Late Comment Received: 4/22/2009 10:59 AM

TK/CSC

O'Laughlin & Paris LLP

Attorneys at Law

STATE WATER RESOURCES CONTROL BOARD

2009 APR 22 AM 10:59

DIV OF WATER RIGHTS SACRAMENTO

April 20, 2009

Chris Carr
State Water Resources Control Board
Division of Water Rights
P.O. Box 2000
Sacramento, CA 95812-2000

Re: Data Request

Enclosed is the following information to respond to the SWRCB request for data.

6(a) Flow quality and timing- See enclosed work by Dan Steiner

6(b) Temperature- See enclosed work by Avry Dotan

We are gathering information to respond to your other data requests and will continue to send information to you as we put it in a format to meet your request.

Should you have any question then please call.

Very truly yours,
O'LAUGHLIN & PARIS LLP

By:

2580 Sierra Sunrise Terrace, Suite 210
Chico, CA 95928
www.olaughlinandparis.com

530.899.9755 tel
530.899.1367 fax

Late Comment Received: 4/22/2009 10:59 AM

DANIEL B. STEINER
CONSULTING ENGINEER

STATE WATER RESOURCES
CONTROL BOARD
2009 APR 22 AM 10:59
DIV OF WATER RIGHTS
SACRAMENTO

April 9, 2009

Tim O'Laughlin
O'Laughlin & Paris
P.O. Box 9259
Chico, California 95927-9259

Dear Tim:

Enclosed as requested are a couple of original prints and data disks for the report prepared by me for submittal to the State Water Resources Control Board. The report titled *Information and Data Submission Concerning Consideration of Potential Amendments to the Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary Relating to Southern Delta Salinity and San Joaquin River Flow Objectives, San Joaquin River Group Authority, Prepared by Daniel B. Steiner, Consulting Engineer, April 3, 2009* contains various information regarding current hydrology and modeling of the San Joaquin River.

Please do not hesitate to call me if you need additional information.

Sincerely,

Daniel B. Steiner

Enclosure: (2) CDs
(2) original prints of report

P.O. BOX 2175, GRANITE BAY, CALIFORNIA 95746-2175
PHONE 916-791-2511 ! FAX 916-791-7712

Late Comment Received: 4/22/2009 10:59 AM

Information and Data Submission Concerning Consideration of Potential Amendments to the Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary Relating to Southern Delta Salinity and San Joaquin River Flow Objectives

San Joaquin River Group Authority
Prepared by Daniel B. Steiner, Consulting Engineer

April 3, 2009

1. Introduction

The State Water Resources Control Board staff has provided notice of a Public Staff Workshop that will be conducted commencing April 22, 2009 concerning receipt of information regarding and the discussion of potential amendments or revisions to the southern Delta salinity and San Joaquin River flow objectives included in the 2006 Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary and their implementation. This submittal is part of several packages of information that has been prepared on behalf of the San Joaquin River Group Authority (SJRGA) concerning the request for information. Included in this submittal are: 1) discussion of the CalSim-II computer model and its use for evaluating San Joaquin River hydrology and operations, 2) an example of a contemporary depiction of San Joaquin River hydrology, 3) changes to current hydrology anticipated in the near future, 4) unimpaired hydrology of the San Joaquin River Basin, 5) historical records of hydrologic parameters for the San Joaquin River Basin, and 6) discussion and references concerning climate change affects to hydrology.

2. CalSim-II San Joaquin River Component

The San Joaquin River watershed is depicted in CalSim-II, which is an application of computer software representing the State Water Project (SWP) and Central Valley Project (CVP). CalSim-II was jointly developed by the Department of Water Resources (DWR) and the U.S. Bureau of Reclamation (Reclamation), and simulates a significant portion of the water resources infrastructure of the Central Valley and Delta regions. As the official planning model of both agencies, CalSim-II is used to support various on-going studies concerning infrastructure, operational rules, regulations, water demands, and climate.

Refinements to the CalSim-II depiction of San Joaquin River tributary operations, hydrology, and demands have been developed and implemented over the last several years, and continue. During this development the San Joaquin River component of the model was submitted to external peer review in August 2005 which identified several concerns and short-term and long-term recommendations. These concerns and recommendations were addressed by Reclamation. The model remains the best available tool for assessing the comprehensive, and at times interdependent planning and operation of several major San Joaquin River Basin systems. For the subject of assessing affects of San Joaquin River salinity and flow objectives upon San Joaquin River operations, CalSim-II should be utilized. Depending on the form of alternative flow and salinity objectives, if they differ than those incorporated in CalSim-II, modifications to the model may be necessary. Also, depending on the breadth of implementation of flow and salinity of objectives, e.g., the affected entities, modifications to the model may be needed or additional processing of results may be required.

The integration of the San Joaquin River component within the overall CalSim-II model is illustrated in Figure 2.1. The San Joaquin River component is also described by the schematic shown in Figure 2.2, which illustrates the node structure and linkages of the modeled features.

Figure 2.1
CalSim-II Structure

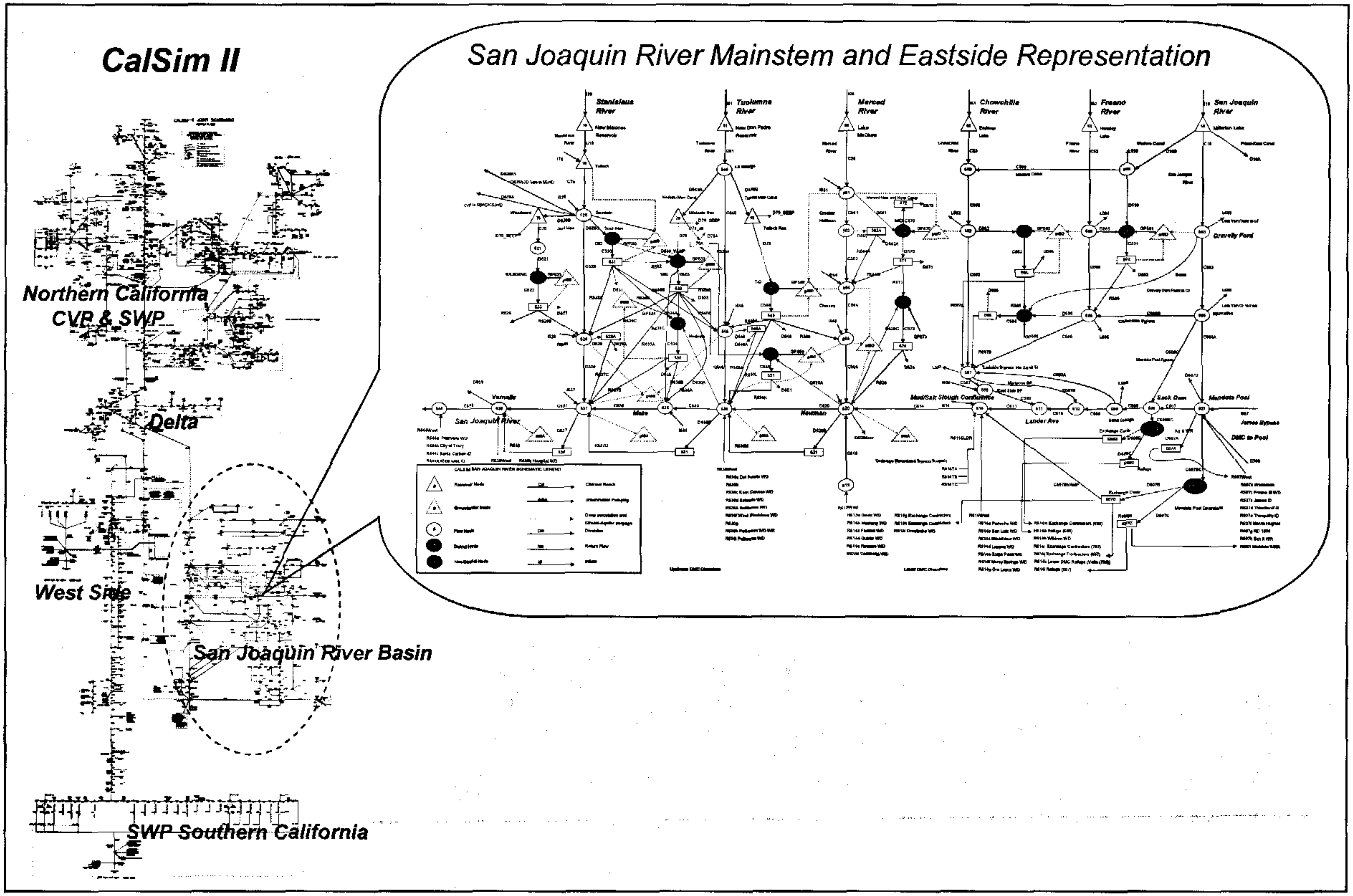
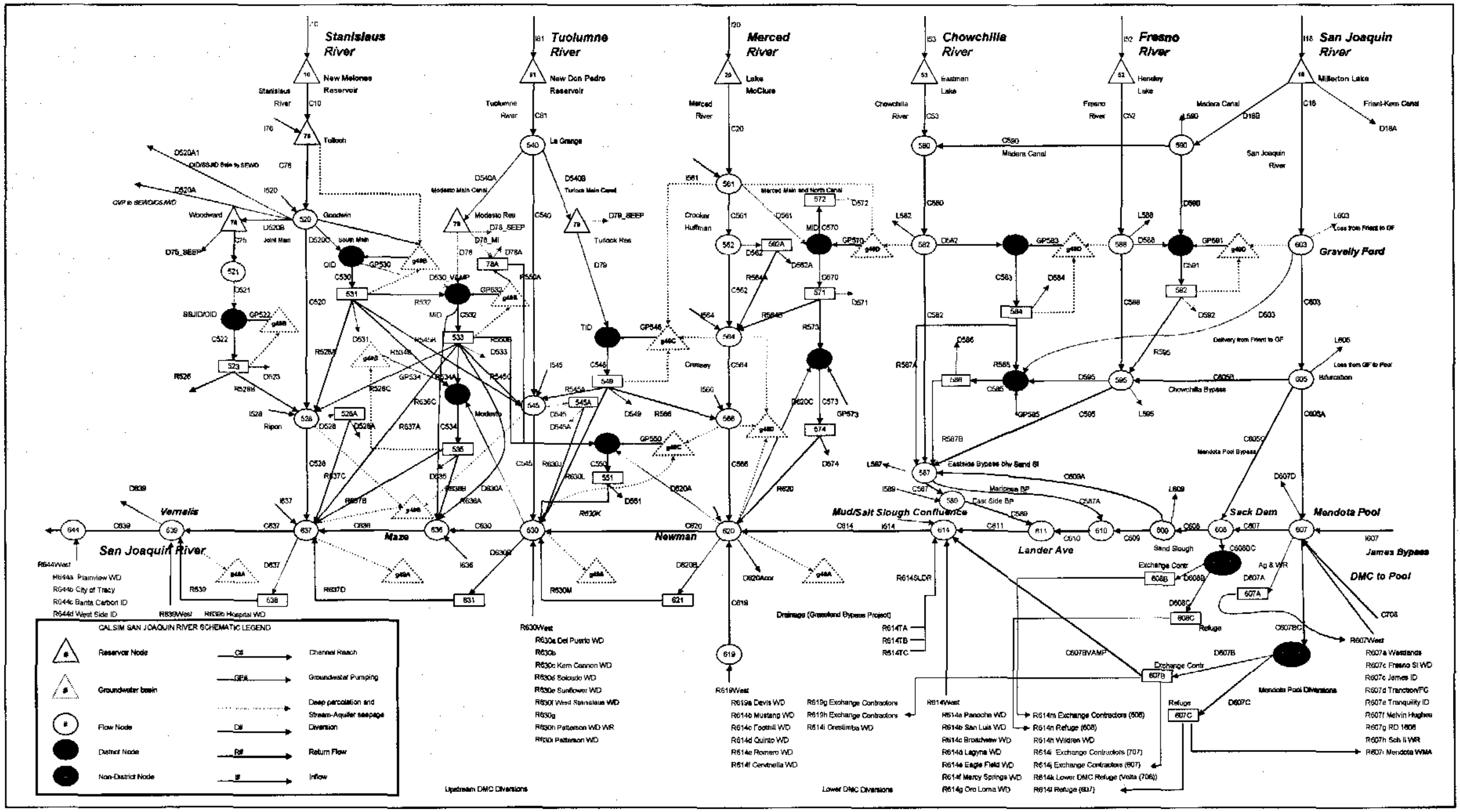


Figure 2.2
CalSim-II San Joaquin River Schematic



The San Joaquin River component of CalSim-II has been described previously to the SWRCB, and in other forums. Submission of information regarding the CalSim-II model and preliminary results for San Joaquin River conditions was presented to the SWRCB in its Triennial Review Process (2004) and can be accessed at "http://www.waterrights.ca.gov/baydelta/docs/exhibits/SJRG-EXH-07.pdf". A supplemental presentation of refinements to the model and preliminary results for San Joaquin River hydrologic conditions was provided to the SWRCB by the SJRGA in March, 2005. The presentation can be accessed at "http://www.waterrights.ca.gov/baydelta/docs/exhibits/SJRG-EXH-13.ppt". Concurrent with the external peer review process, draft documentation of the model ("Calsim-II San Joaquin River Model (Draft)", Reclamation, April 2005), was developed by Reclamation. The draft documentation can be accessed at "http://science.calwater.ca.gov/pdf/calsim/CALSIMSJR_DRAFT_072205.pdf ". The external peer review report concerning the model and its documentation ("Review Panel Report San Joaquin River Valley Calsim II Model Review", January 2006) can be accessed at "http://science.calwater.ca.gov/pdf/calsim/calsim_II_final_report_011206.pdf". Reclamation's response to the review can be accessed through "http://www.usbr.gov/mp/mp700/modeling/calsim/index.html".

In April, 2006, the SWRCB sponsored a public workshop during which Reclamation and DWR provided statements concerning the model and the SJRGA provided a presentation of the model and its capabilities and recent refinements, and a discussion of how results differ from earlier modeling attempts. The SJRGA's presentation can be accessed at "http://www.waterrights.ca.gov/baydelta/docs/presentation_handout.pdf". Accompanying that document was documentation concerning additional model development. Those documents can be accessed at "http://www.waterrights.ca.gov/baydelta/docs/supplemental_documentation.pdf".

The model continues to evolve as different needs occur. Since the time of the last SJRGA presentation of the model several additional capabilities have been incorporated into the model. The model has been enhanced to depict working assumptions for the implementation of the settlement for restoring flows in the San Joaquin River from Friant. Other additional refinements have been developed to better represent the hydrology and operations of the San Joaquin River. CalSim-II results presented in this submission are derived from recent work-in-progress studies associated with Reclamation's environmental documentation of the San Joaquin River Restoration Program. The results are provided as a general representation of the settings described. It is anticipated that studies specific to the needs of the SWRCB staff would be developed at some time during this investigative process.

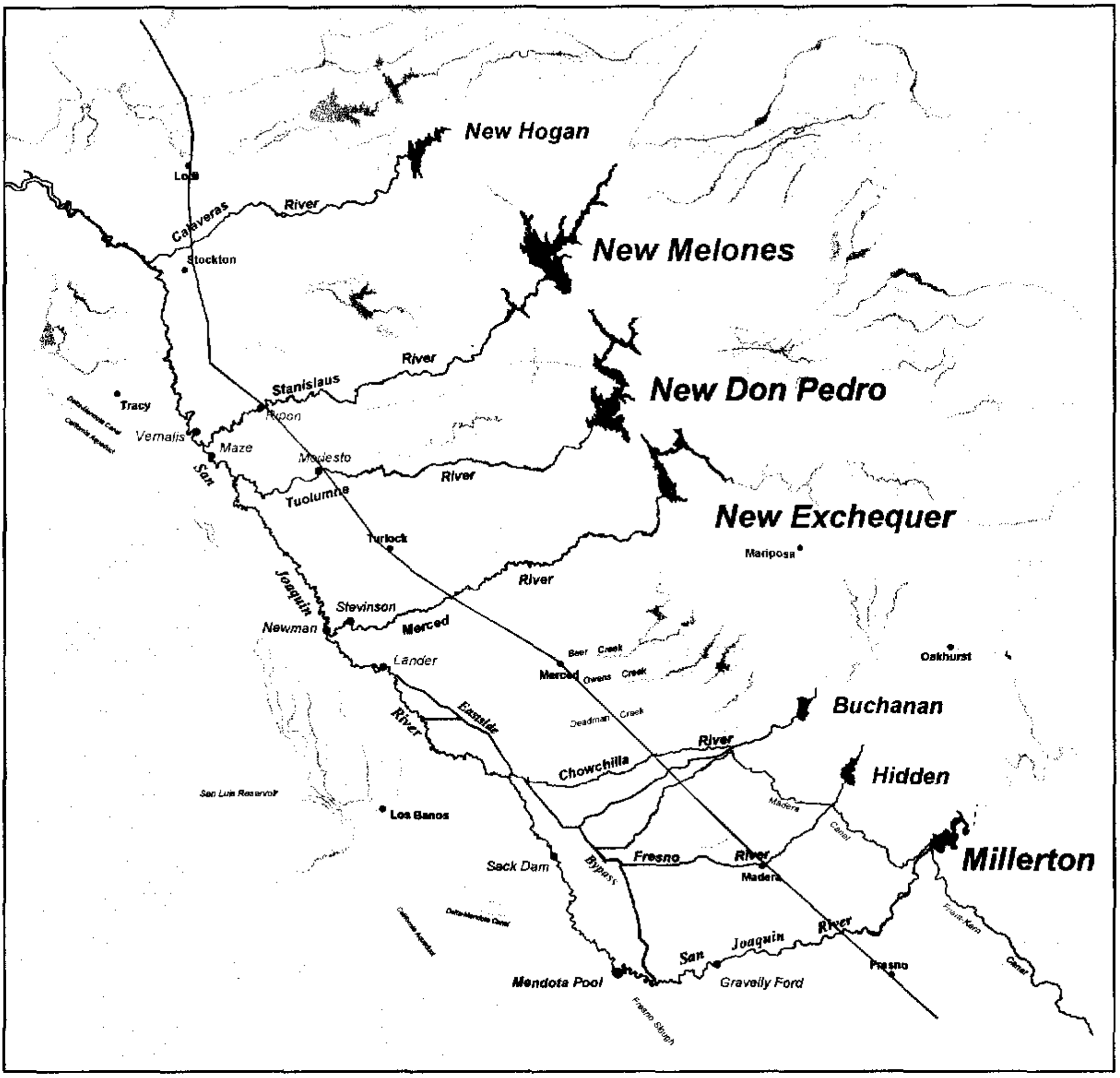
3. Current San Joaquin River Conditions - Modeled

CalSim-II simulates many components of San Joaquin River Basin operations, and provides hydrologic results for hundreds of individual parameters modeled in the system. Figure 3.1 illustrates the general aerial scope of the San Joaquin River component of CalSim-II, the major streams that are modeled and key locations incorporated in the model.

The model provides a monthly simulation of operations for the period spanning water years 1922 through 2003. Current basin operations are reflective of the regulatory and institutional requirements of Decision 1641 and Decision 1422, the New Melones 1997 Interim Plan of Operations, the San Joaquin River Agreement, and current tributary requirements such as FERC flow requirements. The individual systems are modeled to operate consistent with recent performance.

There are many hydrologic parameters that describe the capabilities of the projects within the basin and their performance. These parameters include reservoir storage, diversions and releases to streams. Additionally, there are several hydrologic parameters that describe the hydrology of the streams, including flow and water quality. This submission provides a depiction of the system as it would perform over a long sequence of historically experienced hydrologic conditions, at a constant state of land use, facility development and operational objectives. The data set included with this submission provides the full output from the CalSim-II simulations (2 files within folder "13_CalSim_Existing_ConditionsDSS"), including the performance of the tributary systems. Although many more parameters could be illustrated, this description of results focuses on the hydrologic condition of the San Joaquin River at two points in the San Joaquin River, a location upstream of the Stanislaus River confluence with the San Joaquin River (known as Maze), and a second location downstream of that confluence (Vernalis).

Figure 3.1
Geographical Scope of CalSim-II San Joaquin River Component



3.1 Upstream Hydrologic Conditions at Maze

The hydrologic condition upstream of the Stanislaus River confluence with the San Joaquin River is largely representative of the independent operations of the Merced River and Tuolumne River systems, and the occurrence of diversions, accretions and depletions and return flows below the control of the major water systems and along the mainstem of the San Joaquin River. A location upstream of this confluence referred to as "Maze" is modeled in CalSim-II. This location is convenient as it physically exists as a flow and water quality measurement point in the San Joaquin River. The physical record at this location provides a validation point for model results. Under the current regulatory and institutional Bay-Delta setting (that mostly affects the CVP's operation of its New Melones Project as opposed to affecting the other tributaries) the condition at Maze is largely static to the dynamic changes in the Delta.

The current flow and quality of the San Joaquin River at Maze is illustrated by Figure 3.1.1. The graphs depict the sequential average flow and quality of the San Joaquin River as estimated by CalSim-II over the 82-year period of simulated operations. The time-sequential graphs plot average flow and quality conditions for "split month" periods during the year. The x-axis labels indicate the periods as denoted by the ending date of the period, e.g., the data point associated with 10/15/21 represents the average results for the 15-day period ending October 15, 1921. Generally, the split month data is the same for both halves of a month except during April and May. During these months CalSim-II has been programmed to calculate the partial month operations of the Vernalis Adaptive Management Plan (VAMP). The Vernalis 30-day average salinity objective is also plotted in the figure as a comparison to the water quality at Maze. At times the water quality at Maze is worse than the Vernalis objective, and incidental or deliberate operations at New Melones will normally provide compliance to the objective.

The seasonal trend of water quality and flow at Maze is illustrated in Figure 3.1.2. Shown in the figure is the range (indicated by a vertical line) in average water quality and flow that occurs within a month (period) over the 82-years of simulated operations. Also shown is the average water quality and flow during the period. The trend of water quality and flow at Maze by year type[1] is illustrated in Figure 3.1.3. Shown in the figure is the average monthly quality and flow within each year type. The quality and flow at Maze during the separate non-pulse and pulse flow periods of April and May (representative of the VAMP period) are illustrated in Figure 3.1.4. The figures illustrate how the supplemental flow during the VAMP period (the last half of April and the first half of May) contributes to increases of flow at Maze during the period and provides a corresponding improvement in water quality.

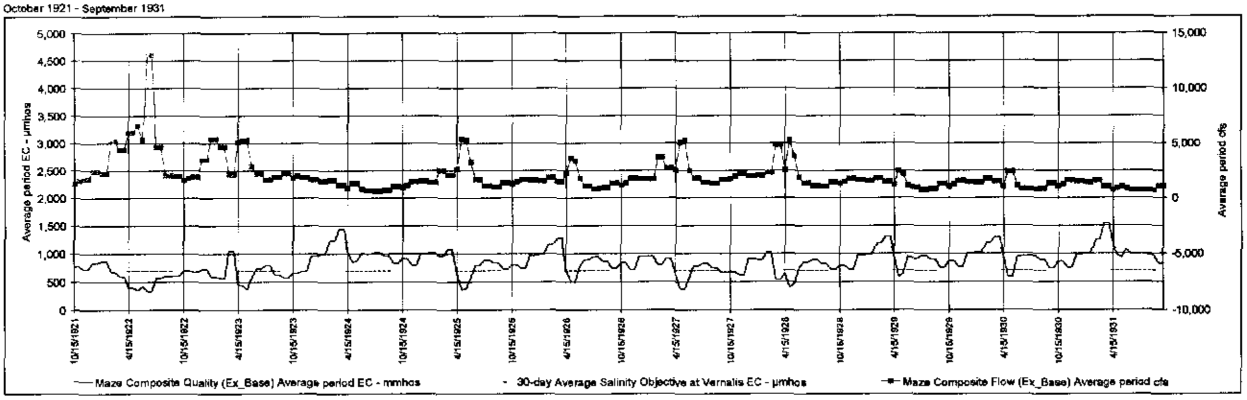
While CalSim-II computes water quality (EC) at certain other upstream locations, caution is advised when using those results. The method of calibration/validation of the San Joaquin River water quality component of CalSim-II distributed the load closure term for salinity at two somewhat arbitrary locations (at Maze and a location upstream of the Merced River confluence). Simulated water quality results at locations upstream of Maze may not be accurate and were not intended to be utilized as absolute values.

---

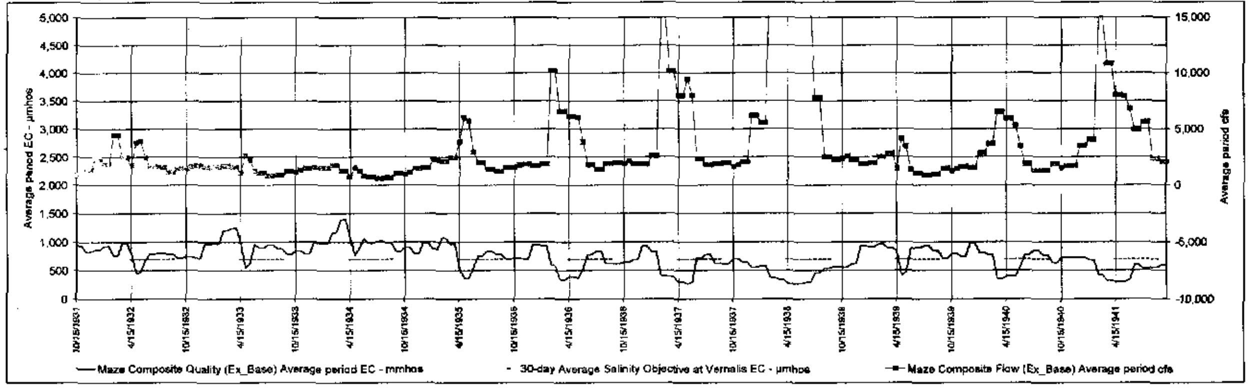
[1] Year types are determined by the San Joaquin Valley Water Year Hydrologic Classification (SJR Index) as described in SWRCB 95-1R, May 1995.

Figure 3.1.1 (1 of 2)
Flow and Water Quality at Maze, San Joaquin River

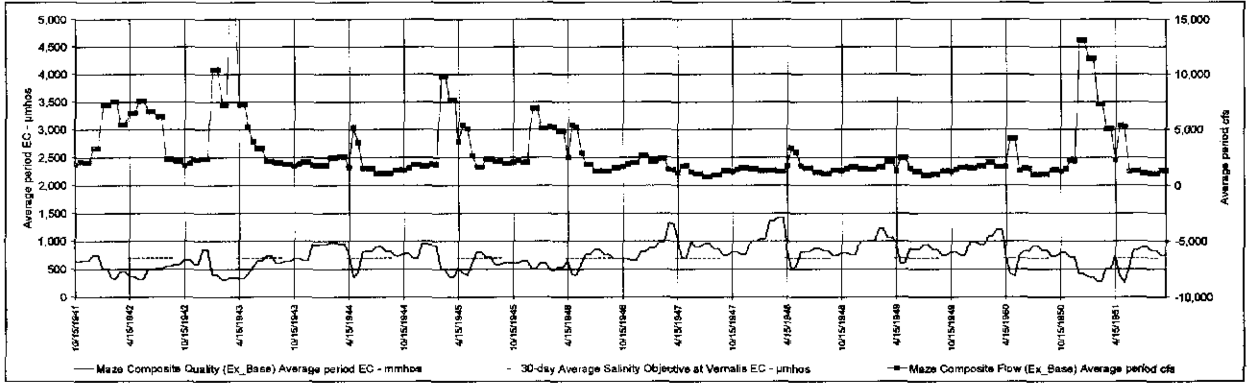
October 1921 - September 1931



October 1931 - September 1941



October 1941 - September 1951



October 1951 - September 1961

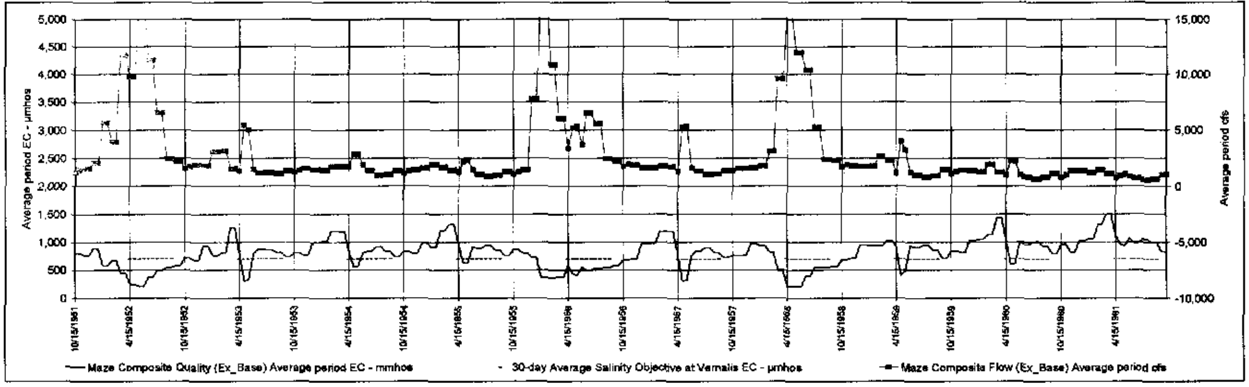
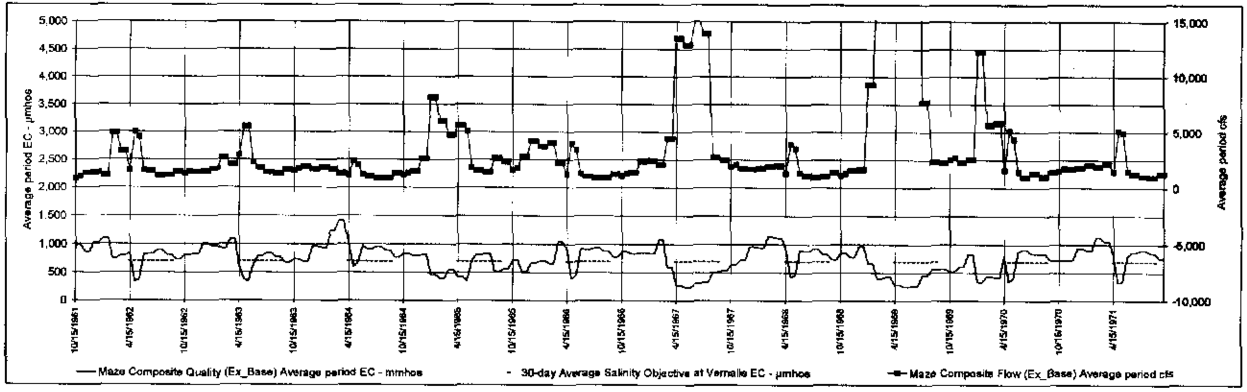
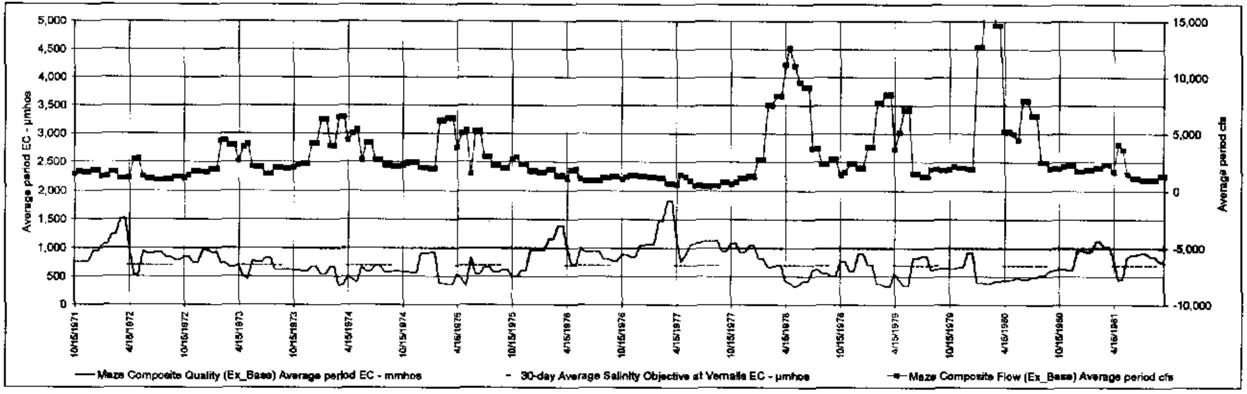


Figure 3.1.1 (2 of 2)
Flow and Water Quality at Maze, San Joaquin River

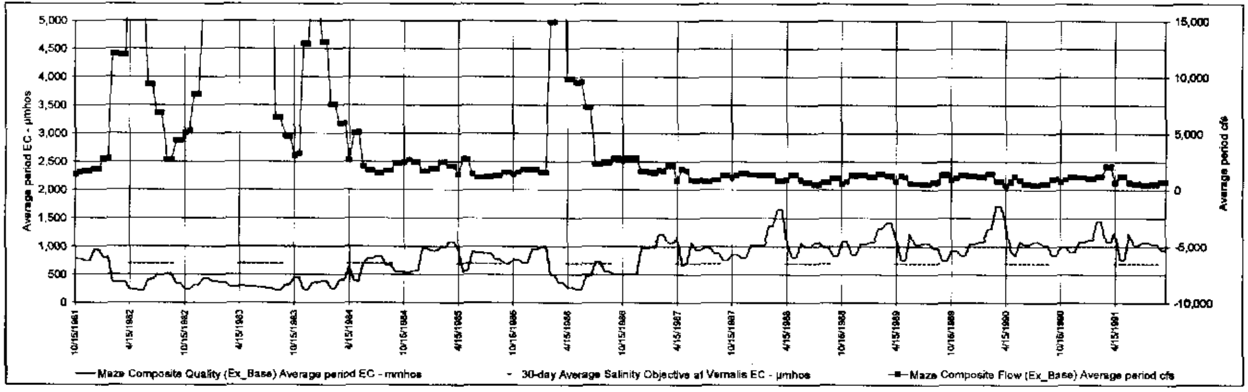
October 1961 - September 1971



October 1971 - September 1981



October 1981 - September 1991



October 1991 - September 2003

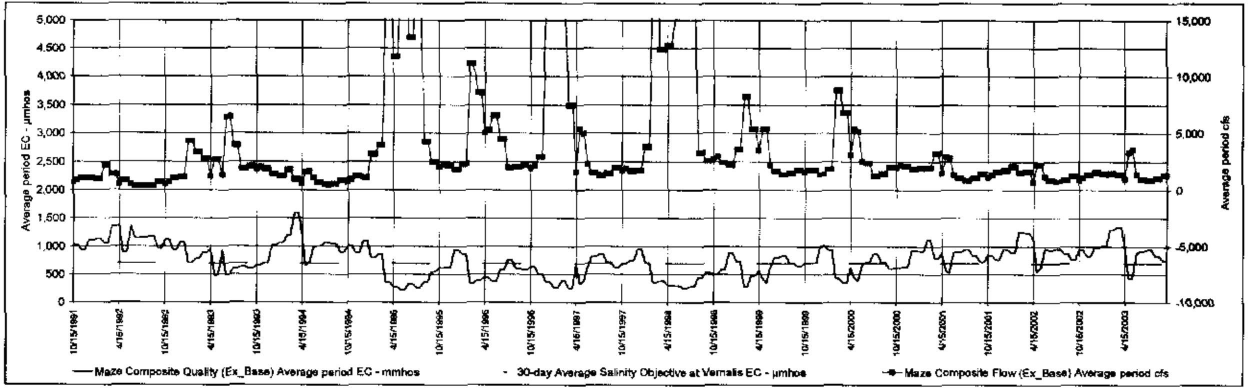


Figure 3.1.2
Seasonal Range and Average Flow and Water Quality at Maze, San Joaquin River

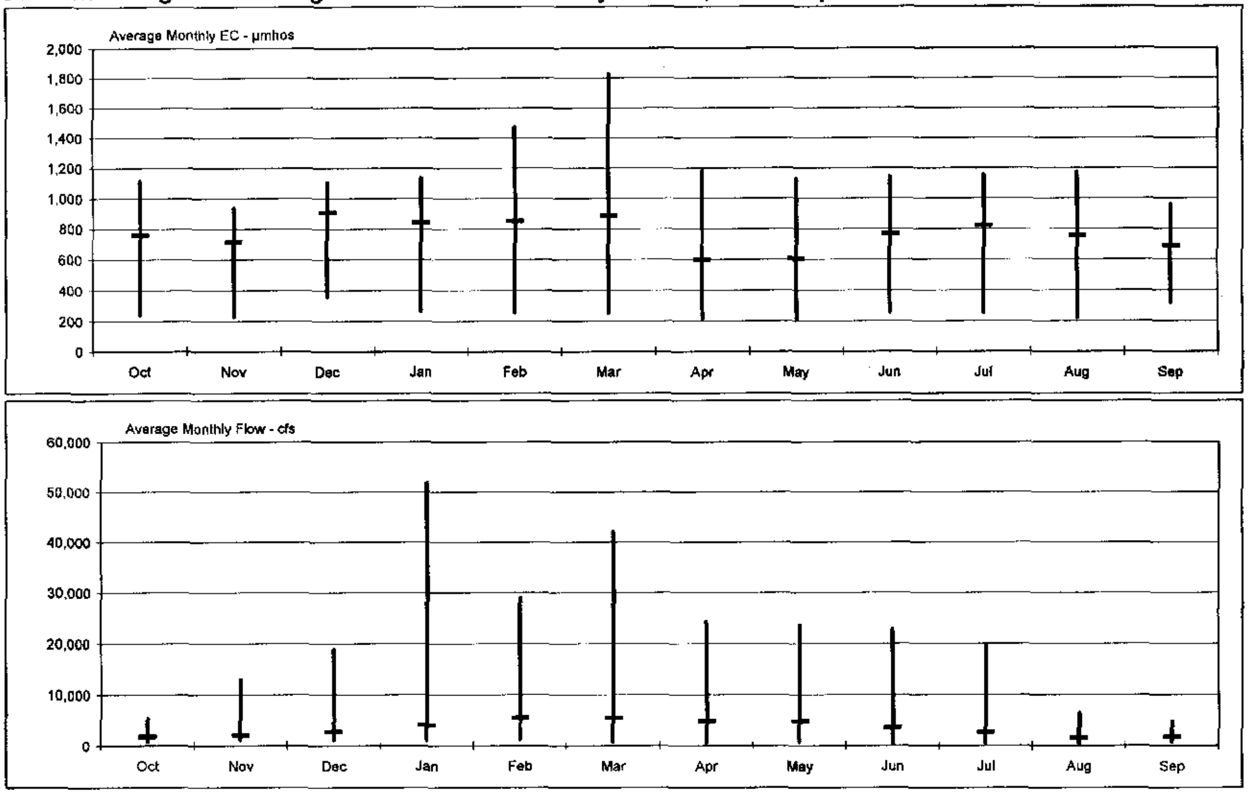


Figure 3.1.3
Average Flow and Water Quality at Maze by Year Type, San Joaquin River

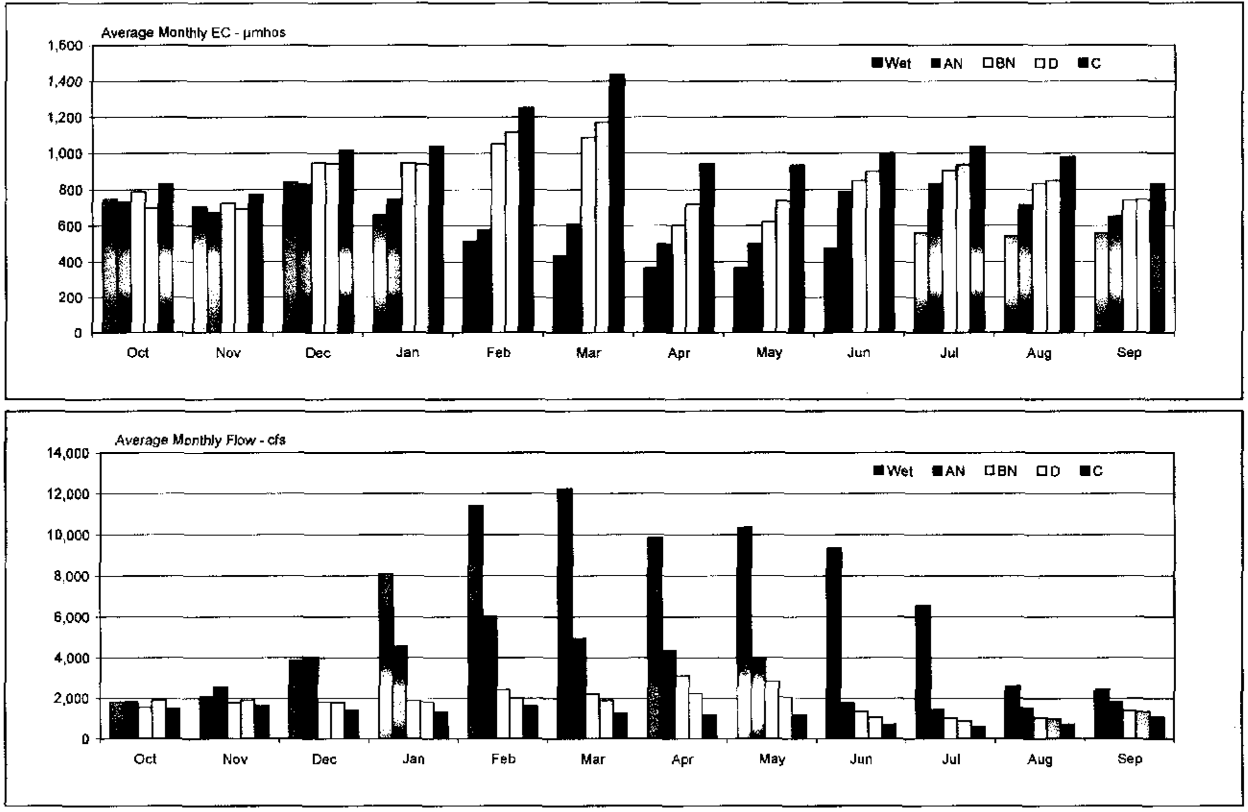
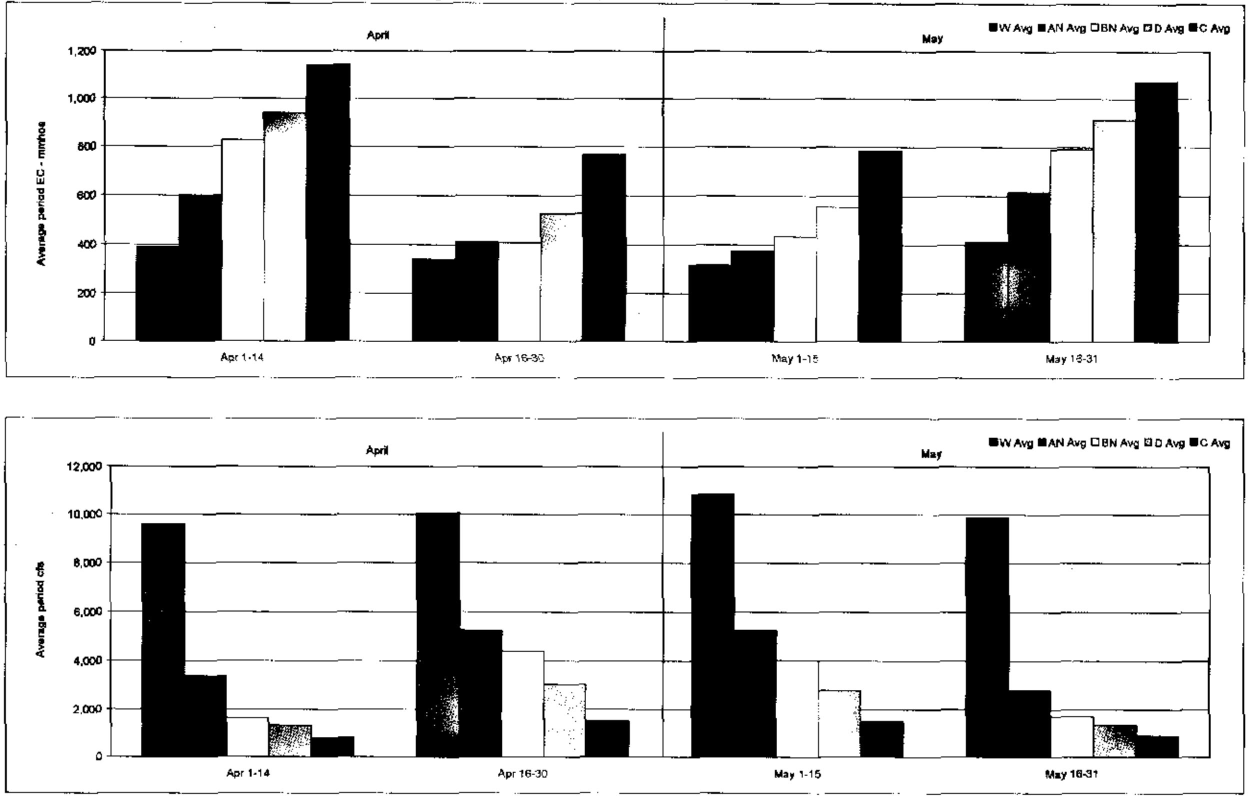


Figure 3.1.4
Flow and Water Quality at Maze During April and May, San Joaquin River



3.2 Hydrologic Conditions at Vernalis

Hydrologic conditions at Vernalis are primarily affected by the flow and quality of the San Joaquin River at Maze and the flow of water from the Stanislaus River. The flow and quality at Maze is to a large extent the result of upstream project operations and stream flow that have no direct linkage to regulatory requirements at Vernalis. The exception is during the VAMP period when members of the SJRGA coordinate and contribute operations to meet the flow objectives at Vernalis. During other times of the year there is only incidental linkage of the upstream operations to the conditions at Maze and downstream to Vernalis. The regulatory requirements of D1641 at Vernalis are currently the responsibility of Reclamation, which at times operates its New Melones Project to comply.

The model results presented here for Vernalis reflect the assumption that Reclamation operates its New Melones Project according the protocols described in the 1997 New Melones Interim Plan of Operations (IPO). These protocols provide water to the Oakdale Irrigation District and the South San Joaquin Irrigation District according to an agreement with Reclamation, and allocate other water of the basin to fisheries, water quality, X2 requirement support and Stanislaus River CVP contractors. The specifics of the protocols are described in the earlier submittals to the SWRCB that have been cited in this report. Although the plan was developed under circumstances and assumptions at the time and intended to be interim in application, the protocols continue to be the working assumption in on-going Reclamation and DWR model investigations.

The current flow and quality of the San Joaquin River at Vernalis is illustrated by Figure 3.2.1. The graphs depict the sequential average flow and quality of the San Joaquin River as estimated by CalSim-II over the 82-year period of simulated operations. Consistent with the information provided for the Maze location, the time-sequential graphs plot average flow and quality conditions for "split month" periods during the year.

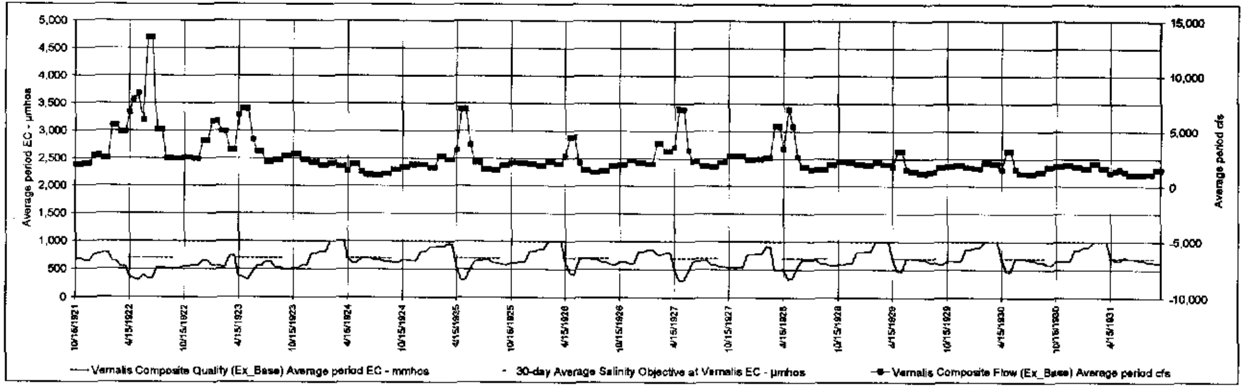
The seasonal trend of water quality and flow at Vernalis is illustrated in Figure 3.2.2. Shown in the figure is the range (indicated by a vertical line) in average water quality and flow that occurs within a month (period) over the 82-years of simulated operations. Also shown is the average water quality and flow during the period. The trend of water quality and flow at Vernalis by year type is illustrated in Figure 3.2.3. Shown in the figure is the average monthly quality and flow within each year type. The quality and flow at Vernalis during the separate non-pulse and pulse flow periods of April and May (representative of the VAMP period) are illustrated in Figure 3.2.4.

Under current conditions that includes the assumed modeled IPO operation of the New Melones Project, the flow and water quality at Vernalis is on occasion in a state of non-compliance with D1641 objectives. The simulation shows a total of 14 periods of non-compliance of water quality objectives. Of the 14 periods, most were very minor exceptions or were potentially the result of an IPO modeling assumption that releases water allocated for Vernalis water quality purposes prior to the release for Stanislaus River dissolved oxygen purposes. This priority (which is reversed in recent practice) exhausts the water quality allocation earlier in the model than would occur in practice; thus, a few of the exceptions occurring late in the summer or in the following late winter would not be expected to occur if the modeling was corrected. In any interpretation of the results, sufficient storage exists in New Melones Reservoir during each of these potential exceedence periods to allow full compliance to the Vernalis water quality objective. It is only the strict CalSim-II modeling of the IPO which is intended to provide guidance to the operation of the New Melones Project that demonstrates the potential exceedence of Vernalis objectives. During the tenure of D1641 there has not been an exceedence of the Vernalis water quality objective.

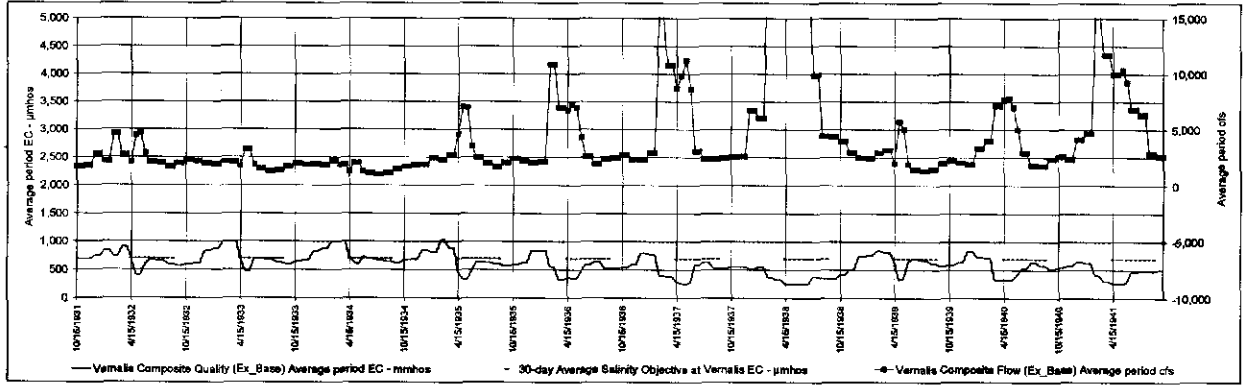
Simulated compliance with the Vernalis flow objective (February through June, excluding the VAMP pulse flow period) is shown in Table 3.2.1. Shown in the table is the estimated Vernalis non-pulse flow objective for the February through June periods. The flow objective is base on a combination of the SJR Index and the required position of X2. The second set of columns show the calculation of flow that is in excess or the deficiency to the objective. Positive values indicate compliance with the objective, while highlighted negative flows indicate non-compliance with the objective. Also shown is the New Melones Index for each

Figure 3.2.1 (1 of 2)
Flow and Water Quality at Vernalis, San Joaquin River

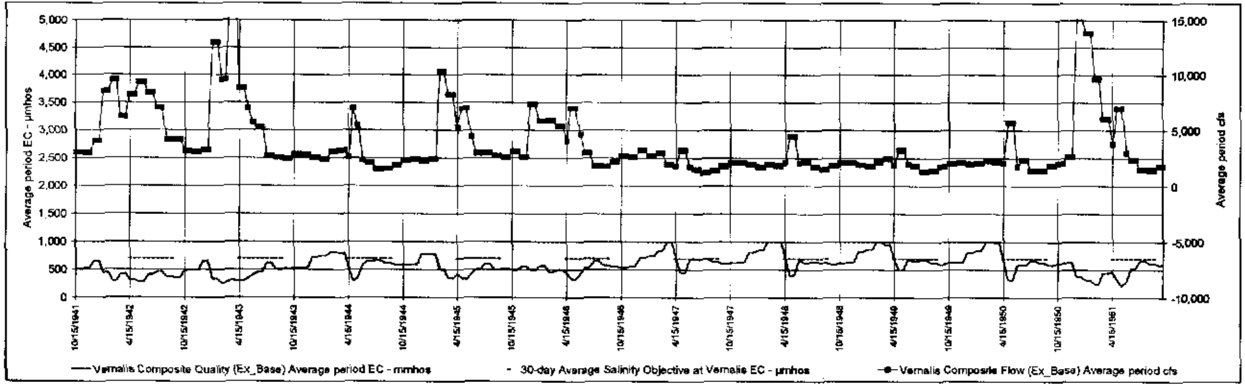
October 1921 - September 1931



October 1931 - September 1941



October 1941 - September 1951



October 1951 - September 1961

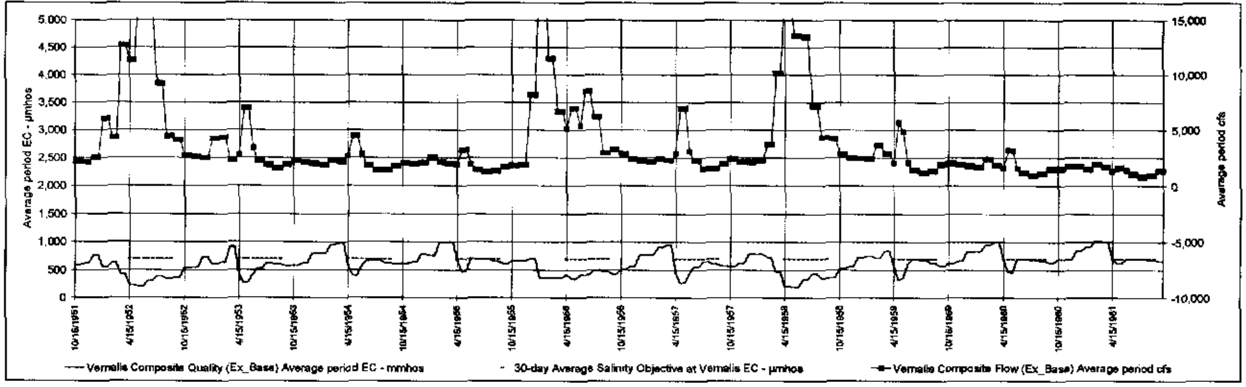
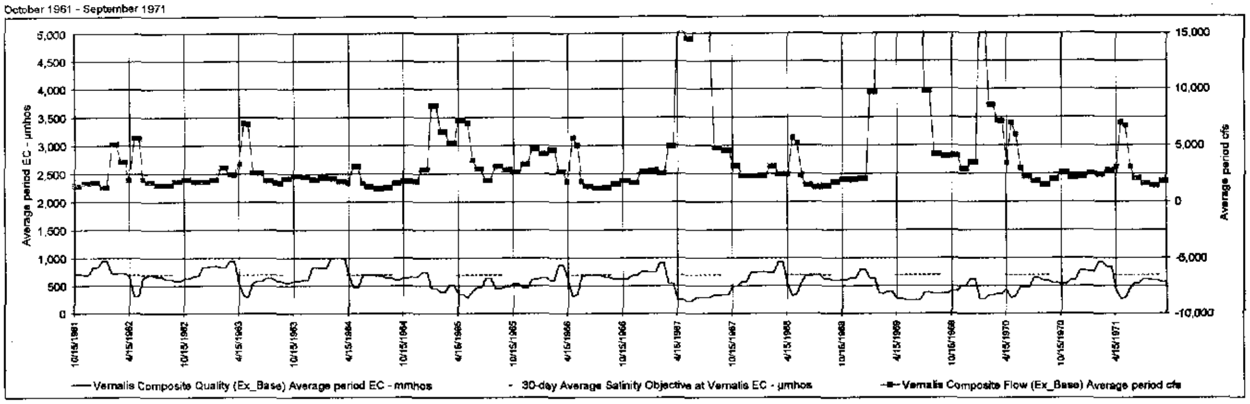
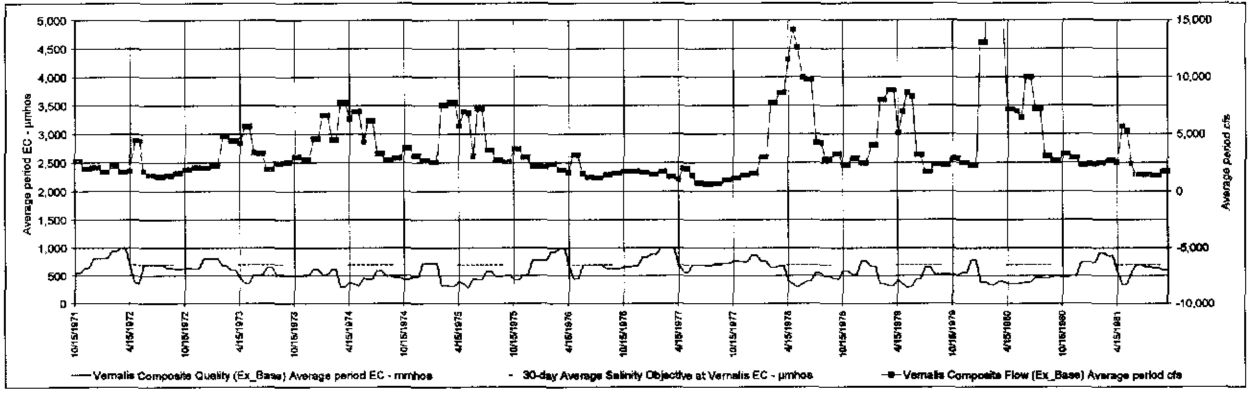


Figure 3.2.1 (2 of 2)
Flow and Water Quality at Vernalis, San Joaquin River

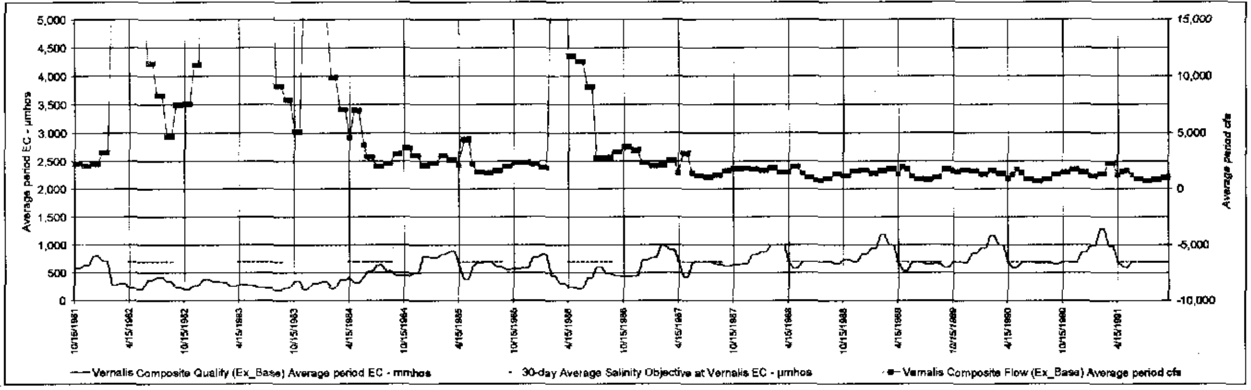
October 1961 - September 1971



October 1971 - September 1981



October 1981 - September 1991



October 1991 - September 2003

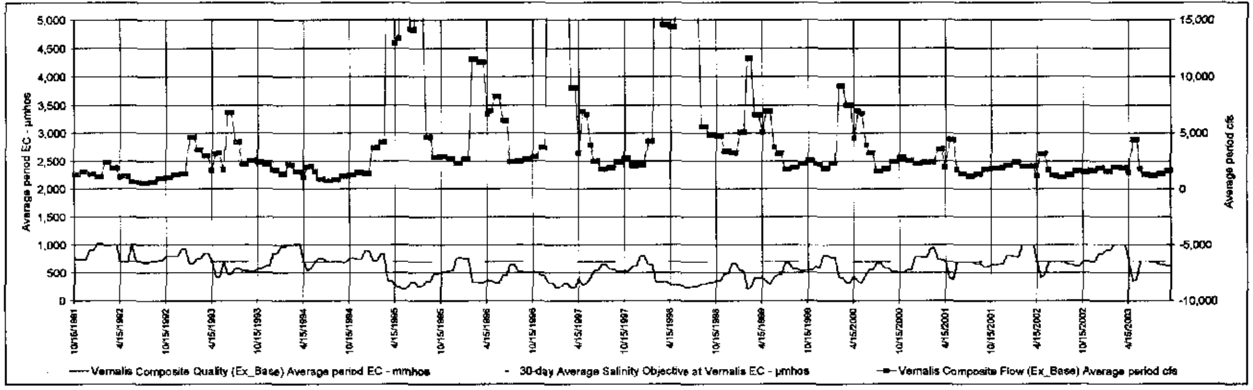


Figure 3.2.2
Seasonal Range and Average Flow and Water Quality at Vernalis, San Joaquin River

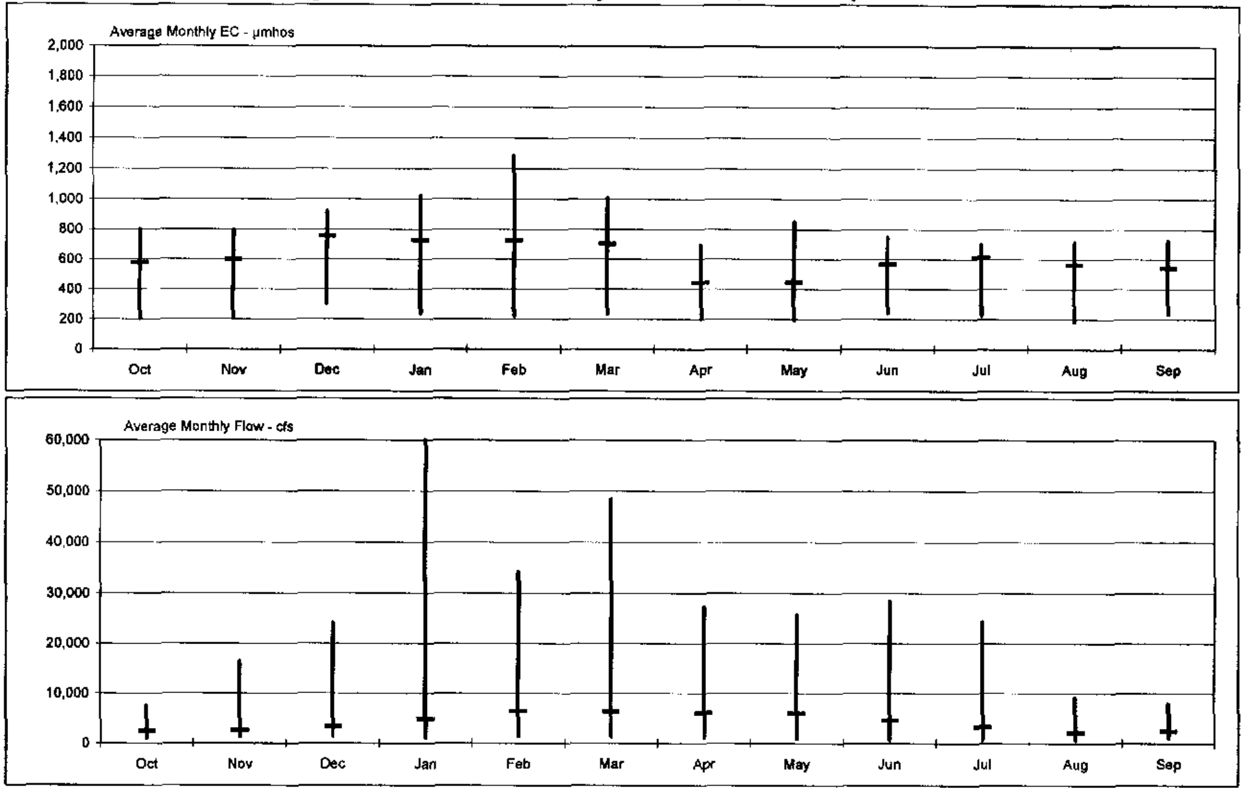


Figure 3.2.3
Average Flow and Water Quality at Vernalis by Year Type, San Joaquin River

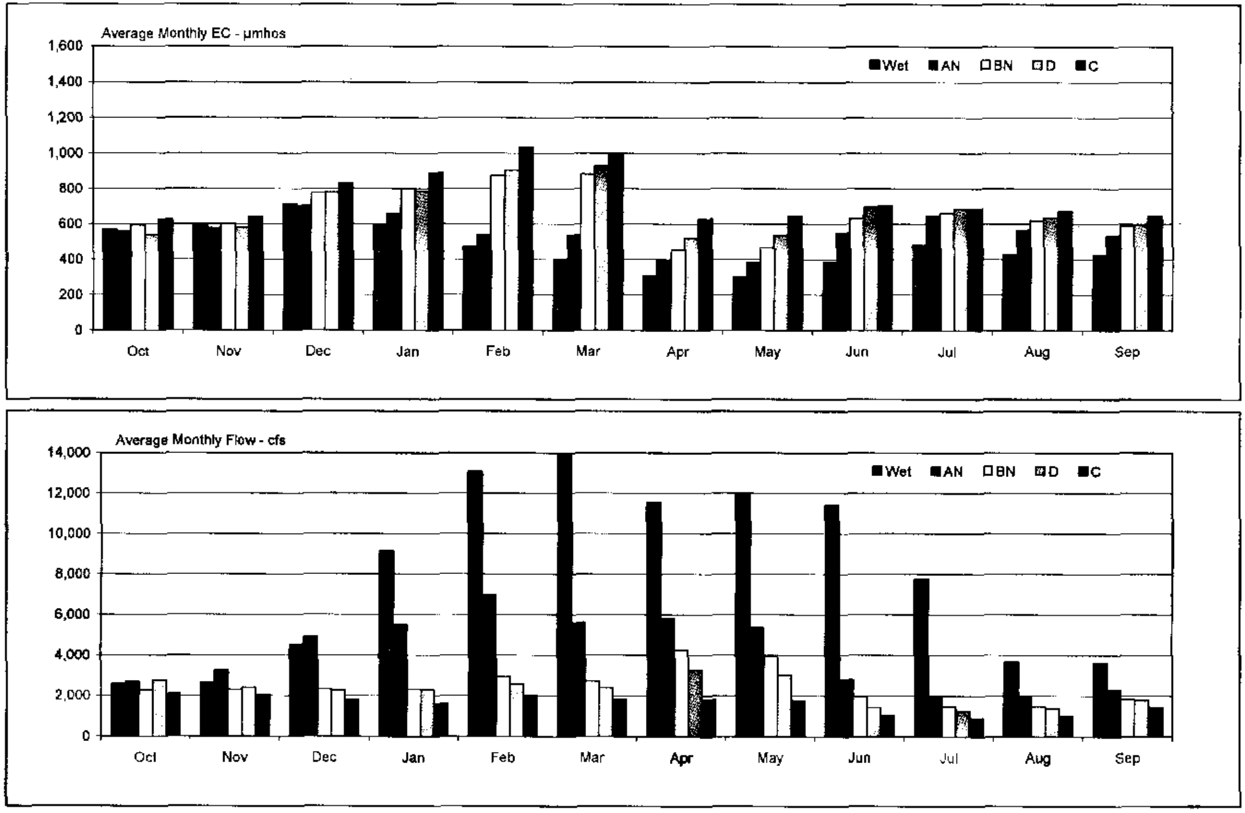


Figure 3.2.4
Flow and Water Quality at Vernalis During April and May, San Joaquin River

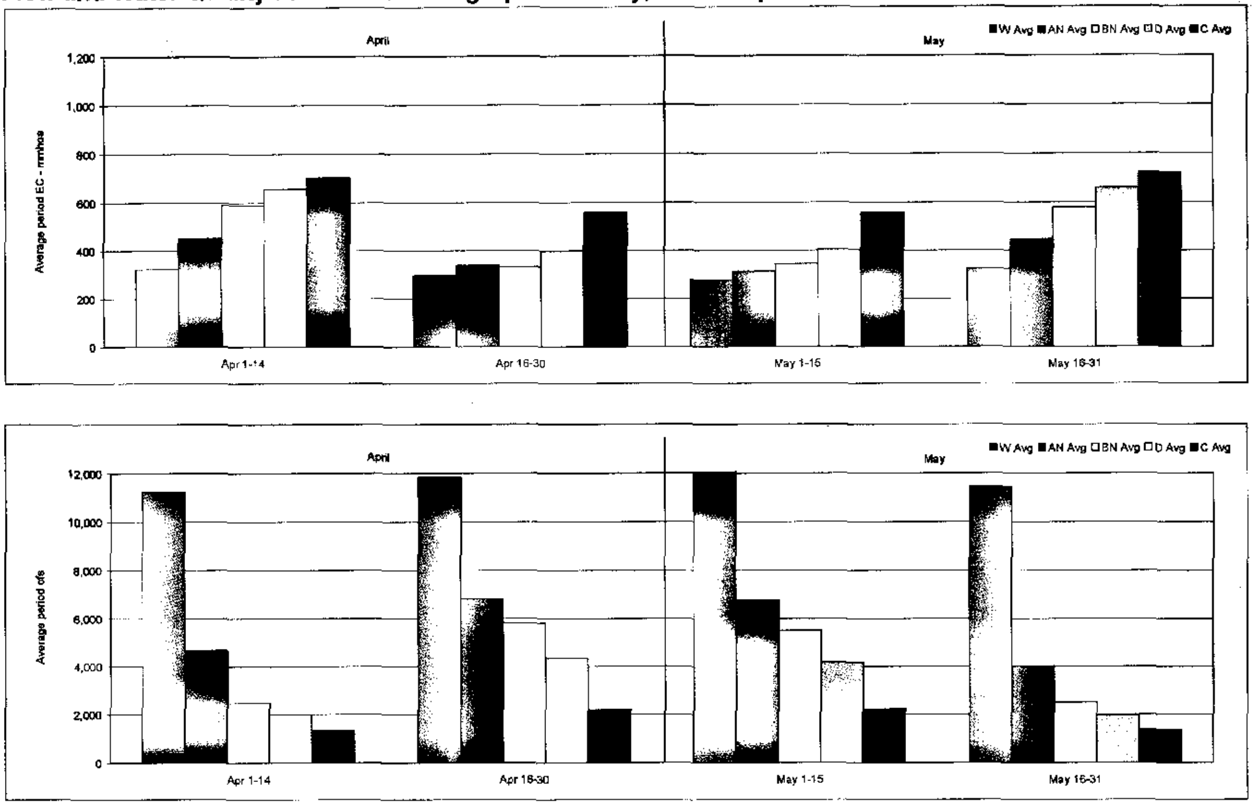


Table 3.2.1
Modeled Compliance of D1641 Vernalis Flow Objective at Vernalis, San Joaquin River

	Vernalis Flow Objective - cfs					Excess / Deficient to Objective - cfs					NM	SJR
WY	Feb	Mar	Apr 1-14	May 16-31	Jun	Feb	Mar	Apr 1-14	May 16-31	Jun	Index - TAF	Index
1922	3420	3420	3334	3420	3420	2120	1492	3961	2533	10099	2297	W
1923	3420	3254	2689	3378	2818	1525	0	4055	840	311	[illegible]	AN
1924	784	1043	710	710	710	1293	728	997	576	311	1778	C
1925	2034	2280	2165	2280	1907	670	135	3109	1478	257	2162	BN
1926	1666	2280	1993	2280	1420	520	[illegible]	1643	[illegible]	31	1930	D
1927	3420	3420	3420	3420	3205	468	[illegible]	1962	[illegible]	[illegible]	2359	AN
1928	2250	2280	2280	2280	1535	350	3178	3042	383	227	2370	BN
1929	802	1001	810	710	724	1347	976	1714	834	612	1883	C
1930	1140	1140	1126	932	710	994	881	1284	604	468	1726	C
1931	848	738	782	710	710	1201	889	527	602	344	1334	C
1932	3376	3420	3377	2921	3162	1243	[illegible]	[illegible]	[illegible]	[illegible]	1714	AN
1933	1635	1448	2079	1448	1449	480	614	412	379	19	1453	D
1934	1140	1140	1040	710	710	1022	707	584	536	375	1138	C
1935	3420	3420	3248	3420	3334	[illegible]	[illegible]	2624	81	[illegible]	1433	AN
1936	3376	3420	3377	3420	2861	7476	3548	3617	872	[illegible]	2025	AN
1937	2360	3420	3420	3420	3377	13302	7362	5879	5223	[illegible]	2310	W
1938	3420	3420	3420	3420	3420	20199	25796	14934	18598	17777	[illegible]	W
1939	1696	1503	2079	1420	1420	1242	1663	1881	476	21	2329	D
1940	3376	3420	3420	3420	2947	621	3751	4370	1595	0	[illegible]	AN
1941	3420	3420	3420	3420	3420	12245	8325	6549	5823	3413	[illegible]	W
1942	3420	3420	3291	3420	3334	6122	2817	4902	5916	5079	3100	W
1943	3420	3420	3420	3420	2732	6180	16604	5395	2281	2497	3090	W
1944	1687	2280	2108	1448	1707	1424	906	2833	845	368	2377	BN
1945	3420	3420	3248	3045	2947	6878	4787	2946	1392	0	2652	AN
1946	3420	3420	3291	3378	2861	2488	1964	2316	1261	117	2734	AN
1947	1604	2280	2251	1503	1420	1342	[illegible]	292	220	62	2216	D
1948	2250	1475	1850	2280	2194	[illegible]	347	1510	[illegible]	3	2122	BN
1949	1574	1642	2280	2225	1735	573	799	294	[illegible]	90	1958	BN
1950	2280	2280	2251	2280	1936	6	[illegible]	1732	[illegible]	411	2151	BN
1951	3420	3420	3377	3045	2388	6239	2609	2120	-40	0	2695	AN
1952	3376	3420	3420	3420	3420	948	9297	7913	14612	12262	3409	W
1953	2280	2280	2165	2225	1735	2048	0	2874	1165	526	[illegible]	BN
1954	2280	2280	2280	2280	1649	0	[illegible]	1338	567	204	2406	BN
1955	2280	1697	1621	1448	1649	[illegible]	277	972	495	[illegible]	2045	D
1956	3376	3420	3420	3378	3377	8122	3272	2711	1999	5142	[illegible]	W
1957	1696	2280	2280	1614	1993	752	0	2784	1479	240	2649	BN
1958	3420	3420	3420	3420	3420	286	6719	14334	10200	10055	3155	W
1959	2280	2280	2137	1531	1420	1348	619	1844	548	[illegible]	2374	D
1960	918	1140	1140	863	724	1484	686	1308	714	460	1949	C
1961	864	1140	1054	724	710	1069	569	405	681	358	1559	C
1962	1696	2280	2223	2280	1592	3445	1310	1743	[illegible]	196	1668	BN
1963	3420	3420	3248	3420	3377	-357	[illegible]	2073	[illegible]	[illegible]	2096	AN
1964	2250	1781	1535	1448	1449	-122	63	966	230	[illegible]	1929	D
1965	3420	3420	3162	3420	2947	2807	1800	4105	298	0	[illegible]	W
1966	2280	2280	2251	2225	1449	2340	431	1630	-388	-53	2320	BN
1967	3420	3420	3420	3420	3420	[illegible]	1541	11763	11096	13647	3185	W
1968	2250	2280	2251	1475	1420	919	175	1925	877	91	2413	D
1969	3420	3420	3420	3420	3420	24454	17626	17387	22358	22632	3474	W
1970	3420	3420	3420	2130	2216	5166	3721	1903	847	0	2720	AN
1971	2280	2280	2280	2252	2108	161	542	2889	839	0	2608	BN
1972	2250	2280	2280	1725	1477	0	[illegible]	931	36	-74	2244	D
1973	3420	3420	3420	3295	3334	1460	1007	1584	108	0	2566	AN
1974	3420	3420	3420	3420	3334	1107	4368	3282	916	2871	3018	W
1975	3420	3420	3420	3129	3420	4162	4405	2978	[illegible]	3824	[illegible]	W
1976	799	793	839	710	710	1636	1096	1647	870	530	2198	C
1977	771	724	710	710	710	992	553	832	703	35	1588	C
1978	3420	3420	3420	3420	3334	4306	5227	9541	6560	6452	2257	W
1979	3420	3420	3420	2837	3291	4608	5445	2703	5481	-79	[illegible]	AN
1980	3376	3420	3420	3295	2861	19189	12445	3753	3176	7156	[illegible]	W
1981	2280	2280	2251	1559	1420	231	498	1971	879	82	2381	D
1982	3420	3420	3420	3420	3420	13764	12057	23853	15469	7720	3419	W
1983	3420	3420	3420	3420	3420	30773	44993	19051	21878	25088	3965	W
1984	3376	3420	3420	2588	2775	6523	3658	2460	1364	121	2765	AN
1985	1727	2197	1879	2003	1420	1284	432	1489	261	107	2350	D
1986	3420	3420	3420	3337	2732	13954	24821	8368	7944	6318	3149	W
1987	848	1140	1126	710	710	1266	1418	1255	720	509	2189	C
1988	1125	890	796	710	710	769	589	975	711	309	1713	C
1989	864	863	1140	1126	710	772	940	546	32	185	1597	C
1990	1140	807	1025	710	710	536	601	90	748	176	1268	C
1991	741	724	1126	710	710	625	1605	299	556	201	990	C
1992	784	1140	1068	738	710	1625	755	43	[illegible]	[illegible]	748	C
1993	3420	3420	3420	3420	3377	115	[illegible]	[illegible]	[illegible]	3487	1359	W
1994	833	1112	896	710	710	1320	451	667	860	199	1099	C
1995	3420	3420	3420	3420	3420	791	16048	9774	19459	10750	[illegible]	W
1996	3376	3420	3420	3420	3420	8204	7891	3454	4867	2721	[illegible]	W
1997	3420	3420	3377	2879	2302	19511	5628	1862	1062	215	2749	W
1998	3420	3420	3420	3420	3420	20853	11145	10964	13342	17540	3374	W
1999	3420	3420	3420	3337	3205	8243	3235	2692	444	0	2860	AN
2000	3376	3420	3420	3378	2775	5865	4102	2444	596	482	2680	AN
2001	1819	2280	2223	1420	1420	595	1322	1069	352	[illegible]	2238	D
2002	2280	2280	2194	2030	1449	-239	[illegible]	73	[illegible]	[illegible]	2018	D
2003	2280	2280	2251	2225	2223	-295	[illegible]	815	-414	[illegible]	2029	BN

Notes: [illegible]AF

Goodwing release 1,500 cfs or greater

year (March through following February basis). During years when the index is less than 2,500 TAF (non-highlighted index values) the assumed operation of the IPO does not provide releases for the Vernalis flow objective. Boxed values shown in the table represent periods when Goodwin is modeled to be releasing at least 1,500 cfs, an assumed limit of release unless flood control requires greater releases. There can be instances when the IPO allows releases for the Vernalis flow objective but the required release is not made because of the Goodwin release constraint. Non-compliance can occur during any SJR Index type year, most often during Above Normal, Below Normal and Dry years.

4. Near-future San Joaquin River Conditions - Modeled

Actions within the San Joaquin River Basin are anticipated to occur in the near-future that will alter the flow and quality of the San Joaquin River. These actions include the implementation of San Joaquin River Restoration Program restoration releases from Friant, a potentially altered VAMP flow regime, and the continuing decrease of saline discharges associated with the Grassland Bypass Project. CalSim-II provides an analytical platform to evaluate these actions upon the hydrology of the San Joaquin River.

As an illustration of the magnitude of the changes in flow and quality at Vernalis associated with the San Joaquin River Restoration Program flows, a CalSim-II simulation was developed that isolated the addition of the flows from all other potential changes in the future. The setting created was framed as:

> "What if the San Joaquin River Program restoration settlement flows occur and no changes in current institution or agreements occur?"

To develop this setting in CalSim-II the previously described CalSim-II model was modified to incorporate working assumptions for the implementation of the San Joaquin River Restoration Program (SJRRP) restoration flows. The SJRRP is a comprehensive effort to restore flows to the San Joaquin River from Friant Dam to the confluence of Merced River while reducing or avoiding adverse water supply impacts to the Friant water users from releasing the restoration flows. Information regarding the program can be accessed at "http://www.restoresjr.net/". For this illustration the restoration flow "alone" was assumed implemented in the model below Friant Dam, with essentially no changes to the rest of the depiction of San Joaquin River Basin facilities or institution. The only substantial modification to the model was the method of routing restoration flows, around the Mendota Pool to Sack Dam.

The "no change" assumption includes not changing the modeling protocols of the San Joaquin River Agreement (SJRA) including the operation of VAMP. The no change assumption also includes not changing the modeling protocols of the IPO. The results described below will include the reaction of VAMP and the New Melones Project to the changes in flow from Friant Dam releases upstream of the Merced River confluence.

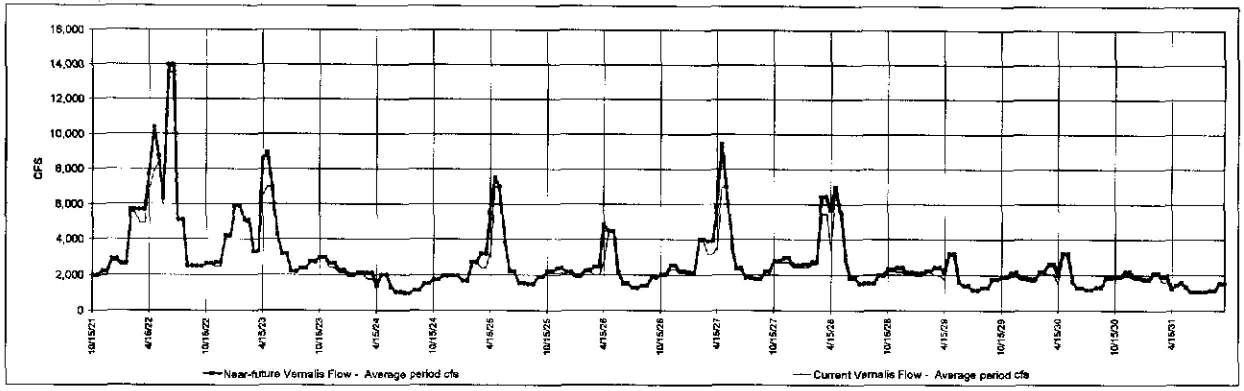
4.1 Hydrologic Conditions at Vernalis

The restoration flows will increase required releases from Friant Dam by up to 556,000 acre-feet in a year. During an extremely dry year (e.g., a recurrence of 1977) only the existing flow regime below Friant might occur. On average, about 200,000 acre-per year will be additionally released from Friant Dam to the river. Assuming no change in practices by the Friant water users in utilizing flood control releases in excess of required river releases, and after incremental seepage losses associated with the flows, it is estimated that a net average annual addition of about 160,000 acre-feet will occur to the San Joaquin River from upstream of the Merced River confluence. This additional flow will occur mostly during the March through April period in many years, and extend through June in the wettest of years. There will be relatively small additional flow occurring during the rest of the year with a pulse occurring in the early portion of November.

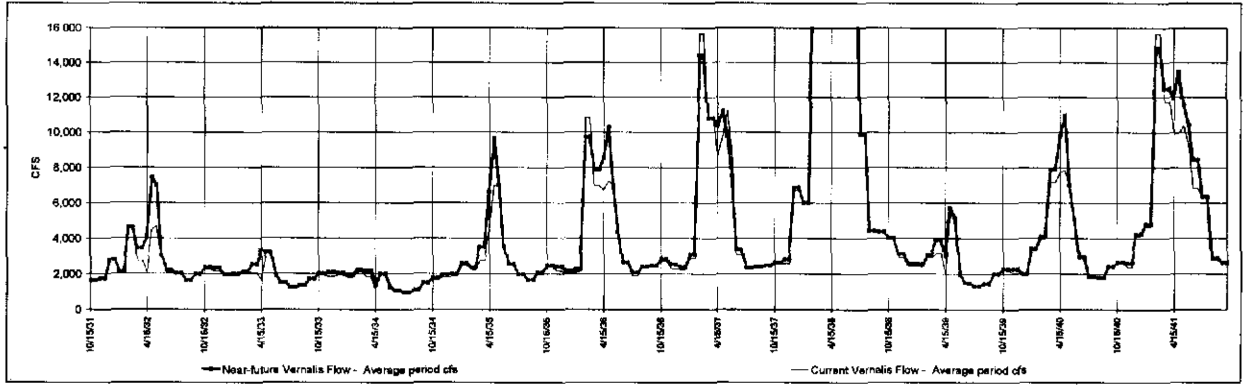
The estimated flow of the San Joaquin River at Vernalis subsequent to restoration flows is illustrated by Figure 4.1.1. The graphs depict the sequential average flow of the San Joaquin River as estimated by CalSim-II over the 82-year period of simulated operations. The time-sequential graphs plot average flow and conditions for "split month" periods during the year. The increases in flow as compared to the current setting are noticeable in the graphs during the March and April periods.

Figure 4.1.1 (1 of 2)
Flow at Vernalis, San Joaquin River – Near-future

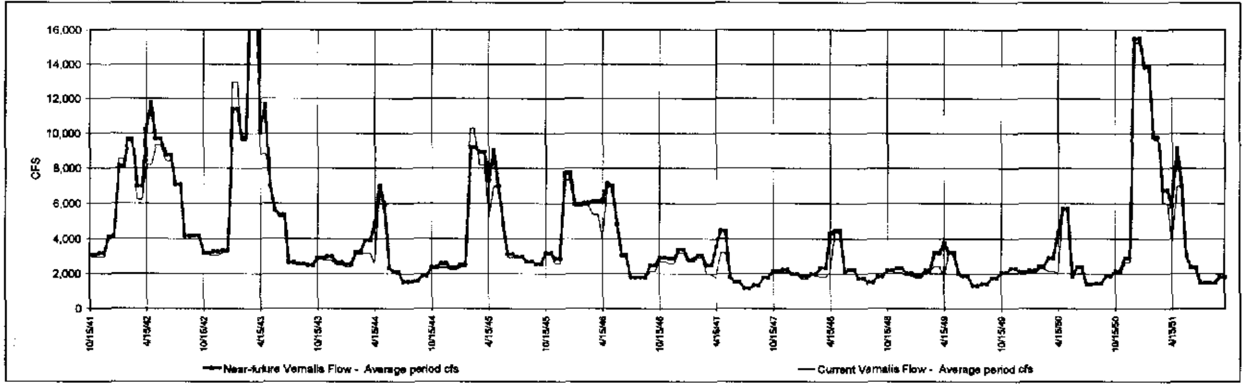
October 1921 - September 1931



October 1931 - September 1941



October 1941 - September 1951



October 1951 - September 1961

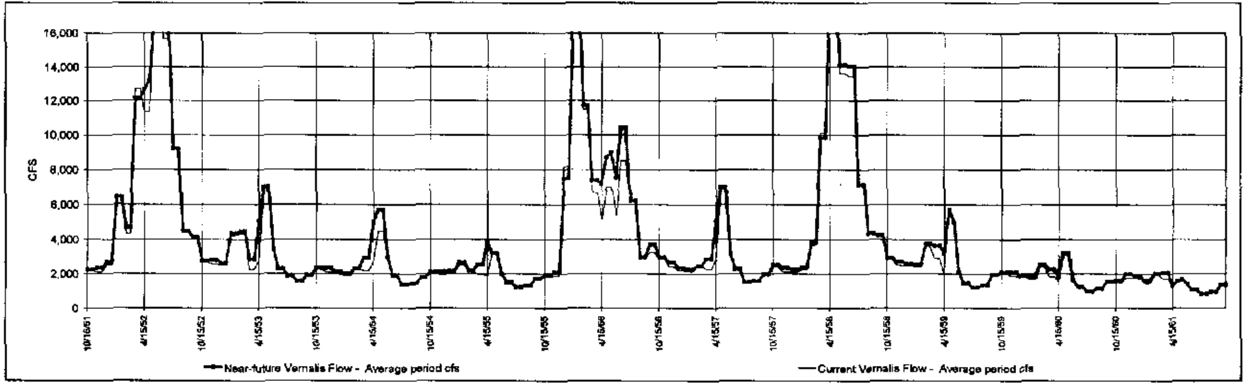
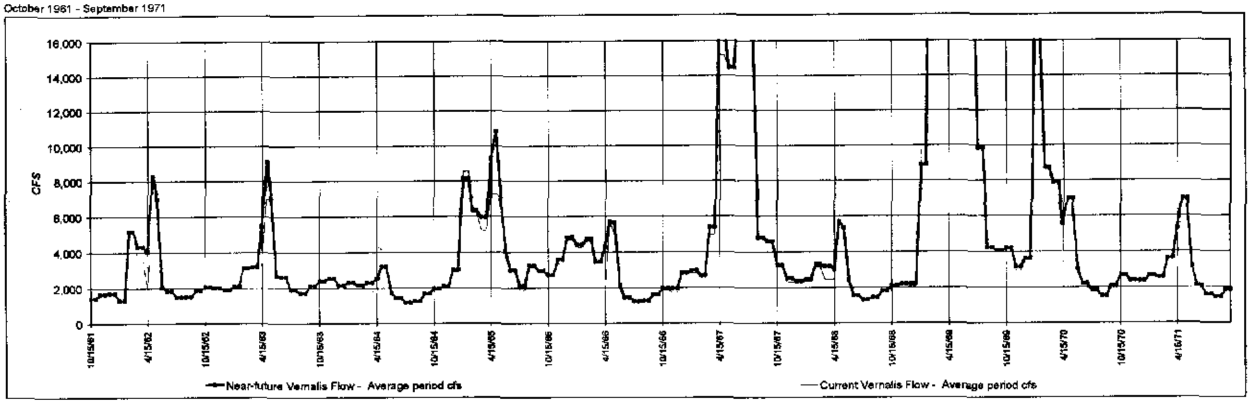
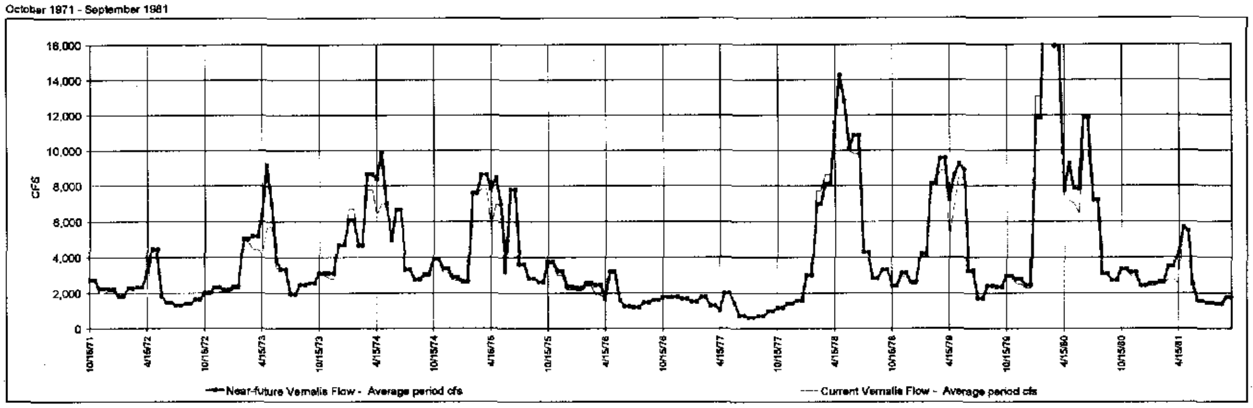


Figure 4.1.1 (2 of 2)
Flow at Vernalis, San Joaquin River – Near-future

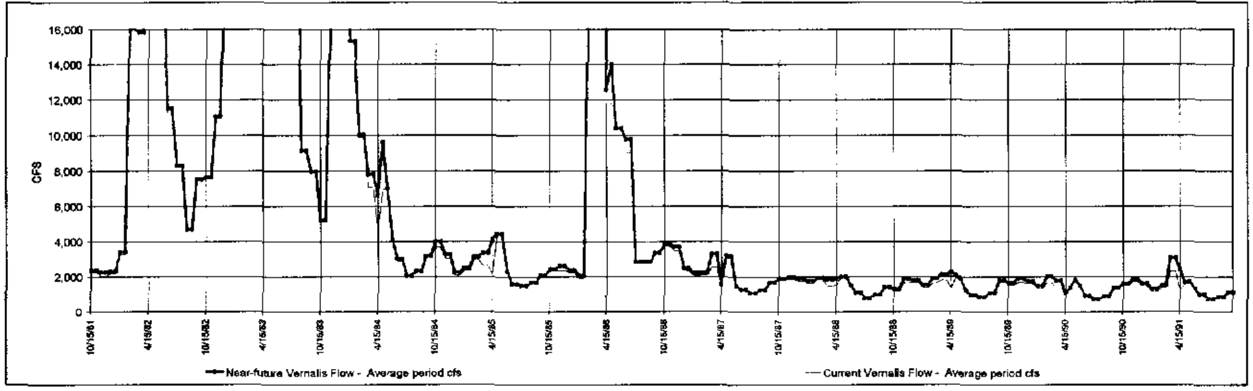
October 1961 - September 1971



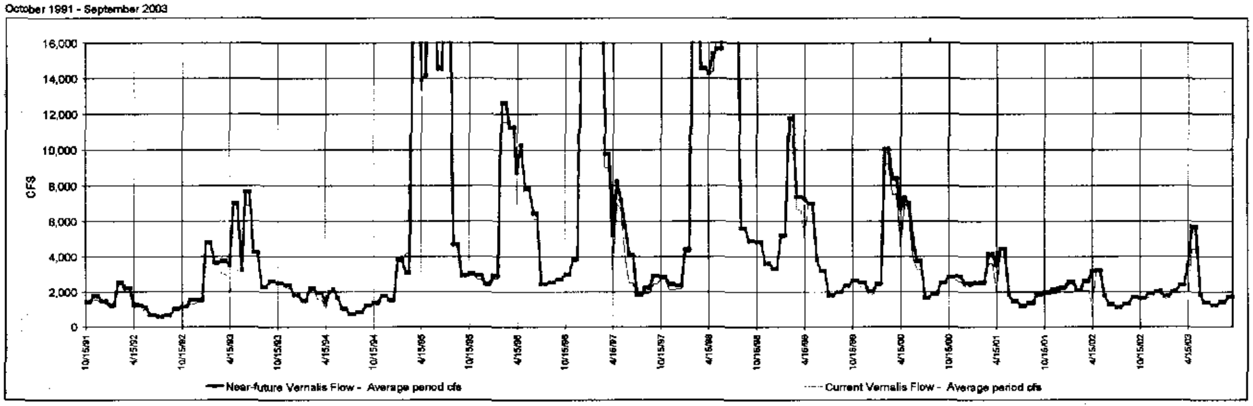
October 1971 - September 1981



October 1981 - September 1991



October 1991 - September 2003



The water quality at Vernalis is illustrated in Figure 4.1.2 for both the near-future and current settings. The Vernalis 30-day average salinity objective is also plotted in the figure as a comparison to the water quality at Vernalis. At times, water quality at Vernalis will also improve due to the restoration releases. However on occasion, when the New Melones Project is operating to maintain the water quality objective at Vernalis, the water quality at Vernalis will remain the same if releases from Goodwin can be reduced in reaction to better water quality occurring at Maze. Reduced releases from Goodwin for Vernalis water quality are modeled to be used for additional water quality releases in the year, reallocated to other IPO purposes, or will be spilled from New Melones in subsequent years.

Without any change to the SJRA and the VAMP protocols, the change in San Joaquin River flow due to the restoration flows will also affect the determination of VAMP flow objectives and the contribution of flow from the SJRGA members. Generally, the modeling uses the restoration flows to increase the underlying "existing flow" during the VAMP pulse flow period; thus, the VAMP flow target might be increased compared to the current setting. In many years the SJRGA member contribution to flow will change due to the different VAMP flow target or due to a lesser contribution needed to meet the same VAMP flow target under both settings.

The seasonal trend of flow at Vernalis is illustrated in Table 4.1.1 for both the current and near-future settings, expressed as average flow rates within SJR Index year types. Also shown is the difference between two settings. The differences shown between the settings illustrate a general increase in flow at Vernalis subsequent to implementation of the restoration flows. The majority of the increased flow occurs during the spring period, with relatively smaller increases occurring during the remainder of the year. Reductions to flow in the near-future setting can occur due to a shifting of flood releases at Friant that would have otherwise occurred had not the restoration flow regime been assumed.

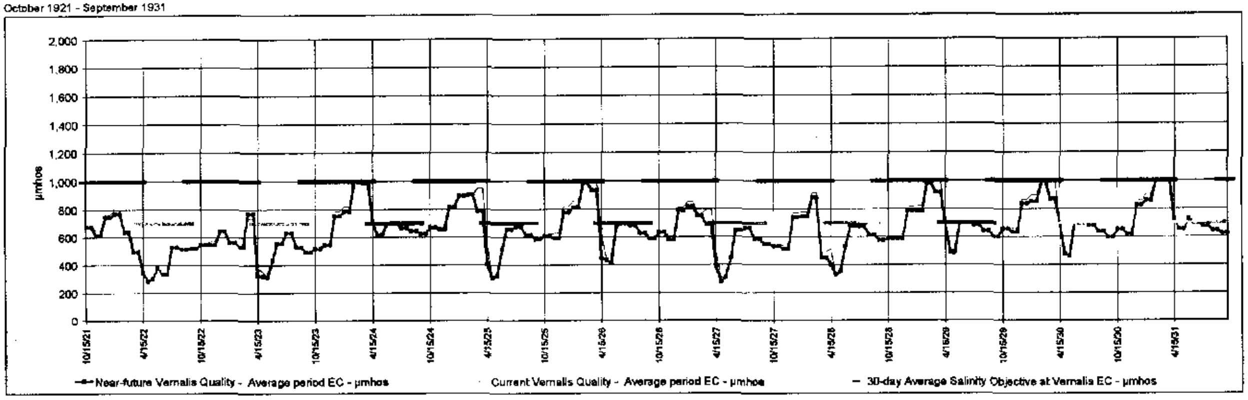
The seasonal trend of quality at Vernalis is similarly illustrated in Table 4.1.2 for the two settings. Commensurate with an increase in tributary water due to the restoration releases, water quality at Vernalis will improve.

4.2 Additional Anticipated Changes

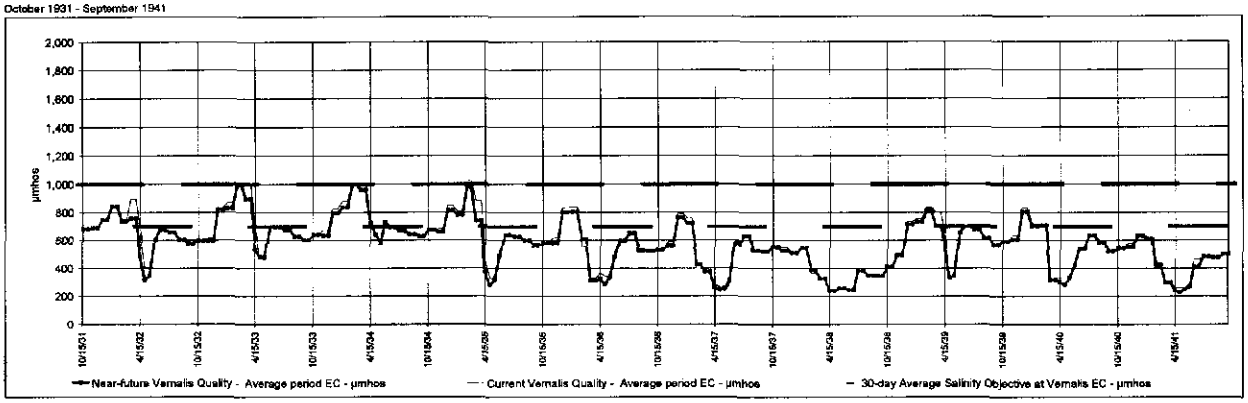
The other identifiable change in the San Joaquin River Basin that is anticipated to affect Vernalis hydrologic conditions in the near-future is the continuing reduction of discharges associated with the Grassland Bypass Project (Westside drainage). CalSim-II studies that test the sensitivity of Vernalis flow and quality provide a preliminary estimate that a reduction of 20 to 50 cfs (average monthly flow) of 3,000 to 5,000 μmhos (EC) water will generally improve water quality by about 30 to 60 μmhos (EC) at Vernalis. The potential reaction of the New Melones Project operations to a change in flow and quality at Maze will affect these estimates, and the rate at which drainage is reduced will affect the schedule for the realization of the water quality improvement.

Figure 4.1.2 (1 of 2)
Water Quality at Vernalis, San Joaquin River – Near-future

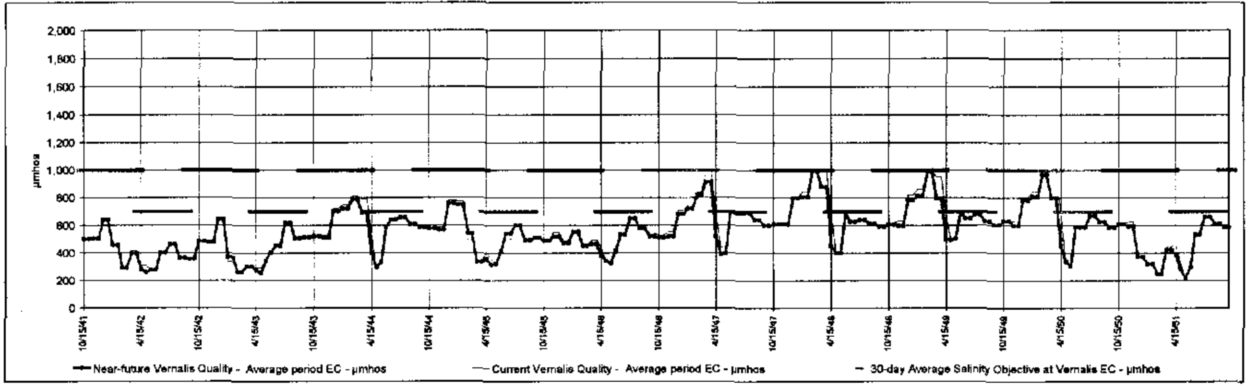
October 1921 - September 1931



October 1931 - September 1941



October 1941 - September 1951



October 1951 - September 1961

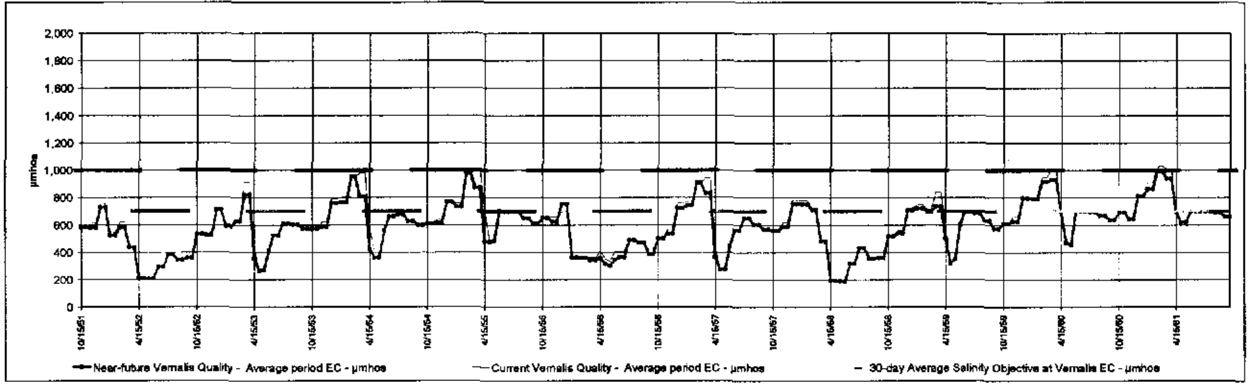
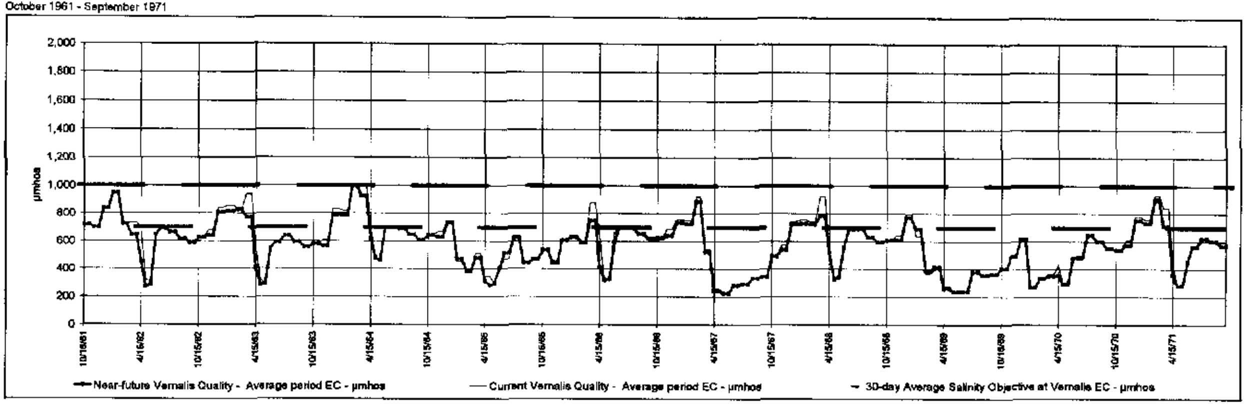
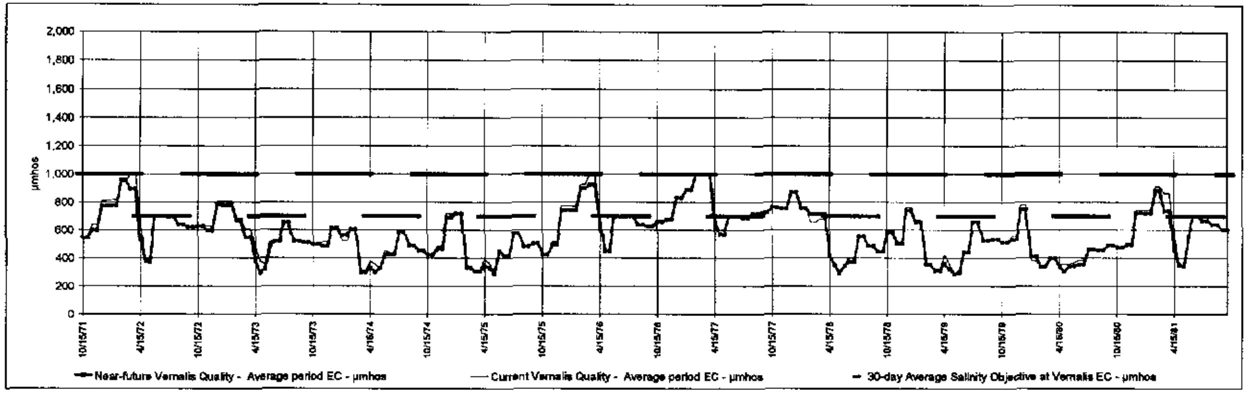


Figure 4.1.2 (2 of 2)
Water Quality at Vernalis, San Joaquin River – Near-future

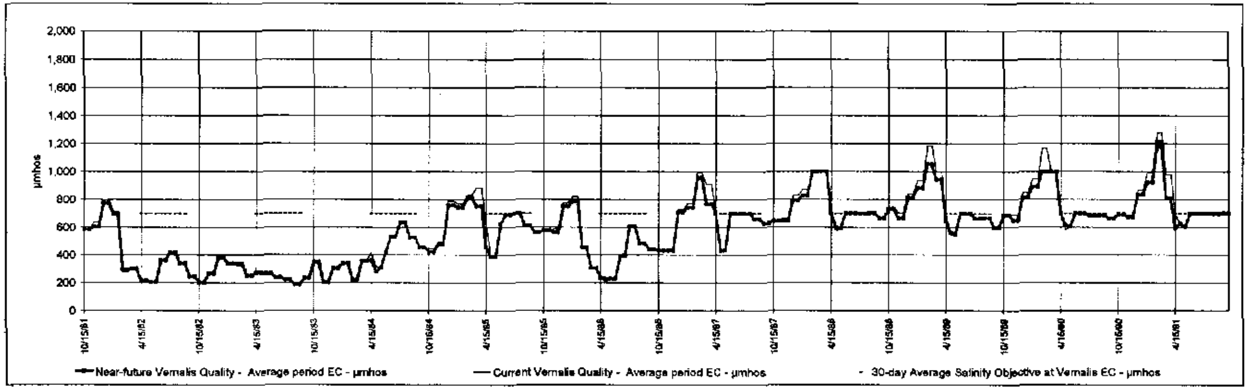
October 1961 - September 1971



October 1971 - September 1981



October 1981 - September 1991



October 1991 - September 2003

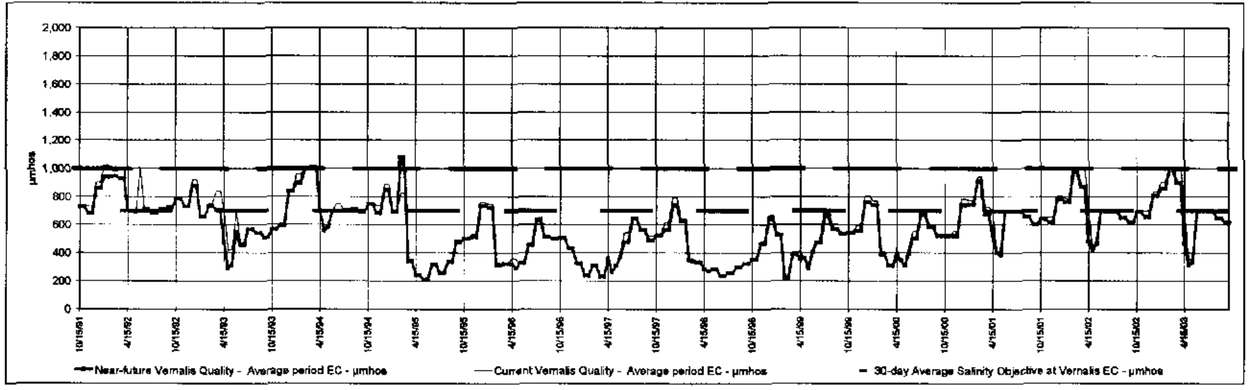


Table 4.1.1
Flow at Vernalis, San Joaquin River – Current and Near-future

Vernalis Flow - Average Year Type cfs Ranked by SJR Index 60-20-20 Current

	Oct	Nov	Dec	Jan	Feb	Mar	Apr 1-14	Apr 15-30	May 1-15	May 16-31	Jun	Jul	Aug	Sep
Wet	2,590	2,654	4,537	9,140	13,062	13,889	11,232	11,840	12,560	11,455	11,441	7,744	3,660	3,635
AN	2,675	3,249	4,918	5,511	6,985	5,612	4,667	6,821	6,788	4,018	2,785	1,928	1,984	2,319
BN	2,271	2,281	2,309	2,309	2,926	2,713	2,466	5,812	5,502	2,509	1,950	1,492	1,470	1,819
D	2,756	2,405	2,259	2,280	2,574	2,399	1,991	4,350	4,165	1,966	1,437	1,261	1,380	1,785
C	2,087	2,057	1,815	1,618	2,022	1,811	1,326	2,187	2,227	1,365	1,021	900	1,040	1,427
All	2,484	2,555	3,366	4,794	6,452	6,324	5,163	6,834	6,967	5,113	4,628	3,255	2,113	2,366

Vernalis Flow - Average Year Type cfs Ranked by SJR Index 60-20-20 Near-future

	Oct	Nov	Dec	Jan	Feb	Mar	Apr 1-14	Apr 15-30	May 1-15	May 16-31	Jun	Jul	Aug	Sep
Wet	2,665	2,869	4,559	8,994	12,640	14,144	12,630	13,881	12,814	11,744	12,132	7,770	3,683	3,702
AN	2,747	3,454	5,046	5,589	6,990	6,326	6,745	8,741	7,133	4,247	2,867	1,948	1,993	2,364
BN	2,337	2,474	2,409	2,423	3,001	3,413	4,663	6,248	5,903	2,592	1,994	1,499	1,477	1,844
D	2,852	2,642	2,387	2,413	2,662	3,002	3,506	4,446	4,301	2,012	1,491	1,270	1,387	1,810
C	2,157	2,253	1,921	1,742	2,130	2,222	1,611	2,212	2,245	1,427	1,070	903	1,044	1,444
All	2,560	2,764	3,454	4,830	6,377	6,824	6,622	7,895	7,198	5,274	4,871	3,269	2,125	2,406

Difference Near-future minus Current

Vernalis Flow - Average Year Type cfs Ranked by SJR Index 60-20-20

	Oct	Nov	Dec	Jan	Feb	Mar	Apr 1-14	Apr 15-30	May 1-15	May 16-31	Jun	Jul	Aug	Sep
Wet	76	215	21	-146	-422	255	1,398	2,041	255	289	690	25	22	67
AN	72	205	128	78	5	714	2,078	1,920	345	229	82	19	10	45
BN	66	192	100	114	75	700	2,197	436	401	83	44	6	6	25
D	96	237	128	134	88	603	1,515	96	136	46	53	8	7	25
C	70	196	107	123	108	410	285	25	18	62	49	3	5	17
All	75	209	88	36	-75	501	1,459	1,061	231	162	243	14	11	40

Table 4.1.2
Quality at Vernalis, San Joaquin River – Current and Near-future

Vernalis Quality - Average Year Type µmhos Ranked by SJR Index 60-20-20 Current

	Oct	Nov	Dec	Jan	Feb	Mar	Apr 1-14	Apr 15-30	May 1-15	May 16-31	Jun	Jul	Aug	Sep
Wet	571	593	717	596	471	401	324	296	277	325	385	480	426	427
AN	560	575	700	659	538	537	451	339	314	447	548	646	564	534
BN	595	602	777	802	875	882	589	332	344	578	632	661	619	590
D	539	582	778	785	905	926	657	398	404	659	694	686	635	596
C	625	641	831	890	1,032	995	703	559	557	722	702	684	671	646
All	578	599	755	728	726	703	518	378	370	519	567	613	565	543

Vernalis Quality - Average Year Type µmhos Ranked by SJR Index 60-20-20 Near-future

	Oct	Nov	Dec	Jan	Feb	Mar	Apr 1-14	Apr 15-30	May 1-15	May 16-31	Jun	Jul	Aug	Sep
Wet	566	562	699	592	483	391	294	265	272	313	372	479	426	423
AN	555	549	679	641	536	490	370	305	308	440	551	647	564	532
BN	590	577	755	774	864	759	418	327	334	571	634	662	620	590
D	533	551	750	754	892	821	510	398	401	660	696	687	636	597
C	620	612	802	843	997	936	693	566	560	703	699	686	672	649
All	573	570	732	705	719	643	441	362	365	510	563	614	565	542

Difference Near-future minus Current

Vernalis Quality - Average Year Type µmhos Ranked by SJR Index 60-20-20

	Oct	Nov	Dec	Jan	Feb	Mar	Apr 1-14	Apr 15-30	May 1-15	May 16-31	Jun	Jul	Aug	Sep
Wet	-5	-31	-18	-4	12	-10	-30	-31	-5	-12	-13	-1	-1	-4
AN	-4	-26	-21	-18	-2	-47	-81	-35	-7	-7	3	1	0	-2
BN	-5	-25	-22	-27	-11	-123	-171	-5	-10	-7	2	1	1	0
D	-6	-31	-28	-32	-13	-105	-147	0	-3	1	2	1	1	1
C	-5	-29	-29	-47	-36	-59	-10	7	3	-19	-3	2	1	2
All	-5	-29	-23	-23	-8	-60	-77	-15	-4	-10	-3	1	0	-1

5. Unimpaired Flow Data

5.1 San Joaquin River Basin

The Department of Water Resources periodically estimates and publishes unimpaired flows for California Central Valley subbasins and the Sacramento-San Joaquin Delta. The latest published edition of these estimates appears in "California Central Valley Unimpaired Flow Data, Fourth Edition, Bay-Delta Office Department of Water Resources, November 2006". In its 2006 report, DWR describes unimpaired flow to be:

> "... runoff that would have occurred had water flow remained unaltered in rivers and streams instead of stored in reservoirs, imported, exported, or diverted. The data is a measure of the total water supply available for all uses after removing the impacts of most upstream alterations as they occurred over the years. Alterations such as channel improvements, levees, and flood bypasses are assumed to exist."

Table 5.1.1 presents a calculation of unimpaired flow by water year for the San Joaquin River at Vernalis which is the sum of several computational locations:

- UF 16 – Stanislaus River at Melones Reservoir
- UF 17 – San Joaquin River Floor
- UF 18 – Tuolumne River at Don Pedro Reservoir
- UF 19 – Merced River at Exchequer Reservoir
- UF 20 – Chowchilla River at Buchanan Reservoir
- UF 21 – Fresno River near Dalton
- UF 22 – San Joaquin River at Millerton Reservoir
- UF 23 – Tulare Lake Basin Outflow

The computation of each of these components of flow for the period 1921 through 2003 is described in the DWR report. The record was extended by me through water year 2008 by extraction of data from the California Data Exchange Center (CDEC).[2] UF 17 data were extended by a procedure similarly used by DWR. Also indicated in Table 5.1.1 is the San Joaquin River Basin Index for each year. Table 5.1.2 presents the same data arranged by calendar year, rank-ordered by San Joaquin Valley Index, from the wettest year to the driest year.

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[2] The extracted DWR data through 2003 and the extension of the data are provided in the accompanying spreadsheet "San_Joaquin_River_Vernalis_Unimpaired_Flow_Data_1921_2008(Steiner).xls".

Table 5.1.1
Historical Unimpaired Flow at Vernalis , San Joaquin River and SJR Index

	1,000 Acre-feet													SJR Index	
WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total	Index maf	Type
1921	96	153	212	577	487	734	824	1,399	1,413	340	64	31	6,330	3.23	AN
1922	24	26	247	281	777	656	833	2,491	2,535	652	129	44	8,695	4.54	W
1923	36	98	445	411	304	370	952	1,796	970	495	102	69	6,048	3.55	AN
1924	83	49	50	66	112	121	376	550	76	38	11	7	1,539	1.42	C
1925	36	126	138	128	642	492	1,062	1,602	993	359	102	29	5,709	2.93	BN
1926	51	51	85	65	323	373	1,229	1,012	325	79	22	13	3,628	2.30	D
1927	18	221	221	213	838	594	1,147	1,665	1,506	460	97	38	7,018	3.56	AN
1928	55	267	143	164	264	974	851	1,276	464	100	28	12	4,598	2.63	BN
1929	13	30	55	64	122	273	442	1,085	633	153	30	8	2,908	2.00	C
1930	11	13	55	115	198	433	720	797	777	155	35	16	3,325	2.02	C
1931	31	51	33	71	113	174	422	587	154	36	15	9	1,676	1.20	C
1932	12	23	409	304	911	571	846	1,715	1,644	566	114	36	7,151	3.41	AN
1933	30	19	40	95	107	264	538	788	1,227	247	54	27	3,436	2.44	D
1934	12	29	132	173	255	437	550	421	240	56	22	18	2,345	1.44	C
1935	33	112	141	387	339	492	1,567	1,781	1,568	361	91	29	6,891	3.56	AN
1936	37	53	55	259	1,332	699	1,324	1,730	1,110	376	82	22	7,079	3.74	AN
1937	26	33	103	133	1,233	847	1,073	2,308	1,336	338	70	21	7,521	3.90	W
1938	28	47	936	373	1,354	2,151	1,628	2,767	2,717	1,031	246	88	13,366	5.89	W
1939	124	125	106	128	180	430	879	645	262	83	35	41	3,038	2.20	D
1940	115	48	54	761	866	1,106	1,111	1,900	1,031	207	46	13	7,258	3.36	AN
1941	31	41	443	463	954	1,065	1,074	2,395	1,890	773	156	43	9,328	4.43	W
1942	47	101	502	594	549	554	1,142	1,674	2,044	766	134	35	8,142	4.44	W
1943	29	218	248	851	607	1,482	1,391	1,687	1,068	442	106	29	8,158	4.03	W
1944	35	50	67	122	257	467	509	1,404	820	314	61	20	4,126	2.76	BN
1945	30	249	224	173	1,132	674	996	1,635	1,486	541	120	37	7,297	3.59	AN
1946	162	274	630	375	223	520	1,138	1,556	804	243	61	27	6,013	3.30	AN
1947	74	222	272	149	252	408	616	1,061	371	89	22	17	3,553	2.18	D
1948	87	66	49	99	90	235	686	1,394	1,278	287	46	20	4,337	2.70	BN
1949	25	33	59	66	120	397	908	1,373	740	131	40	21	3,913	2.53	BN
1950	20	43	46	221	403	384	1,061	1,432	905	216	40	19	4,790	2.85	BN
1951	56	1,535	1,668	549	483	547	783	1,100	756	236	55	17	7,785	3.14	AN
1952	35	78	376	839	491	965	1,508	2,856	2,076	926	219	68	10,437	5.17	W
1953	38	53	175	428	196	310	814	798	1,132	483	68	25	4,520	3.03	BN
1954	26	51	66	126	285	631	1,093	1,388	571	161	29	14	4,441	2.72	BN
1955	17	49	130	199	181	262	452	1,150	930	177	38	13	3,598	2.30	D
1956	16	40	2,208	1,389	619	622	957	1,881	1,777	766	171	65	10,511	4.46	W
1957	66	77	73	99	310	451	553	1,216	1,218	251	57	25	4,396	3.01	BN
1958	45	62	138	187	565	969	1,649	2,669	1,928	729	220	75	9,236	4.77	W
1959	40	40	35	183	369	388	702	674	412	82	22	120	3,067	2.21	D
1960	35	27	33	71	325	416	719	859	447	77	24	14	3,047	1.85	C
1961	15	60	97	61	124	204	488	610	352	57	45	19	2,132	1.38	C
1962	19	33	69	190	809	448	1,256	1,227	1,369	429	83	28	5,960	3.07	BN
1963	54	32	67	318	989	379	841	1,732	1,399	580	130	56	6,577	3.57	AN
1964	62	272	141	156	142	220	510	915	616	137	46	24	3,241	2.19	D
1965	28	142	1,415	1,004	454	470	1,091	1,475	1,448	692	303	79	8,601	3.81	W
1966	39	379	274	261	231	458	952	1,075	323	95	42	25	4,154	2.51	BN
1967	28	137	741	431	391	1,027	1,287	2,464	2,671	1,616	314	116	11,223	5.25	W
1968	54	52	102	135	371	364	583	809	394	86	43	23	3,016	2.21	D
1969	38	183	242	2,054	1,459	1,319	1,978	3,563	2,663	1,180	255	72	15,006	6.09	W
1970	113	115	277	1,176	433	668	540	1,271	918	265	79	32	5,887	3.18	AN
1971	28	189	358	352	291	443	650	1,079	1,180	358	86	37	5,051	2.89	BN
1972	25	95	238	175	220	562	492	1,019	606	106	30	70	3,638	2.16	D
1973	49	104	215	445	741	695	908	2,184	1,239	246	83	30	6,939	3.50	AN
1974	56	425	405	628	258	871	1,077	1,897	1,391	392	124	42	7,566	3.90	W
1975	46	51	114	153	487	746	608	1,880	1,847	455	101	59	6,547	3.85	W
1976	176	140	96	58	124	219	313	577	137	62	59	62	2,023	1.57	C
1977	39	27	17	33	45	65	204	266	299	40	16	10	1,061	0.84	C
1978	9	27	263	713	902	1,381	1,606	2,345	2,267	1,045	276	303	11,137	4.58	W
1979	78	89	101	496	571	853	901	1,991	963	252	85	38	6,418	3.67	AN
1980	74	108	142	1,692	1,442	1,124	1,129	1,731	1,762	1,070	229	84	10,587	4.73	W
1981	55	42	82	168	201	380	754	977	486	96	46	33	3,320	2.44	D
1982	64	401	550	792	1,249	1,216	2,572	2,535	1,745	953	292	346	12,715	5.45	W
1983	426	676	1,150	1,323	1,665	2,585	1,460	2,717	3,792	2,151	731	261	18,937	7.22	W
1984	263	981	1,254	773	482	635	714	1,600	864	345	108	44	8,063	3.69	AN
1985	78	220	149	134	228	380	926	997	420	95	43	45	3,715	2.40	D
1986	68	148	249	378	2,311	1,966	1,384	1,941	1,643	478	139	81	10,786	4.31	W
1987	63	30	45	52	137	287	569	624	242	60	34	17	2,160	1.86	C
1988	35	76	104	193	169	310	499	627	337	105	42	19	2,516	1.48	C
1989	21	46	75	93	158	719	947	858	523	108	34	36	3,618	1.96	C
1990	109	76	62	108	138	363	645	523	322	112	25	11	2,494	1.51	C
1991	14	17	18	23	24	538	510	987	874	231	53	28	3,317	1.96	C
1992	46	69	58	81	339	341	711	635	170	166	44	21	2,681	1.56	C
1993	31	46	135	1,052	593	1,049	1,144	2,146	1,659	719	177	83	8,834	4.20	W
1994	57	41	65	73	164	291	545	820	371	89	50	28	2,594	2.05	C
1995	75	156	160	1,152	497	2,237	1,458	2,468	2,734	2,088	515	139	13,679	5.95	W
1996	60	41	209	385	1,168	998	1,158	1,947	1,141	420	108	37	7,672	4.12	W
1997	37	352	1,374	3,810	879	782	952	1,600	845	242	122	53	11,048	4.13	W
1998	47	70	114	650	1,387	1,149	1,473	1,876	3,048	1,951	500	169	12,434	5.65	W
1999	90	143	195	380	726	490	784	1,682	1,151	302	96	63	6,102	3.59	AN
2000	39	58	41	388	974	802	1,037	1,655	938	213	94	51	6,290	3.38	AN
2001	57	55	62	103	193	531	681	1,276	234	78	24	18	3,312	2.20	D
2002	22	97	281	304	238	417	921	1,095	630	109	32	17	4,163	2.34	D
2003	10	198	220	264	224	406	663	1,571	1,102	202	93	40	4,993	2.81	BN
2004	17	44	206	208	344	753	808	894	438	122	38	18	3,890	2.21	D
2005	129	143	223	842	588	1,016	961	2,725	1,903	834	155	58	9,577	4.75	W
2006	55	56	666	820	495	1,027	2,414	3,050	2,207	696	140	67	11,693	5.90	W
2007	59	59	106	101	273	440	539	677	192	61	36	26	2,569	1.97	C
2008	30	20	57	259	345	376	612	1,107	617	146	36	21	3,626	2.07	C

Table 5.1.2
Historical Unimpaired Flow at Vernalis , San Joaquin River and SJR Index

	1,000 Acre-feet													SJR Index	
Cal Yr	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Index maf	Type
1921	577	487	734	824	1,399	1,413	340	64	31	24	26	247	6,166	3.23	AN
1922	281	777	656	833	2,491	2,535	652	129	44	36	98	445	8,977	4.54	W
1923	411	304	370	952	1,796	970	495	102	69	83	49	50	5,651	3.55	AN
1924	66	112	121	376	550	76	38	11	7	36	126	138	1,657	1.42	C
1925	128	642	492	1,062	1,602	993	359	102	29	51	51	85	5,596	2.93	BN
1926	65	323	373	1,229	1,012	325	79	22	13	18	221	221	3,901	2.30	D
1927	213	838	594	1,147	1,665	1,506	460	97	38	55	267	143	7,023	3.56	AN
1928	164	264	974	851	1,276	464	100	28	12	13	30	55	4,231	2.63	BN
1929	64	122	273	442	1,085	633	153	30	8	11	13	55	2,889	2.00	C
1930	115	198	433	720	797	777	155	35	16	31	51	33	3,361	2.02	C
1931	71	113	174	422	567	154	36	15	9	12	23	409	2,005	1.20	C
1932	304	911	571	846	1,715	1,644	566	114	36	30	19	40	6,796	3.41	AN
1933	95	107	264	538	788	1,227	247	54	27	12	29	132	3,520	2.44	D
1934	173	255	437	550	421	240	56	22	18	33	112	141	2,458	1.44	C
1935	387	339	492	1,567	1,781	1,568	351	91	29	37	53	55	6,750	3.56	AN
1936	259	1,332	699	1,324	1,730	1,110	376	82	22	26	33	103	7,096	3.74	AN
1937	133	1,233	847	1,073	2,308	1,336	338	70	21	28	47	936	8,370	3.90	W
1938	373	1,354	2,151	1,628	2,767	2,717	1,031	246	88	124	125	106	12,710	5.89	W
1939	128	180	430	879	645	262	83	35	41	115	48	54	2,900	2.20	D
1940	761	866	1,106	1,111	1,900	1,031	207	46	13	31	41	443	7,556	3.36	AN
1941	463	954	1,065	1,074	2,395	1,890	773	156	43	47	101	502	9,463	4.43	W
1942	594	549	554	1,142	1,674	2,044	766	134	35	29	218	248	7,987	4.44	W
1943	851	607	1,482	1,391	1,687	1,068	442	106	29	35	50	67	7,815	4.03	W
1944	122	257	467	509	1,404	820	314	61	20	30	249	224	4,477	2.76	BN
1945	173	1,132	674	996	1,635	1,486	541	120	37	162	274	630	7,860	3.59	AN
1946	375	223	520	1,138	1,556	804	243	61	27	74	222	272	5,515	3.30	AN
1947	149	252	408	618	1,061	371	89	22	17	87	66	49	3,187	2.18	D
1948	99	90	235	686	1,394	1,278	287	46	20	25	33	59	4,252	2.70	BN
1949	66	120	397	908	1,373	740	131	40	21	20	43	46	3,905	2.53	BN
1950	221	403	384	1,061	1,432	905	216	40	19	56	1,535	1,668	7,940	2.85	BN
1951	549	483	547	783	1,100	756	236	55	17	35	78	376	5,015	3.14	AN
1952	839	491	965	1,508	2,856	2,076	926	219	68	38	53	175	10,214	5.17	W
1953	428	196	310	814	798	1,132	483	68	25	26	51	66	4,397	3.03	BN
1954	126	285	631	1,093	1,388	571	161	29	14	17	49	130	4,494	2.72	BN
1955	199	181	262	452	1,150	930	177	38	13	16	40	2,208	5,666	2.30	D
1956	1,389	619	622	957	1,881	1,777	766	171	65	66	77	73	8,463	4.46	W
1957	99	310	451	553	1,216	1,218	251	57	25	45	62	138	4,425	3.01	BN
1958	187	565	969	1,649	2,669	1,928	729	220	75	40	40	35	9,106	4.77	W
1959	183	369	388	702	674	412	82	22	120	35	27	33	3,047	2.21	D
1960	71	325	416	719	859	447	77	24	14	15	60	97	3,124	1.85	C
1961	61	124	204	488	610	352	57	45	19	19	33	69	2,081	1.38	C
1962	190	809	448	1,256	1,227	1,369	429	83	28	54	32	67	5,992	3.07	BN
1963	318	989	379	841	1,732	1,399	580	130	56	62	272	141	6,899	3.57	AN
1964	156	142	220	510	915	616	137	46	24	28	142	1,415	4,351	2.19	D
1965	1,004	454	470	1,091	1,475	1,448	692	303	79	39	379	274	7,708	3.81	W
1966	261	231	458	952	1,075	323	95	42	25	28	137	741	4,368	2.51	BN
1967	431	391	1,027	1,287	2,464	2,671	1,616	314	116	54	52	102	10,525	5.25	W
1968	135	371	364	583	809	394	86	43	23	38	183	242	3,271	2.21	D
1969	2,054	1,459	1,319	1,978	3,563	2,663	1,180	255	72	113	115	277	15,048	6.09	W
1970	1,176	433	668	540	1,271	918	265	79	32	28	189	358	5,957	3.18	AN
1971	352	291	443	650	1,079	1,180	358	86	37	25	95	238	4,834	2.89	BN
1972	175	220	562	492	1,019	606	106	30	70	49	104	215	3,648	2.16	D
1973	445	741	695	908	2,184	1,239	246	83	30	56	425	405	7,457	3.50	AN
1974	628	258	871	1,077	1,897	1,391	392	124	42	46	51	114	6,891	3.90	W
1975	153	487	746	608	1,880	1,847	455	101	59	176	140	96	6,748	3.85	W
1976	58	124	219	313	577	137	62	59	62	39	27	17	1,694	1.57	C
1977	33	45	65	204	266	299	40	16	10	9	27	263	1,277	0.84	C
1978	713	902	1,381	1,606	2,345	2,267	1,045	276	303	78	89	101	11,106	4.58	W
1979	496	571	853	901	1,991	963	252	85	38	74	108	142	6,474	3.67	AN
1980	1,692	1,442	1,124	1,129	1,731	1,762	1,070	229	84	55	42	82	10,442	4.73	W
1981	168	201	380	754	977	486	96	46	33	64	401	550	4,156	2.44	D
1982	792	1,249	1,216	2,572	2,535	1,745	953	292	346	426	676	1,150	13,952	5.45	W
1983	1,323	1,665	2,585	1,460	2,717	3,792	2,151	731	261	263	981	1,254	19,183	7.22	W
1984	773	482	635	714	1,600	864	345	108	44	78	220	149	6,012	3.69	AN
1985	134	228	380	926	997	420	95	43	45	68	148	249	3,733	2.40	D
1986	378	2,311	1,966	1,384	1,941	1,643	478	139	81	63	30	45	10,459	4.31	W
1987	52	137	287	569	624	242	60	34	17	35	76	104	2,237	1.86	C
1988	193	169	310	499	627	337	105	42	19	21	46	75	2,443	1.48	C
1989	93	158	719	947	858	523	108	34	36	109	76	62	3,723	1.96	C
1990	108	138	363	645	523	322	112	25	11	14	17	18	2,296	1.51	C
1991	23	24	538	510	987	874	231	53	28	46	69	58	3,441	1.96	C
1992	81	339	341	711	635	170	166	44	21	31	46	135	2,720	1.56	C
1993	1,052	593	1,049	1,144	2,146	1,659	719	177	83	57	41	65	8,785	4.20	W
1994	73	164	291	545	820	371	89	50	28	75	156	160	2,822	2.05	C
1995	1,152	497	2,237	1,458	2,468	2,734	2,088	515	139	60	41	209	13,598	5.95	W
1996	385	1,168	998	1,158	1,947	1,141	420	108	37	37	352	1,374	9,125	4.12	W
1997	3,810	879	782	952	1,600	845	242	122	53	47	70	114	9,516	4.13	W
1998	650	1,387	1,149	1,473	1,876	3,048	1,951	500	169	90	143	195	12,631	5.65	W
1999	380	726	490	784	1,682	1,151	302	96	63	39	58	41	5,812	3.59	AN
2000	388	974	802	1,037	1,655	938	213	94	51	57	55	62	6,326	3.38	AN
2001	103	193	531	681	1,276	234	78	24	18	22	97	281	3,538	2.20	D
2002	304	238	417	921	1,095	630	109	32	17	10	198	220	4,191	2.34	D
2003	264	224	406	663	1,571	1,102	202	93	40	17	44	206	4,832	2.81	BN
2004	208	344	753	808	894	438	122	38	18	129	143	223	4,118	2.21	D
2005	842	588	1,016	961	2,725	1,903	834	155	58	55	56	666	9,859	4.75	W
2006	820	495	1,027	2,414	3,050	2,207	696	140	67	59	59	106	11,140	5.90	W
2007	101	273	440	539	677	192	61	36	26	30	20	57	2,452	1.97	C
2008	259	345	376	612	1,107	617	146	36	21	22	150	80	3,771	2.07	C

5.2 Sampling of Daily Unimpaired Flow

Procedures have been developed by DWR and others to estimate the unimpaired flow for various locations in California. Various forms of this data occur, ranging from a post-processing of recorded data to develop a record of what has already occurred, to estimating unimpaired flow that is yet to occur based on currently occurring and projected meteorological events. The foregoing section (Section 5.1) illustrates one form of estimated unimpaired data, namely a long-term record of data assembled as a monthly volume. A finer gradation of data may be need in some circumstances to capture the rate of change of hydrology within a month. The following provides an example of a calculation of daily unimpaired flow for the San Joaquin River.

For this illustration, the unimpaired flow of the San Joaquin River at Vernalis will be conceptually the sum of the flow components: 1) unimpaired flows at the "rim" reservoirs at the foothill elevation (e.g., San Joaquin River at Friant, Merced River below Merced Falls, Tuolumne River below La Grange Reservoir, Stanislaus River below Goodwin Reservoir, and other less substantial watersheds), 2) runoff from the San Joaquin Valley floor (area below the "rim"), 3) runoff for streams along the west side of the San Joaquin Valley, and 4) overflow from the Kings River Basin.

Comparable to the record of monthly unimpaired volume provided in Section 5.1, Figure 5.1.1 depicts the unimpaired flow above Vernalis on a daily basis for the years 2003 through 2007. The data generally represent the same "control points" described above for the computation of unimpaired flow at Vernalis, except for an inclusion of Calaveras River runoff and the exclusion of James Bypass flow from the Kings River Basin.[3]

The sum of the four watersheds' unimpaired runoff at the rim locations can be a surrogate of the unimpaired flow at Vernalis, particularly during the late snowmelt season. As described above, the unimpaired runoff at Vernalis would be comprised of several additional components. However, these other components may be minor during the season in question. Runoff during this season from the Valley floor or from the other minor streams within the basin originate their runoff primarily from precipitation events as compared to the runoff of the four major watersheds that originate their runoff during this season from snowmelt. By late May and June, these other sources of runoff diminish to a couple of 100 cfs or less, and this runoff could easily be depleted by infiltration to the ground within the local watersheds, upstream of Vernalis. Net groundwater accretion to the rivers is comparably small in comparison to the snowmelt runoff component, and there would be some use of water by vegetation along the streams.

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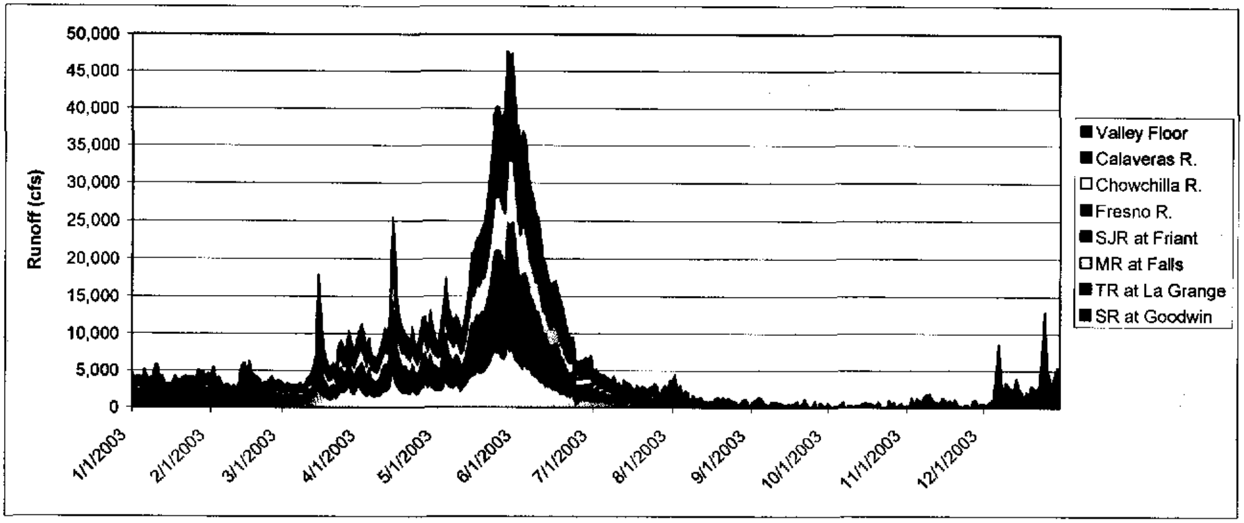
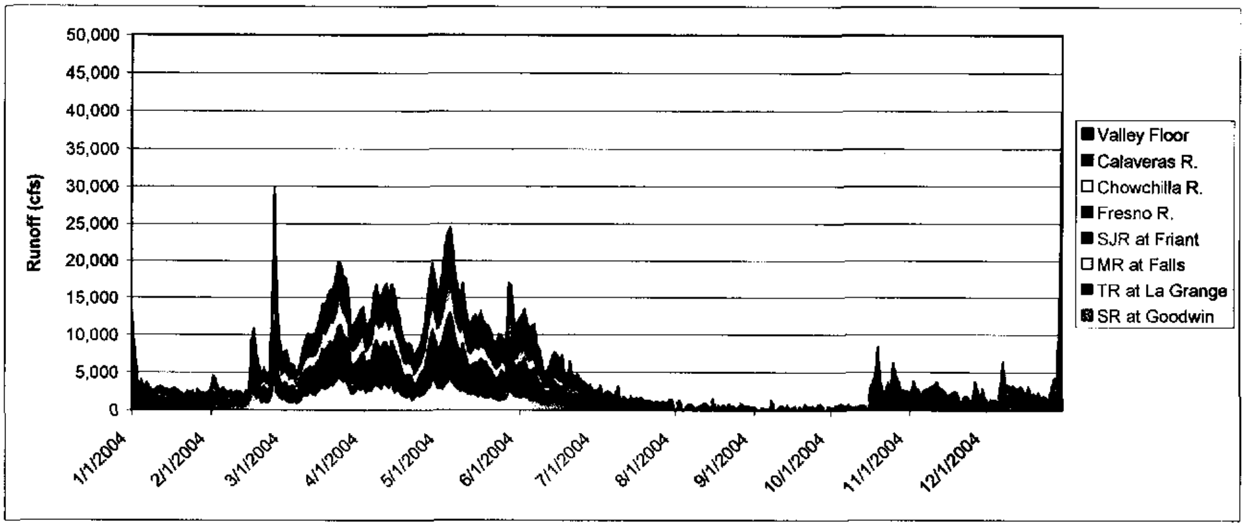
[3] Friant: USBR; Fresno, Chowchilla and Calaveras: USCOE; Merced and Tuolumne: CDEC; Stanislaus: USBR and CDEC; and Valley Floor: computation. Data used for Figure 5.1.1 exists in attached spreadsheet "Daily_Unimpaired_2003_2007(Steiner).wks".

Figure 5.2.1 (1 of 2)
Historical Unimpaired Daily Flow above Vernalis , San Joaquin River

2003 SJRB Index 2.81 BN



2004 SJRB Index 2.21 D



2005 SJRB Index 4.75 W

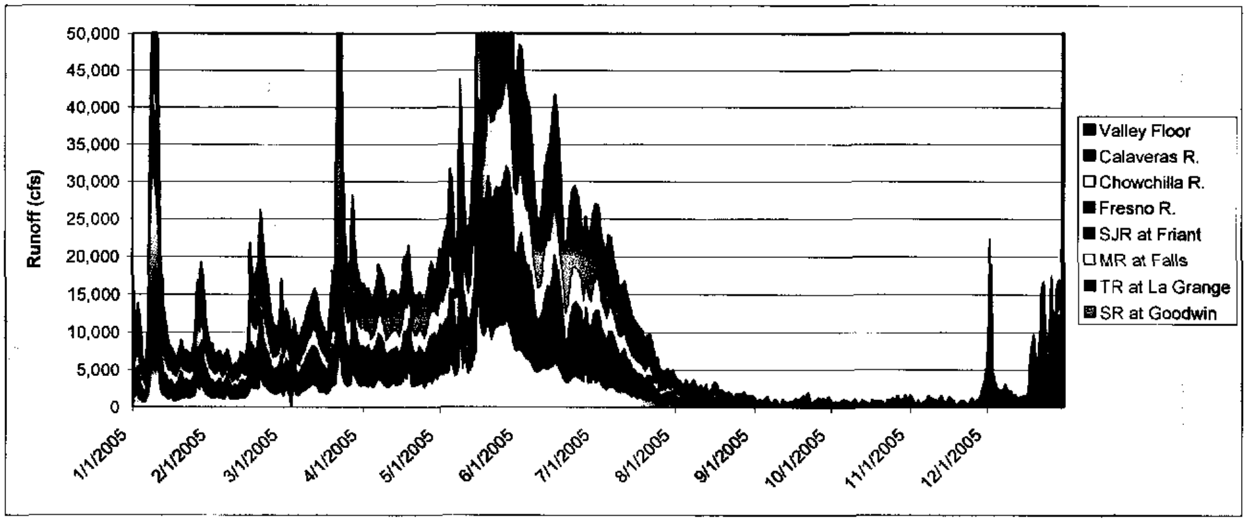
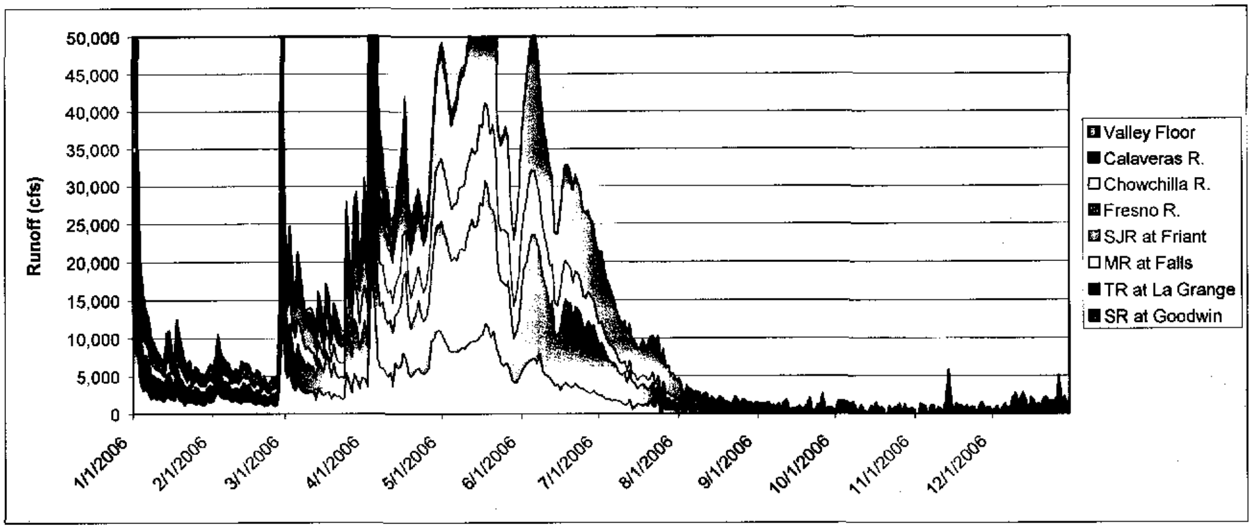
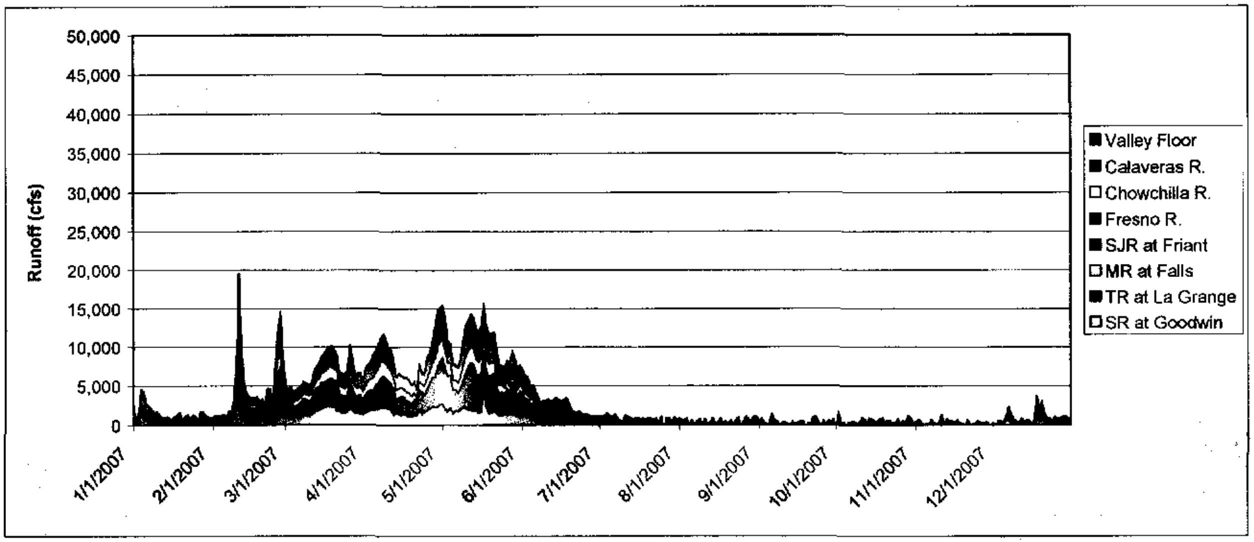


Figure 5.2.1 (2 of 2)
Historical Unimpaired Daily Flow above Vernalis , San Joaquin River

2006 **SJRB Index 5.90 W**



2007 *SJRB Index 1.97 C*



6. Recorded Hydrologic Data

Hydrologic data can be acquired from numerous public sources. The periodicity of the data can range from grab samples and events to summaries of daily, monthly or annual records. A few of the web-accessed sites that report hydrologic data include:

United States Bureau of Reclamation:

http://www.usbr.gov/mp/cvo/

United States Geological Survey (USGS):

http://waterdata.usgs.gov/ca/nwis/

California Data Exchange Center (CDEC):

http://cdec.water.ca.gov/

United States Army Corps of Engineers (USCOE):

http://www.spk-wc.usace.army.mil/plots/plot_menu_ca.html

For any data accessed it is advisable to research the record and understand the original source of the information, its reliability, and its representation as either a preliminary or "final" state of information. For instance, the California Data Exchange Center receives records and reports data from many sources on a daily basis. The original source of the information may at a later date revise the data. CDEC does not in all instances become aware of these changes and may not subsequently modify its database.

6.1 Measured Vernalis Flow Data

An example of data acquired from public sources is the mean monthly flow reported for the San Joaquin River at Vernalis. This USGS record can be accessed at "http://waterdata.usgs.gov/nwis/monthly/?referred_module=sw&site_no=11303500&por_11303500_4=2208959,00060,4,1923-10,2008-10&format=html_table&date_format=YYYY-MM-DD&rdb_compression=file&submitted_form=parameter_selection_list". Table 6.1.1 illustrates the data reported for the period 1924 through 2008. Some of the data for the latest dates of the record are considered preliminary and subject to change.[4]

6.2 Measured Vernalis Quality Data

A record of recent daily mean water quality of Vernalis can be acquired from Reclamation's website "http://www.usbr.gov/mp/cvo/". Reclamation is the source of this data which is submitted to other reporting agencies. Table 6.2.1 illustrates a summary of water quality data at Vernalis for the period 1963 through 2008. The data represent the mean monthly value of EC (µmhos) at the location.[5]

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[4] The data are included in the accompanying spreadsheet: Vernalis_Unimpaired_and_Recorded_Data_1921_2008(Steiner).xls

[5] The data are included in the accompanying spreadsheet: Vernalis_Unimpaired_and_Recorded_Data_1921_2008(Steiner).xls

Table 6.1.1
Measured Mean Monthly Flow at Vernalis, San Joaquin River - cfs

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1924	2,592	1,316	1,573	1,478	1,399	1,035	1,476	1,276	575	420	420	417
1925												
1926												
1927												
1928												
1929												
1930	1,408	1,234	1,285	1,799	1,701	2,454	2,581	2,214	2,754	1,237	920	1,433
1931	1,669	1,644	1,914	1,546	1,602	881	389	444	392	233	228	320
1932	478	643	1,251	3,340	10,770	4,887	4,814	11,590	15,100	5,793	1,164	1,067
1933	1,671	1,897	1,869	2,007	3,005	1,737	1,147	1,384	5,308	1,114	666	1,150
1934	1,534	1,528	2,409	2,745	2,240	1,695	702	639	627	395	384	501
1935	849	1,291	1,606	3,638	3,535	4,075	14,760	16,380	15,780	2,698	995	1,350
1936	2,033	1,939	2,535	3,304	12,410	14,170	13,020	16,780	11,120	3,048	1,121	1,281
1937	1,890	1,960	2,855	3,291	12,390	13,210	14,460	20,050	15,560	3,260	1,129	1,396
1938	1,899	1,979	5,308	6,199	23,420	34,150	22,410	28,350	36,650	14,610	3,359	2,224
1939	2,665	3,798	3,700	4,091	4,171	2,026	2,467	2,036	991	756	715	1,033
1940	1,485	1,436	1,586	4,131	8,582	14,950	16,910	14,300	10,850	1,995	1,186	1,688
1941	1,604	1,715	3,012	7,134	13,110	21,170	17,090	21,280	22,300	9,142	2,095	1,686
1942	2,199	2,329	4,776	8,431	12,730	8,675	13,410	16,530	22,240	7,776	1,685	1,916
1943	2,237	2,333	4,366	5,647	13,070	23,120	18,060	14,970	11,650	2,208	1,542	1,689
1944	2,108	1,952	2,388	2,689	2,861	4,793	2,300	3,827	3,384	1,245	1,091	1,199
1945	1,648	2,473	3,788	3,864	10,860	9,216	8,987	13,920	11,320	3,880	1,780	2,031
1946	2,759	3,483	5,733	9,510	5,955	3,734	6,015	13,060	5,783	1,465	1,224	1,483
1947	1,615	2,616	3,617	2,782	2,407	2,260	1,487	2,046	943	527	569	1,074
1948	1,314	1,773	1,695	1,384	827	599	1,393	5,001	8,606	1,328	725	1,088
1949	1,549	1,492	1,487	1,741	1,415	3,469	2,058	3,530	2,003	563	602	715
1950	1,267	1,582	1,571	1,998	3,542	2,205	5,367	5,012	5,014	687	621	946
1951	1,324	8,102	25,130	10,280	10,810	7,769	2,652	6,525	3,336	870	760	1,035
1952	1,785	1,763	3,136	8,851	11,510	13,750	20,200	27,640	23,340	3,498	1,355	1,620
1953	1,866	2,176	3,664	5,947	3,674	1,162	1,520	3,059	4,914	1,604	748	1,093
1954	1,630	1,662	1,762	1,656	2,359	4,459	5,059	6,716	1,286	542	546	754
1955	1,043	1,386	1,814	2,965	2,451	1,561	917	1,150	1,496	416	431	610
1956	799	1,071	10,910	27,050	17,280	7,486	6,261	13,980	12,250	3,483	1,902	1,885
1957	1,999	2,212	2,505	1,921	1,763	3,054	1,326	2,581	3,759	875	753	1,149
1958	2,056	2,248	2,494	2,421	5,434	12,090	27,920	22,420	15,620	4,092	1,535	2,242
1959	2,835	3,632	2,955	2,332	3,268	2,069	812	791	533	312	402	786
1960	877	1,051	1,184	1,395	1,722	595	517	618	293	222	268	385
1961	713	1,013	1,287	1,338	1,118	444	200	380	207	104	151	321
1962	410	593	712	804	5,778	5,933	2,085	2,621	3,497	856	694	993
1963	1,454	1,643	2,435	1,754	8,185	2,607	8,616	9,339	6,663	1,822	1,095	1,515
1964	2,677	3,021	3,533	2,872	1,697	929	764	703	650	383	440	900
1965	1,411	2,355	6,037	14,380	7,927	5,326	9,859	5,296	5,650	1,973	1,221	1,678
1966	2,944	3,644	6,233	5,268	4,091	1,915	982	863	570	440	500	725
1967	1,101	1,330	4,375	3,208	6,363	6,536	14,490	20,360	20,000	10,450	2,021	2,029
1968	2,725	3,473	3,635	2,940	2,617	3,093	1,435	891	592	503	768	938
1969	1,384	1,604	2,533	13,810	32,550	30,870	22,120	24,610	27,890	5,803	2,325	3,255
1970	4,462	4,628	4,012	11,120	9,191	7,180	1,673	2,393	2,704	1,330	1,044	1,319
1971	1,466	1,655	5,044	5,204	4,391	2,589	1,961	1,833	2,322	1,066	892	1,097
1972	2,253	1,646	2,398	3,117	2,701	1,380	1,037	744	587	481	543	1,563
1973	1,992	2,216	2,502	4,059	7,988	7,611	4,203	2,937	2,576	1,082	1,067	1,471
1974	2,546	2,281	3,586	7,781	5,094	4,817	5,850	4,106	3,860	1,636	1,615	2,846
1975	3,497	3,891	4,162	3,766	6,212	5,685	3,957	3,972	5,708	1,718	1,680	2,652
1976	4,543	3,906	3,745	3,326	2,115	1,823	1,293	939	798	671	1,055	1,067
1977	1,274	1,136	965	1,091	789	524	212	400	118	93	124	179
1978	246	430	506	2,276	7,319	11,470	20,030	19,120	7,069	1,908	1,418	2,730
1979	3,327	3,498	2,812	5,233	7,138	8,652	3,506	2,524	2,254	1,334	1,451	1,841
1980	2,790	2,311	2,487	13,070	18,780	25,300	10,250	9,912	5,305	3,384	1,969	3,802
1981	4,072	3,278	2,949	3,251	2,879	3,122	2,532	1,967	1,499	1,265	1,269	1,181
1982	1,386	1,564	1,852	3,889	6,845	10,060	22,960	18,650	7,584	6,163	4,017	6,129
1983	8,179	6,974	16,490	19,070	31,600	40,040	36,450	31,770	26,080	19,230	9,035	11,310
1984	13,320	10,680	19,130	25,630	10,830	7,502	4,285	3,240	2,297	1,904	2,179	2,917
1985	3,814	2,822	4,771	4,065	3,241	2,736	2,466	2,132	1,748	2,557	2,601	1,925
1986	2,072	1,929	2,205	2,060	8,744	25,040	19,590	8,764	6,233	2,894	3,183	4,181
1987	3,741	2,808	3,706	2,305	2,136	3,415	2,867	2,178	1,990	1,632	1,627	1,597
1988	1,370	1,548	1,278	1,483	1,389	2,241	2,146	1,781	1,711	1,357	1,557	1,452
1989	1,127	1,274	1,372	1,255	1,234	2,023	1,915	1,949	1,583	1,284	1,169	1,353
1990	1,401	1,404	1,381	1,242	1,365	1,760	1,309	1,279	1,116	1,009	1,033	876
1991	993	1,115	918	816	758	1,779	1,168	1,049	568	594	537	574
1992	789	1,084	895	959	2,091	1,470	1,418	892	481	447	483	635
1993	849	956	982	4,120	3,035	2,702	3,421	3,610	2,341	1,510	1,998	2,771
1994	3,041	1,759	1,628	1,773	1,987	2,206	1,863	1,973	1,109	1,135	867	869
1995	1,370	1,288	1,295	4,599	6,559	14,610	19,930	22,190	14,010	9,881	3,925	4,734
1996	5,692	2,428	2,250	2,431	11,470	15,070	7,500	8,422	3,739	2,209	2,034	2,164
1997	2,691	2,715	12,190	30,380	35,060	13,030	4,728	4,785	2,647	1,756	1,875	2,069
1998	2,706	1,981	2,116	6,025	28,120	19,350	21,940	17,950	17,760	13,190	5,442	5,758
1999	6,153	3,290	4,331	4,730	11,700	8,332	6,437	5,551	3,016	2,094	1,969	2,037
2000	2,532	2,158	1,688	2,136	7,559	12,100	5,013	4,814	2,772	1,898	2,171	2,330
2001	2,826	2,526	2,238	2,442	3,092	3,430	3,008	3,527	1,549	1,400	1,330	1,376
2002	2,003	2,096	2,064	2,662	1,898	2,134	2,598	2,739	1,407	1,227	1,116	1,175
2003	1,705	1,715	1,988	1,913	1,879	2,193	2,668	2,625	2,034	1,321	1,281	1,308
2004	1,999	1,647	1,503	1,792	2,201	3,361	2,751	2,647	1,404	1,147	1,125	1,121
2005	1,753	1,632	1,578	4,918	5,303	8,065	10,060	10,410	9,979	4,155	2,615	2,412
2006	2,619	2,038	3,521	13,170	6,458	11,700	27,940	26,050	15,690	5,547	3,697	3,316
2007	3,851	2,538	2,354	2,587	2,534	2,555	2,225	2,898	1.745	1,138	1,008	1,014
2008	1,570	1,711	1,503	2,319	2,369	2,115	2,409	2,755	1,033	864	869	902

Table 6.2.1
Measured Mean Monthly Water Quality at Vernalis, San Joaquin River - μmhos

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1968	489	354	386	607	664	536	826	959	1,087	1,097	995	946
1969	762	799	541	307	185	215	164	107	103	351	597	403
1970	284	317	412	297	294	438	838	572	408	800	823	757
1971	774	817	426	435	423	564	710	711	518	816	826	777
1972	497	625	495	473	588	662	849	967	1,061	1,124	1,070	578
1973	539	718	693	593	536	543	598	556	516	887	832	699
1974	589	590	487	341	460	413	438	435	420	778	645	507
1975	485	388	400	483	446	436	556	410	379	752	716	484
1976	279	345	403	637	827	773	933	1,028	1,056	1,131	866	866
1977	971	1,064	1,048	1,357	1,521	1,146	1,474	1,326	1,502	1,608	1,524	1,440
1978	1,427	1,125	949	643	800	364	192	140	237	690	766	404
1979	293	359	448	352	357	348	753	666	569	770	742	580
1980	369	512	436	229	245	208	251	185	364	503	719	323
1981	285	377	NR	NR	NR	NR	770	672	731	731	729	729
1982	647	694	741	554	432	292	190	173	287	350	401	216
1983	136	248	176	217	261	243	178	146	126	192	303	165
1984	NR	NR	NR	179	325	417	603	577	695	680	631	447
1985	321	465	313	426	568	698	741	707	712	484	480	591
1986	533	693	748	796	493	163	195	271	341	606	503	340
1987	318	452	363	611	799	780	649	679	723	755	795	756
1988	767	807	903	1,102	1,299	793	687	710	733	794	792	764
1989	810	807	854	1,125	1,281	826	759	682	772	757	769	769
1990	772	819	936	1,136	1,154	805	742	718	824	763	714	783
1991	714	616	896	1,028	1,071	959	1,123	659	872	769	834	816
1992	739	573	780	901	762	1,095	739	606	838	847	872	894
1993	866	820	853	537	920	1,058	642	475	606	758	563	401
1994	396	771	807	764	869	853	697	623	831	746	799	849
1995	625	714	771	499	415	419	222	150	215	261	555	321
1996	276	648	738	787	284	234	352	229	575	680	608	538
1997	407	531	210	128	144	387	535	436	574	639	618	568
1998	478	694	832	477	256	305	204	166	121	152	312	239
1999	262	457	349	435	217	352	345	337	475	544	522	583
2000	494	672	759	766	565	226	332	352	537	594	497	467
2001	405	569	685	752	712	834	583	387	639	627	651	610
2002	512	627	740	734	888	917	521	380	679	582	635	623
2003	532	722	784	956	948	966	601	462	448	588	632	627
2004	475	679	773	821	813	702	464	438	613	625	658	690
2005	520	723	852	521	612	460	263	167	199	382	475	482
2006	507	703	580	198	319	198	128	95	110	359	367	358
2007	297	614	619	569	657	653	554	350	475	638	625	654
2008	580	601	759	682	750	848	479	365	669	612	599	686

7. Climate Change

Climate change and its affect on California water resource management is the current subject of broad discussion. Numerous studies have evolved to hypothesize water management implications associated with future climate scenarios. These studies have been based on reasonable climate projection information from various sources and investigations. While the generation of mathematical results are possible for alternative climate scenarios, there appears to be no consensus of which climate change outcome will occur and at what rate it will occur. The key to the discussion of climate change within the context of this SWRCB investigation seems to be the recognition of factors that may be affected by alternative outcomes of climate change. If quantitative system operations studies, and derivative studies such as stream flow temperature analysis need to be performed, informed assumptions can be developed to frame a range of studies to address the potential implications of climate change.

Recently Reclamation issued its "Biological Assessment on the Continued Long-term Operations of the Central Valley Project and State Water Project" (August 2008). This document includes a discussion (Appendix R) of the formulation and performance of an assessment of climate change in the context of CVP and SWP operations. The hydrologic parameters discussed and analyzed include sea level change and runoff. The approach used by Reclamation to frame a range of studies to capture potential climate change outcomes appears reasonable and could be considered for use by this SWRCB investigation. The focus of Reclamation's analysis was CVP/SWP oriented including analysis of Reclamation San Joaquin River Basin operations. Additional, more detailed attention may be required to address the potential affects of climate change upon the San Joaquin River Basin area.

Appendix R of Reclamation's document can be accessed through "http://www.usbr.gov/mp/cvo/ocap_page.html". The document also provides a contemporary discussion of the analysis of climate change and provides numerous citations to other relevant documents.

Referenced/Attatched Documents

01_SJRG-EXH-07(Steiner).pdf	566,648	03/19/2009	8:40am
02_SJRG-EXH-13(Steiner).pdf	971,153	04/03/2009	11:51am
03_CALSIMSJR_DRAFT_072205.pdf	1,655,064	03/24/2009	9:53am
04_calsim_I_final_report_011206(Panel Report).pdf	5,591,200	03/17/2009	6:52am
05a_calsim_rpt(CalSim-II San Joaquin River Peer Review Respons_1_17_07).pdf	1,750,558	03/17/2009	5:20am
05b_calsim_sensitivity_tables(SJR Peer Review).zip	3,132,708	03/17/2009	5:22am
05c_calsim_uncertainty(SJR Peer Review).zip	13,539,774	03/17/2009	8:23am
06_presentation_handout(Steiner).pdf	1,081,923	03/19/2009	9:14am
07_supplemental_documentation(Steiner).pdf	670,127	03/19/2009	9:16am
08_California Central Valley Unimpaired Flow Fourth Edition.pdf	6,014,139	03/24/2009	10:03am
09_San_Joaquin_River_Vernalis_Unimpaired_Flow_Data_1921_2008(Steiner).xls	379,392	04/03/2009	12:01pm
10_Daily_Unimpaired_2003_2007(Steiner).xls	640,704	03/30/2009	2:15pm
11_Vernalis_Unimpaired_and_Recorded_Data_1921_2008(Steiner).xls	157,184	03/30/2009	4:01pm
12_OCAP BA Appendix_R_Climate Change_.pdf	1,974,523	03/31/2009	1:29pm
14 files; 38,325,100 bytes			

Within Folder 13_Calsim_Existing_ConditionsDSS

EX_A1_A_No16B_DV.DSS	42,258,944	01/29/2009	3:00pm
EX_BASE_DV.DSS	42,257,920	01/19/2009	8:01pm
2 files; 84,516,864 bytes			

Late Comment Received: 4/23./2009 11:19 AM

O'Laughlin & Paris LLP

Attorneys at Law

May 1, 2009

Chris Carr
State Water Resources Control Board
Division of Water Rights
P.O. Box 2000
Sacramento, CA 95812-2000

Re: Data Request

Enclosed is the following information to respond to the SWRCB request for data.

6(a) Flow quality and timing- See enclosed work by Doug Demko

6(b) Temperature- See enclosed work by Doug Demko

6(c) Habitat- See enclosed work by Doug Demko

6(d) Dissolved Oxygen- See enclosed work by Doug Demko

6(g) Predation- See enclosed work by Doug Demko

6(h) Climate Change- See enclosed work by Doug Demko

We are gathering information to respond to your other data requests and will continue to send information to you as we put it in a format to meet your request.

Should you have any question then please call.

Very truly yours,
O'LAUGHLIN & PARIS LLP

By: ____________________

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Comments submitted to the *SWRCB Water Quality Control Planning Workshop: Flow Quantity and Timing*

<u>Fall flow pulses ***temporarily*** stimulate upstream migration of Chinook salmon into San Joaquin Basin tributaries, but no evidence that attraction flows are needed</u>

- Prolonged, high volume pulse flows in the fall are not warranted. Equivalent stimulation of adult migration may be achieved through relatively modest pulse flows (Pyper and others 2006).
    - Relatively modest pulse-flow event (an increase of roughly 200 cfs for 3 days) was found to stimulate migration
    - Stimulatory effect of both pulse-flow and attraction flows were short in duration (migration increased for 2-3 days)
- Migration rate and timing is not dependent upon flows, exports, temperature or dissolved oxygen concentrations (Mesick 2001; Pyper and others 2006).
    - No evidence that low flows (1,000 to 1,500 cfs) in the San Joaquin River (SJR) are an impediment to migration
- Migration appears to be stimulated by pulse flows, but no evidence that fish would stray or not migrate to San Joaquin tributaries if no pulse
    - "Consistent movement patterns [Klamath fall Chinook migrants] with or without pulse flows is compelling evidence that these flows did not trigger upriver movement or otherwise substantially alter migration behavior" (Strange 2007)
    - No clear relationship between increased water flow and stimulated Atlantic salmon migration was found in River Mandalselva (southern Norway) (Thorstad and Heggberget 1998)
    - To attract adult Atlantic salmon migration into rivers, flows must occur in conjunction with other cues such as cooler weather or natural freshets (Mills 1991)

<u>Juvenile Chinook migration out of the upper tributaries is ***temporarily*** stimulated by changes in flow, but long duration pulse flows do not “flush” fish out of the tributaries</u>

- Juvenile Chinook migration is temporarily stimulated by changes in flow, but the stimulatory effect is short lived (few days) and only affects fish that are ready to migrate (Demko et al. 2001, 2000, 1996; Demko and Cramer 1995).
- Juvenile migration from the tributaries typically begins in January and nearly all juveniles migrate out of the tributaries by May 15 (SJRGA 2008).

Higher flows increase fry survival in the tributaries, but not necessarily true for parr and smolts

- Over a decade of studies in the Stanislaus River show that flow has a strong positive relationship with migration survival of Chinook fry, but associations between flow and survival of parr and smolts were weak (Pyper and Justice 2006). Increasing New Melones reservoir releases to more than 600 cfs in April and May only slightly improve survival (SRFG 2004).
- The contribution rate to total production from early-moving (Feb/March) fry that come down or are displaced by high flows is unknown (Baker and Morhardt 2001; SRFG 2004; SJRGA 2008; Pyper and Justice 2006).
- Smolt survival indices in the SJR from the Merced River downstream to Mossdale indicate little relationship to flow (TID/MID 2007).

Flow does not explain low Delta survival of juvenile Chinook observed since 2003, so more flow is unlikely the solution.

- South Delta survival has been low since 2003. During this period, even flood flows of approximately 10,000 cfs and 25,000 cfs during outmigration in two years (2005 and 2006) did not increase survival near levels when flows were moderately high (5,700 cfs) in 2000. It is unclear why smolt survival between 2003 and 2006 has been so low (SJRGA 2007).
- Smolt survival during 2003-2006 was unexpectedly far lower than historically. Models based on historical data that do not accurately represent recent conditions (such as Newman 2008 and others) should not be used to predict future scenarios (VAMP Tech. Team 2009).

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Comments submitted to the *SWRCB Water Quality Control Planning Workshop: Temperature*

Temperature criteria from Pacific Northwest stocks do not apply to San Joaquin salmon and steelhead; and little is known about the responses of Central Valley species to temperature.

- The San Joaquin River (SJR) represents the southernmost extent of the current range of Chinook salmon. These stocks have evolved under much warmer and drier meteorological conditions than stocks in the Northwest.
- The applicability of thermal criteria derived from the laboratory has long been debated, and there has been no confirmatory data for the growth vs. temperature relationship for any of the listed species in the Central Valley to assess if laboratory results are transferable to these southern stocks (Myrick and Cech 2004).
- Wild Chinook salmon in the Central Valley often experience temperatures higher than "optimal" (as based on northern stock data) yet still have high growth and survival. It is this flexibility that has made Chinook salmon so successful in the Central Valley and able to thrive where less temperature tolerant salmonids cannot (Moyle 2005).
- Juvenile Chinook can survive exposure to temperatures of 24ºC (75.2ºF), depending on their thermal history, availability of refuges in cooler water, and night-time temperatures (Moyle 2005).
- While much information is available on lifestage-specific temperature ranges of Chinook salmon and steelhead in the northwest, little is known about the specific responses of Central Valley species to temperature (Williams et al. 2007).
- Seven-day single temperature averages are often used as standards not-to-be exceeded because of the simplicity of doing so, but they do not reflect the temperatures that juvenile Chinook salmon regularly experience in Central Valley streams at some times of the year. For example, the most productive spring-run Chinook salmon stream left in California (i.e., Butte Creek) can experience daily maxima up to 24ºC (75.2ºF) with minima of 18-20ºC (64.4-68.0ºF) for short periods of time in pools where juveniles are rearing and adults are holding (Ward et al. 2003). It is thus possible for Chinook salmon to maintain populations even when they experience periods of suboptimal or even near-lethal conditions.
- Anecdotal evidence suggests that some species of CV salmonids are heat tolerant: "the high temperature tolerance of San Joaquin River fall run salmon, which survived temperatures of 80°F (26.7ºC), inspired interest in introducing those salmon into the warm rivers of the eastern and southern US (Yoshiyama 1996)."
- Historically, the San Joaquin basin has had higher water temperatures than all the other rivers that support Chinook salmon and so it is possible that the San Joaquin race has evolved to withstand higher temperatures than 65°F (18.3ºC) (CALFED 1999).

- Southerly steelhead stocks of the Central Valley may have greater thermal tolerance than those in the Pacific Northwest (Myrick and Cech 2004).
- The optimum growth temperature for American River steelhead was nearly 5ºF warmer than the optimum growth temperature for northerly stocks (Wurtsbaugh and Davis 1977; Myrick and Cech 2004; Myrick and Cech 2001.

<u>There is no evidence that temperatures are unsuitable for adult Chinook upstream migration</u>

- No associations between adult migration timing and conditions for temperature, dissolved oxygen (DO), or turbidity (Pyper and others 2006; Mesick 2001).
- Although temperatures were exceptionally cool during September 2006, salmon did not migrate earlier than during 2003-2005. During September 2006, temperatures were as much as 5°F cooler in the San Joaquin River at Rough and Ready Island (RM 37.9), Mossdale (RM 56.3), and Vernalis (RM 72.3), and as much as 9°F cooler in the Stanislaus River at Ripon (RM 15.7) as compared to monthly average temperatures at the same locations during 2003-2005. September flows in the Stanislaus and San Joaquin Rivers exceeded average unimpaired flow conditions during all of these years (CDEC; Ripon gauge).
- Temperatures at Rough and Ready Island (RRI) typically above 70°F during early migration season; larger fraction of early migrants traveled under higher temperatures in 2003 than other years (Pyper and others 2006).
- Managed flows in the San Joaquin River Basin during September are higher than historic unimpaired (computed natural) flows. Natural San Joaquin River flows were lowest during September and flows were extremely low or nonexistent in dry years. During 1922-1992, the average unimpaired flows during September were 117 cfs in the Stanislaus River, 185 cfs in the Tuolumne River, 84 cfs in the Merced River, and 808 cfs in the San Joaquin River (CDWR 1994).
- If temperatures were a problem for adult migrants in the SJR Basin, one would expect to observe problems with pre-spawning mortality. However, studies conducted by CDFG demonstrated that the incidence of pre-spawn mortality is quite low (i.e., 0%-4.5%) and appears to be density, not temperature, dependent (Guignard 2005 through 2008).
- Bay temperatures over 65°F in September when fish are migrating (CDEC; various stations).

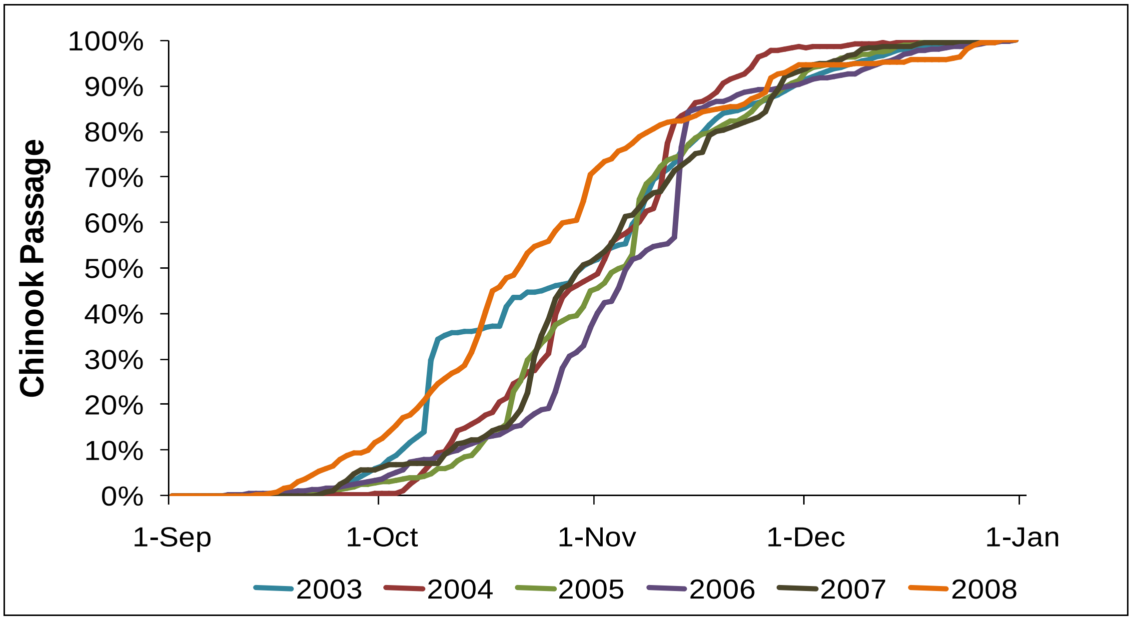

Figure 1. Cumulative upstream passage at the Stanislaus River Weir during 2003-2008 (FishBio 2009).

<u>There is no evidence that temperatures for juvenile rearing and migration need to be colder or maintained through June 15.</u>

- Nearly all juveniles migrate prior to May 15, and <1% migrate after May.
- Existing 7DADM temperatures are generally ≤20°C (68ºF) in the San Joaquin and the eastside tributaries through May 15.
  - After spawning, after incubation, the temperatures should remain below 21°C (70ºF) (Fjelstadt 1973, D-1422 testimony).
  - Studies evaluating the relationship between growth and temperature of Central Valley Chinook found no difference in growth rates between 13-16°C (55-61ºF) and 17-20°C (63-68ºF) (Marine 1997).
  - Chinook salmon juveniles transform into smolts in the wild at temperatures in excess of 19°C (66ºF), and in a laboratory study highest growth and survival of smolts was found if they underwent transformation at temperatures of 13-17°C (55-63ºF; Marine and Cech 2004). Growth rate increased up to 19°C (66ºF; Cech and Myrick 1999).
  - Existing water temperatures have <u>at most</u>, a slightly negative effect on juvenile salmon survival (Newman 2008).
  - No evidence from Stanislaus River smolt survival experiments that existing water temperatures reduce juvenile salmon survival (SRFG 2004).

<u>The dominant factor influencing water temperature is ambient air temperatures, not flow.</u>

- Ambient air temperature is the primary factor affecting water temperature.
- By the end of May, water temperatures at Vernalis range between 65°F and 70°F regardless of flow levels between 3,000 cfs and 30,000 cfs. (SRFG 2004)

<u>The restoration of the San Joaquin River upstream of the Merced River will have future implications to flow and temperature management in the SJR Basin.</u>

- Friant Restoration flows will adversely affect water temperatures in the lower San Joaquin during the spring and fall. Reducing temperatures will require larger releases from the Merced, which can only be sustained for a short period because of storage limitations in the Merced River, and therefore will not meet CDFG criteria at the confluence (AD Consultants 2007).

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Comments submitted to the *SWRCB Water Quality Control Planning Workshop: Habitat*

The physical habitat for Delta fishes has been substantially reduced and altered

- Diverse habitats historically available in Delta have been simplified and reduced by development of watershed (Lindley et al. 2009).
- Spawning and rearing habitat eliminated, total abundance down, and salmon diversity reduced from past alterations (McEvoy, 1986; Yoshiyama et al., 1998, 2001; Williams 2006).
- 48% stream lengths (1700 km) for spawning, holding and migration (outside of Delta) gone from Central Valley (Yoshiyama et al. 2001).
- 95% of tidal wetlands lost to levee construction and agricultural conversion since the mid 1800's (Williams 2006).
- Major change in system is loss of shallow rearing habitat (Lindley et al. 2009).
- Reduction in suitable physical habitat for delta smelt has reduced carrying capacity (Feyrer et al. 2007)

Habitat alterations are linked with invasive species expansions

- *Egeria densa* (Brazilian waterweed) expansion has increased habitat and abundance of largemouth bass and other invasive predators (Baxter et al. 2008)
- The area near the CVP intake has significant amounts of *E. densa* (Baxter et al. 2008)
- Current habitat structure benefits introduced predators more than natives (Brown 2003).
- *Egeria* has strong influence on results of habitat alterations as different fish communities are found in its presence (Brown 2003)

Habitat influences growth, survival and reproduction through biological and physical mechanisms

- High turbidity and low salinity water is primary habitat for delta smelt (Baxter et al. 2008)
- Estuaries important rearing habitat for Chinook; salmon fry in Delta grew faster than in river (Healey 1991, Kjelson et al. 1982).
- Shallow water habitats support high growth in Central Valley; juvenile Chinook had higher growth rates in small tributaries of Sacramento River than in the main Sacramento (Sommer et al. 2001; Jeffres et al. 2008; Maslin et al.

1997, 1998, 1999; Moore 1997).

Water quality aspect of habitat is highly variable

- Aquatic vegetation increase, especially *E. densa*, over past 20 years has increased water clarity by trapping suspended solids, with measurable effects on fish communities (Nobriga et al. 2005)
- Variability in habitat likely causes regional differences in relationship between delta smelt abundance and water quality (Baxter et al. 2008)
- Reduced pumping from the SWP in October of 2001 lowered salinity in Western Delta (as desired), but led to opposite and unexpected result of increased salinity in central Delta (Monsen et al. 2007)

Improving habitat for increased abundance of native fishes

- Increase productive capacity with access to floodplains, streams, and shallow wetlands (Lindley et al. 2009).
- Long term: Must enhance habitat quantity, quality, spatial distribution and diversity to promote life history diversity that will increase resilience and stability of salmon populations (Lindley et al. 2009).

Migration Routes and Barriers

- *Head of Old River Barrier (HORB)*: A temporary barrier is installed at the Head of Old River during the spring salmon smolt outmigration in some years. Entrainment of juvenile salmon into Old River has been reduced from more than 58% to less than 1.5% by the installation of the barrier. Recent analyses concluded that preventing salmon smolts from entering Old River resulted in a 16-61% increase in salmon smolt survival (Newman 2008).

- *Delta Cross Channel (DCC) Gates*: Built in 1951 by the US Bureau of Reclamation to increase the amount of water transferred from the Sacramento River to the federal pumping plant at Tracy (the CVP), the DCC has two gates that can be opened to convey water from the Sacramento River to the Delta. Juvenile salmon from the Sacramento River also enter the Delta through the DCC, and interior Delta survival has been estimated to be about 44% of the survival for the Sacramento River (Newman 2008).

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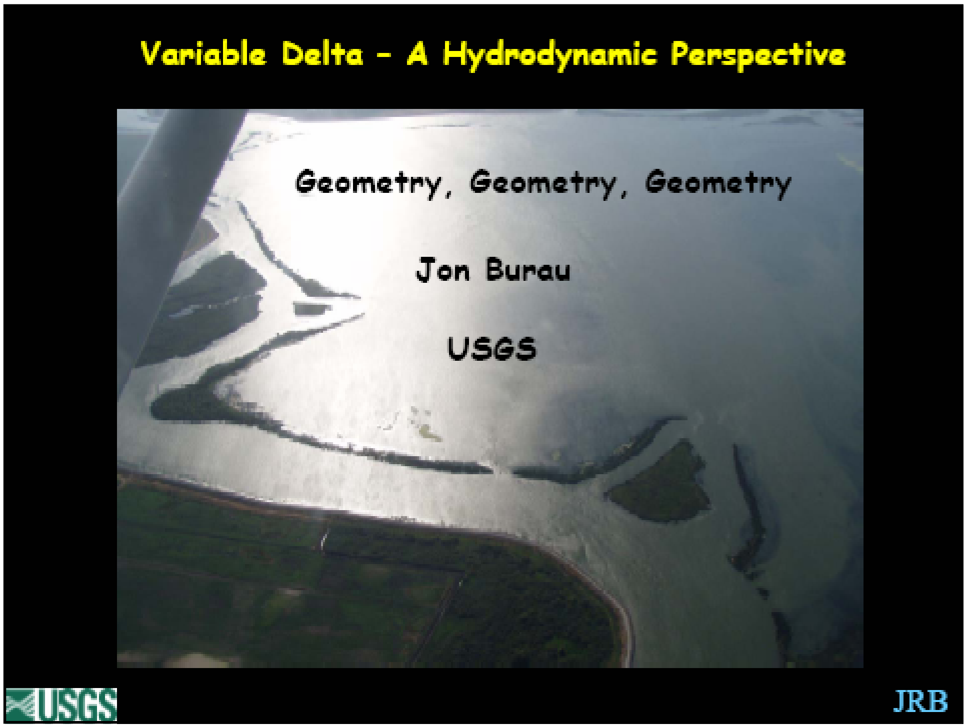
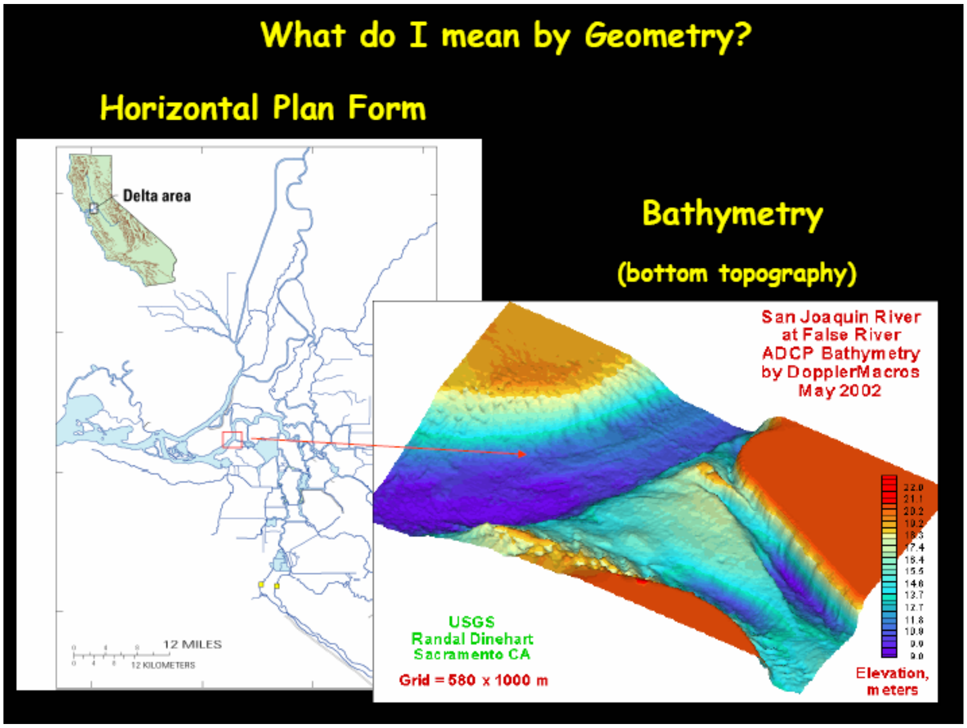


Variable Delta - A Hydrodynamic Perspective

Geometry, Geometry, Geometry

Jon Burau

USGS



What do I mean by Geometry?

Horizontal Plan Form

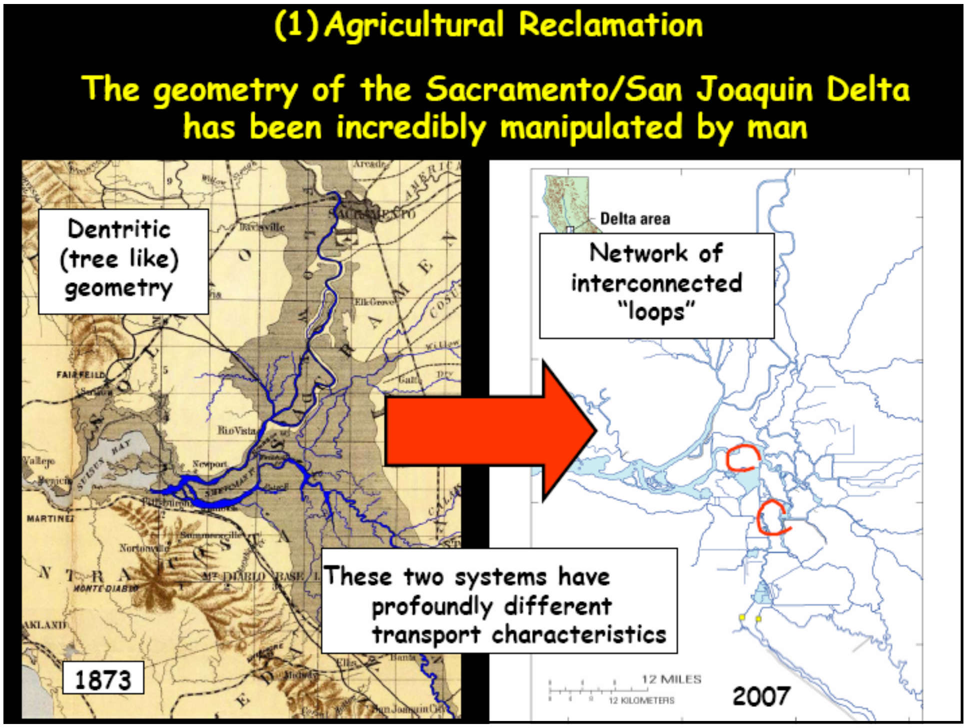
Bathymetry

(bottom topography)

San Joaquin River
at False River
ADCP Bathymetry
by DopplerMacros
May 2002

USGS
Randal Dinehart
Sacramento CA

Grid = 580 x 1000 m



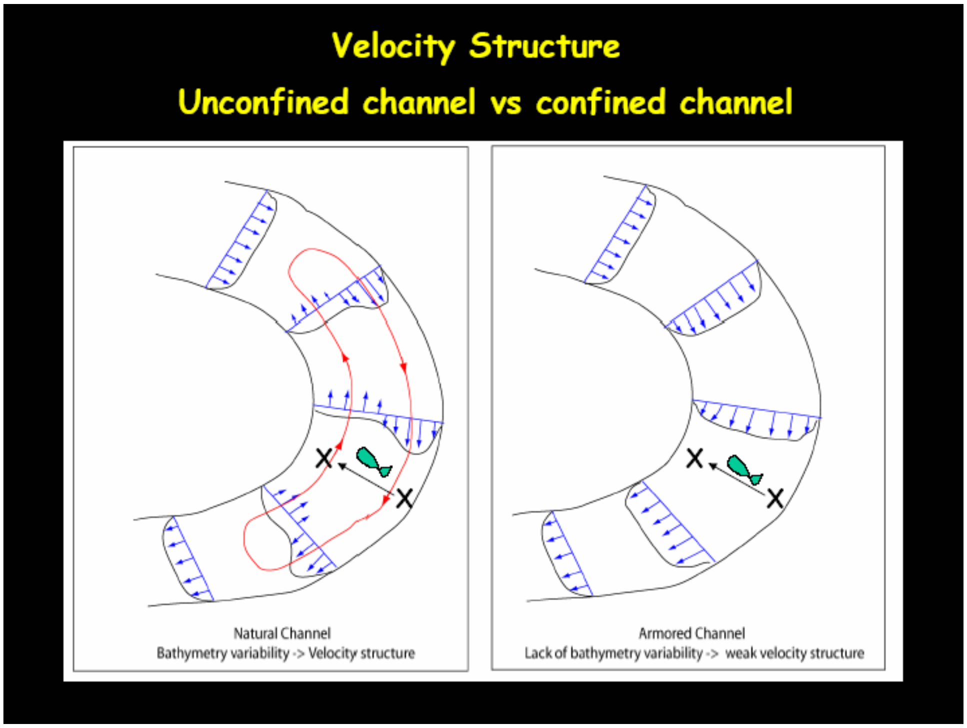
(1) Agricultural Reclamation

The geometry of the Sacramento/San Joaquin Delta has been incredibly manipulated by man

Dentritic (tree like) geometry

Network of interconnected "loops"

These two systems have profoundly different transport characteristics

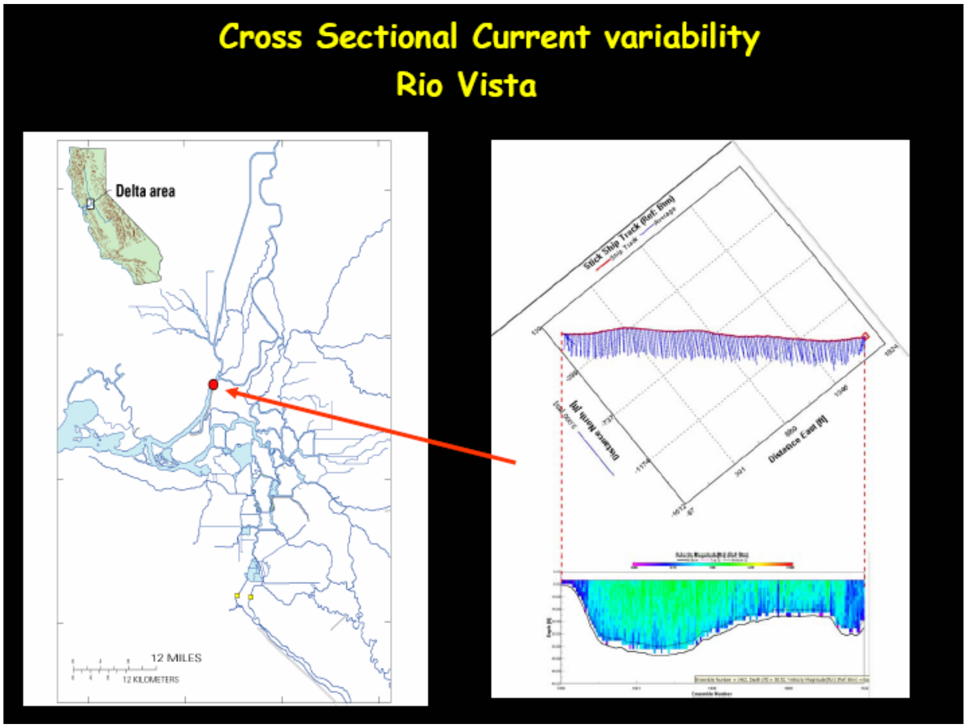


Velocity Structure

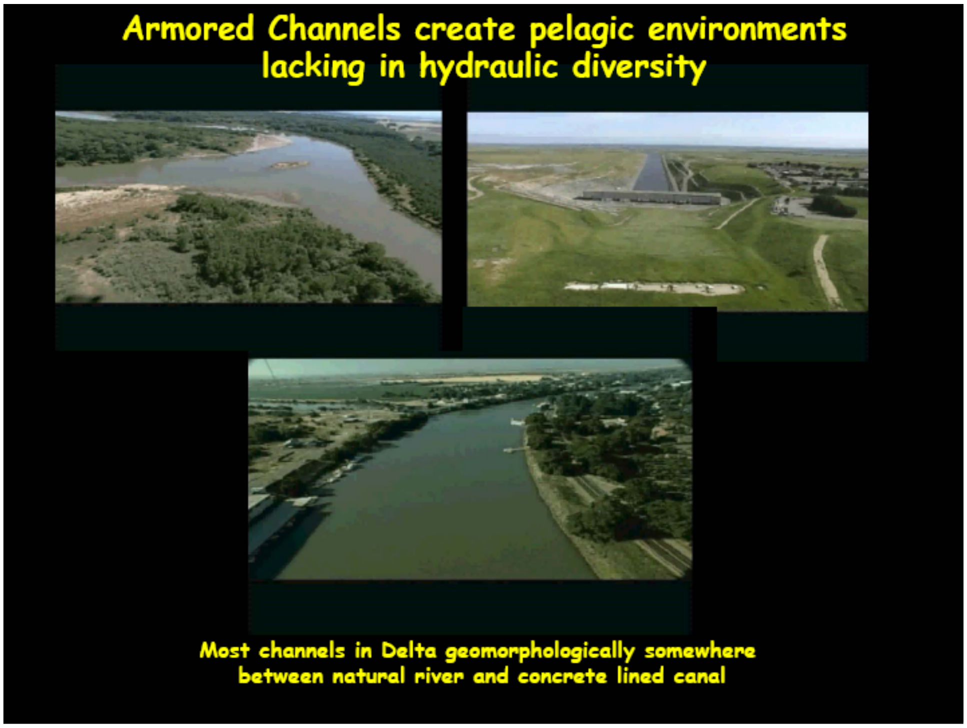
Unconfined channel vs confined channel

Natural Channel
Bathymetry variability -> Velocity structure

Armored Channel
Lack of bathymetry variability -> weak velocity structure



Cross Sectional Current variability
Rio Vista



Armored Channels create pelagic environments lacking in hydraulic diversity

Most channels in Delta geomorphologically somewhere between natural river and concrete lined canal

Central Delta is an Homogenized environment

Dispersive mixing occurs when:
tidal excursions
Longer than channel lengths

This occurs in virtually
Every channel in the central Delta

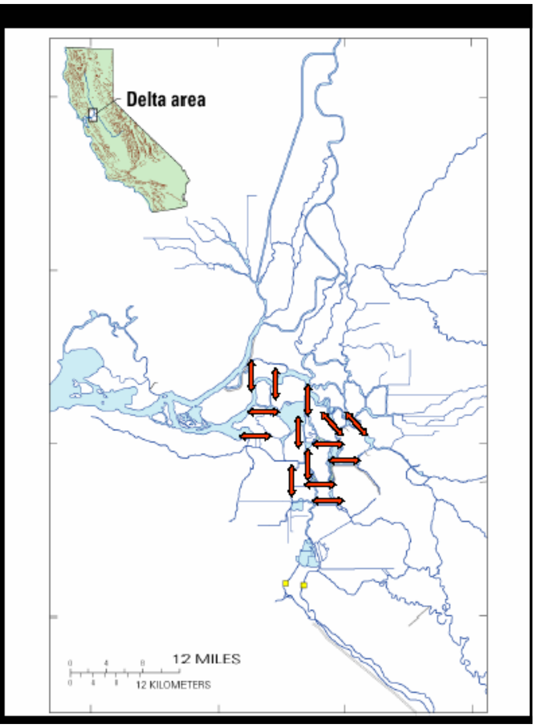
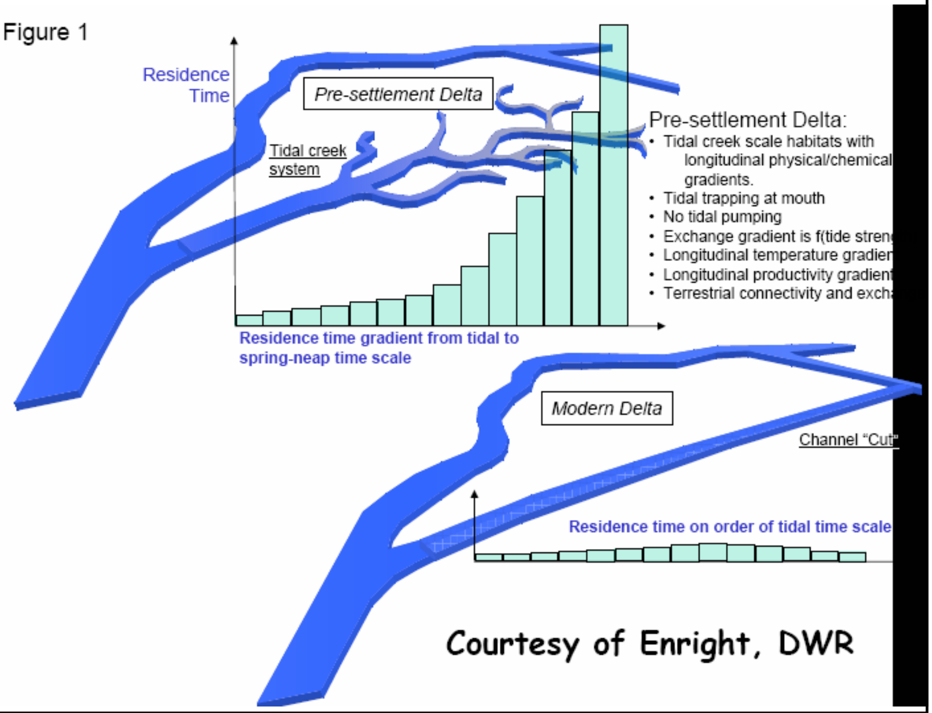


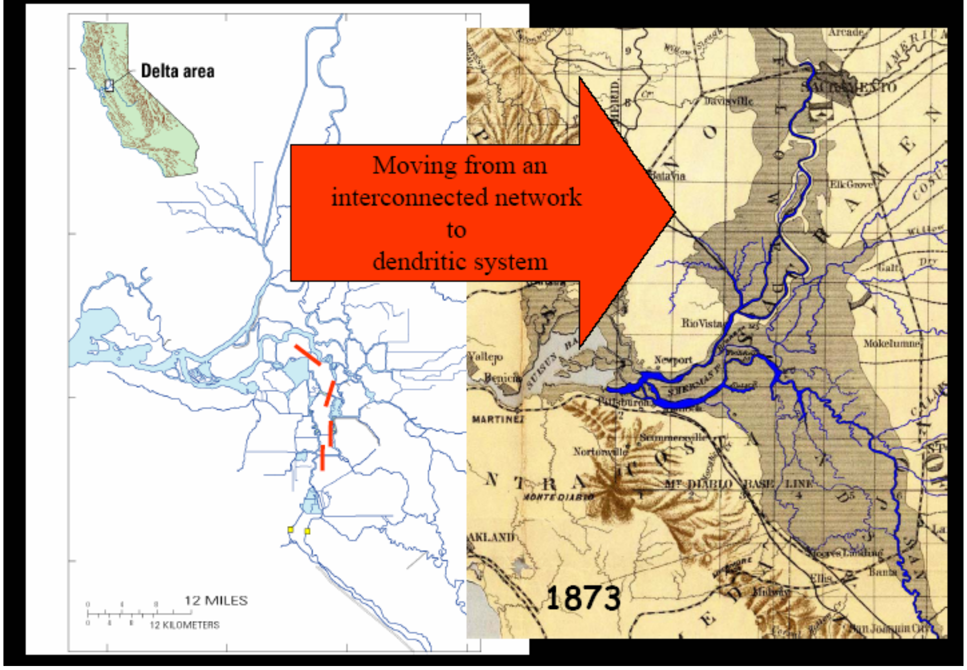
Figure 1



Pre-settlement Delta:
- Tidal creek scale habitats with longitudinal physical/chemical gradients.
- Tidal trapping at mouth
- No tidal pumping
- Exchange gradient is f(tide stren
- Longitudinal temperature gradien
- Longitudinal productivity gradient
- Terrestrial connectivity and exch

Courtesy of Enright, DWR

Evolution back to natural (historical) geometric form



Moving from an
interconnected network
to
dendritic system

Conclude

Current Delta geometry promotes homogeneity and
is lacking in proximate residence time gradients

Current Delta geometry
is inconsistent with "variable delta"

Connected but distinct habitats characterized
by a diversity of residence times doesn't exist in the Delta

Which had (has) the greatest impact on ecosystem function?

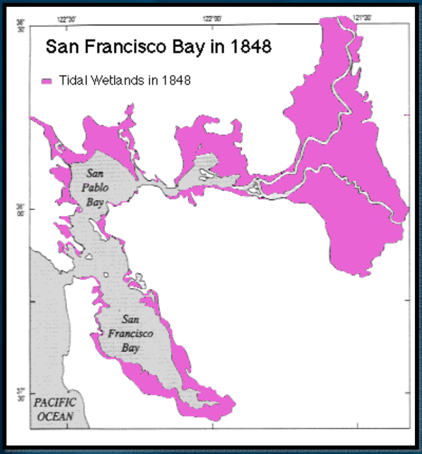
(1) Changes in Geometry

(2) Dams
(reservoir releases)

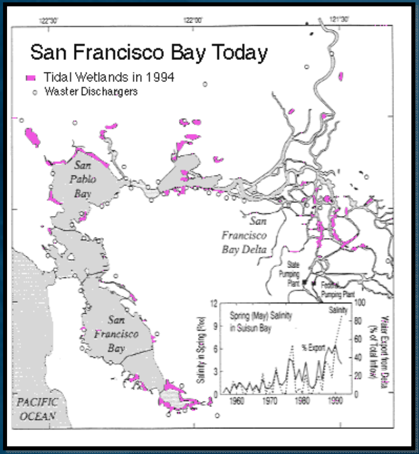
(3) Export of Water from the Delta

Native Fish Habitat is Gone

Fish Habitat Then



Fish Habitat Now



Frederic Nichols - An Estuary Undergoing Change

Comments submitted to the *SWRCB Water Quality Control Planning Workshop: Dissolved Oxygen*

Low dissolved oxygen (DO) concentrations are limited to the Deep Water Ship Channel (DWSC), and are the result of anthropogenic manipulation of channel geometry

- The DWSC, starting at the Port of Stockton where the San Joaquin River (SJR) drops from 8-10 feet deep to 35-40 feet deep, is a major factor in DO depletion below the water quality objective. If the DWSC did not exist, there would be few, if any, low-DO problems in the channel.
- The critical reach of the SJR DWSC for low DO problems is approximately the seven miles just downstream of the Port to Turner Cut. (Lee and Jones-Lee 2003)
- The eastside rivers (Tuolumne, Stanislaus and Merced) have been found to discharge high-quality Sierra Nevada water to the SJR which has low planktonic algal content and oxygen demand, and are not a major source of oxygen demand contributing to the low DO problem in the DWSC.

Dissolved oxygen concentrations in the DWSC are influenced by Delta exports, but can be ameliorated by installation of the Head of Old River Barrier (HORB)

- Delta export pumping artificially changes the flows in the South Delta, which results in more of the San Joaquin River going through Old River. Water diverted through Old River can significantly reduce the SJR flow through the DWSC, thereby directly contributing to low DO in the DWSC.
- Head of Old River Barrier (HORB) is installed to improve DO levels in fall.

Existing dissolved oxygen concentrations do not impact salmon and steelhead migration

- Migration rate and timing is not dependent upon flows, exports, temperature or dissolved oxygen concentrations, though fall flow pulses may *temporarily* stimulate upstream migration of Chinook (Mesick 2001; Pyper and others 2006).
- Contrary to often cited Hallock et al. (1970) report that indicates adult migration prevented under low dissolved oxygen, migration has been observed at DO less than 5mg/L (Pyper and others 2006).
- Salmon and steelhead migrate in the upper portion of the water column where DO concentrations are highest due to photosynthesis and atmospheric surface aeration (Lee and Jones-Lee 2003).
- No evidence from smolt survival experiments that juvenile salmon survival is correlated with existing dissolved oxygen concentrations. (SRFG 2004; SJRGA 2002 and 2003)

DO objective for DWSC is inconsistent with U.S. EPA national standard

- The current US EPA national water quality criterion for DO allows for averaging and for low DO concentrations to occur near the sediment-water interface. Central Valley Regional Water Quality Control Board Basin Plan DO water quality objective does not include these adjustments. (Lee and Jones-Lee 2003)
- DO concentrations near the bottom in the DWSC waters are sometimes 1-2 mg/L lower than those found in the surface waters. (Lee and Jones-Lee 2003)

DO objective on the Stanislaus River at Ripon is not needed year round to protect the salmon or steelhead fishery

- While the Stanislaus River contains fish and aquatic habitat that benefit from a minimum DO concentration of 7.0 mg/L, such fish and aquatic habitat are located more than 30 miles upstream of the Ripon compliance point during the summer months.
- Salmonids migrate through area during late September though May. Neither salmon nor steelhead are typically located anywhere in the Stanislaus River downstream of Orange Blossom Bridge from June through August each year.

Species	Stage	Timing	Geographic Location
Fall-run Chinook salmon			
	Adult Migration	Late September - December	Goodwin Dam to confluence
	Spawning	October – December	Goodwin Dam to Riverbank
	Egg Incubation	October – March	Goodwin Dam to Riverbank
	Juvenile Rearing	Mid December – May	Goodwin Dam to Riverbank
		June – mid December	Goodwin Dam to Orange Blossom Bridge
	Juvenile Migration	January – May	Goodwin Dam to confluence
Steelhead			
	Adult Migration	Late September - March	Goodwin Dam to confluence
	Spawning	December – March	Goodwin Dam to Riverbank
	Egg Incubation	December – July	Goodwin Dam to Riverbank
	Juvenile Rearing	Year-round	Goodwin Dam to Riverbank
	Juvenile Migration	February – May	Goodwin Dam to confluence

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Comments submitted to the *SWRCB Water Quality Control Planning Workshop: Non-native Species and Predation*

Striped bass prey on juvenile Chinook.

- Many studies have found that striped bass eat salmon (Shapovalov 1936, Stevens 1966, Thomas 1967, Pickard et al. 1982, Merz 1994, Gingras 1997, Tucker et al. 1998).
- Striped bass stomachs have been collected with juvenile Chinook composing up to 65% (by volume) of the total contents (Thomas 1967).
- Waddell Creek stomach contents in April of 1935 found that large striped bass fed heavily on young salmon and trout (30.8% by number of occurrence) (Shapovalov 1936).
- Eleven to 51% of the estimated salmon smolts in the Mokelumne River were lost to striped bass predation in the Woodbridge Dam afterbay in 1993. Chinook were 24% (by volume) of juvenile bass stomach content in the spring in the Mokelumne River (Stevens 1966).
- Below Red Bluff Diversion Dam juvenile salmon outweighed other food types in striped bass stomach samples by a three to one margin (Tucker et al. 1998).
- Almost any fish occurring in the same habitat as striped bass will appear in the bass diet (Moyle 2002).
- There are roughly 1 million adult striped bass in the Delta and their abundance remains relatively high despite curtailment of a stocking program in 1992 (CDFG 2009).
- Recent concerns about the survival of endangered winter-run Chinook salmon in the Sacramento River have focused on the impacts of striped bass predation on outmigrants and the effects of striped bass population enhancement on winter-run Chinook population viability (Lindley and Mohr 1999). It was estimated that at a population of 765,000 striped bass adults, 6% of Sacramento River winter Chinook salmon outmigrants would be eaten each year (Lindley and Mohr 1999, 2003).

Striped bass in the San Joaquin River and South Delta prey on juvenile Chinook to such an extent that they significantly reduce the number of Chinook returning to the San Joaquin Basin.

- High predation losses at the State Water Project (SWP) are particularly detrimental to San Joaquin Chinook salmon populations since over 50% of juvenile salmon from the San Joaquin travel through Old River on their way to the ocean, exposing them to predation at Clifton Court Forebay (CCF) and causing substantially reduced survival.

- Predation rates in CCF are as high as 66-99% of salmon smolts (Gingras 1997; Buell 2003; Kimmerer and Brown 2006).
- Striped bass are generally associated with the bulk of predation in CCF since their estimated populations have ranged between 30,000 and 905,000 (Healey 1997; Cohen and Moyle 2004); however, studies indicate that six additional invasive predators occur in the CCF (i.e., white catfish, black crappie, largemouth bass, smallmouth bass, spotted bass, redeye bass) with white catfish being the most numerous, having estimated populations of 67,000 to 246,000 (Kano 1990).
- Yoshiyama et al. (1998) noted that "[S]uch heavy predation, if it extends over large portions of the Delta and lower rivers, may call into question current plans to restore striped bass to the high population levels of previous decades, particularly if the numerical restoration goal for striped bass (2.5 to 3 million adults; USFWS 1995; CALFED 1997) is more than double the number of all naturally produced Central Valley Chinook salmon (990,000 adults, all runs combined; USFWS 1995)."
- In 2005, Hanson conducted a pilot investigation of predation on acoustically tagged steelhead ranging from 221-275mm, and estimated that 22 of 30 (73%) were preyed upon.
- Nobriga and Feyrer (2007) state: "Striped bass likely remains the most significant predator of Chinook salmon, *Oncorhyncus tschawytscha* (Lindley and Mohr 2003), and threatened Delta smelt, *Hypomesus transpacificus* (Stevens 1966), due to its ubiquitous distribution in the Estuary and its tendency to aggregate around water diversion structures where these fishes are frequently entrained (Brown et al. 1996)."

<u>Recent San Joaquin Basin VAMP studies support high predation rates by striped bass on Chinook salmon in the lower San Joaquin River and South Delta.</u>

- In 2006 and 2007, the first two years of an acoustic tag monitoring study were conducted to evaluate survival of salmon smolts emigrating from the San Joaquin River through the Delta (SJRGA 2008).
    - In 2006, results indicated that without the, "Head of Old River Barrier in place and during high-flow conditions many (half or more) of the acoustic-tagged fish, released near Mossdale, migrated into Old River."
    - In 2007, a total of 970 juvenile salmon were tagged with acoustic transmitters and were detected by a combination of receivers:
        - Mobile tracking found that 20% of released fish (n=192) were potentially consumed by predators at three "hotspots" located near Stockton Treatment Plant (n=116), just upstream of the Tracy Fish Facility trashracks (n=57), and at the head of Old River flow split downstream of Mossdale (n=19).

    - Stationary detections indicate an average 45% loss, potentially attributable to predation, which does not account for losses at the largest “hotspot” at Stockton Treatment Plant, nor in the greater Delta past Stockton and Hwy 4.

<u>Significant predation losses are also occurring in the San Joaquin Basin tributaries due to non-native predators.</u>

- Radio tracking studies conducted during May and June of 1998 and 1999 (Demko and others 1998; FISHBIO unpublished data) suggest that the survival of large naturally produced and hatchery juveniles, 105 to 150 mm fork length, was less than 10% in the Stanislaus River downstream of the Orange Blossom Bridge (Demko and others 1998).
- Individual based, spatially explicit model – Piscivores consume an estimated 13-57% of fall-run Chinook in Tuolumne River (Jager et al. 1997).
- Significant numbers of striped bass migrate into the Stanislaus River each spring and are thought to prey heavily on outmigrating Chinook smolts.

<u>The overwhelming majority of predation on juvenile Chinook is the result of non-native predators that were intentionally stocked by CDFG, and whose abundance can be reduced to minimize the impacts on Chinook.</u>

- Most of the non-native fish species (69%) in California, including major predators, were intentionally stocked by CDFG for recreation and consumption beginning in the 1870’s. All of the top predators responsible for preying on native fish are currently managed to maintain or increase their abundance. Historically, the Delta consisted of approximately 29 native fish species, none of which were significant predators. Today, 12 of these original species are either eliminated from the Delta or threatened with extinction, and the Delta and lower tributaries are full of large non-native predators such as striped bass that feed “voraciously” throughout long annual freshwater stays. (McGinnis 2006)

    - Lee (2000) found a remarkable increase in the number of black bass tournaments and angler effort devoted to catching bass in the Delta over the last 15 years.
    - According to Nobriga and Feyrer (2007), “largemouth bass likely have the highest per capita impact on nearshore fishes, including native fishes,” and concludes that “shallow water piscivores are widespread in the Delta and generally respond in a density-dependent manner to seasonal changes in prey availability.”

- “In recent years, both spotted bass (*Micropterus punctulatus*) and redeye bass (*M. coosae*) have invaded the Delta. While their impact in the Delta has not yet been determined, the redeye bass has devastated the native fish fauna of the Cosumnes River basin, a Delta tributary” (Moyle *et al.* 2003 as cited by Cohen and Moyle 2004).

- Black crappie were responsible for a high level of predation during a 1966/67 CDFG study. As many as 87 recognizable fish were removed from the stomach of one crappie, and counts of 40 to 50 were common. Most of the fish were undigested, hence not in the stomachs for very long. Therefore, an individual crappie could presumably eat several times the observed number in one day, perhaps 100 or 150 fish. The average numbers for striped bass could be 200 to 300 fish, on the conservative side.

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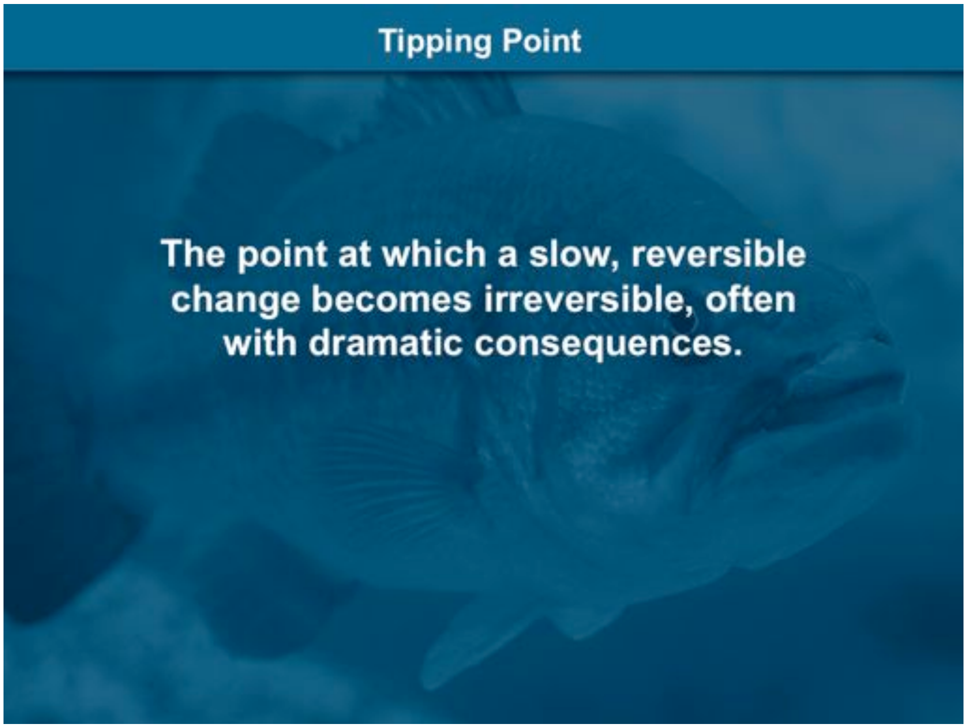
Late Comment Received: 4/23./2009 11:19 AM

The Delta Tipping Point.

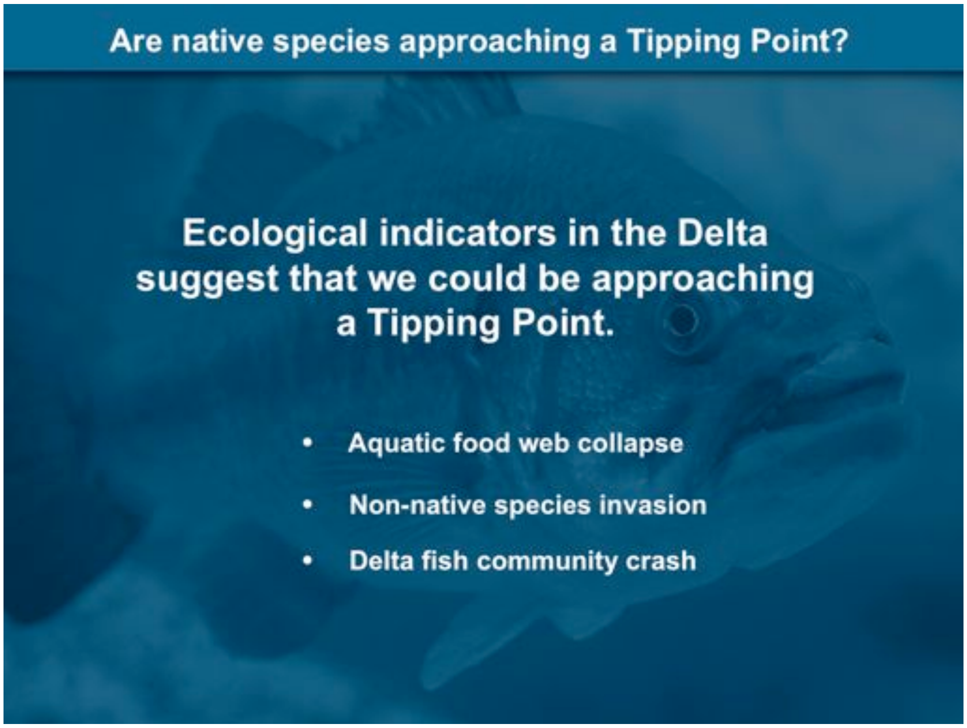


Tipping Point

The point at which a slow, reversible change becomes irreversible, often with dramatic consequences.

The Tipping Point.

The dictionary defines Tipping Point as “the point at which a slow, reversible change becomes irreversible, often with dramatic consequences.”



Are native species approaching a Tipping Point?

Ecological indicators in the Delta suggest that we could be approaching a Tipping Point.

- Aquatic food web collapse
- Non-native species invasion
- Delta fish community crash

Are native species approaching a Tipping Point in the Delta?

Many ecological indicators suggest that we could be approaching a Tipping Point, including a collapse of the aquatic food web, replacement of native plant and animal communities with non-native species, and what's referred to by many as the "crash" of delta fish communities.

Why are native species near a Tipping Point?

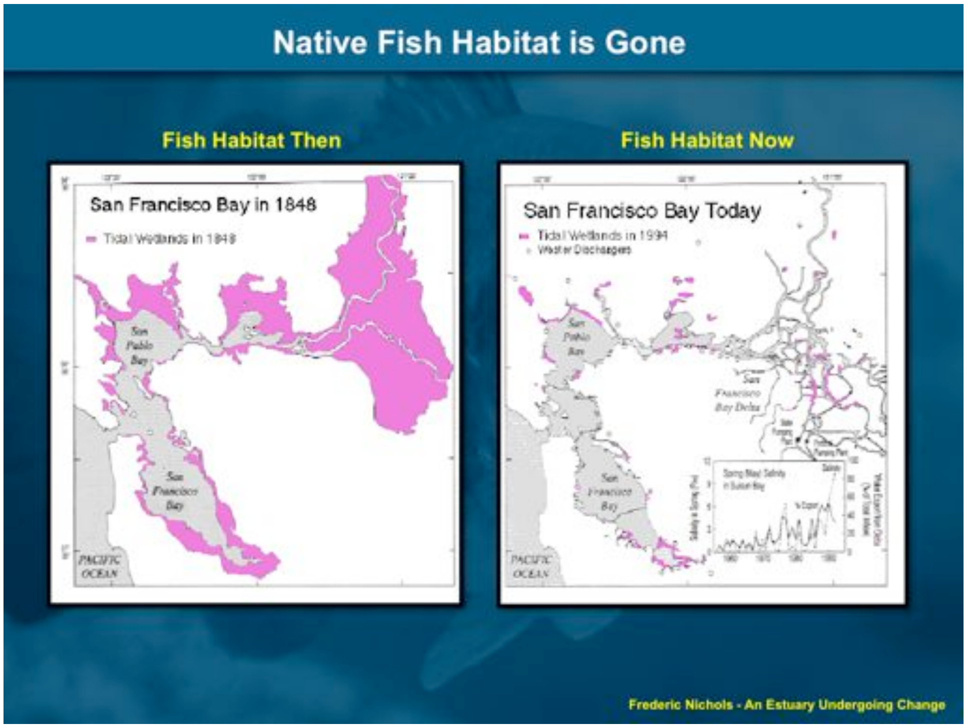
Delta Habitat Destruction

Non-native Species

Competition and Predation

Why are native species near a Tipping Point?

Experts are investigating the many potential causes for the decline of the Delta. However, there is no doubt that historical Delta habitat destruction, invasion of non-native species at different trophic levels, and competition from non-native fish are major factors associated with the decline of native Delta fishes.



Native Fish Habitat is Gone

Fish Habitat Then

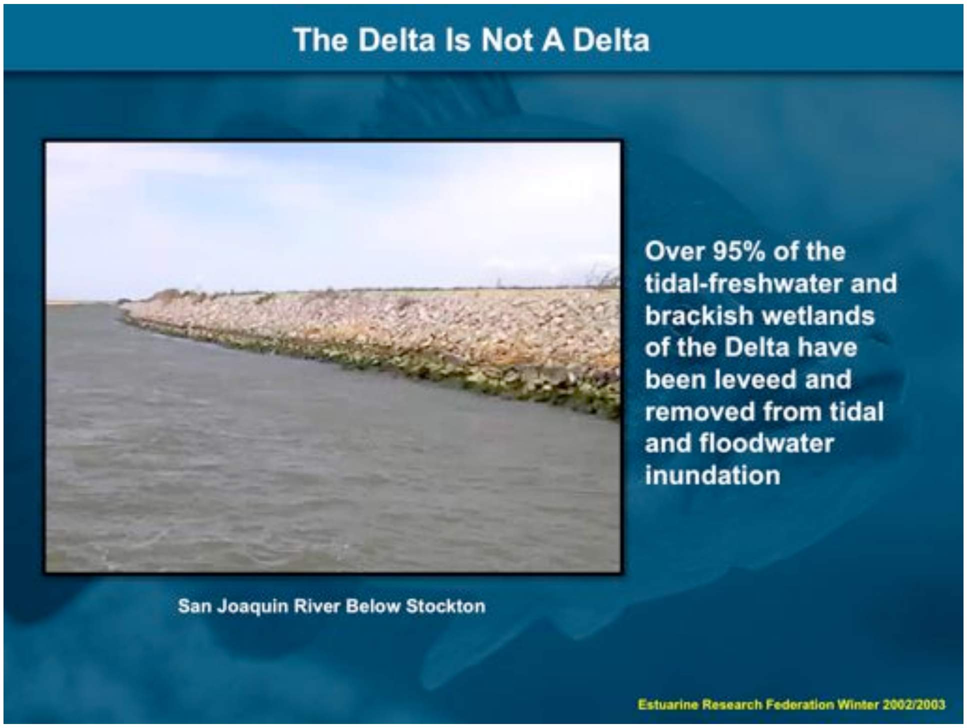
Fish Habitat Now

Frederic Nichols - An Estuary Undergoing Change

Native fish habitat is gone.

Perhaps the most obvious and dramatic change in the Delta is the widespread loss of shallow water habitat, the vital nursery area for juveniles of almost all fish species. Shallow water habitat is also important for primary and secondary producers, the organisms at the base of the food chain that ultimately provide food for native fish.

Source: The San Francisco Bay and Delta - An Estuary Undergoing Change
Frederic H. Nichols
http://sfbay.wr.usgs.gov/general_factsheets/change.html



The Delta Is Not A Delta

Over 95% of the tidal-freshwater and brackish wetlands of the Delta have been leveed and removed from tidal and floodwater inundation

San Joaquin River Below Stockton

Estuarine Research Federation Winter 2002/2003

The Delta is not a Delta

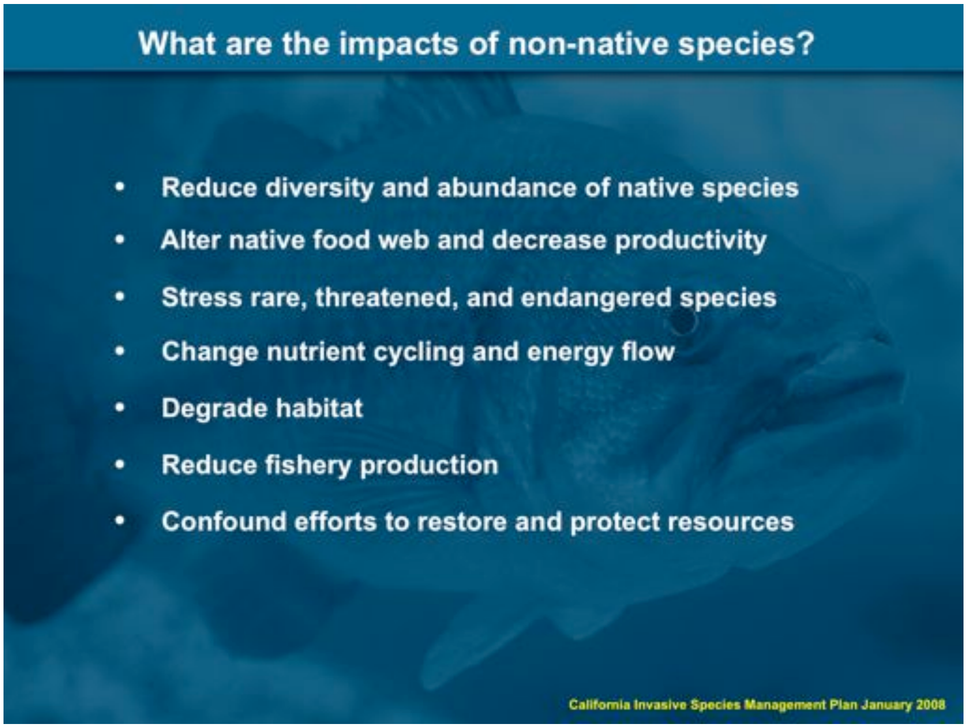
The modern Delta is a network of rip-rapped water conveyance canals that favor non-native fish over native fish, and perhaps non-native primary and secondary producers over native ones too.

Levees reduce native fish habitat complexity throughout the Delta and lower Central Valley tributaries by decreasing gravel and woody debris recruitment, and decreasing food production.

Estimates are that over 95% of Delta wetlands have been destroyed due to levees.

Source: Estuarine Research Federation Winter 2002/2003 Newsletter

http://www.erf.org/newsletter/Winter02-BREACH.htm



What are the impacts of non-native species?

- Reduce diversity and abundance of native species
- Alter native food web and decrease productivity
- Stress rare, threatened, and endangered species
- Change nutrient cycling and energy flow
- Degrade habitat
- Reduce fishery production
- Confound efforts to restore and protect resources

California Invasive Species Management Plan January 2008

What are the impacts of non-native species?

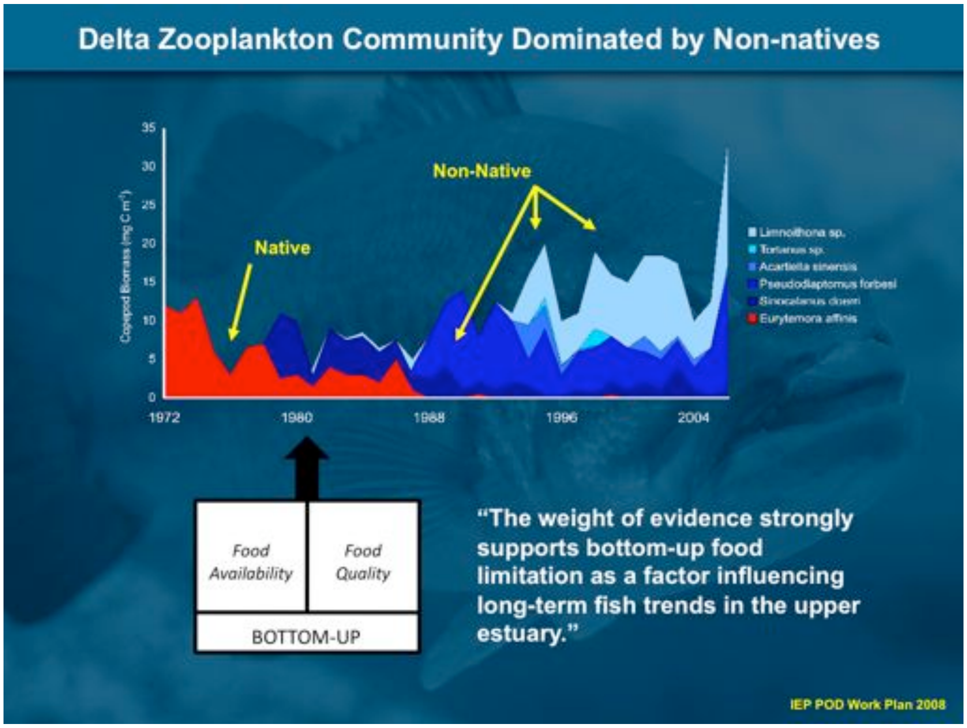
The impacts of non-native species are well studied and well understood.

They reduce the diversity and abundance of native species, alter the food web, stress rare, threatened, and endangered species, change nutrient cycling and energy flow, degrade habitat, reduce fishery production, and perhaps most importantly confound our efforts to restore and protect natural, native resources.

Source: State of California Resources Agency Department of Fish and Game January 2008. California Aquatic Invasive Species Management Plan

http://www.nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=3868

Additional source: Light, T., T. Grosholz and P. Moyle (May 2005). Delta Ecological Survey (Phase I): Nonindigenous aquatic species in the Sacramento-San Joaquin Delta, a Literature Review http://www.delta.dfg.ca.gov/nis/docs/DeltaSurveyFinalReport.pdf



Delta Zooplankton Community Dominated by Non-natives

"The weight of evidence strongly supports bottom-up food limitation as a factor influencing long-term fish trends in the upper estuary."

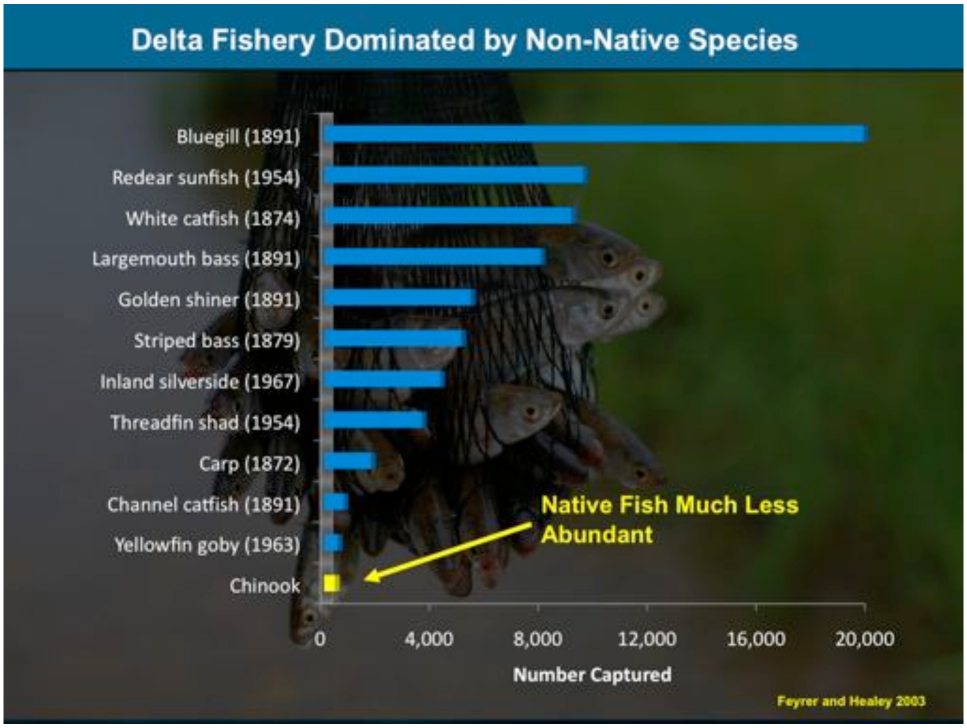
IEP POD Work Plan 2008

The delta zooplankton community is dominated by non-natives.

Non-native species have drastically altered the Delta food web, such that native zooplankton species have been replaced by non-native species, some thought to be less available as prey and with lower nutritional value than native zooplankton.

These significant changes in food resources have the potential to limit native fish production, and according to new research by the Interagency Ecological Program, "the weight of evidence strongly supports bottom-up food limitation as a factor influencing long-term fish trends in the upper estuary."

Source: Baxter R., R. Breuer, L. Brown, M. Chotkowski, F. Feyrer, B. Herbold, P. Hrodey, A. Mueller-Solger, M. Nobriga, T. Sommer, and K. Souza. June 2008. Interagency Ecological Program 2008 Work Plan to Evaluate the Decline of Pelagic Species in the Upper San Francisco Estuary. http://www.science.calwater.ca.gov/pdf/workshops/POD/IEP_POD_2008_workplan_060208.pdf



Delta Fishery Dominated by Non-Native Species

Native Fish Much Less Abundant

Feyrer and Healey 2003

The Delta fishery is dominated by non-naïve species.

Zooplankton aren't the only communities that have been replaced by non-native species. In a decade of fish sampling by government agencies in the south Delta, the 11 most abundant fish captured were non-native species. In this study, which is consistent with other Delta studies, the overwhelming majority of the biomass consisted of non-native fish species.

Many of these species compete with native fish, such as juvenile salmon, for limited food and space. Others, such as striped bass, largemouth bass, and white catfish are known to be significant predators that prey on salmon smolts as they move through the Delta. As Professor Mount stated, from a biomass perspective the Delta is doing very well, it just isn't producing what we want.

Source: Feyrer, F. and M.P. Healey 2003. Fish community structure and environmental correlates in the highly altered southern Sacramento-San Joaquin Delta. *Environmental Biology of Fishes* 66: 123-132, 2003

Non-Native Predator Fish Deliberately Introduced

Moyle and Nichols 1974; Brown and Moyle 1993; Dill and Cordone 1997

As you would expect, the predator community in the Delta is dominated by non-native species too.

Historically, the Delta consisted of approximately 29 native fish species, none of which were significant predators of other fish. Presently, 12 of these original species are either eliminated from the Delta or threatened with extinction.

Although none of these original fish populations were significant predators, today the Delta and lower tributaries are full of large non-native predators that were deliberately introduced into the Delta and its tributaries by the California Department of Fish and Game, and it's predecessor, the California Fish and Game Commission.

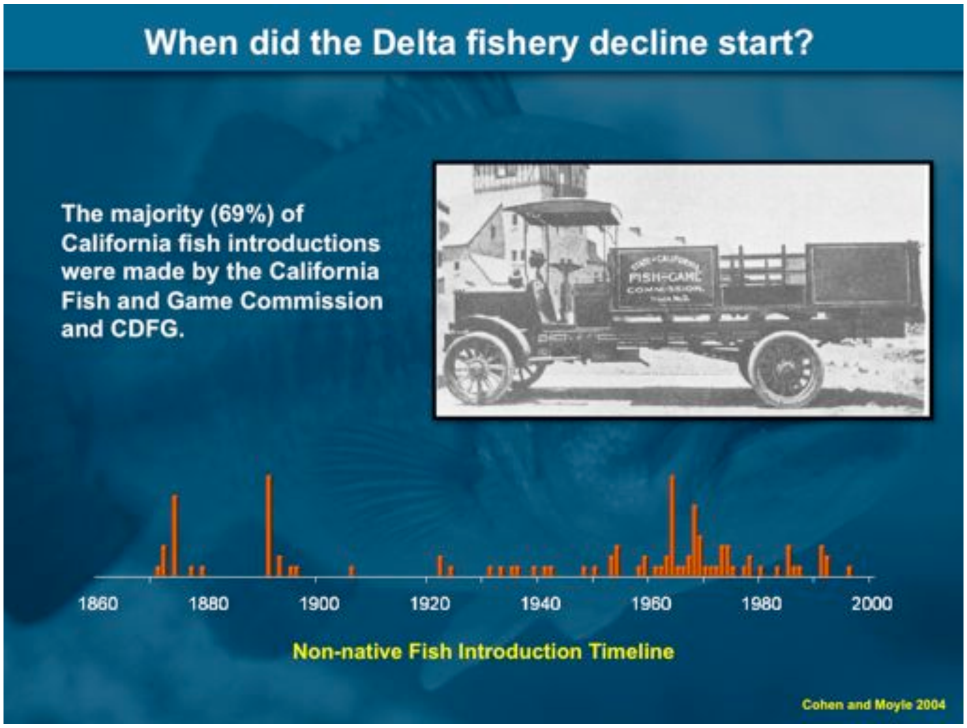
All of the top predators responsible for preying on native fish are currently managed with angling gear, season, and size regulations to maintain or increase their abundance.

Sources:

Moyle, P. B., and R. Nichols. 1974. Decline of the native fish fauna of the Sierra Nevada foothills, central California. The American Midland Naturalist 92(1):72-83

Brown, L. R., and P. B. Moyle. 1993. Distribution, ecology, and status of the fishes of the San Joaquin River drainage, California. California Fish and Game 79:96-113

Dill, W. A. and A. J. Cordone. 1997. History and status of introduced fishes in California, 1871-1996. Fish Bulletin 178: 1-414. California Department of Fish and



When did the Delta fishery decline start?

The majority (69%) of California fish introductions were made by the California Fish and Game Commission and CDFG.

Non-native Fish Introduction Timeline

Cohen and Moyle 2004

So, where did these non-native fish come from and when did the decline of the Delta fishery start?

Although people generally think of non-native species as “hitchhikers” that arrive with ballast water or bait buckets, the majority of non-native fish introductions in California were deliberately planted by the California Fish and Game Commission and later the California Department of Fish and Game.

Although the reasoning for these introductions varies from sport fish forage to mosquito control, collectively these introductions have harmed native fish through predation and competition for food and space.

Source: Cohen, A.N. and P.B. Moyle. 2004. Summary of data and analyses indicating that exotic species have impaired the beneficial uses of certain California waters. A report submitted to the State Water Resources Control Board. June,2004.
http://www.sfei.org/bioinvasions/Reports/2004-ImpairedCalWaters382.pdf

Additional sources:

Moyle P.B., L.H. Davis. 2000. A List of Freshwater, Anadromous, and Euryhaline Fishes of California. California Fish and Game 86(4):244-258.
http://www.dfg.ca.gov/wildlife/species/docs/fishofcalif.pdf

McGinnis, S.M. 2006. Field Guide to Fresh Water Fishes of California. University of California Press, Berkeley and Los Angeles, California.

A World Class Fishery That is Still Improving

Annual Largemouth Bass Tournament Catch

Data from Lee 2000 (missing data values estimated for 2000-2003);
Nobriga and Feyrer 2007; Grimaldo et al 2004

Although the native fishery is in decline, the delta bass fishery is would class and still improving.

As a recent government study states, *"Although none of the IEP surveys adequately tracks largemouth bass population trends, the Delta has become the top sport fishing destination in North American for largemouth bass, which illustrates the recent success of this species. Each year, lucrative fishing tournaments are held in the Delta to take advantage of the large number of trophy-sized bass in the region. Largemouth bass have a much more limited distribution in the estuary than striped bass, but a higher per capita impact on small fishes (Nobriga and Feyrer 2007).*

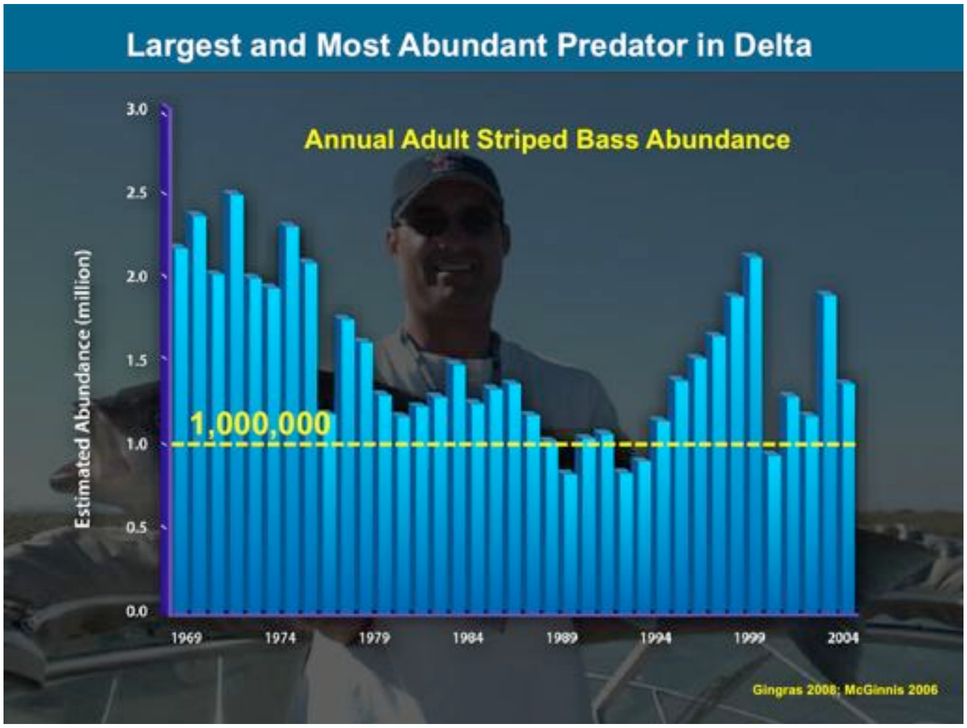
Sources: Lee, D.P. 2000. The Sacramento-San Joaquin Delta largemouth bass fishery. IEP Newsletter, Summer 2000 vol. 13, No. 3

http://iep.water.ca.gov/AES/NobrigaFeyrer2007.pdf

Black Bass Data1985-1999 From Lee 2000

2004-2006 From CDFG

2000-2003 No data, estimated missing values

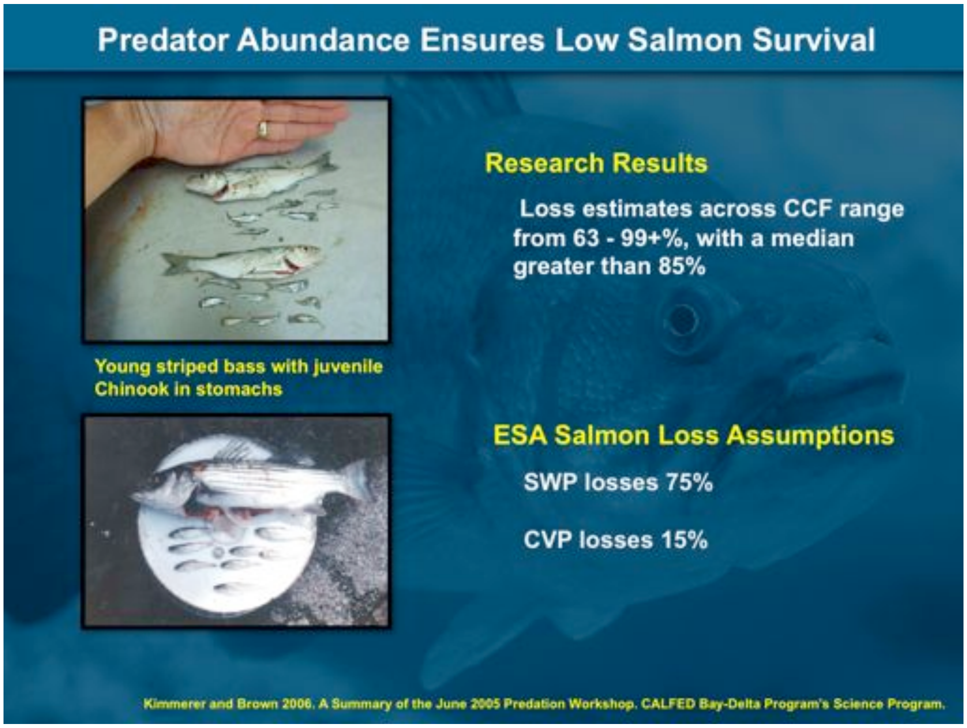


The largest and most abundant predator in the Delta.

Striped bass were first introduced in the Delta in 1879, and were so successful that by 1890 there was a commercial fishery underway. As Professor McGinnis notes in his recent book on California freshwater fish, prior to the 1870's the Delta had no large, pelagic predator that fed voraciously during a long annual stay in freshwater.

Today, although many think that the striped bass population is collapsing, the California Department of Fish and Game estimates that there are over 1 million stripers in the bay and Delta. Their abundance remains high, even though in 1992 the stocking of striped bass in the Delta was curtailed due to concern over predation on the endangered winter-run Chinook salmon.

Gingras M. 2008. DFG Striped Bass Population estimates and stocking data. KNB Data Registry: urn:lsid:knb.ecoinformatics.org:nceas:908:2 (http://knb.ecoinformatics.org/knb/metacat/nceas.908.2/nceas <http://knb.ecoinformatics.org/knb/metacat?action=read&qformat=nceas&sessionid=&docid=nceas.908>).



Predator Abundance Ensures Low Salmon Survival

Young striped bass with juvenile Chinook in stomachs

Research Results

Loss estimates across CCF range from 63 - 99+%, with a median greater than 85%

ESA Salmon Loss Assumptions

SWP losses 75%

CVP losses 15%

Kimmerer and Brown 2006. A Summary of the June 2005 Predation Workshop. CALFED Bay-Delta Program's Science Program.

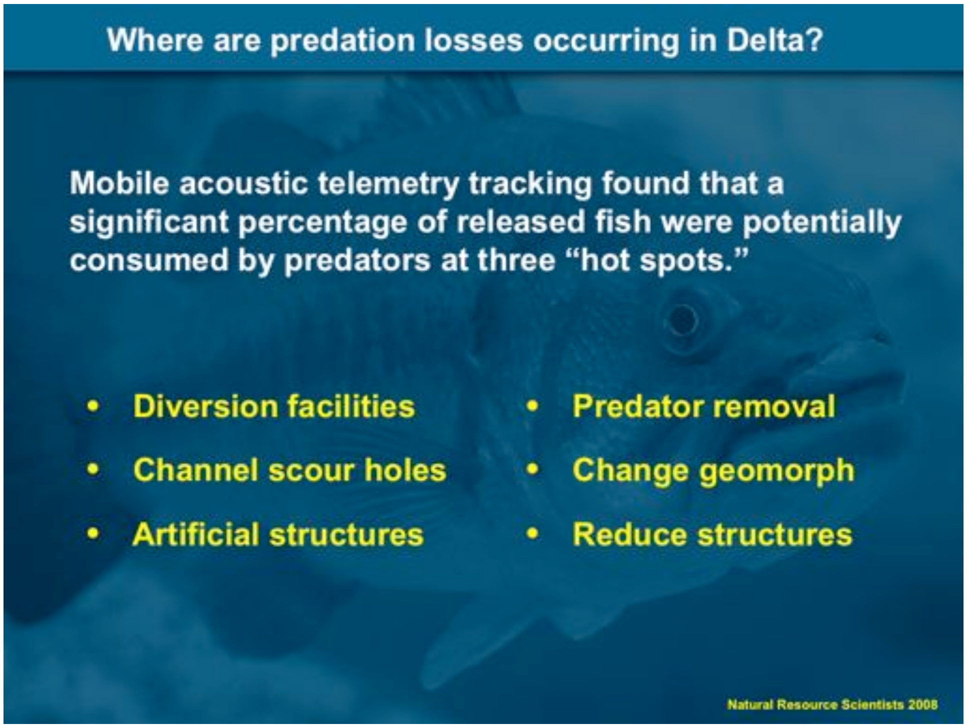
Predator abundance in the south Delta ensures low salmon survival.

Although predation on juvenile Chinook Salmon in Clifton Court Forebay is difficult to accurately assess, all evidence suggests that predation losses are extremely high, with a mean predation rate of several studies over 85%.

Losses of juvenile Chinook are so high in Clifton Court that for ESA permitting purposes prescreen losses are estimated at 75%. That means the majority of Chinook that enter Clifton Court Forebay are eaten by non-native predators, who’s abundance could be reduced by a variety of methods.

Source: Kimmerer, W., and R. Brown. May 2006. A Summary of the June 22 -23, 2005 Predation Workshop, Including the Expert Panel Final Report. CALFED Bay-Delta Program’s Science Program.

http://science.calwater.ca.gov/pdf/workshops/SP_workshop_predation_report_final_052706.pdf



Where are predation losses occurring in Delta?

Mobile acoustic telemetry tracking found that a significant percentage of released fish were potentially consumed by predators at three "hot spots."

- Diversion facilities
- Channel scour holes
- Artificial structures
- Predator removal
- Change geomorph
- Reduce structures

Natural Resource Scientists 2008

We know predation losses in and around Clifton Court Forebay are high, but where else are predation losses occurring in the Delta.

Recent acoustic telemetry research by government and private water interests suggests that predation may be high at hot spots such as diversion facilities, channel scour holes, and artificial structures.

Such findings are important since predation can be reduced through predator removal programs, changes in channel geomorphology, and reductions in the number of instream structures.

Source: Dave Vogel 2008 personal communication. Natural Resource Scientists.

Additional source: San Joaquin River Group Authority, 2008. 2007 Annual Technical Report on the Implementation and Monitoring of the San Joaquin River Agreement and the Veranlis Adaptive Management Plan. January 2008. http://www.sjrg.org/technicalreport/default.htm

Mossdale Bridge Predator Video

Natural Resource Scientists 2008

Acoustic video of predators.

Because the Delta is too turbid to visually observe fish, a high-tech acoustic video camera was recently used to observe fish abundance and behavior at suspected predation hot spots. Divers recorded visual evidence that corroborates telemetry data suggesting that predators congregate at scour holes and around artificial structures

This underwater acoustic video on the San Joaquin River shows a large number of predators, probably striped bass, congregating behind the Mossdale Bridge pilings. Many fish naturally associate with structure, and predators can use velocity shadows created by structures to conserve energy and hide from downstream migrating fish.

Source: Dave Vogel 2008 personal communication. Natural Resource Scientists.

Why do we attempt to “manage” competing fisheries?

Why do we attempt to “manage” competing native and non-native fisheries?

Why do we use ESA restrictions to protect native species such as Chinook salmon, steelhead trout, Delta smelt, and Sacramento splittail, while increasing the abundance of non-native fish species that potentially prey on and compete with them?

Why do resource managers ignore their own recommendations and continue to promote competing resources?

And perhaps most importantly, is this leading us to the Tipping Point?

What can we do about conflicting management?

[illegible]

- Modify Delta bass fishing regulations
- Catch and non-release of introduced predators
- Remove length and season restrictions
- Reduce or eliminate cost of fishing license

CDFG and DWR Pelagic Fish Action Plan March 2007

What can we do about conflicting management?

Perhaps better questions include:

How can we immediately reduce competition for limited resources, and reduce predation of native fish by non-native fish?

How can we improve conditions for native fish while reducing the abundance of non-native fish, at no cost?

In a joint action plan the California Department of Fish and Game and California Department of Water Resources recommended 4 key steps to improving our native fisheries including modifying Delta bass fishing regulations to harvest the top predators and reduce their population sizes, catch and non-release of introduced predatory fishes, removal of length or season restrictions, and reducing or eliminating the cost of a fishing license.

Source: CDFG and DWR. 2007. Pelagic Fish Action Plan. California Department of Water Resources and California Department of Fish and Game. March 2007.http://www.water.ca.gov/deltainit/docs/030507pod.pdf

Clear Record of Ecosystem Level Changes

[illegible]

Food Web

Native Fisheries

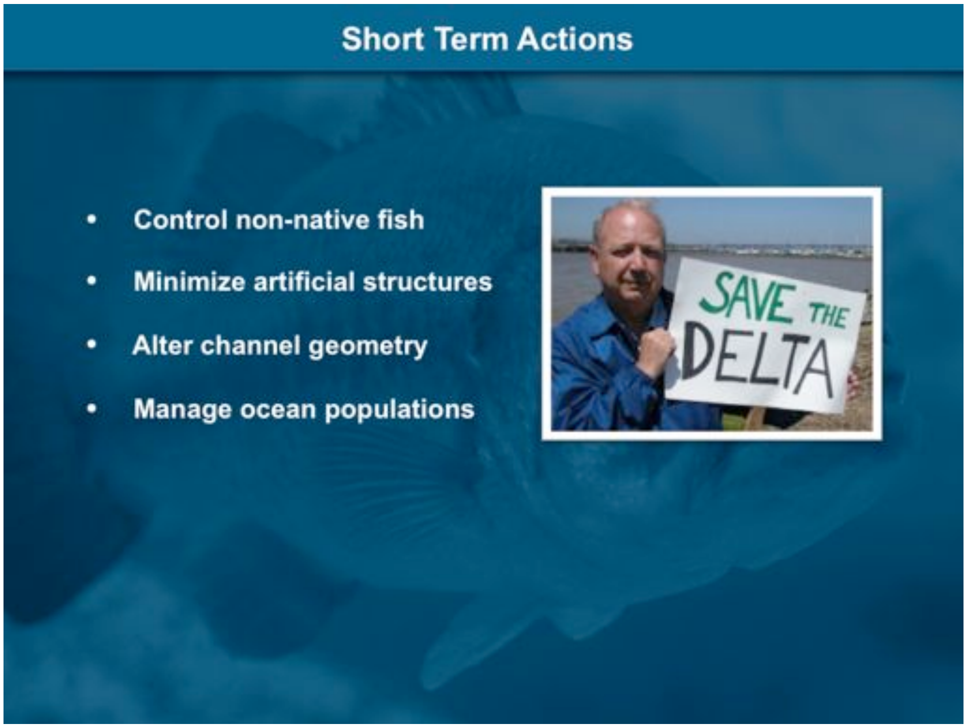
Non-Native Fisheries

Clear record of ecosystem-level changes.

Overall, there is a clear record of ecosystem-level changes in in fish habitat, zooplankton and the aquatic food chain, and both native and non-native fish communities within the Delta.

It is clear that these changes are significant enough that they confound our ability to protect and restore native fisheries, represent immediate and irreversible threats to salmon populations, and are consistent with the theory that we may be reaching a Tipping Point in the Delta.

Additionally, it is clear that immediate actions are needed to first protect and then restore native fishery resources.



Short Term Actions

- Control non-native fish
- Minimize artificial structures
- Alter channel geometry
- Manage ocean populations

Short term actions to protect the Delta.

Several key actions must be implemented if we are going to keep our native fisheries from the Tipping Point, including eliminating non-native fish throughout the Delta by localized predator control, minimizing artificial structures in salmon migration corridors, altering channel geometry at scour holes, and better managing ocean harvest

Long Term Actions

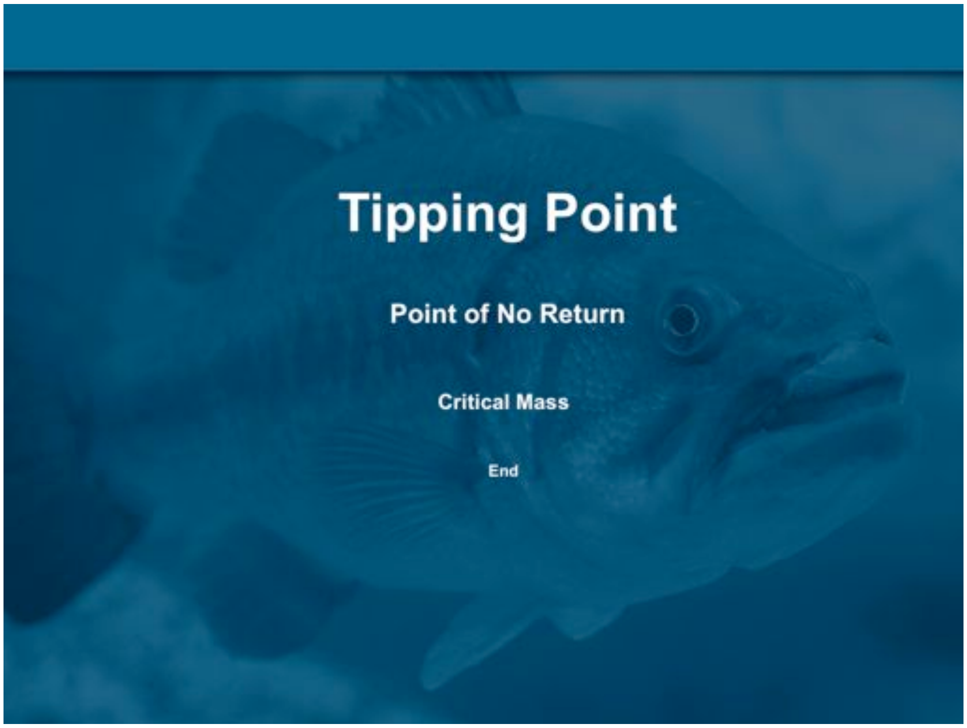
- Restore interconnected habitat
- Establish migratory corridors
- Reduce fish mortality by:
  - Diversion management
  - Conveyance improvements
  - Relocate diversions

Delta Vision 2008

Long-term actions.

Long term action needed to protect and restore our native fish populations, including salmon and steelhead, include restoring interconnected habitats within the Delta, establishing migratory corridors for fish and flood flows along selected Delta River channels, and reducing mortality around the South Delta Diversion Facilities by instituting diversion management, implementing conveyance improvements, and relocating diversions.

Source: Blue Ribbon Task Force 2008. Final Delta Vision Strategic Plan. October 2008. http://deltavision.ca.gov/StrategicPlanningDocumentsandComments.shtml-FinalDraft



Tipping Point

Point of No Return

Critical Mass

End

The Tipping Point presentation was developed by the San Joaquin River Group and other San Joaquin Basin interests.


THE DELTA
TIPPING POINT

Comments submitted to the *SWRCB Water Quality Control Planning Workshop: Climate Change*

Expected changes in precipitation and flow: higher variability and altered timing

- Inflows to Delta will change in timing, magnitude and duration (Mount et al. 2006)
- Interannual variation will increase (Mount et al. 2006)
- Reduced spring and summer inflows to Delta (Mount et al. 2006)
- Proportion of precipitation as snow vs. rain will change, causing peak runoff timing to shift toward winter (Dettinger et al., 2004; Hayhoe et al., 2004).

Changing precipitation, temperature, and sea level influence water quality and habitat

- Precipitation:
  - Average precipitation will slightly decrease according to most models (Dettinger 2005)
  - Winter extreme precipitation events likely increase in magnitude and frequency (Kim (2005)
- Temperature:
  - Models project warming (Knowles and Cayan 2002, Dettinger 2005, Mount et al. 2006, Christensen et al. 2007, Baxter et al. 2008)
  - July water temperatures of 21-24°C in upper estuary are already high for delta smelt (Baxter et al. 2008)
  - Delta smelt lethal temperature limit about 25°C (Swanson et al. 2000).
- Sea Level Rise:
  - Expected sea level rise by 2100 = 0.7-1.0 m (28-39 in.), conservative estimates (Mount 2007)
  - Increasing saline intrusion pushes distributions upstream, effectively reducing available habitat for less tolerant species (Baxter et al. 2008)
- Failure to meet quality standards from SJR inflows likely will increase under current climate change scenarios (Van Rheenan et al. 2004)
- SJR (San Joaquin River) inflows of poor quality linked with dry years (Mount et al. 2006)
- Low inflows increase salinity and influence of tides on circulation, making it harder to meet X2 standards (Mount et al. 2006)
- 2090 projections for Sacramento-San Joaquin watershed (Knowles and Cayan 2002):
  - Temperature increase of 2.1˚ C
  - Lose half of average April snowpack
  - Spring runoff reduced by 20% (5.6 km^3)
  - Increased winter flood peaks
  - Salinity increased in spring/summer up to 9 psu

- Long-term and negative impact on pelagic habitat expected (Baxter et al. 2008).
- Key data need: level of impact on water quality from reduced spring and summer inflows (Mount et al. 2006)

Climate change and associated impacts influence reproduction and recovery

- Reproduction of pelagic fish is often linked with historic runoff patterns, and is impeded by changes in hydrographs (Moyle 2002).
- Water temperature increases of only 2^{o}C have substantial impacts on spawning and recruitment, especially for Delta smelt (Bennett 2005)
- Estimates of population viability from a "mechanistic" PVA (pop. viability analysis) were highly influenced by assumptions of future climate conditions, and increasing juvenile carrying capacity is important for recovery of Chinook (Zabel et al. 2006)
- Populations with distinctive habitats respond differently to climate variability (Crozier et al. 2008)
- Risk of extinction for anadromous fishes is increased from climate change impacts on freshwater stages (Crozier et al. 2008)
- Unusual coastal conditions (low upwelling, warm sea surface temperature, low prey densities) in 2005-2006 caused low survival of 2004-2005 Sacramento fall run Chinook broods (sea birds with similar diet had low reproduction too) → but poor freshwater conditions exacerbate declines when ocean survival is low (Lawson 1993)
- Interannaul abundance variations influenced by climate variability (Lindley et al. 2009)
- Increasing climate variability enhances variation in abundance of Sacramento fall run Chinook and other coastal stocks (Lindley et al. 2009)
- Potential increased intensity and frequency of rare events (Christianson et al. 2007) and more variability in ocean conditions (Lindley et al. 2009)
- Drop in spawner numbers linked with oceanic regime shifts of 1976-1977 and 1989-1990, and listed Evolutionary Significant Units (ESUs) (if include Central Valley fall run) declined more than non-listed ESUs across the regime boundaries (Tolimieri and Levin 2004)
- Sub-units of the same species react differently to long-term climate changes, which are important for Chinook population dynamics (Tolimieri and Levin 2004)

Adaptation and mitigation strategies needed immediately

- Current assemblage of populations is more vulnerable to climatic variation because of reduced life history diversity caused by simplified habitat (Lindley et al. 2009)

- Freshwater temperature and flow influenced by same factors as ocean variability and combined they increase potential for extremes (lows and highs) in escapement numbers (Lindley et al. 2009)
- Improving/maintaining diversity of habitats important for improving resiliency of populations facing climate change impacts (Crozier et al. 2008)
- "The most comprehensive of the mitigation alternatives examined satisfied only 87-96% of environmental targets in the Sacramento system, and less than 80% in the San Joaquin system. It is evident that demand modification and system infrastructure improvements will be required to account for the volumetric and temporal shifts in flows predicted to occur with future climates in the Sacramento-San Joaquin River basins." (Van Rheenen et al. 2004)

Ocean conditions are highly variable and influential for salmonids

The fate of salmon once they enter the ocean is difficult to determine and further research is needed. Salmon face highly variable conditions in the ocean including predation, temperature, salinity, currents, food availability and upwelling.

- Inter-annual variation in salmon abundance, growth and survival is substantial and could be influenced by alterations in habitat caused by climatic shifts at regional and local scales (NPAFC 2005)
- The climactic factors that impact marine fish production are showing increasing variation in timing, frequency, and amplitude (NPAFC 2005)
- The size of mature coho and Chinook salmon from Washington, Oregon and California is negatively affected by El-Nino-like events and their growth trajectory is set after the first ocean winter (Wells et al. 2006).
- 1-year-ahead forecasts were highly predictive of changes in ocean survival of Snake River Chinook based on indices of coastal upwelling (Scheurrell and Williams 2005)
- The greatest rates of growth and energy accumulation for Chinook salmon occur in the first one to three months after ocean entry. Conditions when Chinook salmon entered the ocean in 2005 and 2006 were unfavorable to growth and survival. Indices suggest that conditions in these years were worse than all others except the El Niño years (1982-83, 1992-93, 1999) (MacFarlane et al. 2008).

- Fall-run Central Valley Chinook: Composed 90% of the total Chinook caught in August north of Cape Blanco, OR and 20% of all Chinook caught south of Cape Blanco. They were associated with cooler temperatures, higher salinities, higher chlorophyll-*a* concentrations, and shallower depths. (Brodeur et al. 2004)
  - 1983 El Niño had apparent impact in Chinook size and fecundity (Wells et al. 2006).
  - More likely to go north, compared to winter-run, and may go as far as British Columbia. (Williams 2006)
  - 1998 best growth for juveniles, even though unusually warm year, because upwelling was strong and high runoff from Central Valley

rivers added nutrients to the waters in the Gulf of the Farallones making for high food production. Ocean conditions in the Gulf are likely most important. (Williams 2006)

- Estimated average survival from smolt to adult is 3.1% (Quinn 2005)
- Calm periods between periods of wind can improve coastal productivity, because Ekman transport and persistent northwest winds move upwelled water away from the coast before nutrients have time to move up the food web (Chavez et al. 2002)

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