct the figure because bank failures typically occur during or after the recession of peak flows. The result is a nomograph giving critical bank heights for a range of bank angles and cohesive strengths that can be used to estimate stable bank configurations for worst-case conditions, such as saturation during rapid decline in river stage. For example, a saturated bank at an angle of 55 degrees and a

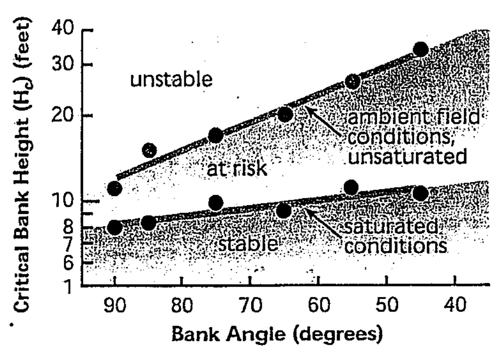

Figure 7.32: Example of a bank stability chart for estimating critical bank height (H_c). Existing bank stability can be assessed, as well as potential stable design heights and slopes.

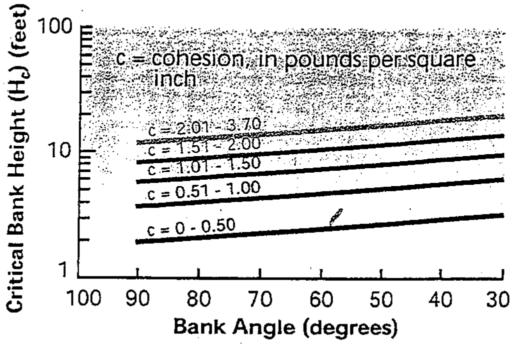

*Figure 7.33: **Critical bank-slope configurations for various ranges of cohesive strengths under saturated conditions.** Specific data on the cohesive strength of bank materials can be collected to determine stable configurations.*

cohesive strength of 1.75 pounds per square inch would be unstable when bank heights exceed about 10 feet.

Predictions of Bank Stability and Channel Width

Bank stability charts can be used to determine the following:

- The timing of the initiation of general bank instabilities (in the case of degradation and increasing bank heights).

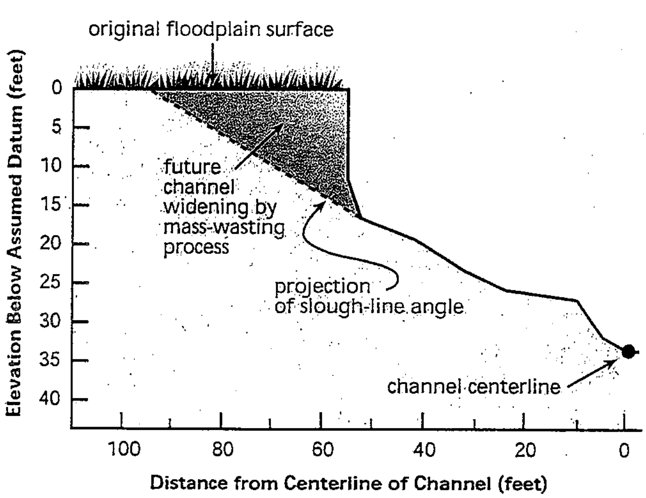

*Figure 7.34: **Method to estimate future channel widening (10–20 years) for one side of the channel.** The ultimate bank width can be predicted so that the future stream morphology can be visualized.*

- The timing of renewed bank stability (in the case of aggradation and decreasing bank heights).
- The bank height and angle needed for a stable bank configuration under a range of moisture conditions.

Estimates of future channel widening also can be made using measured channel-width data over a period of years and then fitting a nonlinear function to the data (**Figure 7.34**). Williams and Wolman (1984) used a dimensionless hyperbolic function of the following form to estimate channel widening downstream from dams:

$$(W_i / W_t) = j_1 + j_2 \, (1 / t)$$

where:

W_i = initial channel width, in feet

W_t = channel width at t years after W_1, in feet

t = time, in years

j_1 = intercept

j_2 = slope of the fitted straight line on a plot of W_i / W_t versus 1/t

Wilson and Turnipseed (1994) used a power function to describe widening after channelization and to estimate future channel widening in the loess area of northern Mississippi:

$$W = x\,t^d$$

where:

W = channel width, in feet

x = coefficient, determined by regression, indicative of the initial channel width

t = time, in years

d = coefficient, determined by regression, indicative of the rate of channel widening.

7.C Chemical Characteristics

Assessing water chemistry in a stream restoration initiative can be one of the ways to determine if the restoration was successful. A fundamental understanding of the chemistry of a given system is critical for developing appropriate data collection and analysis methods. Although data collection and analysis are interdependent, each has individual components. It is also critical to have a basic understanding of the hydrologic and water quality processes of interest before data collection and analysis begin. Averett and Schroder (1993) discuss some fundamental concepts used when determining a data collection and analysis program.

Data Collection

Constituent Selection

Hundreds of chemical compounds can be used to describe water quality. It is typically too expensive and too time-consuming to analyze every possible chemical of interest in a given system. In addition to selecting a particular constituent to sample, the analytical techniques used to determine the constituent also must be considered. Another consideration is the chemistry of the constituent; for example, whether the chemical is typically in the dissolved state or sorbed onto sediment makes a profound difference in the methods used for sampling and analysis, as well as the associated costs.

Often it is effective to use parameters that integrate or serve as indicators for a number of other variables. For instance, dissolved oxygen and temperature measurements integrate the net impact of many physical and chemical processes on a stream system, while soluble reactive phosphorus concentration is often taken as a readily available indicator of the potential for growth of attached algae. Averett and Schroder (1993) discuss additional factors involved in selecting constituents to sample.

Sampling Frequency

The needed frequency of sampling depends on both the constituent of interest and management objectives. For instance, a management goal of reducing average instream nutrient concentrations may require monitoring at regular intervals, whereas a goal of maintaining adequate dissolved oxygen (DO) during summer low flow and high temperature periods may require only targeted monitoring during critical conditions. In general, water quality constituents that are highly variable in space or time require more frequent monitoring to be adequately characterized.

In many cases, the concentration of a constituent depends on the flow condition. For example, concentrations of a hydrophobic pesticide, which sorbs strongly to particulate matter, are likely to be highest during scouring flows or erosion washoff events, whereas concentrations of a dissolved chemical that is loaded to the stream at relatively steady rates will exhibit highest concentrations in extremely low flows.

In fact, field sampling and water quality analyses are time-consuming and expensive, and schedule and budget constraints often determine the frequency of data collection. Such constraints make it even more important to design data collection efforts that maximize the value of the information obtained.

Statistical tools often are used to help determine the sampling frequency. Statistical techniques, such as simple random sampling, stratified random sampling, two-stage sampling, and systematic sampling, are described in Gilbert (1987) and Averett and Schroder (1993). Sanders et al. (1983) also describe methods of determining sampling frequency.

Site Selection

The selection of sampling sites is the third critical part of a sampling design. Most samples represent a point in space and provide direct information only on what is happening at that point. A key objective of site selection is to choose a site that gives information that is representative of conditions throughout a particular reach of stream. Because most hydrologic systems are very complex, it is essential to have a fundamental understanding of the area of interest to make this determination.

External inputs, such as tributaries or irrigation return flow, as well as output, such as ground water recharge, can drastically change the water quality along the length of a stream. It is because of these processes that the hydrologic system must be understood to interpret the data from a particular site. For example, downstream from a significant lateral source of a load, the dissolved constituent(s) might be distributed uniformly in the stream channel. Particulate matter, however, typically is stratified. Therefore, the distribution of a constituent sorbed onto particulate matter is not evenly distributed. Averett and Schroder (1993) discuss different approaches to selecting sites to sample both surface water and ground water. Sanders et al. (1983) and Stednick (1991) also discuss site selection.

Finally, practical considerations are an important part of sample collection. Sites first must be accessible, preferably under a full range of potential flow and weather conditions. For this reason, sampling is often conducted at bridge crossings, taking into consideration the degree to which artificial channels at bridge crossings may influence sample results. Finally, where constituent loads and concentrations are of interest, it is important to align water quality sample sites with locations at which flow can be accurately gauged.

Sampling Techniques

This section provides a brief overview of water quality sampling and data collection techniques for stream restoration efforts. Many important issues can be treated only cursorily within the context of this document, but a number of references are available to provide the reader with more detailed guidance.

Key documents describing methods of water sample collection for chemical analysis are the U.S. Geological Survey (USGS) protocol for collecting and processing surface water samples for determining inorganic constituents in filtered water (Horwitz et al. 1994), the field guide for collecting and processing stream water samples for the National Water Quality Assessment program (Shelton 1994), and the field guide for collecting and processing samples of streambed sediment for analyzing trace elements and organic contaminants for the National Water Quality Assessment program (Shelton and Capel 1994). A standard reference document describing methods of sediment collection is the USGS *Techniques for Water-Resource Investigations, Field Methods for Measurement of Fluvial Sediment* (Guy and Norman 1982). The USGS is preparing a national field manual that describes techniques for collecting and processing water quality samples (Franceska Wilde, personal communication, 1997).

Sampling Protocols for Water and Sediment

Stream restoration monitoring may involve sampling both water and sediment quality. These samples may be collected by hand (manual samples), by using an automated sampler (automatic samples), as individual point-in-time samples (grab or discrete samples), or combined with other samples (composite samples). Samples collected and mixed in relation to the measured volume within or flow through a system are commonly termed volume- or flow-weighted composite samples, whereas equal-volume samples collected at regular vertical intervals through a portion or all of the water column may be mixed to provide a water column composite sample.

Manual Sampling and Grab Sampling

Samples collected by hand using various types of containers or devices to collect water or sediment from a receiving water or discharge often are termed grab samples. These samples can require little equipment and allow recording miscellaneous additional field observations during each sampling visit.

Manual sampling has several advantages. These approaches are generally uncomplicated and often inexpensive (particularly when labor is already available). Manual sampling is required for sampling some pollutants. For example, according to *Standard Methods* (APHA 1995), oil and grease, volatile compounds, and bacteria must be analyzed from samples collected using manual methods. (Oil, grease, and bacteria can adhere to hoses and jars used in automated sampling equipment, causing inaccurate results; volatile compounds can vaporize during automated sampling procedures or can be lost from poorly sealed sample containers; and bacteria populations can grow and community compositions change during sample storage.)

Disadvantages of grab sampling include the potential for personnel to be available around the clock to sample during storms and the potential for personnel to be exposed to hazardous conditions during sampling. Long-term sampling programs involving many sampling locations can be expensive in terms of labor costs.

Grab sampling is often used to collect discrete samples that are not combined with other samples. Grab samples can also be used to collect volume- or flow-weighted composite samples, where several discrete samples are combined by proportion to measured volume or flow rates; however, this type of sampling is often more easily accomplished using automated samplers and flow meters. Several examples of manual methods for flow weighting are presented in USEPA (1992a). Grab sampling also may be used to composite vertical water column or aerial composite samples of water or sediment from various kinds of water bodies.

Automatic Sampling

Automated samplers have been improved greatly in the last 10 years and now have features that are useful for many sampling purposes. Generally, such sampling devices require larger initial capital investments or the payment of rental fees, but they can reduce overall labor costs (especially for long-running sampling programs) and increase the reliability of flow-weighted compositing.

Some automatic samplers include an upper part consisting of a microprocessor-based controller, a pump assembly, and a filling mechanism, and a lower part containing a set of glass or plastic sample containers and a well that can be filled with ice to cool the collected samples. More expensive automatic samplers can include refrigeration equipment in place of the ice well; such devices, however, require a 120-volt power supply instead of a battery. Also, many automatic samplers can accept input signals from a flowmeter to activate the sampler and to initiate a flow-weighting compositing program. Some samplers can accept input from a rain gauge to activate a sampling program.

Most automatic samplers allow collecting multiple discrete samples or single or multiple composited samples. Also, samples can be split between sample bottles or can be composited into a single bottle. Samples can be collected on a predetermined time basis or in proportion to flow measurement signals sent to the sampler.

In spite of the obvious advantages of automated samplers, they have some disadvantages and limitations. Some pollutants cannot be sampled by automated equipment unless only qualitative results are desired. Although the cleaning sequence provided by most such samplers provide reasonably separate samples, there is some cross-contamination of the samples since water droplets usually remain in the tubing. Debris in the sampled receiving water can block the sampling line and prevent sample collection. If the sampling line is located in the vicinity of a flowmeter, debris caught on the sampling line can also lead to erroneous flow measurements.

While automatic samplers can reduce manpower needs during storm and runoff events, these devices must be checked for accuracy during these events and must be regularly tested and serviced. If no field checks are made during a storm event, data for the entire event may be lost. Thus, automatic samplers do not eliminate the need for field personnel, but they can reduce these needs and can produce flow-weighted composite samples that might be tedious or impossible using manual methods.

Discrete versus Composite Sampling

Flow rates, physical conditions, and chemical constituents in surface waters often vary continuously and simultaneously. This presents a difficulty when determining water volumes, pollutant concentrations, and masses of pollutants or their loads in the waste discharge flows and in receiving waters. Using automatic or continuously recording flowmeters allows obtaining reasonable and continuous flow rate measurements for these waters. Pollutant loads can then be computed by multiplying these flow volumes over the period of concern by the average pollutant concentration determined from the discrete or flow-composited samples. When manual (instantaneous) flow measurements are used, actual volume flows over time can be estimated only for loading calculations, adding additional uncertainty to loading estimates.

Analyzing constituents of concern in a single grab sample collection provides the minimum information at the minimum cost. Such an approach, however, could be appropriate where conditions are relatively stable; for example, during periods without rainfall or other potential causes of significant runoff and when the stream is well-mixed. Most often, the usual method is to collect a random or regular series of grab samples at predefined intervals during storm or runoff events.

When samples are collected often enough, such that concentration changes between samples are minimized, a clear pattern or time series for the pollutant's concentration dynamics can be obtained. When sampling intervals are spaced too far apart in relation to changes in the pollutant concentration, less clear understanding of these relationships is obtained. Mixing samples from adjacent sampling events or regions (compositing) requires fewer samples to be analyzed; for some assessments, this is a reasonable approach. Sample compositing provides a savings, especially related to costs for water quality analyses, but it also results in loss of information. For example, information on maximum and minimum concentrations during a runoff event is usually lost. But compositing many samples collected through multiple periods during the events can help ensure that the samples analyzed do not include only extreme conditions that are not entirely representative of the event.

Even though analytical results from composited samples rarely equal average conditions for the event, they can still be used, when a sufficient distribution of samples is included, to provide reasonably representative conditions for computing loading estimates. In some analyses, however, considerable errors can be made when using analytical results from composited samples in completing loading analyses. For example, when maximum pollutant concentrations accompany the maximum flow rates, yet concentrations in high and low flows are treated equally, true loadings can be underestimated.

Consequently, when relationships between flow and pollutant concentrations are unknown, it is often preferable initially to include in the monitoring plan at least three discrete or multiple composite sample collections: during the initial period of increasing flow, during the period of the peak or plateau flow, and during the period of declining flow.

The most useful method for sample compositing is to combine samples in relation to the flow volume occurring during study period intervals. There are two variations for accomplishing flow-weighted compositing:

1. Collect samples at equal time intervals at a volume proportional to the flow rate (e.g., collect 100 mL of sample for every 100 gallons of flow that passed during a 10-minute interval) or
2. Collect equal-volume samples at varying times proportional to the flow (e.g., collect a 100-mL sample for each 100 gallons of flow, irrespective of time).

The second method is preferable for estimating load accompanying wet weather flows, since it results in samples being collected most often when the flow rate is highest.

Another compositing method is time-composited sampling, where equal sample volumes are collected at equally spaced time intervals (e.g., collect 100 mL of sample every 10 minutes during the monitored event). This approach provides information on the average conditions at the sampling point during the sampling period. It should be used, for example, to determine the average toxic concentrations to which resident aquatic biota are exposed during the monitored event.

Field Analyses of Water Quality Samples

Concentrations of various water quality parameters may be monitored both in the field and in samples submitted to a laboratory (**Figure 7.35**). Some parameters, such as water temperature, must be obtained in the field. Parameters such as concentrations of specific synthetic organic chemicals require laboratory analysis. Other parameters, such as nu-

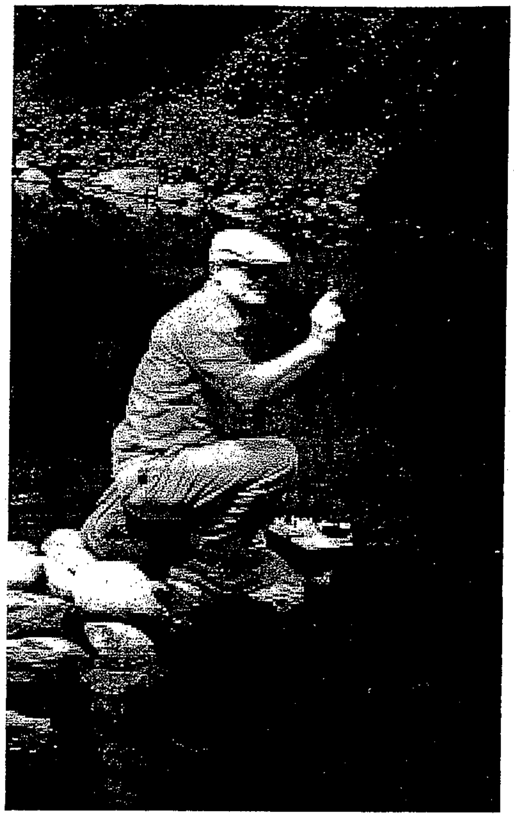

*Figure 7.35: **Field sampling.** Sampling can also be automated.*

trient concentrations, can be measured by both field and laboratory analytical methods. For chemical constituents, field measurements generally should be considered as qualitative screening values since rigorous quality control is not possible. In addition, samples collected for compliance with Clean Water Act requirements must be analyzed by a laboratory certified by the appropriate authority, either the state or the USEPA. The laboratories must use analytic techniques listed in the *Code of Federal Regulations* (CFR), Title 40, Part 136, "Guidelines Establishing Test Procedures for Analysis of Pollutants Under the Clean Water Act."

The balance of this subsection notes special considerations regarding those parameters typically sampled and analyzed in the field, including pH, temperature, and dissolved oxygen (DO).

pH

Levels of pH can change rapidly in samples after collection. Consequently, pH often is measured in the field using a hand-held pH electrode and meter. Electrodes are easily damaged and contaminated and must be calibrated with a standard solution before each use. During calibrations and when site measurements are conducted, field instruments should be at thermal equilibrium with the solutions being measured.

Temperature

Because water temperature changes rapidly after collection, it must be measured either in the field (using in situ probes) or immediately after collecting a grab sample. EPA Method 170.1 describes procedures for thermometric determination of water temperature. Smaller streams often experience wide diurnal variations in temperature, as well as pH and DO. Many streams also experience vertical and longitudinal variability in temperature from shading and flow velocity. Because of the effect of temperature on other water quality factors, such as dissolved oxygen concentration, temperatures always should be recorded when other field measurements are made.

Dissolved Oxygen

When multiple DO readings are required, a DO electrode and meter (EPA method 360.1) are typically used. To obtain accurate measurements, the Winkler titration method should be used to calibrate the meter before and after each day's use. Often it is valuable to recheck the calibration during days of intensive use, particularly when the measurements are of critical importance.

Oxygen electrodes are fragile and subject to contamination, and they need frequent maintenance. Membranes covering these probes must be replaced when bubbles form under the membrane, and the electrode should be kept full of fresh electrolyte solution. If the meter has temperature and salinity compensation controls, they should be used carefully, according to the manufacturer's instructions.

Water Quality Sample Preparation and Handling for Laboratory Analysis

Sample collection, preparation, preservation, and storage guidelines are designed to minimize altering sample constituents. Containers must be made of materials that will not interact with pollutants in the sample, and they should be cleaned in such a way that neither the container nor the cleaning agents interfere with sample analysis. Sometimes, sample constituents must be preserved before they degrade or transform prior to analysis. Also, specified holding times for the sample must not be exceeded. Standard procedures for collecting, preserving, and storing samples are presented in APHA (1995) and at 40 CFR Part 136. Useful material also is contained in the USEPA *NPDES Storm Water Sampling Guidance Document* (1992a).

Most commercial laboratories provide properly cleaned sampling containers with appropriate preservatives. The laboratories also usually indicate the maximum allowed holding periods for each analysis. Acceptable procedures for cleaning sample bottles, preserving their contents, and analyzing for appropriate chemicals are detailed in various methods manuals, including APHA (1995) and USEPA (1979a). Water samplers, sampling hoses, and sample storage bottles always should be made of materials compatible with the goals of the study. For example, when heavy metals are the concern, bottles should not have metal components that can contaminate the collected water samples. Similarly, when organic contaminants are the concern, bottles and caps should be made of materials not likely to leach into the sample.

Sample Preservation, Handling, and Storage

Sample preservation techniques and maximum holding times are presented in APHA (1995) and 40 CFR Part 136. Cooling samples to a temperature of 4 degrees Celsius (C) is required for most water quality variables. To accomplish this, samples are usually placed in a cooler containing ice or an ice substitute. Many automated samplers have a well next to the sample bottles to hold either ice or ice substitutes. Some more expensive automated samplers have refrigeration equipment requiring a source of electricity. Other preservation techniques include pH adjustment and chemical fixation. When needed, pH adjustments are usually made using strong acids and bases, and extreme care should be exercised when handing these substances.

Bacterial analysis may be warranted, particularly where there are concerns regarding inputs of sewage and other wastes or fecal contamination. Bacterial samples have a short holding time and are not collected by automated sampler. Similarly, volatile compounds must be collected by grab sample, since they are lost through volatilization in automatic sampling equipment.

Sample Labeling

Samples should be labeled with waterproof labels. Enough information should be recorded to ensure that each sample label is unique. The information recorded on sample container labels also should be recorded in a sampling notebook kept by field personnel. The label typically includes the following information:

- Name of project.
- Location of monitoring.
- Specific sample location.
- Date and time of sample collection.
- Name or initials of sampler.
- Analysis to be performed.
- Sample ID number.
- Preservative used.
- Type of sample (grab, composite).

Sample Packaging and Shipping

It is sometimes necessary to ship samples to the laboratory. Holding times should be checked before shipment to ensure that they will not be exceeded. Although wastewater samples are not usually considered hazardous, some samples, such as those with extreme pH, require special procedures. If the sample is shipped through a common carrier or the U.S. Postal Service, it must comply with Department of Transportation Hazardous Material Regulations (49 CFR Parts 171-177). Air shipment of samples defined as hazardous may be covered by the requirements of the International Air Transport Association.

Samples should be sealed in leakproof bags and padded against breakage. Many samples must be packed with an ice substitute to maintain a temperature of 4 degrees C during shipment. Plastic or metal recreational coolers make ideal shipping containers because they protect and insulate the samples. Accompanying paperwork, such as the chain-of-custody documentation, should be sealed in a waterproof bag in the shipping container.

Chain of Custody

Chain-of-custody forms document each change in possession of a sample, starting at its collection and ending when it is analyzed. At each transfer of possession, both the relinquisher and the receiver of the samples are required to sign and date the form. The form and the procedure document possession of the samples and help prevent tampering. The container holding samples also can be sealed with a signed tape or seal to help ensure that samples are not compromised.

Copies of the chain-of-custody form should be retained by the sampler and by the laboratory. Contract laboratories often supply chain-of-custody forms with sample containers. The form is also useful for documenting which analyses will be performed on the samples. These forms typically contain the following information:

- Name of project and sampling locations.
- Date and time that each sample is collected.
- Names of sampling personnel.
- Sample identification names and numbers.
- Types of sample containers.
- Analyses performed on each sample.
- Additional comments on each sample.
- Names of all those transporting the samples.

Collecting and Handling Sediment Quality Samples

Sediments are sinks for a wide variety of materials. Nonpoint source discharges typically include large quantities of suspended material that settle out in sections of receiving waters having low water velocities. Nutrients, metals, and organic compounds can bind to suspended solids and settle to the bottom of a water body when flow velocity is insufficient to keep them in suspension. Contaminants bound to sediments may remain separated from the water column, or they may be resuspended in the water column.

Flood scouring, bioturbation (mixing by biological organisms), desorption, and biological uptake all promote the release of adsorbed pollutants. Organisms that live and feed in sediment are especially vulnerable to contaminants in sediments. Having entered the food chain, contaminants can pass to feeders at higher food (trophic) levels and can accumulate or concentrate in these organisms. Humans can ingest these contaminants by eating fish.

Sediment deposition also can physically alter benthic (bottom) habitats and affect habitat and reproductive potentials for many fish and invertebrates. Sediment sampling should allow all these impact potentials to be assessed.

Collection Techniques

Sediment samples are collected using hand- or winch-operated dredges. Although a wide variety of dredges are available, most operate in the following similar fashion:

1. The device is lowered or pushed through the water column by hand or winch.
2. The device is released to allow closure, either by the attached line or by a weighted messenger that is dropped down the line.
3. The scoops or jaws of the device close either by weight or spring action.
4. The device is retrieved to the surface.

Ideally, the device disturbs the bottom as little as possible and closes fully so that fine particles are not lost. Common benthic sampling devices include the Ponar, Eckman, Peterson, Orangepeel, and Van Veen dredges. When information is needed about how chemical depositions and accumulations have varied through time, sediment cores can be collected with a core sampling device. Very low density or very coarse sediments can be sampled by freeze coring. A thorough description of sediment samplers is included in Klemm et al. (1990).

Sediment sampling techniques are useful for two types of investigations related to stream assessments:
(1) chemical analysis of sediments and (2) investigation of benthic macroinvertebrate communities. In either type of investigation, sediments from reference stations should be sampled so that they can be compared with sediments in the affected receiving waters. Sediments used for chemical analyses should be removed from the dredge or core samples by scraping back the surface layers of the collected sediment and extracting sediments from the central mass of the collected sample. This helps to avoid possible contamination of the sample by the sample device. Sediment samples for toxicological and chemical examination should be collected following method E 1391 detailed in ASTM (1991). Sediments for benthic population analyses may be returned in total for cleaning and analysis or may receive a preliminary cleaning in the field using a No. 30 sieve.

Sediment Analyses

There are a variety of sediment analysis techniques, each designed with inherent assumptions about the behavior of sediments and sediment-bound contaminants. An overview of developing techniques is presented in Adams et al. (1992). EPA has evaluated 11 of the methods available for assessing sediment quality (USEPA 1989b). Some of the techniques may help to demonstrate attainment of narrative requirements of some water quality standards. Two of these common analyses are introduced briefly in the following paragraphs.

Bulk sediment analyses analyze the total concentration of contaminants that are either bound to sediments or present in pore water. Results are reported in milligrams or micrograms per kilogram of sediment material. This type of testing often serves as a screening analysis to classify dredged material. Results of bulk testing tend to overestimate the mass of contaminants that will be available for release or for biological uptake because a portion of the contaminants are not biologically available or likely to dissolve.

Elutriate testing estimates the amount of contaminants likely to be released from sediments when mixed with water. In an elutriate test, sediment is mixed with water and then agitated. The standard elutriate test for dredge material mixes four parts water from the receiving water body with one part sediment (USEPA 1990). After vigorous mixing, the sample is allowed to settle before the supernatant is filtered and analyzed for contaminants. This test was designed to estimate the amount of material likely to enter the dissolved phase during dredging; however, it is also useful as a screening test for determining whether further testing should be performed and as a tool for comparing sediments upstream and downstream of potential pollutant sources.

Data Management

All monitoring data should be organized and stored in a readily accessible form. The potentially voluminous and diverse nature of the data, and the variety of individuals who can be involved in collecting, recording, and entering data, can easily lead to the loss of data or the recording of erroneous data. Lost or erroneous data can severely damage the quality of monitoring programs. A sound and efficient data management program for a monitoring program should focus on preventing such problems. This requires that data be managed directly and separately from the activities that use them.

Data management systems include technical and managerial components. The technical components involve selecting appropriate computer equipment and software and designing the database, including data definition, data standardization, and a data dictionary. The managerial components include data entry, data validation and verification, data access, and methods for users to access the data.

To ensure the integrity of the database, it is imperative that data quality be controlled from the point of collection to the time the information is entered into the database. Field and laboratory personnel must carefully enter data into proper spaces on data sheets and avoid transposing numbers. To avoid transcription errors, entries into a database should be made from original data sheets or photocopies. As a preliminary screen for data quality, the database design should include automatic parameter range checking. Values outside the defined ranges should be flagged by the program and immediately corrected or included in a follow-up review of the entered data. For some parameters, it might be appropriate to include automatic checks to disallow duplicate values. Preliminary database files should be printed and verified against the original data to identify errors.

Additional data validation can include expert review of the verified data to identify possible suspicious values. Sometimes, consultation with the individuals responsible for collecting or entering original data is required to resolve problems. After all data are verified and validated, they can be merged into the monitoring program's master database. To prevent loss of data from computer failure, at least one set of duplicate (backup) database files should be maintained at a location other than where the master database is kept.

Quality Assurance and Quality Control (QA/QC)

Quality assurance (QA) is the management process to ensure the quality of data. In the case of monitoring projects, it is managing environmental data collection to ensure the collection of high-quality data. QA focuses on systems, policies, procedures, program structures, and delegation of responsibility that will result in high-quality data. Quality control (QC) is a group of specific procedures designed to meet defined data quality objectives. For example, equipment calibration and split samples are QC procedures. QA/QC procedures are essential to ensure that data collected in environmental monitoring programs are useful and reliable.

The following are specific QA plans required of environmental monitoring projects that receive funding from EPA:

- State and local governments receiving EPA assistance for environmental monitoring projects must complete a quality assurance program plan acceptable to the award official. Guidance for producing the program plan is contained in USEPA (1983d).
- Environmental monitoring projects that receive EPA funding must file a quality assurance project plan, or QAPP, (40 CFR 30.503), the purpose of which is to ensure quality of a specific project. The QAPP describes quality assurance practices designed to produce data of quality sufficient to meet project objectives. Guidance for producing the QAPP (formerly termed the QAPjP) is contained in USEPA (1983e). The plan must address the following items:
  - Title of project and names of principal investigators.
  - Table of contents.
  - Project description.
  - Project organization and QA/QC responsibility.
  - Quality assurance objectives and criteria for determining precision, accuracy, completeness, representativeness, and comparability of data.
  - Sampling procedures.
  - Sample custody.
  - Calibration procedures.
  - Analytical procedures.
  - Data reduction, validation, and reporting.
  - Internal quality control checks.
  - Performance and system audits.
  - Preventive maintenance procedures.
  - Specific routine procedures to assess data precision, accuracy, representativeness, and comparability.
  - Corrective action.
  - Quality assurance reports.

Sample and Analytical Quality Control

The following quality control techniques are useful in assessing sampling and analytic performance (see also USEPA 1979b, Horwitz et al. 1994):

- *Duplicate samples* are independent samples collected in such a manner that they are equally representative of the contaminants of interest. Dupli-

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cate samples, when analyzed by the same laboratory, provide precision information for the entire measurement system, including sample collection, homogeneity, handling, shipping, storage, preparation, and analysis.

- *Split samples* have been divided into two or more portions at some point in the measurement process. Split samples that are divided in the field yield results relating precision to handling, shipping, storage, preparation, and analysis. The split samples may be sent to different laboratories and subjected to the same measurement process to assess interlaboratory variation. Split samples serve an oversight function in assessing the analytical portion of the measurement system, whereas error due to sampling technique may be estimated by analyzing duplicate versions of the same sample.
- *Spiked samples* are those to which a known quantity of a substance is added. The results of spiking a sample in the field are usually expressed as percent recovery of the added material. Spiked samples provide a check of the accuracy of laboratory and analytic procedures.

Sampling accuracy can be estimated by evaluating the results obtained from blanks. The most suitable types of blanks for this appraisal are equipment, field, and trip blanks.

- *Equipment blanks* are samples obtained by running analyte-free water through sample collection equipment, such as a bailer, pump, or auger, after decontamination procedures are completed. These samples are used to determine whether variation is introduced by sampling equipment.
- *Field blanks* are made by transferring deionized water to a sample container at the sampling site. Field blanks test for contamination in the deionized water and contamination introduced through the sampling procedure. They differ from trip blanks, which remain unopened in the field.
- *Trip blanks* test for cross-contamination during transit of volatile constituents, such as many synthetic organic compounds and mercury. For each shipment of sample containers sent to the analytical laboratory, one container is filled with analyte-free water at the laboratory and is sealed. The blanks are transported to the site with the balance of the sample containers and remain unopened. Otherwise, they are handled in the same manner as the other samples. The trip blanks are returned to the laboratory with the samples and are analyzed for the volatile constituents.

Field Quality Assurance

Errors or a lack of standardization in field procedures can significantly decrease the reliability of environmental monitoring data. If required, a quality assurance project plan should be followed for field measurement procedures and equipment. If the QAPP is not formally required, a plan including similar material should be developed to ensure the quality of data collected. Standard operating procedures should be followed when available and should be developed when not.

It is important that quality procedures be followed and regularly examined. For example, field meters can provide erroneous values if they are not regularly calibrated and maintained. Reagent solutions and probe electrolyte solutions have expiration periods and should be refreshed periodically.

Nearly all analytical procedures for assessing the condition of biological resources can be used in stream corridor restoration. Such procedures differ, however, in their scale and focus and in the assumptions, knowledge, and effort required to apply them. These procedures can be grouped into two broad classes synthetic measures of system condition and analyses based on how well the system satisfies the life history requirements of target species or species groups.

The most important difference between these classes is the logic of how they are applied in managing or restoring a stream corridor system. This chapter focuses on metrics of biological conditions and does not describe, for example, actual field methods for counting organisms.

Synthetic Measures of System Condition

Synthetic measures of system condition summarize some aspect of the structural or functional status of a system at a particular point in time. Complete measurement of the state of a stream corridor system, or even a complete census of all of the species present, is not feasible. Thus, good indicators of system condition are efficient in the sense that they summarize the health of the overall system without having to measure everything about the system.

Use of indicators of system condition in management or restoration depends completely on comparison to values of the indicator observed in other systems or at other times. Thus, the current value of an indicator for a degraded stream corridor can be compared to a previously measured preimpact value for the corridor, a desired future value for the corridor, a value observed at an "unimpacted" reference site, a range of values observed in other systems, or a normative value for that class of stream corridors in a stream classification system. However, the indicator itself and the analysis that establishes the value of the indicator provide no direct information about what has caused the system to have a particular value for the indicator.

Deciding what to change in the system to improve the value of the indicator depends on a temporal analysis in which observed changes in the indicator in one system are correlated with various management actions or on a spatial analysis in which values of the indicator in different systems are correlated with different values of likely controlling variables. In both cases, no more than a general empirical correlation between specific causal factors and the indicator variable is attempted. Thus, management or restoration based on synthetic measures of system condition relies heavily on iterative monitoring of the indicator variable and trial and error, or adaptive management, approaches. For example, an index of species composition based on the presence or absence of a set of sensitive species might be generally correlated with water quality, but the index itself provides no information on how water quality should be improved. However, the success of management actions in improving water quality could be tracked and evaluated through iterative measurement of the index.

Synthetic measures of system condition vary along a number of important dimensions that determine their applicability. In certain situations, single species might be good indicators of

Stream Visual Assessment Protocol

This is another assessment tool that provides a basic level of stream health evaluation. It is intended to be the first level in a four-part hierarchy of assessment protocols that facilitate planning stream restorations. Scores are assigned by the planners for the following:

- *Channel condition*
- *Hydrologic alteration*
- *Riparian zone width*
- *Bank stability*
- *Canopy cover*
- *Water appearance*
- *Nutrient enrichment*
- *Manure presence*
- *Salinity*
- *Barriers to fish movement*
- *Instream fish cover*
- *Pools*
- *Riffle quality*
- *Invertebrate habitat*
- *Macroinvertebrates observed*

The planning assessment concludes with narratives of the suspected causes of observed problems, as well as recommendations or further steps in the planning process (USDA-NRCS 1998).

some aspect of a stream corridor system; in others, community metrics, such as diversity, might be more suitable. Some indicators incorporate physical variables, and others do not. Measurements of processes and rates, such as primary productivity and channel meandering rates, are incorporated into some and not into others. Each of these dimensions must be evaluated relative to the objectives of the restoration effort to determine which, if any, indicator is most appropriate.

Indicator Species

Landres et al. (1988) define an indicator species as an organism whose characteristics (e.g., presence or absence, population density, dispersion, reproductive success) are used as an index of attributes too difficult, inconvenient, or expensive to measure for other species or environmental conditions of interest. Ecologists and management agencies have used aquatic and terrestrial indicator species for many years as assessment tools, the late 1970s and early 1980s being a peak interest period. During that time, Habitat Evaluation Procedures (HEP) were developed by the U.S. Fish and Wildlife Service, and the U.S. Forest Service's use of management indicator species was mandated by law with passage of the National Forest Management Act in 1976. Since that time, numerous authors have expressed concern about the ability of indicator species to meet the expectations expressed in the above definition. Most notably, Landres et al. (1988) critically evaluated the use of vertebrate species as ecological indicators and suggested that rigorous justification and evaluation are needed before the concept is used. The discussion of indicator species below is largely based on their paper.

The Good and Bad of Indicator Species

Indicator species have been used to predict environmental contamination, population trends, and habitat quality; however, their use in evaluating water quality is not covered in this section. The assumptions implicit in using indicators are that if the habitat is suitable for the indicator it is also suitable for other species (usually in a similar ecological guild) and that wildlife populations reflect habitat conditions. However, because each species has unique life requisites, the relationship between the indicator and its guild may not be completely reliable, although the literature is inconsistent in this regard (see Riparian Response Guilds subsection below). It is also difficult to include all the factors that might limit a population when selecting a group of species that an indicator is expected to represent. For example, similarities in breeding habitat between the indicator and its associates might appear to group species when in fact differences in predation rates, disease, or winter habitat actually limit populations.

Some management agencies use vertebrate indicators to track changes in habitat condition or to assess the influence of habitat alteration on selected species. Habitat suitability indices and other habitat models are often used for this purpose, though the metric chosen to measure a species' response to its habitat can influence the outcome of the investigation. As Van Horne (1983) pointed out, density and other abundance metrics may be misleading indicators of habitat quality. Use of diversity and other indices to estimate habitat quality also creates problems when the variation in measures yields an average value for an index that might not represent either extreme.

Selecting Indicators

Landres et al. (1988) suggest that if the decision is made to use indicators, then several factors are important to consider in the selection process:

- Sensitivity of the species to the environmental attribute being evaluated. When possible, data that suggest a cause-and-effect relationship are preferred to correlates (to ensure the indicator reflects the variable of interest and not a correlate).
- Indicator accurately and precisely responds to the measured effect. High variation statistically limits the ability to detect effects. Generalist species do not reflect change as well as more sensitive endemics. However, because specialists usually have lower populations, they might not be the best for cost-effective sampling. When the goal of monitoring is to evaluate on-site conditions, using indicators that occur only within the site makes sense. However, although permanent residents may better reflect local conditions, the goal of many riparian restoration efforts is to provide habitat for neotropical migratory birds. In this case, residents such as cardinals or woodpeckers might not serve as good indicators for migrating warblers.
- Size of the species home range. If possible, the home range should be larger than that of other species in the evaluation area. Management agencies often are forced to use high-profile game or threatened and endangered species as indicators. Game species are often poor indicators simply because their populations are highly influenced by hunting mortality, which can mask environmental effects. Species with low populations or restrictions on sampling methods, such as threatened and endangered species, are also poor indicators because they are difficult to sample adequately, often due to budget constraints. For example, Verner (1986) found that costs to detect a 10 percent change in a randomly sampled population of pileated woodpeckers would exceed a million dollars per year.
- Response of an indicator species to an environmental stressor cannot be expected to be consistent across varying geographic locations or habitats without corroborative research.

Riparian Response Guilds

Vertebrate response guilds as indicators of restoration success in riparian ecosystems may be a valuable monitoring tool but should be used with the same cautions presented above. Croonquist and Brooks (1991) evaluated the effects of anthropogenic disturbances on small mammals and birds along Pennsylvania waterways. They evaluated species in five different response guilds, including wetland dependency, trophic level, species status (endangered, recreational, native, exotic), habitat specificity, and seasonality (birds).

They found that community coefficient indices were better indicators than species richness. The habitat specificity and seasonality response guilds for birds were best able to distinguish those species sensitive to disturbance from those which were not affected or were benefited. Neotropical migrants and species with specific habitat requirements were the best predictors of disturbance. Edge and exotic species were greater in abundance in the disturbed habitats and might serve as good indicators there. Seasonality analysis showed migrant breeders were more common in undisturbed areas, which, as suggested by Verner (1984), indicates the ability of guild analysis to distinguish local impacts. Mammalian response guilds did not exhibit any significant sensitivity to disturbance and were considered unsuitable as indicators.

In contrast, Mannan et al. (1984) found that in only one of the five avian guilds tested was the density of birds consistent across managed and undisturbed forests. In other words, population response to restoration might not be consistent across different indicator guilds. Also, periodically monitoring restoration initiatives is necessary to document when, during the recovery stage, the more sensitive species outcompete generalists.

Aquatic Invertebrates

Aquatic invertebrates have been used as indicators of stream and riparian health for many years. Perhaps more than other taxa, they are closely tied to both aquatic and riparian habitat. Their life cycles usually include periods in and out of the water, with ties to riparian vegetation for feeding, pupation, emergence, mating, and egg laying (Erman 1991).

It is often important to look at the entire assemblage of aquatic invertebrates as an indicator group. Impacts to a stream often decrease diversity but might increase the abundance of some species, with the size of the first species to be affected often larger (Wallace and Gurtz 1986). In summary, a good indicator species should be low on the food chain to respond quickly, should have a narrow tolerance to change, and should be a native species (Erman 1991).

Diversity and Related Indices

Biological diversity refers to the number of species in an area or region and includes a measure of the variety of species in a community that takes into account the relative abundance of each species (Ricklefs 1990). When measuring diversity, it is important to clearly define the biological objectives, stating exactly what attributes of the system are of concern and why (Schroeder and Keller 1990). Different measures of diversity can be applied at various levels of complexity, to different taxonomic groups, and at distinct spatial scales. Several factors should be considered in using diversity as a measure of system condition for stream corridor restoration.

Levels of Complexity

Diversity can be measured at several levels of complexity genetic, population/species, community/ecosystem, and landscape (Noss 1994). There is no single correct level of complexity to use because different scientific or management issues are focused on different levels (Meffe et al. 1994). The level of complexity chosen for a specific stream corridor restoration initiative should be determined based on careful consideration of the biological objectives of the project.

Subsets of Concern

Overall diversity within any given level of complexity may be of less concern than diversity of a particular subset of species or habitats. Measures of overall diversity include all of the elements of concern and do not provide information about the occurrence of specific elements. For example, measures of overall species diversity do not provide information about the presence of individual species or species groups of management concern.

Any important subsets of diversity should be described in the process of setting biological objectives. At the community level, subsets of species of interest might include native, endemic, locally rare or threatened, specific guilds (e.g., cavity users), or taxonomic groups (e.g., amphibians, breeding birds, macroinvertebrates). At the terrestrial landscape level, subsets of diversity could include forest types or seral stages (Noss 1994). Thus, for a specific stream corridor project, measurement of diversity may be limited to a target group of special concern. In this manner, comparison of diversity levels becomes more meaningful.

Spatial Scale

Diversity can be measured within the bounds of a single community, across community boundaries, or in large areas encompassing many communities. Diversity within a relatively homogeneous community is known as alpha diversity. Diversity between communities, described as the amount of differentiation along habitat gradients, is termed beta diversity. The total diversity across very large landscapes is gamma diversity. Noss and Harris (1986) note that management for alpha diversity may increase local species richness, while the regional landscape (gamma diversity) may become more homogeneous and less diverse overall. They recommend a goal of maintaining the regional species pool in an approximately natural relative abundance pattern. The specific size of the area of concern should be defined when diversity objectives are established.

Measures of Diversity

Magurran (1988) describes three main categories of diversity measures richness indices, abundance models, and indices based on proportional abundance. Richness indices are measures of the number of species (or other element of diversity) in a specific sampling unit and are the most widely used indices (Magurran 1988). Abundance models account for the evenness (equitability) of distribution of species and fit various distributions to known models, such as the geometric series, log series, lognormal, or broken stick. Indices based on the proportional abundance of species combine both richness and evenness into a single index. A variety of such indices exist, the most common of which is the Shannon-Weaver diversity index (Krebs 1978):

$$H = -\Sigma p_i \log_e p_i$$

where

H = index of species diversity

S = number of species

p_i = proportion of total sample belonging to the i^{th} species

Results of most studies using diversity indices are relatively insensitive to the particular index used (Ricklefs 1979). For example, bird species diversity indices from 267 breeding bird censuses were highly correlated ($r = 0.97$) with simple counts of bird species richness (Tramer 1969). At the species level, a simple measure of richness is most often used in conservation biology studies because the many rare species that characterize most systems are generally of greater interest than the common species that dominate in diversity indices and because accurate population density estimates are often not available (Meffe et al. 1994).

Simple measures of species richness, however, are not sensitive to the actual species composition of an area. Similar richness values in two different areas may represent very different sets of species. The usefulness of these measures can be increased by considering specific subsets of species of most concern, as mentioned above. Magurran (1988) recommends going beyond the use of a single diversity measure and examining the shape of the species abundance distribution as well. Breeding bird census data from an 18-hectare (ha) riparian deciduous forest habitat in Ohio (Tramer 1996) can be used to illustrate these different methods of presentation (**Figure 7.36**). Breeding bird species richness in this riparian habitat was 38.

Pielou (1993) recommends the use of three indices to adequately assess diversity in terrestrial systems:

- A measure of plant species diversity.
- A measure of habitat diversity.
- A measure of local rarity.

Other indices used to measure various aspects of diversity include vegetation measures, such as foliage height diversity (MacArthur and MacArthur 1961), and landscape measures, such as fractal dimension, fragmentation indices, and juxtaposition (Noss 1994).

Related Integrity Indices

Karr (1981) developed the Index of Biotic Integrity to assess the diversity and health of aquatic communities. This index is designed to assess the present status of the aquatic community using fish community parameters related to species composition, species richness, and ecological factors. Species composition and richness parameters may include the presence of intolerant species, the richness and composition of specific species groups (e.g., darters), or the proportion of specific groups (e.g., hybrid individuals). Ecological parameters may include the proportion of top carnivores, number of individuals, or proportion with disease or other anomalies. Key parameters are developed for the stream system of interest, and each parameter is assigned a rating. The overall rating of a stream is used to evaluate the quality of the aquatic biota.

Rapid Bioassessment

Rapid bioassessment techniques are most appropriate when restoration goals are nonspecific and broad, such as improving the overall aquatic community or establishing a more balanced and diverse community in the stream corridor. Bioassessment often refers to use of biotic indices or composite analyses, such as those used by Ohio EPA (1990), and rapid bioassessment protocols (RBP), such as those documented by Plafkin et al. (1989). Ohio

EPA evaluates biotic integrity by using an invertebrate community index (ICI) that emphasizes structural attributes of invertebrate communities and compares the sample community with a reference or control community. The ICI is based on 10 metrics that describe different taxonomic and pollution tolerance relationships within the macroinvertebrate community. The RBP established by USEPA (Plafkin et al. 1989) were developed to provide states with the technical information necessary for conducting cost-effective biological assessments. The RBP are divided into five sets of protocols (RBP I to V), three for macroinvertebrates and two for fish (Table 7.8).

Algae

Although not detailed by Plafkin et al. (1989), algal communities are useful for bioassessment. Algae generally have short life spans and rapid reproduction rates, making them useful for evaluating short-term impacts. Sampling impacts are minimal to resident biota, and collection requires little effort. Primary productivity of algae is affected by physical and chemical impairments. Algal communities are sensitive to some pollutants that might not visibly affect other aquatic communities. Algal communities can be examined for indicator species, diversity indices, taxa richness, community respiration, and colonization rates. A variety of nontaxonomic evaluations, such as biomass and chlorophyll, may be used and are summarized in Weitzel (1979). Rodgers et al. (1979) describe functional measurements of algal communities, such as primary productivity and community respiration, to evaluate the effects of nutrient enrichment.

Although collecting algae in streams requires little effort, identifying for metrics, such as diversity indices and taxa

Species Sequence	Species	Abundance in 18-ha Plot
1	American robin	18.5
2	House wren	13
3	Gray catbird	10.5
4	Song sparrow	9.5
5	Northern cardinal	7.5
6	Baltimore oriole	7
7	Warbling vireo	6
8	Wood thrush	4.5
9	Common grackle	4.5
10	Eastern wood-pewee	4
11	Red-eyed vireo	4
12	Indigo bunting	4
13	Red-winged blackbird	4
14	Mourning dove	3
15	Northern flicker	3
16	Blue jay	3
17	Tufted titmouse	3
18	White-breasted nuthatch	3
19	American redstart	3
20	Rose-breasted grosbeak	3
21	Downy woodpecker	2
22	Great crested flycatcher	2
23	Black-capped chickadee	2
24	Carolina wren	2
25	European starling	2
26	Yellow warbler	2
27	Brown-headed cowbird	2
28	American goldfinch	2
29	Wood duck	1
30	Ruby-throated hummingbird	1
31	Red-bellied woodpecker	1
32	Hairy woodpecker	1
33	Tree swallow	1
34	Blue-gray gnatcatcher	1
35	Prothonotary warbler	1
36	Common yellowthroat	1
37	Eastern phoebe	1
38	N. rough-winged swallow	1

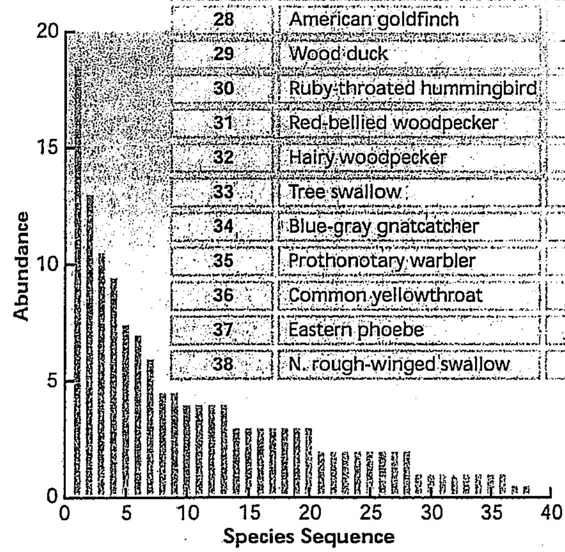

Figure 7.36: Breeding bird census data. *Species abundance curve in a riparian deciduous forest habitat.*
Source: Tramer 1996.

Table 7.8: ***Five tiers of the rapid bioassessment protocols.*** *RBPs are used to conduct cost-effective biological assessments.*
Source: Plafkin et al. 1989.

Level or Tier	Organism Group	Relative Level of Effort	Level of Taxonomy/ Where Performed	Level of Expertise Required
I	Benthic invertebrates	Low; 1-2 hr per site (no standardized sampling)	Order, family/field	One highly-trained biologist
II	Benthic invertebrates	Intermediate; 1.5-2.5 hr per site (all taxonomy performed in field)	Family/field	One highly-trained biologist and one technician
III	Benthic invertebrates	Most rigorous; 3-5 hr per site (2-3 hr of total are for lab taxonomy)	Genus or species/laboratory	One highly-trained biologist and one technician
IV	Fish	Low; 1-3 hr per site (no fieldwork involved)	Not applicable	One highly-trained biologist
V	Fish	Most rigorous; 2-7 hr per site (1-2 hr per site are for data analysis)	Species/field	One highly-trained biologist and 1-2 technicians

richness, may require considerable effort. A great deal of effort may be expended to document diurnal and seasonal variations in productivity.

Benthic Macroinvertebrates

The intent of the benthic rapid bioassessment is to evaluate overall biological condition, optimizing the use of the benthic community's capacity to reflect integrated environmental effects over time. Using benthic macroinvertebrates is advantageous for the following reasons:

- They are good indicators of localized conditions.
- They integrate the effects of short-term environmental variables.
- Degraded conditions are easily detected.
- Sampling is relatively easy.
- They provide food for many fish of commercial or recreational importance.
- Macroinvertebrates are generally abundant.
- Many states already have background data.

As indicated above, the RBP are divided into three sets of protocols (RBP I to III) for macroinvertebrates. RBP I is a "screening" or reconnaissance-level analysis used to discriminate obviously impaired and nonimpaired sites from potentially affected areas requiring further investigation. RBP II and III use a set of metrics based on taxon tolerance and community structure similar to the ICI used by the state of Ohio. Both are more labor-intensive than RBP I and incorporate field sampling. RBP II uses family-level taxonomy to determine the following set of metrics used in describing the biotic integrity of a stream:

- Taxa richness.
- Hilsenhoff biotic index (Hilsenhoff 1988).
- Ratio of scrapers to filtering collectors.
- Ratio of Ephemeroptera/Plecoptera/Trichoptera (EPT) and chironomid abundances.
- Percent contribution of dominant taxa.
- EPT index.
- Community similarity index.
- Ratio of shredders to total number of individuals.

RBP III further defines the level of biotic impairment and is essentially an intensified version of RBP II that uses species-level taxonomy. As with ICI, the RBP metrics for a site are compared to metrics from a control or reference site.

Fish

Hocutt (1981) states "perhaps the most compelling ecological factor is that structurally and functionally diverse fish communities both directly and indirectly provide evidence of water quality in that they incorporate all the local environmental perturbations into the stability of the communities themselves."

The advantages of using fish as bioindicators are as follows:

- They are good indicators of long-term effects and broad habitat conditions.
- Fish communities represent a variety of trophic levels.
- Fish are at the top of the aquatic food chain and are consumed by humans.
- Fish are relatively easy to collect and identify.
- Water quality standards are often characterized in terms of fisheries.
- Nearly one-third of the endangered vertebrate species and subspecies in the United States are fish.

The disadvantages of using fish as bioindicators are as follows:

- The cost.
- Statistical validity may be hard to attain.
- It is difficult to interpret findings.

Electrofishing is the most commonly used field technique. Each collecting station should be representative of the study reach and similar to other reaches sampled; effort between reaches should be equal. All fish species, not just game species, should be collected for the fish community assessment (Figure 7.37). Karr et al. (1986) used 12 biological metrics to assess biotic integrity using taxonomic and trophic composition and condition and abundance of fish. Although the Index of Biological Integrity (IBI) developed by Karr was designed for small midwestern streams, it has been modified for many regions of the country and for use in large rivers (see Plafkin et al. 1989).

Establishing a Standard of Comparison

With stream restoration activities, it is important to select a desired end condition for the proposed management action. A predetermined standard of comparison provides a benchmark against which to measure progress. For example, if the chosen diversity measure is native species richness, the standard of comparison might be the maximum expected native species richness for a defined geographic area and time period.

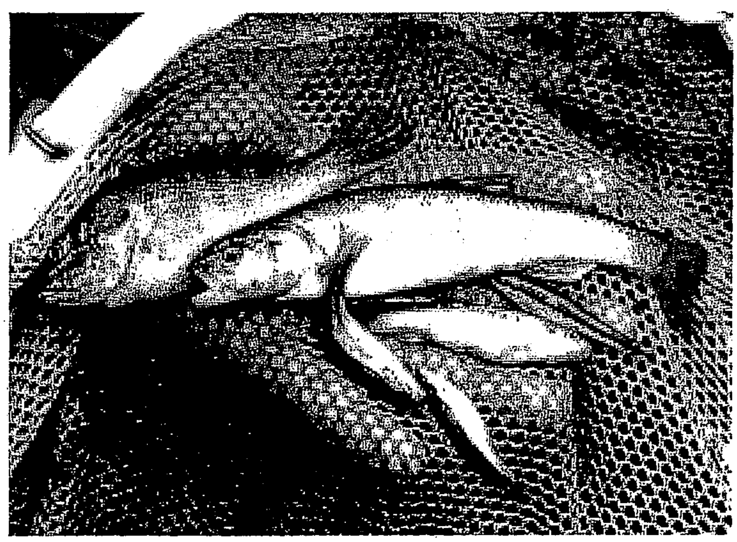

__Figure 7.37: Fish samples.__ Water quality standards are often characterized in terms of fisheries.

Historical conditions in the region should be considered when establishing a standard of comparison. If current conditions in a stream corridor are degraded, it may be best to establish the standard at a period in the past that represented more natural or desired conditions. Knopf (1986) notes that for certain western streams, historical diversity might have been less than current due to changes in hydrology and encroachment of native and exotic riparian vegetation in the floodplain. Thus, it is important to agree on what conditions are desired prior to establishing the standard of comparison. In addition, the geographic location and size of the area should be considered. Patterns of diversity vary with geographic location, and larger areas are typically more diverse than smaller areas.

The IBI is scaled to a standard of comparison determined through either professional judgment or empirical data, and such indices have been developed for a variety of streams (Leonard and Orth 1986, Bramblett and Fausch 1991, Lyons et al. 1996).

Evaluating the Chosen Index

For a hypothetical stream restoration initiative, the following biological diversity objective might be developed. Assume that a primary concern in the area is conserving native amphibian species and that 30 native species of amphibians have been known to occur historically in the 386 m^2 watershed. The objective could be to manage the stream corridor to provide and maintain suitable habitat for the 30 native amphibian species.

Stream corridor restoration efforts must be directed toward those factors that can be managed to increase diversity to the desired level. Those factors might be the physical and structural features of the stream corridor or possibly the presence of an invasive species in the community. Knowledge of the important factors can be obtained from existing literature and from discussions with local and regional experts.

Diversity can be measured directly or predicted from other information. Direct measurement requires an actual inventory of the element of diversity, such as counting the amphibian species in the study area. The IBI requires sampling fish populations to determine the number and composition of fish species. Measures of the richness of a particular animal group require counts. Determining the number of species in a community is best accomplished with a long-term effort because there can be much variation over short periods. Variation can arise from observer differences, sampling design, or temporal variation in the presence of species.

Direct measures of diversity are most helpful when baseline information is available for comparing different sites. It is not possible, however, to directly measure certain attributes, such as species richness or the population level of various species, for various future conditions. For example, the IBI cannot be directly computed for a predicted stream corridor condition, following management action.

Predictions of diversity for various future conditions, such as with restoration or management, require the use of a predictive model. Assume the diversity objective for a stream corridor restoration effort is to maximize native amphibian species richness. Based on knowledge of the life history of the species, including requirements for habitat, water quality, or landscape configuration, a plan can be developed to restore a stream corridor to meet these needs. The plan could include a set of criteria or a model to describe the specific features that should be included to maximize amphibian richness. Examples of indirect methods to assess diversity include habitat models (Schroeder and Allen 1992, Adamus 1993) and cumulative impact assessment methods (Gosselink et al. 1990, Brooks et al. 1991).

Predicting diversity with a model is generally more rapid than directly measuring diversity. In addition, predictive methods provide a means to analyze alternative future conditions before implementing specific restoration plans. The reliability and accuracy of diversity models should be established before their use.

Classification Systems

Classification is an important component of many of the scientific disciplines relevant to stream corridors—hydrology, geomorphology, limnology, plant and animal ecology. **Table 7.9** lists some of the classification systems that might be useful in identifying and planning riverine restoration activities. It is not the intent of this section to exhaustively review all classification schemes or to present a single recommended classification system. Rather, we focus on some of the principal distinctions among classification systems and factors to consider in the use of classification systems for restoration planning, particularly in the use of a classification system as a measure of biological condition. It is likely that multiple systems will be useful in most actual riverine restoration programs.

The common goal of classification systems is to organize variation. Important dimensions in which riverine classification systems differ include the following:

- *Geographic domain.* The range of sites being classified varies from rivers of the world to local differences in the composition and characteristics of patches within one reach of a single river.
- *Variables considered.* Some classifications are restricted to abiotic vari-

Table 7.9: Selected riverine and riparian classification systems. *Classification systems are useful in characterizing biological conditions.*

Classification System	Subject	Geographic Domain	Citation
Riparian vegetation of Yampa, San Miguel/Dolores River Basins	Plant communities	Colorado	Kittel and Lederer (1993)
Riparian and scrubland communities of Arizona and New Mexico	Plant communities	Arizona and New Mexico	Szaro (1989)
Classification of Montana riparian and wetland sites	Plant communities	Montana	Hansen et al. (1995)
Integrated riparian evaluation guide	Hydrology, geomorphology, soils, vegetation	Intermountain	U.S. Forest Service (1992)
Streamflow cluster analysis	Hydrology with correlations to fish and invertebrates	National	Poff and Ward (1989)
River Continuum	Hydrology, stream order, water chemistry, aquatic communities	International, national	Vannote et al. (1980)
World-wide stream classification	Hydrology, water chemistry, substrate, vegetation	International	Pennak (1971)
Rosgen's river classification	Hydrology, geomorphology: stream and valley types	National	Rosgen (1996)
Hydrogeomorphic wetland classification	Hydrology, geomorphology, vegetation	National	Brinson (1993)
Recovery classes following channelization	Hydrology, geomorphology, vegetation	Tennessee	Simon and Hupp (1992)

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ables of hydrology, geomorphology, and aquatic chemistry. Other community classifications are restricted to biotic variables of species composition and abundance of a limited number of taxa. Many classifications include both abiotic and biotic variables. Even purely abiotic classification systems are relevant to biological evaluations because of the important correlations (e.g., the whole concept of physical habitat) between abiotic structure and community composition.

- *Incorporation of temporal relations.* Some classifications focus on describing correlations and similarities across sites at one, perhaps idealized, point in time. Other classifications identify explicit temporal transitions among classes, for example, succession of biotic communities or evolution of geomorphic landforms.
- *Focus on structural variation or functional behavior.* Some classifications emphasize a parsimonious description of observed variation in the classification variables. Others use classification variables to identify types with different behaviors. For example, a vegetation classification can be based primarily on patterns of species co-occurrence, or it can be based on similarities in functional effect of vegetation on habitat value.
- *The extent to which management alternatives or human actions are explicitly considered as classification variables.* To the extent that these variables are part of the classification itself, the classification system can directly predict the result of a management action. For example, a vegetation classification based on grazing intensity would predict a change from one class of vegetation to another class based on a change in grazing management.

Use of Classification Systems in Restoring Biological Conditions

Restoration efforts may apply several national and regional classification systems to the riverine site or sites of interest because these are efficient ways to summarize basic site description and inventory information and they can facilitate the transference of existing information from other similar systems.

Most classification systems are generally weak at identifying causal mechanisms. To varying degrees, classification systems identify variables that efficiently describe existing conditions. Rarely do they provide unequivocal assurance about how variables actually cause the observed conditions. Planning efficient and effective restoration actions generally requires a much more mechanistic analysis of how changes in controllable variables will cause changes toward desired values of response variables. A second limitation is that application of a classification system does not substitute for goal setting or design. Comparison of the degraded system to an actual unimpacted reference site, to the ideal type in a classification system, or to a range of similar systems can provide a framework for articulating the desired state of the degraded system. However, the desired state of the system is a management objective that ultimately comes from outside the classification of system variability.

Analyses of Species Requirements

Analyses of species requirements involve explicit statements of how variables interact to determine habitat or how well a system provides for the life requisites of fish and wildlife species. Complete specification of relations between all relevant variables and all species in a stream corridor system is not possible. Thus, analyses based on species requirements focus on one or more target species or groups of species. In a simple case, this type of analysis may be based on an explicit statement of the physical factors that distinguish good habitat for a species (places where it is most likely to be found or where it best reproduces) from poor habitat (places where it is unlikely to be found or reproduces poorly). In more complicated cases, such approaches incorporate variables beyond those of purely physical habitat, including other species that provide food or biotic structure, other species as competitors or predators, or spatial or temporal patterns of resource availability.

Analyses based on species requirements differ from synthetic measures of system condition in that they explicitly incorporate relations between "causal" variables and desired biological attributes. Such analyses can be used directly to decide what restoration actions will achieve a desired result and to evaluate the likely consequences of a proposed restoration action. For example, an analysis using the habitat evaluation procedures might identify mast production (the accumulation of nuts from a productive fruiting season which serves as a food source for animals) as a factor limiting squirrel populations. If squirrels are a species of concern, at least some parts of the stream restoration effort should be directed toward increasing mast production. In practice, this logical power is often compromised by incomplete knowledge of the species habitat requirements.

The complexity of these methods varies along a number of important dimensions, including prediction of habitat suitability versus population numbers, analysis for a single place and single time versus a temporal sequence of spatially complex requirements, and analysis for a single target species versus a set of target species involving tradeoffs. Each of these dimensions must be carefully considered in selecting an analysis procedure appropriate to the problem at hand.

The Habitat Evaluation Procedures (HEP)

Habitat evaluation procedures (HEP) can be used for several different types of habitat studies, including impact assessment, mitigation, and habitat management. HEP provides information for two general types of habitat comparisons the relative value of different areas at the same point in time and the relative value of the same area at different points in time. Potential changes in wildlife (both aquatic and terrestrial) habitat due to proposed projects are characterized by combining these two types of comparisons.

Basic Concepts

HEP is based on two fundamental ecological principles habitat has a definable carrying capacity, or suitability, to support or produce wildlife populations (Fretwell and Lucas 1970), and the suitability of habitat for a given wildlife species can be estimated using measurements of vegetative, physical, and chemical traits of the habitat. The suitability of a habitat for a given species is described by a habitat suitability index (HSI) constrained between 0 (unsuitable habitat) and 1 (optimum habitat). HSI models have been developed and published by the U.S. Fish and Wildlife Service (Schamberger et al. 1982; Terrell and Carpenter, in press), and USFWS (1981) provides guidelines for use in developing HSI models for specific projects. HSI models can be developed for many of the previously described metrics, including species, guilds, and communities (Schroeder and Haire 1993).

The fundamental unit of measure in HEP is the Habitat Unit, computed as follows:

$$HU = AREA \times HSI$$

where HU is the number of habitat units (units of area), AREA is the areal extent of the habitat being described (units of area), and HSI is the index of suitability of the habitat (unitless). Conceptually, an HU integrates the quantity and quality of habitat into a single measure, and one HU is equivalent to one unit of optimal habitat.

Use of HEP to Assess Habitat Changes

HEP provides an assessment of the net change in the number of HUs attributable to a proposed future action, such as a stream restoration initiative. A HEP application is essentially a two-step process calculating future HUs for a particular project alternative and calculating the net change as compared to a base condition.

The steps involved in using and applying HEP to a management project are outlined in detail in USFWS (1980a). However, some early planning decisions often are given little attention although they may be the most important part of a HEP study. These initial decisions include forming a study team, defining the study boundaries, setting study objectives, and selecting the evaluation species. The study team usually consists of individuals representing different agencies and viewpoints. One member of the team is generally from the lead project planning agency and other members are from resources agencies with an interest in the resources that would be affected.

One of the first tasks for the team is to delineate the study area boundaries. The study area boundaries should be drawn to include any areas of direct impact, such as a flood basin for a new reservoir, and any areas of secondary impact, such as a downstream river reach that might have an altered flow, increased turbidity, or warmer temperature, or riparian or upland areas subject to land use changes as a result of an increased demand on recreational lands. Areas such as an upstream spawning ground that are not contiguous to the primary impact site also might be affected and therefore should be included in the study area.

The team also must establish project objectives, an often neglected aspect of project planning. Objectives should state what is to be accomplished in the project and specify an endpoint to the project. An integral aspect of objective setting is selecting evaluation species, the specific wildlife resources of concern for which HUs will be computed in the HEP analysis. These are often individual species, but they do not have to be. Depending on project objectives, species' life stages (e.g., juvenile salmon), species' life requisites (e.g., spawning habitat), guilds (e.g., cavity-nesting birds), or communities (e.g., avian richness in riparian forests) can be used.

Instream Flow Incremental Methodology

The Instream Flow Incremental Methodology (IFIM) is an adaptive system composed of a library of models that are linked to describe the spatial and temporal habitat features of a given river. IFIM is described in Chapter 5 under *Supporting Analysis for Selecting Restoration Alternatives.*

Physical Habitat Simulation

The Physical Habitat Simulation (PHABSIM) model was designed by the U.S. Fish and Wildlife Service primarily for instream flow analysis (Bovee 1982). It represents the habitat evaluation component of a larger instream flow incremental methodology for incorporating fish habitat consideration into flow management, presented in Chapter 5. PHABSIM is a collection of computer programs that allows evaluation of available habitat within a study reach for various life stages of different fish species. The two basic components of the model are hydraulic simulation (based on field-measured cross-sectional data) and several standard hydraulic methods for predicting water surface elevations and velocities at unmeasured discharges (e.g., stage vs. discharge relations, Manning's equation, step-backwater computations). Habitat simulation integrates species and life-stage-specific habitat suitability curves for water depth, velocity, and substrate with the hydraulic data. Output is a plot of weighted usable area (WUA) against discharge for the species and life stages of interest. **(Figure 7.38)**

The stream hydraulic component predicts depths and water velocities at unobserved flows at specific locations on a cross section of a stream. Field measurements of depth, velocity, substrate material, and cover at specific sampling points on a cross section are taken at different observable flows. Hydraulic measurements, such as water surface elevations, also are collected during the field inventory. These data are used to calibrate the hydraulic simulation models. The models then are used to predict depths and velocities at flows different from those measured.

The habitat component weights each stream cell using indices that assign a relative value between 0 and 1 for each habitat attribute (depth, velocity, substrate material, cover), indicating how suitable that attribute is for the life stage under consideration. These attribute indices are usually termed habitat suitability indices and are developed from direct observations of the attributes used most often by a life stage, from expert opinion about what the life requisites are, or a combination. Various approaches are taken to factor assorted biases out of these suitability data, but they remain indices that are used as weights of suitability. In the last step of the habitat component, hydraulic estimates of depth and velocity at different flow levels are combined with the suitability values for those attributes to weight the area of each cell at the simulated flows. The weighted values for all cells are summed to produce the WUA.

There are many variations on the basic approach outlined above, with specific analyses tailored for different water management phenomena (such as hydropeaking and unique spawning habitat needs), or for special habitat needs (such as bottom velocity instead of mean column velocity) (Milhous et al. 1989). However, the fundamentals of hydraulic and habitat modeling remain the same, resulting in a WUA versus discharge function. This function should be combined with the appropriate hydrologic time series (water availability) to develop an idea of what life states might be affected by a loss or gain of available habitat and at what time of the year. Time series analysis plays this role and also factors in any physical and institutional constraints on water management so that alternatives can be evaluated (Milhous et al. 1990).

Several things must be remembered about PHABSIM. First, it provides an index to microhabitat availability; it is not a measure of the habitat actually used by aquatic organisms. It can be used only if the species under consideration exhibit documented preferences for depth, velocity, substrate material, cover, or other predictable microhabitat attributes in a specific environment of

REVERSE
Review Chapter 5's Supporting Analysis for Selecting Restoration Alternatives

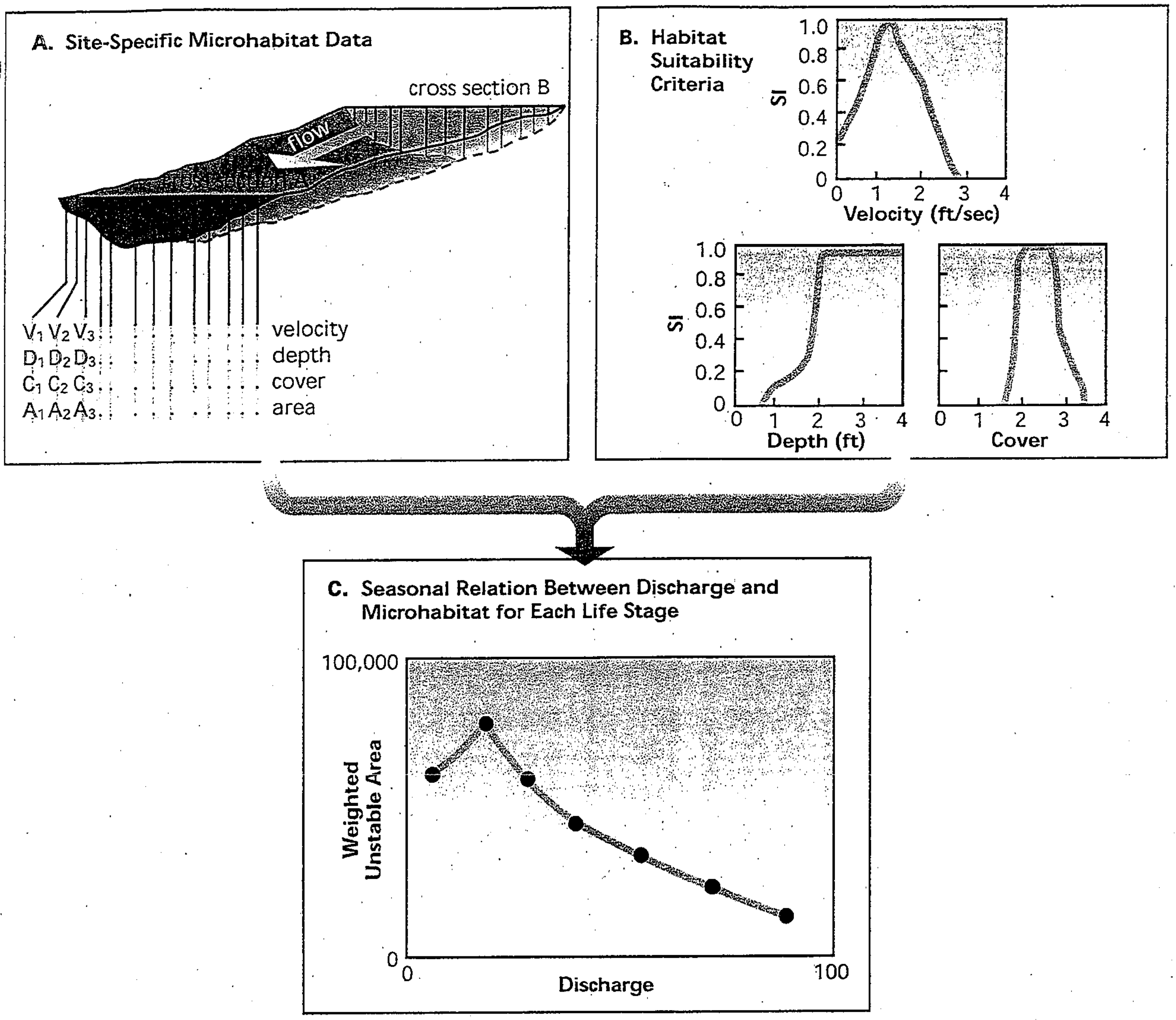


Figure 7.38: Conceptualization of how PHABSIM calculates habitat values as a function of discharge. *A. First, depth (Di), velocity (Vi), cover conditions (Ci), and area (Ai) are measured or simulated for a given discharge. B. Suitability index (SI) criteria are used to weight the area of each cell for the discharge. The habitat values for all cells in the study reach are summed to obtain a single habitat value for the discharge. C. The procedure is repeated for a range of discharges.*
Modified from Nestler et al. 1989.

competition and predation. The typical application of PHABSIM assumes relatively steady flow conditions such that depths and velocities are comparably stable within the chosen time step. PHABSIM does not predict the effects of flow on channel change. Finally, the field data and computer analysis requirements can be relatively large.

Two-dimensional Flow Modeling

Concern about the simplicity of the one-dimensional hydraulic models used in PHABSIM has led to current research interest in the use of more sophisticated two-dimensional hydraulic models to simulate physical conditions of depth and velocity for use in fish habitat analysis. A two-dimensional hydraulic model can be spatially adjusted to represent the scale of aquatic habitat and the variability of other field data. For example, the physical relationship between different aquatic habitat types is often a key parameter when considering fish habitat use. The spatial nature of two-dimensional flow modeling allows for the analysis of these relationships. The model can also consider the drying and wetting of intermittent stream channels.

Leclerc et al. (1995) used two-dimensional flow modeling to study the effect of a water diversion on the habitat of juvenile Atlantic salmon (*Salmo salar*) in the Moisie River in Quebec, Canada. Average model error was reduced when compared with traditional one-dimensional models. Output from the two-dimensional modeling was combined with habitat suitability indexes with finite element calculation techniques. Output from the analysis included maps displaying the spatial distribution of depth, velocity, and habitat suitability intervals.

Physical data collection for this modeling tool is intensive. Channel contour and bed material mapping is required along with discharge relationships and the upstream and downstream boundaries of each study reach. Velocity and water-surface measurements for various discharges are required for model calibration. Two-dimensional modeling does not address all of the issues related to hydrodynamics and flow modeling. Mobile bed systems and variability in Manning's coefficient are still problematic using this tool (Leclerc et al. 1995). Moderate to large rivers with a stable bedform are most suited to this methodology.

Riverine Community Habitat Assessment and Restoration Concept Model (RCHARC)

Another modeling approach to aquatic habitat restoration is the Riverine Community Habitat Assessment and Restoration (RCHARC) concept. This model is based on the assumption that aquatic habitat in a restored stream reach will best mimic natural conditions if the bivariate frequency distribution of depth and velocity in the subject channel is similar to a reference reach with good aquatic habitat. Study site and reference site data can be measured or calculated using a computer model. The similarity of the proposed design and reference reach is expressed with three-dimensional graphs and statistics (Nestler et al. 1993, Abt 1995). RCHARC has been used as the primary tool for environmental analysis on studies of flow management for the Missouri River and the Alabama-Coosa-Tallapoosa Apalachicola-Chattahoochee-Flint Basin.

Time Series Simulations

A relatively small number of applications have been made of time series simulations of fish population or individual fish responses to riverine habitat changes. Most of these have used PHABSIM to accomplish hydraulic model development and validation and hydraulic simulation, but some have substituted time-series simulations of individual or population responses for habitat suitability curve development and validation, and habitat suitability modeling. PHABSIM quantifies the relationship of hydraulic estimates (depth and velocity) and measurements (substrate and cover) with habitat suitability for target fish and invertebrate life stages or water-related recreation suitability. It is useful when relatively steady flow is the major determinant controlling riverine resources. Use of PHABSIM is generally limited to river systems in which dissolved oxygen, suspended sediment, nutrient loading, other chemical aspects of water quality, and interspecific competition do not place the major limits on populations of interest. These limitations to the use of PHABSIM can be abated or removed with models that simulate response of individual fish or fish populations.

Individual-based Models

The Electric Power Research Institute (EPRI) program on compensatory mechanisms in fish populations (CompMech) has the objective of improving predictions of fish population response to increased mortality, loss of habitat, and release of toxicants (EPRI 1996). This technique has been applied by utilities and resource management agencies in assessments involving direct mortality due to entrainment, impingement, or fishing; instream flow; habitat alteration (e.g., thermal discharge, water-level fluctuations, water diversions, exotic species); and ecotoxicity. Compensation is defined as the capacity of a population to self-mitigate decreased growth, reproduction, or survival of some individuals in the population by increased growth, reproduction, or survival of the remaining individuals. The CompMech approach over the past decade has been to represent in simulation models the processes underlying daily growth, reproduction, and survival of individual fish (hence the classification of individual-based models) and then to aggregate over individuals to the population level.

The models can be used to make short-term predictions of survival, growth, habitat utilization, and consumption for critical life stages. For the longer term, the models can be used to project population abundance through time to assess the risk that abundance will fall below some threshold requiring mitigation. For stream situations, several CompMech models have been developed that couple the hydraulic simulation method of PHABSIM directly with an individual-based model of reproduction and young-of-year dynamics, thereby eliminating reliance on the habitat-based component of PHABSIM (Jager et al. 1993). The CompMech model of smallmouth bass is being used to evaluate the effects of alternative flow regimes on nest success, growth, mortality, and ultimately year class strength in a Virginia stream to identify instream flows that protect fisheries with minimum impact on hydropower production.

A model of coexisting populations of rainbow and brown trout in California is being used to evaluate alternative instream flow and temperature scenarios (Van Winkle et al. 1996). Model predictions will be compared with long-term field observations before and after experimental flow increases; numerous scientific papers are expected from this intensive study.

An individual-based model of smolt production by Chinook salmon, as part of an environmental impact statement for the Tuolumne River in California, considered the minimum stream flows necessary to ensure continuation and maintenance of the anadromous fishery (FERC 1996). That model, the Oak Ridge Chinook salmon model (ORCM), predicts annual production of salmon smolts under specified reservoir minimum releases by evaluating critical factors, including influences on upstream migration of adults, spawning and incubation of eggs, rearing of young, and predation and mortality losses during the downstream migration of smolts. Other physical habitat analyses were used to supplement the population model in evaluating benefits of alternative flow patterns. These habitat evaluations are based on data from an instream flow study; a stream temperature model was used to estimate flows needed to maintain downstream temperatures within acceptable limits for salmon.

SALMOD

The conceptual and mathematical models for the Salmonid Population Model (SALMOD) were developed for Chinook salmon in concert with a 12-year flow evaluation study in the Trinity River of California using experts on the local river system and fish species in workshop settings (Williamson et al. 1993, Bartholow et al. 1993). SALMOD was used to simulate young-of-year production, assuming that the flow schedules to be evaluated were released from Lewiston Reservoir in every year from 1976 to 1992 (regardless of observed reservoir inflow, storage, and release limitations).

The structure of SALMOD is a middle ground between a highly aggregated classical population model that tracks cohorts/size groups for a generally large area without spatial resolution, and an individual-based model that tracks individuals at a great level of detail for a generally small area. The conceptual model states that fish growth, movement, and mortality are directly related to physical hydraulic habitat and water temperature, which in turn relate to the timing and amount of regulated streamflow. Habitat capacity is characterized by the hydraulic and thermal properties of individual mesohabitats, which are the model's spatial computational units.

Model processes include spawning (with redd superimposition), growth (including maturation), movement (freshet-induced, habitat-induced, and seasonal), and mortality (base, movement-related, and temperature-related). The model is limited to freshwater habitat for the first 9 months of life; estuarine and ocean habitats are not included. Habitat area is computed from flow/habitat area functions developed empirically. Habitat capacity for each life stage is a fixed maximum number per unit of habitat available. Thus, a maximum number of individuals for each computational unit is calculated for each time step based on streamflow and habitat type. Rearing habitat capacity is derived from empirical relations between available habitat area and number of individual fish observed.

Partly due to drought conditions, most of the flow alternatives to be evaluated did not actually occur during the flow evaluation study. When there is insufficient opportunity to directly observe and evaluate impacts of flow alternatives on fish populations, SALMOD can be used to simulate young-of-the-year production that may result from proposed flow schedules to be released or regulated by a control structure such as a reservoir or diversion.

Other physical habitat analyses can be used to supplement population models in evaluating benefits of alternative flow patterns. In the Trinity River Flow Study, a stream temperature model was used to estimate flows needed to maintain downstream temperatures within acceptable limits for salmon. Both the ORCM (FERC 1996) and SALMOD models concentrated on development, growth, movement, and mortality of young-of-year Chinook salmon but with different mechanistic inputs, spatial resolution, and temporal precision.

Preview Chapter 8's information on vegetation-hydroperiod model.

Vegetation-Hydroperiod Modeling

In most cases, the dominant factor that makes the riparian zone distinct from the surrounding uplands, and the most important gradient in structuring variation within the riparian zone, is site moisture conditions, or hydroperiod (**Figure** 7.39). Hydroperiod is defined as the depth, duration, and frequency of inundation and is a powerful determinant of what plants are likely to be found in various positions in the riparian zone. Formalizing this relation as a vegetation-hydroperiod model can provide a powerful tool for analyzing existing distributions of riparian vegetation, casting forward or backward in time to alternative distributions, and designing new distributions. The suitability of site conditions for various species of plants can be described with the same conceptual approach used to model habitat suitability for animals. The basic logic of a vegetation-hydroperiod model is straightforward. How wet a site is has a lot to do with what plants typically grow on the site. It is possible to measure how wet a site is and, more importantly, to predict how wet a site will be based on the relation of the site to a stream. From this, it is possible to estimate what vegetation is likely to occur on the site.

Components of a Vegetation-hydroperiod Model

The two basic elements of the vegetation-hydroperiod relation are the physical conditions of site moisture at various locations and the suitability of those sites for various plant species. In the simplest case of describing existing patterns, site moisture and vegetation can be directly measured at a number of locations. However, to use the vegetation-hydroperiod model to predict or design new situations, it is necessary to predict new site moisture conditions. The most useful vegetation-hydroperiod models have the following three components:

- *Characterization of the hydrology or pattern of streamflow.* This can take the form of a specific sequence of flows, a summary of how often different flows occur, such as a flow duration or flood frequency curve, or a representative flow value, such as bankfull discharge or mean annual discharge.
- *A relation between streamflow and moisture conditions at sites in the riparian zone.* This relation can be measured as the water surface elevation at a variety of discharges and summarized as a stage vs. discharge curve. It can also be calculated by a number of hydraulic models that relate water surface elevations to discharge, taking into account variables of channel geometry and roughness or resistance to flow. In some cases, differences in simple elevation above the channel bottom may serve as a reasonable approximation of differences in inundating discharge.
- *A relation between site moisture conditions and the actual or potential vegetation distribution.* This relation expresses the suitability of a site for a plant species or cover type based on the moisture conditions at the site. It can be determined by sampling the distribution of vegetation at a variety of sites with known moisture conditions and then deriving probability distributions of the likelihood of finding a plant on a site given the moisture conditions at the site. General relations are also available from the literature for many species.

The nature and complexity of these components can vary substantially and still provide a useful model. However, the components must all be expressed in consistent units and must have a domain of application that is appropriate to the questions being asked of the model (i.e., the model must be capable of changing the things that need to be changed to answer the question). In many cases, it may be possible to formulate a vegetation-hydroperiod model using representations of stream hydrology and hydraulics that have been developed for other analyses such as channel stability, fish habitat suitability, or sediment dynamics.

Identifying Non-equilibrium Conditions

In altered or degraded stream systems, current moisture conditions in the riparian zone may be dramatically unsuitable for the current, historical, or desired riparian vegetation. Several conditions can be relatively easily identified by comparing the distribution of vegetation to the distribution of vegetation suitabilities.

- The hydrology of the stream has been altered; for example, if streamflow has diminished by diversion or flood attenuation, sites in the riparian zone may be drier and no longer suitable for the historic vegetation or for current long-lived vegetation that was established under a previous hydrologic regime.
- The inundating discharges of plots in the riparian zone have been altered so that streamflow no longer has the same relation to site moisture conditions; for example, levees, channel modifications, and bank treatments may have either increased or decreased the discharge required to inundate plots in the riparian zone.
- The vegetation of the riparian zone has been directly altered, for example, by clearing or planting so that the vegetation on plots no longer corresponds to the natural vegetation for which the plots are suitable.

Figure 7.39: Vegetation/water relationship. *Soil moisture conditions often determine the plant communities in riparian areas.* Source: C. Zabawa.

In many degraded stream systems all of these things have happened. Understanding how the moisture conditions of plots correspond to the vegetation in the current system, as well as how they will correspond in the restored system, is an important element of formulating reasonable restoration objectives and designing a restoration plan.

Vegetation Effects of System Alterations

In a vegetation-hydroperiod model, vegetation suitability is determined by streamflow and the inundating discharges of plots in the riparian zone. The model can be used to predict effects of alteration in streamflow or the relations of streamflow to plot moisture conditions on the suitability of the riparian zone for different types of vegetation. Thus, the effects of flow alterations and changes in channel or bottomland topography proposed as part of a stream restoration plan can be examined in terms of changes in the suitability of various locations in the riparian zone for different plant species.

Flooding Tolerances of Various Plant Species

There is a large body of information on the flooding tolerances of various plant species. Summaries of this literature include Whitlow and Harris (1979) and the multivolume Impact of Water Level Changes on Woody Riparian and Wetland Communities (Teskey and Hinckley 1978, Walters et al. 1978, Lee and Hinckley 1982, Chapman et al. 1982). This type of information can be coupled to site moisture conditions predicted by applying discharge estimates or flood frequency analyses to the inundating discharges of sites in the riparian zone. The resulting relation can be used to describe the suitability of sites for various plant species, e.g., relatively flood-prone sites will likely have relatively flood-tolerant plants. Inundating discharge is strongly related to relative elevation within the floodplain. Other things being equal (i.e., within a limited geographic area and with roughly equivalent hydrologic regimes), elevation relative to a representative water surface line, such as bankfull discharge or the stage at mean annual flow, can thus provide a reasonable surrogate for site moisture conditions. Locally determined vegetation suitability can then be used to determine the likely vegetation in various elevation zones.

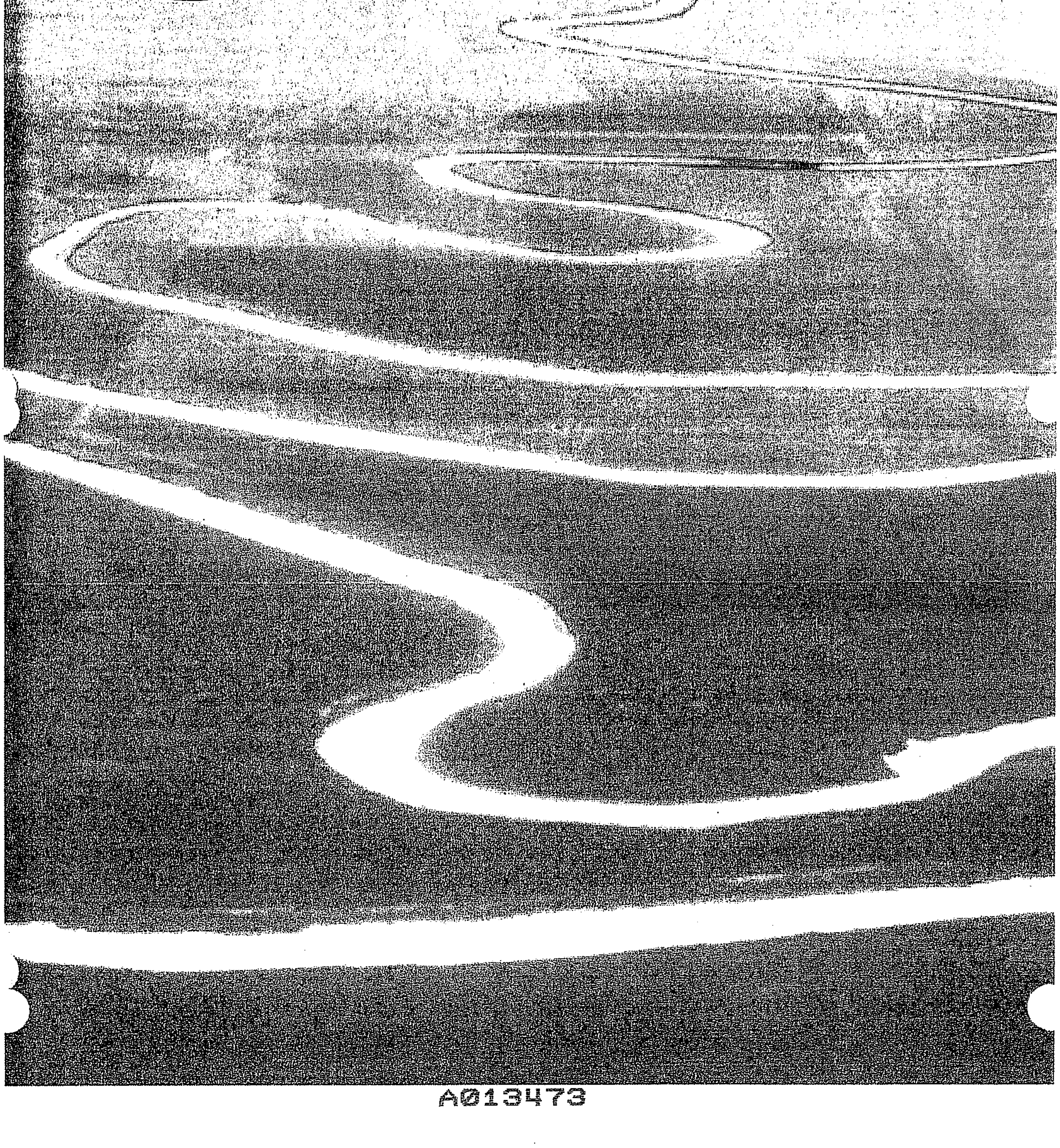
Extreme Events and Disturbance Requirements

Temporal variability is a particularly important characteristic of many stream ecosystems. Regular seasonal differences in biological requirements are examples of temporal variability that are often incorporated into biological analyses based on habitat suitability and time series simulations. The need for episodic extreme events is easy to ignore because these are so widely perceived as destructive both of biota and of constructed river features. In reality, however, these extreme events seem to be essential to physical channel maintenance and to the long-term suitability of the riverine ecosystem for disturbance-dependent species. Cottonwood in western riparian systems is one well-understood case of a disturbance-dependent species. Cottonwood regeneration from seed is generally restricted to bare, moist sites. Creating these sites depends heavily on channel movement (meandering, narrowing, avulsion) or new flood deposits at high elevations. In some western riparian systems, channel movement and deposition tend to occur infrequently in association with floods. The same events are also responsible for destroying stands of trees. Thus maintaining good conditions for existing stands, or fixing the location of a stream's banks with structural measures, tends to reduce the regeneration potential and the long-term importance of this disturbance-dependent species in the system as a whole.

Zonation of Vegetation

There are a number of statistical procedures for estimating the frequency and magnitude of extreme events (see flood frequency analysis section of chapter 8) and describing various aspects of hydrologic variation. Changing these flow characteristics will likely change some aspect of the distribution and abundance of organisms. Analyzing more specific biological changes generally requires defining the requirements of target species; defining requirements of their food sources, competitors, and predators; and considering how those requirements are influenced by episodic disturbance events.

8 Restoration Design



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8.A Valley Form, Connectivity, and Dimension

- *How do you incorporate all the spatial dimensions of the landscape into stream corridor restoration design?*
- *What criteria can be applied to facilitate good design decisions for stream corridor restoration?*

8.B Soil Properties

- *How do soil properties impact the design of restoration activities?*
- *What are the major functions of soils in the stream corridor?*
- *How are important soil characteristics, such as soil microfauna and soil salinity, accounted for in the design process?*

8.C Vegetative Communities

- *What is the role of vegetative communities in stream corridor restoration?*
- *What functions do vegetative communities fulfill in a stream corridor?*
- *What are some considerations in designing plant community restoration to ensure that all landscape functions are addressed?*
- *What is soil bioengineering and what is its role in stream corridor restoration?*

8.D Riparian / Terrestrial Habitat Recovery

- *What are some specific tools and techniques that can be used to ensure recovery of riparian and terrestrial habitat recovery?*

8.E Stream Channel Restoration

- *When is stream channel reconstruction an appropriate restoration option?*
- *How do you delineate the stream reach to be reconstructed?*
- *How is a stream channel designed and reconstructed?*
- *What are important factors to consider in the design of channel reconstruction (e.g., alignment and average slope, channel dimensions)?*
- *Are there computer models that can assist with the design of channel reconstruction?*

8.F Streambank Restoration Design

- *When should streambank stabilization be included in a restoration?*
- *How do you determine the performance criteria for streambank treatment, including the methods and materials to be used?*
- *What are some streambank stabilization techniques that can be considered for use?*

8.G In-Stream Habitat Recovery

- *What are the principal factors controlling the quality of instream habitat?*
- *How do you determine if an instream habitat structure is needed, and what type of structure is most appropriate?*
- *What procedures can be used to restore instream habitat?*
- *What are some examples of instream habitat structures?*
- *What are some important questions to address before designing, selecting or installing an instream habitat structure?*

8.H Land Use Scenarios

- *What role does land use play in stream corridor degradation and restoration?*
- *What design approaches can be used to address the impacts of various land uses (e.g., dams, agriculture, forestry, grazing, mining, recreation, urbanization)?*
- *What are some disturbances that are often associated with specific land uses?*
- *What restoration measures can be used to mitigate the impacts of various land uses?*
- *What are the potential effects of the restoration measures?*

8 Restoration Design

Design can be defined as the intentional shaping of matter, energy, and process to meet an expressed need. Planning and design connect natural processes and cultural needs through exchanges of materials, flows of energy, and choices of land use and management. One test of a successful stream corridor design is how well the restored system sustains itself over time while accommodating identified needs.

*To achieve success, those carrying out restoration design and implementation in variable-land-use settings must understand the stream corridor, watershed, and landscape as a complex of working ecosystems that influence and are influenced by neighboring ecosystems (**Figure 8.1**). The probability of achieving long-term, self-sustaining functions across this spatial complex increases with*

Figure 8.1: Stream running through a wet meadow. Restoration design must consider site-specific conditions as an integral part of larger systems.

"Leave It Alone / Let It Heal Itself"

There is a renewed emphasis on recovering damaged rivers (Barinaga 1996). Along with this concern, however, people should be reminded periodically that they serve as stewards of watersheds, not just tinkerers with stream sites. Streams in pristine condition, for example, should not be artificially "improved" by active rehabilitation methods.

At the other end of the spectrum, and particularly where degradation is caused by off-stream activities, the best solution to a river management problem might be to remove the problem source and "let it heal itself." Unfortunately, in severely degraded streams this process can take a long time. Therefore the "leave it alone" concept can be the most difficult approach for people to accept (Gordon et al. 1992).

an understanding of these relationships, a common language for expressing them, and subsequent response. Designing to achieve stream- or corridor-specific solutions might not resolve problems or recognize opportunities in the landscape.

Stream corridor restoration design is still largely in an experimental stage. It is known however, that restoration design must consider site-specific or local conditions to be successful. That is, the design criteria, standards, and specifications should be for the specific project in a specific physical, climatic, and geographic location. These initiatives, however, can and should work with, rather than against, the larger systems of which they are an integral part.

This approach produces multiple benefits, including:

- *A healthy, sustainable pattern of land uses across the landscape.*
- *Improved natural resource quality and quantity.*
- *Restored and protected stream corridors and associated ecosystems.*
- *A diversity of native plants and animals.*
- *A gene pool that promotes hardiness, disease resistance, and adaptability.*
- *A sense of stewardship for private landowners and the public.*
- *Improved management measures that avoid narrowly focused and fragmented land treatment.*

Building on information presented in Parts I and II, this chapter contains design guidance and techniques to address changes caused by major disturbances and to restore stream corridor structure and function to a desired level. It begins with larger-scale influences that design may have on stream corridor ecosystems, offers design guidance primarily at the stream corridor and stream scales, and concludes with land use scenarios.

The chapter is divided into seven sections.

Section 8.A: Valley Form, Connectivity, and Dimension

This section focuses on restoring structural characteristics that prevail at the stream corridor and landscape scales.

Section 8.B: Soil Properties

The restoration of soil properties that are critical to stream corridor structure and functions are addressed in this section.

Section 8.C: Plant Communities

Restoring vegetative communities is a highly visible and integral component of a functioning stream corridor.

Section 8.D: Habitat Measures

This section presents design guidance for some habitat measures. They are often integral parts of stream corridor structure and functions.

Section 8.E: Stream Channel Restoration

Restoring stream channel structure and functions is often a fundamental step in restoring stream corridors.

Section 8.F: Streambank Restoration

This section focuses on design guidelines and related techniques for streambank stabilization. These measures can help reduce surface runoff and sediment transport to the stream.

Section 8.G: Instream Habitat Recovery

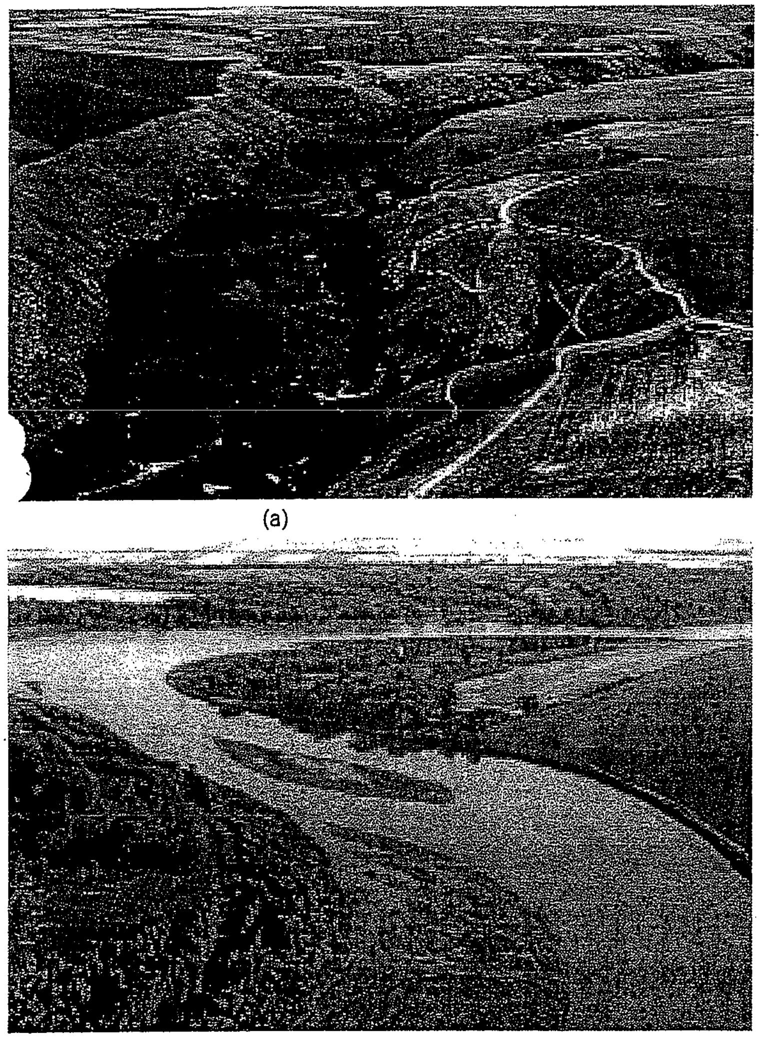
Restoring instream habitat structure and functions is often a key component of stream corridor restoration.

Section 8.H: Land Use Scenarios

This final section offers broad design concepts in the context of major land use scenarios.

8A Valley Form, Connectivity, and Dimension

Valley form, connectivity, and dimension are variable structural characteristics that determine the interrelationship of functions at multiple scales. Valley intersections (nodes) with tributary stream corridors, slope of valley sides, and floodplain gradient are characteristics of valley form that influence many functions (Figure 8.2).



(a)

(b)

*Figure 8.2: **Stream corridors.** (a) Stream valley side slopes and (b) floodplain gradients influence stream corridor function.*

The broad concept of connectivity, as opposed to fragmentation, involves linkages of habitats, species, communities, and ecological processes across multiple scales (Noss 1991). Dimension encompasses width, linearity, and edge effect, which are critical for movement of species, materials, and energy within the stream corridor and to or from ecosystems in the surrounding landscape. Design should therefore address these large-scale characteristics and their effect on functions.

Valley Form

In some cases, entire stream valleys have changed to the point of obscuring geomorphic boundaries, making stream corridor restoration difficult. Volcanoes, earthquakes, and landslides are examples of natural disturbances that cause changes in valley form. Encroachment and filling of floodplains are among the human-induced disturbances that modify valley shape.

Stream Corridor Connectivity and Dimension

Connectivity and dimensions of the stream corridor present a set of design-related decisions to be made. How wide should the corridor be? How long should the corridor be? What if there are gaps in the corridor? These structural characteristics have a significant impact on corridor functions. The width, length, and connectivity of existing or potential stream corridor vegetation, for example, are critical to habitat functions within the corridor and adjacent ecosystems.

Generally, the widest and most contiguous stream corridor which achieves habitat, conduit, filter, and other functions (see Chapter 2) should be an ecologically derived goal of restoration. Thresholds for each function are likely found at different corridor widths. The appropriate width varies according to soil type, with steep slopes requiring a wider corridor for filter functions. A conservative indicator of effective corridor width is whether a stream corridor can significantly prevent chemical contaminants contained in runoff from reaching the stream (Forman 1995).

As discussed in Chapter 1, the corridor should extend across the stream, its banks, the floodplain, and the valley slopes. It should also include a portion of upland for the entire stream length to maintain functional integrity (Forman and Godron 1986).

A contiguous, wide stream corridor might not be achievable, however, particularly where competing land uses prevail. In these cases, a ladder pattern of natural habitat crossing the floodplain and connecting the upland segments might facilitate sediment trapping during floods and provide hydraulic storage and organic matter for the stream system (Dramstad et al. 1996).

Figure 8.3 presents an example of these connections. The open areas within the ladder pattern are representative of areas that are unavailable for restoration because of competing land uses.

Innovative management practices that serve the functions of the corridor beyond land ownership boundaries can often be prescribed where land owners are supportive of restoration. Altering land cover, reducing chemical inputs, carefully timed mowing, and other management practices can reduce disturbance in the corridor.

Practical considerations may restrict restoration to a zone of predefined width adjacent to the stream. Although often unavoidable, such restrictions

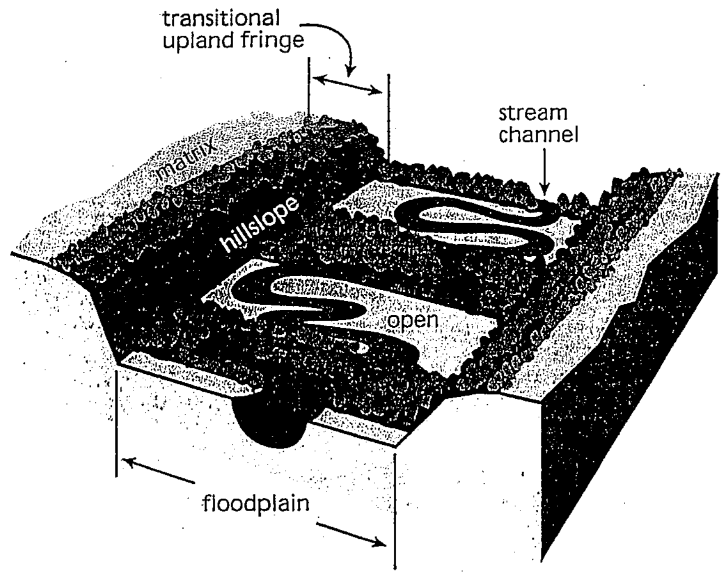


Figure 8.3: Connections across a stream corridor. *A ladder pattern of natural habitat can restore structure and functions where competing land uses prevail.*
Adapted from Ecology of Greenways: Design and Function of Linear Conservation Areas. Edited by Smith and Hellmund. © University of Minnesota Press 1993.

tend to result in underrepresentation of older, off-channel environments that support vegetation different from that in stream-front communities. Restricting restoration to a narrow part of the stream corridor usually does not restore the full horizontal diversity of broad floodplains, nor does it fully accommodate functions that occur during flood events, such as use of the floodplain by aquatic species (Wharton et al. 1982).

In floodplains where extensive subsurface hydrologic connections exist, limiting restoration to streamside buffer zones is not recommended since significant amounts of energy, nutrient transformation, and invertebrate activities can occur at great distances from the stream channel outside the buffer areas (Sedell et al. 1990). Similarly, failure to anticipate channel migration or periodic beaver activity might result in a corridor that does not accommodate

Corridor Width Variables

*The minimum width of stream corridors based on ecological criteria (**Figure 8.4**). Five basic situations in a river system are identified, progressing from seepage to river. The key variables determining minimum corridor width are listed under each.*

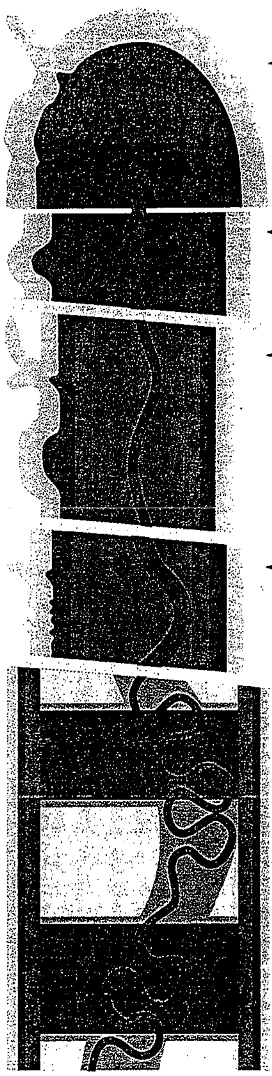


***Figure 8.4: Factors for determining minimum corridor widths.** Stream corridor functions are directly influenced by corridor width.*
Source: Forman 1995. Reprinted with permission of Cambridge University Press.

Seepage
1. Sponge effect for hydrologic flows, mimimizing downstream flooding
2. Control of dissolved-substance inputs from matrix

1st Order Stream
1. Same as for seepage

2nd to 4th Order Stream with Closed Canopy
1. Conduit for upland interior species; both sides of stream so species readily crossing floodplain have alternate routes
2. Control of dissolved-substance inputs from matrix
3. Conduit for streambank and floodplain species, where beaver activities maintain water across the floodplain and alter hillslope vegetation
4. Minimize hillslope erosion
5. Sponge effect for hydrologic flows, minimizing downstream flooding
6. Friction effect, minimizing downstream sedimentation
7. Protect high habitat diversity and species richness of floodplain

2nd to 4th Order Stream with Open Canopy
1. Same as for 2nd to ca. 4th order stream, closed canopy
2. Provide interior habitat for species conduit, as migrating open stream intersects hillslopes causing them to be open habitat

5th to 10th Order River
1. Conduit for upland interior species, on both sides of river so species that rarely can cross the floodplain have a route on each side
2. Provide interior habitat for species conduit, as migrating open river intersects hillslopes causing them to be open habitat
3. Minimize hillslope erosion
4. Shade and logs provide fish habitat where river is adjacent to hillslope
5. Source of soil organic matter, an important base of the river food chain
6. Shade and logs provide fish habitat wherever river is as it migrates across the floodplain
7. Genetic benefit to upland species that can use habitat continuity to infrequently cross floodplain
8. Sponge effect for hydrologic flows, minimizing downstream flooding
9. Friction effect minimizing downstream sedimentation
10. Protect high habitat diversity and species richness of floodplain
11. Conduit for semiaquatic and other organisms dependent on river channel resources

matrix
edge portion of corridor in upland
interior portion of corridor in upland
hillslope
floodplain
meander band
interior of patch of natural floodplain vegetation
edge of patch of natural floodplain vegetation
other ecologically-compatible land use

fundamental dynamic processes (Malanson 1993).

As previously discussed, restoration of an ecologically effective stream corridor requires consideration of uplands adjacent to the channel and floodplain. Hillslopes might be a source area for water maintaining floodplain wetlands, a sediment source for channels on bedrock, and the principal source of organic debris in high-gradient streams.

Despite these considerations, stream corridors are often wrongly viewed as consisting of only the channel and an adjacent vegetative buffer. The width of the buffer is determined by specific objectives such as control of agricultural runoff or habitat requirements of particular animal species. This narrow definition obviously does not fully accommodate the extent of the functions of a stream corridor; but where the corridor is limited by immovable resource uses, it often becomes a part of a restoration strategy.

Cognitive Approach: The Reference Stream Corridor

Ideal stream corridor widths, as previously defined, are not always achievable in the restoration design. A local reference stream corridor might provide dimensions for designing the restoration.

Examination of landscape patterns is beneficial in identifying a reference stream corridor. The reference should provide information about gap width, landform, species requirements, vegetative structure, and boundary characteristics of the stream corridor (Figure 8.5).

Restoration objectives determine the desired levels of functions specified by the restoration design. If a nearby stream corridor in a similar landscape setting and with similar land use variables provides these functions adequately, it can be used to indicate the connectivity and

Figure 8.5: A maple in a New Mexico floodplain. *A rare occurrence of a remnant population may reflect desired conditions in a reference stream corridor.*

width attributes that should be part of the design.

Analytical Approach: Functional Requirements of a Target Species

The restoration plan objectives can be used to determine dimensions for the stream corridor restoration. If, for example, a particular species requires that the corridor offer interior habitat, the corridor width is sized to provide the necessary habitat. The requirements of the most sensitive species typically are used for optimum corridor dimensions. When these dimensions extend beyond the land base available for restoration, management of adjacent land uses becomes a tool for making the corridor effectively wider than the project parameters.

Optimum corridor dimensions can be achieved through collaboration with individuals and organizations who have management authority over adjacent lands. Dimensions include width of edge effect associated with boundaries of the corridor and pattern variations within the corridor, maximum acceptable width of gaps within the corridor, and maximum number of gaps per unit length of corridor.

Designing for Drainage and Topography

The stream corridor is dependent on interactions with the stream to sustain its character and functions (see Chapter 2). Therefore, to the extent feasible, the restoration process should include blockage of artificial drainage systems, removal or setback of artificial levees, and restoration of natural patterns of floodplain topography, unless these actions conflict with other social or environmental objectives (e.g., flooding or habitat).

Restoration of microrelief is particularly important where natural flooding has been reduced or curtailed because a topographically complex floodplain supports a mosaic of plant communities and ecosystem functions as a result of differential ponding of rainfall and interception of ground water. Microrelief restoration can be accomplished by selective excavation of historic features within the floodplain such as natural wetlands, levees, oxbows, and abandoned channels. Aerial photography and remotely sensed data, as well as observations in reference corridors, provide an indication of the distribution and dimensions of typical floodplain microrelief features.

8B Soil Properties

Stream corridor functions depend not only on the connectivity and dimensions of the stream corridor, but also on its soils and associated vegetation. The variable nature of soils across and along stream corridors results in diverse plant communities (**Figure 8.6**). When designing stream corridor restoration measures, it is important to carefully analyze the soils and their related potentials and limitations to support diverse native plant and animal communities, as well as for restoration involving channel reconstruction.

Where native floodplain soils remain in place, county soil surveys should be used to determine basic site conditions and fertility and to verify that the proposed plant species to be restored are appropriate. Most sites with fine-textured alluvium will not require supplemental fertilization, or fertilizers might be required only for initial establishment. In these cases excessive fertil-

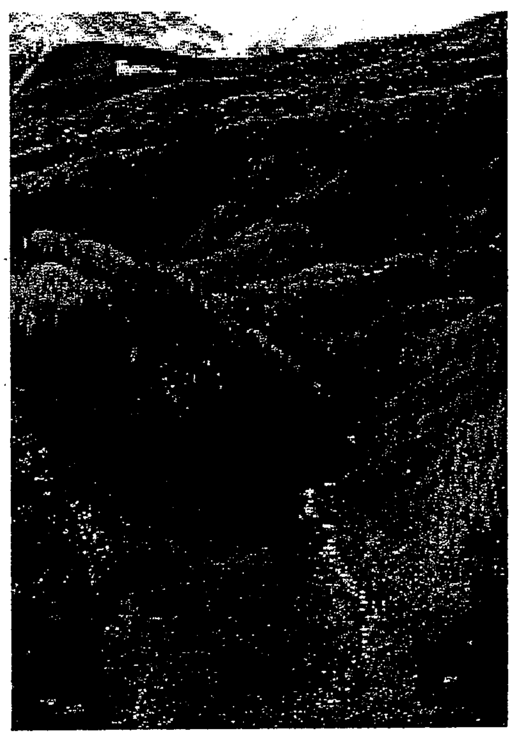


Figure 8.6: Distinct vegetation zones along a mountain stream. *Variable soils result in diverse plant communities.*

ization could encourage competing weed species or exotics. Soil should always be tested before making any fertilizer design recommendations.

County soil surveys can provide basic information such as engineering limitations or suitabilities. Site-specific soil samples should, however, be collected and tested when the restoration involves alternatives that include stream reconstruction.

The connections and feedback loops between runoff and the structure and functions of streams are described in Chapter 2. The functions of soil and the connection between soil quality, runoff, and water quality are also established in that chapter. These connections need to be identified and considered in any stream corridor restoration plan and design. For all land uses, emphasis needs to be placed on implementing conservation land treatment that promotes soil quality and the ability of the soils to carry out four major functions:

- Regulating and partitioning the flow of water (a conduit and filter function).
- Storing and cycling nutrients and other chemicals (a sink and filter function).
- Filtering, buffering, degrading, immobilizing, and detoxifying organic and inorganic materials (a filter, sink, and barrier function).
- Supporting biological activity in the landscape (a source and habitat function).

References such as *Field Office Technical Guide* (USDA-NRCS) contain guidance on the planning and selection of conservation practices and are available at most county offices.

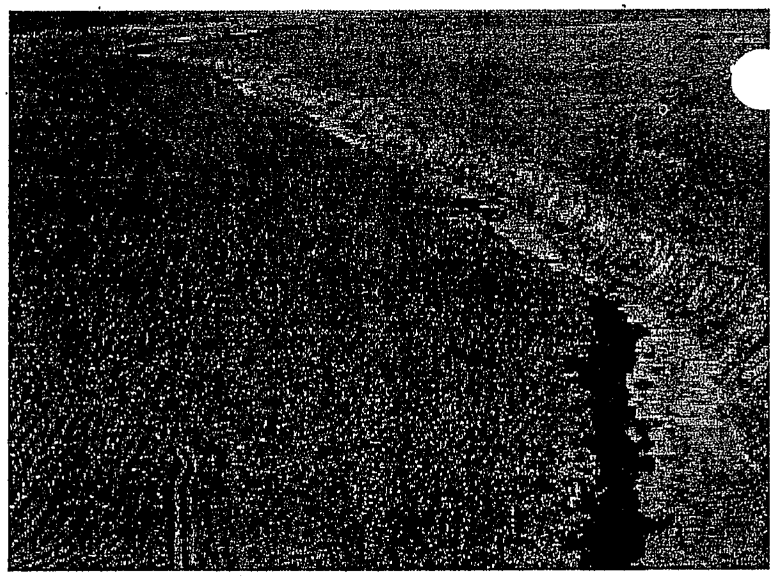


Figure 8.7: Compaction of streamside soil. *Compact soils may require deep plowing, ripping, or vegetative practices to break up the impermeable layer.*

Compaction

Soils that have been in row crops or have undergone heavy equipment traffic (such as that associated with construction) can develop a relatively impermeable compacted layer (plow pan or hard pan) that restricts water movement and root penetration (**Figure 8.7**). Such soils might require deep plowing, ripping, or vegetative practices to break up the pan, although even these are sometimes ineffective. Deep plowing is usually expensive and, at least in the East, should be used only if the planting of a species that is able to penetrate the pan layer is not a viable option.

Soil Microfauna

On new or disturbed substrates, or on row-cropped sites, essential soil microorganisms (particularly mycorrhizal fungi) might not exist. These are most effectively replaced by using rooted plant material that is inoculated or naturally infected with appropriate fungi. Stockpiling and reincorporating local topsoils into the substrate prior to planting is also effective (Allen 1995). Particular care should be taken to avoid disturbing large trees or stumps since the soils around and under them are likely source areas for reestablishment of a wide variety of microorganisms. Inoculation can be useful in restoring some soil mycorrhizal fungi for particular species when naturally infected plant stock is unavailable.

Soil Salinity

Soil salinity is another important consideration in restoration because salt accumulation in the soil can restrict plant growth and the establishment of riparian species. High soil salinity is not common in healthy riparian ecosystems where annual spring floods remove excess salts. Soil salinity can also be altered by leaching salts through the soil profile with irrigation (Anderson et al. 1984). Because of agricultural drainage and altered flows due to dam construction, salt accumulation often contributes to riparian plant community declines.

Soil sampling throughout a restoration site may be necessary since salinity can vary across a floodplain, even on sites of less than 20 acres. If salinity is a problem, one must select plant materials adapted to a saline soil environment.

8C Plant Communities

Vegetation is a fundamental controlling factor in stream corridor function. Habitat, conduit, filter/barrier, source, and sink functions are all critically tied to the vegetative biomass amount, quality, and condition (**Figure 8.8**). Restoration designs should protect existing native vegetation and restore vegetative structure to result in a contiguous and connected stream corridor.

Restoration goals can be general (e.g., returning an area to a reference condition) or specific (e.g., restoring habitats for particular species of interest such as the least Bell's vireo, Vireo *bellii* [Baird and Rieger 1988], or yellow-billed cuckoo, *Coccyzus americana* [Anderson and Laymon 1988]).

Numerous shrubs and trees have been evaluated as restoration candidates, including willows (Svejcar et al. 1992, Hoag 1992, Conroy and Svejcar 1991, Anderson et al. 1978); alder, serviceberry, oceanspray, and vine maple (Flessner et al. 1992); cottonwood and poplar (Hoag 1992); Sitka and thinleaf alder (Java and Everett 1992); palo verde and honey mesquite (Anderson et al. 1978); and many others. Selection of vegetative species may be based on the desire to provide habitat for a particular species of interest. The current trend in restoration, however, is to apply a multispecies or ecosystem approach.

Figure 8.8: Stream corridor vegetation. *Vegetation is a fundamental controlling factor in the functioning of stream corridors.*

Riparian Buffer Strips

Managers of riparian systems have long recognized the importance of buffer strips, for the following reasons (USACE 1991):

- Provide shade that reduces water temperature.
- Cause deposition of (i.e., filter) sediments and other contaminants.
- Reduce nutrient loads of streams.
- Stabilize streambanks with vegetation.
- Reduce erosion caused by uncontrolled runoff.
- Provide riparian wildlife habitat.
- Protect fish habitat.
- Maintain aquatic food webs.
- Provide a visually appealing greenbelt.
- Provide recreational opportunities.

Although the value of buffer strips is well recognized, criteria for their sizing are variable. In urban stream corridors a wide forest buffer is an essential component of any protection strategy. Its primary value is to provide physical protection for the stream channel from future disturbance or encroachment. A network of buffers acts as the right-of-way for a stream and functions as an integral part of the stream ecosystem.

Often economic and legal considerations have taken precedence over ecological factors. For Vermont, USACE (1991) suggests that narrow strips (100 ft. wide) may be adequate to provide many of the functions listed above. For breeding bird populations on Iowa streams, Stauffer and Best (1980) found that minimum strip widths varied from 40 ft. for cardinals to 700 ft. for scarlet tanagers, American redstarts, and rufous-sided towhees.

In urban settings buffer sizing criteria may be based on existing site controls as well as economic, legal, and ecological factors. Practical performance criteria for sizing and managing urban buffers are presented in the box Designing Urban Stream Buffers. Clearly, no single recommendation would be suitable for all cases.

Because floodplain/riparian habitats are often small in area when compared to surrounding uplands, meeting the minimum area needs of a species, guild, or community is especially important. Minimum area is the amount of habitat required to support the expected or appropriate use and can vary greatly across species and seasons. For example, Skagen (USGS, Biological Resources Division, Ft. Collins, Colorado; unpubl. data) found that, contrary to what might be considered conventional wisdom, extensive stream corridors in southeastern Arizona were not more important to migrating birds than isolated patches or oases of habitat. In fact, oases that were <2.5 miles long and <30 ft. in width had more species and higher numbers of nonbreeding migrants than did corridors. Skagen found that the use of oases, as well as corridors, is consistent with the observed patterns of long distance migrants, where migration occurs along broad fronts rather than north-south corridors. Because small and/or isolated patches of habitat can be so important to migrants, riparian restoration efforts should not overlook the important opportunities they afford.

Existing Vegetation

Existing native vegetation should be retained to the extent feasible, as should woody debris and stumps (**Figure 8.9**). In addition to providing habitat and erosion and sediment control, these features provide seed sources and harbor a

Designing Urban Stream Buffers

The ability of an urban stream buffer to realize its many benefits depends to a large degree on how well it is planned, designed, and maintained. Ten practical performance criteria are offered to govern how a buffer is to be sized, managed, and crossed. The key criteria include:

Criteria 1: Minimum total buffer width.

Most local buffer criteria require that development be set back a fixed and uniform distance from the stream channel. Nationally, urban stream buffers range from 20 to 200 ft. in width from each side of the stream according to a survey of 36 local buffer programs, with a median of 100 ft. (Schueler 1995). In general, a minimum base width of at least 100 feet is recommended to provide adequate stream protection.

Criteria 2: Three-zone buffer system.

Effective urban stream buffers have three lateral zones—stream side, middle core, and outer zone. Each zone performs a different function, and has a different width, vegetative target and management scheme. The ***stream side zone*** *protects the physical and ecological integrity of the stream ecosystem. The vegetative target is mature riparian forest that can provide shade, leaf litter, woody debris, and erosion protection to the stream. The* ***middle zone*** *extends from the outward boundary of the stream side zone, and varies in width, depending on stream order, the extent of the 100-yr floodplain, adjacent steep slopes, and protected wetland areas. Its key functions are to provide further distance between upland development and the stream. The vegetative target for this zone is also mature forest, but some clearing may be allowed for storm water management, access, and recreational uses.*

The ***outer zone*** *is the buffer's "buffer," an additional 25-ft. setback from the outward edge of the middle zone to the nearest permanent structure. In most instances, it is a residential backyard. The vegetative target for the outer zone is usually turf or lawn, although the property owner is encouraged to plant trees and shrubs, and thus increase the total width of the buffer. Very few uses are restricted in this zone. Indeed, gardening, compost piles, yard wastes, and other common residential activities often will occur in the outer zone.*

Criteria 3: Predevelopment vegetative target.

The ultimate vegetative target for urban stream buffers should be specified as the predevelopment riparian plant community—usually mature forest. Notable exceptions include prairie streams of the Midwest, or arroyos of the arid West, that may have a grass or shrub cover in the riparian zone. In general, the vegetative target should be based on the natural vegetative community present in the floodplain, as determined from reference riparian zones. Turfgrass is allowed for the outer zone of the buffer.

Criteria 4: Buffer expansion and contraction.

Many communities require that the minimum width of the buffer be expanded under certain conditions. Specifically, the average width of the middle zone can be expanded to include:

- *the full extent of the 100-yr floodplain;*
- *all undevelopable steep slopes (greater than 25%);*
- *steep slopes (5 to 25% slope, at four additional ft. of slope per one percent increment of slope above 5%); or*
- *any adjacent delineated wetlands or critical habitats.*

Criteria 5: Buffer delineation.

Three key decisions must be made when delineating the boundaries of a buffer. At what mapping scale will streams be defined? Where does the stream begin and the buffer end? And from what point should the inner edge of the buffer be measured? Clear and workable delineation criteria should be developed.

Criteria 6: Buffer crossings.

Major objectives for stream buffers are to maintain an unbroken corridor of riparian forest and to allow for upstream and downstream fish passage in the stream network. From a practical standpoint, however, it is not always possible to try to meet these goals everywhere along the stream buffer network. Some provision must be made for linear forms of development that must cross the stream or the buffer, such as roads, bridges, fairways, underground utilities, enclosed storm drains or outfall channels.

Criteria 7: Storm water runoff.

Buffers can be an important component of the storm water treatment system at a development site. They cannot, however, treat all the storm water runoff generated within a watershed (generally, a buffer system can only treat runoff from less than 10% of the contributing watershed to the stream). Therefore, some kind of structural BMP must be installed to treat the quantity and quality of storm water runoff from the remaining 90% of the watershed.

Criteria 8: Buffers during plan review and construction.

The limits and uses of the stream buffer systems should be well defined during each stage of the development process—from initial plan review, through construction.

Criteria 9: Buffer education and enforcement.

The future integrity of a buffer system requires a strong education and enforcement program. Thus, it is important to make the buffer "visible" to the community, and to encourage greater buffer awareness and stewardship among adjacent residents. Several simple steps can be taken to accomplish this.

- Mark the buffer boundaries with permanent signs that describe allowable uses
- Educate buffer owners about the benefits and uses of the buffer with pamphlets, stream walks, and meetings with homeowners associations
- Ensure that new owners are fully informed about buffer limits/uses when property is sold or transferred
- Engage residents in a buffer stewardship program that includes reforestation and backyard "bufferscaping" programs
- Conduct annual buffer walks to check on encroachment

Criteria 10: Buffer flexibility.

In most regions of the country, a hundred-foot buffer will take about 5% of the total land area in any given watershed out of use or production. While this constitutes a relatively modest land reserve at the watershed scale, it can be a significant hardship for a landowner whose property is adjacent to a stream. Many communities are legitimately concerned that stream buffer requirements could represent an uncompensated "taking" of private property. These concerns can be eliminated if a community incorporates several simple measures to ensure fairness and flexibility when administering its buffer program. As a general rule, the intent of the buffer program is to modify the location of development in relation to the stream but not its overall intensity. Some flexible measures in the buffer ordinance include:

- Maintaining buffers in private ownership
- Buffer averaging
- Density compensation
- Variances
- Conservation easements

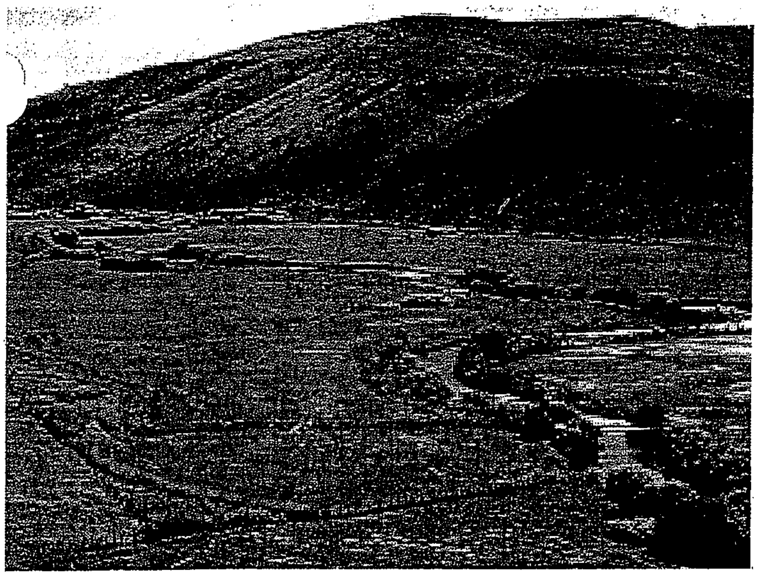


Figure 8.9: Remnant vegetation and woody debris along a stream. *Attempts should be made to preserve existing vegetation within the stream corridor.*

variety of microorganisms, as described above. Old fencerows, vegetated stumps and rock piles in fields, and isolated shade trees in pastures should be retained through restoration design, as long as the dominant plant species are native or are unlikely to be competitors in a matrix of native vegetation (e.g., fruit trees).

Nonnative vegetation can prevent establishment of desirable native species or become an unwanted permanent component of stream corridor vegetation. For example, kudzu will kill vegetation. Generally, forest species planted on agricultural land will eventually shade out pasture grasses and weeds, although some initial control (disking, mowing, burning) might be required to ensure tree establishment.

Plant Community Restoration

An objective of stream corridor restoration work might be to restore natural patterns of plant community distribution within the stream corridor. Numerous publications describe general distribution patterns for various geomorphic settings and flow conditions (e.g., Brinson et al. 1981, Wharton et al. 1982), and county soil surveys generally describe native vegetation for particular soils. More detailed and site-specific plant community descriptions may be available from state Natural Heritage programs, chapters of The Nature Conservancy, or other natural resources agencies and organizations.

Examination of the reference stream corridor, however, is often the best way to develop information on plant community composition and distribution. Once reference plant communities are defined, design can begin to detail the measures required to restore those communities (**Figure 8.10**). Rarely is it feasible or desirable to attempt to plant the full complement of appropriate species on a particular site. Rather, the more typical approach is to plant the dominant species or those species unlikely to colonize the site readily. For example, in the complex bottom-

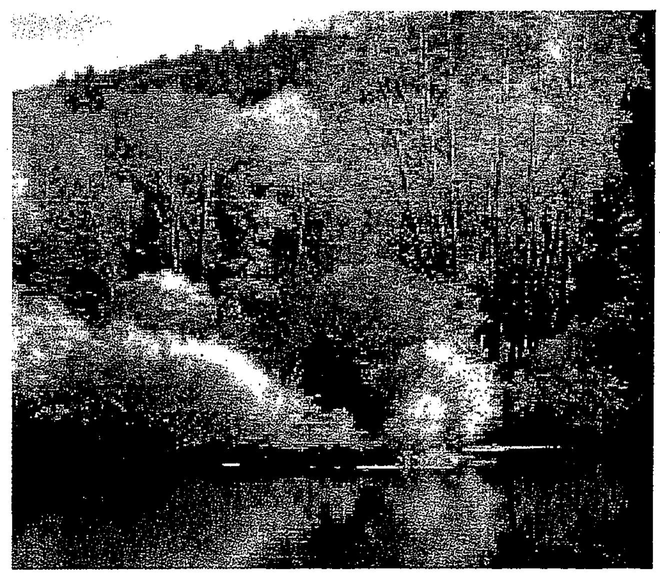


Figure 8.10: A thriving and diverse plant community within a stream corridor. *Examination of reference plant communities is often the best way to develop information on the composition and distribution of plant communities at the restoration site.*

land hardwood forests of the Southeast, the usual focus is on planting oaks. Oaks are heavy-seeded, are often shade-intolerant, and may not be able to readily invade large areas for generations unless they are introduced in the initial planting plan, particularly if flooding has been reduced or curtailed. It is assumed that lighter-seeded and shade-tolerant species will invade the site at rates sufficient to ensure that the resulting forest is adequately diverse. This process can be accelerated by planting corridors of fast-growing species (e.g., cottonwoods) across the restoration area to promote seed dispersal.

In areas typically dominated by cottonwoods and willows, the emphasis might be to emulate natural patterns of colonization by planting groves of particular species rather than mixed stands, and by staggering the planting program over a period of years to ensure structural variation. Where conifers tend to eventually succeed riparian hardwoods, some restoration designs may include scattered conifer plantings among blocks of pioneer species, to accelerate the transition to a conifer-dominated system.

Large-scale restoration work sometimes includes planting of understory species, particularly if they are required to meet specific objectives such as providing essential components of endangered species habitat. However, it is often difficult to establish understory species, which are typically not tolerant to full sun, if the restoration area is open. Where particular understory species are unlikely to establish themselves for many years, they can be introduced in adjacent forested sites, or planted after the initial tree plantings have matured sufficiently to create appropriate understory conditions. This may also be an appropriate approach for introducing certain overstory species that might not survive planting in full sun (**Figure 8.11**).

Figure 8.11: Restoration of understory plant species. *Understory species can be introduced at the restoration site after the initial tree plantings have matured sufficiently.*

The concept of focusing restoration actions on a limited group of overstory species to the exclusion of understory and other overstory species has been criticized. The rationale for favoring species such as oaks has been to ensure that restored riparian and floodplain areas do not become dominated by opportunistic species, and that wildlife functions and timber values associated with certain species will be present as soon as possible. It has been documented that heavy-seeded species such as oaks may be slow to invade a site unless planted (see Tennessee Valley Authority Floodplain Reforestation Projects—50 Years Later), but differential colonization rates probably exclude a variety of other species as well. Certainly, it would be desirable to introduce as wide a variety of appropriate species as possible; however, costs and the difficulties of doing supplemental plantings over a period of years might preclude this approach in most instances.

Low Water Availability

In areas where water levels are low, artificial plantings will not survive if their roots cannot reach the zone of saturation. Low water availability was associated with low survival rates in more than 80 percent of unsuccessful revegetation work examined in Arizona (Briggs 1992). Planting long poles (20 ft.) of Fremont cottonwood (Populus fremontii) and Gooding willow in augered holes has been successful where the ground water is more than 10 ft. below the surface (Swenson and Mullins 1985). In combination with an irrigation system, many planted trees are able to reach ground water 10 ft. below the surface when irrigated for two seasons after planting (Carothers et al. 1990). Sites closest to ground water, such as secondary channels, depressions, and low sites where water collects, are the best candidates for planting, although low-elevation sites are more prone to flooding and flood damage to the plantings. Additionally, the roots of many riparian species may become dormant or begin to die if inundated for extended periods of time (Burrows and Carr 1969).

Plant species should be distributed within a restoration site with close attention to microsite conditions. In addition, if stream meandering behavior or scouring flows have been curtailed, special effort is required to maintain communities that normally depend on such behavior for natural establishment. These may include oxbow and swale communities (bald cypress, shrub wetlands, emergent wetlands), as well as communities characteristic of newly deposited soils (cottonwoods, willows, alders, silver maple, etc.). It is important to recognize that planting vegetation on sites where regeneration mechanisms no longer operate is a temporary measure, and long-term management and periodic replanting is required to maintain those functions of the ecosystem.

In the past, stream corridor planting programs often included nonnative species selected for their rapid growth rates, soil binding characteristics, ability to produce abundant fruits for wildlife, or other perceived advantages over native species. These actions sometimes have unintended consequences and often prove to be extremely detrimental (Olson and Knopf 1986). As a result, many local, county, state, and federal agencies discourage or prohibit planting of nonnative species within wetlands or streamside buffers. Stream corridor restoration designs should emphasize native plant species from local sources. It may be feasible in some cases to focus restoration actions on encouraging the success of local seedfall to ensure that locally adapted populations of stream corridor vegetation are maintained on the site (Friedmann et al. 1995).

Plant establishment techniques vary greatly depending on site conditions and species characteristics. In arid regions, the emphasis has been on using poles or cuttings of species that sprout readily, and planting them to depths that will ensure contact with moist soil during the dry season (**Figure 8.12**). Where water tables have declined precipitously, deep auguring and temporary irrigation are used to establish cuttings and rooted or container-grown plants. In environments where precipitation or ground water is adequate to sustain planted vegetation, prolonged irrigation is less common, and bare-root or container-grown plants are often used, particularly for species that do not sprout reliably from cuttings. On large floodplains of the South and East, direct seeding of acorns and planting of dormant bare-root material have been highly successful. Other options, such as transplanting of salvaged plants, have been tried with varying degrees of success. Local experience should be sought to determine the most reliable and efficient plant establishment approaches for particular areas and species, and to determine what problems to expect.

It is important to protect plantings from livestock, beaver, deer, small mammals, and insects during the establishment period. Mortality of vegetation from deer browsing is common and can be prevented by using tree shelters to protect seedlings.

Figure 8.12: Revegetation with the use of deeply planted live cuttings. *In arid regions, poles or cuttings of species that sprout readily are often planted to depths that assure contact with moist soil.*

Horizontal Diversity

Stream corridor vegetation, as viewed from the air, would appear as a mosaic of diverse plant communities that runs from the upland on one side of the stream corridor, down the valley slope, across the floodplain, and up the opposite slope to the upland. With such broad dimensional range, there is a large potential for variation in vegetation. Some of the variation is a result of hydrology and stream dynamics, which will be discussed later in this chapter. Three important structural characteristics of horizontal diversity of vegetation are connectivity, gaps, and boundaries.

Stream corridor restoration designs should emphasize native plant species from local sources.

Connectivity and Gaps

As discussed earlier, connectivity is an important evaluation parameter of stream corridor functions, facilitating the processes of habitat, conduit, and filter/barrier. Stream corridor restoration design should maximize connections between ecosystem functions. Habitat and conduit functions can be enhanced by linking critical ecosystems to stream corridors through design that emphasizes orientation and proximity. Designers should consider functional connections to existing or potential features such as vacant or abandoned land, rare habitat, wetlands or meadows, diverse or unique vegetative communities, springs, ecologically innovative residential areas, movement corridors for flora and fauna, or associated stream systems. This allows for movement of materials and energy, thus increasing conduit functions and effectively increasing habitat through geographic proximity.

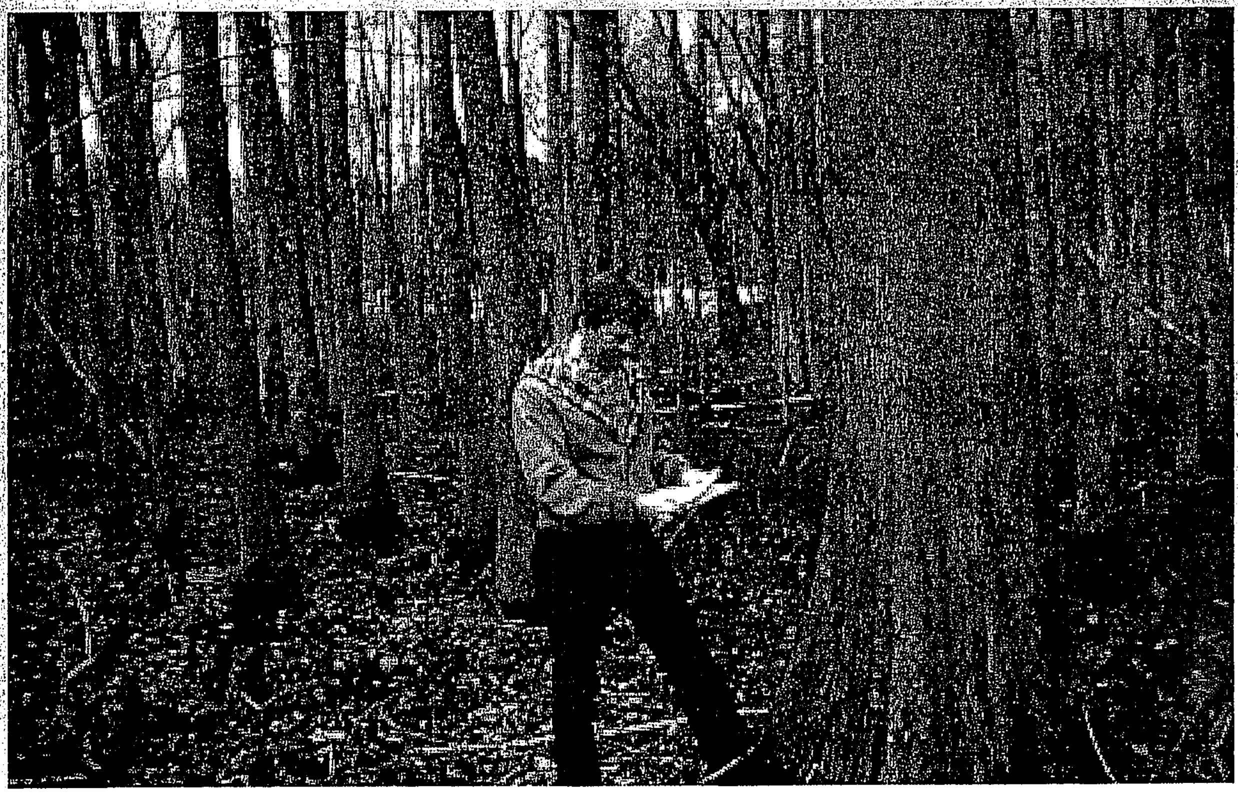
Generally, a long, wide stream corridor with contiguous vegetative cover is favored, though gaps are commonplace. The most fragile ecological functions determine the acceptable number and size of gaps. Wide gaps can be barriers to mi-

Tennessee Valley Authority Floodplain Reforestation Projects—50 Years Later

*The oldest known large-scale restoration of forested wetlands in the United States was undertaken by the Tennessee Valley Authority in conjunction with reservoir construction projects in the South during the 1940s. Roads and railways were relocated outside the influence of maximum pool elevations, but where they were placed on embankments, TVA was concerned that they would be subject to wave erosion during periods of extreme high water. To reduce that possibility, agricultural fields between the reservoir and the embankments were planted with trees (**Figure 8.13**). At Kentucky Reservoir in Kentucky and Tennessee, approximately 1,000 acres were planted, mostly on hydric soils adjacent to tributaries of the Tennessee River. Detailed records were kept regarding the species planted and survival rates. Some of these stands were recently located and studied to evaluate the effectiveness of the original reforestation effort, and to determine the extent to which the planted forests have come to resemble natural stands in the area.*

Because the purpose of the plantings was erosion control, little thought was given to recreating natural patterns of plant community composition and structure. Trees were evenly spaced in rows, and planted species were apparently chosen for maximum flood tolerance. As a result, the studied stands had an initial composition dominated by bald cypress, green ash, red maple, and similarly

Figure 8.13: Kentucky Reservoir watershed, 1943. *Planting abandoned farmland with trees.*



water-tolerant species, but they did not originally contain many of the other common bottomland forest species, such as oaks.

Shear et al. (in press) compared the plant communities of the planted stands with forests on similar sites that had been established by natural invasion of abandoned fields. They also looked at older stands that had never been converted to agriculture. The younger planted and natural stands were similar to the older stands with regard to understory composition, and measures of stand density and biomass were consistent with patterns typical for the age of the stands. Overstory composition of the planted stands was very different from that of the others, reflecting the original plantings. However, both the planted sites and the fields that had been naturally invaded had few individuals of heavy-seeded species (oaks and hickories), which made up 37 percent of the basal area of the older stands.

Figure 8.14: Kentucky Reservoir watershed in 1991. *Thriving bottomland hardwood forest.*

Oaks are an important component of southern bottomlands and are regarded as particularly important to wildlife. In most modern restoration plantings, oaks are favored on the assumption that they will not quickly invade agricultural fields. The stands at Kentucky Reservoir demonstrate that planted bottomland forests can develop structural and understory conditions that resemble those of natural stands within 50 years (**Figure 8.14**). Stands that were established by natural invasion of agricultural fields had similar characteristics. The major compositional deficiency in both of the younger stands was the lack of heavy-seeded species. The results of this study appear to support the practice of favoring heavy-seeded species in bottomland forest restoration initiatives.

gration of smaller terrestrial fauna and indigenous plant species. Aquatic fauna may also be limited by the frequency or dimension of gaps. The width and frequency of gaps should therefore be designed in response to planned stream corridor functions. Bridges have been designed to allow migration of animals, along with physical and chemical connections of river and wetland flow. In Florida, for example, underpasses are constructed beneath roadways to serve as conduits for species movement (Smith and Hellmund 1993). The Netherlands has experimented with extensive species overpasses and underpasses to benefit particular species (**Figure 8.15**). Although not typically equal to the magnitude of an undisturbed stream corridor lacking gaps, these measures allow for modest functions as habitat and conduit.

estored plant ommunities hould be de- igned to ex- ibit structural iversity and anopy closure imilar to that f the refer- nce stream orridor.

The filtering capacity of stream corridors is affected by connectivity and gaps. For example, nutrient and water discharge flowing overland in sheet flow tends to concentrate and form rills. These rills in turn often form gullies. Gaps in vegetation offer no opportunity to slow overland flow or allow for infiltration. Where reference dimensions are similar and transferable, restored plant communities should be designed to exhibit structural diversity and canopy closure similar to that of the reference stream corridor. The reference stream corridor can provide information regarding plant species and their frequency and distribution. Design should aim to maintain the filtering capacity of the stream corridor by minimizing gaps in the corridor's width and length.

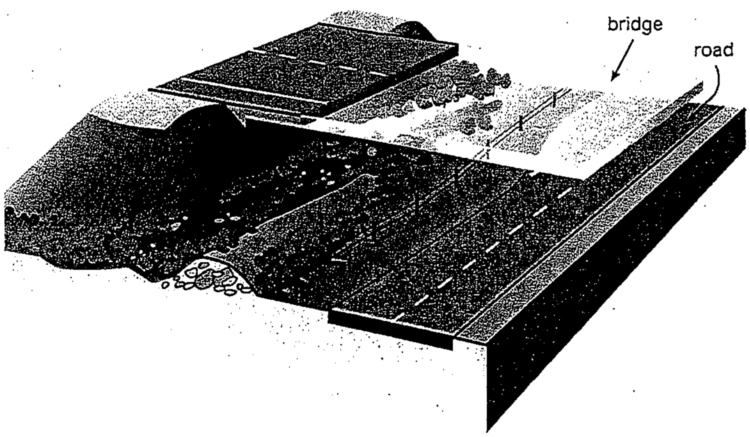


Figure 8.15: Underpass design. Underpasses should be designed to accommodate both vehicular traffic and movement of small fauna.

Buffer configuration and composition have also received attention since they influence wildlife habitat quality, including suitability as migration corridors for various species and suitability for nesting habitat. Reestablishment of linkages among elements of the landscape can be critically important for many species (Noss 1983, Harris 1984). However, as noted previously, fundamental considerations include whether a particular vegetation type has ever existed as a contiguous corridor in an area, and whether the predisturbance corridor was narrow or part of an expansive floodplain forest system. Establishment of inappropriate and narrow corridors can have a net detrimental influence at local and regional scales (Knopf et al. 1988). Local wildlife management priorities should be evaluated in developing buffer width criteria that address these issues.

Boundaries

The structure of the edge vegetation between a stream corridor and the adjacent landscape affects the habitat, conduit, and filter functions. A transition between two ecosystems in an undisturbed environment typically occurs across a broad area.

Boundaries between stream corridors and adjacent landscapes may be straight or curvilinear. A straight boundary allows relatively unimpeded movement along the edge, thereby decreasing species interaction between the two ecosystems. Conversely, a curvilinear boundary with lobes of the corridor and adjoining areas reaching into one another encourages movement across boundaries, resulting in increased interaction. The shape of the boundary can be designed to integrate or discourage these interactions, thus affecting the habitat, conduit, and filter functions.

Species interaction may or may not be desirable depending on the project goals. The boundary of the restoration initiative can, for example, be designed to capture seeds or to integrate animals, including those carrying seeds. In some cases, however, this interaction is dictated by the functional requirements of the adjacent ecosystem (equipment tolerances within an agricultural field, for instance).

Vertical Diversity

Heterogeneity within the stream corridor is an important design consideration. The plants that make up the stream corridor, their form (herbs, shrubs, small trees, large trees), and their diversity affect function, especially at the reach and site scales. Stratification of vegetation affects wind, shading, avian diversity, and plant growth (Forman 1995). Typically, vegetation at the edge of the stream corridor is very different from the vegetation that occurs within the interior of the corridor. The topography, aspect, soil, and hydrology of the corridor provide several naturally diverse layers and types of vegetation.

The difference between edge and interior vegetative structure are important design considerations (**Figure 8.16**). An edge that gradually changes from the stream corridor into the adjacent ecosystems will soften environmental gradients and minimize any associated disturbances. These transitional zones encourage species diversity and buffer variable nutrient and energy flows. Although human intervention has made edges more abrupt, the conditions of naturally occurring edge vegetation can be restored through design. The plant community and landform of a restored edge should reflect the structural variations found in the reference stream corridor. To maintain a connected and contiguous vegetative cover at the edge of small gaps, taller vegetation should be designed to continue through the gap. If the gap is wider than can be breached by the tallest or widest vegetation, a more gradual edge may be appropriate.

Vertical structure of the corridor interior tends to be less diverse than that of the

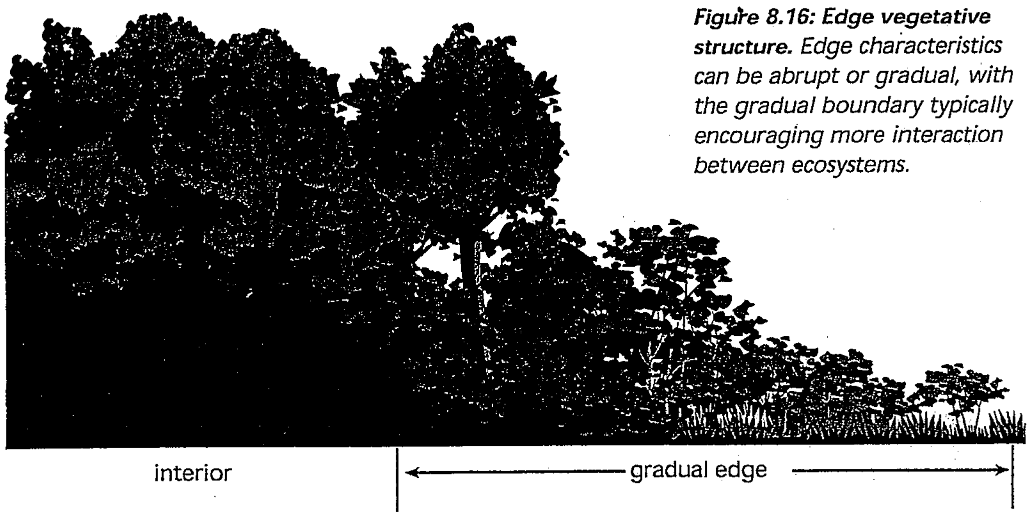


Figure 8.16: Edge vegetative structure. *Edge characteristics can be abrupt or gradual, with the gradual boundary typically encouraging more interaction between ecosystems.*

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edge. This is typically observed when entering a woodlot: edge vegetation is shrubby and difficult to traverse, whereas inner shaded conditions produce a more open forest floor that allows for easier movement. Snags and downed wood may also provide important habitat functions. When designing to restore interior conditions of stream corridor vegetation, a vegetation structure should be used that is less diverse than the vegetation structure used at the edge. The reference stream corridor will yield valuable information for this aspect of design.

Influence of Hydrology and Stream Dynamics

Natural floodplain plant communities derive their characteristic horizontal diversity primarily from the organizing influence of stream migration and flooding (Brinson et al. 1981). As discussed earlier, when designing restoration of stream corridor vegetation, nearby reference conditions are generally used as models to identify the appropriate plant species and communities. However, the original cover and older existing trees might have been established before stream regulation or other changes in the watershed that affect flow and sediment characteristics.

A good understanding of current and projected flooding is necessary for design of appropriately restored plant communities within the floodplain. Water management and planning agencies are often the best sources of such data. In wildland areas, stream gauge data may be available, or on-site interpretation of landforms and vegetation may be required to determine whether floodplain hydrology has been altered through channel incision, beaver activity, or other causes. Discussions with local residents and examination of aerial photography may also provide information on water diversions, ground water depletion, and similar changes in the local hydrology.

A vegetation-hydroperiod model can be used to forecast riparian vegetation distribution (Malanson 1993). The model identifies the inundating discharges of various locations in the riparian zone and the resulting suitability of moisture conditions for desired plants. Grading plans, for example, can be adjusted to alter the area inundated by a given discharge and thus increase the area suitable for vegetation associated with a particular frequency and duration of flooding. A focus on the vegetation-hydroperiod relationship will demonstrate the following:

- The importance of moisture conditions in structuring vegetation of the riparian zone;
- The existence of reasonably well accepted physical models for calculating inundation from streamflow and the geometry of the bottomland.
- The likelihood that streamflow and inundating discharges have been altered in degraded stream systems or will be modified as part of a restoration effort.

Generally, planting efforts will be easier when trying to restore vegetation on sites that have suitable moisture conditions for the desired vegetation, such as in replacing historical vegetation on cleared sites that have unaltered streamflow and inundating discharges. Moisture suitability calculations will support designs. Sometimes the restoration objective is to restore more of the desired vegetation than the new flow conditions would naturally support. Direct manipulation by planting and controlling competition can often produce the desired results within the physiological tolerances of the desired species. However, the vegetation on these sites will be out of balance with the site moisture conditions and might require continued maintenance. Management of vegetation can also accelerate succession to a more desirable state.

Projects that require long-term supplemental watering should be avoided due to high maintenance costs and decreased potential for success. Inversely, there may be cases where the absence of vegetation, especially woody vegetation, is desired near the stream channel. Alteration of streamflow or inundating discharges might make moisture conditions on these sites unsuitable for woody vegetation.

The general concept of site suitability for plant species can be extended from moisture conditions determined by inundation to other variables determining plant distribution. For example, Ohmart and Anderson (1986) suggests that restoration of native riparian vegetation in arid southwestern river systems may be limited by unsuitable soil salinities. In many arid situations, depth to ground water might be a more direct measure of the moisture effects of streamflow on riparian sites than actual inundation. Both inundating discharge and depth to ground water are strongly related to elevation. However, depth to ground water may be the more appropriate causal variable for these rarely inundated sites, and a physical model expressing the dependence of alluvial ground water levels on streamflow might therefore be more important than a hydraulic model of surface water elevations.

Some stream corridor plant species have different requirements at different life stages. For example, plants tolerating extended inundation as adults may require a drawdown for establishment, and plants thriving on relatively high and dry sites as adults may be established only on moist surfaces near the water's edge. This can complicate what constitutes suitable moisture conditions and may require separate consideration of establishment requirements, and perhaps consideration of how sites might change over time. The application of simulation models of plant dynamics based on solving sets of explicit rules for how plant composition will change over time may become necessary as increasingly complex details of different requirements at different plant life history stages are incorporated into the evaluation of site suitability. Examples of this type of more sophisticated plant response model include van der Valk (1981) for prairie marsh species and Pearlstine et al. (1985) for bottomland hardwood tree species.

Soil Bioengineering for Floodplains and Uplands

Soil bioengineering is the use of live and dead plant materials, in combination with natural and synthetic support materials, for slope stabilization, erosion reduction, and vegetative establishment.

There are many soil bioengineering systems, and selection of the appropriate system or systems is critical to successful restoration. Reference documents should be consulted to ensure that the principles of soil bioengineering are understood and applied. The NRCS Engineering Field Handbook, Part 650 [Chapter 16, Streambank and Shoreline Protection (USDA-NRCS 1996) and Chapter 18, Soil Bioengineering for Upland Slope Protection and Erosion Reduction (USDA-NRCS 1992)] offers background and guidelines for application of this technology. A more detailed description of soil bioengineering systems is offered in Section 8.F, Streambank Stabilization Design, of this chapter and in Appendix A.

FAST FORWARD

Preview Chapter 8, Section F for more information on soil bioengineering techniques.

Other measures may be used to provide structure and functions. They may be implemented as separate actions or as an integral part of the restoration plan to improve habitat, in general, or for specific species. Such measures can provide short-term habitat until overall restoration results reach the level of maturity needed to provide the desired habitat. These measures can also provide habitat that is in short supply. Greentree reservoirs, nest structures, and food patches are three examples. Beaver are also presented as a restoration measure.

Greentree Reservoirs

Short-term flooding of bottomland hardwoods during the dormant period of tree growth enhances conditions for some species (e.g., waterfowl) to feed on mast and other understory food plants, like wild millet and smartweed. Acorns are a primary food source in stream corridors for a variety of fauna, including ducks, nongame birds and mammals, turkey, squirrel, and deer. Greentree reservoirs are shallow, forested floodplain impoundments usually created by building low levees and installing outlet structures (Figure 8.17). They are usually flooded in early fall and drained during late March to mid-April. Draining prevents damage to overstory hardwoods (Rudolph and Hunter 1964). Most existing greentree reservoirs are in the Southwest.

The flooding of greentree reservoirs, by design, differs from the natural flood regime. Greentree reservoirs are typically flooded earlier and at depths greater than would normally occur under natural conditions. Over time, modifications of natural flood conditions can result in vegetation changes, lack of regeneration, decreased mast production, tree mortality, and disease. Proper management of green tree reservoirs requires knowledge of the local system—especially the natural flood regime—and the integration of management goals that are consistent with system requirements. Proper management of greentree reservoirs can provide

Figure 8.17: Bottomland hardwoods serving as a greentree reservoir. Proper management of greentree reservoirs requires knowledge of the local system.

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quality habitat on an annual basis, but the management plan must be well designed from construction through management for waterfowl.

Nest Structures

Loss of riparian or terrestrial habitat in stream corridors has resulted in the decline of many species of birds and mammals that use associated trees and tree cavities for nesting or roosting. The most important limiting factor for cavity-nesting birds is usually the availability of nesting substrate (von Haartman 1957), generally in the form of snags or dead limbs in live trees (Sedgwick and Knopf 1986). Snags for nest structures can be created using explosives, girdling, or topping of trees. Artificial nest structures can compensate for a lack of natural sites in otherwise suitable habitat since many species of birds will readily use nest boxes or other artificial structures. For example, along the Mississippi River in Illinois and Wisconsin, where nest trees have become scarce, artificial nest structures have been erected and constructed for double-crested cormorants using utility poles (Yoakum et al. 1980). In many cases, increases in breeding bird density have resulted from providing such structures (Strange et al. 1971, Brush 1983). Artificial nest structures can also improve nestling survival (Cowan 1959).

Nest structures must be properly designed and placed, meeting the biological needs of the target species. They should also be durable, predator-proof, and economical to build. Design specifications for nest boxes include hole diameter and shape, internal box volume, distance from the floor of the box to the opening, type of material used, whether an internal "ladder" is necessary, height of placement, and habitat type in which to place the box. Other types of nest structures include nest platforms for waterfowl and raptors; nest baskets for doves, owls, and waterfowl; floating nest structures for geese; and tire nests for squirrels. Specifications for nest structures for riparian and wetland nesting species (including numerous Picids, passerines, waterfowl, and raptors) can be found in many sources including Yoakum et al. (1980), Kalmbach et al. (1969), and various state wildlife agency and conservation publications.

Food Patches

Food patch planting is often expensive and not always predictable, but it can be carried out in wetlands or riparian systems mostly for the benefit of waterfowl. Environmental requirements of the food plants native to the area, proper time of year of introduction, management of water levels, and soil types must all be taken into consideration. Some of the more important food plants in wetlands include pondweed (Potamogeton spp.), smartweed (Polygonum spp.), duck potato, spike sedges (Carex spp.), duckweeds (Lemna spp.), coontail, alkali bulrush (Scirpus paludosus), and various grasses. Two commonly planted native species include wild rice (Zizania) and wild millet. Details on suggested techniques for planting these species can be found in Yoakum et al. (1980).

Importance of Beaver to Riparian Ecosystems

Beaver have long been recognized for their potential to influence riparian systems. In rangelands, where loss of riparian functional value has been most dramatic, the potential role of beaver in restoring degraded streams is least understood.

*Beaver dams on headwater streams can positively influence riparian function in many ways, as summarized by Olson and Hubert (1994) (**Figure 8.18**). They improve water quality by trapping sediments behind dams and by reducing stream velocity, thereby reducing bank erosion (Parker 1986). Beaver ponds can alter water chemistry by changing adsorption rates for nitrogen and phosphorus (Maret 1985) and by trapping coliform bacteria (Skinner et al. 1984). The flow regime within a watershed can also be influenced by beaver. Beaver ponds create a sponge-like effect by increasing the area where soil and water meet (**Figure 8.19**). Headwaters retain more water from spring runoff and major storm events, which is released more slowly, resulting in a higher water table and extended summer flows. This increase in water availability, both surface and subsurface, usually increases the width of the riparian zone and, consequently, favors wildlife communities that depend on that vegetation. There can be negative impacts as well, including loss of spawning habitat, increase in water temperatures beyond optimal levels for some fish species, and loss of riparian habitat.*

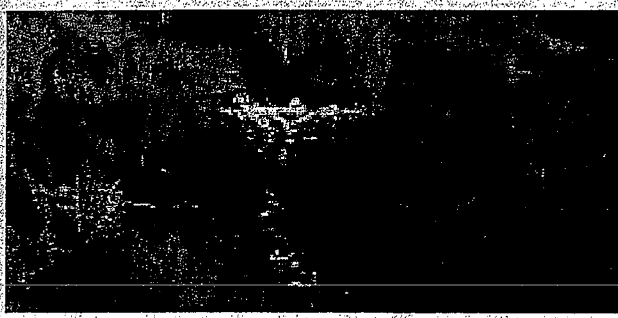

Figure 8.18: Beaver dam on a headwater stream. *Beavers have many positive impacts on headwater streams.*

Richness, diversity, and abundance of birds, herpetiles, and mammals can be increased by the activities of beaver (Baker et al. 1992; Medin and Clary 1990). Beaver ponds are important waterfowl production areas and can also be used during migration (Call 1970; Ringelman 1991). In some high-elevation areas of the Rocky Mountains, beaver are solely responsible for the majority of local duck production. In addition, species of high interest, such as trumpeter swans, sandhill cranes, moose, mink, and river otters, use beaver ponds for nesting or feeding areas (Collins 1976).

Transplanting Beaver to Restore Stream Functions

Beaver have been successfully transplanted into many watersheds throughout the United States during the past 50 years. This practice was very common during the 1950s after biologists realized the loss of ecological function resulting from overtrapping of beaver by fur traders before the turn of the century. Reintroduction of beaver has restored the U.S. beaver population to 6-12 million, compared to a pre-European level of 60-400 million (Naiman et al. 1986). Much unoccupied habitat or potential habitat still remains, especially in the shrub-steppe ecosystem.

*In forested areas, where good beaver habitat already exists, reintroduction techniques are well established. The first question asked should be "If the habitat is suitable, why are beaver absent?" In the case of newly restored habitat or areas far from existing populations, reintroduction without habitat improvement might be warranted (**Figure 8.20**). Beavers are livetrapped from areas that have excess populations or from areas where they are a nuisance. It is advisable to obtain beavers from habitat that is similar to where they will be introduced to ensure*

Figure 8.19: A beaver pond. *Beaver ponds create a sponge-like effect.*

Figure 8.20: Beaver habitat. It is advisable to obtain beaver from habitat that is similar to where they will be introduced.

they are familiar with available food and building materials (Smith and Prichard 1992). This is particularly important in shrub-steppe habitats.

Reintroduction into degraded riparian areas within the shrub-steppe zone is controversial. Conventional wisdom holds that a yearlong food supply must be present before introducing beaver. In colder climates, this means plants with edible bark, such as willow, cottonwood, or aspen, must be present to provide a winter food supply for beaver (**Figure 8.21**). But often these species are the goal of restoration. In some cases willows or other species can be successfully planted as described in other sections of this document. In other areas, conditions needed to sustain planted cuttings, such as a high water table and minimal competition with other vegetation, might preclude successful establishment. Transplanting beaver before willows are established may create the conditions needed to both establish and maintain riparian shrubs or trees. In these cases it may be helpful to provide beaver with a pickup truck load of aspen or other trees to use as building material at or near the reintroduction site. This may encourage beaver to stay near the site and strengthen dams built of sagebrush or other shrubs (Apple et al, 1985).

Nuisance Beaver

Unfortunately, beaver are not beneficial in all situations, which is all too obvious to those managing damage control. In many cases where they live in close proximity to humans or features important to humans, beaver need to be removed or their damage controlled. Common problems include cutting or eating desirable vegetation, flooding roads or irrigation ditches by plugging culverts, and increasing erosion by burrowing into the banks of streams or reservoirs. In addition, beaver carry Giardia species pathogens, which can infect drinking water supplies and cause human health problems.

Control of nuisance beaver usually involves removing the problem animals directly or modifying their habitat. Beaver can be livetrapped (Bailey or Hancock traps) and relocated to a more acceptable location or killed by dead-traps (e.g., Conibear #330) or shooting (Miller 1983). In cases where the water level in a dam must be controlled to prevent flooding, a pipe can be placed through the dam with the upstream side perforated to allow water flow.

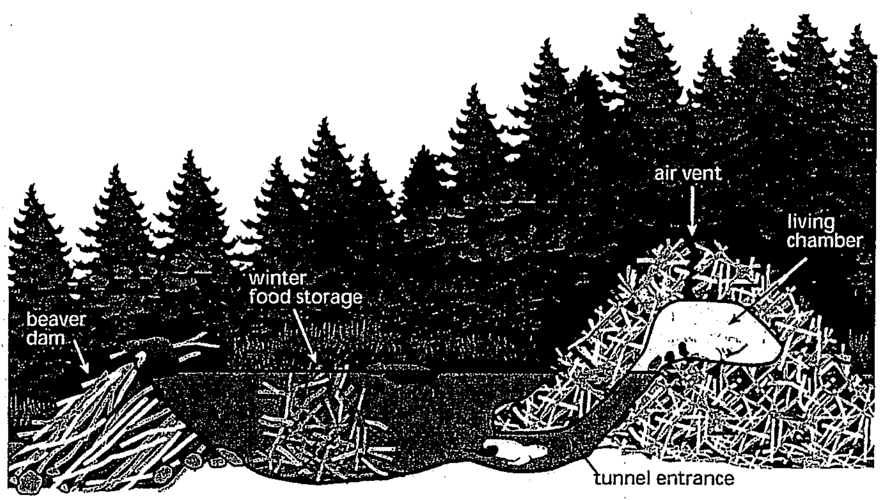

Figure 8.21: A beaver lodge. The living chamber in a beaver lodge is above water and used year-round. Deep entrances enable beavers to obtain food from underwater caches in winter.

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8E Stream Channel Restoration

Some disturbances to stream channels (e.g., from surface mining activities, extreme weather events, or major highway construction) are so severe that restoration within a desired time frame requires total reconstruction of a new channel. Selecting dimensions (width, depth, cross-sectional shape, pattern, slope, and alignment) for such a reconstructed channel is perhaps the most difficult component of stream restoration design. In the case of stream channel reconstruction, stream corridor restoration design can proceed along one of two broad tracks:

REVERSE

Review Chapter 4's Data Collection Planning section.

1. A single-species restoration that focuses on habitat requirements of certain life stages of species (for example, rainbow trout spawning). The existing system is analyzed in light of what is needed to provide a given quantity of acceptable habitat for the target species and life stage, and design proceeds to remedy any deficiencies noted.
2. An "ecosystem restoration" or "ecosystem management" approach that focuses design resources on the chemical, hydrologic, and geomorphic functions of the stream corridor. This approach assumes that communities will recover to a sustainable level if the stream corridor structure and functions are adequate. The strength of this approach is that it recognizes the complex interdependence between living things and the totality of their environments.

Although methods for single-species restoration design pertaining to treatments for aquatic habitat are included elsewhere in this chapter, the second track is emphasized in this section.

Procedures for Channel Reconstruction

If watershed land use changes or other factors have caused changes in sediment yield or hydrology, restoration to an historic channel condition is not recommended. In such cases, a new channel design is needed. The following procedures are suggested:

1. Describe physical aspects of the watershed and characterize its hydrologic response.

   This step should be based on data collected during the planning phase, as described in Chapter 4.
2. Considering reach and associated constraints, select a preliminary right-of-way for the restored stream channel corridor and compute the valley length and valley slope.
3. Determine the approximate bed material size distribution for the new channel.

Many of the channel design procedures described below require the designer to supply the size of bed sediments. If the project is not likely to modify bed sediments, the existing channel bed may be sampled using procedures reviewed in Chapter 7. If predisturbance conditions were different from those of the existing channel, and if those conditions must be restored, the associated sediment size distribution must be determined. This can be done by collecting representative samples of bed sediments from nearby, similar streams; by excavating to locate the predisturbance bed; or by obtaining the information from historic resources.

Like velocity and depth, bed sediment size in natural streams varies continuously in time and space. Particularly troublesome are streams with sediment size distributions that are bimodal mixtures of sand and gravel, for example. The median (D_{50}) of the overall distribution might be virtually absent from the bed. However, if flow conditions allow development of a well-defined armor layer, it might be appropriate to use a higher percentile than the median (e.g., the D_{75}) to represent the bed material size distribution. In some cases, a new channel excavated into a heterogeneous mixture of noncohesive material will develop an armor layer. In such a case, the designer must predict the likely size of the armor layer material. Methods presented by Helwig (1987) and Griffiths (1981) could prove helpful in such a situation.

4. Conduct a hydrologic and hydraulic analysis to select a design discharge or range of discharges.

Conventional channel design has revolved around selecting channel dimensions that convey a certain discharge at or below a certain elevation. Design discharge is usually based on flood frequency or duration or, in the case of canals, on downstream supply needs. Channel restoration, on the other hand, implies designing a channel similar to one that would develop naturally under similar watershed conditions.

Therefore, the first step in selecting a design discharge for restoration is not to determine the controlling elevation for flood protection but to determine what discharge controls channel size. Often this will be at or close to the 1- to 3-year recurrence interval flow. See Chapters 1 and 7 for discussions of channel-forming, effective, and design discharges. Additional guidance regarding streamflow analysis for gauged and ungauged sites is presented in Chapter 7. The designer should, as appropriate to the stream system, compute effective discharge or estimate bankfull discharge.

A sediment rating curve must be developed to integrate with the flow duration curve to determine the effective discharge. The sediment load that is responsible for shaping the channel (bed material load) should be used in the calculation of the effective discharge. This sediment load can be determined from measured data or computed using an appropriate sediment transport equation. If measured suspended sediment data are used, the wash load, typically consisting of particles less than 0.062 mm, should be deleted and only the suspended bed material portion of the suspended load used. If the bed load in the stream is considered to be only a small percentage of the total bed material load, it might be acceptable to simply use the measured suspended bed material load in the effective discharge calculations. However, if the bed load is a significant portion of the load, it should be calculated using an appropriate sediment transport function and then added to the suspended bed material load to provide an estimate of the total bed material load. If bed load measurements are available, which seldom is the case, these observed data can be used.

Review Chapter 1 and Chapter 7's channel-forming, effective, and design discharges sections.

Flow levels and frequencies that cause flooding also need to be identified to help plan and design out-of-stream restoration measures in the rest of the stream corridor. If flood management is a constraint, additional factors that are beyond the scope of this document enter the design. Environmental features for flood control channels are described elsewhere (Hey 1995, Shields and Aziz 1992, USACE 1989a, Brookes 1988).

Channel reconstruction and stream corridor restoration are most difficult for incised streams, and hydrologic analyses must consider several additional factors. Incised stream channels are typically much larger than required to convey the channel-forming discharge. Restoration of an incised channel may involve raising the bottom of a stream to restore overbank flow and ecological functions of the floodplain. In this type of restoration, compatibility of restored floodplain hydrology with existing land uses must be considered.

Review Chapter 7's hydrologic analysis and stage-discharge relationships sections.

A second option in reconstructing incised channels is to excavate one or both sides to create a new bankfull channel with a floodplain (Hey 1995). Again, adjacent land uses must be able to accommodate the new, excavated floodplain/channel.

A third option is to stabilize the incised channel in place, and to enhance the low-flow channel for environmental benefits. The creation of a floodplain might not be necessary or possible as part of a stream restoration.

In cases where channel sizing, modification, or realignment are necessary, or where structures are required to enhance vertical or lateral stability, it is critical that restoration design also include consideration of the range of flows expected in the future. In urbanizing watersheds, future conditions may be quite different from existing conditions, with higher, sharper, peak flows.

If certain instream flow levels are required to meet restoration objectives, it is imperative that those flows be quantified on the basis of a thorough understanding of present and desired conditions. Good design practice also requires checking stream channel hydraulics and stability at discharges well above and below the design condition. Stability checks (described below) may be quite simple or very sophisticated. Additional guidance on hydrologic analysis and development of stage-discharge relationships are presented in Chapter 7.

5. Predict stable planform type (straight, meandering, or braided).

Channel planform may be classified as straight, braided, or meandering, but thresholds between categories are arbitrary since channel form can vary continuously from straight to single-channel meanders to multiple braids. Naturally straight, stable alluvial channels are rare, but meandering and braided channels are common and can display a wide range of lateral and vertical stability.

Relationships have been proposed that allow prediction of channel planform based on channel slope, discharge, and bed material size (e.g., Chang 1988), but they are sometimes unreliable (Chitale 1973, Richards 1982) and give widely varying estimates of the slope threshold between meandering and braiding. As noted by Dunne (1988), "The planform aspects of rivers are the most difficult to predict," a sentiment echoed by USACE (1994), "... available analytical techniques cannot determine reliably whether a given channel modification will be liable to meander development, which is sensitive to difficult-to-quantify factors like bank vegetation and cohesion."

Stable channel bed slope is influenced by a number of factors, including sediment load and bank resistance to erosion. For the first iteration, restoration designers may assume a channel planform similar to stable reference channels in similar watersheds. By collecting data for stable channels and their valleys in reference reaches, insight can be gained on what the stable configuration would be for the restoration area. The morphology of those stream types can also provide guidance or additional converging lines of evidence that the planform selected by the designer is appropriate.

After initial completion of these five steps, any one of several different paths may be taken to final design. Three approaches are summarized in Table 8.1. The tasks are not always executed sequentially because trial and error and reiteration are often needed.

Alignment and Average Slope

In some cases, it might be desirable to divert a straightened stream into a meandering alignment for restoration purposes. Three approaches for meander design are summarized in the adjacent box.

For cases where the design channel will carry only a small amount of bed mate-

Table 8.1: Three approaches to achieving final design. There are variations of the final steps to a restoration design, after the first five steps described in the text are done.

Approach A		Approach B (Hey 1994)		Approach C (Fogg 1995)	
Task	**Tools**	**Task**	**Tools**	**Task**	**Tools**
Determine meander geometry and channel alignment.[1]	Empirical formulas for meander wavelength and adaptation of measurements from predisturbed conditions or nearly undisturbed reaches.	Determine bed-material discharge to be carried by design channel at design discharge; compute bed-material sediment concentration.	Analyze measured data or use appropriate sediment transport function[2] and hydraulic properties of reach upstream from design reach.	Compute mean flow, width, depth, and slope at design discharge.[4]	Regime or hydraulic geometry formulas with regional coefficients.
Compute sinuosity, channel length, and slope.	Channel length = sinuosity X valley length. Channel slope= valley slope/ sinuosity.	Compute mean flow, width, depth, and slope at design discharge.[4]	Regime or hydraulic geometry formulas with regional coefficients, or analytical methods (e.g. White, et al., 1982, or Copeland, 1994).[3]	Compute or estimate flow resistance coefficient at design discharge.	Appropriate relationship between depth, bed sediment size, and resistance coefficient, modified based on expected sinuosity and bank/berm vegetation.
Compute mean flow width and depth at design discharge.[4]	Regime or hydraulic geometry formulas with regional coefficients, and resistance equations or analytical methods (e.g. tractive stress, Ikeda and Izumi, 1990, or Chang, 1988).	Compute sinuosity and channel length.	Sinuosity = valley slope/ channel slope. Channel length= sinuosity X valley length.	Compute mean channel slope and depth required to pass design discharge.	Uniform flow equation (e.g. Manning, Chezy) continuity equation, and design channel cross-sectional shape; numerical water surface profile models may be used instead of uniform flow equation.
Compute riffle spacing (if gravel bed), and add detail to design.	Empirical formulas, observation of similar streams, habitat criteria.	Determine meander geometry and channel alignment.	Lay out a piece of string scaled to channel length on a map (or equivalent procedure) such that meander arc lengths vary from 4 to 9 channel widths.	Compute velocity or boundary sheer stress at design discharge.	Allowable velocity or shear stress criteria based on channel boundary materials.
Check channel stability and reiterate as needed.	Check stability.	Compute riffle spacing (if gravel bed), and add detail to design.	Empirical formulas, observation of similar streams, habitat criteria.	Compute sinuosity and channel length.	Sinuosity = valley slope/channel slope. Channel length= sinuosity X valley length.
		Check channel stability and reiterate as needed.	Check stability.	Compute sinuosity and channel length.	Lay out a piece of string scaled to channel length on a map (or equivalent procedure) such that meander arc lengths vary from 4 to 9 channel widths.
				Check channel stability and reiterate as needed.	Check stability.

1 Assumes meandering planform would be stable. Sinuosity and arc-length are known.

2 Computation of sediment transport without calibration against measured data may give highly unreliable results for a specific channel (USACE, 1994, Kuhnle, et al., 1989).

3 The two methods listed assume a straight channel. Adjustments would be needed to allow for effects of bends.

4 Mean flow width and depth at design discharge will give channel dimensions since design discharge is bankfull. In some situations channel may be increased to allow for freeboard. Regime and hydraulic geometry formulas should be examined to determine if they are mean width or top width.

USACE Channel Restoration Design Procedure

A systematic design methodology has been developed for use in designing restoration projects that involve channel reconstruction (USACE, WES). The methodology includes use of hydraulic geometry relationships, analytical determination of stable channel dimensions, and a sediment impact assessment. The preferred geometry is a compound channel with a primary channel designed to carry the effective or "channel forming" discharge and an overbank area designed to carry the additional flow for a specified flood discharge. Channel width may be determined by analogy methods, hydraulic geometry predictors, or analytically. Currently under development are hydraulic geometry predictors for various stream types. Once a width is determined for the effective discharge, depth and channel slope are determined analytically by balancing sediment inflow from upstream with sediment transport capacity through the restored channel. Meander wavelength is determined by analogy or hydraulic geometry relationships. Assumption of a sine-generated curve then allows calculation of channel planform. The stability of the channel design is then evaluated for the full range of expected discharges by conducting a sediment impact assessment. Refinements to the design include variation of channel widths at crossings and pools, variable lateral depths in pools, coarsening of the channel bed in riffles, and bank protection.

rial load, bed slope and channel dimensions may be selected to carry the design discharge at a velocity that will be great enough to prevent suspended sediment deposition and small enough to prevent erosion of the bed. This approach is suitable only for channels with beds that are stationary or move very infrequently—typically stable cobble- and gravel-bed streams.

Once mean channel slope is known, channel length can be computed by multiplying the straight line down-valley distance by the ratio of valley slope to channel slope (sinuosity). Meanders can then be laid out using a piece of string on a map or an equivalent procedure, such that the meander arc length L (the distance between inflection points, measured along the channel) ranges from 4 to 9 channel widths and averages 7 channel widths. Meanders should not be uniform.

The incised, straightened channel of the River Blackwater (Norfolk, United Kingdom) was restored to a meandering form by excavating a new low-level floodplain about 50 to 65 feet wide containing a sinuous channel about 16 feet wide and 3 feet deep (Hey 1995). Preliminary calculations indicated that the bed of the channel was only slightly mobile at bankfull discharge, and sediment loads were low. A carbon copy design process was used, recreating meander geometry from the mid-19th century (Hey 1994). The River Neath (Wales, United Kingdom), an active gravel-bed stream, was diverted at five locations into meandering alignments to allow highway construction. Existing slopes were maintained through each diversion, effectively illustrating a "slope-first" design (Hey 1994).

Channel Dimensions

Selection of channel dimensions involves determining average values for width and depth. These determinations are based on the imposed water and sediment discharge, bed sediment size, bank vegetation, resistance, and average bed slope. However, both width and depth may be constrained by site factors, which the designer must consider once stability criteria are met. Channel width must be less than the available corridor width, while depth is dependent on the upstream and downstream controlling elevations, resistance, and the elevation of the adjacent ground surface. In some cases, levees or floodwalls might be needed to match site constraints and depth requirements. Average dimensions determined in this step should not be applied uniformly. Instead, in the detailed design step described below, nonuniform slopes and cross sections should be specified to create converging and diverging flow and resulting physical diversity.

The average cross-sectional shape of natural channels is dependent on discharge, sediment inflow, geology, roughness, bed slope, bank vegetation, and bed and bank materials. Although bank vegetation is considered when using some of the empirical tools presented below, many of the analytical approaches do not consider the influence of bank material and vegetation or make unrealistic assumptions (e.g., banks are composed of the same material as the bed). These tools should be used with care. After initial selection of average channel width and depth, designers should consider the compatibility of these dimensions with reference reaches.

Reference Reaches

Perhaps the simplest approach to selecting channel width and depth is to use dimensions from stable reaches elsewhere in the watershed or from similar reaches in the region. The difficulty in this approach is finding a suitable reference reach. A reference reach is a reach of stream outside the project reach that is used to develop design criteria for the project reach.

A reference reach used for stable channel design should be evaluated to make sure that it is stable and has a desirable morphological and ecological condition. In addition, the reference reach must be similar enough to the desired project reach so that the comparison is valid. It must be similar to the desired project reach in hydrology, sediment load, and bed and bank material.

The term reference reach has several meanings. As used above, the reference reach is a reach that will be used as a template for the geometry of the restored channel. The width, depth, slope, and planform characteristics of the reference reach are transferred to the design reach, either exactly or by using analytical or empirical techniques to scale them to fit slightly different characteristics of the project reach (for example, a larger or smaller drainage area).

It is impossible to find an exact replica of the watershed in which the restoration work is located, and subjective judgement may play a role in determining what constitutes similarity. The level of uncertainty involved may be reduced by considering a large number of stable reaches. By classifying the reference streams, width and depth data can be grouped by stream type to reduce the scatter inherent in regional analyses.

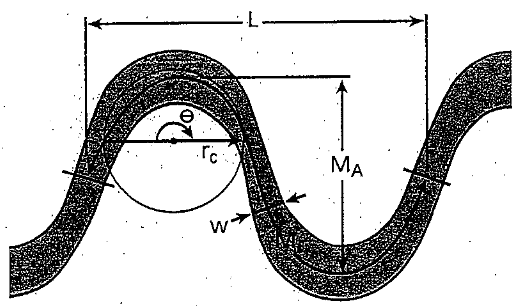
A second common meaning of the term reference reach is a reach with a desired biological condition, which will be used as a target to strive for when comparing various restoration options. For instance, for a stream in an urbanized area, a stream with a similar drainage area in a nearby unimpacted watershed might be used as a reference reach to show what type of aquatic and riparian community might be possible in the project reach. Although it might not be possible to return the urban stream to predevelopment conditions, the characteristics of the reference reach can be used to indicate what direction to move toward. In this use of the term, a reference reach defines desired biological and ecological conditions, rather than stable channel geometry. Modeling tools such as IFIM and RCHARC (see Chapter 7) can be used to determine what restoration options come closest to replicating the habitat conditions of the reference reach (although none of the options may exactly match it).

Meander Design

Five approaches to meander design are described below, not in any intended order of priority. The first four approaches result in average channel slope being determined by meander geometry. These approaches are based on the assumption that the controlling factors in the stream channel (water and sediment inputs, bed material gradation, and bank erosional resistance) will be similar to those in the reference reach (either the restoration reach before disturbance or undisturbed reaches). The fifth approach requires determination of stream channel slope first. Sinuosity follows as the ratio of channel slope to valley slope, and meander geometry ***(Figure 8.22)*** *is developed to obtain the desired sinuosity.*

1. ***Replacement of meanders exactly as found before disturbance (the carbon copy technique).*** *This method is appropriate if hydrology and bed materials are very similar or identical to predisturbance conditions. Old channels are often filled with cohesive soils and may have cohesive boundaries. Accordingly, channel stability may be enhanced by following a previous channel alignment.*

2. ***Use of empirical relationships that allow computation of meander wavelength, L, and amplitude based on channel width or discharge.*** *Chang (1988) presents graphical and algebraic relationships between meander wavelength, width-depth ratio, and friction factor. In addition to meander wavelength, specification of channel alignment requires meander radius of curvature (Hey 1976) and meander amplitude or channel slope. Hey (1976) also suggests that L is not usually uniquely determined by channel width or discharge. Rechard and Schaefer (1984) provide an example of development of regional formulas for meander restoration design. Chapter 7 includes a number of meander geometry relationships developed from regional data sets. Newbury and Gaboury (1993) designed meanders for a straightened stream (North Pine River) by selecting meander amplitude to fit between floodplain terraces. Meander wavelength was set at 12.4 times the channel width (on the high end of the literature range), and radius of curvature ranged from 1.9 to 2.3 times the channel width.*



L meander wavelength
M_L meander arc length
w average width at bankfull discharge
M_A meander amplitude
r_c radius of curvature
θ arc angle

Figure 8.22: Variables used to describe and design meanders. *Consistent, clear terminology is used in meander design.*
Adapted from Williams 1986.

3. **Basin-wide analysis to determine fundamental wavelength, mean radius of curvature, and meander belt width in areas "reasonably free of geologic control."** *This approach has been used for reconstruction of streams destroyed by surface mining in subhumid watersheds of the western United States. Fourier analysis may be used with data digitized from maps to determine fundamental meander wavelength (Hasfurther 1985).*

4. **Use of undisturbed reaches as design models.** *If the reach targeted for restoration is closely bounded by undisturbed meanders, dimensions of these undisturbed reaches may be studied for use in the restored reach (**Figure 8.23**). Hunt and Graham (1975) describe successful use of undisturbed reaches as models for design and construction of two meanders as part of river relocation for highway construction in Montana. Brookes (1990) describes restoration of the Elbaek in Denmark using channel width, depth, and slope from a "natural" reach downstream, confirmed by dimensions of a river in a neighboring watershed with similar area, geology, and land use.*

5. **Slope first.** *Hey (1994) suggests that meanders should be designed by first selecting a mean channel slope based on hydraulic geometry formulas. However, correlation coefficients for regime slope formulas are always much smaller than those for width or depth formulas, indicating that the former are less accurate. Channel slope may also be determined by computing the value required to convey the design water and sediment discharges (White et al. 1982, Copeland 1994). The main weakness of this approach is that bed material sediment discharge is required by analytical techniques and in some cases (e.g., Hey and Thorne 1986) by hydraulic geometry formulas. Sediment discharges computed without measured data for calibration may be unreliable.*

Site-specific bed material samples and channel geometries are needed to apply these analytical techniques and to achieve confidence in the resulting design.

***Figure 8.23: The natural meander of a stream.** Rivers meander to increase length and reduce gradient. Stream restorations often attempt to reconstruct the channel to a previous meandering condition or one "copied" from a reference reach.*

Application of Regime and Hydraulic Geometry Approaches

Typical regime and hydraulic geometry relationships are presented in Chapter 7. These formulas are most reliable for width, less reliable for depth, and least reliable for slope.

Exponents and coefficients for hydraulic geometry formulas are usually determined from data for the same stream, the same watershed, streams of a similar type, or the same physiographic region. Because formula coefficients vary, application of a given set of hydraulic geometry or regime relationships should be limited to channels similar to the calibration sites. Classifying streams can be useful in refining regime relationships (See Chapter 7's section on Stream Classification).

Published hydraulic geometry relationships are usually based on stable, single-thread alluvial channels. Hydraulic geometry relationships determined through stream classification of reference reaches can also be valuable for designing the stream restoration. Channel geometry-discharge relationships are more complex for multithread channels. Individual threads may fit the relationships if their partial bankfull discharges are used in place of the total streamflow. Also, hydraulic geometry relationships for gravel-bed rivers are far more numerous in the literature than those for sand-bed rivers.

A trial set of channel properties (average width, depth, and slope) can be evaluated by using several sets of regime and hydraulic geometry formulas and comparing results. Greatest weight should be given to formulas based on sites similar to the project reach. A logical second step is to use several discharge levels in the best-suited sets of formulas. Because hydraulic geometry relationships are most compatible with single-channel sand and gravel streams with low bed-material sediment discharge, unstable channels (aggrading or degrading profiles) can depart strongly from published relationships.

Literature references to the use of hydraulic geometry formulas for sizing restored channels are abundant. Initial estimates for width and depth for the restored channel of Seminary Creek, which drains an urban watershed in Oakland, California, were determined using regional hydraulic geometry formulas (Riley and MacDonald 1995). Hey (1994, 1995) discusses use of hydraulic geometry relationships determined using regression analyses of data from gravel bed rivers in the United Kingdom for restoration design. Newbury and Gaboury (1993) used regional hydraulic geometry relations based on drainage area to check width and depth of restored channels in Manitoba.

Hydraulic geometry formulas for sizing stream channels in restoration efforts must be used with caution since a number of pitfalls are associated with their use:

- The formulas represent hydraulic geometry only at bankfull or mean annual discharge. Designers must also select a single statistic to describe bed sediment size when using hydraulic geometry relationships. (However, refinements to the Hey and Thorne [1986] formulas for slope in Table 7.5 should be noted.)
- Downstream hydraulic geometry formulas are usually based on the bankfull discharge, the elevation of which can be extremely difficult to identify in vertically unstable channels.
- Exponents and coefficients selected for design must be based on streams with slopes, bed sediments, and bank

materials similar to the one being designed.

- The premise is that the channel shape is dependent on only one or two variables.
- Hydraulic geometry relationships are power functions with a fair degree of scatter that may prove too great for reliable engineering design. This scatter is indicative of natural variability and the influence of other variables on channel geometry.

In summary, hydraulic geometry relationships are useful for preliminary or trial selection of design channel properties. Hydraulic and sediment transport analyses are recommended for final design for the restoration.

Analytical Approaches for Channel Dimensions

Analytical approaches for designing stream channels are based on the idea that a channel system may be described by a finite number of variables. In most practical design problems, a few variables are determined by site conditions (e.g., valley slope and bed material size), leaving up to nine variables to be computed. However, designers have only three governing equations available: continuity, flow resistance (such as Manning, Chezy, and Darcy-Weisbach), and sediment transport (such as Ackers-White, Einstein, and Brownlie). Since this leaves more unknowns than there are equations, the system is indeterminate. Indeterminacy of the stable channel design problem has been addressed in the following ways:

- Using empirical relationships to compute some of the unknowns (e.g., meander parameters).
- Assuming values for one or more of the unknown variables.
- Using structural controls to hold one or more unknowns constant (e.g., controlling width with bank revetments).
- Ignoring some unknown variables by simplifying the channel system. For example, a single sediment size is sometimes used to describe all boundaries, and a single depth is used to describe water depth rather than mean and maximum depth as suggested by Hey (1988).
- Adopting additional governing equations based on assumed properties of streams with movable beds and banks. The design methods based on "extremal hypotheses" fall into this category. These approaches are discussed below under analytical approaches for channels with moving beds.

REVERSE

Review Chapter 7's section on hydraulic geometry relationships.

Table 8.2 lists six examples of analytical design procedures for sand-bed and gravel channels. These procedures are data-intensive and would be used in high-risk or large-scale channel reconstruction work.

Stable Channel Method		Domain	Resistance Equation	Sediment Transport Equation	Third Relation
Copeland	1994	Sand-bed rivers	Brownlie	Brownlie	Left to designer's discretion
Chang	1988	Sand-bed rivers	Various	Various	Minimum stream power
Chang	1988	Gravel-bed rivers	Bray	Chang (similar in form to Parker, Einstein)	Minimum slope
Abou-Saida and Saleh	1987	Sand-bed canals	Liu-Hwang	Einstein-Brown	Left to designer's discretion
White et al.	1981	Sand-bed rivers	White et al.	Ackers-White	Maximum sediment transport
Griffiths	1981	Gravel-bed rivers	Griffiths	Shields entrainment	Empirical stability index

Table 8.2: Selected analytical procedures for stable channel design.

Tractive Stress (No Bed Movement)

Tractive stress or tractive force analysis is based on the idea that by assuming negligible bed material discharge ($Q_s = 0$) and a straight, prismatic channel with a specified cross-sectional shape, the inequality in variables and governing equations mentioned above is eliminated. Details are provided in many textbooks that deal with stable channel design (e.g., Richards 1982, Simons and Senturk 1977, French 1985). Because the method is based on the laws of physics, it is less empirical and region-specific than regime or hydraulic geometry formulas. To specify a value for the force "required to initiate motion," the designer must resort to empirical relationships between sediment size and critical shear stress. In fact, the only difference between the tractive stress approach for design stability analysis and the allowable stress approach is that the effect of cross-sectional shape (in particular, the bank angles) is considered in the former (**Figure 8.24**). Effects of turbulence and secondary currents are poorly represented in this approach.

Tractive stress approaches typically presume constant discharge, zero bed material sediment transport, and straight, prismatic channels and are therefore poorly suited for channels with moving beds. Additional limitations of the tractive stress design approach are discussed by Brookes (1988) and USACE (1994). Tractive stress approaches are appropriate for designing features made of rock or gravel (artificial riffles, revetments, etc.) that are expected to be immobile.

__Figure 8.24: Low energy system with small bank angles.__ Bank angles need to be considered when using the tractive stress approach.

Channels with Moving Beds and Known Slope

More general analytical approaches for designing channels with bed material discharge reduce the number of variables by assuming certain constant values (such as a trapezoidal cross-sectional shape or bed sediment size distribution) and by adding new equations based on an extremal hypothesis (Bettess and White 1987). For example, in a refinement of the tractive stress approach, Parker (1978) assumed that a stable gravel channel is characterized by threshold conditions only at the junction point between bed and banks. Using this assumption and including lateral diffusion of longitudinal momentum due to fluid turbulence in the analysis, he showed that points on the bank experience stresses less than threshold while the bed moves.

Following Parker's work, Ikeda et al. (1988) derived equations for stable width and depth (given slope and bed material gradation) of gravel channels with unvegetated banks composed of noncohesive material and flat beds in motion at bankfull. Channels were assumed to be nearly straight (sinuosity < 1.2) with trapezoidal cross sections free of alternate bars. In a subsequent paper Ikeda and Izumi (1990) extended the derivation to include effects of rigid bank vegetation.

Extremal hypotheses state that a stable channel will adopt dimensions that lead to minimization or maximization of some quantity subject to constraints imposed by the two governing equations (e.g., sediment transport and flow resistance). Chang (1988) combined sediment transport and flow resistance formulas with flow continuity and minimization of stream power at each cross section and through a reach to generate a numerical model of flow and sediment transport. Special relationships for flow and transverse sediment transport in bends were also derived. The model was used to make repeated computations of channel geometry with various values for input variables. Results of the analysis were used to construct a family of design curves that yield d (bankfull depth) and w (bankfull width), given bankfull Q, S, and D_{50}. Separate sets of curves are provided for sand and gravel bed rivers. Regime-type formulas have been fit to the curves, as shown in Table 8.3. These relationships should be used with tractive stress analyses to develop converging data that increase the designer's confidence that the appropriate channel dimensions have been selected.

Subsequent work by Thorne et al. (1988) modified these formulas to account for effects of bank vegetation along gravel-bed rivers. The Thorne et al. (1988) formulas in Table 8.3 are based on the data presented by Hey and Thorne (1986) in Table 7.6.

Channels with Moving Beds and Known Sediment Concentration

White et al. (1982) present an analytical approach based on the Ackers and White sediment transport function, a companion flow resistance relationship, and maximization of sediment transport for a specified sediment concentration. Tables (White et al. 1981) are available to assist users in implementing this procedure. The tables contain entries for sediment sizes from 0.06 to 100 millimeters, discharges up to 35,000 cubic feet per second, and sedi-

Table 8.3: Equations for river width and depth.

Author	Year	Data	Domain	k_1	k_2	k_4	k_5
Chang	1988		Meandering or braided sand-bed rivers with:				
		Equiwidth point-bar streams and stable canals	$0.00238 < SD_{50}^{-0.5} Q^{-0.51}$ and $SD_{50}^{-0.5} Q^{-0.55} < 0.05$	$3.49k_1$*		$3.51k_4$*	0.47
		Straight braided streams	$0.05 < SD_{50}^{-0.5} Q^{-0.55}$ and $SD_{50}^{-0.5} Q^{-0.51} < 0.047$	Unknown and unusual			
		Braided point-bar and wide-bend point-bar streams; beyond upper limit lie steep, braided streams	$0.047 < SD_{50}^{-0.5} Q^{-0.51} <$ indefinite upper limit	$33.2k_1$**	0.93	$1.0k_4$**	0.45
Thorne et al.	1988	Same as for Thorne and Hey 1986	Gravel-bed rivers	$1.905 + k_1$***	0.47	$0.2077 + k_4$***	0.42
		Adjustments for bank vegetation[a]	Grassy banks with no trees or shrubs	$w = 1.46 w_c - 0.8317$		$d = 0.8815 d_c + 0.2106$	
			1-5% tree and shrub cover	$w = 1.306 w_c - 8.7307$		$d = 0.5026 d_c + 1.7553$	
			5-50% tree and shrub cover	$w = 1.161 w_c - 16.8307$		$d = 0.5413 d_c + 2.7159$	
			Greater than 50% tree and shrub cover, or incised into flood plain	$w = 0.9656 w_c - 10.6102$		$d = 0.7648 d_c + 1.4554$	

Chang equations for determining river width and depth. Coefficients for equations of the form $w = k_1 Q^{K_2}$; $d = K_4 Q^{K_5}$; where w is mean bankfull width (ft), Q is the bankfull or dominant discharge ($ft^3/_s$), d is mean bankfull depth (ft), D_{50} is median bed-material size (mm), and S is slope (ft/ft).

[a] w_c and d_c in these equations are calculated using exponents and coefficients from the row labeled "gravel-bed rivers".

k_1* = $(S D_{50}^{-0.5} - 0.00238 Q^{-0.51})^{0.02}$.

k_4* = $\exp[-0.38 (420.17 S D_{50}^{-0.5} Q^{-0.51} - 1)^{0.4}]$.

k_1** = $(S D_{50}^{-0.5})^{0.84}$.

k_4** = $0.015 - 0.025 \ln Q - 0.049 \ln (S D_{50}^{-0.5})$.

k_1*** = $0.2490[\ln(0.0010647 D_{50}^{1.15}/SQ^{0.42})]^2$.

k_4*** = $0.0418 \ln(0.0004419 D_{50}^{1.15}/SQ^{0.42})$.

ment concentrations from 10 to 4,000 parts per million. However, this procedure is not recommended for gravel bed channels (USACE 1994). Sediment concentration at bankfull flow is required as an input variable, which limits the usefulness of this procedure. Procedures for computing sediment discharge, Q_s, are outlined in Chapter 7. Copeland (1994) found that the White et al. (1982) method for channel design was not robust for cohesive bed materials, artificial grade controls, and disequilibrium sediment transport. The method was also found inappropriate for an unstable, high-energy ephemeral sand-bed stream (Copeland 1994). However, Hey (1990) found the Ackers-White sediment transport function performed well when analyzing stability of 18 flood control channels in Britain.

The approach described by Copeland (1994) features use of the Brownlie (1981) flow-resistance and sediment-transport relations, in the form of the software package "SAM" (Thomas et al. 1993). Additional features include the determination of input bed material concentration by computing sediment concentration from hydraulic parameters for an upstream "supply reach" represented by a bed slope, a trapezoidal cross section, bed-material gradation, and a discharge. Bank and bed roughness are composited using the equal velocity method (Chow 1959) to obtain roughness for a cross section. A family of slope-width solutions that satisfy the flow resistance and sediment transport relations are then computed. The designer then selects any combination of channel properties that are represented by a point on the slope-width curve. Selection may be based on minimum stream power, maximum possible slope, width constraint due to right-of-way, or maximum allowable depth. The current (1996) version of the Copeland procedure assumes a straight channel with a trapezoidal cross section and omits the portion of the cross section above side slopes when computing sediment discharge. Effects of bank vegetation are considered in the assigned roughness coefficient.

The Copeland procedure was tested by application to two existing stream channels, the Big and Colewa Creeks in Louisiana and Rio Puerco in New Mexico (Copeland 1994). Considerable professional judgment was used in selection of input parameters. The Copeland method was found inapplicable to the Big and Colewa Creeks (relatively stable perennial streams with sand-clay beds), but applicable to Rio Puerco (high-energy, ephemeral sand-bed stream with stable profile and unstable banks). This result is not surprising since all stable channel design methods developed to date presume alluvial (not cohesive or bedrock) beds.

Use of Channel Models for Design Verification

In general, a model can be envisioned as a system by whose operation the characteristics of other similar systems may be predicted. This definition is general and applies to both hydraulic (physical) and computational (mathematical) models. The use and operation of computer models has improved in recent years as a result of better knowledge of fluvial hydraulics and the development of sophisticated digital control and data acquisition systems.

Any stream corridor restoration design needs careful scrutiny because its long-term impact on the stream system is not easy to predict. Sound engineering often dictates the use of computer models or physical models to check the validity of a proposed design. Since most practitioners do not have easy access to physical modeling facilities, computer models are much more widely used. Computer models can be run in a qualitative mode with very little data or in a highly precise quantitative mode with a great deal of field data for calibration and verification.

Computer models can be used to easily and cheaply test the stability of a restoration design for a range of conditions, or for a variety of alternative channel configurations. A "model" can vary in cost from several hundred dollars to several hundred thousand dollars, depending on what model is used, the data input, the degree of precision required, and the length and complexity of the reach to be modeled. The decision as to what models are appropriate should be made by a hydraulic engineer with a background in sediment transport.

The costs of modeling could be small compared to the cost of redesign or reconstruction due to failure. If the consequences of a project failure would result in a high risk of catastrophic damage or death, and the site-specific conditions result in an unacceptable level of uncertainty when applying computer models, a physical model is the appropriate tool to use for design.

Physical Models

In some instances, restoration designs can become sufficiently complicated to exceed the capabilities of available computational models. In other situations, time might be of the essence, thus precluding the development of new computational modeling capabilities. In such cases the designer must resort to physical modeling for verification.

Depending on the scaling criteria used to achieve similitude, physical models can be classified as distorted, fixed, or movable-bed models. The theory and practice of physical modeling are covered in detail by French (1985), Jansen et al. (1979), and Yalin (1971) and are beyond the scope of this document. Physical modeling, like computational modeling, is a technology that requires specialized expertise and considerable experience. The U.S. Army Waterways Experiment Station, Vicksburg, Mississippi, has extensively developed the technique of designing and applying physical models of rivers.

Computer Models

Computer models are structured and operated in the same way as a physical model (**Figure 8.25**). One part of the code defines the channel planform, the bathymetry, and the material properties of transported constituents. Other parts of the code create conditions at the boundaries, taking the place of the limiting walls and flow controls in the physical model. At the core of the computer code are the water and sediment transport solvers. "Turning on" these solvers is equivalent to running the physical model. At the end of the simulation run the new channel bathymetry and morphology are described by the model output. This section summarizes computational channel models that can be useful for evaluation of stream corridor restoration designs. Since it is not possible to include every existing model

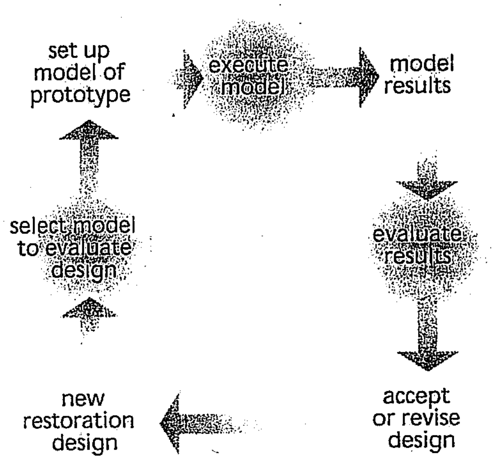


Figure 8.25: Use of models for design evaluation. *Modeling helps evaluate economics and effectiveness of alternative designs.*

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Table 8.4: Examples of computational models.

Model	CHARIMA	Fluvial-12	HEC-6	TABS-2	Meander	USGS	D·O·T	GSTARS
Discretization and formulation:								
Unsteady flow | stepped hydrograph	Y | Y	Y | Y	N | Y	Y | Y	N | Y	Y | Y	N | Y	N | Y
One-dimensional | quasi-two-dimensional	Y | N	Y | Y	Y | N	N | N	N | N	N	Y | Y	Y | Y
Two-dimensional | depth-average flow	N	N	N	Y	Y	Y | Y	N	N | Y
Deformable bed | banks	Y | N	Y | Y	Y | N	Y | N	Y | N	Y | N	Y | Y	Y | Y
Graded sediment load	Y	Y	Y	Y	Y	N	Y	Y
Nonuniform grid	Y	Y	Y	Y	Y	Y	Y	Y
Variable time stepping	Y	N	Y	N	N	N	N	Y
Numerical solution scheme:								
Standard step method	N	Y	Y	N	N	N	Y	Y
Finite difference	Y	N	Y	N	Y	Y	Y	Y
Finite element	N	N	N	Y	N	N	N	N
Modeling capabilities:								
Upstream water and sediment hydrographs	Y	Y	Y	Y	Y	Y	Y	Y
Downstream stage specification	Y	Y	Y	Y	Y	N	Y	Y
Floodplain sedimentation	N	N	N	Y	N	N	N	N
Suspended | total sediment transport	Y | N	Y | N	N | Y	Y | N	N | N	N | Y	N | Y	N | Y
Bedload transport	Y	Y	Y	N	Y	N	N	Y
Cohesive sediments	N	N	Y	Y	N	Y	N	Y
Bed armoring	Y	Y	Y	N	N	N	Y	Y
Hydraulic sorting of substrate material	Y	Y	Y	N	N	N	Y	Y
Fluvial erosion of streambanks	N	Y	N	N	N	N	Y	Y
Bank mass failure under gravity	N	N	N	N	N	N	Y	N
Straight | irregular nonprismatic reaches	Y | N	Y | N	Y | N	Y | Y	N | N	N | N	Y | Y	Y | Y
Branched | looped channel network	Y | Y	Y | N	Y | N	Y | Y	N | N	N | N	N | N	N | N
Channel beds	N	Y	N	Y	Y	N	Y	N
Meandering belts	N	N	N	N	N	Y	N	N
Rivers	Y	Y	Y	Y	Y	Y	Y	Y
Bridge crossings	N	N	N	Y	N	N	N	N
Reservoirs	N	Y	Y	N	N	N	N	Y
User support:								
Model documentation	Y	Y	Y	Y	Y	Y	Y	Y
User guide | hot-line support	N | N	Y | N	Y | Y	Y | N	N | N	Y | N	N | N	Y | N

Note: Y = Yes; N = No.

in the space available, the discussion here is limited to a few selected models (Table 8.4). In addition, Garcia et al. (1994) review mathematical models of meander bend migration.

These models are characterized as having general applicability to a particular class of problems and are generally available for desktop computers using DOS operating systems. Their conceptual and numerical schemes are robust, having been proven in field applications, and the code can be successfully used by persons without detailed knowledge of the core computational techniques. Examples of these models and their features are summarized in Table 8.4. The acronyms in the column titles identify the following models: CHARIMA (Holly et al. 1990), FLUVIAL-12 (Chang 1990), HEC-6, TABS-2 (McAnally and Thomas 1985), MEANDER (Johannesson and Parker 1985), the Nelson/Smith-89 model (Nelson and Smith 1989), D-O-T (Darby and Thorne 1996, Osman and Thorne 1988), GSTARS (Molinas and Yang 1996) and GSTARS 2.0 (Yang et al. 1998). GSTARS 2.0 is an enhanced and improved PC version of GSTARS. HEC-6, TABS-2, and USGS are federal, public domain models, whereas CHARIMA, FLUVIAL-12, MEANDER, and D-O-T are academic, privately owned models.

With the exception of MEANDER, all the above models calculate at each computational node the fractional sediment load and rate of bed aggradation or degradation, and update the channel topography. Some of them can simulate armoring of the bed surface and hydraulic sorting (mixing) of the underlying substrate material. CHARIMA, FLUVIAL-12, HEC-6, and D-O-T can simulate transport of sands and gravels. TABS-2 can be applied to cohesive sediments (clays and silts) and sand sediments that are well mixed over the water column. USGS is specially designed for gravel bed-load transport. FLUVIAL-12 and HEC-6 can be used for reservoir sedimentation studies. GSTARS 2.0 can simulate bank failure.

Comprehensive reviews on the capabilities and performance of these and other existing channel models are provided in reports by the National Research Council (1983), Fan (1988), Darby and Thorne (1992), and Fan and Yen (1993).

Detailed Design

Channel Shape

Natural stream width varies continuously in the longitudinal direction, and depth, bed slope, and bed material size vary continuously along the horizontal plane. These variations give rise to natural heterogeneity and patterns of velocity and bed sediment size distribution that are important to aquatic ecosystems.

Widths, depths, and slopes computed during design should be adopted as reach mean values, and restored channels should be constructed with asymmetric cross sections (Hunt and Graham 1975, Keller 1978, Iversen et al. 1993, MacBroom 1981) (**Figure 8.26**). Similarly, meander planform should vary from bend to bend about average values of arc length and radius. A reconstructed floodplain should not be perfectly flat (**Figure 8.27**).

Channel Longitudinal Profile and Riffle Spacing

In stream channels with significant amounts of gravel (D_{50} > 3 mm) (Higginson and Johnston 1989), riffles should be associated with steep zones near meander inflection points. Riffles are not found in channels with beds of finer materials. Studies conducted by Keller and Melhorn (1978) and confirmed by Hey and Thorne (1986) indicate pool-riffle spacing should vary between 3 and 10 channel widths and average about 6 channel widths even in bedrock channels. More recent work by Roy and Abrahams (1980) and Higginson and Johnston (1989) indicates that pool-riffle spacing varies widely within a given channel.

Average riffle spacing is often (but not always) half the meander length since riffles tend to occur at meander inflection points or crossovers. Riffles sometimes appear in groups or clusters. Hey and Thorne (1986) analyzed data from 62 sites on gravel-bed rivers in the United Kingdom and found riffle spacing varied from 4 to 10 channel widths

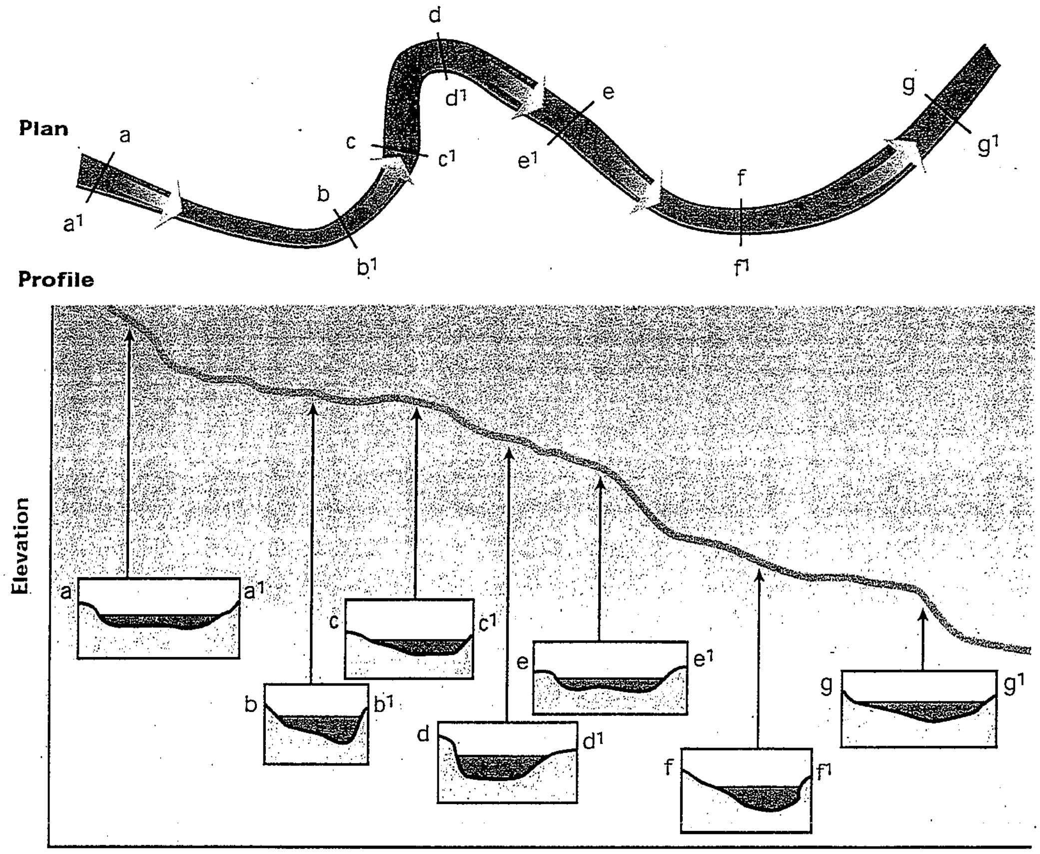


Figure 8.26: Example plan and profile of a naturally meandering stream. Channel cross sections vary based on width, depth, and shape.

with the least squares best fit at 6.31 channel widths. Riffle spacing tends to be nearer 4 channel widths on steeper gradients and 8 to 9 channel widths on more gradual slopes (R.D. Hey, personal communication, 1997). Hey and Thorne (1986) also developed regression formulas for riffle width, mean depth, and maximum depth.

Stability Assessment

The risk of a restored channel being damaged or destroyed by erosion or deposition is an important consideration for almost all restoration work. Designers of restored streams are confronted with rather high levels of uncertainty. In some cases, it may be wise for designers to compute risk of failure by calculating the joint probability of design assumptions being false, design equation inaccuracy, and occurrence of extreme hydrologic events during project life. Good design practice also requires checking channel performance at discharges well above and below the design condition. A number of approaches are available for checking both the vertical (bed) and horizontal (bank) stability of a designed stream. These stability checks are an important part of the design process.

Vertical (Bed) Stability

Bed stability is generally a prerequisite for bank stability. Aggrading channels are liable to braid or exhibit accelerated lateral migration in response to middle or point bar growth. Degrading channels widen explosively when bank heights and angles exceed a critical threshold specific to bank soil type. Bed aggradation can be addressed by stabilizing eroding channels upstream, controlling erosion on the watershed, or installing sediment traps, ponds (Haan et al. 1994), or debris basins (USACE 1989b). If aggradation is primarily due to deposition of fines, it can be addressed by narrowing the channel, although a narrower channel might require more bank stabilization.

If bed degradation is occurring or expected to occur, and if modification is planned, the restoration initiative should include flow modification, grade control measures, or other approaches that reduce the energy gradient or the energy of flow. There are many types of grade control structures. The applicability of a particular type of structure to a specific restoration depends on a number of factors, such as hydrologic conditions, sediment size and loading, channel morphology, floodplain and valley characteristics, availability of construction materials, ecological objectives, and time and funding constraints. For more information on various structure designs, refer to Neilson et. al. (1991), which provides a comprehensive literature review on grade control structures with an annotated bibliography. Grouted boulders can be used as a grade control structure. They are a key component in the successful restoration of the South Platte River corridor in Denver, Colorado (McLaughlin Water Engineers, Ltd., 1986).

Grade control structure stilling basins can be valuable habitats in severely degraded warm water streams (Cooper and Knight 1987, Shields and Hoover 1991). Newbury and Gaboury (1993) describe the construction of artificial riffles that serve as bed degradation controls. Kern (1992) used "river bottom ramps" to control bed degradation in a River Danube meander restoration initiative. Ferguson (1991) reviews creative designs for grade control structures that improve streamside habitat and aesthetic resources (Figure 8.28).

Figure 8.27: A stream meander and raised floodplain. *Natural floodplains rise slightly between a crossover and an apex of a meander.*

Horizontal (Bank) Stability

Bank stabilization may be necessary in restored channels due to floodplain land uses or because constructed banks are more prone to erosion than "seasoned" ones, but it is less than ideal if ecosystem restoration is the objective.

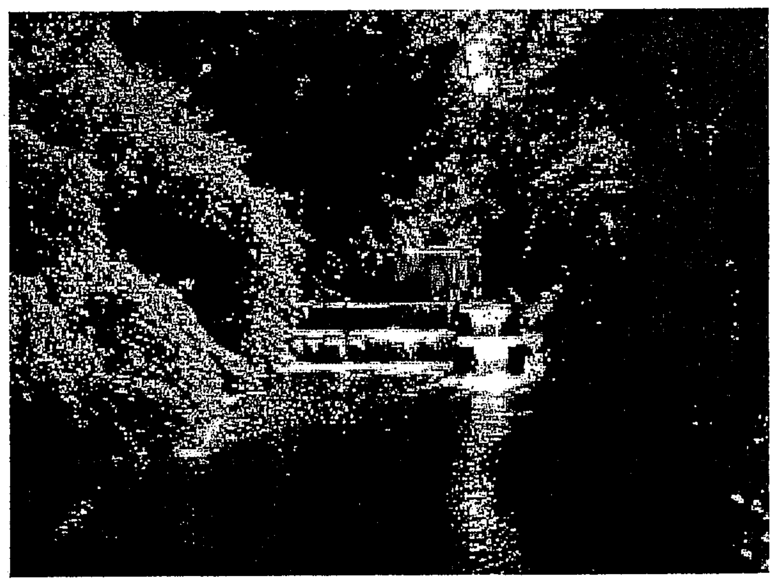


Figure 8.28: Grade control structure. *Control measures can double as habitat restoration devices and aesthetic features.*

Floodplain plant communities owe their diversity to physical processes that include erosion and deposition associated with lateral migration (Henderson 1986). Bank erosion control methods must be selected with the dominant erosion mechanisms in mind (Shields and Aziz 1992).

Bank stabilization can generally be grouped into one of the following three categories: (1) indirect methods, (2) surface armor, and (3) vegetative methods. Armor is a protective material in direct contact with the streambank. Armor can be categorized as stone, other self-adjusting armor (sacks, blocks, rubble, etc.), rigid armor (concrete, soil cement, grouted riprap, etc.) and flexible mattress (gabions, concrete blocks, etc.). Indirect methods extend into the stream channel and redirect the flow so that hydraulic forces at the channel boundary are reduced to a nonerosive level. Indirect methods can be classified as dikes (permeable and impermeable) and other flow deflectors such as bendway weirs, stream "barbs," and Iowa vanes. Vegetative methods can function as either armor or indirect protection and in some applications can function as both simultaneously. A fourth category is composed of techniques to correct problems caused by geotechnical instabilities.

Guidance on selection and design of bank protection measures is provided by Hemphill and Bramley (1989) and Henderson (1986). Coppin and Richards (1990), USDA-NRCS (1996), and Shields et al. (1995) provide additional detail on the use of vegetative techniques (see following section). Newly constructed channels are more susceptible to bank erosion than older existing channels, with similar inflows and geometries, due to the influence of vegetation, armoring, and the seasoning effect of clay deposition on banks (Chow 1959). In most cases, outer banks of restored or newly constructed meanders will require protection. Structural techniques are needed (e.g., Thorne et al. 1995) if immediate stability is required, but these may incorporate living components. If time permits, the new channel may be constructed "in the dry" and banks planted with woody vegetation. After allowing the vegetation several growing seasons to develop, the stream may be diverted in from the existing channel (R.D. Hey, personal communication, 1997).

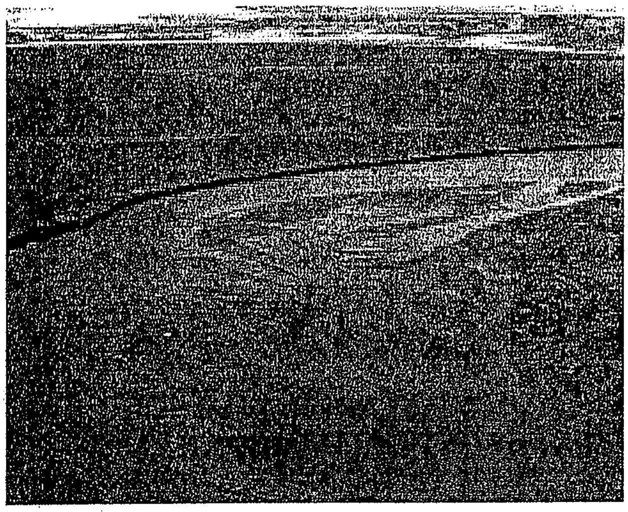
Bank Stability Check

Outer banks of meanders erode, but erosion rates vary greatly from stream to stream and bend to bend. Observation of the project stream and similar reaches, combined with professional judgment, may be used to determine the need for bank protection, or erosion may be estimated by simple rules of thumb based largely on studies that relate bend migration rates to bend geometry (e.g., Apmann 1972 and review by Odgaard 1987) (**Figure 8.29**). More accurate prediction of the rate of erosion of a given streambank is at or beyond the current state of the art. No standard methods exist, but several recently developed tools are available. None of these have been used in extremely diverse settings, and users should view them with caution.

Tools for predicting bank erosion may be divided into two groups: (1) those which predict erosion primarily due to the action of water on the streambank surface and (2) those which focus on subsurface geotechnical characteristics.

Among the former is an index of streambank erodibility based on field observations of emergency spillways (Moore et al. 1994, Temple and Moore 1997). Erosion is predicted for sites

__Figure 8.29: Channel exhibiting accelerated lateral migration.__ Erosion of an outer bank on the Missouri River is a natural process; however, the rate of erosion should be monitored.



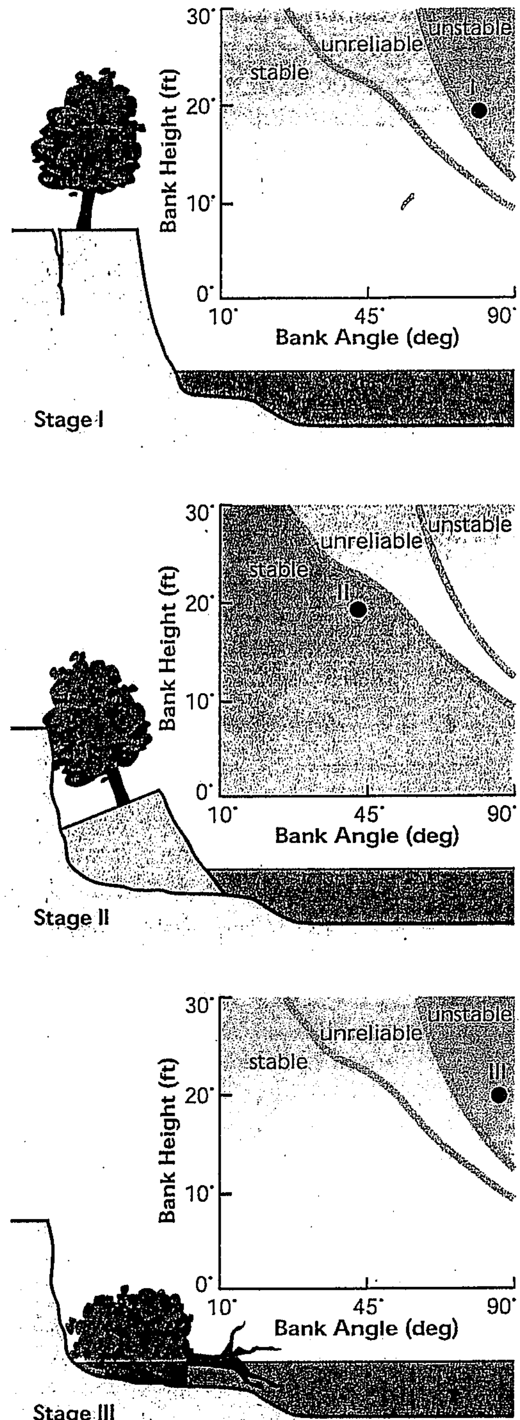


__Figure 8.30: Bank failure stages.__ Stability of a bank will vary from stable to unstable depending on bank height, bank angle, and soil conditions.

where a power number based on velocity, depth, and bend geometry exceeds an erodibility index computed from tabulated values of streambank material properties. Also among this group are analytical models such as the one developed by Odgaard (1989), which contain rather sophisticated representations of flow fields, but require input of an empirical constant to quantify soil and vegetation properties. These models should be applied with careful consideration of their limitations. For example, Odgaard's model should not be applied to bends with "large curvature."

The second group of predictive tools focuses on banks that undergo mass failure due to geotechnical processes. Side slopes of deep channels may be high and steep enough to be geotechnically unstable and to fail under the influence of gravity. Fluvial processes in such a situation serve primarily to remove blocks of failed material from the bank toe, leading to a resteepened bank profile and a new cycle of failure, as shown in Figure 8.30. Study of bank failure processes along incised channels has led to a procedure for relating bank geometry to stability for a given set of soil conditions (Osman and Thorne 1988). If banks of a proposed design channel are to be higher than about 10 feet, stability analysis should be conducted. These analyses are described in detail in Chapter 7. Bank height estimates should allow for scour along the outside of bends. High, steep banks are also susceptible to internal erosion, or piping, as well as streambanks of soils with high dispersion rates.

Allowable Velocity Check

Fortier and Scobey (1926) published tables regarding the maximum nonscouring velocity for given channel boundary materials. Different versions of these tables have appeared in numerous subsequent documents, notably Simons and Senturk (1977) and USACE (1991). The applicability of these tables is limited to relatively straight silt and sand-bed channels with depths of flow less than 3 feet and very low bed material loads. Adjustments to velocities have been suggested for situations departing from those specified. Although slight refinements have been made, these data still form the basis of the allowable velocity approach.

Figure 8.31 contains a series of graphs that summarize the tables and aid in selecting correction factors for flow depth, sediment concentration, flow frequency, channel curvature, bank slope, and channel boundary soil properties. Use of the allowable velocity approach is not recommended for channels transporting a significant load of material larger than 1 mm. The restoration design, however, should also consider the effects of hydraulic roughness and the protection afforded by vegetation.

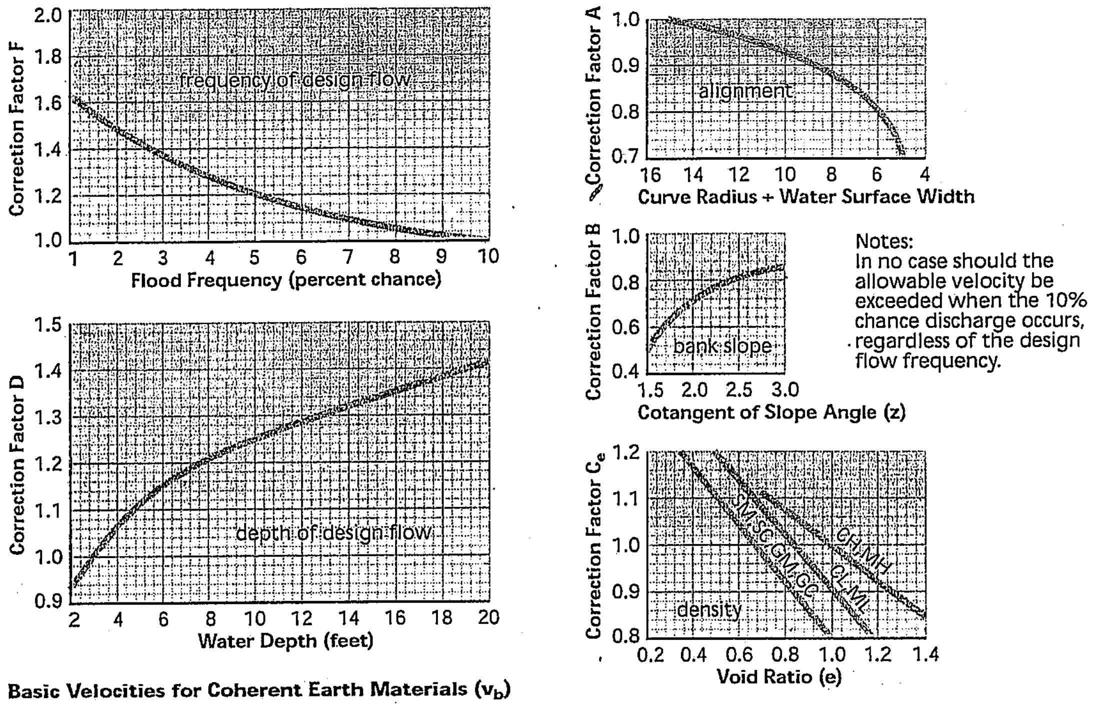
Perhaps because of its simplicity, the allowable velocity method has been used directly or in slightly modified form for many restoration applications. Miller et al. (1983) used allowable velocity criteria to design man-made gravel riffles located immediately downstream of a dam releasing a constant discharge of sediment-free water. Shields (1983) suggested using allowable velocity criteria to size individual boulders placed in channels to serve as instream habitat structures. Tarquin and Baeder (1983) present a design approach based on allowable velocity for low-order ephemeral streams in Wyoming landscapes disturbed by surface mining. Velocity of the design event (10-year recurrence interval) was manipulated by adjusting channel length (and thus slope), width, and roughness. Channel roughness was adjusted by adding meanders, planting shrubs, and adding coarse bed material. The channel width-to-depth ratio design was based on the pre-mining channel configuration.

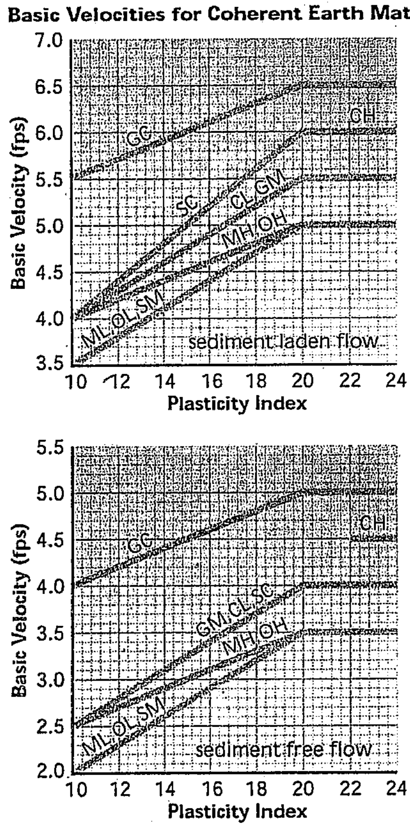
Allowable Stress Check

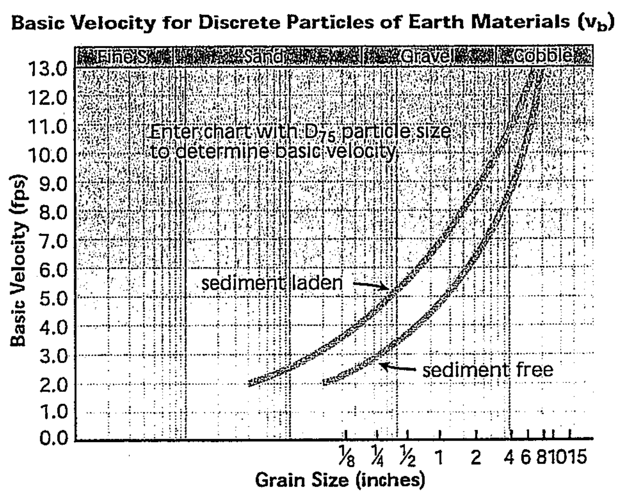
Since boundary shear stress is more appropriate than velocity as a measure of the forces driving erosion, graphs have also been developed for allowable shear stress. The average boundary shear stress acting on an open channel conveying a uniform flow of water is given by the product of the unit weight of water (γ, lb/ft^3) times the hydraulic radius (R, ft) times the bed slope S:

$$\tau = \gamma RS$$

Figure 8.32 is an example of allowable shear stress criteria presented in graphical form. The most famous graphical presentation of allowable shear stress criteria is the Shields diagram, which depicts conditions necessary for initial movement of noncohesive particles on





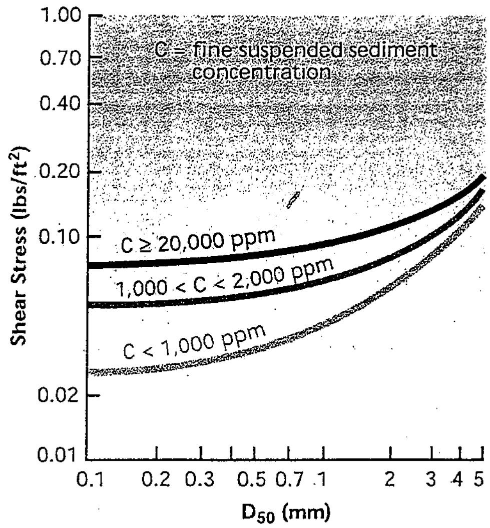


Allowable Velocities for Unprotected Earth Channels	
Channel Boundary Materials	**Allowable Velocity**
Discrete Particles	
Sediment Laden Flow	
$D_{75} > 0.4$mm	basic velocity chart value x D x A x B
$D_{75} < 0.4$mm	2.0 fps
Sediment Free Flow	
$D_{75} > 0.2$mm	basic velocity chart value x D x A x B
$D_{75} < 0.2$mm	2.0 fps
Coherent Earth Materials	
PI > 10	basic velocity chart value x D x A x F x C_e
PI < 10	2.0 fps

Figure 8.31: Allowable velocities for unprotected earth channels. *Curves reflect practical experience in design of stable earth channels.*

Source: USDA Soil Conservation Service 1977.

Figure 8.32: ***Allowable mean shear stress for channels with boundaries of noncohesive material larger than 5 mm carrying negligible bed material load.*** *Shear stress diminishes with increased suspended sediment concentrations.*
Source: Lane 1955.



a flat bed straight channel in terms of dimensionless variables (Vanoni 1975). The Shields curve and other allowable shear stress criteria (e.g., Figure 10.5, Henderson 1966; Figure 7.7, Simons and Senturk 1977) are based on laboratory and field data. In simplest form, the Shields criterion for channel stability is (Henderson 1966):

$$RS/[(S_s-1)D_s] < \text{a constant}$$

$$\text{for } D_s > \sim 6 \text{ mm}$$

where S_s is the specific gravity of the sediment and D_s is a characteristic bed sediment size, usually taken as the median size, D_{50}, for widely graded material. Note that the hydraulic radius, R, and the characteristic bed sediment size, D_s, must be in the same units for the Shields constant to be dimensionless. The dimensionless constant is based on measurements and varies from 0.03 to 0.06 depending on the data set used to determine it and the judgment of the user (USACE 1994).

These constant values are for straight channels with flat beds (no dunes or other bedforms). In natural streams, bedforms are usually present, and values of this dimensionless constant required to cause entrainment of bed material may be greater than 0.06. It should be noted that entrainment does not imply channel erosion. Erosion will occur only if the supply of sediment from upstream is less than that transported away from the bed by the flow. However, based on a study of 24 gravel-bed rivers in the Rocky Mountain region of Colorado, Andrews (1984) concluded that stable gravel-bed channels cannot be maintained at values of the Shields constant greater than about 0.080. Smaller Shields constant values are more conservative with regard to channel scour, but less conservative with regard to deposition. If S_s = 2.65, and the constant is assumed to be 0.06, the equation above simplifies to D_{50} = 10.1RS.

Allowable shear stress criteria are not very useful for design of channels with beds dominated by sand or finer materials. Sand beds are generally in motion at design discharge and have dunes, and their shear stress values are much larger than those indicated by the Shields criterion, which is for incipient motion on a plane bed. Allowable shear stress data for cohesive materials show more scatter than those for sands and gravels (Grissinger et al. 1981, Raudkivi and Tan 1984), and experience and observation with local channels are preferred to published charts like those shown in Chow (1959). Models of cohesive soil erosion require field or laboratory evaluation of model parameters or constants. Extrapolation of laboratory flume results to field conditions is difficult, and even field tests are subject to site-specific influences. Erosivity of cohesive soils is affected by the chemical composition of the soil, the soil water, and the stream, among other factors.

However, regional shear stress criteria may be developed from observations of channels with sand and clay beds. For example, USACE (1993) determined that reaches in the Coldwater River Watershed in northwest Mississippi should be stable with an average boundary shear stress at channel-forming (2-year) discharge of 0.4 to 0.9 lb/ft^2.

The value of the Shields constant also varies with bed material size distribution, particularly for paved or armored beds. Andrews (1983) derived a regression relationship that can be expressed as:

$$RS/[(S_s - 1)D_i] < 0.0834\ (D_i/D_{50})^{-0.872}$$

When the left side of the above expression equals the right, bed-sediment particles of size D_i are at the threshold of motion. The D_{50} value in the above expression is the median size of subsurface material. Therefore, if D_{50} = 30 mm, particles with a diameter of 100 mm will be entrained when the left side of the above equation exceeds 0.029. This equation is for self-formed rivers that have naturally sorted gravel and cobble bed material. The equation holds for values of D_i/D_{50} between 0.3 and 4.2. It should be noted that R and D_i on the left side of the above equation must be expressed in the same units.

Practical Guidance: Allowable Velocity and Shear Stress

Practical guidance for application of allowable velocity and shear stress approaches is provided by the Natural Resources Conservation Service (USDA-NRCS), formerly the U.S. Soil Conservation Service (SCS) (1977), and USACE (1994). See Figure 8.31.

Since form roughness due to sand dunes, vegetation, woody debris, and large geologic features in streams dissipates energy, allowable shear stress for bed stability may be higher than indicated by laboratory flume data or data from uniform channels. It is important to compute cross-sectional average velocities or shear stresses over a range of discharges and for seasonal changes in the erosion resistance of bank materials, rather than for a single design condition. Frequency and duration of discharges causing erosion are important factors in stability determination. In cobble- or boulder-bed streams, bed movement sometimes occurs only for discharges with return periods of several years.

Computing velocity or shear stress from discharge requires design cross sections, slope, and flow resistance data. If the design channel is not extremely uniform, typical or average conditions for rather short channel reaches should be considered. In channels with bends, variations in shear stress across the section can lead to scour and deposition even when average shear stress values are within allowable limits. The NRCS (formerly SCS) (1977) gives adjustment factors for channel curvature in graphical form that are based on very limited data (see Figure 8.31). Velocity distributions and stage-discharge relations for compound channels are complex (Williams and Julien 1989, Myers and Lyness 1994).

Allowable velocity or shear stress criteria should be applied to in-channel flow for a compound cross section with overbank flow, not cross-sectional average conditions (USACE 1994). Channel flow resistance predictors that allow for changing conditions with changing discharge and stage should be used rather than constant resistance values.

If the existing channel is stable, design channel slope, cross section, and roughness may be adjusted so that the current and proposed systems have matching curves of velocity versus discharge (USACE 1994). This approach, while based on allowable velocity concepts, releases the procedure from published empirical values collected in other rivers that might be intrinsically different from the one in question.

Allowable Stream Power or Slope

Brookes (1990) suggested the product of bankfull velocity and shear stress, which is equal to the stream power per unit bed area, as a criterion for stability in stream restoration initiatives. This is based on experience with several restoration initiatives in Denmark and the United Kingdom with sandy banks, beds of glacial outwash sands, and a rather limited range of bankfull discharges (~15 to 70 cfs). These data are plotted as squares, triangles, and circles in **Figure 8.33.**

Brookes suggested that a stream power value of 2.4 $ft\text{-}lb/sec/ft^2$ discriminated well between stable and unstable channels. Projects with stream powers less than about 1.0 $ft\text{-}lb/sec/ft^2$ failed through deposition, whereas those with stream powers greater than about 3.4 $ft\text{-}lb/sec/ft^2$ failed through erosion.

Since these criteria are based on observation of a limited number of sites, application to different stream types (e.g., cobble-bed rivers) should be avoided.

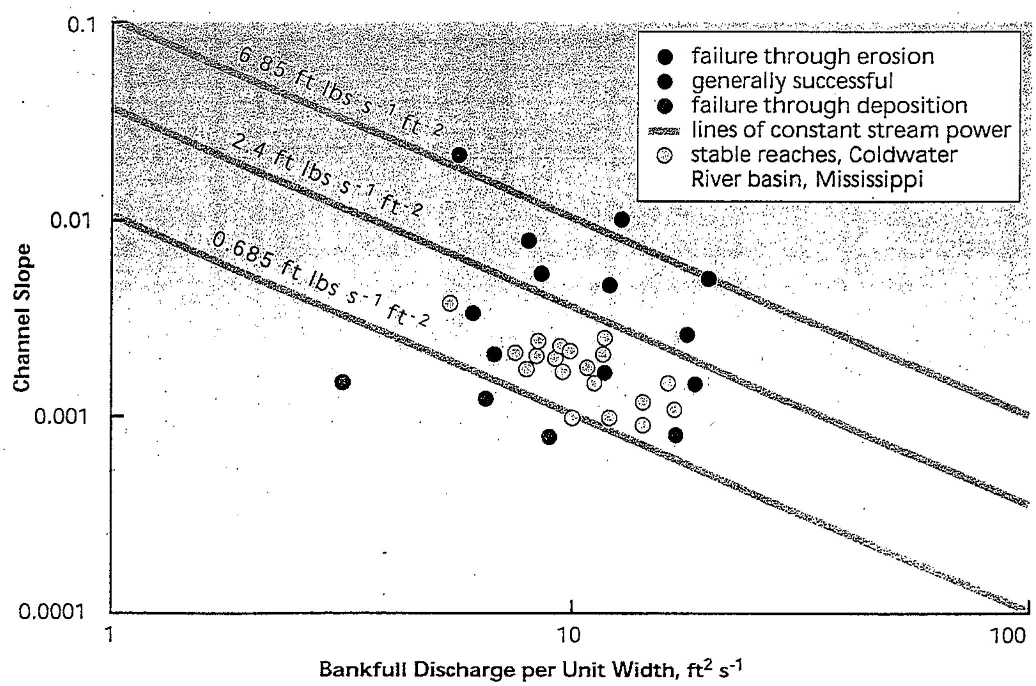
However, similar criteria may be developed for basins of interest. For example, data points representing stable reaches in the Coldwater River watershed of northwestern Mississippi are shown in Figure 8.34 as stars. This watershed is characterized by incised, straight (channelized) sand-bed channels with cohesive banks. Slopes for stable reaches were measured in the field, and 2-year discharges were computed using a watershed model (HEC-1) (USACE 1993).

Brookes' stream power criterion is one of several region-specific stability tests. Others include criteria based on slope and shear stress. Using empirical data and observation, the Corps of Engineers has developed relationships between slope and drainage area for various watersheds in northwestern Mississippi (USACE 1989c). For example, stable reaches in three watersheds had slopes that clustered around the regression line:

$$S = 0.0041\ A^{-0.365}$$

where A is the contributing drainage area in square miles. Reaches with much steeper slopes tended to be degra-

***Figure 8.33:* Brookes' stream power stability criteria.** *Stream power is the product of bankfull velocity and shear stress.*



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Allowable Shear Stress

The shape of the bed material size distribution is an important parameter for determining the threshold of motion of individual sediment sizes in a bed containing a mixture of sand and gravel. Beds composed of unimodal (particle-size distribution shows no secondary maxima) mixtures of sand and gravel were found to have a narrow range of threshold shear stresses for all sizes present on the bed surface. For unimodal beds, the threshold of motion of all grain sizes on the bed was found to be estimated adequately by using the Shields curve for the median grain size. Bed sediments composed of bimodal (particle-size distribution shows one secondary maximum) mixtures of sands and gravels were found to have threshold shear stresses that are still a function of grain size, although much less so than predicted by the Shields curve. For bed material with bimodal size distributions, using the Shields curve on individual grain sizes greater than the median size overestimates the threshold of motion and underestimates the threshold of motion for grain sizes less than the median size. Critical shear stresses for gravel beds may be elevated if gravels are tightly interlocked or imbedded.

Jackson and Van Haveren (1984) present an iterative technique for designing a restored channel based on allowable shear stress. Separate calculations were performed for channel bed and banks. Channel design included provision for gradual channel narrowing as the bank vegetation develops, and bank cohesion and resistance to erosion increase. Newbury and Gaboury (1993) use an allowable tractive force graph from Lane (1955) to check stability of channel restoration initiatives in Manitoba streams with cobble and gravel beds. Brookes (1991) gives an example of the application of this method for designing urban channels near London. From a practical standpoint, boundary shear stresses can be more difficult to measure and conceptualize than velocities (Brookes 1995). Allowable shear stress criteria may be converted to allowable velocities by including mean depth as a parameter.

The computed shear stress values are averages for the reach in question. Average values are exceeded at points, for example, on the outside of a bend.

dational, while those with more gradual slopes tended to be aggradational. Downs (1995) developed stability criteria for channel reaches in the Thames Basin of the United Kingdom based entirely on slope: channels straightened during the 20th century were depositional if slopes were less than 0.005 and erosional if slopes were greater.

Sediment Yield and Delivery

Sediment Transport

If a channel is designed using an empirical or a tractive stress approach, computation of sediment-transport capacity allows a rough check to determine whether deposition is likely to be a problem. Sediment transport relationships are heavily dependent on the data used in their development. Inaccuracy may be reduced by selecting transport functions appropriate to the stream type and bed sediment size in question. Additional confidence can be achieved by obtaining calibration data; however, calibration data are not available from a channel yet to be constructed. If the existing channel is reasonably stable, designers can compute a sediment discharge versus streamflow relationship for the existing and proposed design channels using the same sediment transport function and try to match the curves as closely as possible (USACE 1994).

If information is available regarding sediment inflows into the new channel, a multiyear sediment budget can be computed to project likely erosion and deposition and possible maintenance needs. Sediment load can also be computed, using the hydraulic properties and bed material gradations of the upstream supply reach and a suitable sediment transport function. The USACE software SAM (Copeland 1994) includes routines that compute hydraulic properties for uniform flow and sediment discharge for single cross sections of straight channels using any of 13 different sediment transport functions. Cross sections may have complex geometry and boundary materials that vary along the section. Output can be combined with a hydrograph or a flow duration curve to obtain sediment load.

HEC-6 (USACE 1993) is a one-dimensional movable-boundary, open-channel-flow numerical model designed to simulate and predict changes in river profiles resulting from scour and deposition over moderate time periods, typically years, although applications to single flood events are possible. A continuous discharge record is partitioned into a series of steady flows of variable discharge and duration. For each discharge, a water surface profile is calculated, providing energy slope, velocity, depth, and other variables at each cross section. Potential sediment transport rates are then computed at each section. These rates, combined with the duration of the flow, permit a volumetric accounting of sediment within each reach. The amount of scour or deposition at each section is then computed, and the cross section geometry is adjusted for the changing sediment volume. Computations then proceed to the next flow in the sequence, and the cycle is repeated using the updated cross section geometry. Sediment calculations are performed by grain size fractions, allowing the simulation of hydraulic sorting and armoring.

HEC-6 allows the designer to estimate long-term response of the channel to a predicted series of water and sediment supply. The primary limitation is that HEC-6 is one-dimensional, i.e., geometry is adjusted only in the vertical direction. Changes in channel width or planform cannot be simulated. Another Federal sediment routing model is the GSTARS 2.0 (Yang et al. 1998). GSTARS 2.0 can be used for a combination of subcritical and supercritical flow computations without interruption in a semi-two-dimensional manner. The use of stream tube concept in sediment routing enables GSTARS 2.0 to simulate channel geometry changes in a semi-three-dimensional manner.

The amount and type of sediment supplied to a stream channel is an important consideration in restoration because sediment is part of the balance (i.e., between energy and material load) that determines channel stability. A general lack of sediment relative to the amount of stream power, shear stress, or energy in the flow (indexes of transport capacity) usually results in erosion of sediment from the channel boundary of an alluvial channel. Conversely, an oversupply of sediment relative to the transport capacity of the flow usually results in deposition of sediment in that reach of stream.

Bed material sediment transport analyses are necessary whenever a restoration initiative involves reconstructing a length of stream exceeding two meander wavelengths. A reconstruction that modifies the size of a cross section and the sinuosity for such a length of channel should be analyzed to ensure that upstream sediment loads can be transported through the reconstructed reach with minimal deposition or erosion. Different storm events and the average annual transported bed material load also should be examined.

Sediment Discharge Functions

The selection of an appropriate discharge formula is an important consideration when attempting to predict sediment discharge in streams. Numerous sediment discharge formulas have been proposed, and extensive summaries are provided by Alonso and Combs (1980), Brownlie (1981), Yang (1996), Bathurst (1985), Gomez and Church (1989), and Parker (1990).

Sediment discharge rates depend on flow velocity; energy slope; water temperature; size, gradation, specific gravity, and shape of the bed material and suspended-sediment particles; channel geometry and pattern; extent of bed surface covered by coarse material; rate of supply of fine material; and bed configuration. Large-scale variables such as hydrologic, geologic, and climatic conditions also affect the rate of sediment transport. Because of the range and number of variables, it is not possible to select a sediment transport formula that satisfactorily encompasses all the conditions that might be encountered. A specific formula might be more accurate than others when applied to a particular river, but it might not be accurate for other rivers.

Selection of a sediment transport formula should include the following considerations (modified from Yang 1996):

- Type of field data available or measurable within time, budget, and work hour limitations.
- Independent variables that can be determined from available data.
- Limitations of formulas versus field conditions.

If more than one formula can be used, the rate of sediment discharge should be calculated using each formula. The formulas that best agree with available measured sediment discharges should be used to estimate the rate of sediment discharge during flow conditions when actual measurements are not available.

The following formulas may be considered in the absence of any measured sediment discharges for comparison:

- Meyer-Peter and Muller (1948) formula when the bed material is coarser than 5 mm.
- Einstein (1950) formula when bed load is a substantial part of the total sediment discharge.
- Toffaleti (1968) formula for large sand-bed rivers.
- Colby (1964) formula for rivers with depths less than 10 feet and median bed material values less than 0.8 mm.
- Yang (1973) formula for fine to coarse sand-bed rivers.
- Yang (1984) formula for gravel transport when most of the bed material ranges from 2 to 10 mm.
- Ackers and White (1973) or Engelund and Hansen (1967) formula for sand-bed streams having subcritical flow.
- Laursen (1958) formula for shallow rivers with fine sand or coarse silt.

Available sediment data from a gaging station may be used to develop an empirical sediment discharge curve in the absence of a satisfactory sediment discharge formula, or to verify the sediment discharge trend from a selected formula. Measured sediment discharge or concentration should be plotted against streamflow, velocity, slope, depth, shear stress, stream power, or unit stream power. The curve with the least scatter and systematic deviation should be selected as the sediment rating curve for the station.

Sediment Budgets

A sediment budget is an accounting of sediment production in a watershed. It attempts to quantify processes of erosion, deposition, and transport in the basin. The quantities of erosion from all sources in a watershed are estimated using various procedures. Typically, the tons of erosion from the various sources are multiplied by sediment delivery ratios to estimate how much of the eroded soil actually enters a stream. The sediment delivered to the streams is then routed through the watershed.

The sediment routing procedure involves estimating how much of the sediment in the stream ends up being deposited in lakes, reservoirs, wetlands, or floodplains or in the stream itself. An analysis of the soil textures by erosion process is used to convert the tons of sediment delivered to the stream into tons of silt and clay, sand, and gravel. Sediment transport processes are applied to help make decisions during the sediment routing analysis. The end result is the sediment yield at the mouth of the watershed or the beginning of a project reach.

Table 8.5 is a summary sediment budget for a watershed. Note that the information in the table may be from measured values, from estimates based on data from similar watersheds, or from model outputs (AGNPS, SWRRBWQ, SWAT, WEPP, RUSLE, and others. Contact the NRCS National Water and Climate Data Center for more information on these models). Sediment delivery ratios are determined for watershed drainage areas, based on sediment gauge data and reservoir sedimentation surveys.

The watershed is subdivided into subwatersheds at points where significant sediment deposition occurs, such as at bridge or road fills; where stream crossings cause channel and floodplain constrictions; and at reservoirs, lakes, significant flooded areas, etc. Sediment budgets similar to the table are constructed for each subwatershed so the sediment yield to the point of deposition can be quantified.

A sediment budget has many uses, including identification of sediment sources for treatment (**Figure 8.34**). If the goal for a restoration initiative is to reduce sedimentation from a watershed, it is critical to know what type of erosion is producing the most sediment and where that erosion is occurring. In stream corridor restoration, sediment yield (both in terms of quantity and average grain size diameter) to a stream and its floodplain need to be identified and considered in designs. In channel stability investigations, the amount of sand and gravel sediment entering the stream from the watershed needs to be quantified to refine bed material transport calculations.

Example of a Sediment Budget

A simple application of a sediment transport equation in a field situation illustrates the use of a sediment budget. **Figure 8.35** shows a stream reach being evaluated for stability prior to developing a stream corridor restoration plan. Five representative channel cross sections (A, B, C, D, and E) are surveyed. Locations of the cross sections are selected to represent the reach above and below the points where tributary streams, D and E, enter the reach. Additional cross sections would need to be surveyed if the stream at A, B, C, D, or E is not typical of the reach.

An appropriate sediment transport equation is selected, and the transport capacity at each cross section for bed material is computed for the same flow conditions. Figure 8.35 shows the sediment loads in the stream and the transport capacities at each point.

Table 8.5: Example of a sediment budget for a watershed.

Protection Level	Erosion Source	Acres or Miles	Average Erosion Rate (tons/acre/year or tons/bank mile/year)	Annual Erosion (tons/year)	Sediment Delivery Ratio (percent)	Sediment to Streams	Sediment Deposited Uplands & Floodplains (tons/year)	Sediment Delivered to Blue Stem Lake (tons/year)	Sediment Delivered to Blue Stem Lake (percent)
	Sheet, rill, and ephemeral gully								
Adequate	Cropland	6000	3.0	18,000	30	5400	14,380	3620	33.7
Inadequate	Cropland	1500	6.5	9750	30	2930	7790	1960	18.3
Adequate	Pasture/hayland	3400	1.0	3400	20	680	2940	460	4.3
Inadequate	Pasture/hayland	600	6.0	3600	20	720	3120	480	4.5
Adequate	Forestland	1200	0.5	600	20	120	520	80	0.7
Inadequate	Forestland	300	5.5	1650	20	330	1430	220	2.1
Adequate	Parkland	700	1.0	700	30	210	560	140	1.3
Inadequate	Parkland	0	0	0	30	0	0	0	0.0
Adequate	Other	420	2.0	840	20	170	730	110	1.0
Inadequate	Other	0	0	0	20	0	0	0	0.0
	Classic gully	N/A	N/A	600	40	240	440	160	1.5
	Streambank								
	Slight	14	50	100	700	5400	140	560	5.2
	Moderate	10.5	150	1580	100	1580	320	1260	11.7
	Severe	3.5	600	2100	100	2100	420	1680	15.7
			Total erosion	43,520			Total sediment to Blue Stem Lake	10,730	

The transport capacities at each point are compared to the sediment load at each point. If the bed material load exceeds the transport capacity, deposition is indicated. If the bed material transport capacity exceeds the coarse sediment load available, erosion of the channel bed or banks is indicated.

Figure 8.35 compares the loads and transport capacities within the reach. The stream might not be stable below B due to deposition. The 50 tons/day deposition is less than 10 percent of the total bed material load in the stream. This small amount of sediment is probably within the area of uncertainty in such analyses. The stream below C probably is unstable due to the excess energy (transport capacity) causing either the banks or bottom to be eroded.

After this type of analysis is complete, the stream should be inspected for

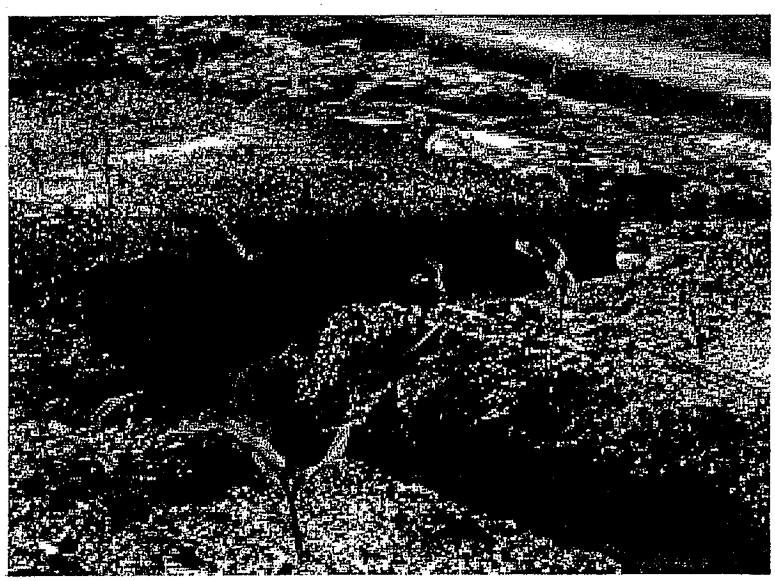

***Figure 8.34: Eroded upland area.** Upland sediment sources should be identified in a sediment budget.*

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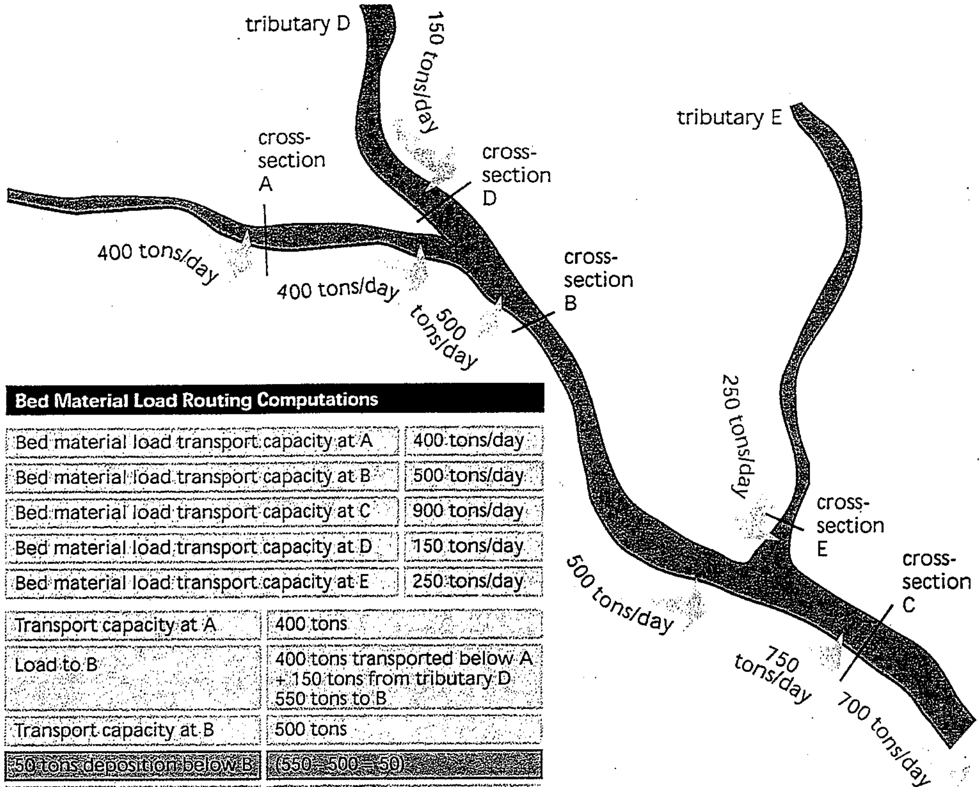
Figure 8.35: ***Sediment budget.*** *Stream reaches should be evaluated for stability prior to developing a restoration plan.*



Bed Material Load Routing Computations

Bed material load transport capacity at A	400 tons/day
Bed material load transport capacity at B	500 tons/day
Bed material load transport capacity at C	900 tons/day
Bed material load transport capacity at D	150 tons/day
Bed material load transport capacity at E	250 tons/day

Transport capacity at A	400 tons
Load to B	400 tons transported below A + 150 tons from tributary D 550 tons to B
Transport capacity at B	500 tons
50 tons deposition below B	(550 – 500 = 50)
Load to C	500 tons transported below B + 250 tons from tributary E 750 tons to C
Transport capacity at C	900 tons
150 tons erosion below C	(750 – 900 = –150 tons)

areas where sediment is building up or where the stream is eroding. If these problem areas do not match the predictions from the calculations, the sediment transport equation may be inappropriate, or the sediment budget, the hydrology, or the channel surveys may be inaccurate.

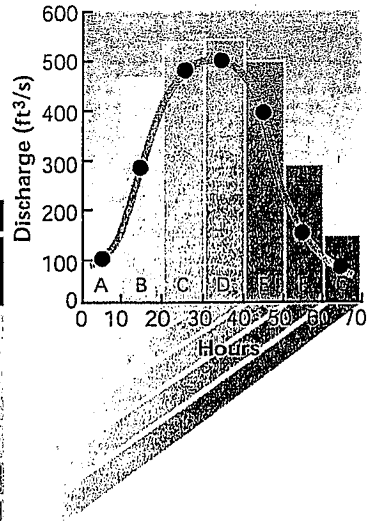
Single Storm versus Average Annual Sediment Discharge

The preceeding example predicts the amount of erosion and deposition that can be expected to occur over one day at one discharge. The bed material transport equation probably used one grain size of sediment. In reality, a variety of flows over varying lengths of time move a variety of sediment particle sizes. Two other approaches should be used to help predict the quantity of bed material sediment transported by a stream during a single storm event or over a typical runoff year.

To calculate the amount of sediment transported by a stream during a single storm event, the hydrograph for the event is divided into equal-length segments of time. The peak flow or the average discharge for each segment is determined. A spreadsheet can be developed that lists the discharges for each segment of a hydrograph in a column (**Table 8.6**). The transport capacity from the sediment rating curve for each discharge is shown in another column (**Figure 8.36**). Since the transport capacity is in tons/day, a third column should include the length of time represented by each segment of the hydro-

Table 8.6: ***Sediment discharges for segments of a hydrograph.*** *The amount of sediment discharged through a reach varies with time during a stream flow event.*

Column 1	Column 2	Column 3	Column 4	Column 5
Segment of Hydrograph	**Segment Discharge (ft^3/s)**	**Transport Capacity (tons/day)**	**Segment Time (days)**	**Actual Transport (tons)**
A	100	150	.42	62
B	280	1700	.42	708
C	483	6000	.42	2500
D	500	6500	.42	2708
E	390	4500	.42	1875
F	155	530	.42	221
[illegible]	80	[illegible]	.42	[illegible]
[illegible]				[illegible]



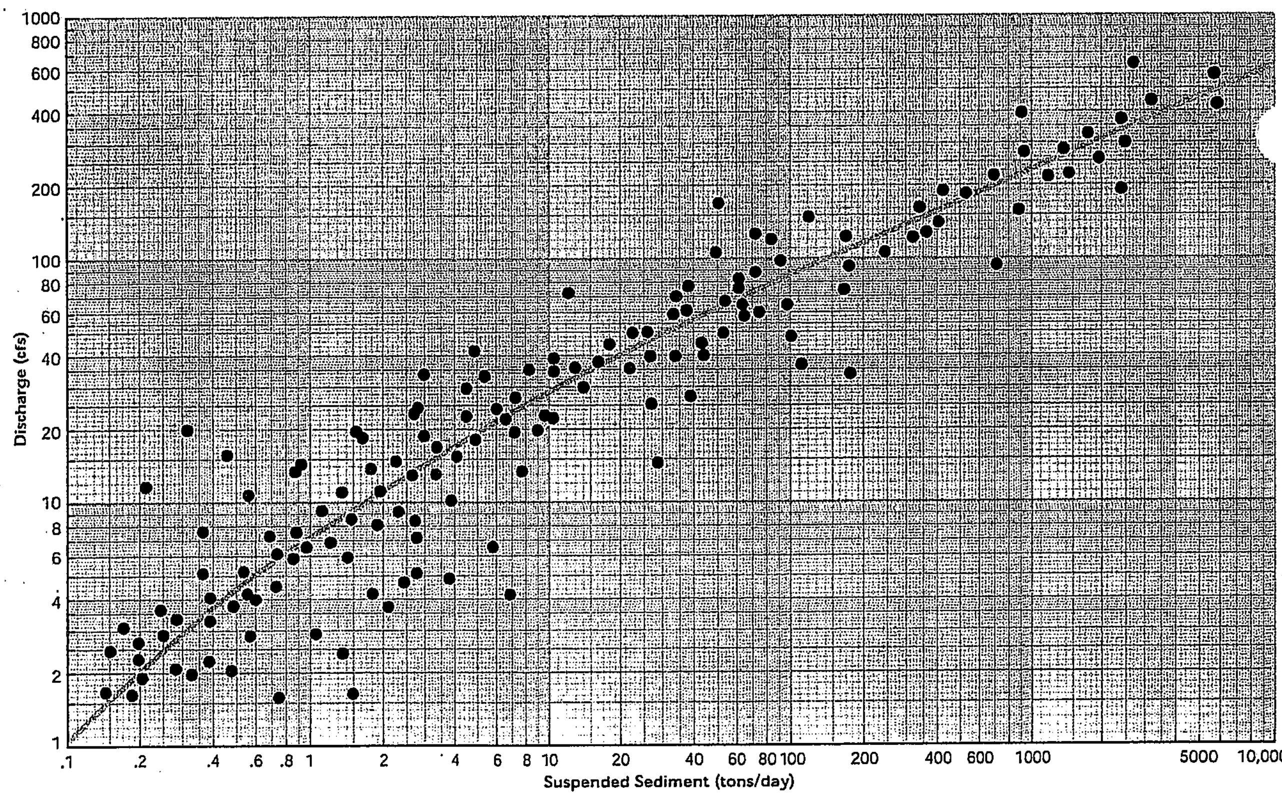


Figure 8.36: Sediment rating curve. *A "sediment rating curve" rates the quantity of sediment carried by a specific stream flow at a defined point or gage.*

graph. This column is multiplied by the transport capacity to create a final column that represents the amount of sediment that could be transported over each segment of the hydrograph. Summing the values in the last column shows the total bed material transport capacity generated by that storm.

Average annual sediment transport in a stream can be determined using a procedure very similar to the storm prediction. The sediment rating curve can be developed from predictive equations or from physical measurements. The annual flow duration curve is substituted for the segmented hydrograph. The same type of spreadsheet described above can be used, and the sum of the values in the last column is the annual sediment-transport capacity (based on predictive equations) or the actual annual sediment transport if the rating curve is based on measured data.

Sediment Discharge After Restoration

After the sediment transport analysis results have been field-checked to ensure that field conditions are accurately predicted, the same analyses are repeated for the new cross sections and slope in a reconstructed stream or stream reach. Plans and designs may be modified if the second analysis indicates significant deposition or erosion could occur in the modified reach. If potential changes in runoff or sediment yield are predicted to occur in the watershed above a potential restoration site, the sediment transport analyses should be done again based on these potential changes.

Stability Controls

The risk of a restored channel's being damaged or destroyed by erosion or deposition can be reduced if economic considerations permit installation of control measures. Control measures are also required if "natural" levels of channel instability (e.g., meander migration) are unacceptable in the restored reach.

In many cases, control measures double as habitat restoration devices or aesthetic features (Nunnally and Shields 1985, Newbury and Gaboury 1993). Control measures may be categorized as bed stabilization devices, bank stabilization devices, and hydrologic measures. Reviews of control measures are found in Vanoni (1975), Simons and Senturk (1977), Petersen (1986), Chang (1988), and USACE (1989b, 1994), and are treated only briefly here. Haan et al. (1994) provide design guidance for sediment control on small watersheds. In all cases, sediment control systems should be planned and designed with the geomorphic evolution of the watershed in mind.

Even where streams retain relatively natural patterns of flow and flooding, stream corridor restoration might require that streambanks be temporarily (years to decades) stabilized while floodplain vegetation recovers. The objective in such instances is to arrest the accelerated erosion often associated with unvegetated banks, and to reduce erosion to rates appropriate for the stream system and setting. In these situations, the initial bank protection may be provided primarily with vegetation, wood, and rock as necessary (refer to Appendix A).

In other cases, land development or modified flows may dictate the use of hard structures to ensure permanent stream stability, and vegetation is used primarily to address specific ecological deficiencies such as a lack of channel shading. In either case (permanent or temporary bank stabilization), streamflow projections are used (as described in Chapter 7) to determine the degree to which vegetation must be supplemented with more resistant materials (natural fabrics, wood, rock, etc.) to achieve adequate stabilization.

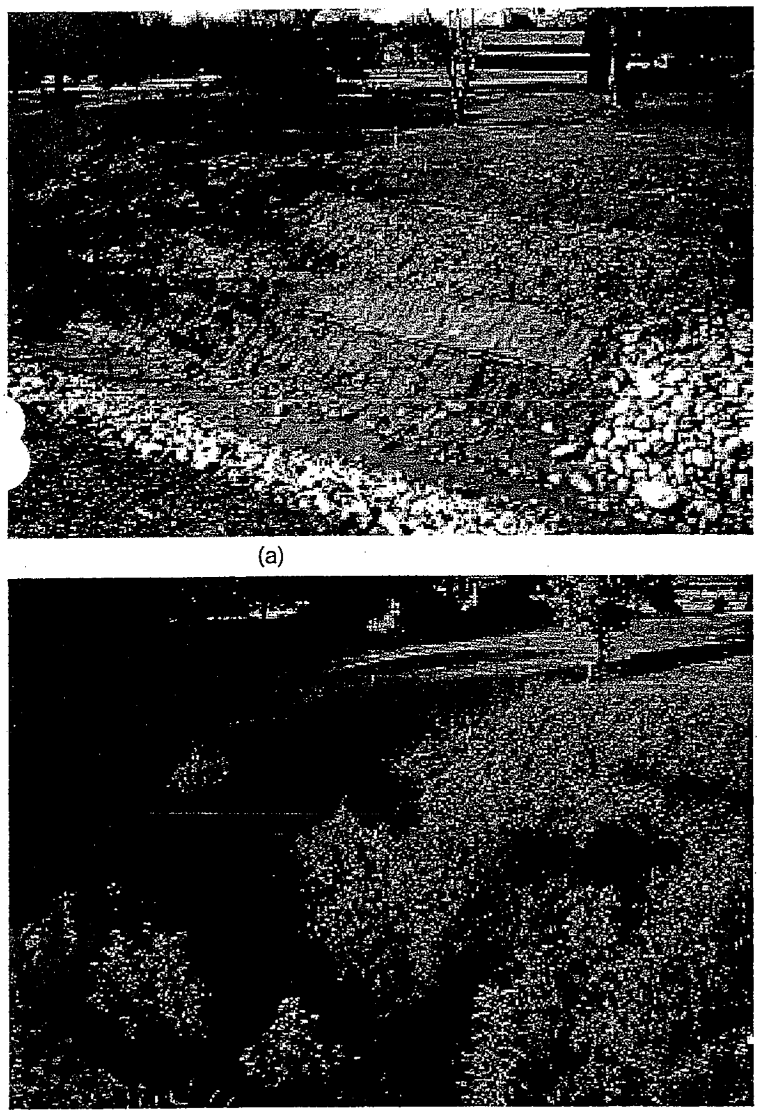
The causes of excessive erosion may be reversible through changes in land use, livestock management, floodplain restoration, or water management. In some cases, even normal rates of bank erosion and channel movement might be considered unacceptable due to adjacent development, and vegetation might be used primarily to recover some habitat functions in the vicinity of "hard" bank stabilization measures. In either case, the considerations discussed above with respect to soils, use of native plant species, etc., are applicable within the bank zone. However, a set of specialized techniques can be employed to help ensure plant establishment and improve habitat conditions.

As discussed earlier in this chapter, integration of woody vegetative cuttings, independently or in combination with other natural materials, in streambank erosion control projects is generally referred to as soil bioengineering. Soil-bioengineered bank stabilization systems have not been standardized for general application under particular flow conditions, and the decision as to whether and how to use them requires careful consideration of a variety of factors. On larger streams or where erosion is severe, an effective approach involves a team effort that includes expertise in soils, biology, plant sciences, landscape architecture, geology, engineering, and hydrology.

Soil bioengineering approaches usually employ plant materials in the form of live woody cuttings or poles of readily sprouting species, which are inserted deep into the bank or anchored in various other ways. This serves the dual purposes of resisting washout of plants during the early establishment period, while providing some immediate erosion protection due to the physical resistance of the stems. Plant materials alone are sufficient on some streams or some bank zones, but as erosive forces increase, they can be combined with other materials such as rocks, logs or brush, and natural fabrics (**Figure 8.37**). In some cases, woody debris is incorporated specifically to improve habitat characteristics of the bank and near-bank channel zones.

Preliminary site investigations (see **Figure 8.38**) and engineering analyses must be completed, as described in Chapter 7, to determine the mode of bank failure and the feasibility of using vegetation as a component of bank stabilization work. In addition to the technical analyses of flows and soils, preliminary investigations must include consideration of access, maintenance, urgency, and availability of materials.

Generalizations regarding water levels and flow velocities should be taken only as indications of the experiences reported from various bank stabilization projects. Any particular site must be evaluated to determine how vegetation can or cannot be used. Soil cohesiveness, the presence of gravel lenses, ice accumulation patterns, the amount of sunlight reaching the bank, and the ability to ensure that grazing will be precluded are all considerations in assessing the suitability of vegetation to achieve bank stabilization. In addition, modified flow patterns may make portions of the bank inhospitable to plants because of inappropriate timing of inundation rather than flow velocities and durations (Klimas 1987). The need to extend protection well beyond the immediate focus of erosion and to protect against flanking is an important design consideration.



(a)

(b)

Figure 8.37: A stabilized streambank. *Plant materials can be combined with other materials such as rocks, logs or brush, and natural fabrics. [(a) during and (b) after.]*

As noted in Section 8.E, streambank stabilization techniques can generally be classified as armor, indirect methods, or vegetative methods. The selection of the appropriate stabilization technique is extremely important and can be expressed in terms of the factors discussed below.

Effectiveness of Technique

The inherent factors in the properties of a given bank stabilization technique, and in the physical characteristics of a proposed work site, influence the suitability of that technique for that site. Effectiveness refers to the suitability and adequacy of the technique. Many techniques can be designed to adequately solve a specific bank stability problem by resisting erosive forces and geotechnical failure. The challenge is to recognize which technique matches the strength of protection against the strength of attack and therefore performs most efficiently when tested by the strongest process of erosion and most critical mechanism of failure. Environmental and economic factors are integrated into the selection procedure, generally making soil bioengineering methods very attractive. The chosen so-

CASE STUDY Careless Creek, Montana

In the Big Snowy Mountains of central Montana, Careless Creek begins to flow through rangelands and fields until it reaches the Musselshell River. At the beginning of the century, the stream was lined with a riparian cover, primarily of willow. This stream corridor was home to a diversity of wildlife such as pheasant, beaver, and deer.

In the 1930s, a large reservoir was constructed to the west with two outlets, one connected to Careless Creek. These channels were meant to carry irrigation water to the area fields and on to the Musselshell River. Heavy flows during the summer months began to erode the banks (Figure 8.39a). In the following years, ranchers began clearing more and more brush for pasture, sometimes burning it out along a stream.

"My Dad carried farmer's matches in his pocket. There was a worn spot on his pants where he would strike a match on his thigh," said Jessie Zeier, who was raised on a ranch near Careless Creek, recalling how his father often cleared brush.

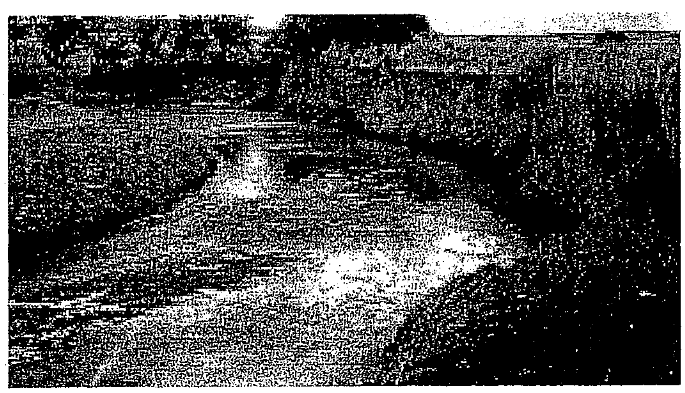
Any remaining willows or other species were eliminated in the following years as ranchers began spraying riparian areas to control sagebrush. This accelerated the streambank erosion as barren, sometimes vertical, banks began sloughing off chunks of salted g<None>s developed to help the planning effort. Many organizations took part, including the Upper and Lower Musselshell Conservation Districts; Natural Resources Conservation Service; Montana Department of Natural Resources and Conservation; Montana Department of Fish; Wildlife and Parks; Deadman's Basin Water Users Association; U.S. Bureau of Reclamation; Central Montana RC&D; City of Roundup; Roundup Sportsmen; county commissioners; and local landowners.

As part of the planning effort, a geographic information system resource inventory was begun in 1993. The inventory revealed about 50 percent of the banks along the 18 miles of Careless Creek were eroding. The inventory helped to locate the areas causing the most problems. Priority was given to headquarters, corrals, and croplands, where stabilization of approximately 5,000 feet of streambank has taken place, funded by EPA monies.

Passive efforts have also begun to stabilize the banks. Irrigation flows in Careless Creek have been decreased for the past 5 years, enabling some areas, such as the one pictured, to begin to self-heal (Figure 8.39b). Vegetation has been given a chance to root as erosion has begun to stabilize. Other practices, such as fencing, are being implemented, and future treatments are planned to provide a long-term solution.

Figure 8.39: Careless Creek. *(a) Eroded streambank (May 1995) and (b) streambank in recovery (December 1997).*

(a)



(b)

Figure 8.38: Eroded bank. Preliminary site investigation and analyses are critical to successful streambank stabilization design.

lution, however, must first fulfill the requirement of being effective as bank stabilization; otherwise, environmental and economic attributes will be irrelevant. Soil bioengineering can be a useful tool in controlling streambank erosion, but it should not be considered a panacea. It must be performed in a judicious manner by personnel experienced in channel processes, biology, and streambank stabilization techniques.

Stabilization Techniques

Plants may be established on upper bank and floodplain areas by using traditional techniques for seeding or by planting bare-root and container-grown plants. However, these approaches provide little initial resistance to flows, and plantings may be destroyed if subjected to high water before they are fully established. Cuttings, pole plantings, and live stakes taken from species that sprout readily (e.g., willows) are more resistant to erosion and can be used lower on the bank (Figure 8.40). In addition, cuttings and pole plantings can provide immediate moderation of flow velocities if planted at high densities. Often, they can be placed deep enough to maintain contact with adequate soil moisture levels, thereby eliminating the need for irrigation. The reliable sprouting properties, rapid growth, and general availability of cuttings of willows and other pioneer species makes them particularly appropriate for use in bank revegetation projects, and they are used in most of the integrated bank protection approaches described here (see Figure 8.41).

Anchored Cutting Systems

Several techniques are available that employ large numbers of cuttings arranged in layers or bundles, which can be secured to streambanks and partially buried. Depending on how these systems are arranged, they can provide direct protection from erosive flows, prevent erosion from upslope water sources, promote trapping of sediments, and quickly develop dense roots and sprouts. Brush mattresses and woven mats are typically used on the face of a bank and consist of cuttings laid side by side and interwoven or pinned down with jute cord or wire held in place by stakes. Brush layers are cuttings laid on terraces dug into the bank, then buried so that the branch ends extend from the bank. Fascines or wattles are bundles of cuttings tied together, placed in shallow trenches arranged horizontally on the bank face, partially buried, and staked in place. A similar system, called a reed roll, uses partially buried and staked burlap rolls filled with soil and root material or rooted shoots to establish herbaceous species in appropriate habitats. Anchored bundles of live cuttings also have been installed perpendicular to the channel on newly constructed gravel floodplain areas to dissipate floodwater energy and encourage deposition of sediment (Karle and Densmore 1994).

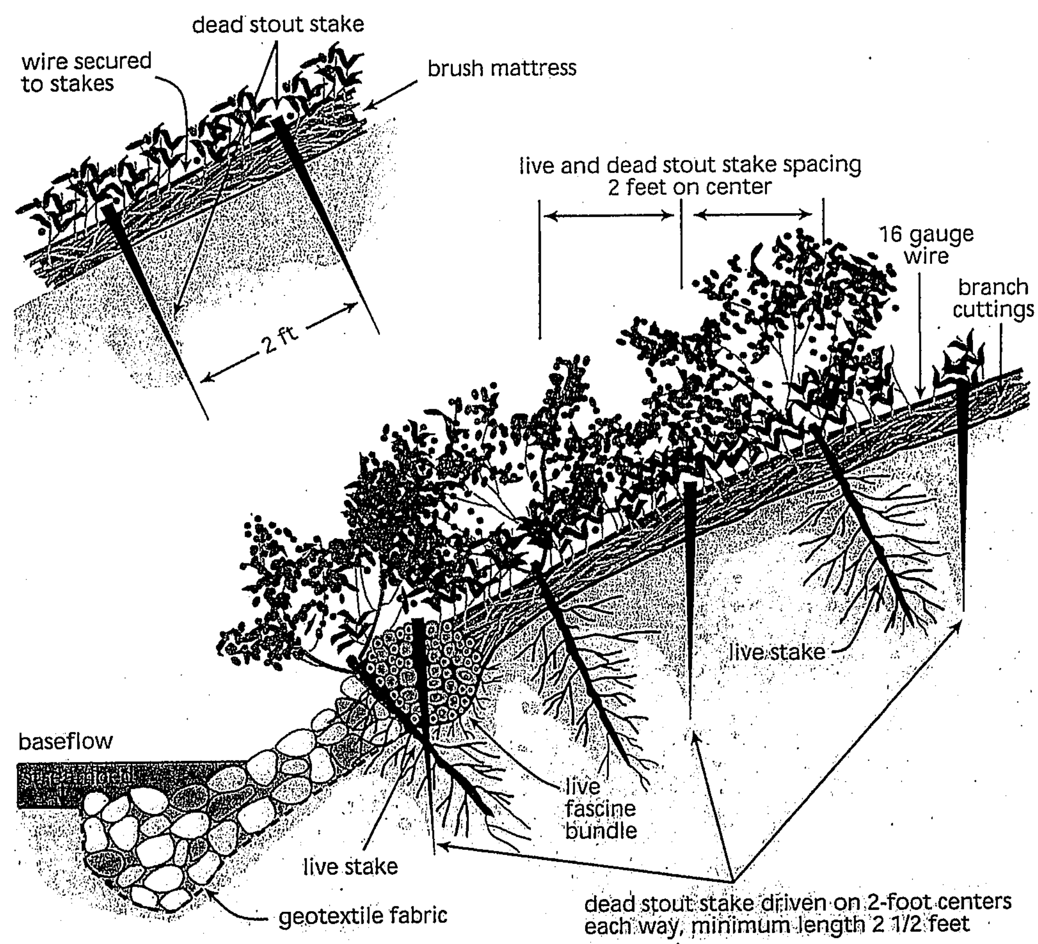


Figure 8.40: Cutting systems. Details of brushmattress technique.
Source: USDA-NRCS 1996a.
Note: Rooted/leafed condition of the living plant material is not representative at the time of installation.

Geotextile Systems

Geotextiles have been used for erosion control on road embankments and other upland settings, usually in combination with seeding, or with plants placed through slits in the fabric. In self-sustaining streambank applications, only natural, biodegradable materials should be used, such as jute or coconut fiber (Johnson and Stypula 1993). The typical streambank use for these materials is in the construction of vegetated geogrids, which are similar to brush layers except that the fill soils between the layers of cuttings are encased in fabric, allowing the bank to be constructed of successive "lifts" of soil, alternating with brush layers. This approach allows reconstruction of a bank and provides considerable erosion resistance (see Green River case study). Natural fibers are also used in "fiber-schines," which are sold specifically for streambank applications. These are cylindrical fiber bundles that can be staked to a bank with cuttings or rooted plants inserted through or into the material.

Vegetated plastic geogrids and other nondegradable materials can also be used where geotechnical problems require drainage or additional strength.

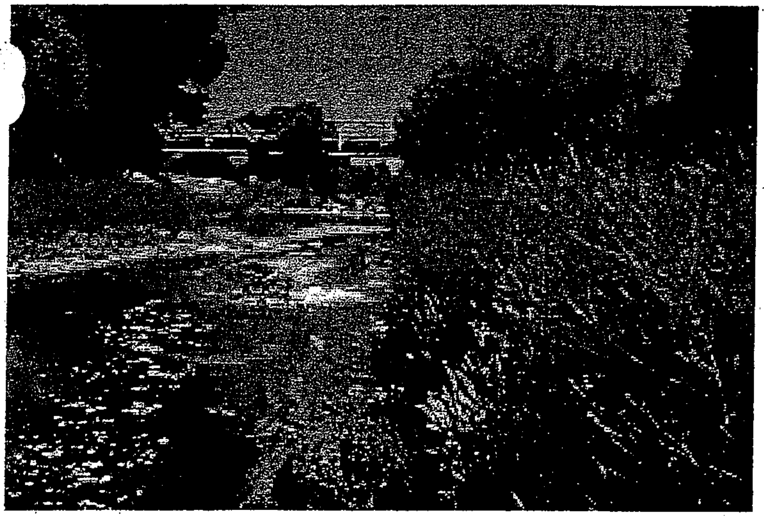


Figure 8.41: ***Results of live staking along a streambank.*** *Pioneer species are often most appropriate for use in bank revegetation projects.*

Integrated Systems

A major concern with the use of structural approaches to streambank stabilization is the lack of vegetation in the zone directly adjacent to the water. Despite a long-standing concern that vegetation destabilizes stone revetments, there has been little supporting evidence and even some evidence to the contrary (Shields 1991). Assuming that loss of conveyance is accounted for, the addition of vegetation to structures should be considered. This can involve placement of cuttings during construction, or insertion of cuttings and poles between stones on existing structures. Timber cribwalls may also be constructed with cuttings or rooted plants extending through the timbers from the backfill soils.

Trees and Logs

Tree revetments are made from whole tree trunks laid parallel to the bank, and cabled to piles or deadman anchors. Eastern red cedar (Juniperus virginiana) and other coniferous trees are used on small streams, where their springy branches provide interference to flow and trap sediment. The principal objective to these systems is the use of large amounts of cable and the potential for trees to be dislodged and cause downstream damage.

Some projects have successfully used large trees in conjunction with stone to provide bank protection as well as improved aquatic habitat (see case study). Large logs with intact root wads are placed in trenches cut into the bank, such that the root wads extend beyond the bank face at the toe (**Figure 8.42**). The logs are overlapped and/or braced with stone to ensure stability, and the protruding rootwads effectively reduce flow velocities at the toe and over a range of flow elevations (**Figure 8.43**). A major advantage of this approach is that it reestablishes one of the natural roles of large woody debris in streams by creating a dynamic near-bank environment that traps organic material and provides colonization substrates for invertebrates and refuge habitats for fish. The logs eventually rot, resulting in a more natural bank. The revetment stabilizes the bank until woody vegetation has matured, at which time the channel can return to a more natural pattern.

In most cases, bank stabilization projects use combinations of the techniques described above in an integrated approach. Toe protection often requires the use of stone, but amounts can be greatly reduced if large logs can also be used. Likewise, stone blankets on the bank face can be replaced with geogrids or supplemented with interstitial plantings. Most upper bank areas can usually be stabilized using vegetation alone, although anchoring systems might be required. The Green River bank restoration case study illustrates one successful application of an integrated approach on a moderate-sized river in Washington State.

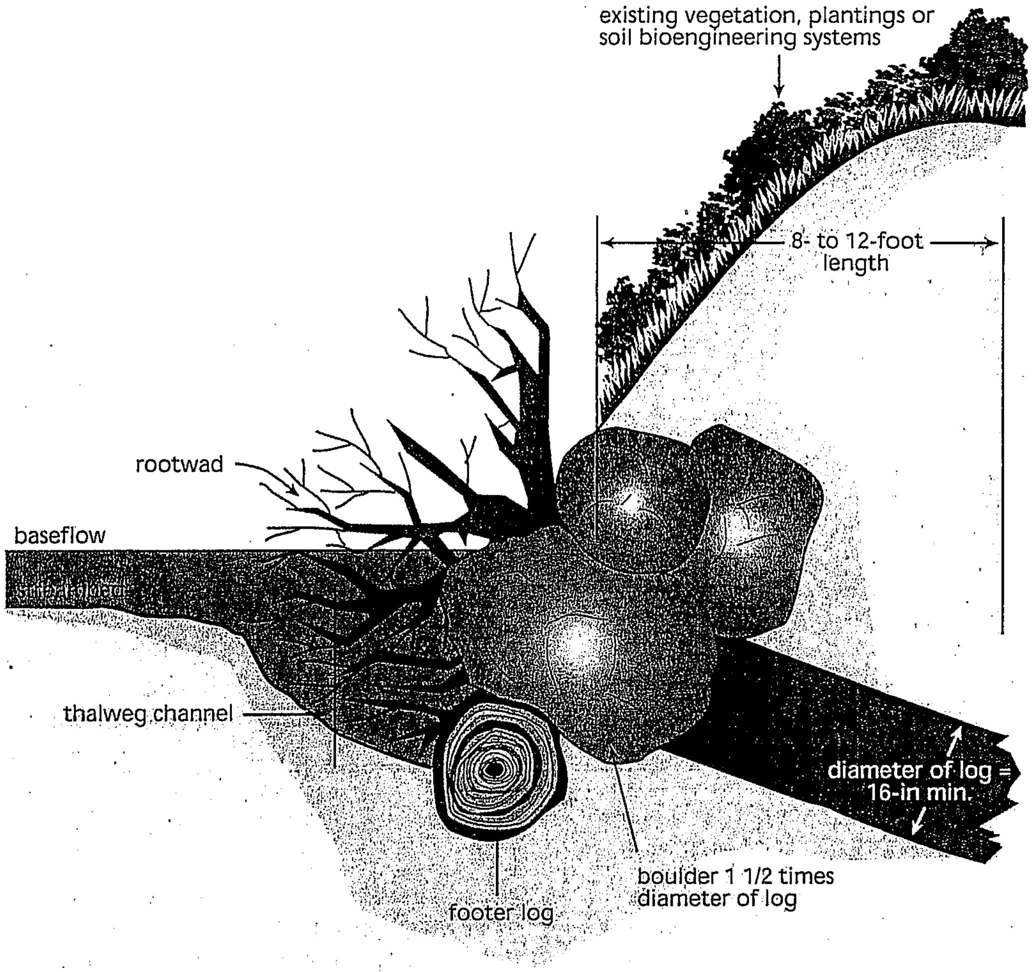


Figure 8.42: Revetment system. *Detail of rootwad and boulder technique.* Source: USDA-NRCS 1996a.

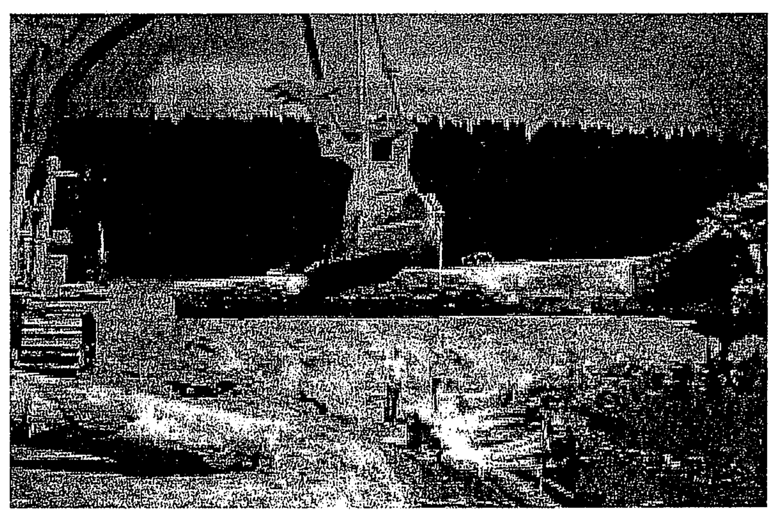


Figure 8.43: Installation of logs with intact root wads. *An advantage to using tree revetments is the creation of habitat for invertebrates and fish along the streambank.*

CASE STUDY Green River Bank Restoration Initiative

King County, Washington

The King County, Washington, Surface Water Management Division initiated a bank restoration initiative in 1994 that illustrates a variety of project objectives and soil bioengineering approaches (**Figure 8.44**). The project involved stabilization of the bank of the Green River along a 500-foot section of a meander bend that was rapidly migrating into the adjacent farm field. The project objectives included improvement of fish and wildlife habitat, particularly for salmonids.

Site investigations included surveys of stream cross sections, velocity measurements at two discharge levels, soil characterizations, and assessment of fish use of existing habitat features in the area. The streambank was vertical, 5 to 10 feet high, and composed of silty-clay-loam alluvium with gravel lenses. Flow velocities were 2 to 5 fps for flows of 200 and 550 cfs. Fish were primarily observed in areas of low velocities and/or near woody debris, and along the channel margins.

In August, large woody debris was installed along the toe of the bank. The logs were cedar and fir, 25 feet long and 28 to 36 inches in diameter, with root wads 6 to 8 feet in diameter. The logs were placed in trenches cut 15 feet back into the bank so that the root wads extended into the channel, and large (3- to 4-foot diameter) boulders were placed among the logs at the toe. Log and boulder placement was designed to interlock and brace the logs and prevent movement. The project used approximately 10 logs and 20 boulders per 100 lineal feet of bank. In September, vegetated geogrids were installed above the toe zone to stabilize the high bank (**Figure 8.45**). The project was completed with installation of a variety of plants, including container-grown conifers and understory species, in a minimum 25-foot buffer along the top of the bank.

Within 2 months of completion, the site was subjected to three high flows, including an 8,430-cfs event in December 1994. Measured velocities along the bank were less than 2 fps at the surface and less than 1 fps 2 feet below the surface, indicating the effectiveness of the root wads in moderating flow velocities (**Figure 8.46**). Some surface erosion and washout of plants along the top bank occurred, and a subsequent event caused minor damage to the geogrid at one location. The maintenance repairs consisted of replanting and placement of additional logs to

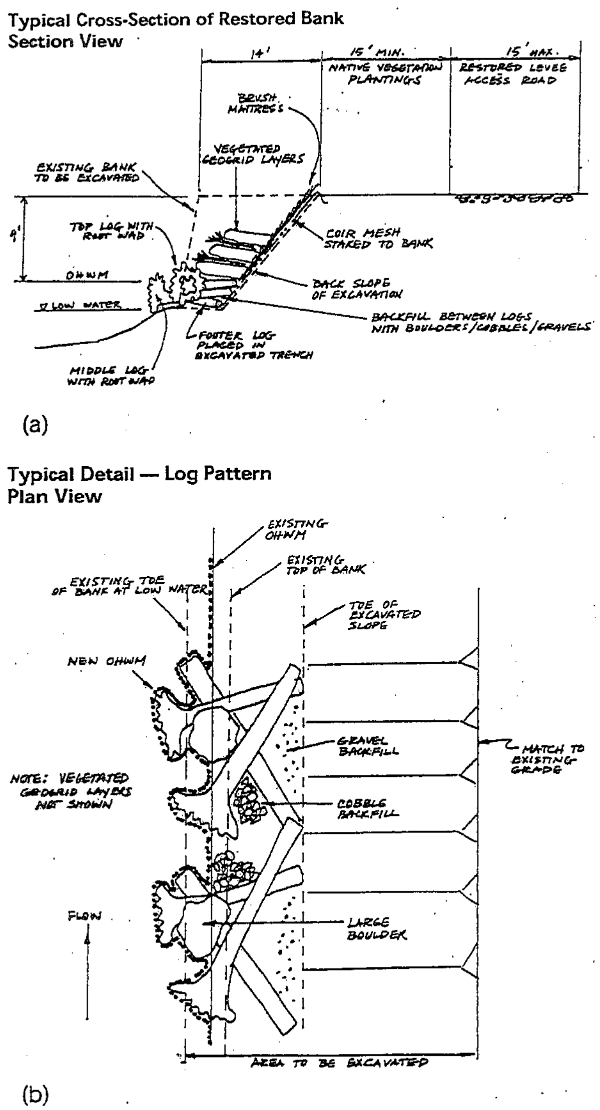


Figure 8.44: Construction details.
Source: King County Surface Water Management Division.

Figure 8.45: Partially installed vegetated geogrid. *Installed above the toe to stabilize high bank.*

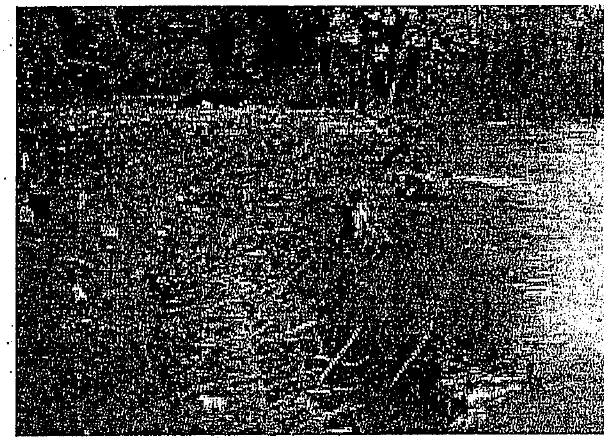


Figure 8.46: Completed system. *Note calm water along bankline during high flow.*

*halt undermining of the geogrid. The 1995 growing season produced dramatic growth of the willow cuttings in the geogrid, although many of the planted trees in the overbank zone died (**Figure 8.47**). Initial observations have documented extensive fish use of the slow-water habitats among the root wads at the toe of the bank, and in scour holes created by flows deflected toward the channel bottom.*

The site continues to be carefully monitored, and the effectiveness of the approach has led to the implementation of similar designs elsewhere in the region. The project designers have concluded that future projects of this type should use small plants rather than large rooted material in the overbank zone to reduce costs, improve survival, and minimize damage due to equipment access for maintenance or repair. Based on their observations of fish response along the restored bank and in nearby stream reaches, they also recommend that future projects incorporate a greater variety of woody debris, including brushy material and tree tops, along the toe and lower bank.

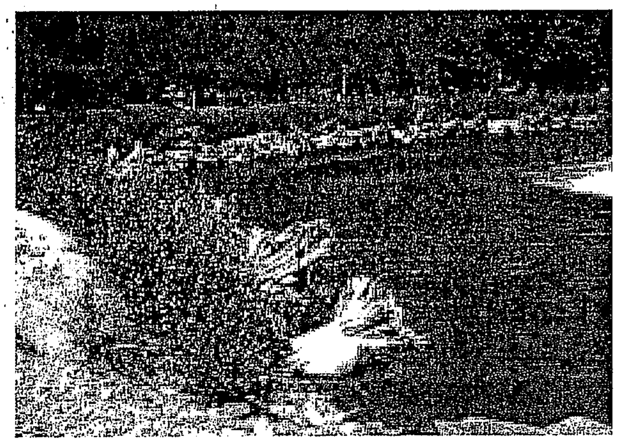


Figure 8.47: Completed system after one year. *Note dramatic willow growth from vegetated geogrid.*

8G Instream Habitat Recovery

As described in Chapter 2, habitat is the place where a population lives and includes living and nonliving components. For example, fish habitat is a place, or set of places, in which a single fish, a population, or an assemblage of fish can find the physical, chemical, and biological features needed for life, including suitable water quality, passage routes, spawning grounds, feeding and resting sites, and shelter from predators and adverse conditions (**Figure 8.48**). Principal factors controlling the quality of the available aquatic habitat include:

- Streamflow conditions.
- Physical structure of the channel.
- Water quality (e.g., temperature, pH, dissolved oxygen, turbidity, nutrients, alkalinity).
- The riparian zone.
- Other living components.

The existing status of aquatic habitats within the stream corridor should be assessed during the planning stage (Part II). Design of channels, structures, or restoration features can be guided and fine tuned by assessing the quality and quantity of habitats provided by the proposed design. Additional guidance on assessing the quantity and quality of aquatic habitat is provided in Chapter 7.

This section discusses the design of instream habitat structures for the purpose of enhancing physical aquatic habitat quality and quantity. It should be noted, however, that the best approach to habitat recovery is to restore a fully functional, well-vegetated stream corridor within a well-managed watershed. Man-made structures are less sustainable and rarely as effective as a stable channel. Over the long term, design should rely on natural fluvial processes interacting with floodplain vegetation and associated woody debris to provide high-quality aquatic habitat. Structures have little effect on populations that are limited by factors other than physical habitat.

Figure 8.48: Instream habitat. *Suitable water quality, passage routes, and spawning grounds are some of the characteristics of fish habitat.*

Instream Habitat Features

The following procedures to restore instream habitat are adapted from Newbury and Gaboury (1993) and Garcia (1995).

- Select stream. Give priority to reaches with the greatest difference between actual (low) and potential (high) fish carrying capacity and with a high capacity for natural recovery processes.
- Evaluate fish populations and their habitats. Give priority to reaches with habitats and species of special interest. Is this a biological, chemical, or physical problem? If a physical problem:
- Diagnose physical habitat problems.
  - Drainage basin. Trace watershed lines on topographical and geological maps to identify sample and rehabilitation basins.
  - Profiles. Sketch main stem and tributary long profiles to identify discontinuities that might cause abrupt changes in stream characteristics (falls, former base levels, etc.).
  - Flow. Prepare flow summary for rehabilitation reach using existing or nearby records if available (flood frequency, minimum flows, historical mass curve). Correct for drainage area differences. Compare magnitude and duration of flows during spawning and incubation to year class strength data to determine minimum and maximum flows required for successful reproduction.
  - Channel geometry survey. Select and survey sample reaches to establish the relationship between channel geometry, drainage area, and bankfull channel-forming discharge (**Figure 8.49**). Quantify hydraulic parameters at design discharge.
  - Rehabilitation reach survey. Survey rehabilitation reaches in sufficient detail to prepare channel cross section profiles and construction drawings and to establish survey reference markers.
  - Preferred habitat. Prepare a summary of habitat factors for biologically preferred reaches using regional references and surveys. Identify multiple limiting factors for the species and life stages of greatest concern. Where possible, undertake reach surveys in reference streams with proven populations to identify local flow conditions, substrate, refugia, etc.
- Design a habitat improvement plan. Quantify the desired results in terms of hydraulic changes, habitat improvement, and population increases. Integrate selection and sizing of rehabilitation works with instream flow requirements.
  - Select potential schemes and structures that will be reinforced by the

Man-made structures are less sustainable and rarely as effective as a stable channel.

Figure 8.49: Surveying a stream. *Channel surveys establish baseline information needed for restoration design.*

existing stream dynamics and geometry. The following section provides additional detail on use of habitat structures.

  - Test designs for minimum and maximum flows and set target flows for critical periods derived from the historical mass curve.
- Implement planned measures.
  - Arrange for on-site location and elevation surveys and provide advice for finishing details in the stream.
- Monitor and evaluate results.
  - Arrange for periodic surveys of the rehabilitated reach and reference reaches, to improve the design, as the channel ages.

FAST FORWARD
Preview Chapter 9 for an introduction to construction and monitoring follow-up activities.

Instream Habitat Structures

Aquatic habitat structures (also called instream structures and stream improvement structures) are widely used in stream corridor restoration. Common types include weirs, dikes, random rocks, bank covers, substrate reinstatement, fish passage structures, and off-channel ponds and coves. Institutional factors have favored their use over more holistic approaches to restoration. For example, it is often easier to obtain authority and funding to work within a channel than to influence riparian or watershed land use. Habitat structures have been used more along cold water streams supporting salmonid fisheries than along warm water streams, and the voluminous literature is heavily weighted toward cold water streams.

In a 1995 study entitled Stream Habitat Improvement Evaluation Project, 1,234 structures were evaluated according to their general effectiveness, the habitat quality associated with the given structure type, and actual use of the structures by fish (Bio West 1995). The study determined approximately 18 percent of the structures need maintenance. Where inadequate flows and excessive sediment delivery occur, structures have a brief lifespan and limited value in terms of habitat improvement. Furthermore, the study concluded that instream habitat structures generally provided increased fish habitat.

Before structural habitat features are added to a stream corridor restoration design, project managers should carefully determine whether they address the real need and are appropriate. Major caveats include the following:

- Structures should never be viewed as a substitute for good riparian and upland management.
- Defining the ecological purpose of a structure and site selection are as important as construction technique.
- Scour and deposition are natural stream processes necessary to create fish habitat. Overstabilization therefore limits habitat potential, whereas properly designed and sited structures can speed ecological recovery.
- Use of native materials (stone and wood) is strongly encouraged.
- Periodic maintenance of structures will be necessary and must be incorporated into project planning.

Instream Habitat Structure Design

Design of aquatic habitat structures should proceed following the steps presented below (Shields 1983). However, the process should be viewed as iterative, and considerable recycling among steps should be expected.

- Plan layout.
- Select types of structures.
- Size the structures.
- Investigate hydraulic effects.

- Consider effects on sediment transport.
- Select materials and design structures.

Each step is described below. Construction and monitoring follow-up activities are described in Chapter 9.

Plan Layout

The location of each structure should be selected. Avoid conflicts with bridges, riparian structures, and existing habitat resources (e.g., stands of woody vegetation). The frequency of structures should be based on the habitat requirements previously determined, within the context of the stream morphology and physical characteristics (see Chapter 7). Care should be taken to place structures where they will be in the water during baseflow. Structures should be spaced to avoid large areas of uniform conditions. Structures that create pools should be spaced five to seven channel widths apart. Weirs placed in series should be spaced and sized carefully to avoid placing a weir within the backwater zone of the downstream structure, since this would create a series of pools with no intervening riffles or shallows.

Select Types of Structures

The main types of habitat structures are weirs, dikes (also called jetties, barbs, deflectors (**Figure 8.50**), spurs, etc.), random rocks (also called boulders), and bank covers (also called lunkers). Substrate reinstatement (artificial riffles), fish passage structures, and off-channel ponds and coves have also been widely employed. Fact sheets on several of these techniques are provided in the *Techniques Appendix*, and numerous design web sites are available (White and Brynildson 1967, Seehorn 1985, Wesche 1985, Orsborn et al. 1992, Orth and White 1993, Flosi and Reynolds 1994).

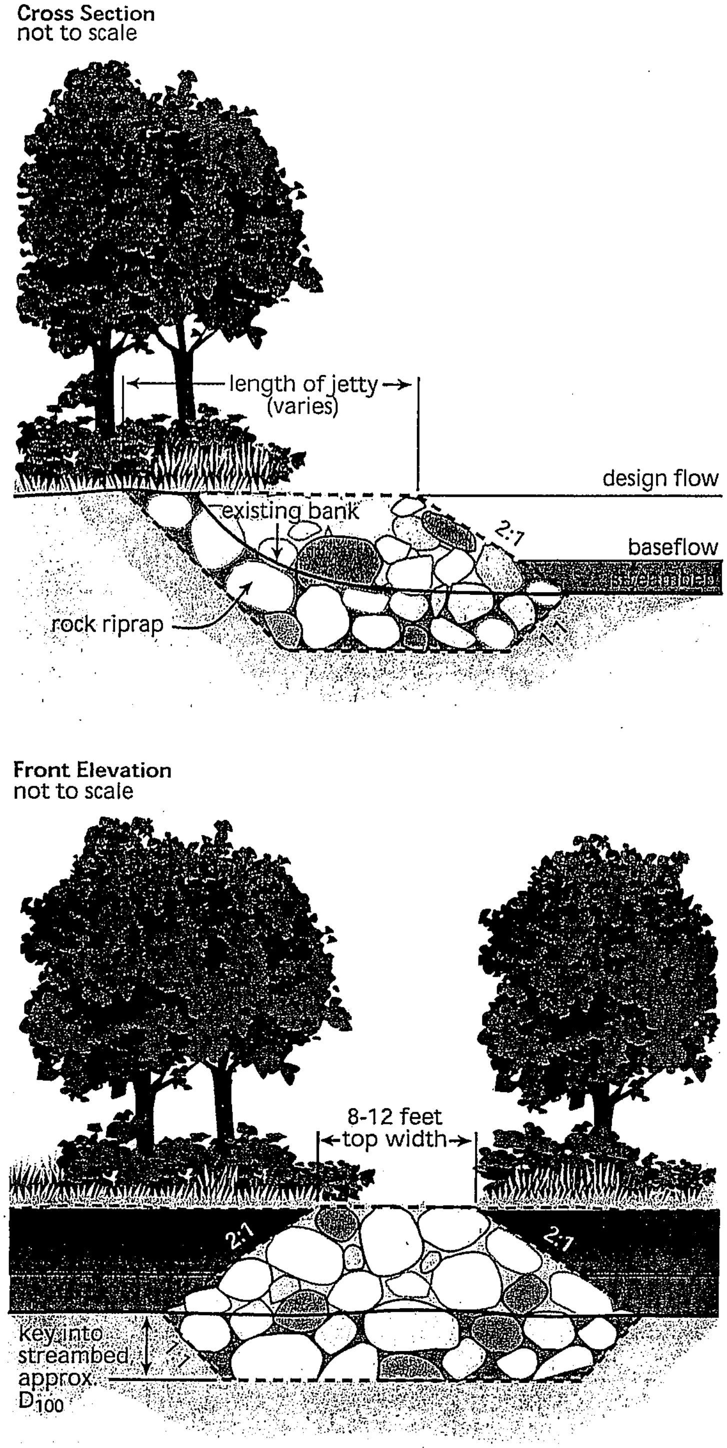


Figure 8.50: Instream habitat structure.
Wing deflector habitat structure.
Source: USDA-NRCS 1996a.

Evidence suggests that traditional design criteria for widespread bank and bed stabilization measures (e.g., concrete grade control structures, homogeneous riprap) can be modified, with no functional loss, to better meet environmental objectives and improve habitat diversity. **Table 8.7** may be used as a general guide to relate structural type to habitat requirement. Weirs are generally more failure-prone than deflectors. Deflectors and random rocks are minimally effective in environments where higher flows do not produce sufficient local velocities to produce scour holes near structures. Random rocks (boulders) are especially susceptible to undermining and burial when placed in sand-bed channels, although all types of stone structures experience similar problems. Additional guidance for evaluating the general suitability of various fish habitat structures for a wide range of morphological stream types is provided by Rosgen (1996). Seehorn (1985) provides guidance for small streams in the eastern United States. The use of any of these guides should also consider the relative stability of the stream, including aggradation and incision trends, for final design.

Size the Structures

Structures should be sized to produce the desired aquatic habitats at the normal range of flows from baseflow to bankfull discharge. A hydrological analysis can provide an estimate of the normal range of flows (e.g., a flow duration curve), as well as an estimate of extreme high and low flows that might be expected at the site (see Chapter 7). In general, structures should be low enough that their effects on the water surface profile will be slight at bankfull discharge. Detailed guidance by structural type is presented in the Techniques Appendix. For informal design, empirical equations like those presented by Heiner (1991) can be used to roughly estimate the depth of scour holes at weirs and dikes.

Investigate Hydraulic Effects

Hydraulic conditions at the design flow should provide the desired habitat; however, performance should also be evaluated at higher and lower flows. Barriers to movement, such as extremely shallow reaches or vertical drops not submerged at higher flows, should be avoided. If the conveyance of the channel is an issue, the effect of the proposed structures on stages at high flow should be investigated. Structures may be included in a standard backwater calculation model as contractions, low weirs, or increased flow resistance (Manning) coefficients, but the amount of increase is a matter of judgment or limited by National Flood Insurance Program ordinances. Scour holes should be included in the channel geometry downstream of weirs and dike since a major portion of the head loss occurs in the scour hole. Hydraulic analysis should include estimation or computation of velocities or shear stresses to be experienced by the structure.

Consider Effects on Sediment Transport

If the hydraulic analysis indicates a shift in the stage-discharge relationship, the sediment rating curve of the restored reach may change also, leading to deposition or erosion. Although modeling analyses are usually not cost-effective for a habitat structure design effort, informal analyses based on assumed relationships between velocity and sediment discharge at the bankfull discharge may be helpful in detecting potential problems. An effort should be made to predict the locations and magnitude of local scour and deposi-

Table 8.7: Fish habitat improvement structures—suitability for stream types.
Source: Rosgen 1996.

Channel Type	Low St. Check Dam	Medium St. Check Dam	Boulder Placement	Bank Boulder Placement	Single Wing Deflector	Double Wing Deflector	Channel Constrictor	Bank Cover
A1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
A2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
B1-1	Poor	Poor	Good	Excellent	Poor	Poor	Poor	Good
B1	Excellent	Excellent	N/A	N/A	Excellent	Excellent	N/A	Excellent
B2	Excellent	Good	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
B3	Fair	Poor	Poor	Good	Poor	Poor	Poor	Poor
B4	Fair	Poor	Poor	Good	Poor	Poor	Poor	Poor
B5	Fair	Poor	Poor	Good	Poor	Poor	Poor	Poor
C1-1	Poor	Poor	Fair	Excellent	Poor	Poor	Poor	Good
C1	Good	Fair	Fair	Excellent	Good	Good	Fair	Good
C2	Excellent	Good	Good	Excellent	Good	Excellent	Excellent	Good
C3	Fair	Poor	Poor	Good	Fair	Fair	Fair	Good
C4	Fair	Poor	Poor	Good	Poor	Poor	Poor	Fair
C5	Fair	Poor	Poor	Good	Poor	Poor	Poor	Poor
C6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
D1	Fair	Poor	Poor	Fair	Fair	Fair	Fair	Poor
D2	Fair	Poor	Poor	Fair	Fair	Fair	Fair	Poor

Channel Type	Half Log Cover	Floating Log Cover	Submerged Shelter		Migration Barrier	Gravel Traps		Gravel Placement
			Meander	Straight		"V" Shaped	Log	
A1	N/A	N/A	N/A	N/A	Excellent	Good	Poor	Poor
A2	N/A	N/A	N/A	N/A	Excellent	Excellent	Excellent	Poor
B1-1	Good	Good	Good	Excellent	Fair	Good	Good	Fair
B1	Good	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Fair
B2	Excellent	Excellent	Good	Excellent	Good	Good	Good	Good
B3	Poor	Fair	Fair	Fair	Poor	Poor	Poor	Poor
B4	Poor	Fair	Fair	Fair	Poor	Poor	Poor	Poor
B5	Poor	Fair	Fair	Fair	Poor	Poor	Poor	Poor
C1-1	Good	Good	Good	Excellent	Poor	Fair	Fair	Fair
C1	Good	Good	Good	Excellent	Poor	Fair	Good	Fair
C2	Good	Excellent	Excellent	Excellent	Poor	Good	Excellent	Excellent
C3	Fair	Good	Fair	Good	Poor	N/A	N/A	N/A
C4	Poor	Good	Fair	Good	Poor	Poor	Poor	Poor
C5	Poor	Good	Fair	Good	Poor	Poor	Poor	Poor
C6	N/A	N/A	N/A	N/A	Poor	Poor	Fair	Fair
D1	Poor	Poor	Poor	Poor	Poor	Poor	N/A	Poor
D2	Poor	Poor	Poor	Poor	Poor	N/A	Poor	Poor

Key:

Excellent - No limitation to location of structure placement or special modification in design.

Good - Under most conditions, very effective. Minor modification of design or placement required.

Fair - Serious limitation which can be overcome by placement location, design modification, or stabilization techniques. Generally not recommended due to difficulty of offsetting potential adverse consequences and high probability of reduced effectiveness.

Poor - Not recommended due to morphological character of stream type and very low probability of success.

Not Applicable- Generally not considered since habitat components are not limiting.

Note: A3, A3-a, A4, A4-a, A5, A5-a channel types are not evaluated due to limited fisheries value.

tion. Areas projected to experience significant scour and deposition should be prime sites for visual monitoring after construction.

Select Materials

Materials used for aquatic habitat structures include stone, fencing wire, posts, and felled trees. Priority should be given to materials that occur on site under natural conditions. In some cases, it may be possible to salvage rock or logs generated from construction of channels or other project features. Logs give long service if continuously submerged. Even logs not continuously wet can give several decades of service if chosen from decay-resistant species. Logs and timbers must be firmly fastened together with bolts or rebar and must be well anchored to banks and bed. Stone size should be selected based on design velocities or shear stress.

8H Land Use Scenarios

As discussed in Chapter 3, most stream corridor degradation is directly attributable to land use practices and/or hydrologic modifications at the watershed level that cause fundamental disruption of ecosystem functions (Beschta et al. 1994) (**Figure 8.51**). Ironically, land use practices, including hydrologic modifications, can offer the opportunity for restoring these same degraded stream corridors. Where feasible, the objective of the restoration design should be to eliminate or moderate disruptive influences sufficiently to allow recovery of dynamic equilibrium over time (NRC 1992).

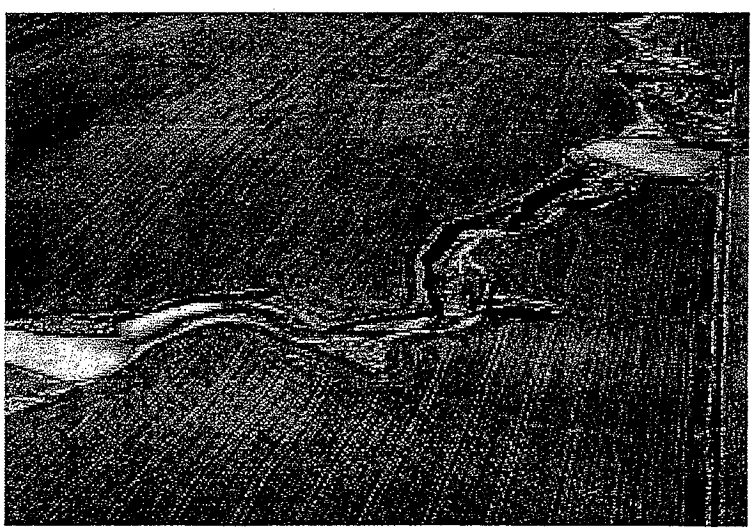


*Figure 8.51: **Sediment-laden stream.** Most stream corridor degradation can be attributed to impacts resulting from surrounding land uses.*

If chronic land use impacts on the stream or riparian system cannot be controlled or moderated, or if some elements of the stream network (e.g., headwaters) are not included in the restoration design, it must be recognized that the restoration action may have limited effectiveness in the long-term.

Restoration measures can be designed to address particular, site-specific deficiencies (an eroding bank, habitat features), but if they do not restore self-maintaining processes and the functions of a stream corridor, they must be regarded as a focused "fix" rather than an ecosystem restoration. In cases where land use practices are the direct cause of stream corridor degradation and there is a continuing downward trend in landscape condition, there is little point in expending resources to address symptoms of the problem rather than the problem itself (DeBano and Schmidt 1989).

Design Approaches for Common Effects

Agriculture, forestry, grazing, mining, recreation, and urbanization are some of the principal land uses that can result in disturbance of stream corridor structure and functions. A watershed analysis will help prioritize and coordinate restoration actions (Platts and Rinne 1985, Swanson 1989) and may indicate critical or chronic land use activities causing disturbance both inside and outside the stream corridor. Addressing these in the restoration plan and design, may greatly improve the effectiveness and success of restoration work.

Restoration measures designed in response to these effects may be similar across land uses. Sediment and nutrient management in urban, agricultural, and forest settings, for instance, may require the use of buffer strips. Although the buffer strips have many common design characteristics, each setting has site-specific factors.

Dams

Dams alter the flow of water, sediment, organic matter, and nutrients, resulting in both direct physical and indirect biological effects in tailwaters and downstream riparian and floodplain areas (see Chapter 3). Stream corridors below dams can be partially restored by modifying operation and management approaches. Impacts from the operation of dams on surface water quality and aquatic and riparian habitat should be assessed and the potential for improvement evaluated. The modification of operation approaches, where possible, in combination with the application of properly designed and applied best management practices, can reduce the impacts caused by dams on downstream riparian and floodplain habitats. Best management practices can be applied individually or in combination to protect and improve surface water quality and aquatic habitat in reservoirs as well as downstream. Several approaches have been designed for improving or maintaining acceptable levels of dissolved oxygen (DO), temperature, and other constituents in reservoirs and tailwaters. One design approach uses pumps, air diffusers, or air lifts to induce circulation and mixing of the oxygen-poor but cold hypolimnion with the oxygen-rich but warm epilimnion, resulting in a more thermally uniform reservoir with increased DO. Another design approach for improving water quality in tailwaters for trout fisheries involves mixing of air or oxygen with water passing through the turbines at hydropower dams to improve concentrations of DO. Reservoir waters can also be aerated by venting turbines to the atmosphere or by injecting compressed air into the turbine chamber (USEPA 1993).

Modification to the intakes, the spillway, or the tailrace of a dam can also be designed to improve temperature or DO levels in tailwaters. Installing various types of weirs downstream of a dam achieves similar results. These design practices rely on agitation and turbulence to mix reservoir releases with atmospheric air to increase levels of DO (USEPA 1993).

Adequate fish passage around dams, diversions, and other obstructions may be a critically important component of restoring healthy fish populations to previously degraded rivers and streams. A fact sheet in Appendix A shows an example for fish passages. However, designing, installing, and operating fish passage facilities at dams are beyond the scope of this handbook. Further, the type of fish passage facility and the flows necessary for operation are generally site specific. Further information on fish passage technology can be found in other references, including Environmental Mitigation at Hydroelectric Projects - Volume II. Benefits and Costs of Fish Passage and Protection (Francfort et al., 1994); and Fish Passage Technologies: Protection at Hydropower Facilities (Office of Technology Assessment, Congress of the United States, Washington DC, OTA-ENV-641).

Adjusting operation procedures at some dams can also result in improved quality of reservoir releases and downstream conditions. Partial restoration of stream corridors below dams can be achieved by designing operation procedures that mimic the natural hydrograph, or desirable aspects of the hydrograph. Modifications include scheduling releases or the duration of shutoff periods, instituting procedures for the maintenance of minimum flows, and making seasonal adjustments in pool levels and in the timing and variation of the rates of drawdowns (USEPA 1993).

Modifying operation and management approaches, in combination with the application of properly designed best management practices, can be an effective approach to partially restoring stream corridors below dams. However, dam removal is the only way to begin to fully restore a stream to its natural condition. It is important to note, however, that unless accomplished very carefully, with sufficient studies and modeling and at significant cost, removing a dam can cause more damage downstream (and upstream) than the dam is currently causing until a state of dynamic equilibrium is reached. Dam removal lowers the base level of upstream tributaries, which can cause rejuvenation, bed and bank instability, and increased sediment loads. Dam removal can also result in the loss of wetlands and habitat in the reservoir and tributary deltas.

Three options should be considered—complete removal, partial removal, and staged breaching. The option is selected based on the condition of the dam and future maintenance required if not completely removed, and on the best way to deal with the sediment now stored behind the dam. The following elements must be considered in managing sediment:

- Removing features of dams necessary to restore fish passage and ensure safety.
- Revegetation of the reservoir areas.
- Long-term monitoring of sediment transport and river channel topography, water quality, and aquatic ecology.
- Long-term protection of municipal and industrial water supplies.
- Mitigation of flood impacts caused by long-term river aggradation.
- Quality of sediment, including identification of the lateral and vertical occurrence of toxic or otherwise poor-quality sediment.

Water quality issues are primarily related to suspended sediment concentration and turbidity. These are important to municipal, industrial, and private water users, as well as to aquatic communities. Water quality will primarily be affected by any silt and clay released from the reservoirs and by reestablishment of the natural sediment loads downstream. During removal of the dam and draining of the lake, the unvegetated reservoir bottoms will be exposed. Lakebeds will be expected to have large woody debris and other organic material. A revegetation program is necessary to control dust, surface runoff, and erosion and to restore habitat and aesthetic values. A comprehensive sediment management plan is needed to address the following:

- Sediment volume and physical properties.
- Sediment quality and associated disposal requirements.
- Hydraulic and biological characteristics of the reservoir and downstream channel.
- Alternative measures for sediment management.
- Impacts on downstream environment and channel hydraulics.
- Recommended measures to manage sediment properly and economically.

Objectives of sediment management should include flood control, water quality, wetlands, fisheries, habitat, and riparian rights.

For hydropower dams, the simplest decommissioning program is to dismantle the turbine-generator and seal the water passages, leaving the dam and water-retaining structures in place. No action is taken concerning the sediments since they will remain in the reservoir and the hydraulic and physical characteristics of the river and reservoir will remain essentially unchanged. This approach is viable only if there are no deficiencies in the water-retaining structures (such as inadequate spillway capacity or inadequate factors of safety for stability) and long-term maintenance is ensured. In some cases, decommissioning can include partial removal of water-retaining structures. Partial removal involves demolition of a portion of the dam to create a breach so that it no longer functions as a water-retaining structure.

For additional information, see Guidelines for the Retirement of Hydroelectric Facilities published by the American Society of Civil Engineers (ASCE) in 1997.

Channelization and Diversions

Channelization and flow diversions represent forms of hydrologic modification commonly associated with most principal land uses, and their effects should be considered in all restoration efforts (see Chapter 3). In some cases, restoration design can include the removal or redesign of channel modifications to restore preexisting ecological and flow characteristics.

Modifications of existing projects, including operation and maintenance or management, can improve some negative effects without changing the existing benefits or creating additional problems. Levees may be set back from the stream channel to better define the stream corridor and reestablish some or all of the natural floodplain functions. Setback levees can be constructed to allow for overbank flooding, which provides surface water contact with streamside areas such as floodplains and wetlands.

Instream modifications such as uniform cross sections or armoring associated with channelization or flow diversions may be removed, and design and placement of meanders can be used to reestablish more natural channel characteristics. In many cases, however, existing land uses might limit or prevent the removal of existing channel or floodplain modifications. In such cases, restoration design must consider the effects of existing channel modifications or flow diversions, in the corridor and the watershed.

Exotic Species

Exotic species are another common problem of stream corridor restoration and management. Some land uses have actually introduced exotics that have become uncontrolled, while others have merely created an opportunity for such

CASE STUDY

The Multispecies Riparian Buffer System in the Bear Creek, IA Watershed

Introduction

The Bear Creek Watershed in central Iowa is a small (26.8 mi2) drainage basin located within the Des Moines Lobe subregion of the Western Corn Belt Plains ecoregion, one of the youngest and flattest ecological subregions in Iowa. In general, the land is level to gently rolling with a poorly developed stream network. Soils of the region are primarily developed in glacial till and alluvial, lacustrine, and windblown deposits. Prior to European settlement of the region (ca 1847) the watershed consisted of the vast tallgrass prairie ecosystem, interspersed with wet prairie marshes in topographic lows and gallery forests along larger order streams and rivers. Native forest was limited to the Skunk River corridor into which Bear Creek flows.

Subsequent conversion of the land, including the riparian zone, from native vegetation to row crops, extensive subsurface drainage tile installation, dredge ditching, and grazing of fenced riparian zones have resulted in substantial stream channel modification. Records suggest that artificial drainage of marshes and low prairies in the upper reaches of the Bear Creek watershed was completed about 1902, with ditch dredging completed shortly thereafter. While the main stream pattern appears to have remained about the same since that time, significant channelization continued into the 1970s. Additional intermittent channels have developed in association with new drainage tile and grass waterway installation. Present land use in the Bear Creek watershed is typical of the region, with over 87% of the land area devoted to row crop agriculture.

Landscape modifications and present land-use practices have produced nonpoint source pollution in the watershed, which landowners have addressed by implementing soil conservation practices (e.g. reduced tillage, terracing, grass waterways) and better chemical input management (e.g. more accurate and better timed applications). It has only been recently that placement or enhancement of riparian vegetation or "streamside filter strips" has been recommended to reduce sediment and chemical loading, modify flow regime by reducing discharge extremes, improve structural habitat, and restore energy relationships through the addition of organic matter and reduction in temperature and dissolved oxygen extremes.

The Riparian Management System (RiMS)

The Agroecology Issue Team of the Leopold Center for Sustainable Agriculture, Iowa State University, Ames, IA, is conducting research on the design and establishment of an integrated riparian management system (RiMS) to demonstrate the benefits of properly functioning riparian buffers in the heavily row-cropped landscape of the midwestern U.S. The purpose of the RiMS is to restore the essential ecological functions that riparian ecosystems once provided. Specific objectives of such buffers are to intercept eroding soil and agricultural chemicals from adjacent crop fields, slow floodwaters, stabilize streambanks, provide wildlife habitat, and improve the biological integrity of aquatic ecosystems. The regionalization of this system has been accomplished by designing it with several components, each of which can be modified to fit local landscape conditions and landowner objectives.

The Agroecology Issue Team is conducting detailed studies of important biological and physical processes at both the field and watershed scale to provide the necessary data to allow resource managers to make credible recommendations of buffer placement and design in a wide variety of landscapes. In addition, socioeconomic data collected from landowners in the watershed are being used to identify landowner criteria for accepting RiMS. The team also is quantifying the non-market value placed on the improvement in surface and ground water quality.

The actual development and establishment of the RiMS along Bear Creek was initiated in 1990 along a 0.6-mile length of Bear Creek on the Ron and Sandy Risdal Farm. The buffer strip system has subsequently been planted along 3.5 miles of Bear Creek upstream from this original site. The RiMS consists of three components: 1) a multi-species riparian buffer (MRB), 2) soil bioengineering technologies for streambank stabilization, and 3) constructed wetlands to intercept and process nonpoint source pollutants in agricultural drainage tile water.

Multi-species Riparian Buffer (MRB)

The general MRB consists of three zones. The rapid growth of this buffer community can change a heavily impacted riparian zone into a functioning riparian ecosystem in a few short years. The combinations of trees, shrubs, and native grasses can be modified to fit site conditions (e.g. soils, slope), major buffer biological and physical function(s), owner objectives, and cost-share program requirements.

Soil Bioengineering

It has been estimated that greater than 50% of the stream sediment load in small watersheds in the Midwest is the result of channel erosion. This problem has been worsened by the increased erosive power of streams resulting from stream channelization and loss of riparian vegetation. Several different soil bioengineering techniques have been employed in the Bear Creek watershed. These include the use of willow posts and stakes driven into the bank, live willow fascines, live willow brush mattresses, and biodegradable geotextile anchored with willow stakes on bare slopes. Alternatives used to stabilize the base of the streambank include rock and anchored dead plant material such as cedar or bundled maple.

Constructed Wetlands

Small, constructed wetlands which are integrated into the riparian buffer have considerable potential to remove nitrate and other chemicals from the extensive network of drain tile in the Midwest. To demonstrate this technology, a small (600^{yd2}) wetland was constructed to process drainage tile water from a 12-acre cropped field. The wetland was constructed by excavating a depressional area near the creek and constructing a low berm. The subsurface drainage tile was rerouted to enter the wetland at a point that maximizes residence time of drainage tile water within the wetland. A simple gated water level control structure at the wetland outlet provides control of the water level maintained within the wetland. Cattail rhizomes (Typha glauca Godr.) collected from a local marsh and road ditch were planted within the wetland and native grasses and forbs planted on the constructed berm. Future plans include the construction of additional tile drainage wetlands within the Bear Creek watershed.

System Effectiveness

Long-term monitoring has demonstrated the significant capability of the RiMS to intercept eroding soil from adjacent cropland; intercept and process agricultural chemicals moving in shallow subsurface water, stabilize stream channel movement, and improve instream environments, while also providing wildlife habitat and quality timber products. The buffer traps 70-80% of the sediment carried in surface runoff and has reduced nitrate and atrazine moving in the soil solution to levels well below the maximum contaminant levels specified by the USEPA. Streambank bioengineering systems have virtually stopped bank erosion along treated reaches and are now trapping channel sediment. The constructed wetland has reduced nitrate in the tile drainage water by as much as 80% depending on the season of the year. Wildlife benefits have also appeared in a very short time, with a nearly fivefold increase in bird species diversity observed within the buffer strip versus an adjacent, unprotected stream reach.

While the RiMS function is being assessed through experimental plot work with intensive process monitoring, economic benefits and costs to landowners and society also are being determined. Landowners surveys, focus groups, and one-on-one interviews have identified the concern that water quality should be improved by reducing chemical and sediment inputs by as much as 50%. Landowners are willing to pay for this improved water quality as well as volunteer their time to help initiate the improvements.

CASE STUDY The Multispecies Riparian Buffer System in the Bear Creek, IA Watershed (continued)

While the RiMS can effectively intercept and treat nonpoint source pollution from the uplands, it should be stressed that a riparian management system cannot replace upland conservation practices. In a properly functioning agricultural landscape, both upland conservation practices and an integrated riparian system contribute to achieving environmental goals and improved ecosystem functioning.

Support for this work is from the Leopold Center for Sustainable Agriculture, the Iowa Department of Natural Resources through a grant from the USEPA under the Federal Nonpoint Source Management Program (Section 319 of the Clean Water Act), and the USDA (Cooperative State Research Education and Extension Service), National Research Initiative Competitive Grants Program; and the Agriculture in Concert with the Environment Program.

exotics to spread. Again, control of exotic species has some common aspects across land uses, but design approaches are different for each land use.

Control of exotics in some situations can be extremely difficult and may be impractical if large acreages or well-established populations are involved. Use of herbicides may be tightly regulated or precluded in many wetland and streamside environments, and for some exotic species there are no effective control measures that can be easily implemented over large areas (Rieger and Kreager 1990). Where aggressive exotics are present, every effort should be made to avoid unnecessary soil disturbance or disruption of intact native vegetation, and newly established populations of exotics should be eradicated.

Nonnative species such as salt cedar (Tamarix spp.) and Russian olive (Elaeagnus angustifolia) can outcompete native plantings and negatively affect their establishment and growth. The likelihood of successful reestablishment often increases when artificial flows created by impoundments are altered to favor native species and when exotics such as salt cedar are removed before revegetation is attempted (Briggs et al. 1994).

Salt cedar is an aggressive, exotic colonizer in the West due to its long period and high rate of seed production, as well as its ability to withstand long periods of inundation. Salt cedar can be controlled either by clearing with a bulldozer or by direct application of herbicide (Sudbrock 1993); however, improper treatments may actually increase the density of salt cedar (Neill 1990).

Controlling exotics and weeds can be important because of potential competition with established native vegetation, colonized vegetation, and artificially planted vegetation in restoration work. Exotics compete for moisture, nutrients, sunlight, and space and can adversely influence establishment rates of new plantings. To improve the effectiveness of revegetation work, exotic vegetation should be cleared prior to planting; nonnative growth must also be controlled after planting. General techniques for control of exotics and weeds are mechanical (e.g., scalping or tilling), chemical (herbicides), and fire. For a review of treatment methods and equipment, see U.S. Forest Service (1965) and Yoakum et al. (1980).

Agriculture

America's Private Land—A Geography of Hope (USDA-NRCS 1996b) challenges all of us to "regain our sense of place and renew our commitment to private landowners and the public." It suggests that as we learn more about the complexity of our environment, harmony with ecological processes that extend across all landscapes becomes more of an imperative than an ideal. Furthermore, conservation provisions of the 1996 Farm Bill and accompanying endeavors such as the National Conservation Buffer Initiative (USDA-NRCS 1997) offer flexibility to care for the land as never before. The following land use scenario attempts to express this flexibility in the context of comprehensive, locally led conservation work, including stream corridor restoration.

This scenario offers a brief glimpse into a hypothetical agricultural setting where the potential results of stream corridor restoration might begin to take form. Computer-generated simulations are used to graphically illustrate potential changes brought about by restoration work and associated comprehensive, on-farm conservation planning. It focuses, conceptually, on vegetative clearing, instream modifications, soil exposure and compaction, irrigation and drainage, and sediment or contaminants as the most disruptive activities associated with agricultural land use. Although an agricultural landscape typical of the Midwest was selected for illustrative purposes, the concepts shown can apply in different agricultural settings.

Hypothetical Existing Conditions

Reminiscent of the highly disruptive agricultural activities discussed in Chapter 3, Figure 8.52 illustrates hypothetical conditions that focus primarily on production agriculture. Although functionally isolated contour terraces and a waterway have been installed in the nearby cropland, the scene depicts an ecologically deprived landscape. Many of the potential disturbance

Figure 8.52: Hypothetical conditions. Activities causing change in this agricultural setting.

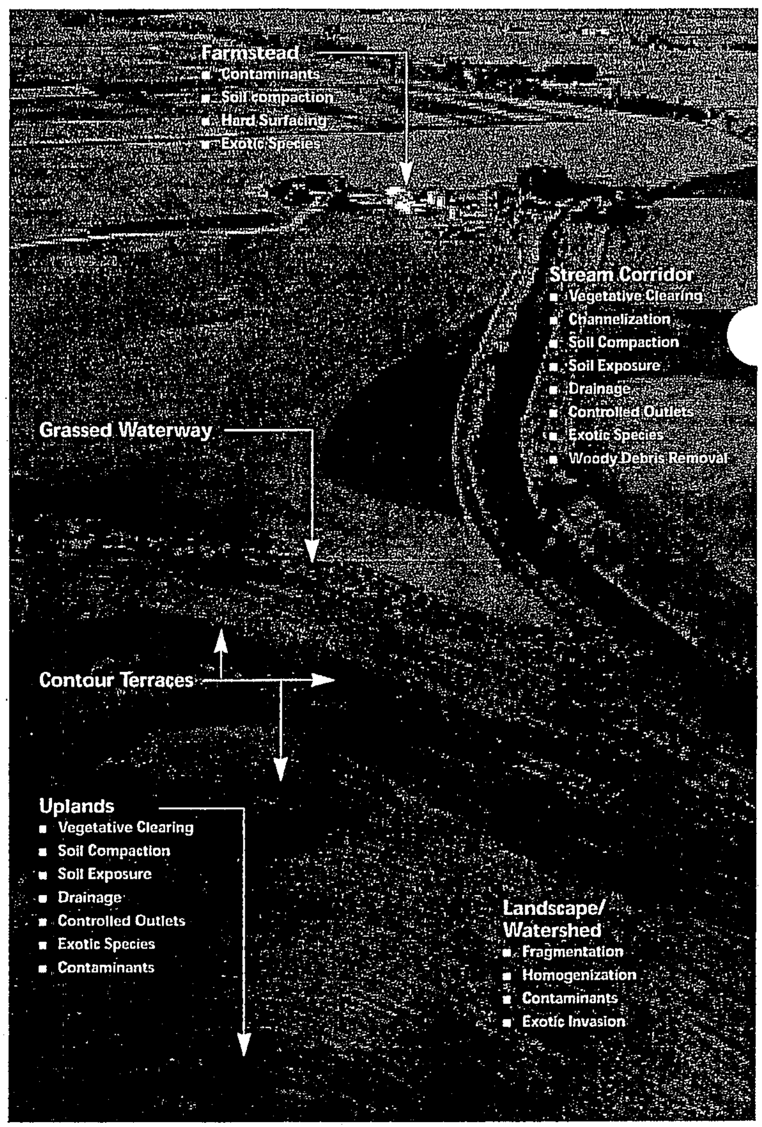
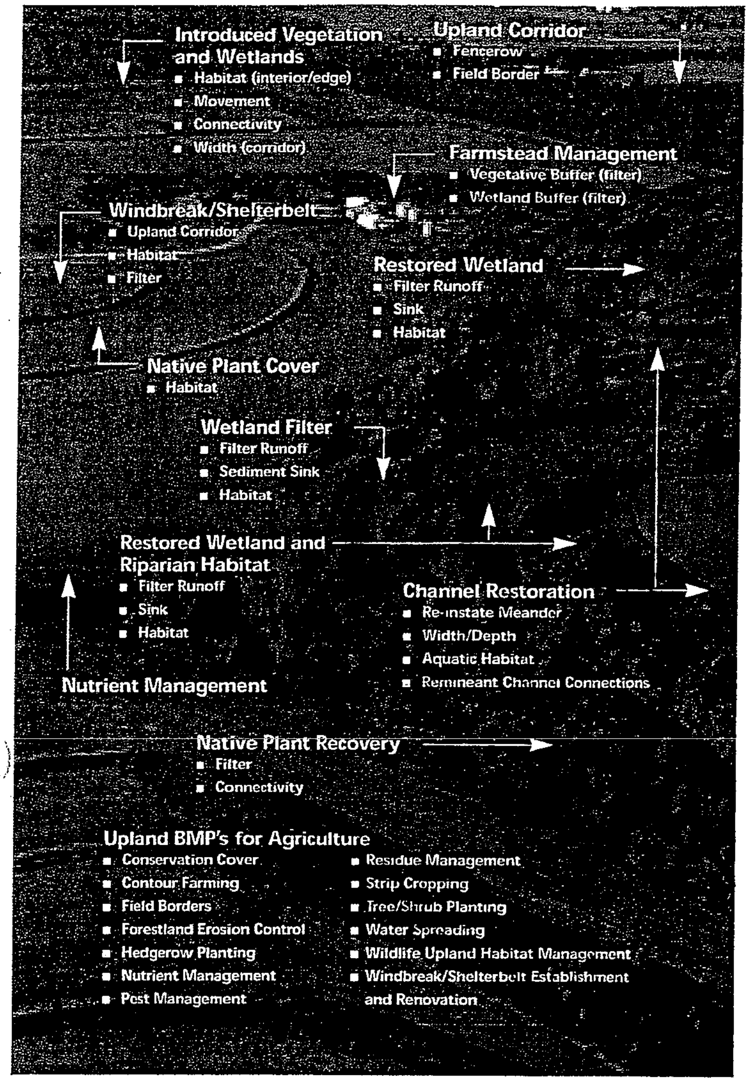


*Figure 8.53: **Hypothetical restoration response.** Possible results of stream corridor restoration are presented in this computer-altered photograph.*



activities and subsequent changes outlined in Chapter 3 come to mind. Those hypothetically reflected in the figure are highlighted in **Table 8.8**.

Hypothetical Restoration Response

Previous sections of this chapter and earlier chapters identified connectivity and dimension (width) as important structural attributes of stream corridors. Nutrient and water flow, sediment trapping during floods, water storage, movement of flora and fauna, species diversity, interior habitat conditions, and provision of organic materials to aquatic communities were described as just a few of the functional conditions affected by these structural attributes. Continuous indigenous vegetative cover across the widest possible stream corridor was generally identified as the most conducive to serving the broadest range of functions. This discussion went on to suggest that a long, wide stream corridor with contiguous vegetative cover is a favored overall characteristic. A contiguous, wide stream corridor may be unachievable, however, where competing land uses prevail. Furthermore, gaps caused by disturbances (utility crossings, highways and access lanes, floods, wind, fire, etc.) are commonplace.

Restoration design should establish functional connections within and external to stream corridors. Landscape elements such as remnant patches of riparian vegetation, prairie, or forest exhibiting diverse or unique vegetative communities; productive land that can support ecological functions; reserve or abandoned land; associated wetlands or meadows; neighboring springs and stream systems; ecologically innovative residential areas; and movement corridors for flora and fauna (field borders, windbreaks, waterways, grassed terraces, etc.) offer opportunities to establish these connections. An edge (transition zone) that gradually changes from one land use into another will soften environmental gradients and minimize disturbance.

With these and the broad design guidelines presented in previous sections of this chapter in mind, **Figure 8.53** presents a conceptual computer-generated illustration of hypothetical restoration

Table 8.8: Summary of prominent agriculturally related disturbance activities and potential effects.

Potential Effects	Existing Disturbance Activities: Vegetative Clearing	Channelization	Streambed Disturbance	Soil Exposure or Compaction	Contaminants	Woody Debris Removal	Piped Discharge/Cont. Outlets
Decreased landscape diversity	D	D	I	I	I	I	I
Point source pollution	I	I	I	I	D	I	D
Nonpoint source pollution	D	D	D	I	D	D	D
Dense compacted soil	D	I	I	D	I	I	I
Increased upland surface runoff	D	I	I	D	I	I	I
Increased sheetflow with surface erosion rill and gully flow	D	I	I	D	I	I	I
Increased levels of fine sediment and contaminants in stream corridor	D	D	D	D	D	D	D
Increased soil salinity	I	I	I	I	D	I	I
Increased peak flood elevation	D	D	I	D	I	D	D
Increased flood energy	D	D	D	D	I	D	D
Decreased infiltration of surface runoff	D	I	I	D	I	I	D
Decreased interflow and subsurface flow to and within the stream corridor	D	D	I	D	D	I	D
Reduced ground water recharge and aquifer volumes	D	I	I	D	I	I	D
Increased depth to ground water	D	D	I	D	I	I	I
Decreased ground water inflow to stream	D	D	I	D	I	I	D
Increased flow velocities	D	D	D	D	I	D	D
Reduced stream meander	I	D	D	I	I	D	D
Increased or decreased stream stability	D	D	D	I	I	D	D
Increased stream migration	D	I	D	I	I	D	D
Channel widening and downcutting	D	D	D	I	I	D	D
Increased stream gradient and reduced energy dissipation	I	D	D	I	I	D	D
Increased flow frequency	D	I	I	D	I	I	D
Reduced flow duration	D	D	D	D	I	D	D
Decreased capacity of floodplain and upland	D	I	I	D	D	I	D
Increased sediment and contaminants	D	I	I	D	D	D	D
Decreased capacity of stream	I	D	D	I	D	D	D
Reduced stream capacity to assimilate nutrients/pesticides	D	D	D	D	D	D	D
Confined stream channel with little opportunity for habitat development	I	D	D	I	I	I	I
Increased streambank erosion and channel scour	D	D	D	D	I	D	D
Increased bank failure	D	D	I	D	I	D	D
Loss of instream organic matter and related decomposition	D	D	D	I	I	D	D
Increased instream sediment, salinity, or turbidity	D	D	D	I	D	D	D
Increased instream nutrient enrichment, sedimentation, and contaminants leading to eutrophication	D	I	D	D	D	D	D

■ (D) Activity has potential for direct impact.

▒ (I) Activity has potential for indirect impact.

Table 8.8: Summary of prominent agriculturally related disturbance activities and potential effects (continued).

Potential Effects	Existing Disturbance Activities: Vegetative Clearing	Channelization	Streambed Disturbance	Soil Exposure or Compaction	Contaminants	Woody Debris Removal	Piped Discharge/Cont. Outlets
Highly fragmented stream corridor with reduced linear distribution of habitat and edge effect	■	■	▒	▒	▒	■	▒
Loss of edge and interior habitat	■	■	■	▒	▒	■	▒
Decreased connectivity and dimension (width) within corridor and to associated ecosystems	■	■	■	▒	▒	▒	▒
Decreased movement of flora and fauna species for seasonal migration, dispersal, repopulation	■	■	■	▒	▒	▒	▒
Reduced stream capacity to assimilate nutrients/pesticides	■	■	■	■	■	■	■
Increase of opportunistic species, predators	■	■	▒	▒	■	■	■
Increased exposure to solar radiation, weather, and temperature	■	■	■	■	▒	■	▒
Magnified temperature and moisture extremes in corridor	■	■	▒	■	▒	▒	▒
Loss of riparian vegetation	■	■	■	■	▒	■	■
Decreased source of instream shade, detritus, food, and cover	■	■	■	▒	▒	▒	■
Loss of edge diversity	■	■	▒	▒	▒	▒	▒
Increased water temperature	■	■	■	▒	▒	▒	■
Impaired aquatic habitat	■	■	■	▒	■	▒	■
Reduced invertebrate population	■	■	■	▒	■	▒	■
Loss of wetland function	▒	■	■	▒	▒	▒	▒
Reduced instream oxygen	▒	■	■	▒	■	▒	■
Invasion of exotic species	■	■	■	▒	▒	▒	▒
Reduced gene pool	■	■	■	▒	▒	▒	■
Reduced species diversity	■	■	■	■	▒	▒	■

■ Activity has potential for direct impact. ▒ Activity has potential for indirect impact.

results. **Table 8.9** identifies some of the restoration measures hypothetically implemented and their potential effects on restoring conditions within the stream corridor and surrounding landscape.

Forestry

Stream corridors are a source of large volumes of timber. Timber harvesting and related forest management practices in riparian corridors often necessitate stream corridor restoration. Forest management may be an on-going land use and part of the restoration effort. Regardless, accessing and harvesting timber affects streams in many ways including:

- Alteration of soil conditions.
- Removal of the forest canopy.
- Reduction in the potential supply of large organic (woody) debris (Belt et al. 1992).

Table 8.9: Summary of prominent restoration measures and potential resulting effects.

Potential Resulting Effects	Restoration Measures: Wetlands	Riparian Habitat	Upland Corridors	Windbreaks/Shelterbelts	Native Plant Cover	Stream Channel Restoration	Upland BMPs for Agriculture
Increased landscape diversity	■	■	■	■	■	■	■
Increased stream order	▨	▨	▨	▨	▨	■	▨
Reduced point source pollution	■	▨	▨	▨	▨	▨	▨
Reduced nonpoint source pollution	■	■	■	■	■	■	■
Increased soil friability	▨	▨	▨	▨	■	▨	■
Decreased upland surface runoff	▨	▨	▨	■	■	▨	■
Decreased sheetflow, width, surface erosion, rill and gully flow	▨	■	▨	▨	■	▨	■
Decreased levels of fine sediment and contaminants in stream corridor	■	■	■	■	■	▨	■
Decreased soil salinity	▨	■	▨	▨	■	▨	■
Decreased peak flood elevation	■	■	■	■	■	■	■
Decreased flood energy	■	■	■	■	■	■	■
Increased infiltration of surface runoff	■	■	■	■	■	■	■
Increased interflow and subsurface flow to and within stream corridor	■	■	▨	▨	■	■	■
Increased ground water recharge and aquifer volumes	■	■	■	■	■	■	■
Decreased depth to ground water	■	■	■	■	■	■	■
Increased ground water inflow to stream	■	■	■	▨	■	■	■
Decreased flow velocities	■	■	■	■	■	■	■
Increased stream meander	▨	▨	▨	▨	▨	■	▨
Increased stream stability	■	■	■	▨	■	■	■
Decreased stream migration	■	■	■	▨	■	■	■
Reduced channel widening and downcutting	■	■	■	▨	■	■	■
Decreased stream gradient and increased energy dissipation	■	■	▨	▨	▨	■	■
Decreased flow frequency	■	■	■	▨	■	▨	■
Increased flow duration	■	■	■	▨	■	■	■
Increased capacity of floodplain and upland	■	■	■	■	■	▨	■
Decreased sediment and contaminants	■	■	■	■	■	▨	■
Increased capacity of stream	■	■	▨	▨	▨	■	▨
Increased stream capacity to assimilate nutrients/pesticides	■	■	▨	▨	▨	■	▨
Enhanced stream channel with more opportunity for habitat development	■	■	▨	▨	▨	■	▨
Decreased streambank erosion and channel scour	■	■	▨	▨	▨	■	■
Decreased bank failure	■	■	▨	▨	▨	■	▨
Gain of instream organic matter and related decomposition	■	■	▨	▨	▨	■	▨
Decreased instream sediment, salinity, or turbidity	■	■	■	■	■	■	■

■ Measure contributes directly to resulting effect. ▨ Measure contributes little to resulting effect.

Table 8.9: Summary of prominent restoration measures and potential resulting effects (continued).

Potential Resulting Effects	Restoration Measures: Wetlands	Riparian Habitat	Upland Corridors	Windbreaks/Shelterbelts	Native Plant Cover	Stream Channel Restoration	Upland BMPs for Agriculture
Decreased instream nutrient enrichment, siltation, and contaminants leading to eutrophication	■	■	■	■	■	■	■
Connected stream corridor with increased linear distribution of habitat and edge effect	■	■			■	■	■
Gain of edge and interior habitat	■	■	■	■	■	■	■
Increased connectivity and dimension (width) within corridor and to associated ecosystems	■	■	■	■	■	■	■
Increased movement of flora and fauna species for seasonal migration, dispersal repopulation	■	■	■	■	■	■	■
Decrease of opportunistic species, predators	■	■	▒		■	■	■
Decreased exposure to solar radiation, weather, and temperature	■	■	■	■	■	■	■
Decreased temperature and moisture extremes in corridor	■	■	■	■	■	■	■
Increased riparian vegetation	■	■	▒	▒	■	■	■
Increased source of instream shade, detritus, food, and cover	■	■			■	■	■
Increase of edge diversity	■	■	■	■	■	■	■
Decreased water temperature	■	■	■	■	■	■	■
Enhanced aquatic habitat	■	■	▒	▒	▒	■	▒
Increased invertebrate population	■	■	▒	▒	▒	■	▒
Increased wetland function	■	■	▒	▒	▒	■	■
Increased instream oxygen	■	■	■	▒		■	■
Decrease of exotic species	■	■	▒	▒	■	▒	■
Increased gene pool	■	■	■	■	■	■	■
Increased species diversity	■	■	■	■	■	■	■

■ Measure contributes directly to resulting effect. ▒ Measure contributes little to resulting effect.

Forest Roads

The vast majority of the restoration design necessary following timber harvest is usually devoted to the road system, where the greatest alteration of soil conditions has taken place. Inadequate drainage, poor location, improperly sized and maintained culverts, and lack of erosion control measures on road prisms, cut-and-fill slopes, and ditches are problems common to a poor road design (Stoner and McFall 1991). The most extreme road system rehabilitation requires full road closure. Full road closure involves removal of culverts and restoration of the streams that were crossed. It can also involve the ripping or tilling of road surfaces to allow plant establishment. If natural vegetation has not already invaded areas of exposed soils, planting and seeding might be necessary.

Full closure might not be a viable alternative if roads are needed to provide access for other uses. In these circumstances a design to restrict traffic might be appropriate. Voluntary traffic control usually cannot be relied on, so traffic barriers like gates, fences, or earth berms could be necessary. Even with traffic restriction, roads require regular inspection for existing or potential maintenance needs. The best time for inspection is during or immediately after large storms or snowmelt episodes so the effectiveness of the culverts and road drainage features can be witnessed first-hand. Design should address regular maintenance activities including road grading, ditch cleaning, culvert cleaning, erosion control vegetation establishment, and vegetation management.

BMP Implementation and Section 319 of the Clean Water Act

Section 319 of the Clean Water Act of 1987 required the states to identify and submit BMPs for USEPA approval to help control nonpoint sources of pollution. As of 1993, 41 of 50 states had EPA-approved voluntary or regulatory BMP programs dealing with silvicultural (forest management) activities. The state BMPs are all similar; the majority deal with roads. Montana, for example, has a total of 55 specifically addressed forest practices. Of those 55 practices, 35 deal with road planning and location, road design, road maintenance, road drainage, road construction, and stream crossings.

Buffer Strips in Forestry

Forested buffer strips are generally more effective in reducing sediment and chemical loadings in the stream corridor than vegetated filter strips (VFS). However, they are susceptible to similar problems with concentrated flows. Buffers constructed as part of a conservation system increase effectiveness. A stiff-stemmed grass hedge could be planted upslope of either a VFS or a woody riparian forest buffer. The stiff-stemmed grass hedge keeps sediment out of the buffer and increases shallow sheet flow through the buffer.

Most state BMPs also have special sections devoted to limitations for forest management activities in riparian "buffer strips" (also referred to as Streamside Management Zones or Streamside Protection Zones).

Budd et al. (1987) developed a procedure for determining buffer widths for streams within a single watershed in the Pacific Northwest. They focused their attention primarily on maintenance of fish and wildlife habitat quality (stream temperature, food supply, stream structure, sediment control) and found that effective buffer widths varied with the slope of adjacent uplands, the distribution of wetlands, soil and vegetation characteristics, and land use. They concluded that practical determinations of stream buffer width can be made using such analyses, but it is clear that a generic buffer width which would provide habitat maintenance while satisfying human demands does not exist. The determination of buffer widths involves a broad perspective that integrates ecological functions and land use. The section on design approaches to common effects at the beginning of this chapter also includes some discussion on stream buffer width.

Stream corridors have varied dimensions, but stream buffer strips have legal dimensions that vary by state (**Table 8.10**). The buffer may be only part of the corridor or it may be all of it. Unlike designing stream corridors for recreation features or grazing use, designing for timber harvest and related forest management activities is quite regimented by law and regulation. Specific requirements vary from state to state; the state Forester's office or local Extension Service can provide guidance on regulatory issues. USDA Natural Resource Conservation Service offices and Soil and Water Conservation District offices also are sources of information. Refer to Belt et al. (1992) and Welsch (1991) for guidance on riparian buffer strip design, function, and management. Salo and Cundy (1987) provide information on forestry effects on fisheries.

Grazing

The closer an ecosystem is managed to allow for natural ecological processes to function, the more successful a restoration strategy will be. In stream corridors that have been severely degraded by grazing, rehabilitation should begin with grazing management to allow for vegetative recovery.

Vegetative recovery is often more effective than installing a structure. The vegetation maintains itself in perpetuity, allows streams to function in ways that artificial structures cannot replicate, and provides resiliency that allows riparian systems to withstand a variety of environmental conditions (Elmore and Beschta 1987)

Designs that promote vegetative recovery after grazing are beneficial in a number of ways. Woody species can provide resistance to channel erosion and improve channel stability so that other species can become established. As vegetation becomes established, channel elevation will increase as sediment is deposited within and along the banks of the channel (aggradation), and water tables will rise and may reach the root zone of plants on former terraces or floodplains. This aggradation of the channel and the rising water table

State	Stream Class	Buffer Strip Requirements		
		Width	Shade or Canopy	Leave Trees
Idaho	Class I*	Fixed minimum (75 feet)	75% current shade[a]	Yes, number per 1000 feet, dependent on stream width[b]
	Class II**	Fixed minimum (5 feet)	None	None
Washington	Type 1, 2, and 3*	Variable by stream width (5 to 100 feet)	50%, 75% if temperature > 60°F	Yes, number per 1000 feet, dependent on stream width and bed material
	Type 4**	None	None	25 per 1000 feet, 6 inches diameter
California	Class I and Class II*	Variable by slope and stream class (50 to 200 feet)	50% overstory and/or understory, dependent on slope and stream class	Yes, number to be determined by canopy density
	Class III**	None[b]	50% understory[e]	None[e]
Oregon	Class I**	Variable, 3 times stream width (25 to 100 feet)	50% existing canopy, 75% existing shade	Yes, number per 1000 feet and basal area per 1000 feet by stream width
	Class II special protection**	None[f]	75% existing shade	None

* Human water supply or fisheries use.
** Streams capable of sediment transport (CA) or other influences (ID and WA) or significant impact (OR) on downstream waters.
[a] In ID, the shade requirement is designed to maintain stream temperatures.
[b] In ID, the leave tree requirement is designed to provide for recruitment of large woody debris.
[c] May range as high as 300 feet for some types of timber harvest.
[d] To be determined by field inspection.
[e] Residual vegetation must be sufficient to prevent degradation of downstream beneficial uses.
[f] In eastern OR, operators are required to "leave stabilization strips of undergrowth... sufficient to prevent washing of sediment into Class I streams below."

Table 8.10: Buffer strip requirements by state.

CASE STUDY

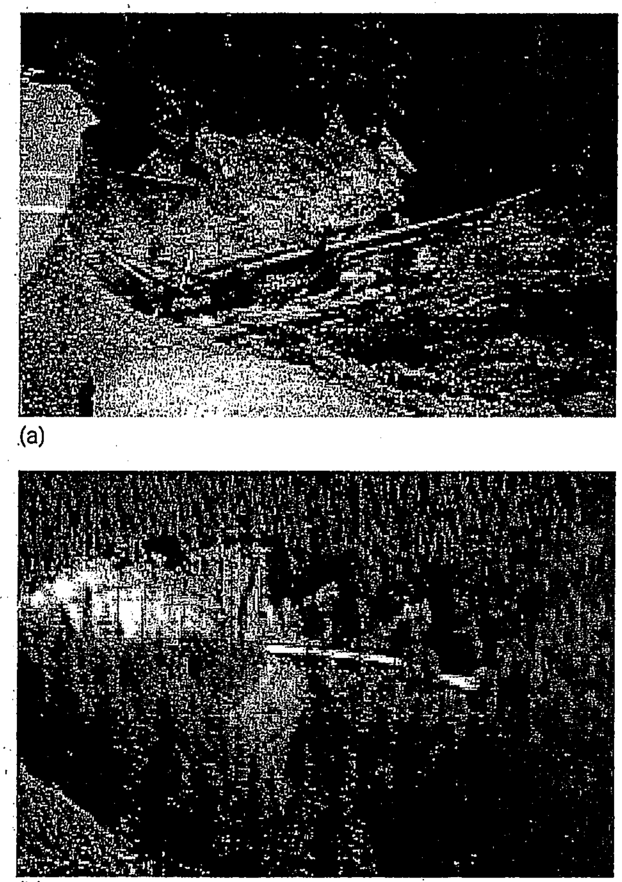
Pacific Northwest Floods of 1996

Floods, Landslides, and Forest Management—'The Rest of The Story'

*Warm winds, intense rainfall, and rapid snowmelt, during the winter of 1995-96 and again in the winter of 1996-97 caused major flooding, landslides, and related damage throughout the Pacific Northwest (**Figure 8.54**). Such flooding had not been seen for more than 30 years in hard-hit areas. Damage to roads, campgrounds, trails, watersheds, and aquatic resources was widespread on National Forest Service lands. These events offered a unique opportunity to investigate the effects of severe weather, examine the influence and effectiveness of various forest management techniques, and implement a repair strategy consistent with ecosystem management principles.*

The road network in the National Forests was heavily damaged during the floods. Decisions about the need to replace roads are based on long-term access and travel requirements. Relocation of roads to areas outside floodplains is a measure being taken. Examination of road crossings at streams concluded with design recommendations to keep the water moving, align culverts horizontally and longitudinally with the stream channel, and minimize changes in stream channel cross section at inlet basins to prevent debris plugs.

Many river systems were also damaged. In some systems, however, stable, well-vegetated slopes and streambanks combined with fully functioning floodplains buffered the effects of the floods. Restoration efforts will focus on aiding natural processes in these systems. Streambank stabilization and riparian plantings will be commonly used. Examination of instream structure durability concluded that structures are more likely to remain in place if they are in fourth-order or smaller streams and are situated in a manner that maintains a connection between the structure and the streambank. They will be most durable in watersheds with low landslide/debris torrent frequency.



(a)

(b)

Figure 8.54: 1996 Landslides. *(a) April landslide: debris took out the track into the Greenwater River and (b) July landslide: debris took out the road and deposited debris into the river.*

allow more water to be stored during wet seasons, thereby prolonging flow even during periods of drought (Elmore and Beschta 1987).

Kauffman et al. (1993) observed that fencing livestock out of the riparian zone is the only grazing strategy that consistently results in the greatest rate of vegetative recovery and the greatest improvement in riparian function. However, fencing is very expensive, requires considerable maintenance, and can limit wildlife access—a negative impact on habitat or conduit functions.

Some specialized grazing strategies hold promise for rehabilitating less severely impacted riparian and wetland areas without excluding livestock for long periods of time. The efficiency of a number of grazing strategies with respect to fishery needs are summarized in **Tables 8.11 and 8.12** (from Platts 1989). They summarize the influence of grazing systems and stream system characteristics on vegetation response, primarily from a western semiarid perspective. Some general design recommendations for selecting a strategy include the following (Elmore and Kauffmann 1994):

- Each strategy must be tailored to a particular stream or stream reach. Management objectives and components of the ecosystem that are of critical value must be identified (i.e., woody species recovery, streambank restoration, increased habitat diversity, etc.). Other information that should be identified includes present vegetation, potential of the site for recovery, the desired future condition, and the current factors causing habitat degradation or limiting its recovery.
- The relationships between ecological processes that must function for riparian recovery should be described. Factors affecting present condition (i.e., management stress vs. natural stress) and conditions required for the stream to resume natural functions need to be assessed. Anthropogenic factors causing stream degradation must be identified and changed.
- Design and implementation should be driven by attainable goals, objectives, and management activities that will achieve the desired structure and functions.
- Implementation should include a monitoring plan that will evaluate management, allowing for corrections or modifications as necessary, and a strong compliance and use supervision program.

The main consideration for selecting a grazing system is to have an adequate vegetative growing season between the period of grazing and timing of high-energy runoff. It is impossible to provide a cookie-cutter grazing strategy for every stream corridor; designs have to be determined on the ground, stream by stream, manager by manager. Simply decreasing the number of livestock is not a solution to degraded riparian conditions; rather, restoring these degraded areas requires fundamental changes in the ways that livestock are grazed (Chaney et al. 1990).

Clearly, the continued use of grazing systems that do not include the functional requirements of riparian vegetation communities will only perpetuate riparian problems (Elmore and Beschta 1987). Kinch (1989) and Clary and Webster (1989) provide greater detail on riparian grazing management and designing alternative grazing strategies. Chaney et al. (1990) present photo histories of a number of interesting grazing restoration case studies, and of the

Table 8.11: Evaluation and rating of grazing strategies.

Strategy[a]	Level to Which Riparian Vegetation is Commonly Used	Control of Animal Distribution (Allotment)	Streambank Stability	Brushy Species Condition	Seasonal Plant Regrowth	Stream Riparian Rehabilitation Potential	Fishery Needs Rating[b]
Continuous season-long (cattle)	Heavy	Poor	Poor	Poor	Poor	Poor	1
Holding (sheep or cattle)	Heavy	Excellent	Poor	Poor	Fair	Poor	1
Short duration-high intensity (cattle)	Heavy	Excellent	Poor	Poor	Poor	Poor	1
Three herd-four pasture (cattle)	Heavy to moderate	Good	Poor	Poor	Poor	Poor	2
Holistic (cattle or sheep)	Heavy to light	Good	Poor to good	Poor	Good	Poor to excellent	2-9
Deferred (cattle)	Moderate to heavy	Fair	Poor	Poor	Fair	Fair	3
Seasonal suitability (cattle)	Heavy	Good	Poor	Poor	Fair	Fair	3
Deferred-rotation (cattle)	Heavy to moderate	Good	Fair	Fair	Fair	Fair	4
Stuttered deferred-rotation (cattle)	Heavy to moderate	Good	Fair	Fair	Fair	Fair	4
Winter (sheep or cattle)	Moderate to heavy	Fair	Good	Fair	Fair to good	Good	5
Rest-rotation (cattle)	Heavy to moderate	Good	Fair to good	Fair	Fair to good	Fair	5
Double rest-rotation (cattle)	Moderate	Good	Good	Fair	good	Good	6
Seasonal riparian preference (cattle or sheep)	Moderate to light	Good	Good	Good	Fair	Fair	6
Riparian pasture (cattle or sheep)	As prescribed	Good	Good	Good	Good	Good	8
Corridor fencing (cattle or sheep)	None	Excellent	Good to excellent	Good to excellent	Good	Excellent	9
Rest-rotation with seasonal preference (sheep)	Light	Good	Good to excellent	Good to excellent	Good	Excellent	9
Rest or closure (cattle or sheep)	None	Excellent	Excellent	Excellent	Excellent	Excellent	10

a Jacoby (1989) and Platts (1989) define these management strategies

b Rating scale based on 1 (poorly compatible) to 10 (highly compatible with fishery needs)

Table 8.12: Generalized relationships between grazing systems, stream system characteristics, and riparian vegetation response.

Grazing System	Steep Low Sediment Load	Steep High Sediment Load	Moderate Low Sediment Load	Moderate High Sediment Load	Flat Low Sediment Load	Flat High Sediment Load
No grazing	Shrubs + Herbs + Banks 0	Shrubs + Herbs + Banks 0 to +	Shrubs + Herbs + Banks 0	Shrubs + Herbs + Banks +	Shrubs + Herbs + Banks +	Shrubs + Herbs + Banks +
Winter or dormant season	Shrubs + Herbs + Banks 0	Shrubs + Herbs + Banks 0 to +	Shrubs + Herbs + Banks +	Shrubs + Herbs + Banks +	Shrubs + Herbs + Banks +	Shrubs + Herbs + Banks +
Early growing season	Shrubs + Herbs + Banks 0	Shrubs + Herbs + Banks 0 to +	Shrubs + Herbs + Banks +	Shrubs + Herbs + Banks +	Shrubs + Herbs + Banks +	Shrubs + Herbs + Banks +
Deferred or late season	Shrubs – Herbs + Banks 0 to –	Shrubs – Herbs + Banks 0 to –	Shrubs – Herbs + Banks 0 to +	Shrubs – Herbs + Banks +	Shrubs – Herbs + Banks +	Shrubs – Herbs + Banks +
Three-pasture rest rotation	Shrubs – Herbs + Banks 0 to –	Shrubs – Herbs + Banks 0 to –	Shrubs – Herbs + Banks 0 to +	Shrubs – Herbs + Banks +	Shrubs – Herbs + Banks +	Shrubs – Herbs + Banks +
Deferred rotation	Shrubs – Herbs + Banks 0 to –	Shrubs – Herbs + Banks 0 to –	Shrubs – Herbs + Banks + to 0	Shrubs – Herbs + Banks +	Shrubs – Herbs + Banks +	Shrubs + Herbs + Banks +
Early rotation	Shrubs + Herbs + Banks 0 to –	Shrubs + Herbs + Banks 0 to +	Shrubs + Herbs + Banks + to 0	Shrubs + Herbs + Banks +	Shrubs + Herbs + Banks +	Shrubs + Herbs + Banks +
Rotation	Shrubs – Herbs + Banks 0 to –	Shrubs – Herbs + Banks 0 to –	Shrubs – Herbs + Banks 0 to +	Shrubs – Herbs + Banks +	Shrubs – Herbs + Banks +	Shrubs – Herbs + Banks +
Season-long	Shrubs – Herbs – Banks 0 to –	Shrubs – Herbs – Banks 0 to –	Shrubs – Herbs – Banks –	Shrubs – Herbs – Banks –	Shrubs – Herbs – Banks –	Shrubs – Herbs – Banks –
Spring and fall	Shrubs – Herbs – Banks 0 to –	Shrubs – Herbs – Banks 0 to –	Shrubs – Herbs – Banks –	Shrubs – Herbs – Banks –	Shrubs – Herbs – Banks – to 0	Shrubs – Herbs – Banks 0 to +
Spring and summer	Shrubs – Herbs – Banks 0 to –	Shrubs – Herbs – Banks 0 to –	Shrubs – Herbs – Banks –	Shrubs – Herbs – Banks – to 0	Shrubs – Herbs – Banks – to 0	Shrubs – Herbs – Banks 0 to +

Note: – = decrease; + = increase; 0 = no change. Stream gradient: 0 to 2% = flat; 2 to 4% = moderate; > 4% = steep. Banks refers to bank stability.

CASE STUDY Oven Run, Pennsylvania

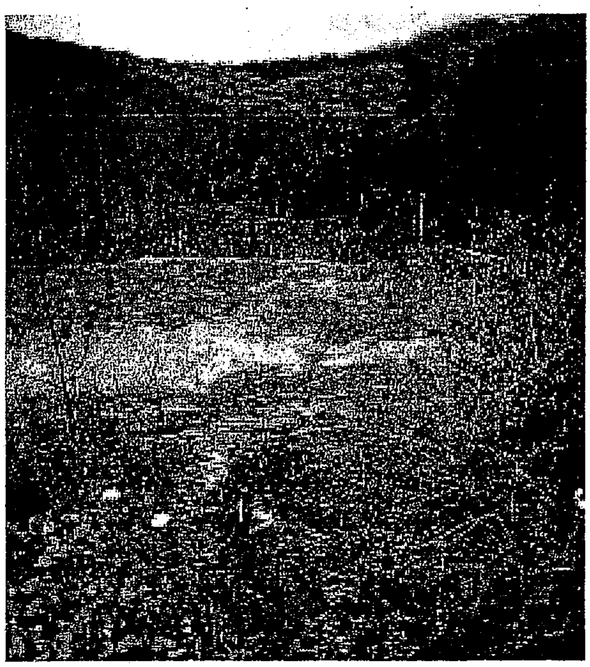
The effects of abandoned mines draining into the surrounding lands cause dramatic changes in the area (**Figure 8.55**(a)). Runoff with high levels of minerals and acidity can denude the ground of vegetation, expose the soil, and allow erosion with the sediment further stressing streams and wetland. Any efforts to restore streams in this environment must deal with the problem if any success is to be likely.

The Natural Resources Conservation Service, formerly known as the Soil Conservation Service, has been working on the Oven Run project along with the Stonycreek Conemaugh River Improvement (SCRIP) to improve water quality in a 4-mile reach above the Borough of Hooversville. SCRIP is a group of local and state government as well as hundreds of individuals interested in improving the water quality in an area on Pennsylvania's Degraded Watersheds list.

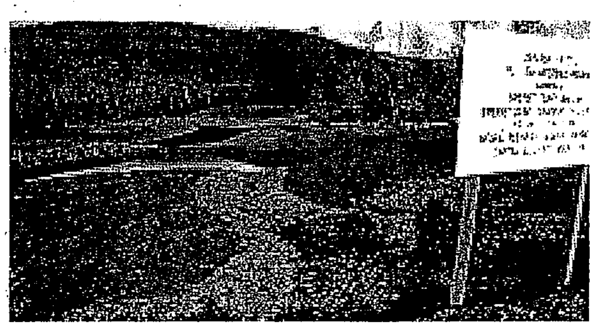
The initial goal of improving water quality resulted in improving habitat and aesthetic qualities. The water coming into Hooversville had higher-than-desired levels of iron, manganese, aluminum, sulfate, and acidity. Six former strip mines, which had a range of problems, were identified. They included deep mine openings that have large flows of acid mine drainage, acid mine seepage into streams, eroding spoil areas, areas of ponded water that infiltrate into ground water (adding to the acid mine drainage), and areas downhill of seepage and deep mine drainage that are denuded and eroding.

Control efforts included grading and vegetating the abandoned mine to reduce infiltration through acid-bearing layers and reduce erosion and sedimentation, surface water controls to carry water around the sites to safer outlets, and treating discharge flow with anoxic limestone drains and chambered passive wetland treatments (Figure 8.55(b)). Additionally, 1,000 feet of trees were planted along one of the site streams to shade the Stoneycreek River. Average annual costs for the six sites were estimated to be $503,000 compared to average annual benefits of $513,000.

The sites are being monitored on a monthly basis, and 4 years after work was begun the treatments have had a measurable success. The acid influent has been neutralized, and the effluent is now a net alkaline. Iron, aluminum, and manganese levels have been reduced, with iron now at average levels of 0.5 mg/L from average levels of 35 mg/L.



(a)



(b)

Figure 8.55: Stream corridor (a) before and (b) after restoration.

short-term results of some of the available grazing strategies.

Mining

Post-mining reclamation of stream corridors must begin with restoration of a properly functioning channel. Because many of the geologic and geomorphic controls associated with the pre-disturbance channel may have been obliterated by mining operations, design of the post-mining channel often requires approaches other than mimicking the pre-disturbance condition. Channel alignment, slope, and size may be determined on the basis of empirical relations developed from other streams in the same hydrologic and physiographic settings (e.g., Rechard and Schaefer 1984, Rosgen 1996). Others (e.g., Hasfurther 1985) have used a combination of empirical and theoretical approaches for design of reclaimed channels. Total reconstruction of stream channels is treated at length in Section 8.E. Other sections of the chapter address stabilization of streambanks, revegetation of floodplains and terraces, and restoration of aquatic and terrestrial habitats. Additional guidance is available in Interfluve, Inc. (1991).

Surface mining is usually associated with large-scale disturbances in the contributing watershed, therefore, a rigorous hydrological analysis of pre- and post-mining conditions is critical for stream corridor restoration of disturbed systems. The hydrologic analysis should include a frequency analysis of extreme high- and low-flow events to assess channel performance in the post-mining landscape.

Hydrologic modeling may be required to generate runoff hydrographs for the post-mining channel because watershed geology, soils, vegetation, and topography may be completely altered by mining operations. Thus, channel design and stability assessments will be based on modeled runoff rates reflecting expected watershed conditions. The hydrologic analysis for post-mining restoration should also address sediment production from the reclaimed landscape. Sediment budgets (see Chapter 7) will be needed for both the period of vegetation establishment and the final revegetated condition.

The hydrologic analyses will provide restoration practitioners with the flow and sediment characteristics needed for restoration design. The analyses may also indicate a need for at least temporary runoff detention and sediment retention during the period of vegetation establishment. However, the post-mining channel should be designed for long-term equilibrium with the fully reclaimed landscape.

Water quality issues (e.g., acid mine drainage) often control the feasibility of stream restoration in mined areas and should be considered in design.

Recreation

Both concentrated and dispersed recreational use of stream corridors can cause damage and ecological change. Ecological damage primarily results from the need for access for the recreational user. A trail often will develop along the shortest or easiest route to the point of access on the stream. Additional resource damage may be a function of the mode of access to the stream: motorcycles and horses cause far more damage to vegetation and trails than do pedestrians. Control of streambank access in developed recreation sites must be part of a restoration design. On undeveloped or unmanaged sites, such control is more difficult but still very necessary (**Figure 8.56**).

Rehabilitation of severely degraded recreation areas may require at least temporary use restrictions. Even actively eroding trails, camp and picnic sites, and stream access points can be stabilized through temporary site closure and combinations of soil and vegetation restoration (Wenger 1984, Marion and Merriam 1985, Hammitt and Cole 1987). Closure will not provide a long-term solution if access is restored without addressing the cause of the original problem. Rather, new trails and recreation sites should be located and constructed based on an understanding of vegetation capabilities, soil limitations, and other physical site characteristics. Basically, the keys to a successful design are:

- Initially locating or moving use to the most damage-resistant sites.
- Influencing visitor use.
- Hardening use areas to make them more resistant.
- Rehabilitating closed sites.

Urbanization

Few land uses have the capacity to alter water and sediment yield from a drainage as much as the conversion of a watershed from rural to urban conditions; thus, few land uses have greater potential to affect the natural environment of a stream corridor.

As a first step in hydrologic analyses, designers should characterize the nature of existing hydrologic response and the likelihood for future shifts in water and sediment yield. Initially, construction activities create excess sediment that can be deposited in downstream channels and floodplains. As impervious cover increases, peak flows increase. Water becomes cleaner as more area is covered with landscaping or impervious material. The increased flows and cleaner

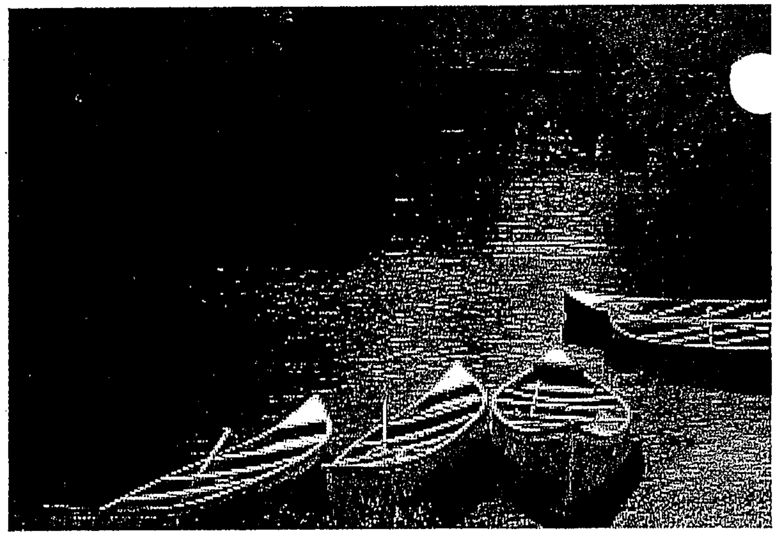


Figure 8.56: Controlled access: *Control of streambank access is an important part of the restoration design.*
Source: J. McShane.

water enlarge channels, which increases sediment loads downstream.

Determine if the watershed is (a) fully urbanized, (b) undergoing a new phase of urbanization, or (c) is in the beginning stages of urbanization (Riley, 1998).

An increase in the amount of impervious cover in a watershed leads to increased peak flows and resulting channel enlargement (**Figure 8.57**). Research has shown that impervious cover of as little as 10 to 15 percent of a watershed can have significant adverse effects on channel conditions (Schueler 1996). Magnitudes of channel-forming or bankfull flood events (typically 1- to 3-year recurrence intervals) are increased significantly, and flood events that previously occurred once every year or two may occur as often as one or two times a month.

Enlargement of streams with subsequent increases in downstream sediment loads in urbanized watersheds should be expected and accommodated in the design of restoration treatments.

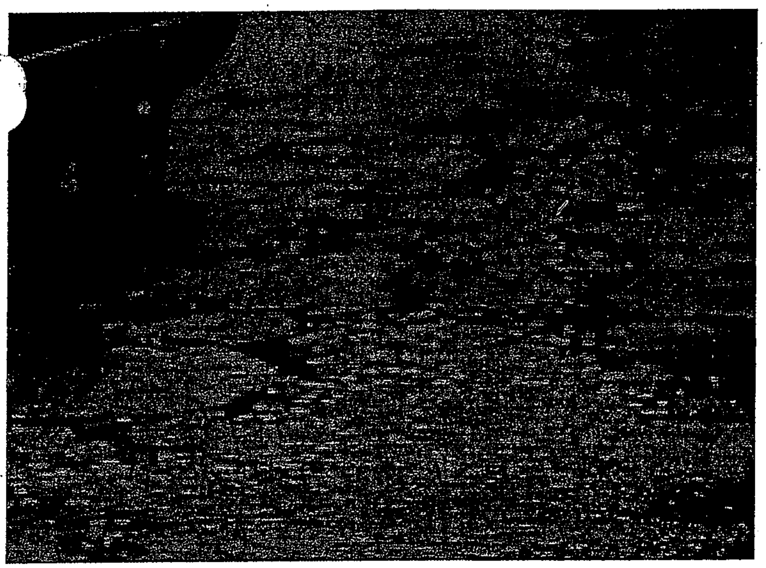


Figure 8.57: Storm water flow on a paved surface. *Impervious surfaces increase peak flows and can result in channel enlargement.* Source: M. Corrigan.

Procedures for estimating peak discharges are described in Chapter 7, and effects of urbanization on magnitude of peak flows must be incorporated into the analysis. Sauer et al. (1983) investigated the effect of urbanization on peak flows by analyzing 199 urban watersheds in 56 cities and 31 states. The objective of the analysis was to determine the increase in peak discharges due to urbanization and to develop regression equations for estimating design floods, such as the 100-year or 1 percent chance annual flood, for ungauged urban watersheds. Sauer et al. (1983) developed regression equations based on watershed, climatic, and urban characteristics that can be used to estimate the 2, 5, 10, 25, 50, 100, and 500-year urban annual peak discharges for ungauged urban watersheds. The equation for the 100-year flood in cubic feet per second (UQ100) is provided as an example:

$$UQ100 = 2.50\ A^{.29}\ SL^{.15}\ (RI2+3)^{1.26}\ (ST+8)^{-.52}\ (13-BDF)^{-.28}\ IA^{.06}\ RQ100^{.63}$$

where the explanatory variables are drainage area in square miles (A), channel slope in feet per mile (SL), the 2-year, 2-hour rainfall in inches (RI2), basin storage in percent (ST), basin development factor (BDF), which is a measure of the extent of development of the drainage system (dimensionless, ranging from 0 to 12), percent impervious area (IA), and the equivalent rural peak discharge in cubic feet per second (RQ100) in the example equation above.

Sauer et al. (1983) provide the allowable range for each variable. The two indices of urbanization in the equation are BDF and IA. They can be used to adjust the rural peak discharge RQ100 (either estimated or observed) to urban conditions.

Sauer et al. (1983) provide equations like the one above and graphs that relate the ratio of the urban to rural peak discharge (UQx/RQx) for recurrence intervals x = 2, 10, and 100 years. The 2-year peak ratio varies from 1.3 to 4.3, depending on the values of BDF and IA; the 10-year ratio varies from 1.2 to 3.1; and the 100-year ratio varies from 1.1 to 2.6. These ratios indicate that urbanization generally has a lesser effect on higher-recurrence-interval floods because watershed soils are more saturated and floodplain storage more fully depleted in large floods, even in the rural condition.

More sophisticated hydrologic analyses than the above are often used, including use of computer models, regional regression equations, and statistical analyses of gauge data. Hydrologic models, such as HEC-1 or TR-20, are often already developed for some urban watersheds.

Once the flood characteristics of the stream are adjusted for urbanization, new equilibrium channel dimensions can be estimated from hydraulic geometry relationships developed using data from stable, alluvial channels in similar (soils, slope, degree of urbanization) watersheds, or other analytical approaches. Additional guidance for design of restored channels is provided earlier in this chapter in the section on channel reconstruction.

Changes in flooding caused by urbanization of a watershed can be mitigated during urban planning through practices designed to control storm runoff. These practices emphasize the use of vegetation and biotechnical methods, as well as structural methods, to maintain or restore water quality and dampen peak runoff rates. Strategies for controlling runoff include the following:

- Increasing infiltration of rainfall and streamflow to reduce runoff and to remove pollutants.
- Increasing surface and subsurface storage to reduce peak flows and induce sediment deposition.
- Filtration and biological treatment of suspended and soluble pollutants (i.e., constructed wetlands).
- Establishment and/or enhancement of forested riparian buffers.
- Management of drainage from the transportation network.
- Introduction of trees, shrubs, etc., for various restoration purposes.

In addition to changes in water yield, urbanization of a watershed frequently generates changes in its sediment yield. In humid climates, vegetative cover prior to urbanization often is adequate to protect soil resources and minimize natural erosion, and the combination of impervious area and vegetation of a fully urban watershed might be adequate to minimize sediment yield. During the period of urbanization, however, sediment yields increase significantly as vegetation is cleared and bare soil is exposed during the construction process. In more arid climates, sediment yield from an urban watershed may actually be lower than the yield from a rural watershed due to the increased impervious area and vegetation associated with landscaping, but the period of urbanization (i.e., construction) is still the time of greatest sediment production.

The effect of urbanization on sediment discharge is illustrated in **Figure 8.58**, which contains data from nine subbasins in a 32-square-mile area in the Rock Creek and Anacostia River Basins north of Washington, DC (Yorke and Herb 1978). During the period of data collection (1963-74), three subbasins remained virtually rural while the others underwent urban development. In 1974, urban land represented from 0 to 60 percent of land use in the nine subbasins. These data were used to develop a relation between suspended sediment yield and the percentage of land under construction. This relation indicated that suspended sediment yield increased about 3.5 times for watersheds with 10 percent of the land area under construction. However, suspended-sediment yields for watersheds where sediment controls (primarily sediment basins) were employed for 50 percent of the construction area were only about one-third of these for areas without controls. The effect of controls is seen in the figure. The three curves present growing season data for three periods of increasing sediment control: 1963-67, when no controls were used on construction sites; 1968-71, when controls were mandatory; and 1972-74, when controls were mandatory and subject to inspection by county officials. It further illustrates that storm runoff is not the only factor affecting storm sedi-

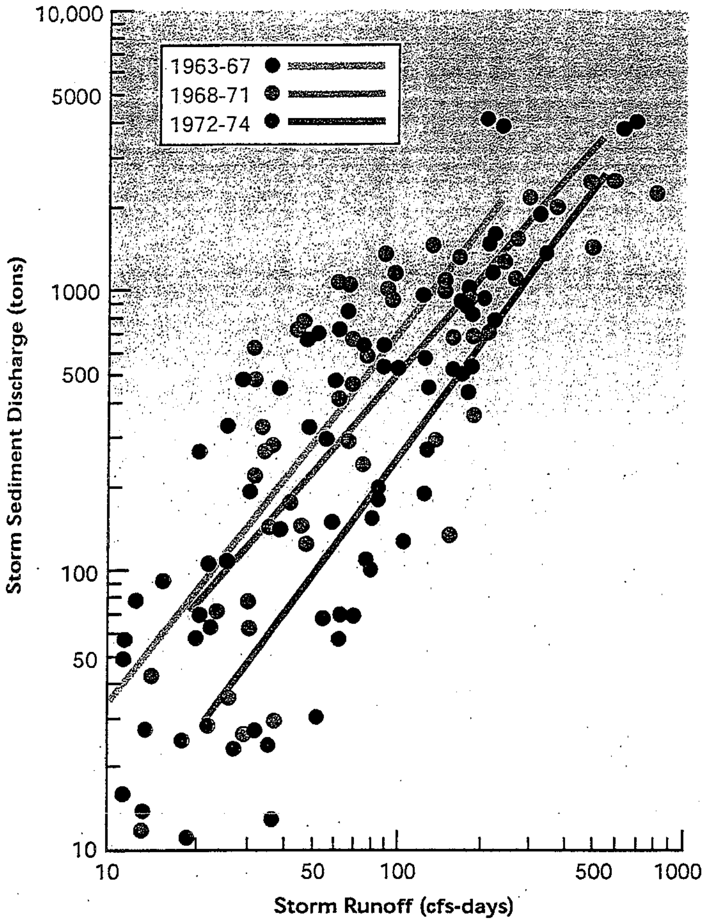


Figure 8.58: Sediment-transport curves for growing season storms. *The effect of urbanization on sediment discharge is illustrated from data collected in a 32-square-mile area.*

ment discharge as evidenced by the significant scatter about each relation.

In addition to sediment basins, management practices for erosion and sediment control focus on the following objectives:

- Stabilizing critical areas along and on highways, roads, and streets.
- Siting and placement of sediment migration barriers.
- Design and location of measures to divert or exclude flow from sensitive areas.
- Protection of waterways and outlets.
- Stream and corridor protection and enhancement.

All of these objectives emphasize the use of vegetation for sediment control. Additional information on BMPs for controlling runoff and sediment in urban watersheds can be found in the *Techniques Appendix*.

In theory, a local watershed management plan might be the best tool to protect a stream corridor from the cumulative impact of urban development; however, in practice, few such plans have realized this goal (Schueler 1996). To succeed, such plans must address the amount of bare ground exposed during construction and the amount of impervious area that will exist during and after development of the watershed. More importantly, success will depend on using the watershed plan to guide development decisions, and not merely archiving it as a one-time study whose recommendations were read once but never implemented (Schueler 1996).

Key Tools of Urban Stream Restoration Design

Restoration design for streams degraded by prior urbanization must consider pre-existing controls and their effects on restoration objectives. Seven restoration tools can be applied to help restore urban streams. (Schereler,1996) These tools are intended to compensate for stream functions and processes that have been diminished or degraded by prior watershed urbanization. The best results are usually obtained when the following tools are applied together.

Tool 1. Partially restore the predevelopment hydrological regime. The primary objective is to reduce the frequency of bankfull flows in the contributing watershed. This is often done by constructing upstream storm water retrofit ponds that capture and detain increased storm water runoff for up to 24 hours before release (i.e., extended detention). A common design storm for extended detention is the one-year, 24 hour storm event. Storm water retrofit ponds are often critical in the restoration of small and midsized streams, but may be impractical in larger streams and rivers.

Tool 2. Reduce urban pollutant pulses. A second need in urban stream restoration is to reduce concentrations of nutrients, bacteria and toxics in the stream, as well as trapping excess sediment loads. Generally, three tools can be applied to reduce pollutant inputs to an urban stream: storm water retrofit ponds or wetlands, watershed pollution prevention programs, and the elimination of illicit or illegal sanitary connections to the storm sewer network

Tool 3. Stabilize channel morphology. Over time, urban stream channels enlarge their dimensions, and are subject to severe bank and bed erosion. Therefore, it is important to stabilize the channel, and if possible, restore equilibrium channel geometry. In addition, it is also useful to provide undercuts or overhead cover to improve fish habitat. Depending on the stream order, watershed impervious cover and the height and angle of eroded banks, a series of different tools can be applied to stabilize the channel, and prevent further erosion. Bank stabilization measures include imbricated rip-rap, brush bundles, soil bioengineering methods such as willow stakes and bio-logs, lunker structures and rootwads. Grade stabilization measures are discussed earlier in this chapter and in Appendix A.

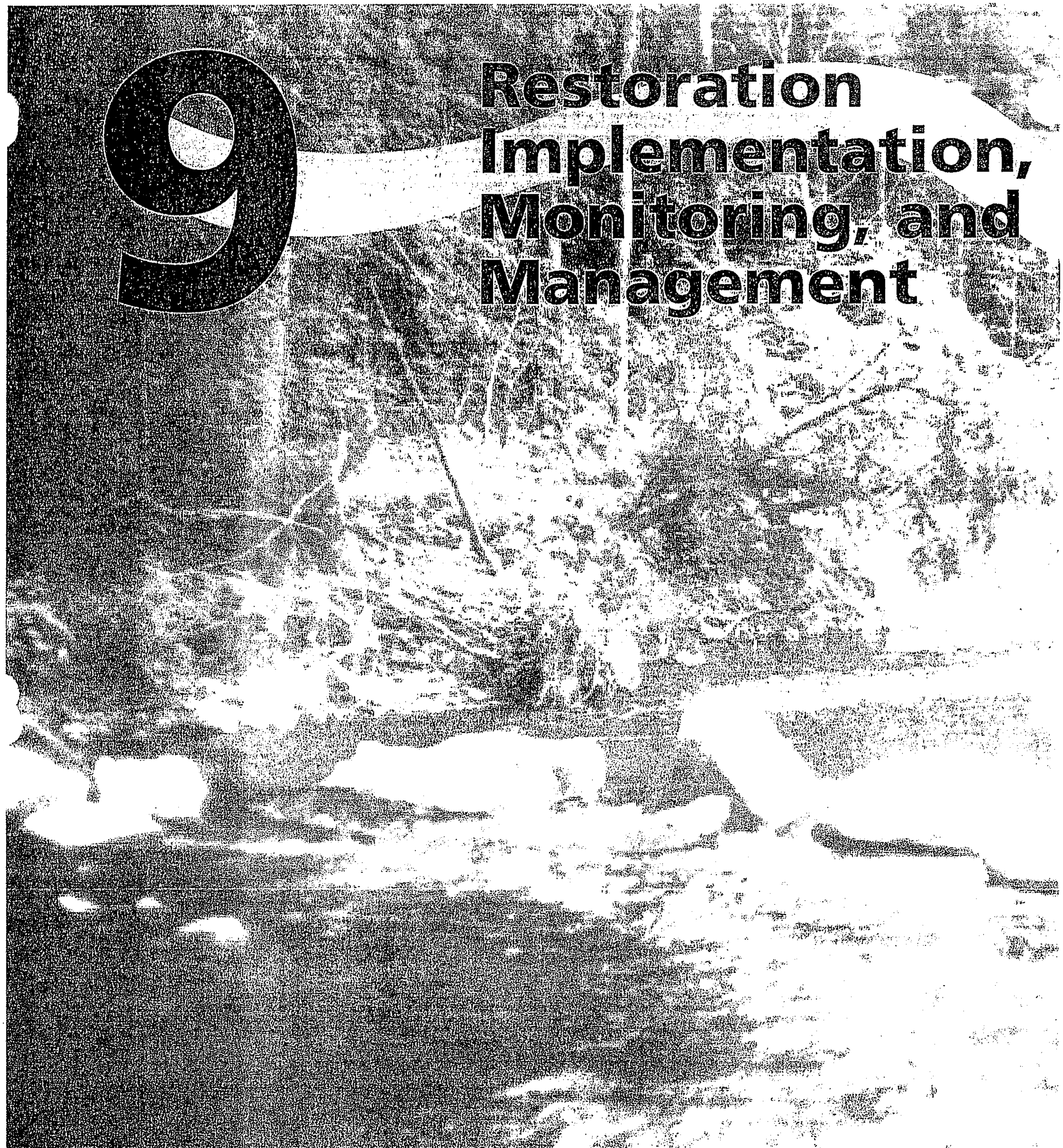
Tool 4. Restore Instream habitat structure. Most urban streams have poor instream habitat structure, often typified by indistinct and shallow low flow channels within a much larger and unstable storm channel. The goal is to restore instream habitat structure that has been blown out by erosive floods. Key restoration elements include the creation of pools and riffles, confinement and deepening of the low flow channels, and the provision of greater structural complexity across the streambed. Typical tools include the installation of log checkdams, stone wing deflectors and boulder clusters along the stream channel.

Tool 5. Reestablish Riparian Cover. Riparian cover is an essential component of the urban stream ecosystem. Riparian cover stabilizes banks, provides large woody debris and detritus, and shades the stream. Therefore, the fifth tool involves reestablishing the riparian cover plant community along the stream network. This can entail active reforestation of native species, removal of exotic species, or changes in mowing operations to allow gradual succession. It is often essential that the riparian corridor be protected by a wide urban stream buffer.

Tool 6. Protect critical stream substrates. A stable, well sorted streambed is often a critical requirement for fish spawning and secondary production by aquatic insects. The bed of urban streams, however, is often highly unstable and clogged by fine sediment deposits. It is often necessary to apply tools to restore the quality of stream substrates at points along the stream channel. Often, the energy of urban storm water can be used to create cleaner substrates—through the use of tools such as double wing deflectors and flow concentrators. If thick deposits of sediment have accumulated on the bed, mechanical sediment removal may be needed.

Tool 7. Allow for recolonization of the stream community. It may be difficult to reestablish the fish community in an urban stream if downstream fish barriers prevent natural recolonization. Thus, the last urban stream restoration tool involves the judgment of a fishery biologist to determine if downstream fish barriers exist, whether they can be removed, or whether selective stocking of native fish are needed to recolonize the stream reach.

9 Restoration Implementation, Monitoring, and Management



9.A Restoration Implementation

- *What are passive forms of restoration and how are they "implemented"?*
- *What happens after the decision is made to proceed with an active rather than a passive restoration approach?*
- *What type of activities are involved when installing restoration measures?*
- *How can impact on the stream channel and corridor be minimized when installing restoration measures (e.g, water quality, air quality, cultural resources, noise)?*
- *What types of equipment are needed for installing restoration measures?*
- *What are some important considerations regarding construction activities in the stream corridor?*
- *How do you inspect and evaluate the quality and impact of construction activities in the stream corridor?*
- *What types of maintenance measures are necessary to ensure the ongoing success of a restoration?*

9.B Monitoring Techniques Appropriate for Evaluating Restoration

- *What methods are available for monitoring biological attributes of streams?*
- *What can assessment of biological attributes tell you about the status of the stream restoration?*
- *What physical parameters should be included in a monitoring management plan?*
- *How are the physical aspects of the stream corridor evaluated?*
- *How is a restoration monitoring plan developed, and what issues should be addressed in the plan?*
- *What are the sampling plan design issues that must be addressed to adequately detect trends in stream corridor conditions?*
- *How do you ensure that the monitoring information is properly collected, analyzed, and assessed (i.e., quality assurance plans)?*

9.C Restoration Management

- *What are important management priorities with ongoing activities and resource uses within the stream corridor?*
- *What are some management decisions that can be made to support stream restoration?*
- *What are some example impacts and management options with various types of resource use within the stream corridor (e.g., forest management, grazing, mining, fish and wildlife, urbanization)?*
- *When is restoration complete?*

9 Restoration Implementation, Monitoring, and Management

*Completion of the restoration design marks the beginning of several important tasks for the stream restoration practitioner. Emphasis must now be placed on prescribing or implementing restoration measures, monitoring and assessing the effectiveness of the restoration, and managing the design to achieve the desired stream corridor conditions (**Figure 9.1**).*

Implementation, management, and monitoring/evaluation may proceed as part of a larger setting, or they may be considered components of a corridor-specific restoration effort. In either case, they require full planning and commitment before the restoration plan is implemented. The technical complexity of a project must be determined by the restoration practitioner based on available resources, technology, and what is necessary to achieve restoration goals. There must be reasonable assurance that there will be continuing access for ongoing inspection, mainte-

Figure 9.1: A restored stream. Stream corridor restoration measures must be properly installed, monitored, and managed to be successful.

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nance, emergency repairs, management, and monitoring activities as well. All cooperators should be aware that implementation, monitoring, and management might require unanticipated work, and that plans and objectives might change over time as knowledge improves or as changes occur.

This chapter builds on the discussion of restoration implementation, monitoring, evaluation, and adaptive management presented in Chapter 6. Specifically, it moves beyond the planning components associated with these key restoration activities and discusses some of the technical issues and elements that restoration practitioners must consider when installing, monitoring, and managing stream corridor restoration measures.

The discussion that follows is divided into three major sections.

Section 9.A: Restoration Implementation

This first section describes the implementation of restoration measures beyond just removing disturbance factors and taking other passive approaches that allow the stream corridor to restore itself over time.

Technical considerations relating to site preparation, site clearing, construction, inspection, and maintenance are discussed in this section.

Section 9.B: Monitoring Techniques Appropriate for Evaluating Restoration

The purpose of restoration monitoring is to gather data that will help to determine the success of the restoration effort. This section presents some of the monitoring techniques appropriate for evaluating restoration.

Section 9.C: Restoration Management

Management of the restoration begins with the implementation of the plan. The "adaptive management" approach was presented in Chapter 6 as an important part of the planning process. It provides the flexibility to detect when changes are needed to achieve success and to be able to make the necessary midcourse, short-term corrections.

Ideally, the long-term management of a successful restoration will involve only periodic monitoring to check that the system is sustaining itself through natural processes. However, this is rarely the case for stream corridors in human-inhabited landscapes.

New crops, markets, and government programs can rapidly and significantly alter the physical, chemical, and biological characteristics of stream corridors and their watersheds, destroying restoration efforts. Conversion of rural lands *and wildlands to urban uses and exploitation of natural resources can change the landscape and cause natural processes to become unbalanced, leaving the stream corridor with no way to sustain itself.*

Additionally, natural imbalances can occur due to local and regional climatic changes, predation, disease, fire, genetic changes, and catastrophes like earthquakes, hurricanes, tornadoes, volcanic eruptions, landslides, and floods. Long-term management of the restored stream corridor will therefore require vigilance, anticipation, and reaction to future changes.

9A Restoration Implementation

Implementation of stream corridor restoration must be preceded by careful planning. Such planning should include the following (at a minimum):

- Determining a schedule.
- Obtaining necessary permits.
- Conducting preimplementation meetings.
- Informing and involving property owners.
- Securing site access and easements.
- Locating existing utilities.
- Confirming sources of materials and ensuring standards of materials.

The careful execution of each planning step will help ensure the success of the restoration implementation. Full restoration implementation, however, involves several actions that require careful execution as well as the cooperation of several participants. See Chapters 4 and 5 for specific guidance on planning a stream corridor initiative.

Site Preparation

Site preparation is the first step in the implementation of restoration measures. Preparing the site requires that the following actions be taken.

Delineating Work Zones

The area in which restoration occurs is defined by many disparate factors. This area is determined most fundamentally by the features of the landscape that must be affected to achieve restoration goals. Boundaries of property ownership, restrictions imposed by permit requirements, and natural or cultural features that might have special significance can also determine the *work zone.* A heavy-equipment operator or crew supervisor cannot be expected to be aware of the multiple requirements that govern where work can occur. Thus, delineation of those zones in the field

Major Elements of Restoration Implementation

- *Review of Plans*
- *Site Preparation*
- *Site Clearing*
- *Installation and Construction*
- *Site Reclamation/Cleanup*
- *Inspection*
- *Maintenance*

should be the first activity conducted on the site. The zones should be marked by visible stakes and more preferably by temporary fencing (usually a bright-colored sturdy plastic netting). This delineation should conform to any special restrictions noted or temporary stakes placed during the preconstruction meeting between the project manager and field inspector.

Preparing Access and Staging Areas

A site is often accessed from a public road in an upland portion of the site. Ideally, for convenience, a staging area for crew, equipment, and materials can be located near an access road close to the restoration site but out of the stream corridor and away from wetlands or areas with highly erodible soils. The staging area should also be out of view from public thoroughfares, if possible, to increase security.

Although property ownership, topography, and preexisting roads make access to every site unique, several principles should guide design, placement, and construction of site access:

- Avoid any sensitive wildlife habitat or plant areas or threatened and endangered species and their designated critical habitat.
- Avoid crossing the stream if at all possible; where crossing is unavoidable, a bridge is almost mandatory.
- Minimize slope disturbance since effective erosion control is difficult on a sloped roadway that will be heavily used.
- Construct roadways with low gradients; ensure that storm water runoff drains to outlets; install an adequate roadbed; and, if possible, set up a truck-washing station at the entrance of the construction site to reduce off-site transport of mud and sediment by vehicles.
- In the event of damage to any private or public access roads used to transport equipment or heavy materials to and from the site, those responsible should be identified and appropriate repairs should be made.

Taking Precautions to Minimize Disturbance

Every effort should be made to minimize and, where possible, avoid site disturbance. Emphasis should be placed on addressing protection of existing vegetation and sensitive habitat, erosion and sediment control, protecting air and water quality, protecting cultural resources, minimizing noise, and providing for solid waste disposal and worksite sanitation.

Protection of Existing Vegetation and Sensitive Habitat

Fencing can be an effective way to ensure protection of areas within the construction site that are to remain undisturbed (e.g., vegetation designated to be preserved, sensitive terrestrial habitat, or sensitive wetland habitat).

As in delineating work zones, fencing should be placed around all protected areas during initial site preparation, even before the access road is fully constructed, if possible, but certainly before wholesale earthmoving begins. Fencing material should be easy to see, and areas should be labeled as protection areas. Caution should always be exercised when grading is planned adjacent to a protected area.

Erosion

Many well-established principles of effective erosion and sediment control can be readily applied to stream corridor restoration (Goldman et al. 1986). Every effort should be made to prevent erosion because prevention is always more effective than having to trap already-eroded sediment particles in runoff. Erosion and sediment controls should be installed during initial site preparation.

The most basic method of control is physical screening of areas to remain undisturbed. Properly chosen, installed, and maintained sediment control measures can provide a significant degree of filtration for sediment-bearing runoff (**Figure 9.2**).

Where undisturbed areas lie downslope of implementation activities, one method of controlling sediment is the use of a silt fence, which is normally made of filter fabric. Silt fences can provide a significant degree of filtration for sediment-bearing runoff, but only if correctly chosen, installed, and maintained. Design guidelines for silt fences include the following:

- Drainage area of 1 acre or less.
- Maximum contributing slope gradient of 2 horizontal to 1 vertical.
- Maximum upslope distance of 100 ft.
- Maximum flow velocity of 1 ft./sec.

Installation is even more critical than material type; most fabric fences fail because either runoff carves a channel beneath them or sediment accumulates against them, causing them to collapse. To help prevent failure, the lower edge of the fabric should be placed in a 4- to 12-inch-deep trench, which is then backfilled with native soil or gravel, and wire fencing should be used to support the fabric.

Figure 9.3 presents example silt fence installation guidelines. Properly installed silt fences commonly fail due to lack of maintenance. One rainfall event can deposit enough sediment that failure will occur during the next rainfall event if the sediment against the fence is not removed.

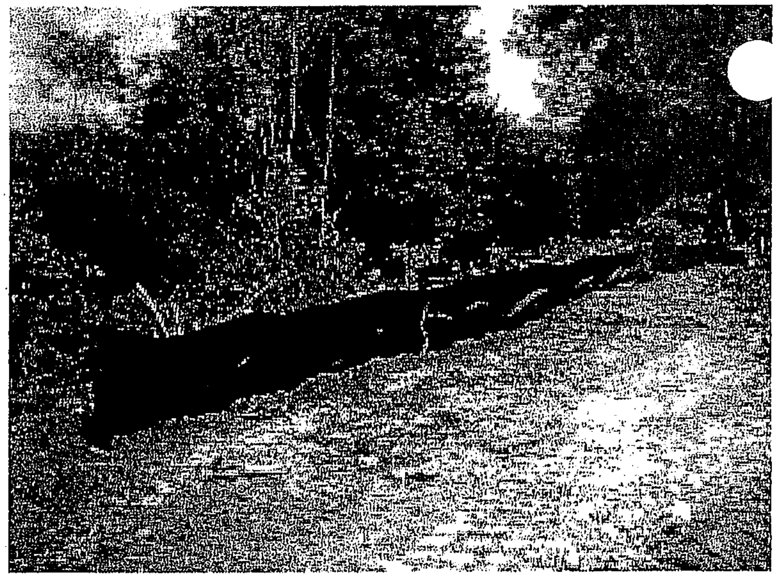


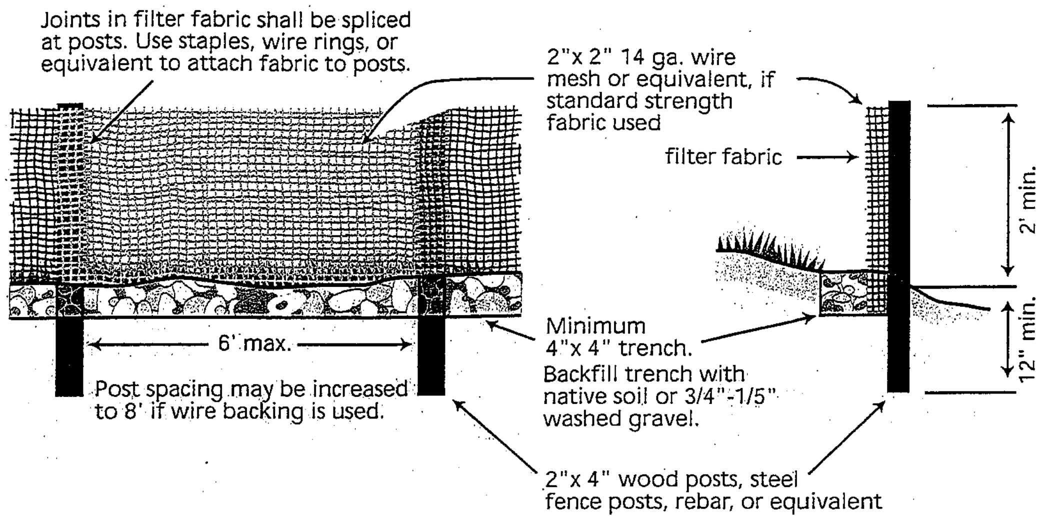
Figure 9.2: Silt fence at a construction site. *Properly chosen and installed silt fences can provide a significant degree of off-site sediment control.*

Erosion and sediment controls should be installed during initial site preparation.

Straw bales are also common sediment control measures. Bales should be placed in trenches about 4 inches deep, staked into the ground, and placed with their ends (not just corners) abutting each other. **Figure 9.4** presents example straw bale installation guidelines. The limitations on siting are the same as for silt fences, but straw bales are typically less durable and might need to be replaced.

Where the scope of a project is so small that no official erosion control plans have been prepared, control measures should be appropriate to the site, installed promptly, and maintained appropriately.

Proper restoration implementation requires managers to prepare for "unexpected" failure of erosion control measures. By the time moderate to heavy rains can be expected, the follow-



Note: Filter fabric fences shall be installed along contour whenever possible.

Figure 9.3: Silt fence installation guidelines. *Erosion control measures must be installed properly.*
Source: King County, Washington.

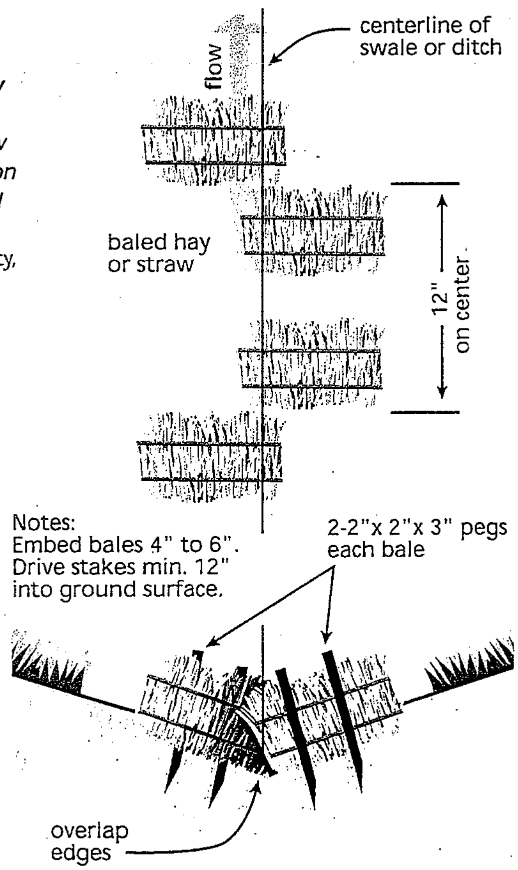


Figure 9.4: Straw bale installation guidelines. *Straw bales are common sediment control measures.*
Source: King County, Washington.

ing preparations should have been made:

- Additional erosion control materials should be stockpiled on site, including straw bales, filter fabric and wire backing, posts, sand and burlap bags, and channel lining materials (rock, geotextile fabric or grids, jute netting, coconut fabric material, etc.).
- Inspection of the construction site should occur during or immediately after a rain storm or other significant runoff event to determine the effectiveness of sediment control measures.
- A telephone number for the site superintendent or project manager should be made available to neighboring residents if they witness any problems on or coming from the site. Residents should be educated on what to watch for, such as sediment-laden runoff or failed structures.

Water Quality

Although sediment is the major source of water quality impairment on construction sites, it is not the only source. Motorized vehicles and equipment or improperly stored containers can leak petroleum products. Vehicles should be steam-cleaned off site on a regular basis and checked for antifreeze leaks and repaired. (Wildlife can be attracted to the sweet taste of most antifreeze and poisoned.) Various other chemicals such as fertilizers and pesticides can be washed off by rain. Most of these problems can be minimized or avoided entirely by thoughtful siting storage areas for chemicals and equipment and staging areas. Gradients should not favor rapid overland flow from these areas into adjacent streams and wetlands. Distances should be as great as possible and the intervening vegetation as dense as site traffic will allow.

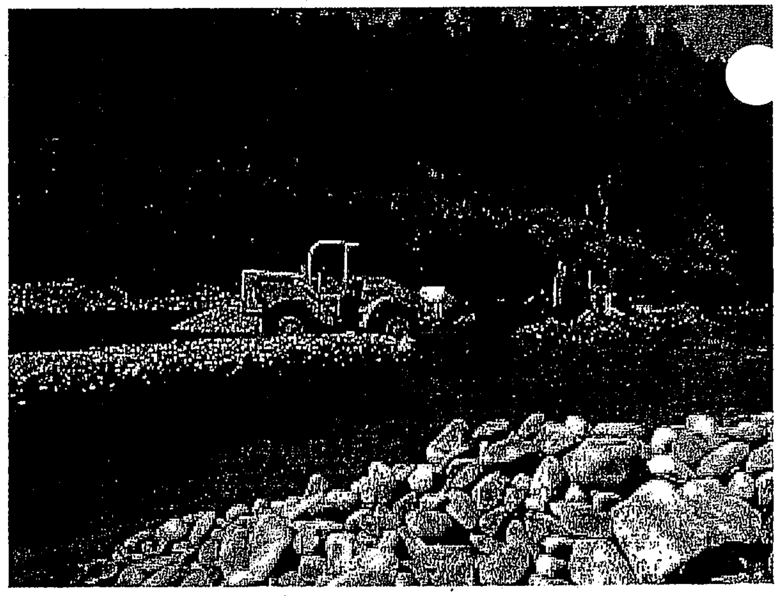


*Figure 9.5: **Heavy equipment.** Avoid heavy equipment in stream channels unless absolutely necessary.*

Occasionally, implementation activities will require the entry or crossing of heavy equipment into the stream channel (Figure 9.5). Construction site planning and layout should always seek to avoid these intrusions. When these intrusions are absolutely necessary, they should be infrequent. Gravelly streambeds are best able to receive traffic; finer substrates should be reinforced with a geoweb network backfilled with gravel. In addition, any equipment used in these activities should be thoroughly steam-cleaned prior to stream entry.

Application of fertilizers and pesticides can also be a source of pollution into water bodies, and their use may be closely regulated in restoration settings. Where their use is permitted, the site manager should closely monitor the quantity applied, the local wind conditions, and the likelihood of rainfall. Potential water quality impacts are a function of the characteristics of the selected pesticide, its form, mode of application, and soil conditions. Pesticides and fertilizers must be stored in a locked and protected storage unit that provides adequate protection from leaks and spills. Pesticides must be prepared or mixed far from streams and, where possible, off site. All containers should be rinsed and disposed of properly.

Air Quality

Air quality in the vicinity of a restoration site can be affected by vehicle emissions and dust. Rarely, however, will either be a major concern during implementation activities. Vehicle emissions are regulated at the source (the vehicle), and dust is usually associated primarily with haul roads or major earthmoving during dry periods. The need for dust control should be evaluated during initial restoration implementation and road planning (if not previously determined during the planning phase of the restoration initiative). Site conditions, duration of construction activities, prevailing winds, and proximity to neighbors should be considered when making decisions on dust control. Temporary road surfaces or periodic water spraying of the road surface are both effective in controlling dust. Covered loads and speed limits on all temporary roads will also reduce the potential for construction-related dust and debris leaving the site (Hunt 1993). Where appropriate, use of volunteer labor in lieu of diesel-powered equipment will help to protect air quality in and surrounding the site. Due to safety concerns, it is recommended that volunteers not be used on a site where heavy equipment will also be used.

Cultural Resources

Since stream corridors have been a powerful magnet for human settlement throughout history, it is not uncommon for historic and prehistoric resources to be buried by sediment or obscured by vegetation along stream corridors. It is quite possible to discover cultural resources during restoration implementation (particularly during restoration that requires earth-disturbing activities). (See Figure 9.6.)

Prior to implementation, any potential cultural resources should be identified in compliance with section 106 of the National Historic Preservation Act. An archaeological record search should be conducted during the planning process in accordance with the State Historic Preservation Officer (SHPO). If a site is uncovered unexpectedly, all activity that might adversely affect the historic property must cease, and the responsible agency official must notify the U.S. Department of the Interior (USDI) National Park Service and the SHPO. Upon notification, the SHPO determines whether the activity will cause an irreparable loss or degradation of significant data. This might require on-site consultation with a 48-hour response time for determining significance and appropriate mitigation actions so as not to delay implementation activities inordinately.

Figure 9.6: Archaeological site. *Cultural resources, such as those at this site in South Dakota, are commonly found near streams.*

If the property is determined not to be significant or the action will not be adverse, implementation activities may continue after documenting consultation findings. If the resource is significant and the on-site activity is determined to be an adverse action that cannot be avoided, implementation activities are delayed until appropriate actions can be taken (i.e., detailed survey, recovery, protection, or preservation of the cultural resources). Under the Historical and Archaeological Data Preservation Act of 1974, USDI may assume liability for delays in implementation.

Noise

Noise from restoration sites is regulated at the state or local level. Although criteria can vary widely, most establish reasonable and fairly consistent standards.

The U.S. Housing and Urban Development (HUD) agency has set a maximum acceptable construction noise emission of 65 A-weighted decibels (dBA) at the property line. Numerous studies conducted since the late 1960s suggest that community complaints rise dramatically above 55 dBA (Thumann and Miller 1986). Meeting the HUD standard (65 dBA) requires that typical construction equipment be over 300 feet away from the listener; avoiding the chance of any significant complaints requires about 500 feet of separation or more. The project manager should contact surrounding neighbors prior to restoration implementation. Public awareness of and appreciation for the project goals help improve tolerance for off-site noise impacts. (Impacts from noise on equipment operators is usually not significant since most construction equipment meets the noise standards imposed by the U.S. General Services Administration of 75 dBA at 50 feet.)

High noise levels might be a concern to wildlife as well, particularly during the breeding season. Any sensitive species that inhabit the project vicinity should be identified and appropriate actions taken to reduce noise levels that could adversely affect these species.

Solid Waste Disposal

Debris is an inevitable by-product of implementation activities. The management of debris is a matter of job site safety, function, and aesthetics. From the first day, the locations of equipment storage, vehicle unloading, stockpiled materials, and waste should be identified. At the end of each workday, all scattered construction debris, plant materials, soil, and tools should be gathered up and brought to their respective holding areas. The site should be left as neat and well organized as possible at the end of each day. Even during the workday, sites in close proximity to business or residential districts should be kept as well organized and "sightly" as possible to avoid complaints and delays initiated by unhappy neighbors.

The importance of these measures to the safety and efficiency of the restoration effort as a whole is sometimes evident only to the project manager. Under such conditions, achieving adequate job site cleanliness is almost impossible because the manager alone does not have time to tidy up trash and debris. Meetings with work crews to emphasize this element of the work should occur early in the construction process and be repeated as often as required. People working on site, whether contractors, volunteers, or government personnel, need to be reminded of these needs as an unavoidable part of doing their jobs.

Worksite Sanitation

Sanitation facilities for work crews should be identified before construction begins. Particularly in remote areas, the temptation to allow ad hoc arrangements will be high. In urban areas, the existing facilities of a neighboring business might be offered. In most settings, however, one or more portable toilets should be provided and might be required by local building or grading permits. Although normally self-contained, any facilities should be located to minimize the risk of contamination of surface water bodies by leakage or overflow.

Obtaining Appropriate Equipment

Standard earthmoving and planting equipment is appropriate for most restoration work. Small channels or wetland pool areas can be excavated with backhoes or track-mounted excavators or trackhoes. Trackhoes are mobile over rough or steep terrain (**Figure 9.7**). They have adequate reach and power to work at a distance from the stream channel; with an opposing "thumb" on the bucket, they can maneuver individual rocks and logs with remarkable precision. Logs can also be

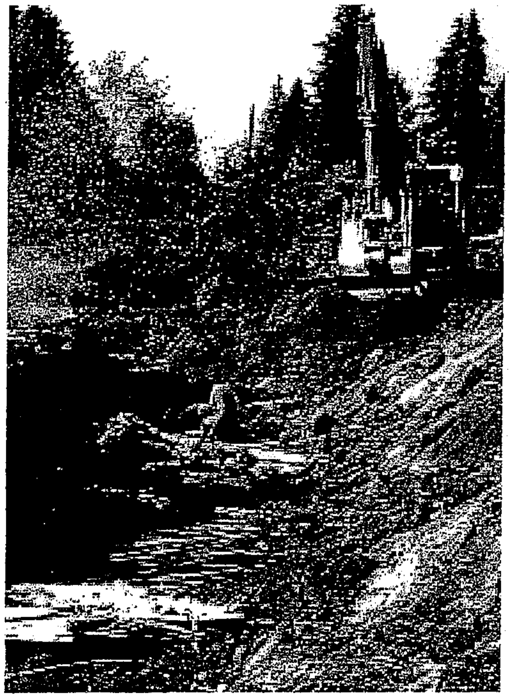


Figure 9.7: Backhoe in operation at a restoration site. Backhoes are mobile in rough terrain and can move rocks and logs with remarkable precision.
Source: M. Landin.

placed by a helicopter's cable. Although the hourly rate is about that of the daily cost of ground-based equipment, the ability to reach a stream channel without use of an access road is sometimes indispensable.

Where access is good but the riparian corridor is intact, instream modifications can be made with a telescoping crane. This equipment comes in a variety of sizes. A fairly large, fully mobile unit can extend across a riparian zone 100 feet wide to deliver construction materials to a waiting crew without disturbing the intervening ground or vegetation. Where operational constraints permit their use, bulldozers and scrapers can be very useful, particularly for earthmoving activities that are absolutely necessary to get the job done. In addition, loaders are excellent tools for transporting rocks, transplanting large plants, and digging and placing sod.

For planting, standard farm equipment, such as tractors with mounted disks or harrows, are generally suitable unless the ground is extremely wet and soft. Under these circumstances, light-tracking equipment with low-pressure tires or rubber tracks might work. Seeds planted on restoration sites are commonly broadcast by hydroseeding, requiring a special tank truck with a pump and nozzle for spraying the mixture of seeds, fertilizer, binder, and water (**Figure 9.8**). A wider range of seed species can be planted more effectively with a seed drill towed behind a tractor (e.g., Haferkamp et al. 1985). Where access is limited, hand planting or aerial spreading of seeds might be feasible.

Site Clearing

Once the appropriate construction equipment has been acquired and site preparation has been completed, any necessary site clearing can begin. Site clearing involves setting the geographic limits, removing undesirable plant species, addressing site drainage issues, and protecting and managing desirable existing vegetation.

Geographic Limits

Site clearing should not proceed unless the limits of activity have been clearly marked in the field. Where large trees are present, each should be marked with colored and labeled flagging to ensure that the field crew understands what is to be cut and what is to remain and be protected from damage.

Removal of Undesirable Plant Species

Undesirable plant species include nonnative and invasive species that might threaten the survival of native species. Undesirable plants are normally removed by mechanical means, but the specific method should be tailored to the species of concern if possible. For example, simply cutting the top growth

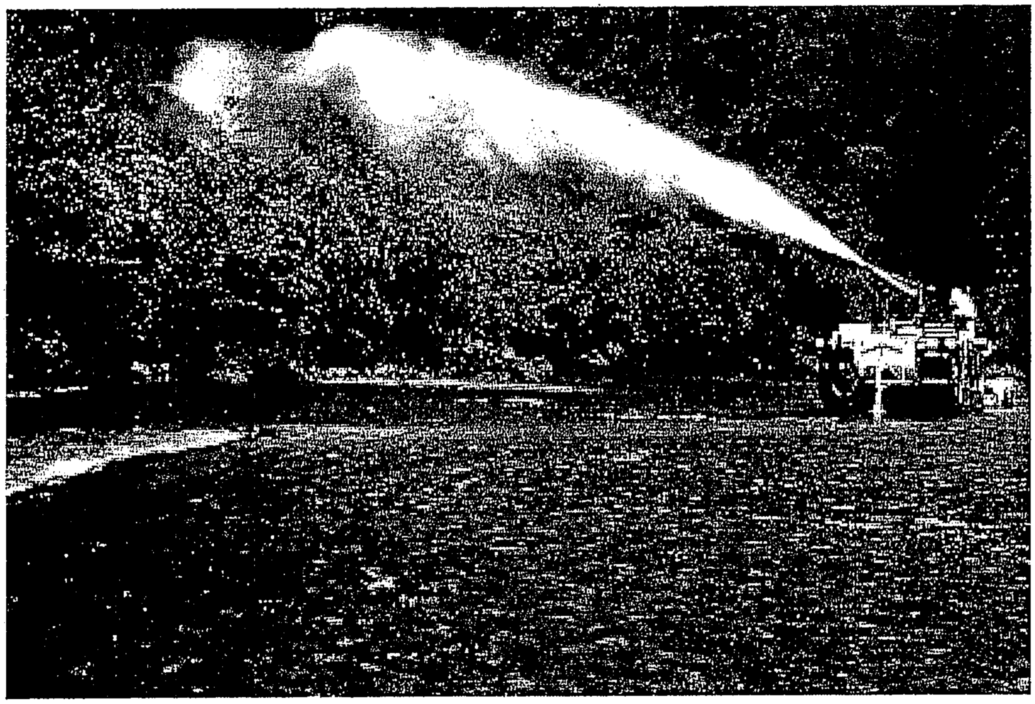


Figure 9.8: Hydroseeding of a streambank. Special tank trucks carrying seed, water, and fertilizer can be used in revegetation efforts.

might be adequate management for some plants, but others might resprout rapidly. Where herbicides are selected (and permitted), their use might need to precede clearing of the top growth by up to 2 weeks to allow full absorption of certain chemicals used for this purpose.

For initial brush removal, a variety of track-mounted and towed equipment is available. Bulldozers are most commonly used because of their ready availability, but other equipment can often work more rapidly or more effectively with minimal site disturbance.

Hand clearing with portable tools might be the only appropriate method in some sensitive or difficult areas.

Drainage

Sites that are very wet and poorly drained might require extra preparation. However, many of the traditional efforts to improve drainage are in partial or direct conflict with wetland-protection regulations and might conflict with the restoration goals of the project as a whole. Standard engineering approaches should be reviewed for appropriateness, as well as the timing and schedule of the restoration activities.

Specific techniques for improving the workability of a wet construction site depend on the particular access, storage needs, and site characteristics. Load-bearing mats can provide stable areas for equipment and the unloading of plant materials. Surface water may be intercepted above the working area by a shallow ditch and temporarily routed around the construction area. Subsurface water can sometimes be intercepted by a perforated pipe set in a shallow trench, such as a French drain, but the topography must be favorable to allow positive drainage of the pipe to a surface outlet.

Protection and Management of Existing Vegetation

Protecting existing vegetation on a restoration site requires a certain degree of attention and advanced planning. An area on a site plan that is far from all earthmoving activity might appear to the site foreman as the ideal location for parking idle equipment or stockpiling excess soil. Only a careless minute with heavy equipment, however, can reduce a vegetated area to churned earth (**Figure 9.9**). Vegetation designed for a protection zone should be clearly marked in the field.

Existing vegetation might also require temporary protection if it occupies a part of the site that will be worked, but only late in the implementation sequence. Before that time, it is best left undisturbed to improve the level of overall erosion control. To save mobilization costs, most earthmoving contractors normally begin construction by clearing every part of the site that will eventually require it. If clearing is to be phased instead, this requirement must be specified in the contract documents and discussed at a preimplementation meeting.

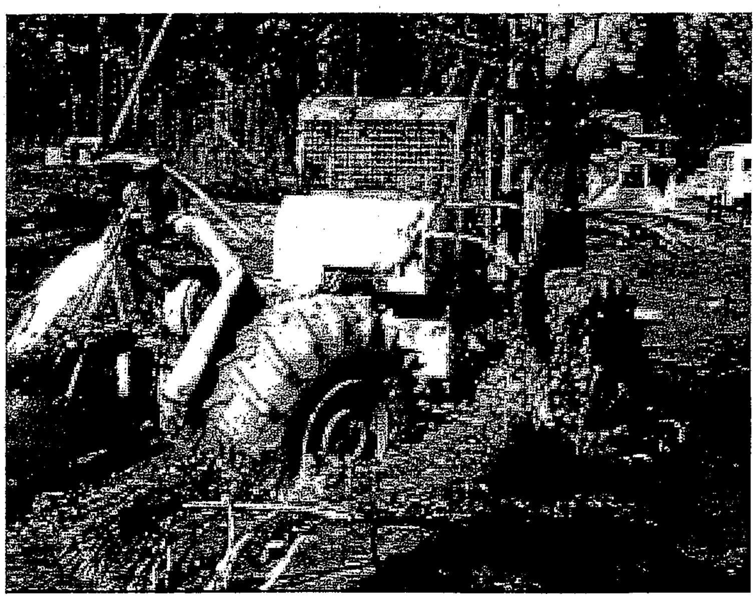


Figure 9.9: Lessons to be learned. *Heavy equipment can quickly reduce a vegetated area to churned earth.*

When identifying and marking vegetation protection zones, the rooting extent of the vegetation should be respected. Fencing and flagging of protected vegetation should be sturdy and maintained. Despite the cool shade and fencing, vegetation protection zones are neither a picnic area nor a storage/staging area. They are zones of no disturbance.

When working in riparian corridors with mature conifers, it is especially important to protect them from mechanical operations which can cause severe damage.

Installation and Construction

Following site preparation and clearing, restoration installation activities such as earthmoving, diversion of flow, and the installation of plant materials can proceed.

Earthmoving

Fill Placement and Disposal

How and where fill is placed on a site should be determined by the final placement of restoration measures. Fills adjacent to retaining walls or similar structures need to meet the criteria for structural fill.

Where plants will be the final treatment of a fill slope, the requirements for soil materials and compaction are not as severe. Loose soil on a steep slope is still prone to erosion or landsliding, however. Where fill is to be placed on slopes steeper than about 2:1, a soils engineer should determine whether any special measures are appropriate (**Figure 9.10**). Even on gentler slopes, surface runoff from above should not be allowed to saturate the new material

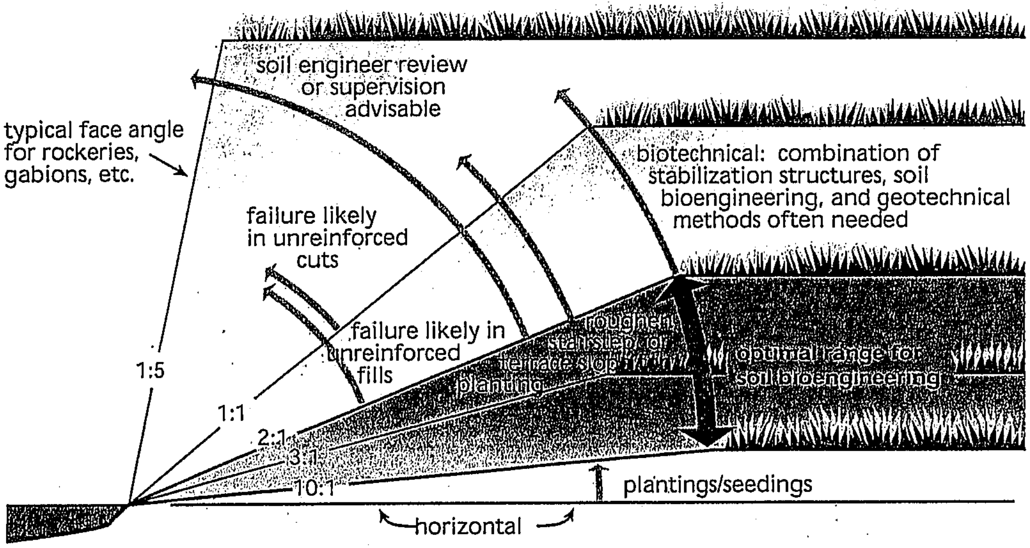


Figure 9.10: ***Treatment of cuts and fills.*** *Slope gradient is an important factor in determining appropriate restoration measures.*

since the stability of noncompacted fills is generally quite low.

To reduce grading expenses, the cut and fill should be balanced so no material needs to be transported to or from the site. If the volume of material resulting from cuts exceeds that from fills, some of the soil must be disposed of off-site. Disposal sites can be difficult to locate and might require an additional grading permit from the local jurisdiction. These possibilities should be planned for far enough in advance to avoid unanticipated delays during implementation.

As a general rule, topsoil removed from the site should be properly stockpiled for reuse during the final stages of implementation. Even if undesirable species are present, the topsoil will provide a growth medium suitable for the plant community appropriate to the site. It will also be a source of native species that can reestablish the desired diversity most rapidly (Liebrand and Sykora 1992). Stockpiled soil also can be vegetated with species that will be used at the restoration site to protect the soil from erosion and noxious weeds.

Contouring

The erosive power of water flowing down a slope should be recognized during earthmoving. The steepest direction down a hillside is also the direction of greatest erosion by overland or channelized flow. The overall topography of the graded surface should be designed to minimize the uncontrolled flow of runoff in this direction. Channelized flow should be diverted to ditches cut into the soil that more closely follow the level contours of the land. Dispersed sheet flow should be broken up by terraces or benches along the slope that also follow topographic contours. On a fine scale, the ground surface can be roughened by the tracks of a bulldozer driven up and down the slope, or by a rake or harrow pulled perpendicularly to the slope. In either case, the result is a set of parallel ridges, spaced only a few inches apart, that follow the contours of the land surface and greatly reduce on-site erosion.

Earthmoving should result in a slope that is stable, minimizes surface erosion by virtue of length and gradient, and provides a favorable environment for plant growth.

Final Grading

Earthmoving should result in a slope that is stable, minimizes surface erosion by virtue of length and gradient, and provides a favorable environment for plant growth. The first two criteria are generally determined by plans and can be modified only minimally by variations in grading techniques. Where plans specify a final slope gradient steeper than about 1:1, however, vegetation reestablishment will be very difficult, and a combination of stabilization structures, soil bioengineering, and geotechnical methods will probably be necessary. The shape at the top of the slope is also important: if it forms a straight abrupt edge, plant regrowth will be nearly impossible. A rounded edge that forms a gradual transition between upland and slope will be much more suitable for growth (Animoto 1978).

Providing a favorable environment for plant growth requires attention to the small-scale features of the slope. Rough-textured slopes, resulting from vehicle tracks or serrated blades, provide a much better environment for seedlings than do smooth-packed surfaces (Figure 9.11). Small terraces should be cut into slopes steeper than about 3:1 to create sites of moisture accumulation and enhanced plant growth. Compaction by excessive reworking from earthmoving equipment can result in a lower rate of rainfall infiltrating the soil and, consequently, a higher rate of erosive surface runoff. The result is a loss of the topsoil needed to support plant growth and less moisture available for the plants that remain.

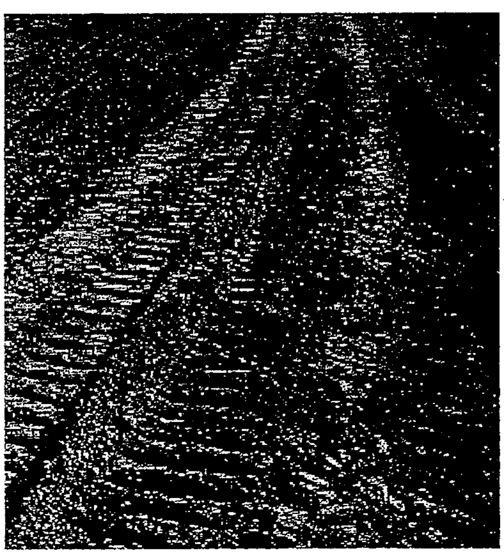


Figure 9.11: Track-roughened area. Rough-textured slopes provide a much better environment for seedlings than do smooth-packed surfaces.

Diversion of Flow

Channelized flow (from stream channels, ditches, ravines, or swales) might need to be diverted, impounded, or otherwise controlled during implementation of restoration measures. In some cases, this need might be temporary, until final grading is complete or plantings have become established. In other cases, the diversion is a permanent part of the restoration. Permanent facilities frequently replace temporary measures at the same location but are often constructed of different materials.

Temporary dikes, lined or grassed waterways, or pipes can be used to divert channelized flow. Runoff can also be impounded in ponds or sediment basins to allow sediment to settle out.

Most temporary measures are not engineered and are constructed from materials at hand. Dikes (ridges of soil up to a few feet high) are compacted to achieve some stability and are sometimes armored to resist erosion. They are used to keep water from washing over a newly graded or planted slope where erosion is otherwise likely, and to divert runoff into a natural or artificial channel. The loosened soil from swales can be readily compacted into an adjacent dike, improving the efficiency and capacity of the runoff diversion. Pipes or rock-lined ditches can carry channelized water down a slope that is steep enough to otherwise suffer erosion; they can also be used to halt erosion that has already occurred from uncontrolled discharges. Flexible plastic pipe is most commonly used in these situations, although the outlet must be carefully located or well armored with rocks or sandbags to avoid merely shifting the point of erosion farther downslope.

Sediment ponds and traps are basins either dug into the soil with a rock-armored overflow or impounded by an embankment with an outlet. A fraction of the sediment carried by the site runoff will settle out in the trap, depending on the ratio of surface area or storage volume to inflow rate. The utility of sediment ponds may be limited depending on the sediment-trapping efficiency. A sediment pond can also release nearly as much sediment as is ultimately trapped if the pond is not built to handle maximum surface water flows or is not maintained properly.

Several techniques are available where the active streamflow must be temporarily isolated from installation activities. Most common are temporary dams, constructed of sandbags, geotextile fences, water control structures, or sheet piles. All may be suitable in certain situations, but have drawbacks. Sandbags are inexpensive, but submerged burlap sacks rot quickly and the sand used to fill them might not be appropriate for the stream. Fabric fences can be used in conjunction with sandbags, but they will not withstand high flows. Water control structures, such as long water-filled tubes available commercially, can be very effective, but need ample lateral space and carry a high initial cost. They also can be swept away by high flows. Sheet piles are effective if heavy equipment is already on site, but their installation and removal can mobilize much fine sediment.

Alternatively, water can be diverted into a bypass pipe, normally made of large flexible plastic (unless anticipated discharges are very great), and the construction area can be kept totally and reliably dry. A dam must be constructed at the pipe inlet to shunt the water, and an adequate apron of nonerosive material must be provided at the discharge. Both of these structures can themselves lead to instream damage, but with care the problems are only temporary. Since fish passage and migration are generally precluded with such a diversion, its applicability is limited.

In some situations unexpectedly erosive conditions will demand better outlet or channel protection than that originally specified in the plans. Erosion control in these settings might require a thick blanket of angular rocks and geotextiles (cloth, plastic grids, or netting) used with plantings. New types of geotextiles are becoming widely available and can serve a wide range of flow conditions. Where possible, channels and spillways should be stabilized using soil bioengineering or other appropriate techniques.

Plant establishment is an important part of most restoration initiatives that require active restoration.

Installation of Plant Materials

Plant establishment is an important part of most restoration initiatives that require active restoration. Detailed local standards and specifications that describe planting techniques and establishment procedures should be developed. Native species should be used where possible to achieve the restoration goals. Vegetation can be installed by seeding; planting vegetative cuttings; or using nursery-grown bare-rooted, potted, and burlap-wrapped specimens. If natural colonization and succession is appropriate, techniques may include controlling exotic species and establishing an initial plant community to hasten succession.

Timing

The optimum conditions for successful plant installations are broad and vary from region to region. As a general rule, temperature, moisture, and sunlight must be adequate for germination and establishment. In the eastern and midwestern United States, these conditions are met beginning in late winter or early spring, after ground thawing, and continuing through mid-autumn. In the West, the typical summertime dryness normally limits successful seedings to late summer or early autumn. Where arid conditions persist through most of the year, plants and seedings must take advantage of whatever rainfall occurs, typically in late autumn or winter, or supplemental irrigation must be provided. Because the requirements can vary so much for different species, the local supplier or a comprehensive reference text (e.g., Schopmeyer 1974, Fordham and Spraker 1977, Hartmann and Kester 1983, Dirr and Heuser 1987) should be consulted early in the restoration design phase. If rooted stock is to be propagated from seed before it is planted at the restoration site, 1 to 2 years (including seed-collection time) should be allowed.

Plants should be installed when dormant for the highest rate of survival. Survival is further influenced by species used and how well they are matched to site conditions, available moisture, and time of installation. In mild climates, the growth of roots occurs throughout the winter, improving survival of fall plantings. Where high wintertime flows are anticipated, however, first-season cuttings might not survive unless given some physical protection from scour. Alternatively, planting can occur in the spring before dormancy ends, but supplemental irrigation might be needed even in areas of abundant summertime rainfall. Irrigation might be necessary in some regions of the country to ensure successful establishment of vegetation.

Acquisition

Native plant species are preferred over exotic ones, which might result in unforeseen problems. Some plant materials can be obtained from commercial sources, but many will need to be collected. When attempting to restore native plant communities, it is desirable to use appropriate genotypes. This requires the collection of seeds and plants from local sources. Early contact with selected sources of rooted stock and seed can ensure that appropriate species in adequate quantities will be available when needed.

The site itself might also be a good source of salvageable plants. Live cuttings can be collected from healthy native vegetation at the donor site. Sharp, clean equipment must be used to harvest the plant material. Vegetation is normally cut at a 40 to 50 degree angle using loppers, pruners, or saws. If the whole plant is being used, the cut is made about 10 inches above the ground, which encourages rapid regeneration in most species. Cuttings typically range from 0.4 to 2 inches in diameter and 2 to 7 feet long.

After harvesting, the donor site should be left in a clean condition. This will avoid the potential for landowner complaints and facilitate potential reuse of the site at some time in the future. Large unused material can be cut for firewood, piled for wildlife cover, or scattered to hasten decomposition. Any diseased material should be burned, per local ordinances.

Transportation and Storage

The requirements for the transport and storage of plant materials vary, depending on the type of material being used. Depending on species, seeds may require a minimum period of dormancy of several weeks or months, with specific temperature requirements during that time. Some seeds may also require scarifying or other special treatment. Nurseries that specialize in native plants are recommended because they should be cognizant of any special requirements. Although the necessary information for any chosen species should be readily available from local seed sources or agricultural extension offices, this interval must be recognized and accounted for in the overall implementation schedule.

Live cuttings present rather severe limitations on holding time. In most cases, they should be installed on the day they are harvested, unless refrigerated storage areas are secured. Thus, donor sites must be close to the restoration site, and access and transportation must be orchestrated to coincide with the correct stage of construction. Live cuttings should be tied in manageable bundles, with the cut ends all lying in the same direction. Since drying is the major threat to survival at this stage, cuttings should be covered with damp burlap during transport and storage (**Figure 9.12**). They should always be shaded from direct sun. On days with low humidity and temperatures above 60 degrees Fahrenheit, the need for care and speed is particularly great. Where temperatures are below this level, "day-after" installation is acceptable, although not optimal. Any greater delay in installation will require refrigeration, reliably cold weather on site, or storage in water.

Figure 9.12: Live cuttings covered with damp burlap to prevent drying during transport. *Drying is a major threat to survival of live cuttings during transport and storage.*

Rooted stock is also prone to drying, particularly if pots or burlap-wrapped roots are exposed to direct sun. Submergence of the roots in water is not recommended for long periods, but 1 to 2 hours of immersion immediately prior to planting is a common practice to ensure the plant begins its in-place growth without a moisture deficit. Onsite storage areas should be chosen with ample shade for pots. Bare-rooted or burlap-wrapped stock should be heeled into damp ground or mulch while awaiting final installation.

Planting Principles

The specific types of plants and plant installations are generally specified in the construction plans and therefore will have been determined long before implementation. A project manager or site foreman should also know the basic installation principles and techniques for the area.

The type of soil used should be determined by the types of plants to be supported. Ideally, the plants have been chosen to match existing site conditions, so stockpiled topsoil can be used to cover the plant material following layout. However, part of the rehabilitation of a severely disturbed site might require the removal of unsuitable topsoil or the import of new topsoil. In these situations, the requirements of the chosen plant species should be determined carefully and the soil procured from suitable commercial or field sites that have no residual chemicals and undesirable plant species.

When using seeds, planting should be preceded by elimination of competing plants and by preparation of the seedbed (McGinnies 1984). The most common methods of seeding in a restoration setting are hand broadcasting and hydroseeding. Hydroseeding and other methods of mechanical seeding might be limited by vehicular access to the restoration site.

When using either cuttings or rooted stock, the soil and the roots must make good contact. This requires compaction of the soil, either by foot or by equipment, to avoid air pockets. It also requires that the soil be at the right moisture content. If it is too dry (a rare condition), the soil particles cannot "slip" past each other to fill in voids. If it is too wet (far more common, especially in wetland or riparian environments), the water cannot squeeze out of the soil rapidly enough to allow compaction to occur.

Another aspect to consider is that quite frequently after planting, the resulting soil is too rough and loose to support vigorous seed growth. The roughness promotes rapid drying, and the looseness yields poor seed-to-soil contact and also erratic planting depths where mechanical seed drills are used. As a result, some means of compaction should be employed to return the soil to an acceptable state for planting.

Special problems may be encountered in arid or semiarid areas (Anderson et al. 1984). The salt content of the soil in these settings is critical and should be tested before planting. Deep tillage is advisable, with holes augured for saplings extended to the water table if at all possible. First-year irrigation is mandatory; ongoing fertilization and weeding will also improve survival.

Competing Plants

Although a well-chosen and established plant community should require no human assistance to maintain vigor and function, competition from other plants during establishment might be a problem. Competing plants commonly do not provide the same long-term benefits for stability, erosion control, wildlife habitat, or food supply. The restoration plan therefore must include some means to suppress or eliminate them during the first year or two after construction.

Competing plants may be controlled adequately by mechanical means. Cutting the top growth of competing plants can slow their development long enough for the desired plants to become established. Hand weeding is also very effective, although it is usually feasible only for small sites or those with an ongoing source of volunteer labor.

Unfortunately, some species can survive even the most extreme mechanical treatment. They will continue to reemerge until heavily shaded or crowded out by dense competing stands. In such cases the alternatives are limited. The soil containing the roots of the undesired vegetation can be excavated and screened or removed from the site, relatively mature trees can be planted to achieve near-instantaneous shading, or chemical fertilizers or herbicides can be applied.

Use of Chemicals

In situations where mechanical controls are not enough, the application of fertilizers and the use of herbicides to suppress undesirable competing species may be necessary.

Herbicides can eliminate undesirable species more reliably, but they may eliminate desirable species. Their use near watercourses may also be severely curtailed by local, state, and federal permit requirements. Several herbicides are approved for near-stream use and degrade quickly, but their use should be considered a last resort and the effects of excessive spray or overspray carefully controlled.

If herbicide use is both advisable and permitted, the specific choice is based first on whether the herbicide is absorbed by the leaves or by the roots (e.g., Jacoby 1987). The most common foliar-absorbed herbicide is 2,4-D, manufactured by numerous companies and particularly effective on broadleaf weeds and some shrubs. Other foliar herbicides have become available more recently and are commonly mixed with 2,4-D for broad-spectrum control. Root-absorbed herbicides are either sprayed (commonly mixed with dye to show the area of application) or spread in granular form. They persist longer than most foliar herbicides, and some are formulated to kill newly sprouted weeds for some time after application.

Since herbicides and fertilizers may be problematic near surface water, they should be used only if other alternatives are not available.

Mulches

Mulching limits surface erosion, suppresses weeds, retains soil moisture, and can add some organic material to the soil following decomposition. A variety of mulches are available with different benefits and limitations, as shown in Table 9.1.

Organic mulches, particularly those based on wood (chips or sawdust), have a high nitrogen demand because of the chemical reactions of decomposition. If nitrogen is not supplied by fertilizers, it will be extracted from the soil, which can have detrimental effects on the vegetation that is mulched. Certain species of wood, such as redwood and cedar, are toxic to certain species of seedlings and should not be used for mulch.

Straw is a common mulch applied on construction and revegetation sites because it is inexpensive, available, and effective for erosion control. Appropriate application rates range from about 3,000 to 8,000 lb/acre. Straw can be spread by hand or broadcast by machine, although uniform application is difficult in windy conditions. Straw must be anchored for the same reason: it is easily transported by wind. It can be punched or crimped into the soil mechanically, which is rapid and inexpensive, but requires high application rates. It can be covered with jute or plastic netting, or it can be covered with a sprayed tackifier (usually asphalt emulsion at rates of about 400 gal/acre). Straw or hay can also be a source of un-

Since herbicides and fertilizers may be problematic near surface water, they should be used only if other alternatives are not available.

Table 9.1: Types of mulches.

Mulch	Benefits	Limitations
Chipped wood	Readily available; inexpensive; judged attractive by most	High nitrogen demand; may inhibit seedlings; may float offsite in surface runoff
Rock	May be locally available and inexpensive	Can inhibit plant growth; adds no nutrients; suppresses diverse plant community; high cost where locally unsuitable or unavailable
Straw or hay	Available and inexpensive; may add undesirable seeds	May need anchoring; may include undesirable seeds
Hydraulic mulches	Blankets soil rapidly and inexpensively	Provides only shallow-rooted grasses, but may outcompete woody vegetation
Fabric mats	Relatively (organic) or very (inorganic) durable; works on steep slopes	High costs; suppresses most plant growth; inorganic materials harmful to wildlife
Commercial compost	Excellent soil amendment at moderate cost	Limited erosion-control effectiveness; expensive over large areas

desirable weed seed and should be inspected prior to application.

Wood fibers provide the primary mechanical protection in hydraulic mulches (usually applied during hydroseeding). Rates of 1 to 1.5 tons/acre are most effective. They can also be applied as the tackifier over straw at about one-third the above rate. Hydraulic mulches are adequate, but not as effective as straw, for controlling erosion in most settings. However, they can be applied on slopes steeper than 2:1, at distances of 100 feet or more, and in the wind. On typical earthmoving and construction projects, they are favored because of the speed at which they can be applied and the appearance of the resulting slope—tidy, smooth, and faintly green. The potential drawbacks—introducing fertilizers and foreign grasses that are frequently mixed into hydraulic mulches—should be carefully evaluated.

he value of n effective nulch to the inal success f an initiative s generally vell in excess f its cost, ven when he most expensive treatment is used.

An appropriate mulch in many restoration settings is a combination of straw and organic netting, such as jute or coconut fibers (**Figure 9.13**). It is the most costly of the commonly used systems, but erosion control and moisture retention are highly effective, and the problems with undesirable seeds and excess fertilizers are reduced. The value of an effective mulch to the final success of an initiative is generally well in excess of its cost, even when the most expensive treatment is used.

Irrigation

In any restoration that involves replanting, the need for irrigation should be carefully evaluated. Irrigation might not be needed in wetland and near-stream riparian sites or where rainfall is well distributed throughout the year. Irrigation may be essential to ensure success on upland sites, in riparian zones where seasonal construction periods limit installation to dry months, or where a wet-weather planting may have to endure a first-year drought. Initial costs are lowest with a simple overhead spraying system. Spray systems, however, have inefficient water delivery and have heightened potential for vandalism. Drip-irrigation systems are therefore more suitable at many sites (Goldner 1984). There is also a greater potential for undesirable species with spray irrigation since the area between individual plants receives moisture.

Fencing

If the plant species chosen for the site are suitable, little or no special effort will be necessary for survival and establishment. During the initial construction and postconstruction phases, however, plants will commonly need some measure of physical protection. Construction equipment, work crews, onlookers, grazing horses and cattle, and browsing deer and other herbivores can reduce a new plant installation to barren or crushed twigs in very short order. Vandalism is also a potential problem in populated areas. Fencing is an effective, low-cost method to provide

Figure 9.13: A well-mulched site. *Mulching is an effective method for improving the final outcome of stream corridor restoration.*

physical protection from these types of hazards and should be included in virtually any restoration.

The type of fencing should be chosen for the type of hazard anticipated. Inexpensive, fluorescent orange plastic fencing is very effective for controlling people and equipment during construction, but it rarely makes a suitable long-term barrier. Domestic cattle can be controlled by a variety of wood and wire fences (**Figure 9.14**). Depending on the density of grazing animals, these fences are best assumed to be permanent installations and their design chosen accordingly. Electric fences can also be effective, and the higher cost of the electrification equipment can be offset by lower costs for materials and installation. Where deer are a known problem, fencing must be robust, but it probably will not need to remain in place permanently after well-chosen plants have matured. Damage from small mammals may be halted with chicken wire alone, surrounding individual saplings, or below-ground collars. Individual wire cages or other control devices might be necessary to protect trees.

Inspection

Frequent, periodic inspection of work, whether done by a landowner, contractor, volunteer group, or government personnel, is mandatory. Defects such as poor planting methods, stressed plant materials, inadequate soil compaction, or sloppy erosion control, may become evident only weeks or months after completion of work unless the activities on the site are regularly reviewed. Some of those activities may require specialized testing, such as the degree of compaction of a fill slope. Most require little more than observations by an inspector familiar with all elements of the design.

Figure 9.14: A permanent livestock fence. *Fencing is an effective, low-cost method of providing physical protection to restoration sites.*

In the case of contracted work, it is the responsibility of the construction inspector to monitor installation activities to ensure that the contractor completes work according to the contract plans and specifications. At key points during construction, the inspector should consult with clients and design team(s) for assistance. The inspector should create comprehensive documentation of the construction history in anticipation of any future audit or quantity dispute. All inspections should result in a written record that includes at least the information shown in **Figure 9.15**.

Daily and weekly reports are invaluable to maintain clear communication about billable days, progress, and anticipated problems. These written reports establish the authority to release payment to the contractor and provide the main documentation in case of a dispute between the client and contractor. Completeness, timeliness, and clarity of documentation are critical.

Inspection of restoration elements that involve management actions (i.e., land-use controls, grazing restrictions, etc.) require follow-up communication with the resource manager or landowner. A

Inspector's Daily Report

Date:

Project:

Contractor:

Inspector:

Temperature: H____ L____ Precip:____ Hours: Workable____
Nonworkable____

Work Done ______________________________

Contractor Equipment On-Site ______________________________

Personnel On-Site ______________________________

Materials Used and Location ______________________________

Remarks ______________________________

Inspection Time __________

Inspector's Signature _______________

Figure 9.15: Sample of an inspector's daily report. *Frequent, periodic inspection is a mandatory part of restoration implementation.*

review of the action against the plan and applicable standards should be conducted. For example, rotational grazing may be a critical plan element to achieve restoration of the stream corridor. Inspection of this plan element would involve a review of the rotation scheme, condition of individual pastures or ranges, and condition of fencing and related watering devices.

Keep in mind that although plans and specifications should be specific to the conditions of the site, they might have been developed from generic sets or from those implemented elsewhere.

On-Site Inspection Following Installation

The final inspection after installation determines the conditions under which the contractor(s) can be paid and the contract finalized. It must occur promptly and should determine whether all elements of the contract have been fulfilled satisfactorily. Before scheduling this final inspection, the project manager and inspector, together with any other necessary members of the restoration team, inspect the work and prepare a list of all items requiring completion by the contractor. This "pre-final" inspection is in fact the most comprehensive review of the work that will occur, so it must be conducted with care and after nearly all of the work has been completed. The final inspection should occur with representatives of both the client and the contractor present after completion of all required work and after site cleanup, but before equipment is removed from the site to facilitate additional work if necessary. It must address removal of protection measures no longer needed, such as silt fences. These are an eyesore and might inhibit restoration. A written report should state the complete or provisional acceptance of the work, the basis on which that judgment has been made, and any additional work that is needed prior to final acceptance and payment.

Follow-up Inspections

Planning for successful implementation should always look beyond the period of installation to the much longer interval of plant establishment. Twelve or more additional site visits are advisable over a period of many months or years. Such inspections will generally require a separate budget item that must be anticipated during restoration planning. If they are included in the specifications, they may be the responsibility of the contractor. A sample inspection schedule is shown in Table 9.2. Although this level of activity after installation might seem beyond the scope of a project, any restoration work that depends on the growth of vegetation will benefit greatly from periodic review, particularly during the first two years.

Documentation of follow-up inspections is important, both to justify recommendations and to provide a record from which chronic problems can be identified. Documentation can include standard checklists, survey data, cross sections, data sheets, data summaries, and field notes. Sketches, maps, and permanent photo points can be used to document vegetation development. Videotape can be particularly useful to document the performance of structures during various flows, to illustrate wildlife use and floodplain storage of floodwaters, and otherwise to record the performance and functions of the corridor system.

Inspection reports are primarily intended to address maintenance issues. Problems discovered in the inspection process should be documented in a report that details deficiencies, recommends specific maintenance, and explains the consequences of not addressing the problems. Postplanting inspections to ensure survival require documentation and immediate action. Consequently, the reporting and response loop should be simple and direct so that inspections indicating the need for emergency structural repairs can be reported and resolved without delay.

General Inspection

To the extent feasible, the entire stream corridor should be inspected annually to detect areas of rapid bank erosion or debris accumulation (**Figure 9.16**). A general inspection can also identify inappropriate land uses, such as encroachments of roads near banks or uncontrolled irrigation water returns, that might jeopardize restoration measures, affect water quality, or otherwise

Table 9.2: Sample inspection schedule.

Time Since Installation	Inspection Interval
2 Months	2 weeks (4 total)
6 Months	1 month (5 total)
2 Years	6 months (3 total)

interfere with restoration objectives. The integrity of fences, water access, crossings, and other livestock control measures should be inspected (**Figure 9.17**). Lack of compliance with agreed-upon best management practices should be noted as well. Aerial photos are particularly useful in the overview inspection, but inspections by boat or on foot can be more informative in many cases.

Bank and Channel Structures

Special inspections should be conducted following high flows, particularly after the first flood event following installation. Soil bioengineering measures should be assessed during prolonged drought and immediately after high flows during the first few years fol-

Figure 9.16: Flood debris. *The entire corridor should be inspected annually to detect areas of debris accumulation from flood flows.*

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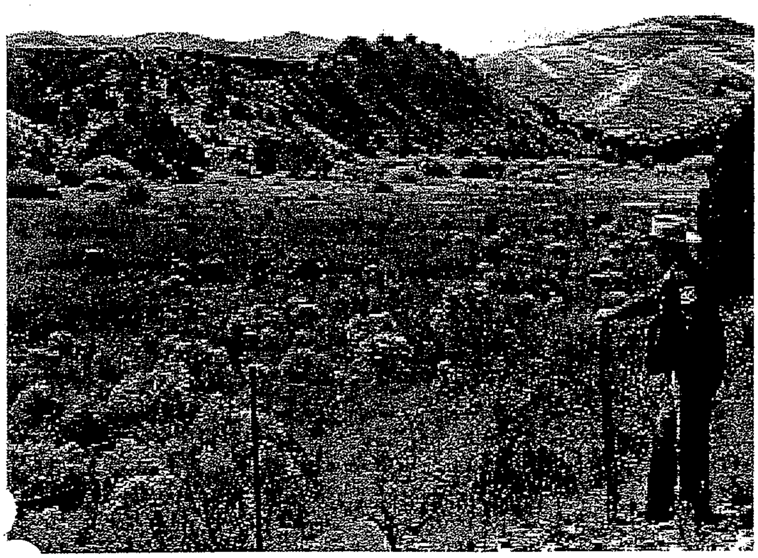
lowing installation until the system is well established.

Most routine inspections of bank and channel measures should be conducted during low-water conditions to allow viewing of the measure as well as channel bed changes that might threaten its future integrity. This is particularly true of bank stabilization works where the principal mechanism of bank failure is undermining at the toe. A low water inspection should involve looking for displaced rock, settling or tilting, undermining, and similar problems (Johnson and Stypula 1993).

In the past, bank stabilization measures were routinely cleared of vegetation to facilitate inspection and prevent damage such as displacement of rock by trees uprooted from a revetment during a flood. However, evidence that vegetation compromises revetment integrity has not been documented (Shields 1987, 1988). Leaving vegetation in place or planting vegetation through rock blankets has been encouraged to realize the environmental benefits of vegetated streambanks. Consequently, agencies have modified inspection and maintenance guidelines accordingly in some areas.

igure 9.17: Fencing. *The integrity of encing should be nspected periodi- ally.*



Vegetation

Streambanks that have been stabilized using plantings alone or soil bioengineering techniques require inspections, especially in the first year or two after planting (**Figure 9.18**). It is important that the planted material be checked frequently to ensure that the material is alive and growing satisfactorily. Any dead material should be replaced and the cause of mortality determined and corrected if possible. If the site requires watering, rodent control, or other remedial actions, the problem must be detected and resolved immediately or the damage may become severe enough to require extensive or complete replanting. Competition from weeds should be noted if it is likely to suppress new plantings. If nonnative plants capable of invading and outcompeting native species are known to be present in the area, both plantings and existing native vegetation should be inspected. Any newly established nonnative populations should be eradicated quickly.

After the first growing season, semiannual to annual evaluations should be sufficient in most cases. At the end of a 2-year period, 50 percent or more of the originally installed plant material should be healthy and growing well (**Figure 9.19**). If not, determining the cause of die-off and subsequent replanting will probably be necessary. If the installation itself is determined to have been improper, any warranty or dispute-resolution clauses in the plant installation contract might need to be invoked.

The effectiveness of bank protection is based largely on the development of the plants and their ability to bind soils at moderate flow velocities. The bank protection measures should be inspected immediately after high-flow events in the first few years, particularly if the plantings have not fully established. Washouts, slumping of geogrids, and similar problems require detection and correction, since they might become the sites of further deterioration and complete failure if left uncorrected.

Floodplain and other off-channel plantings might be important components of the corridor restoration plan as well. Inspection requirements are similar to those on streambank sites but are less critical to the integrity of the project in terms of preventing additional damage. Nevertheless, several site visits are appropriate during the first growing season to detect problems due to browsing, insects, too much or too little water, and other causes. Inspection of plantings that require irrigation during establishment, as well as of the irrigation system, may be needed on a weekly or more frequent basis.

Techniques for inspecting vegetation survival are fairly straightforward. Satisfactory survival rates may be determined using stem counts within sample plots or estimates of cover percentages, depending on the purpose of the plantings. For example, Johnson and Stypula (1993) suggest that woody plantings established for streambank protection should not include open spaces more than 2 feet in dimension. In most cases, such criteria can be established in advance based on common-sense decisions regarding the adequacy of establishment relative to the objectives. Where more detailed monitoring is appropriate to document development of habitat quality or similar objectives, more rigorous monitoring techniques can be used. (See Section 9.B).

Urban Features

Stream corridor objectives may require periodic inspections of features other than the stream, streambank, and corridor vegetation. In urban areas, these features may be a major focus of the inspection program. Facilities, nest boxes, trails, roads, storm water systems, and similar features must be inspected to ensure they are in satisfactory condition and are not contributing to degradation of the stream corridor. Access points required to accomplish maintenance and emergency repairs should be checked for serviceability. Popular public use areas, particularly stream access points, should be evaluated to determine

Figure 9.18: Revegetation project. *It is important that the planted material be inspected frequently to ensure that it is alive and growing satisfactorily.*

Figure 9.19: Revegetation project, 1 to 2 years postconstruction. *At the end of a 2-year period, 50 percent or more of the original plantings should be healthy and growing well.*
Source: King County, Washington.

Preview Section 9.B, Monitoring Techniques Appropriate for Evaluation Restoration.

whether measures are being damaged, erosion is being initiated, or project objectives are otherwise being impeded. Inspection should reveal whether signs, trail closures, and other traffic-control measures are in place and effective. Trash and debris dumping, off-road vehicle damage, vandalism, and a wide variety of other detrimental occurrences may be noted during routine inspections.

Maintenance

Maintenance encompasses those repairs to restoration measures which are based on problems noted in annual inspections, are part of regularly scheduled upkeep, or arise on an emergency basis.

- *Remedial maintenance* is triggered by the results of the annual inspection (Figure 9.20). The inspection report should identify and prioritize maintenance needs that are not emergencies, but that are unlikely to be addressed through normal scheduled maintenance.
- *Scheduled maintenance* is performed at intervals that are preestablished during the design phase or based on project-specific needs. Such maintenance activities as clearing culverts or regrading roads can be anticipated, scheduled, and funded well in advance. In many instances, the scheduled maintenance fund can be a tempting source for emergency funds, but this can result in neglect of routine maintenance, which may eventually produce a new, more costly, emergency.
- *Emergency maintenance* requires immediate mobilization to repair or prevent damage. It may include measures such as replacement of plants that fail to establish in a soil bioengineered bank stabilization, or repair of a failing revetment. Where there is a reasonable probability that repair or replacement might be required (e.g., anything that depends on vegetation establishment), sources of funding, labor, and materials should be identified in advance as part of the contingency planning process. However, there should be some general strategy for allowing rapid response to any emergency.

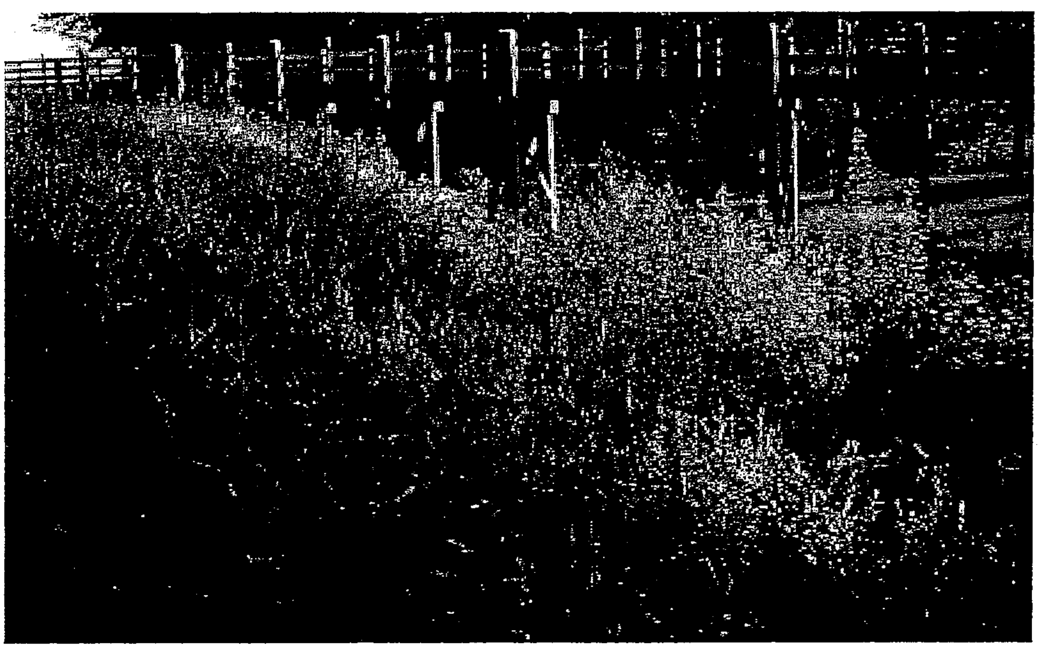


Figure 9.20: Remedial maintenance. *Soil bioengineering used to repair failing revetment.*

Many maintenance actions will require permits, and such requirements should be identified well in advance to accommodate permitting delays. Similarly, access to areas likely to require maintenance (e.g., bank stabilization structures) should be guaranteed at the time of construction, and the serviceability of access roads verified periodically.

Various agencies and utilities may have maintenance responsibilities that involve portions of the stream corridor, such as road and transmission line crossings. This work should be coordinated as necessary to ensure there are no conflicts with corridor objectives.

Channels and Floodplains

Corridor restoration that includes reconfiguration of the channel and floodplain may require remedial action if the system does not perform as expected in the first few years after work has been completed. Any repairs or redesign, however, should be based on a careful analysis of the failure. Some readjustment is to be expected, and a continuing dynamic behavior is fundamental to successful restoration. Because establishment of a dynamic equilibrium condition is usually the intent, maintenance should be limited to actions that promote self-sustainability.

Many traditional channel maintenance actions may be inappropriate in the context of stream corridor restoration. In particular, removal of woody debris may be contrary to restoration objectives (Figure 9.21). Appropriate levels of woody debris loading should be a design specification of the project, and the decision to remove or reposition particular pieces should be based on specific concerns, such as unacceptably accelerated bank erosion due to flow deflection, creation of ice jams causing an increased chance for flooding, or concerns about safety in streams with high recreational use. In cases where woody debris sources have been depleted, periodic addition of debris may be a prescribed maintenance activity. (See next page for story on engineered log jams.)

Protection/Enhancement Measures

Measures intended to enhance fish habitat, deflect flows, or protect banks are likely to require periodic maintenance. If failure occurs soon after installation, the purpose and design of the measure should be reevaluated before it is repaired, and the mechanism of failure should be identified. Early failure is an inherent risk of soil- bioengineered systems that are not fully effective until the plants are well rooted and the stems reach a particular size and density. Although a design weakness may be identifiable and should be corrected, more often the mechanism of failure will be that the measure has not yet developed

Figure 9.21: Accumulated woody debris. *Removal of woody debris may be contrary to restoration objectives.*

full resistance to high-flow velocities or saturation of bank soils. Replanting should be an anticipated potential maintenance need in this situation.

In many stream corridor restoration areas, the intent of streambank and channel measures is to provide temporary stabilization until riparian vegetation develops and assumes those functions. In such cases, maintenance of some structures might become less important over time, and they might eventually be allowed to deteriorate. They can be wholly or partially removed if they represent impediments to natural patterns of channel migration and configuration, or if some components (cables, stone, geofabrics) become hazards.

Vegetation

Routine maintenance of vegetation includes removal of hazardous trees and branches that threaten safety, buildings, fences, and other structures, as well as maintenance of vegetation along road shoulders, trails, and similar features.

Planted vegetation may require irrigation, fertilization, pest control, and similar measures during the first few years of establishment. In large-scale planting efforts, such as floodplain reforestation efforts, maintenance may be precluded. Occasionally, replanting will be needed because of theft.

Maintenance plans should anticipate the need to replant in case soil- bioengineered bank protection structures are subjected to prolonged high water or drought before the plants are fully established. Techniques using numerous cuttings establish successfully, it might be desirable to thin the dense brush that develops to allow particular trees to grow more rapidly, especially if channel shading is a restoration objective. Often, bank protection measures become popular points for people to access the stream (for fishing, etc.). Plantings can be physically removed or trampled. Replanting, fencing, posting signs, or taking other measures might be needed.

Other Features

A wide variety of other restoration features will require regular maintenance or repair. Rural restoration efforts might require regular maintenance and periodic major repair or replacement of fences and access roads for management and fire control. Public use areas and recreational facilities require upkeep of roads, trails, drainage systems, signs, and so forth (**Figure 9.22**). Maintenance of urban corridors may be intensive, requiring trash removal, lighting, and other steps. An administrative contact should be readily available to address problems as they develop. As the level of public use increases, contracting of maintenance services might become necessary, and administration of maintenance duties will become an increasingly important component of corridor management.

Restoration measures placed to benefit fish and wildlife (e.g., nest boxes and platforms, waterers) need annual cleaning and repair. These maintenance activities can be as time-consuming as the original installation, and structures that are in bad condition might draw public attention and criticism. The maintenance commitment should be recognized before such structures are installed. Special wildlife management units, such as moist-soil-management impoundments and green-tree reservoirs, require close attention to be managed effectively.

Flooding and drawdown schedules must be fine-tuned based on site-specific conditions (Fredrickson and Taylor 1982). Special equipment might be needed to maintain levees, to work on soft ground, to repair drainage structures, and to pump out facilities, all of which might incur substantial fuel costs. The maintenance needs in these kinds of situations require that professional resource managers be on site regularly. Not operating the restoration attentively can create nuisance or hazardous conditions, have severe detrimental effects on existing resources, and fail to produce the desired results.

Mosquito control may also be a maintenance concern near inhabited areas, particularly if the restoration encourages the development of slack-water areas, such as beaver ponds, backwaters, and floodplain depressions. In some cases, control techniques may directly interfere with restoration objectives, but threats to people and livestock might make them necessary.

Figure 9.22: Streamside trail. *Public use areas and recreational facilities require upkeep of roads, trails, and signs.*

9B Monitoring Techniques Appropriate for Evaluating Restoration

As discussed in Chapter 6, the completion of implementation does not mark the end of the restoration process. Restoration practitioners must plan for and invest in the monitoring of stream corridor restoration. The type and extent of monitoring will depend on specific management objectives developed as a result of stream corridor characterization and condition analysis. Monitoring may be conducted for a number of different purposes including:

- *Performance evaluation:* Assessed in terms of project implementation and ecological effectiveness. Ecological relationships used in monitoring and assessment are validated through collection of field data.
- *Trend assessment:* Includes longer term sampling to evaluate changing ecological conditions at various spatial and temporal scales.
- *Risk assessment:* Used to identify causes and sources of impairment within ecosystems.
- *Baseline characterization:* Used to quantify ecological processes operating in a particular area.

This section examines monitoring from the perspective of evaluating the performance of a restoration initiative. Such initiatives seek to restore the structure and functions discussed in earlier chapters. Designing a monitoring program that directly relates to those valued functions requires careful planning to ensure that a sufficient amount of information is collected. Such monitoring uses measurements of physical, biological, and chemical parameters to evalu-

REVERSE

Review previous chapters for an introduction to the restoration of stream corridor structure and functions.

CASE STUDY

Engineered Log Jams for Bank Protection and Habitat Restoration

Most riverbank protection measures are not designed to improve aquatic or riparian habitat, and many restoration initiatives lack sufficient engineering and geomorphic analysis to effectively restore natural functions of riparian and aquatic ecosystems. The ecological importance of instream woody debris (WD) has been well documented. Woody debris within a stream can often influence the instream channel structure by increasing the occurrence of pools and riffles. As a result, streams with WD typically have less erosion, slower routing of organic detritus (the main food source for aquatic invertebrates), and greater habitat diversity than straight, even-gradient streams with no debris. Woody debris also provides habitat cover for aquatic species and characteristics ideally suited for fish spawning.

*Reintroduction of WD (or log jams) in many parts of the United States has been extensive, but limited understanding of WD stability has hampered many of these efforts. Engineered log jams (ELJs) can restore riverine habitat and in some situations can provide effective bank protection (**Figure 9.23**). Although WD is often considered a hazard because of its apparent mobility, research in Olympic National Park has documented that stable WD jams can occur throughout a drainage basin (Abbe et al. 1997). Even in large alluvial channels that migrate at rates of 30 ft./yr, jams can persist for centuries, creating a mosaic of stable sites that in turn host the large trees necessary to initiate stable jams. Engineered log jams are designed to emulate natural jams and can meet management or restoration objectives such as bank protection and debris retention.*

After learning about the uncertainty and potential risks of creating man-made log jams, landowners near Packwood, Washington, decided the potential environmental, economic, and aesthetic benefits outweighed the risks. An experimental project consisting of three ELJs was implemented to control severe erosion along 1,400 ft. of the upper Cowlitz River. The channel at the site was 645 ft. wide and had an average bank erosion rate of 50 ft./yr from 1990 to 1995. Five weeks after constructing the log jams, the project experienced a 20-year recurrence flow (30,000 ft.^{3}/s). Each ELJ remained intact and met design objectives by transforming an eroding shoreline into a local depositional environment (i.e., accreting shoreline). Approximately 93 tons of WD that was in transport during the flood was trapped by the ELJs, alleviating downstream hazards and enhancing structure stability. Improvements in physical habitat included creation of complex scour pools at each ELJ (Abbe et al. 1997).

Landowners have been delighted by the experiment. The ELJs have remained intact, increased in size, and reclaimed some of the formerly eroded property even after being subjected to major floods in February 1996 and March 1997. When compared to traditional bank stabilization methods, which typically employ the extensive use of exotic materials such as rock rarely found in low-gradient alluvial channels, ELJs can offer an effective and low-cost alternative for erosion control, flood control, and habitat enhancement. The cumulative effect of most traditional bank stabilization methods over time results in progressive channel confinement and detachment of the riparian environment from the channel (e.g., loss of streamside vegetation). In stark contrast, the cumulative effects of using ELJs include long-term protection of a significant floodplain, improvement of instream and riparian habitat, and bank stabilization (Abbe et al. 1997).

Comprehensive geomorphic and hydraulic engineering analysis is required to determine the type of WD needed and the appropriate size, position, spacing, and type of ELJ structure for the particular site(s) and project objectives. Inappropriate design and application of ELJs can result in negative impacts such as local accelerated bank erosion, unstable debris, or channel avulsion. Acknowledging the potential risks and uncertainties of ELJs, their use should be limited to well-documented experimental situations. Continued research and development of ELJs involving field application in a variety of physiographic and climatic conditions is needed. ELJs can provide a means to meet numerous objectives in the management and restoration of rivers and riparian corridors throughout the United States.

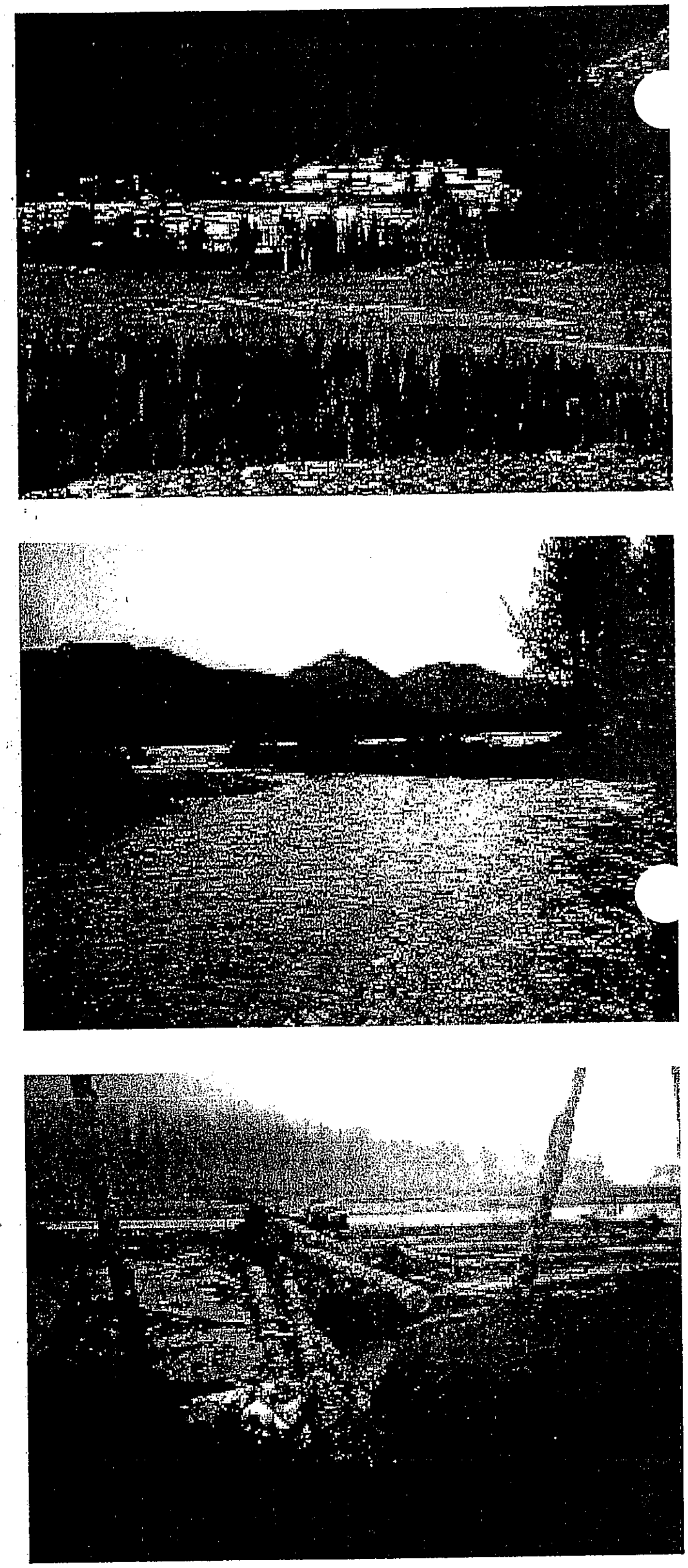


Figure 9.23:* *Engineered log jams. *Engineered log jams (ELJs) can restore riverine habitat and in some situations provide effective bank protection.*

ₑReview Chapter 7D's section on analytical methods for evaluating biological attributes.

ate the effectiveness of the restoration and to facilitate adaptive management where needed. Sampling locations, measurements to be made, techniques to be used, and how the results will be analyzed are important considerations in monitoring.

Adaptive Management

The implementation, effectiveness, and validation components of performance monitoring provide a vehicle to determine the need for adaptive management. Adaptive management is the process of establishing checkpoints to determine whether proper actions have been taken and are effective in providing desired results. Adaptive management provides the opportunity for course correction through evaluation and action.

Implementation Monitoring

Implementation monitoring answers the question, "Were restoration measures done and done correctly?" Evaluating the effectiveness of restoration through physical, biological, and/or chemical monitoring can be time-consuming, expensive, and technically challenging. Time and partnerships are needed to build the capability for evaluating project effectiveness based on changes in ecological condition. Therefore, an important interim step to this goal is implementation monitoring. This comparatively simple process of documenting what was done and whether or not it was done properly can yield valuable information that promotes refinement of restoration practices.

Adaptive management provides the opportunity for course correction through evaluation and action.

Effectiveness Monitoring

Effective monitoring answers the question "Did restoration measures achieve the desired results?" or more simply "Did the restoration initiative work?" Effectiveness monitoring evaluates success by determining whether the restoration had the desired effect on the ecosystem. Monitoring variables focus on indicators that document achievement of desired conditions and are closely linked with project goals. It is important that indicators selected for effectiveness monitoring are sensitive enough to show change, are measurable, are detectable and have statistical validity. This level of monitoring is more time-consuming than implementation monitoring, making it more costly. To save time and money, monitoring at this level is usually performed on a sample population or portion of a project with results extrapolated to the whole population.

Validation Monitoring

Validation monitoring answers the question "Are the assumptions used in restoration design and cause-effect relationships correct?" Validation monitoring considers assumptions made during planning and execution of restoration measures. This level of monitoring is performed in response to nonachievement of desired results once proper implementation is confirmed. A restoration initiative that fails to achieve intended results could be the result of improper assumptions relative to ecological conditions or selection of invalid monitoring indicators. This level of monitoring is always costly and requires scientific expertise.

Evaluation Parameters

Physical Parameters

A variety of channel measurements are appropriate for performance evaluation (**Figure 9.24**). The parameters presented in **Table 9.3** should be considered for measurement of physical performance and stability. Stream pattern and morphology are a result of the interaction of eight measurable parameters—width, depth, channel slope, roughness of channel materials, discharge, velocity, sediment loads, and sediment size (Leopold et al. 1964). These parameters and several other dimensionless ratios (including entrenchment, width/depth ratio, sinuosity, and meander/width ratio) can be used to group stream systems with similar form and pattern. They have been used as delineative criteria in stream classification (Rosgen 1996). Natural streams are not random in their variation.

A change in any of the primary stream variables results in a series of channel adjustments, resulting in alterations of channel pattern and form, and attendant changes in riparian and aquatic habitat.

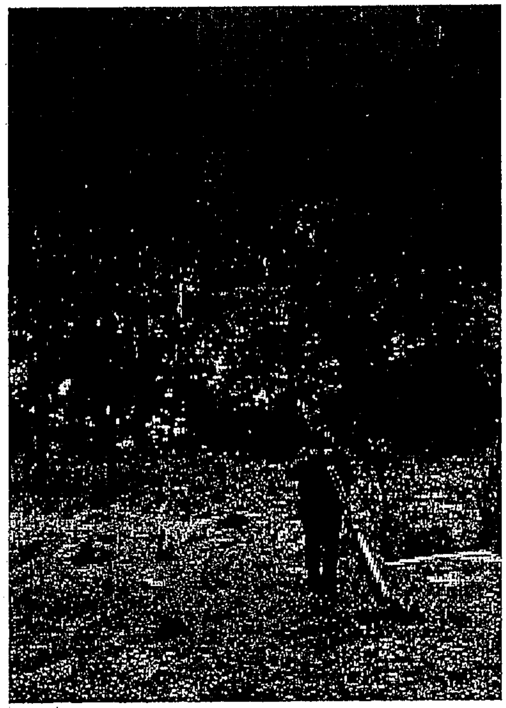


Figure 9.24: Measurement of a stream corridor. Monitoring the physical aspects of the stream corridor system is important in evaluating the success of any restoration effort.

Review Chapters 2 and 7 for information on chemical water parameters and their sampling. Also, review Chapter 8's section on reference reaches.

Biological Parameters

Biological monitoring can cover a broad range of organisms, riparian conditions, and sampling techniques. In most cases, budget and staff will limit the diversity and intensity of evaluation methods chosen. Analytical methods for evaluating biological attributes are discussed in Section 7.D of this document.

Table 9.4 provides examples of the biological attributes of stream ecosystems that may be related to restoration goals. Biological aspects of the stream corridor that may be monitored as part of performance goals include primary productivity, invertebrate and fish communities, riparian/terrestrial wildlife, and riparian vegetation. This may involve monitoring habitat or fauna to determine the degree of success of revegetation efforts or instream habitat improvements.

Biological monitoring programs can include the use of chemical measures. For example, if specific stressors within the stream system, such as high water temperatures and low dissolved oxygen, limit biological communities, direct monitoring of these attributes can provide an evaluation of the performance of more intensive remedial practices, including point source pollution reduction.

Chemical Parameters

Monitoring is necessary to determine if a restoration initiative has had the desired effect on water chemistry. The type and extent of chemical monitoring depends upon the goal of the monitoring program. Major chemical parameters of water and their sampling are discussed in Chapters 2 and 7.

A factor in designing a chemical monitoring approach is the amount of change expected in a system. If the

Table 9.3: Physical parameters to be considered in establishing evaluation criteria for measurement of physical performance and stability.

Plan view	Sinuosity, width, bars, riffles, pools, boulders, logs
Cross sectional profiles — by reach and features	Sketch of full cross section
	Bank response angle
	Depth bankfull
	Width
	Width/depth ratio
Longitudinal profile	Bed particle size distribution
	Water surface slope
	Bed slope
	Pool size/shape/profile
	Riffle size/shape/profile
	Bar features
Classification of existing streams (all reaches)	Varies with classification system
Assessment of hydrologic flow regimes through monitoring	2-, 5-, 10-year storm hydrographs
	Discharge and velocity of base flow
Channel evolutionary track determination	Decreased or increased runoff, flash flood flows
	Incisement/degradation
	Overwidening/aggradation
	Sinuosity trend—evolutionary state, lateral migration
	Increasing or decreasing sinuosity
	Bank erosion patterns
Corresponding riparian conditions	Saturated or ponded riparian terraces
	Alluvium terraces and fluvial levees
	upland/well-drained/sloped or terraced geomorphology
	Riparian vegetation composition, community patterns and successional changes
Corresponding watershed trends–past 20 years and future 20 years	Land use/land cover
	Land management
	Soil types
	Topography
	Regional climate/weather

restoration goal, for example, is to reduce the salinity in a stream by 5 percent, it would be much more difficult to detect than a goal of reducing salinity by 50 percent.

Chemical monitoring can often be used in conjunction with biological monitoring. There are pros and cons for using chemical and biological parameters when monitoring. Biological parameters are often good integrators of several water quality parameters. Biological indicators are especially useful when determining the bioaccumulation of a chemical.

Water chemistry samples are typically easier to replicate, can disclose slow changes over time, and be used to prevent catastrophic events when chemical characteristics are near toxic levels. For example, water quality monitoring might detect a slow decrease in pH over a period of time. Some aquatic organisms, such as trout, might not respond to this gradual change until the water becomes toxic. However, water quality monitoring could detect the change and thereby avoid a catastrophic event. An ideal monitoring program would include both biological and chemical parameters.

Important chemical and physical parameters that might have a significant influence on biological systems include the following:

- Temperature
- Turbidity
- Dissolved oxygen
- pH
- Natural toxics (mercury) and manufactured toxics
- Flow
- Nutrients
- Organic loading (BOD, TOC, etc.)
- Alkalinity/Acidity
- Hardness
- Dissolved and suspended solids
- Channel characteristics
- Spawning gravel
- Instream cover
- Shade
- Pool/riffle ratio
- Springs and ground water seeps
- Bed material load
- Amount and size distribution of large woody debris (i.e., fallen trees)

These parameters may be studied independently or in conjunction with biological measurements of the ecological community.

Reference Sites

Understanding the process of change requires periodic monitoring and measurement and scientific interpretation of the information as it relates to the stream corridor. In turn, an evaluation of the amount of change attributed to restoration must be based on established reference conditions developed by the monitoring of reference sites. The following are important considerations in reference site selection:

- What do we want to know about the stream corridor?
- Are identified sites minimally-disturbed?
- Are the identified sites representative of a given ecological region, and do they reflect the range of natural vari-

Table 9.4: Examples of biological attributes and corresponding parameters that may be related to restoration goals and monitored as part of performance evaluation.

Biological Attribute	Parameter
Primary productivity	Periphyton
	Plankton
	Vascular and nonvascular macrophytes
Zooplankton/diatoms	
Invertebrate community	Species
	Numbers
	Diversity
	Biomass
	Macro/micro
	Aquatic/terrestrial
Fish community	Anadromous and resident species
	Specific populations or life stages
	Number of outmigrating smolts
	Number of returning adults
Riparian wildlife/terrestrial community	Amphibians/reptiles
	Mammals
	Birds
Riparian vegetation	Structure
	Composition
	Condition
	Function
	Changes in time (succession, colonization, extirpation, etc.)

Performance Evaluation of Fish Barrier Modifications

Fish barrier modifications provide a good example of a technically difficult performance evaluation. The goal of the restoration is easily understood and stated. Barrier modification provides one of two options—to increase populations (increase upstream and downstream movement) or to decrease populations (restrict movement).

In all cases, the specific target species should be identified. If the goal is to restore historic runs of commercial fishes, data for commercial landings may be available to provide guidance. Habitat models are available for species such as Atlantic salmon and can provide insight into expected carrying capacities of nursery habitat. Existing runs in adjacent or nearby river(s) may be examined for population levels and trends that can provide insight into realistic goals. Barriers may be planned for only short-term protection of some species (e.g., protection against cannibalism) or for longer term exclusion of problematic or undesirable species.

*Methodologies to evaluate the success of fish barrier modifications can use a variety of field methods to count the number of adult spawners, to determine the abundance of fry, to estimate the size of the outmigrating juvenile population, or to monitor the travel time between specific points within a watershed (**Table 9.5**). However, consideration needs to be given to factors that may influence the success of the population outside the study area. Commercial fishing, disease, predation, limited food supply, or carrying capacity of juvenile or adult habitat may be more important controlling factors than access to spawning and nursery habitat.*

The performance evaluation must allow ample time for the species to complete its life cycle. Many anadromous species have life spans of 4 to 7 years; sturgeon live for decades. Adequate homing to natal areas may require several generations to build a significant migrating population and to fill all year classes. Floods or droughts can impact fry and juvenile life stages and do not become apparent in adult spawning populations until several years have elapsed. Restoration and monitoring goals need to be formulated to take these non-restoration-limiting factors into account. Examination of year-class structure of returning adults might be useful, or investigations that average the size of spawning runs for multiple years might be appropriate.

Table 9.5: Methods to evaluate effectiveness of fish barrier modifications.

Modification	Method
Fishway counts	Observation windows
	Hydroacoustics
	Fish traps/weirs
	Netting
Population estimates	Mark and recapture
	Snorkel counts
	Redd counts
	Creel census
	Direct counts of spawning adults
Timing of migration between observation points	Radio tagging
	Pit tags
	Dyes and other external marks
	Computer-coded tags

Performance evaluation study methodologies must use appropriate monitoring techniques. Collecting techniques need to be relatively nondestructive. Collecting weirs, traps, or nets need to be designed to limit injury or predation and should function over a wide range of flow and debris levels. Monitoring techniques should not extensively limit movement. Weirs and traps should not cause excessive delays in migration, and fish tags should not encumber movement. Techniques are often species- and life stage-specific. Fish tags, including radio tags, may be appropriate for older, larger individuals, whereas chemical marks, dyes, fin clips, or internal microtags may be appropriate for smaller organisms. Certain fish, such as alosids (American shad and river herring), may be more difficult to handle than others, such as salmonids (trout and salmon), and appropriate handling techniques need to be used. Avoiding extreme environmental conditions (excessively high or low water temperature or flow) may be important. Nondestructive techniques, such as hydroacousitics and radio tags, have several advantages, but care needs to be taken to differentiate between background noise (mechanical, debris, entrained air, nonlaminar flow), other species, and target species.

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ability associated with a given stream class?

- What is the least number of sites required to establish reference conditions?
- What are the impediments to reference site access?

Reference sites provide examples of a properly functioning ecosystem. It is from these reference sites that desired conditions are determined and levels of environmental indicators identified. Environmental indicators become the performance criteria to monitor the success of a initiative.

Human Interest Factors

Human activities requiring use of a healthy environment may often be important factors for evaluating stream corridor restorations (**Figure 9.25**). In these cases, the ability of the stream corridor to support the activity indicates benefits drawn from the stream corridor as well as adding insight into stream ecosystem condition. Many human interest-oriented criteria used in performance evaluations can serve the dual function of evaluating elements of human use and ecological condition together:

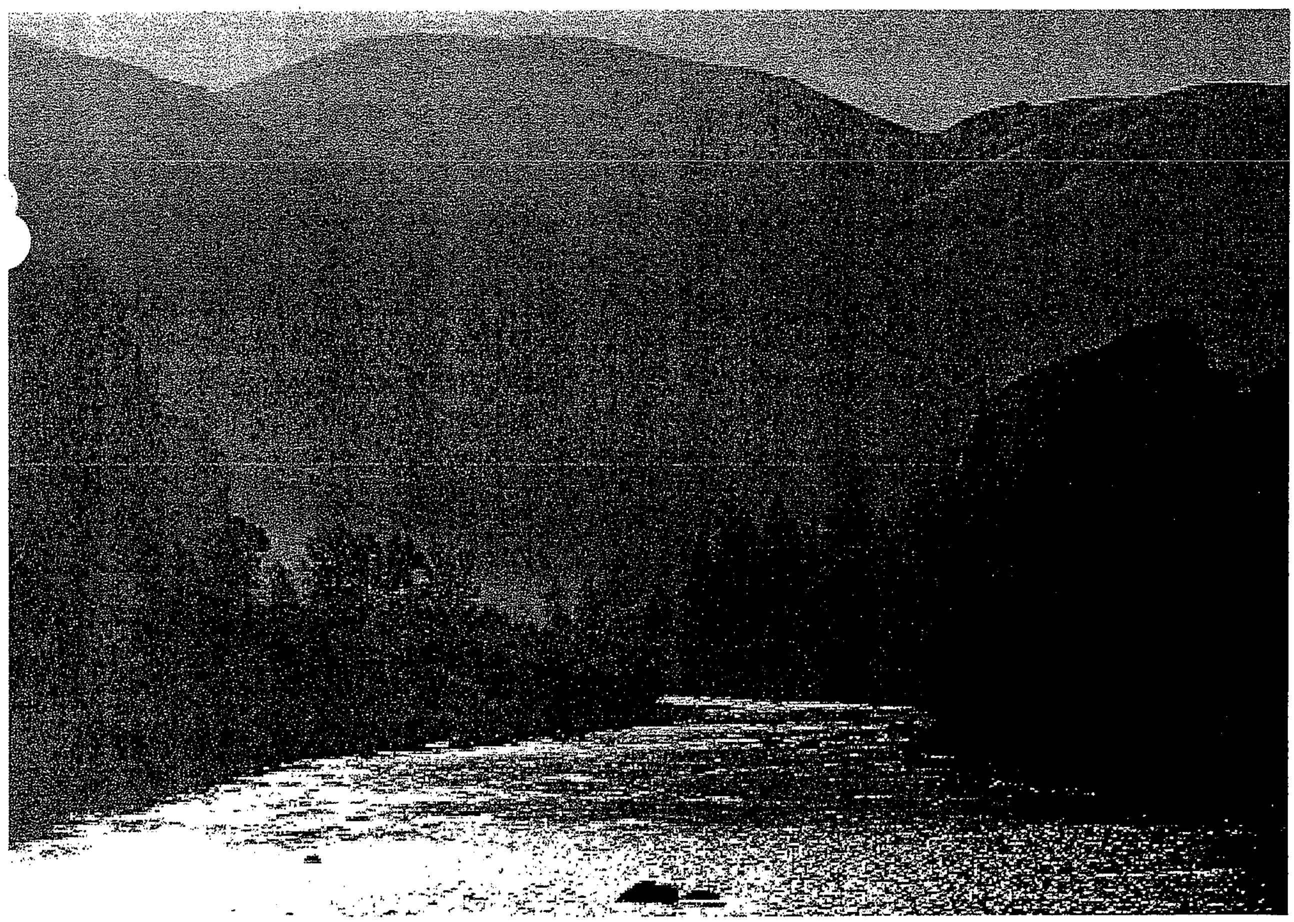

__Figure 9.25: Human interest in the stream corridor.__ Aesthetics are a highly valued benefit associated with a healthy stream corridor.

Additional References for Monitoring

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- Human health (disease, toxic/fish consumption advisories)
- Aesthetics (odor, views, sound, litter)
- Non-consumptive recreation (hiking, birding, whitewater rafting, canoeing, outdoor photography)
- Consumptive recreation (fishing, hunting)
- Research and educational uses
- Protection of property (erosion control, floodwater retention)

Use surveys, which determine the success of the restoration in terms of human use, can provide additional biological data. Angler survey, creel census, birding questionnaires, and sign-in trail boxes that request observations of specific species can also provide biological data. Citizens' groups can participate effectively, providing valuable assistance at minimal cost.

9C Restoration Management

Management is the long-term manipulation and protection of restoration resources to achieve objectives. Management priorities for the stream corridor ecosystem are set during the planning phase and refined during design. These priorities should also be subject to ongoing revision based on regular monitoring and analysis. Management needs can range from relatively passive approaches that involve removal of acute impacts to intensive efforts designed to restore ecosystem functions through active intervention. Whereas a preceding section described the need to provide adequate maintenance for the restoration elements, restoration management is the collective set of decisions made to guide the entire restoration effort to success.

/anagement eeds can ange from relatively passive pproaches that nvolve removal f acute impacts o intensive fforts designed o restore cosystem functions through ctive intervention.

The restoration setting and the priorities of participants can make management a fairly straightforward process or a complex process that involves numerous agencies, landowners, and interested citizens. Development of a management plan is less difficult when the corridor and watershed are under the control of a single owner or agency that can clearly state objectives and priorities. Some stream corridor restorations have, in fact, involved extensive land acquisition to achieve sufficient management control to make restoration feasible. Even then, competing interests can exist. Decisions must be made regarding which resource uses are compatible with the defined objectives.

More commonly, stream corridor management decisions will be made in an environment of conflicting interests, overlapping mandates and regulatory jurisdictions, and complex ownership patterns, both in the corridor and in the surrounding watershed. For example, in a Charles River corridor project in Massachusetts, the complex ownership pattern along the river requires direct active management in some areas and easements in others. In the remainder, management is largely a matter of encouraging appropriate use (Barron 1989). Many smaller restorations might be similarly diversified with management decisions involving a variety of participants. Participation and adherence to restoration best management practices (BMPs) may be encouraged through various programs, such as the NRCS's Conservation Reserve Program, multi-agency riparian buffer restoration initiatives, and cost-sharing opportunities available under the EPA Section 319 Program.

Programs intended to reduce nonpoint source pollution of waterways often encourage the use of practices to address problems such as agricultural runoff or sediment generated by timber harvest operations. Because many practices focus on activities within the stream corridor, existing practices should be reviewed to determine their applicability to the stream corridor restoration plan (**Figure 9.26**). Although the ecological restoration objectives for the corridor might require more restrictive management, existing practices can provide a good starting point and establish a rationale for minimum management prescriptions. In stream corridor restoration efforts involving numerous landowners, it might be appropriate to develop a revised set of practices specific to the restoration area. Participants should have the opportunity to participate in developing the practices and should be willing to commit to compliance before the restoration is implemented.

Regulatory controls influencing management options are increasingly complex and require regular review as management plans evolve and adapt. In some areas, regulatory oversight of activities in streamside areas and in the vicinity of wetlands involves fairly rigid rules that may conflict with specific proposed management actions (e.g., selective tree removals). Implementation of management actions in such cases will require coordination and approval from the regulating agencies. Many state and local jurisdictions vary their restrictions according to classification systems reflecting the condition of the streamside area or wetland in terms of "naturalness"; for example, sites with large trees might receive a higher level of protection than sites that have been heavily disturbed.

Restoration is intended specifically to improve the condition of the stream corridor; however, an activity that is allowable initially might be regulated as the corridor condition improves. These changes should be anticipated to the extent possible in developing long-term management and use plans.

Streams

In effect, stream corridor restoration and ongoing monitoring constitute stream management. Many problems detected during monitoring can be resolved by manipulation of the stream corridor vegetation (**Figure 9.27**), land uses, where possible, and only occasionally, by direct physical manipulation of the channel. If "resetting" of the channel system is necessary, it essentially becomes a redesign problem. Where lateral erosion occurs in unanticipated areas and poses an unacceptable threat to function, property, or infrastructure, another restoration approach might have to be initiated.

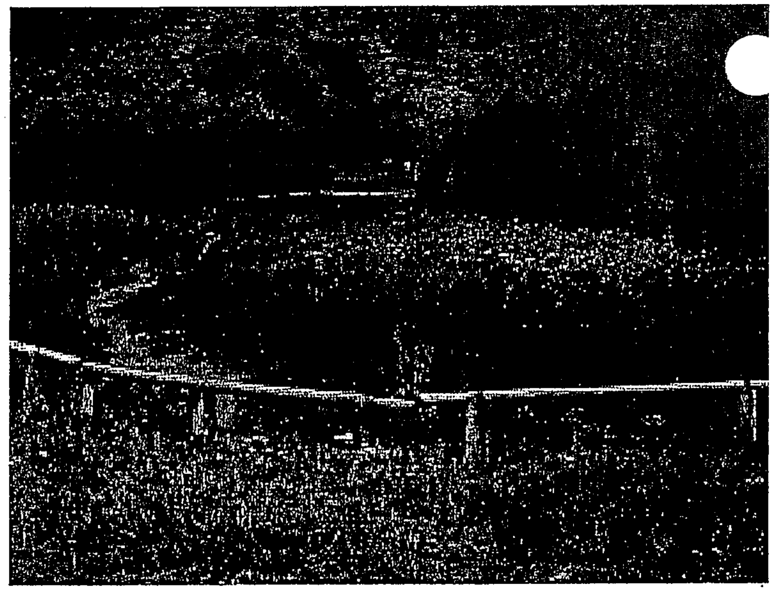


Figure 9.26: Livestock fences used as a BMP. *Reviewing existing BMPs can be useful in establishing management prescriptions.*

Figure 9.27: Pruning streamside vegetation. *Monitoring might detect the need for manipulation of streamside vegetation.*

In cases where streamflow control is an option, it likely will be a significant component of the management plan to maintain baseflows, water temperatures, and other attributes. However, appropriate flow patterns should have been defined during the design phase, with components of corridor management prescribed accordingly. If hydrologic patterns change after the restoration is established, significant redesign or management changes might be required for the entire corridor. Ultimately, a well-planned, prepared stream corridor restoration design predicts and addresses the potential for hydrologic change.

Forests

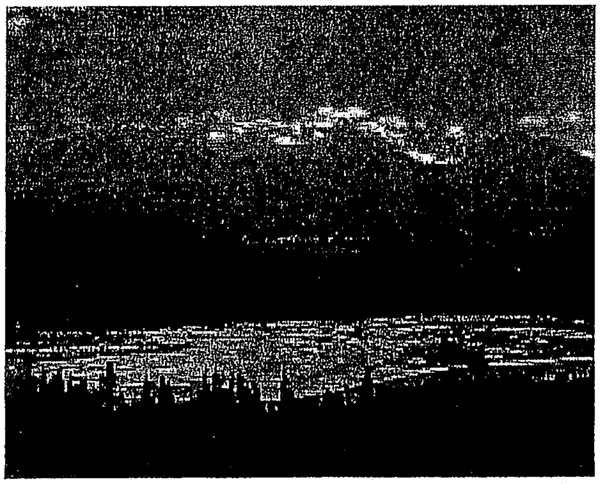
In forested environments, the planning and design phases of stream corridor restoration should set specific objectives for forest structure and composition within the corridor. If existing forests are developing in the desired direction, action may not be needed. In this case, forest management consists of protection rather than intervention. In degraded stream corridor forests, achieving desired goals requires active forest management. In many corridors economic return to private and public landowners is an important objective of the restoration plan. Stream corridor restoration may accommodate economic returns from forest management, but management within the stream corridor should be driven primarily by ecological objectives. If the basic goal is to restore and maintain ecological functions, silviculture should imitate natural processes that normally occur in the corridor.

Numerous forest management activities can promote ecological objectives. For example, some corridor forest types might benefit from prescribed fire or wildfire management programs that maintain natural patterns of structural and compositional diversity and regeneration. In other systems, fire might be inappropriate or might be precluded if the stream corridor is in an urban setting. In the latter case, silvicultural treatments might be needed to emulate the effects of fire.

Recovery of degraded streamside forests can be encouraged and accelerated through silvicultural efforts. Active intervention and management may be essential to maintain the character of native plant communities where river regulation has contributed to hydrology and sedimentation patterns that result in isolation from seed sources (Klimas 1991, Johnson 1994). Streamside forests used as buffers to prevent nutrients from reaching streams may require periodic harvests to remove biomass and maintain net uptake (Lowrance et al. 1984, Welsch 1991). However, buffers intended to intercept and degrade herbicides might be most effective if they are managed to achieve old-growth conditions (Entry et al. 1995).

Management of corridor forests should not proceed in isolation from management of adjacent upland systems (Figure 9.28). Upland harvests can result in raised water tables and tree mortality in riparian zones. Coordinated silvicultural activities can reduce timber losses as well as minimize the need for roads (Oliver and Hinckley 1987).

Forests managed by government agencies are usually subject to established restrictions on activities in riparian areas. Elsewhere, BMPs for forestry practices are designed to minimize nonpoint source pollution and protect water quality. BMPs typically include restrictions on road placement, equipment use, timber removal practices, and other similar considerations. Existing



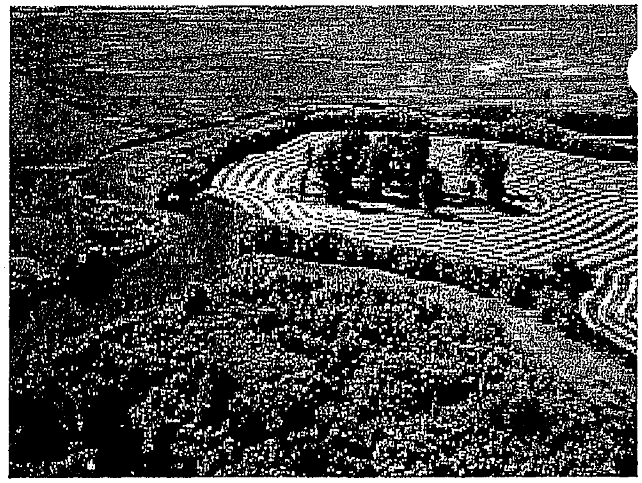


Figure 9.28: Streamside forests and adjacent uplands. *Management of streamside forests should not proceed in isolation from management of adjacent upland systems.*

state BMP guidelines may be appropriate for application within the restoration area but often require some modification to reflect the objectives of the restoration or other pre-identified constraints on activities in the vicinity of streams and wetlands.

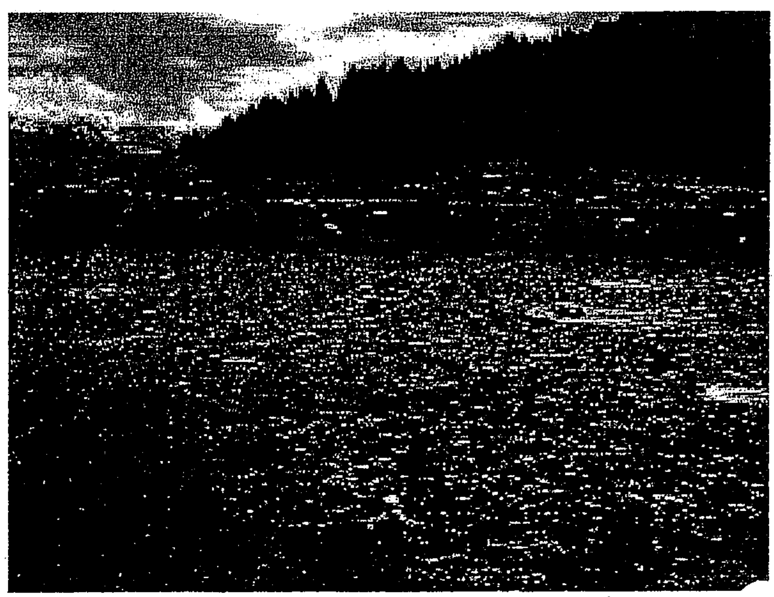
Grazed Lands

Livestock grazing is a very important stream corridor management issue in most nonforested rangelands and in many forested areas. Uncontrolled livestock grazing can have severe detrimental effects on streambanks, riparian vegetation, and water quality, particularly in arid and semiarid environments (Behnke and Raleigh 1978, Elmore and Beschta 1987, Chaney et al. 1990) (**Figure 9.29**). Livestock naturally concentrate in the vicinity of streams; therefore, special efforts must be made to control or prevent access if stream corridor restoration is to be achieved.

In some cases, livestock may act as an agent in restoration. Management of livestock access is critical to ensure their role is a positive one. Existing state BMPs might be sufficient to promote proper grazing, but might not be innovative or adaptive enough to meet the restoration objectives of a corridor management program.

Complete exclusion of livestock is an effective approach to restore and maintain riparian zones that have been badly degraded by grazing. In some cases, exclusion may be sufficient to reverse the damage without additional intervention. In some degraded systems, removal of livestock for a period of years followed by a planned management program may allow recovery with-

Figure 9.29: Livesto in stream. Uncontro livestock grazing can have severe detrimental effects on streambanks, riparian vegetation, and water quality.



CASE STUDY

Partners Working for the Big Spring Creek Watershed

The Big Spring Creek watershed occupies a diverse, primarily agricultural landscape in central Montana, where the nation's third largest freshwater spring (Big Springs) provides untreated drinking water for the 7,000 residents of Lewistown and is the source of one of Montana's best trout streams, Big Spring Creek.

Conservation work by federal, state, and local agencies, private organizations, and citizens in the 255,000-acre Big Spring Creek watershed is not new. Actually, various projects and developments have occurred over the last several decades. For example, the flood control project that protects the city of Lewistown has its roots in the 1960s when, after experiencing a series of floods, the city of Lewistown and community leaders decided to take action. The Fergus County Conservation District, Fergus County Commissioners, City of Lewistown, U.S. Natural Resources Conservation Service, and many community leaders all worked together on this project. The Big Spring Creek Flood Control Project now protects the city of Lewistown from recurrent flooding.

Conservation work now, though, goes beyond flood control. It involves working to solve resource problems on a watershed basis, recognizing that what happens upstream has an effect on the downstream resources. We should look beyond property boundaries at the whole watershed, considering the "cumulative effects" of all our actions. With that in mind, the Fergus County Conservation District, with assistance from its citizen committee, has been working the last few years to improve and protect the watershed. With funding from the Montana Department of Environmental Quality (Section 319), the Big Spring Creek Watershed Partnership was formed.

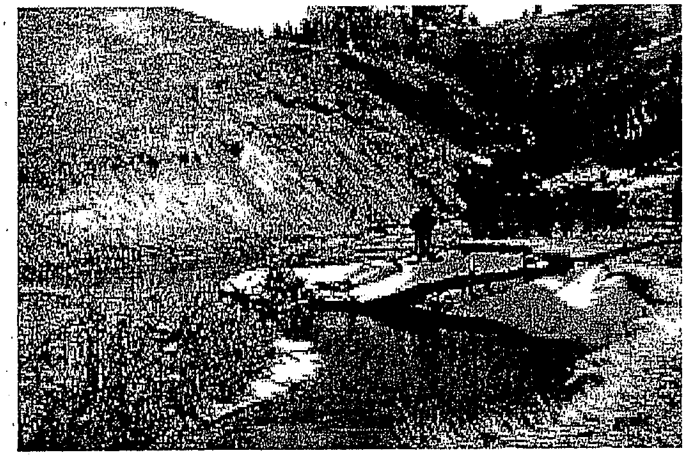
*This project helps agricultural producers and other landowners to plan and install conservation practices to prevent erosion and keep sediment and other pollutants out of streams and lakes. Area landowners are implementing conservation practices such as improving the riparian vegetation (**Figure 9.30**), treating streambank erosion, and developing water sources off the stream for livestock. Because the project has been well received by the agricultural producers, it has been possible for cooperating agencies to participate in additional watershed improvements. The U.S. Fish and Wildlife Service Partners for Wildlife program has provided funding for several stream restoration and riparian improvement projects. In addition, the Montana Department of Fish, Wildlife and Parks is actively participating in fisheries habitat projects, including the Brewery Flats Stream Restoration.*

Implementation of the Big Spring Creek Watershed Partnership has brought many positive changes to the predominantly agricultural Big Spring Creek watershed. Since most of the agricultural operations are livestock or grain, the major emphasis is on riparian/stream improvement and grazing management. Thus far, more than 30 landowners have participated in the project by installing conservation practices that include over 8 miles of fencing, and 13 off-stream water developments, with more than 10 miles of stream/riparian area protected.

Studies show that stream characteristics and water quality are the best indicators of watershed vitality. Thus, an active monitoring strategy in the watershed provides feedback to measure any improvements. Preproject and postproject fisheries (trout) surveys are conducted in cooperation with the Montana Department of Fish, Wildlife and Parks on selected streams. On East Fork Spring Creek, fencing and off-stream water development were implemented on a riparian/stream reach that was severely degraded from livestock use. Fish populations and size structure changed dramatically from preproject to postproject work. Salmonid numbers increased from 12 to 32 per 1,000 feet, and average size increased by 50 percent. In addition to *fisheries surveys; benthic macroinvertebrate communities are collected and analyzed on a number of streams. This analysis relates to the stream's biological health or integrity. Community structure, function, and sensitivity to impact are compared to baseline data. Habitat conditions on three of six monitoring sites on Big Spring Creek from 1990 to 1997 have shown improved conditions from a sub-optimal to an optimal rating. Monitoring will continue on major streams in the watershed, which will help to provide important feedback as to the project's effectiveness.*

Although the major emphasis is on improving and protecting the riparian areas and streams in the watershed, other ongoing efforts include participating in the "Managing Community Growth" initiative, preserving agriculture and open space, and developing recreational and environmental resources. An active committee of the group is involved in one of the largest stream restoration initiatives ever to be undertaken in Montana, planned for 1998. Included in this project is an environmental education trial site being developed with the local schools.

Working with watersheds is a dynamic process, and as a result new activities and partners are continually incorporated into the Big Spring Creek Watershed Partnership. The following agencies and organizations are currently working together with the citizens of the watershed to protect this "very special place."



(a)

(b)

Figure 9.30: The Big Spring Creek watershed. *(a) A heavily impacted tributary within the Big Spring Creek watershed and (b) the same tributary after restoration.*

Fergus County Conservation District

M.S.U.-Extension Service, Fergus County

U.S. Natural Resources Conservation Service

U.S. Fish and Wildlife Service

Montana Department of Fish, Wildlife and Parks

Montana Department of Environmental Quality

Montana Department of Natural Resources and Conservation

U.S. Forest Service

City Of Lewistown

Fergus County Commissioners

Snowy Mountain Chapter Trout Unlimited

Central Montana Pheasants Forever

Lewistown School District No. 1

Lewistown Visioning Group

Lewistown Area Chamber of Commerce

out permanent livestock exclusion (Elmore and Beschta 1987). Systems not badly damaged might respond to grazing management involving seasonal and herd size restrictions, off-channel or restricted-access watering, use of riparian pastures, herding, and similar techniques (Chaney et al. 1990). Response to grazing is specific to channel types and season.

Corridors that include grazing or have livestock in adjacent areas require vigilance to ensure that fences are maintained and herd management BMPs are followed.

In off-channel areas of the stream corridor, grazing may require less intensive management. Grazing might have limited potential to be used as a habitat manipulation tool in certain ecosystems, such as the Northern Plains, where native grazing animals formerly controlled ecosystem structure (Severson 1990). However, where grazing occurs within the stream corridor, it might conflict directly with ecosystem restoration objectives if not properly managed. Corridors that include grazing or have livestock in adjacent areas require vigilance to ensure that fences are maintained and herd management BMPs are followed.

Fish and Wildlife

Stream and vegetation care are the focus of many fish and wildlife management activities in the stream corridor. Hunting and fishing activities (**Figure 9.31**), nuisance animal control, and protection of particular species may be addressed in some restoration plans. Special management units, such as seasonally flooded impoundments specifically designed to benefit particular groups of species (Fredrickson and Taylor 1982), might be appropriate components of the stream corridor, requiring special maintenance and management. Numerous fish and wildlife management tools and techniques that address temporary deficiencies in habitat availability are available (e.g., Martin 1986). Inappropriate or haphazard use of some techniques can have unintended detrimental effects (for example, placing wood duck nest boxes in areas that lack brood habitat). Programs intended to manipulate fish and wildlife populations or habitats should be undertaken in consultation with the responsible state or federal resource agencies.

Restoration of a functional stream corridor can be expected to attract beaver in many areas. Where beaver control is warranted because of possible damage to private timberlands or roads, increased mosquito problems, and other concerns, controls should be placed as soon as possible and not after the damage is done. Techniques are available to prevent beaver from blocking culverts or drain pipes and destroying trees. In some cases, effective beaver control requires removal of problem animals (Olson and Hubert 1994).

Human Use

Stream corridors in urban areas are usually used heavily by people and require much attention to minimize, control, or repair human impacts. In some cases, human disturbance prevents some stream corridor functions from being restored. For example, depending on the amount of degradation that has occurred, urban streams might support relatively few, if any, native wildlife species. Other concerns, such as improved water quality, might be addressed effectively through proper restoration efforts. Addressing impacts from surrounding developed areas (such as uncontrolled storm water runoff and predation by pets) requires coordination with community agencies and citizen groups to minimize, prevent, or reverse damage. Management of urban corridors might tend to em-

CASE STUDY A Creek Ran Through It

Portland, Oregon, sprang up along the Willamette River. As time went on and the city grew, it came to occupy a sequestered spot between the Willamette and Columbia Rivers and the higher reaches of the Sylvan Hills. But before the city expanded to this point, a creek ran through it—Tanner Creek.

The Tanner Creek watershed, comprising approximately 1,600 acres, extended from the forested hills through a canyon and across the valley floor to the Willamette River. During summer months, the creek was placid if not dry. But during the heavy winter rains, the creek became a raging torrent.

As the city of Portland expanded, the creek was diverted into the sewer system and the creek floodway was filled in to make way for development. These combined sewers drained directly to the Willamette River and the Columbia Slough until a series of interceptor pipes and a municipal sewage treatment plant were constructed in the 1940s and 1950s.

However, this new system did not have sufficient capacity to handle the combined sewage and storm water flows during periods of heavy rain, which frequently occur during the winter months. As a result, rather than flowing to the treatment plant for processing and disinfection, the combined sewage and storm water overflowed to outfalls along the Willamette River and the Columbia Slough. Tanner Creek became a part of the cause of combined sewer overflows (CSOs).

In the early 1990s, the city of Portland began to develop a plan to eliminate CSOs. The Tanner Creek Stream Diversion Project was identified early in the CSO planning process as a cornerstone project, a relatively inexpensive method of removing clean storm water from the combined system, thereby reducing CSOs. Nearly 10 miles of pipe ranging from 84 inches to 60 inches in diameter will be constructed to once again carry storm water directly to the river. In addition, best management practices for storm water management will be included. Finally, opportunities for water feature enhancements and educational and cultural opportunities will be explored in partnership with the community and other agencies.

Principal among these opportunities is daylighting a portion of the stream in the city's River District. In partnership with community leaders, special interest groups, a private developer, and other agencies, the city's Bureau of Environmental Services is leading a study of possible design alternatives. For more information contact: Nea Lynn Robinson, Project Manager, Tanner Creek Stream Diversion Project, City of Portland, Oregon.

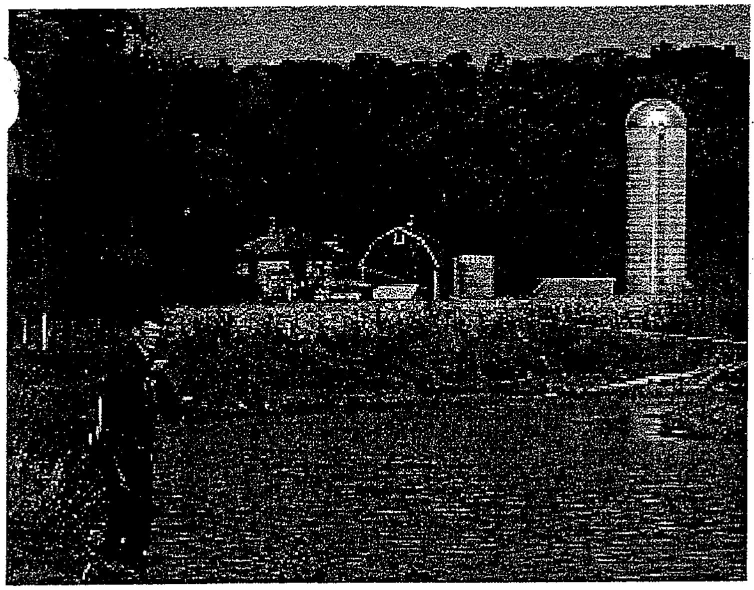


Figure 9.31: Local fisherman. *Fishing and other recreational activities must be considered in restoration management.*

igure 9.32: Off-road ehicle. *Low- and igh-impact use areas iould be clearly rked within public ream corridors.*

phasize recreation, educational opportunities, and community activities more than ecosystem functions. Administrative concerns may focus heavily on local ordinances, zoning, and construction permit standards and limitations.

Community involvement can be an important aspect of urban stream corridor restoration and management. Community groups often initiate restoration and maintain a feeling of ownership that translates into monitoring input, management oversight, and volunteer labor to conduct maintenance and management activities. It is essential that community groups be provided with professional technical guidance including assistance in translating regulatory requirements. It is also important that proposed management actions in urban corridors be discussed in advance with interested groups affected by tree cutting or trail closures.

In nonurban areas, recreation can usually be accommodated without impairing ecological functions if all concerned parties consider ecosystem integrity to be the priority objective (Johnson and Carothers 1982). Strategies can be devised and techniques are available to minimize impacts from activities such as camping, hiking (trail erosion), and even the use of off-road vehicles (Cole and Marion 1988) (**Figure 9.32**). Recreationists should be educated on methods to minimize impacts on the ecosystem and on restoration structures and vegetation. Location of areas designated for low-impact use and areas off-limits to certain high-impact activities (such as off-road vehicles, biking, horseback riding, etc.) should be clearly marked. Access should be restricted to areas where new vegetation has not yet been fully established or where vegetation could be damaged beyond the point of survival.

All the flowers of all the tomorrows are in the seeds of today.

—Chinese proverb

There will come a time when you believe everything is finished. That will be the beginning.

—Louis L'Amour

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- Cooperative State Research, Education, and Extension Service
- Forest Service
- Natural Resources Conservation Service

U.S. Environmental Protection Agency

Tennessee Valley Authority

Federal Emergency Management Agency

U.S. Department of Commerce

- National Oceanographic and Atmospheric Administration
  – National Marine Fisheries Service

U.S. Department of Defense

- Army Corps of Engineers

U.S. Department of Housing and Urban Development

U.S. Department of the Interior

- Bureau of Land Management
- Bureau of Reclamation
- Fish and Wildlife Service
- National Park Service
- U.S. Geological Survey

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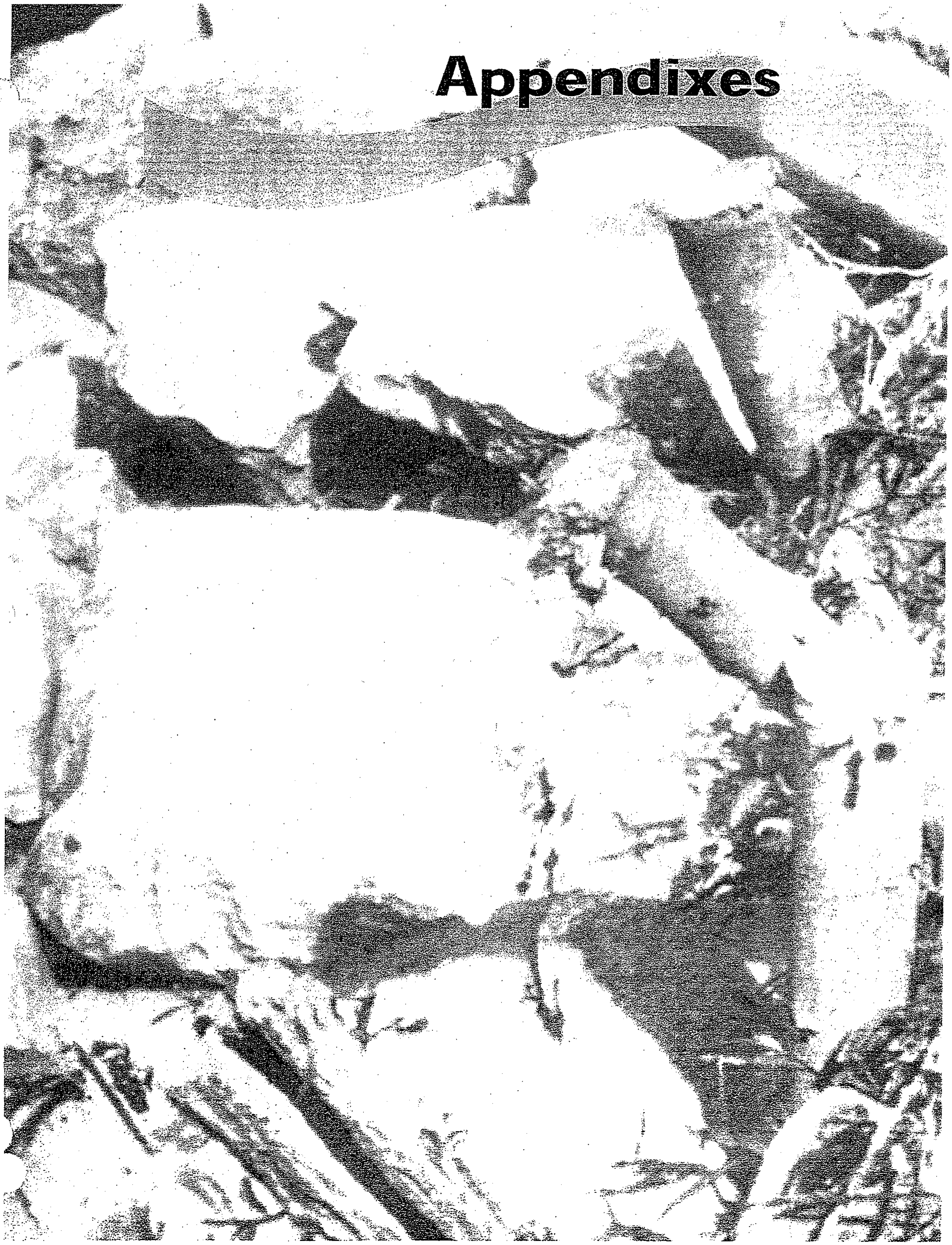
Appendixes



Appendix A

"The outstanding scientific discovery of the twentieth century is not television, or radio, but rather the complexity of the land organism. Only those who know the most about it can appreciate how little we know about it. The last word in ignorance is the man who says of an animal or plant: "What good is it?" If the land mechanism as a whole is good, then every part is good, whether we understand it nor not. If the biota, in the course of aeons, has built something we like but do not understand, then who but a fool would discard seemingly useless parts? To keep every cog and wheel is the first precaution of intelligent tinkering."

—Aldo Leopold 1953, pp. 145-146

Introduction

The user of this document is cautioned not to attempt to replicate or apply any of the techniques displayed without determining their appropriateness as an integral part of the restoration plan.

The following are presented as examples of the many techniques that are being used in support of stream corridor restoration. Only a limited number of techniques by broad category are shown as examples. Neither the number of examples nor their descriptions are intended to be exhaustive. The examples are conceptual and contain little design guidance. All restoration techniques, however, should be designed; often through an interdisciplinary approach discussed in Part II of this document. Limited guidance is provided on applications, but local standards, criteria, and specifications should always be used.

These and other techniques have specific ranges of applicability in terms of physical and climate adaptation, as well as for different physiographic regions of the country. Techniques that are selected must be components of a system designed to restore specific functions and values to the stream corridor. The use of any single technique, without consideration of system functions and values, may become a short-lived, ineffective fix laid on a system-wide problem. All restoration techniques are most effective when included as an integral part of a restoration plan. Typically a combination of techniques are prescribed to address prevailing conditions and desired goals. Effective restoration will respond to goals and objectives that are determined locally through the planning process described in Chapters 4 though 6.

The restoration plan may prescribe a variety of approaches depending on the condition of the stream corridor and the restoration goals:

- *No action.* Simply remove disturbance factors and "let nature heal itself."
- *Management.* Modify disturbance factors to allow continued use of the corridor, while the system recovers.
- *Manipulation.* Change watershed, corridor, or stream conditions through land use changes, intervention, and designed systems ranging from installing practices to altering flow conditions, to changing stream morphology and alignment.

Regardless of the techniques applied, they should restore the desired functions and achieve the goals of the restoration plan. The following are general considerations that apply to many or all of the techniques in this appendix:

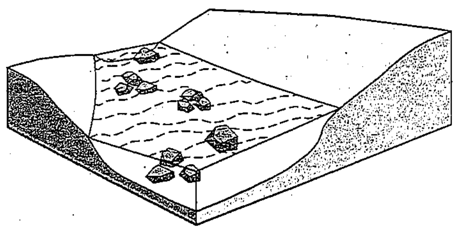
- The potential adverse impacts from failure of these and other techniques should be assessed before they are used.
- Techniques that change the channel slope or cross section have a high potential for causing channel instability upstream and downstream. They should therefore be analyzed and designed by an interdisciplinary team of professionals. These techniques include: weirs, sills, grade control measures, channel realignment, and meander reconstruction.
- The potential impact on flood elevations should be analyzed before these and other techniques are used.
- Many techniques will not endure on streams subject to headcuts or general bed degradation.
- Some form of toe protection will be required for many bank treatment techniques to endure where scour of the streambank toe is anticipated.
- Any restoration technique installed in or in contact with streams, wetlands, floodplains, or other water bodies are subject to various federal, state, and local regulatory programs and requirements. Most techniques presented in this appendix would require the issuance of permits by federal, state, and local agencies prior to installation.

WATERSHED MANAGEMENT PRACTICES

Appendix A: Techniques

INSTREAM PRACTICES

Boulder Clusters



Groups of boulders placed in the base flow channel to provide cover, create scour holes, or areas of reduced velocity.

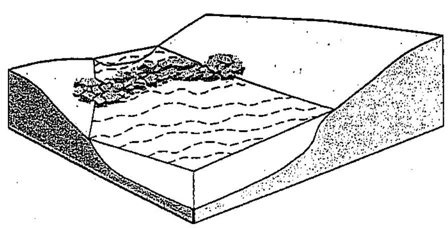
Applications and Effectiveness

- Can be used in most stream habitat types including riffles, runs, flats, glides and open pools.
- Greatest benefits are realized in streams with average flows exceeding 2 feet per second.
- Group placements are most desirable. Individual boulder placement might be effective in very small streams.
- Most effective in wide, shallow streams with gravel or rubble beds.
- Also useful in deeper streams for providing cover and improving substrate.
- Not recommended for sand bed (and smaller bed materials) streams because they tend to get buried.
- Added erosive forces might cause channel and bank failures.
- Not recommended for streams which are aggrading or degrading.
- May promote bar formation in streams with high bed material load.

For More Information

- Consult the following references: Nos. 11, 13, 21, 34, 39, 55, 60, 65, 69.

Weirs or Sills



Log, boulder, or quarrystone structures placed across the channel and anchored to the streambank and/or bed to create pool habitat, control bed erosion, or collect and retain gravel.

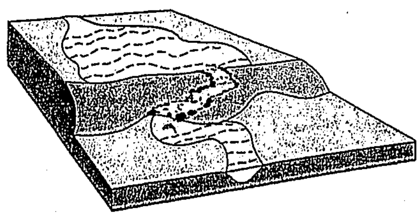
Applications and Effectiveness

- Create structural and hydraulic diversity in uniform channels.
- If placed in series, they should not be so close together that all riffle and run habitat is eliminated.
- Pools will rapidly fill with sediment in streams transporting heavy bed material loads.
- Riffles often are created in downstream deposition areas.
- Weirs placed in sand bed streams are subject to failure by undermining.
- Potential to become low flow migration barriers.
- Selection of material is important.
  - Boulder weirs are generally more permeable than other materials and might not perform well for funneling low flows. Voids between boulders may be chinked with smaller rock and cobbles to maintain flow over the crest.
  - Large, angular boulders are most desirable to prevent movement during high flows.
  - Log weirs will eventually decompose.
- Design cross channel shape to meet specific need(s).
  - Weirs placed perpendicular to flow work well for creating backwater.
  - Diagonal orientations tend to redistribute scour and deposition patterns immediately downstream.
  - Downstream "V's" and "U's" can serve specific functions but caution should be exercised to prevent failures.
  - Upstream "V's" or "U's" provide mid-channel, scour pools below the weir for fish habitat, resting, and acceleration maneuvers during fish passage.
  - Center at lower elevation than sides will maintain a concentrated low flow channel.

For More Information

- Consult the following references: Nos. 11, 13, 44, 55, 58, 60, 69.

Fish Passages



Any one of a number of instream changes which enhance the opportunity for target fish species to freely move to upstream areas for spawning, habitat utilization, and other life functions.

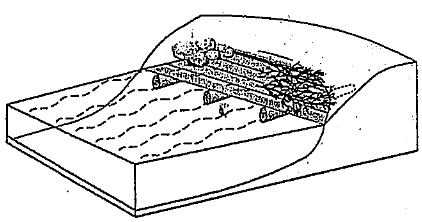
Applications and Effectiveness

- Can be appropriate in streams where natural or human placed obstructions such as waterfalls, chutes, logs, debris accumulations, beaver dams, dams, sills, and culverts interfere with fish migration.
- The aquatic ecosystem must be carefully evaluated to assure that fish passages do not adversely impact other aquatic biota and stream corridor functions.
- Slopes, depths and relative positions of the flow profile for various flow ranges are important considerations. Salmonids, for example, can easily negotiate through vertical water drops where the approach pool depth is 1.25 times the height of the (drop subject to an overall species-specific limit on height) (CA Dept. of Fish and Game, 1994).
- The consequences of obstruction removal for fish passage must be carefully evaluated. In some streams, obstructions act as barriers to undesirable exotics (e.g. sea lamprey) and are useful for scouring and sorting of materials, create important backwater habitat, enhance organic material input, serve as refuge for assorted species, help regulate water temperature, oxygenate water, and provide cultural resources.
- Designs vary from simple to complex depending on the site and the target species.

For More Information

- Consult the following references: Nos., 11, 69, 81.

Log/Brush/Rock Shelters



Logs, brush, and rock structures installed in the lower portion of streambanks to enhance fish habitat, encourage food web dynamics, prevent streambank erosion, and provide shading.

Applications and Effectiveness

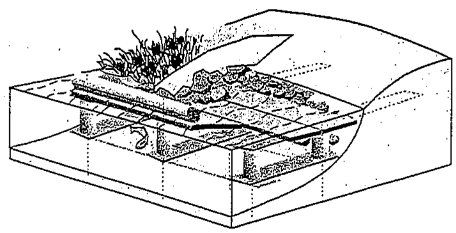
- Most effective in low gradient stream bends and meanders where open pools are already present and overhead cover is needed.
- Create an environment for insects and other organisms to provide an additional food source.
- Can be constructed from readily available materials found near the site.
- Not appropriate for unstable streams which are experiencing severe bank erosion and/or bed degradation unless integrated with other stabilization measures.
- Important in streams where aquatic habitat deficiencies exist.
- Should, where appropriate, be used with soil bioengineering systems and vegetative plantings to stabilize the upper bank and ensure a regenerative source of streambank vegetation.
- Not generally as effective on the inside of bendways.

For More Information

- Consult the following references: Nos. 11, 13, 39, 55, 65.

INSTREAM PRACTICES

Lunker Structures



Cells constructed of heavy wooden planks and blocks which are imbedded into the toe of streambanks at channel bed level to provide covered compartments for fish shelter, habitat, and prevention of streambank erosion.

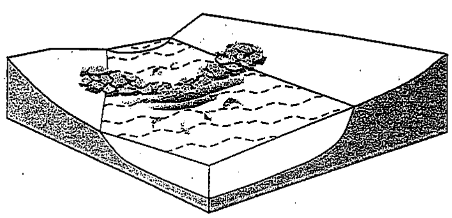
Applications and Effectiveness

- Appropriate along outside bends of streams where water depths can be maintained at or above the top of the structure.
- Suited to streams where fish habitat deficiencies exist.
- Should, where appropriate, be used with soil bioengineering systems and vegetative plantings to stabilize the upper bank and ensure a regenerative source of streambank vegetation.
- Are often used in conjunction with wing deflectors and weirs to direct and manipulate flows.
- Are not recommended for streams with heavy bed material loads.
- Most commonly used in streams with gravel-cobble beds.
- Heavy equipment may be necessary for excavating and installing the materials.
- Can be expensive.

For More Information

- Consult the following references: Nos. 10, 60, 65, 85.

Migration Barriers



Obstacles placed at strategic locations along streams to prevent undesirable species from accessing upstream areas.

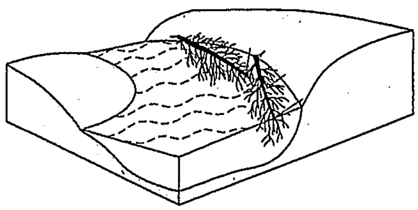
Applications and Effectiveness

- Effective for specific fishery management needs such as separating species or controlling nuisance species by creating a barrier to migration.
- Must be carefully evaluated to assure migration barriers do not adversely impact other aquatic biota and stream corridor functions.
- Both physical structures or electronic measures can be used as barriers.
  - Structures can be installed across most streams, but in general they are most practical in streams with baseflows depths under two feet and widths under thirty feet.
  - Temporary measures such as seines can also be used under the above conditions.
  - Electronic barriers can be installed in deeper channels to discourage passage. Electronic barrier employs lights, electrical pulses or sound frequencies to discourage fish from entering the area. This technique has the advantage of not disturbing the stream and providing a solution for control in deep water.
- Barriers should be designed so that flood flows will not flank them and cause failures.

For More Information

- Consult the following references: Nos. 11, 55.

Tree Cover



Felled trees placed along the streambank to provide overhead cover, aquatic organism substrate and habitat, stream current deflection, scouring, deposition, and drift catchment.

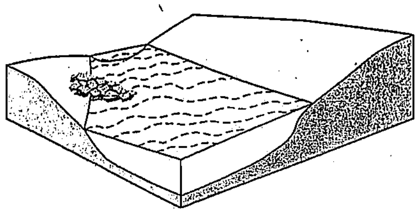
Applications and Effectiveness

- Can provide benefits at a low installation cost.
- Particularly advantageous in streams where the bed is unstable and felled trees can be secured from the top of bank.
- Channels must be large enough to accommodate trees without threatening bank erosion and limiting needed channel flow capacity.
- Design of adequate anchoring systems is necessary.
- Not recommended if debris jams on downstream bridges might cause subsequent problems.
- Require frequent maintenance.
- Susceptible to ice damage.

For More Information

- Consult the following references: Nos. 11, 55, 69.

Wing Deflectors



Structures that protrude from either streambank but do not extend entirely across a channel. They deflect flows away from the bank, and scour pools by constricting the channel and accelerating flow.

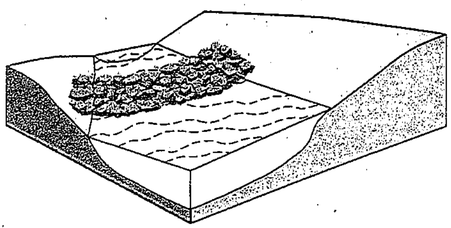
Applications and Effectiveness

- Should be designed and located far enough downstream from riffle areas to avoid backwater effects that would drown out or otherwise damage the riffle.
- Should be sized based on anticipated scour.
- The material washed out of scour holes is usually deposited a short distance downstream to form a bar or riffle area. These areas of deposition are often composed of clean gravels that provide excellent habitat for certain species.
- Can be installed in series on alternative streambanks to produce a meandering thalweg and associated structural diversity.
- Rock and rock-filled log crib deflector structures are most common.
- Should be used in channels with low physical habitat diversity, particularly those with a lack of stable pool habitat.
- Deflectors placed in sand bed streams may settle or fail due to erosion of sand, and in these areas a filter layer or geotextile might be needed underneath the deflector.

For More Information

- Consult the following references: Nos. 10, 11, 18, 21, 34, 48, 55, 59, 65, 69, 77.

Grade Control Measures



Rock, wood, earth, and other material structures placed across the channel and anchored in the streambanks to provide a "hard point" in the streambed that resists the erosion forces of the degradational zone, and/or to reduce the upstream energy slope to prevent bed scour.

Applications and Effectiveness

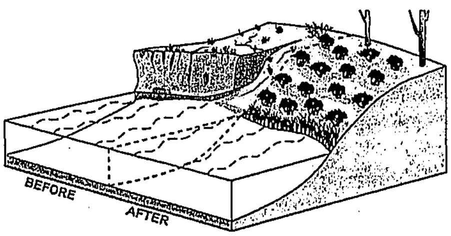
- If a stable channel bed is essential to the design, grade control should be considered as a first step before any restoration measures are implemented (if degradational processes exist in channel system).
- Used to stop headcutting in degrading channels.
- Used to build bed of incised stream to higher elevation.
- Can improve bank stability in an incised channel by reducing bank heights.
- Man-made scour holes downstream of structures can provide improved aquatic habitat.
- Upstream pool areas created by structures provide increased low water depths for aquatic habitat.
- Potential to become low flow migration barrier.
- Can be designed to allow fish passage.
- If significant filling occurs upstream of structure, then downstream channel degradation may result.
- Upstream sediment deposition may cause increased meandering tendencies.
- Siting of structures is critical component of design process, including soil mechanics and geotechnical engineering.
- Design of grade control structures should be accomplished by an experienced river engineer.

For More Information

- Consult the following references: Nos. 1, 4, 5, 6, 7, 12, 17, 18, 25, 26, 31, 37, 40, 63, 66, 84.

STREAMBANK TREATMENT

Bank Shaping and Planting



Regrading streambanks to a stable slope, placing topsoil and other materials needed for sustaining plant growth, and selecting, installing and establishing appropriate plant species.

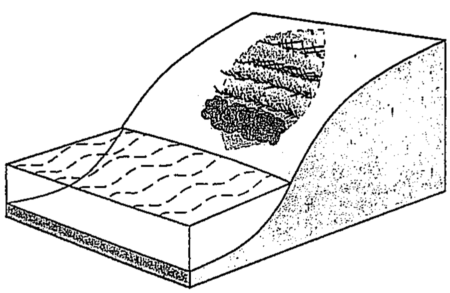
Applications and Effectiveness

- Most successful on streambanks where moderate erosion and channel migration are anticipated.
- Reinforcement at the toe of the embankment is often needed.
- Enhances conditions for colonization of native species.
- Used in conjunction with other protective practices where flow velocities exceed the tolerance range for available plants, and where erosion occurs below base flows.
- Streambank soil materials, probable groundwater fluctuation, and bank loading conditions are factors for determining appropriate slope conditions.
- Slope stability analyses are recommended.

For More Information

- Consult the following references: Nos. 11, 14, 56, 61, 65, 67, 68, 77, 79.

Branch Packing



Alternate layers of live branches and compacted backfill which stabilize and revegetate slumps and holes in streambanks.

Applications and Effectiveness

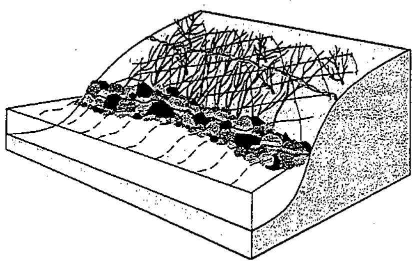
- Commonly used where patches of streambank have been scoured out or have slumped leaving a void.
- Appropriate after stresses causing the slump have been removed.
- Less commonly used on eroded slopes where excavation is required to install the branches.
- Produces a filter barrier that prevents erosion and scouring from streambank or overbank flows.
- Rapidly establishes a vegetated streambank.
- Enhances conditions for colonization of native species.
- Provides immediate soil reinforcement.
- Live branches serve as tensile inclusions for reinforcement once installed.
- Typically not effective in slump areas greater than four feet deep or four feet wide.

For More Information

- Consult the following references: Nos. 14, 21, 34, 79, 81.

STREAMBANK TREATMENT

Brush Mattresses



Combination of live stakes, live facines, and branch cuttings installed to cover and physically protect streambanks; eventually to sprout and establish numerous individual plants.

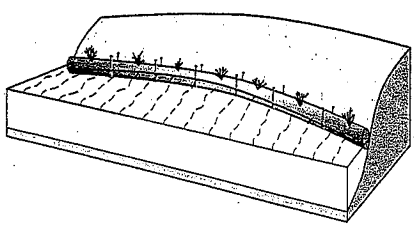
Applications and Effectiveness

- Form an immediate protective cover over the streambank.
- Capture sediment during flood flows.
- Provide opportunities for rooting of the cuttings over the streambank.
- Rapidly restores riparian vegetation and streamside habitat.
- Enhance conditions for colonization of native vegetation.
- Limited to the slope above base flow levels.
- Toe protection is required where toe scour is anticipated.
- Appropriate where exposed streambanks are threatened by high flows prior to vegetation establishment.
- Should not be used on slopes which are experiencing mass movement or other slope instability.

For More Information

- Consult the following references: Nos. 14, 21, 34, 56, 65, 77, 79, 81.

Coconut Fiber Roll



Cylindrical structures composed of coconut husk fibers bound together with twine woven from coconut material to protect slopes from erosion while trapping sediment which encourages plant growth within the fiber roll.

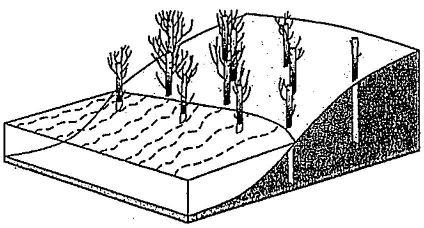
Applications and Effectiveness

- Most commonly available in 12 inch diameter by 20 foot lengths.
- Typically staked near the toe of the streambank with dormant cuttings and rooted plants inserted into slits cut into the rolls.
- Appropriate where moderate toe stabilization is required in conjunction with restoration of the streambank and the sensitivity of the site allows for only minor disturbance.
- Provide an excellent medium for promoting plant growth at the water's edge.
- Not appropriate for sites with high velocity flows or large ice build up.
- Flexibility for molding to the existing curvature of the streambank.
- Requires little site disturbance.
- The rolls are buoyant and require secure anchoring.
- Can be expensive.
- An effective life of 6 to 10 years.
- Should, where appropriate, be used with soil bioengineering systems and vegetative plantings to stabilize the upper bank and ensure a regenerative source of streamside vegetation.
- Enhances conditions for colonization of native vegetation.

For More Information

- Consult the following references: Nos. 65, 77.

Dormant Post Plantings



Plantings of cottonwood, willow, poplar, or other species embedded vertically into streambanks to increase channel roughness, reduce flow velocities near the slope face, and trap sediment.

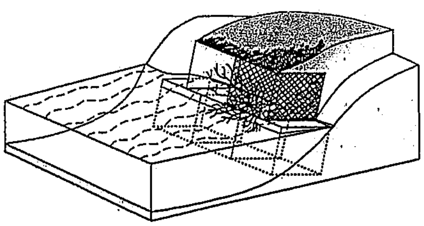
Applications and Effectiveness

- Can be used as live piling to stabilize rotational failures on streambanks where minor bank sloughing is occurring.
- Useful for quickly establishing riparian vegetation, especially in arid regions where water tables are deep.
- Will reduce near bank stream velocities and cause sediment deposition in treated areas.
- Reduce streambank erosion by decreasing the near-bank flow velocities.
- Generally self-repairing and will restem if attacked by beaver or livestock; however, provisions should be made to exclude such herbivores where possible.
- Best suited to non-gravely streams where ice damage is not a problem.
- Will enhance conditions for colonization of native species.
- Are less likely to be removed by erosion than live stakes or smaller cuttings.
- Should, where appropriate, be used with soil bioengineering systems and vegetative plantings to stabilize the upper bank and ensure a regenerative source of streamside vegetation.
- Unlike smaller cuttings, post harvesting can be very destructive to the donor stand, therefore, they should be gathered as 'salvage' from sites designated for clearing, or thinned from dense stands.

For More Information

- Consult the following references: Nos. 65, 77, 79.

Vegetated Gabions



Wire-mesh, rectangular baskets filled with small to medium size rock and soil and laced together to form a structural toe or sidewall. Live branch cuttings are placed on each consecutive layer between the rock filled baskets to take root, consolidate the structure, and bind it to the slope.

Applications and Effectiveness

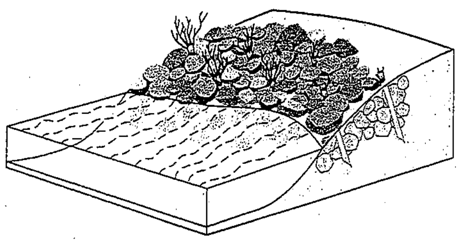
- Useful for protecting steep slopes where scouring or undercutting is occurring or there are heavy loading conditions.
- Can be a cost effective solution where some form of structural solution is needed and other materials are not readily available or must be brought in from distant sources.
- Useful when design requires rock size greater than what is locally available.
- Effective where bank slope is steep and requires moderate structural support.
- Appropriate at the base of a slope where a low toe wall is needed to stabilize the slope and reduce slope steepness.
- Will not resist large, lateral earth stresses.
- Should, where appropriate, be used with soil bioengineering systems and vegetative plantings to stabilize the upper bank and ensure a regenerative source of streambank vegetation.
- Require a stable foundation.
- Are expensive to install and replace.
- Appropriate where channel side slopes must be steeper than appropriate for riprap or other material, or where channel toe protection is needed, but rock riprap of the desired size is not readily available.
- Are available in vinyl coated wire as well as galvanized steel to improve durability.
- Not appropriate in heavy bedload streams or those with severe ice action because of serious abrasion damage potential.

For More Information

- Consult the following references: Nos. 11, 18, 34, 56, 77.

STREAMBANK TREATMENT

Joint Plantings



Live stakes tamped into joints or openings between rock which have previously been installed on a slope or while rock is being placed on the slope face.

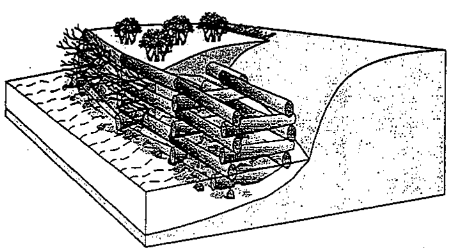
Applications and Effectiveness

- Appropriate where there is a lack of desired vegetative cover on the face of existing or required rock riprap.
- Root systems provide a mat upon which the rock riprap rests and prevents loss of fines from the underlying soil base.
- Root systems also improve drainage in the soil base.
- Will quickly establish riparian vegetation.
- Should, where appropriate, be used with other soil bioengineering systems and vegetative plantings to stabilize the upper bank and ensure a regenerative source of streambank vegetation.
- Have few limitations and can be installed from base flow levels to top of slope, if live stakes are installed to reach ground water.
- Survival rates can be low due to damage to the cambium or lack of soil/stake interface.
- Thick rock riprap layers may require special tools for establishing pilot holes.

For More Information

- Consult the following references: Nos. 21, 34, 65, 77, 81.

Live Cribwalls



Hollow, box-like interlocking arrangements of untreated log or timber members filled above baseflow with alternate layers of soil material and live branch cuttings that root and gradually take over the structural functions of the wood members.

Applications and Effectiveness

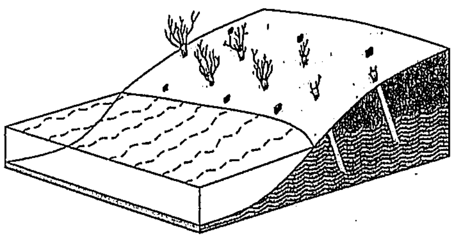
- Provide protection to the streambank in areas with near vertical banks where bank sloping options are limited.
- Afford a natural appearance, immediate protection and accelerate the establishment of woody species.
- Effective on outside of bends of streams where high velocities are present.
- Appropriate at the base of a slope where a low wall might be required to stabilize the toe and reduce slope steepness.
- Appropriate above and below water level where stable streambeds exist.
- Don't adjust to toe scour.
- Can be complex and expensive.
- Should, where appropriate, be used with soil bioengineering systems and vegetative plantings to stabilize the upper bank and ensure a regenerative source of streambank vegetation.

For More Information

- Consult the following references: Nos. 11, 14, 21, 34, 56, 65, 77, 81.

STREAMBANK TREATMENT

Live Stakes



Live, woody cuttings which are tamped into the soil to root, grow and create a living root mat that stabilizes the soil by reinforcing and binding soil particles together, and by extracting excess soil moisture.

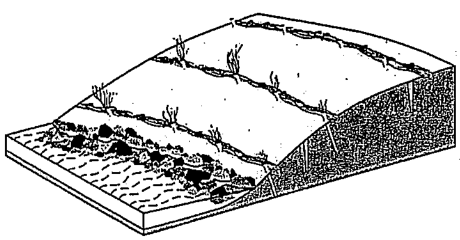
Applications and Effectiveness

- Effective where site conditions are uncomplicated, construction time is limited, and an inexpensive method is needed.
- Appropriate for repair of small earth slips and slumps that are frequently wet.
- Can be used to stake down surface erosion control materials.
- Stabilize intervening areas between other soil bioengineering techniques.
- Rapidly restores riparian vegetation and streamside habitat.
- Should, where appropriate, be used with other soil bioengineering systems and vegetative plantings.
- Enhance conditions for colonization of vegetation from the surrounding plant community.
- Requires toe protection where toe scour is anticipated.

For More Information

- Consult the following references: Nos. 14, 21, 34, 56, 65, 67, 77, 79, 81.

Live Fascines



Dormant branch cuttings bound together into long sausage-like, cylindrical bundles and placed in shallow trenches on slopes to reduce erosion and shallow sliding.

Applications and Effectiveness

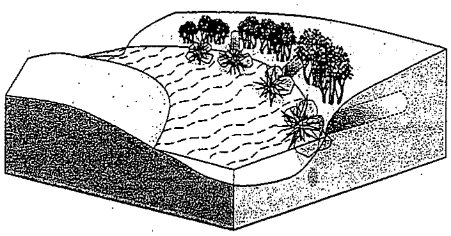
- Can trap and hold soil on streambank by creating small dam-like structures and reducing the slope length into a series of shorter slopes.
- Facilitate drainage when installed at an angle on the slope.
- Enhance conditions for colonization of native vegetation.
- Should, where appropriate, be used with other soil bioengineering systems and vegetative plantings.
- Requires toe protection where toe scour is anticipated.
- Effective stabilization technique for streambanks, requiring a minimum amount of site disturbance.
- Not appropriate for treatment of slopes undergoing mass movement.

For More Information

- Consult the following references: Nos. 14, 21, 34, 65, 77, 81.

STREAMBANK TREATMENT

Log, Rootwad, and Boulder Revetments



Boulders and logs with root masses attached placed in and on streambanks to provide streambank erosion, trap sediment, and improve habitat diversity.

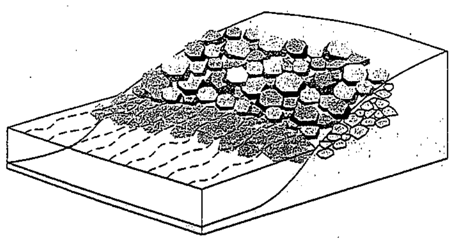
Applications and Effectiveness

- Will tolerate high boundary shear stress if logs and rootwads are well anchored.
- Suited to streams where fish habitat deficiencies exist.
- Should, where appropriate, be used with soil bioengineering systems and vegetative plantings to stabilize the upper bank and ensure a regenerative source of streambank vegetation.
- Will enhance diversity in riparian areas when used with soil bioengineering systems.
- Will have limited life depending on climate and tree species used. Some species, such as cottonwood or willow, often sprout and accelerate colonization.
- Might need eventual replacement if colonization does not take place or soil bioengineering systems are not used.
- Use of native materials can sequester sediment and woody debris, restore streambanks in high velocity streams, and improve fish rearing and spawning habitat.
- Site must be accessible to heavy equipment.
- Materials might not be readily available at some locations.
- Can create local scour and erosion.
- Can be expensive.

For More Information

- Consult the following references: Nos. 11, 34, 77.

Riprap



A blanket of appropriately sized stones extending from the toe of slope to a height needed for long term durability.

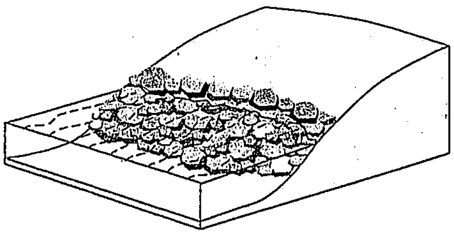
Applications and Effectiveness

- Can be vegetated (see joint plantings).
- Appropriate where long term durability is needed, design discharge are high, there is a significant threat to life or high value property, or there is no practical way to otherwise incorporate vegetation into the design.
- Should, where appropriate, be used with soil bioengineering systems and vegetative plantings to stabilize the upper bank and ensure a regenerative source of streambank vegetation.
- Flexible and not impaired by slight movement from settlement or other adjustments.
- Should not be placed to an elevation above which vegetative or soil bioengineering systems are an appropriate alternative.
- Commonly used form of bank protection.
- Can be expensive if materials are not locally available.

For More Information

- Consult the following references: Nos. 11, 14, 18, 34, 39, 56, 67, 70, 77.

Stone Toe Protection



A ridge of quarried rock or stream cobble placed at the toe of the streambank as an armor to deflect flow from the bank, stabilize the slope and promote sediment deposition.

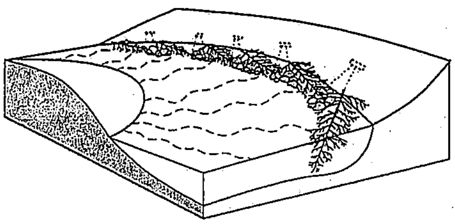
Applications and Effectiveness

- Should be used on streams where banks are being undermined by toe scour, and where vegetation cannot be used.
- Stone prevents removal of the failed streambank material that collects at the toe, allows revegetation and stabilizes the streambank.
- Should, where appropriate, be used with soil bioengineering systems and vegetative plantings to stabilize the upper bank and ensure a regenerated source of streamside vegetation.
- Can be placed with minimal disturbance to existing slope, habitat, and vegetation.

For More Information

- Consult the following references: Nos. 10, 21, 56, 67, 77, 81.

Tree Revetments



A row of interconnected trees attached to the toe of the streambank or to deadmen in the streambank to reduce flow velocities along eroding streambanks, trap sediment, and provide a substrate for plant establishment and erosion control.

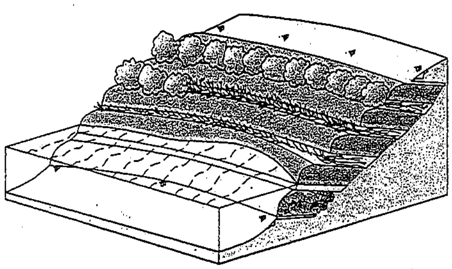
Applications and Effectiveness

- Design of adequate anchoring systems is necessary.
- Wire anchoring systems can present safety hazards.
- Work best on streams with streambank heights under 12 feet and bankfull velocities under 6 feet per second.
- Use inexpensive, readily available materials.
- Capture sediment and enhances conditions for colonization of native species particularly on streams with high bed material loads.
- Limited life and must be replaced periodically.
- Might be severely damaged by ice flows.
- Not appropriate for installation directly upstream of bridges and other channel constrictions because of the potential for downstream damages should the revetment dislodge.
- Should not be used if they occupy more than 15 percent of the channel's cross sectional area at bankfull level.
- Not recommended if debris jams on downstream bridges might cause subsequent problems.
- Species that are resistant to decay are best because they extend the establishment period for planted or volunteer species that succeed them.
- Requires toe protection where toe scour is anticipated.
- Should, where appropriate, be used with soil bioengineering systems and vegetative plantings to stabilize the upper bank and ensure a regenerated source of streamside vegetation.

For More Information

- Consult the following references: Nos. 11, 21, 34, 56, 60, 77, 79.

Vegetated Geogrids



Alternating layers of live branch cuttings and compacted soil with natural or synthetic geotextile materials wrapped around each soil lift to rebuild and vegetate eroded streambanks.

Applications and Effectiveness

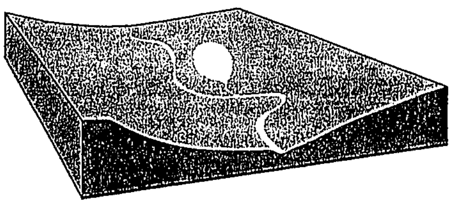
- Quickly establish riparian vegetation if properly designed and installed.
- Can be installed on a steeper and higher slope and has a higher initial tolerance of flow velocity than brush layering.
- Can be complex and expensive.
- Produce a newly constructed, well-reinforced streambank.
- Useful in restoring outside bends where erosion is a problem.
- Capture sediment and enhances conditions for colonization of native species.
- Slope stability analyses are recommended.
- Can be expensive.
- Require a stable foundation.

For More Information

- Consult the following references: Nos. 10, 11, 14, 21, 34, 56, 65, 77.

WATER MANAGEMENT

Sediment Basins



Barriers, often employed in conjunction with excavated pools, constructed across a drainage way or off-stream and connected to the stream by a flow diversion channel to trap and store waterborne sediment and debris.

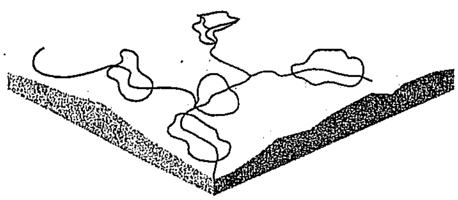
Applications and Effectiveness

- Provide an interim means of reducing the sediment load from a stream.
- Used occasionally to sort sediment sizes.
- Temporarily reduce excessive sediment loads until the upstream watershed can be protected from accelerated erosion.
- Can also be used to separate out sediment which may be causing damages downstream along reaches which are incapable of transporting the sediment sizes.
- Can be integrated with more permanent stormwater management ponds.
- Can only trap the upper range of particle sizes (sand and gravel) and allow finer particles (silt and clay) to pass through.
- Require a high level of analysis.
- Require periodic dredging and other maintenance.

For More Information

- Consult the following references: Nos. 10, 13, 29, 45, 49, 69, 74, 80.

Water Level Control



Managing water levels within the channel and adjoining riparian zone to control aquatic plants and restore desired functions, including aquatic habitat.

Applications and Effectiveness

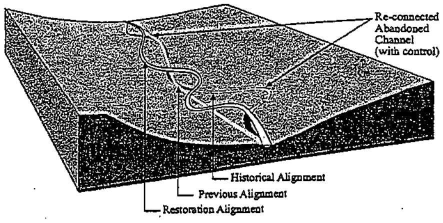
- Appropriate where flow depth in the stream, adjoining wetland, or the interdependent saturation zone in the adjoining riparian area is insufficient to provide desired functions.
- Need will often vary by season and requires flexible control devices which can be managed accordingly.
- The complexities of maintaining sediment balances, temperature elevation, change in channel substrate, changes in flow regime, and a host of other considerations must be factored into planning and design.
- Requires a high level of analysis.

For More Information

- Consult the following references: Nos. 11, 13, 15, 69, 75.

CHANNEL RECONSTRUCTION

Maintenance of Hydraulic Connections



Maintenance of hydraulic connectivity to allow movement of water and biota between the stream and abandoned channel reaches.

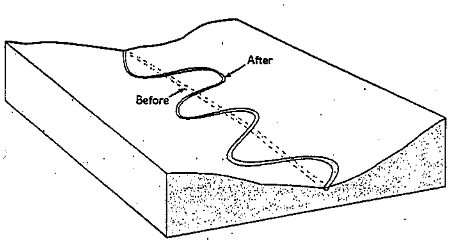
Applications and Effectiveness

- Used to prevent losses of aquatic habitat area and diversity.
- Slackwater areas adjoining the main channel have potential for spawning and rearing areas for many fish species and are a key component of habitat for wildlife species that live in or migrate through the riparian corridor.
- Recreation value can be enhanced if connecting channels are deep enough for small boats or canoes.
- Effective along reaches of realigned channel where cutoffs have been made.
- Not effective in streams with insufficient stages or discharges to maintain satisfactory hydraulic connections to the abandoned channel reaches.
- May require maintenance if sedimentation is a problem.
- May have limited life.
- Require a high level of analysis.

For More Information

- Consult the following references: Nos. 15, 56, 69, 75.

Stream Meander Restoration



Transformation of a straightened stream into a meandering one to reintroduce natural dynamics improve channel stability, habitat quality, aesthetics, and other stream corridor functions or values.

Applications and Effectiveness

- Used to create a more stable stream with more habitat diversity.
- Requires adequate area where adjacent land uses may constrain locations.
- May not be feasible in watersheds experiencing rapid changes in land uses.
- Streambank protection might be required on the outside of bends.
- Significant risk of failure.
- Requires a high level of analysis.
- May cause significant increases in flood elevations.
- Effective discharge should be computed for both existing and future conditions, particularly in urbanized watersheds.

For More Information

- Consult the following references: Nos. 13, 16, 22, 23, 24, 46, 47, 52, 53, 54, 56, 61, 72, 75, 77, 78, 79, 86.

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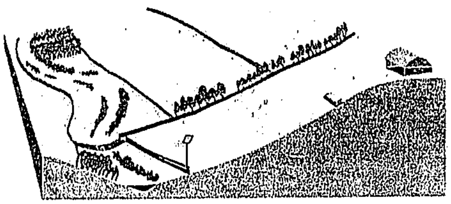
Livestock Exclusion or Management



Fencing, alternate sources of water and shelter, and managed grazing to protect, maintain, or improve riparian flora and fauna and water quality.

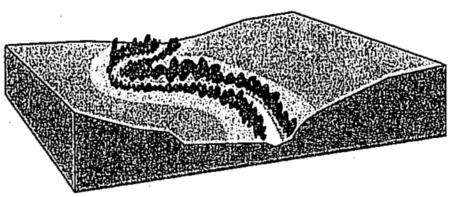
Applications and Effectiveness

- Appropriate where livestock grazing is negatively impacting the stream corridor by reducing growth of woody vegetation, decreasing water quality, or contributing to the instability of streambanks.
- Once the system has recovered, rotational grazing may be incorporated into the management plan.
- Must be coordinated with an overall grazing plan.

For More Information

- Consult the following references: Nos. 18, 39, 73.

Riparian Forest Buffers



Streamside vegetation to lower water temperatures, provide a source of detritus and large woody debris, improve habitat, and to reduce sediment, organic material, nutrients, pesticides and other pollutants migrating to the stream.

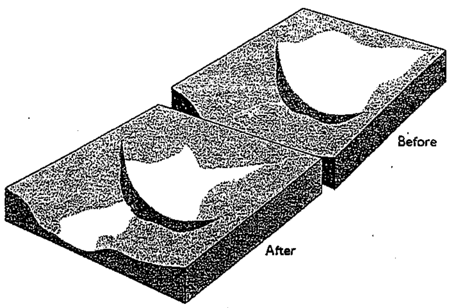
Applications and Effectiveness

- Applicable on stable areas adjacent to permanent or intermittent streams, lakes, ponds, wetlands and areas with ground water recharge.
- Unstable areas such as those with high surface erosion rates, mass soil movement, or active gullies will require stabilization prior to establishment of riparian forest buffers.
- Tolerant plant species and supplemental watering may be needed in some areas.
- Sites in arid and semi-arid regions may not have sufficient soil moisture throughout the growing season to support woody plants.
- Concentrated flow erosion, excessive sheet and rill erosion, or mass soil movement must be controlled in upland areas prior to establishment of riparian forest buffers.

For More Information

- Consult the following references: Nos. 20, 34, 49, 51, 70, 78, 79, 81, 82, 88, 89.

Flushing for Habitat Restoration



A high-magnitude, short duration release from a reservoir to scour fine-grained sediments from the streambed and restore suitable instream habitat.

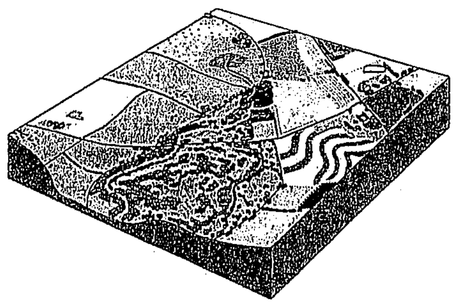
Applications and Effectiveness

- Appropriate as part of an overall watershed management plan.
- May cause flooding of old floodplains below dams, depletion of gravel substrates, and significant changes in channel geometry.
- Flushing of fine sediments at one location may only move the problem further downstream.
- Seasonal discharge limits, rate of change of flow, and river stages downstream of impoundment should be considered to avoid undesirable impacts to instream and riparian habitat.
- Can be effective in improving gradation of streambed materials, suppression of aquatic vegetation, and maintenance of stream channel geometry necessary for desired instream habitat.
- Can induce floodplain scouring to provide suitable growing conditions for riparian vegetation.
- Requires high level of analysis to determine necessary release schedule.
- May not be feasible in areas where water rights are fully allocated.

For More Information

- Consult the following references: Nos. 11, 13, 32, 35, 41, 45, 57, 61, 73, 74, 81.

Best Management Practices: Agriculture



Individual and systematic approaches aimed at mitigating non-point source pollution from agricultural land.

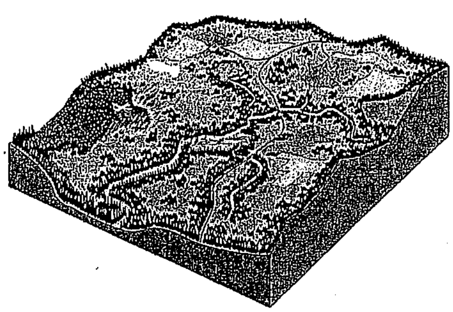
Applications and Effectiveness

- Used where current management systems are causing problems on-site or within farm or field boundaries and have a high potential to impact the stream corridor.
- Also applied where watershed management plans are being implemented to improve environmental conditions.
- Must fit within a comprehensive farm management plan, a watershed action plan, or a stream corridor restoration plan.
- Should consider the four season conservation of the soil, water, and microbial resources base.
- Tillage, seeding, fertility, pest management, and harvest operations should consider environmental qualities and the potential to use adjacent lands in water and soil conservation and management and pest management.
- Grazing land management should protect environmental attributes, including native species protection, while achieving optimum, long-term resource use.
- Where crops are raised and the land class allows, pastures should be managed with crop rotation sequences to provide vigorous forage cover while building soil and protecting water and wildlife qualities.
- Orchards and nursery production should actively monitor pest and water management techniques to protect ecosystem quality and diversity.
- Farm woodlots, wetlands, and field borders should be part of an overall farm plan that conserves, protects, and enhances native plants and animals, soil, water, and scenic qualities.
- BMPs may include: contour farming, conservation tillage, terracing, critical area planting, nutrient management, sediment basins, filter strips, waste storage management, and integrated pest management.

For More Information

- Consult the following references: Nos. 73, 78, 81.

Best Management Practices: Forestland



Individual and systematic approaches for mitigating non-point source pollution from forestland.

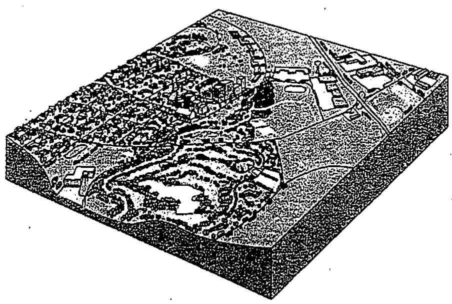
Applications and Effectiveness

- Used where current management systems are causing problems in the watershed and have a high potential to impact the stream corridor.
- Also applied where management plans are being implemented to restore one or more natural resource functions in a watershed.
- Must consider how it fits within a comprehensive forestland management plan, a watershed action plan, or a stream corridor restoration plan.
- BMPs may include: preharvest planning, streamside management measures, road construction or reconstruction, road management, timber harvesting, site preparation and forest generation, fire management, revegetation of disturbed areas, forest chemical management, and forest wetland management.

For More Information

- Consult the following references: Nos. 9, 20, 27, 30, 34, 42, 49, 51, 70, 78, 79, 81, 82, 83, 88, 89.

Best Management Practices: Urban Areas



Individual or systematic approaches designed to offset, reduce, or protect against the impacts of urban development and urban activities on the stream corridor.

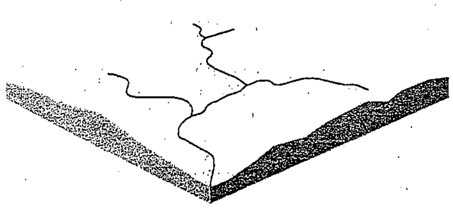
Applications and Effectiveness

- Used to improve and/or restore ecological functions which have been impaired by urban activities.
- Needs to be integrated with BMPs on other lands in the landscape to assure that stream restoration is applied along the entire stream corridor to the extent possible.
- The use of individual urban BMPs should be coordinated with an overall plan for restoring the stream system.
- Urban sites are highly variable and have a high potential for disturbance.
- Applicability of the treatment to the site situation in terms of physical layout, relationship to the overall system, arrangements for maintenance, and protection from disturbances are often critical considerations.
- BMPs may include: extended detention dry basins, wet ponds, constructed wetlands, oil-water separators, vegetated swales, filter strips, infiltration basins and trenches, porous pavement, and urban forestry.

For More Information

- Consult the following references: Nos. 29, 34, 43, 49, 78, 80, 81, 83.

Flow Regime Enhancement



Manipulation of watershed features (such as changes in land use or construction of impoundments) for the purpose of controlling streamflow and improving physical, chemical and biological functions.

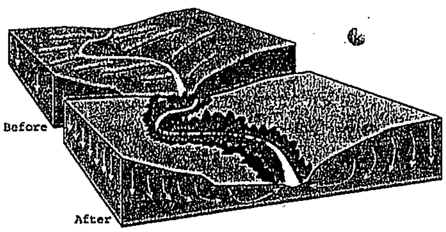
Applications and Effectiveness

- Appropriate where human-induced changes have altered stream flow characteristics to the extent that streams no longer support their former functions.
- Can restore or improve threatened functions (e.g., substrate materials or distribution of flow velocities to support the natural food web).
- Can require extensive changes over broad areas involving many land users.
- Can be expensive.
- Has been used for remediation of depleted dissolved oxygen levels, reduction in salinity levels, or to maintain a minimum flow level for downstream users.
- Must determine what impacts from historical changes in the flow regime over time can be mitigated using flow enhancement techniques.

For More Information

- Consult the following references: Nos. 32, 39, 45, 57, 75, 81.

Streamflow Temperature Management



Streamside vegetation and upland practices to reduce elevated streamflow temperatures.

Applications and Effectiveness

- Effective for smaller streams where bank vegetation can provide substantial shading of the channel and on which much of the canopy has been removed.
- Appropriate practices are those that establish streamside vegetation, increase vegetative cover, increase infiltration and subsurface flow, maintain base flow, and reduce erosion.
- Turbid water absorbs more solar radiation than clear; therefore, erosion control in watersheds can help in reducing thermal pollution.
- Flow releases from cooler strata of reservoirs must be exercised with caution. Although cooler, water from this source is generally low in dissolved oxygen and must be aerated before discharging downstream. Selective mixing of the reservoir withdrawal can moderate temperature as may be required.
- There might be opportunities in irrigated areas to cool return flows prior to discharge to streams.

For More Information

- Consult the following references: Nos. 32, 39, 45, 73, 80, 81, 88, 89.

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