Final Technical Report | **2007**

Surface Water Ambient Monitoring Program (SWAMP) Report on the Carlsbad Hydrologic Unit

July 2007

www.waterboards.ca.gov/swamp

SURFACE WATER AMBIENT MONITORING PROGRAM (SWAMP) REPORT ON THE CARLSBAD HYDROLOGIC UNIT

Raphael D. Mazor
Ken Schiff

Southern California Coastal Water Research Project
3535 Harbor Blvd., Suite 110
Costa Mesa, CA 92626
www.sccwrp.org

Prepared for the California Regional Water Quality Control Board, San Diego Region (Region 9).

This project was funded by the Surface Water Ambient Monitoring Program.

Technical Report 527_Carlsbad

TABLE OF CONTENTS

1. Abstract 1
2. Introduction 2
2.1 Geographic Setting 3
2.1.1 Climate 3
2.1.2 Hydrology 5
2.1.3 Land Use within the Watershed 6
2.1.4 Beneficial Uses and Known Impairments in the Watershed 6
3. Methods 7
3.1 Indicators 9
3.1.1 Water chemistry 9
3.1.2 Toxicity 10
3.1.3 Tissue 10
3.1.4 Bioassessment 10
3.1.5 Physical Habitat 10
3.2 Data Analysis 11
3.2.1 Thresholds 11
3.2.2 Quality Assurance and Quality Control (QA/QC) 15
4. Results 16
4.1 Water Chemistry 16
4.2 Toxicity 26
4.3 Tissue 28
4.4 Bioassessment 29
4.5 Physical Habitat 34
5. Discussion 36
6. Literature Cited 43
7. Appendices 45
APPENDIX I 1
APPENDIX II 1
APPENDIX III 1
APPENDIX IV 1
APPENDIX V 1

LIST OF FIGURES

Figure 1. Location of the Carlsbad HU 3
Figure 2. Rainfall and sampling events at two stations in the San Diego region 4
Figure 3. The Carlsbad watershed, including major waterways. 5
Figure 4. Land use within the Carlsbad HU 6
Figure 5. Location SWAMP and non-SWAMP sampling locations 9
Figure 6. Aquatic life threshold exceedances for water chemistry at SWAMP sites. 25
Figure 7. Map of human health exceedances for water chemistry at SWAMP sites 25
Figure 8. Frequency of toxicity at SWAMP sites 27
Figure 9. Fish tissue exceedances at SWAMP sites 29
Figure 10. IBI scores at sites in the Carlsbad HU 31
Figure 11. Mean IBI scores at each bioassessment site and each season 32
Figure 12. IBI values for each year and site 34
Figure 13. Assessment of physical habitat at SWAMP sites 35
Figure 14. Summary of the ecological health of SWAMP sites. 37

LIST OF TABLES

Table 1. Watersheds monitored under the SWAMP program. 2
Table 2. Sources of data used in this report. 7
Table 3: SWAMP sampling site locations 7
Table 4. Non-SWAMP sampling site locations 8
Table 5. Threshold sources 12
Table 6. Water chemistry thresholds for aquatic life and human health standards 13
Table 7. Threshold concentrations for fish tissue contaminants 15
Table 8. Number of anthropogenic organic compounds detected at each site 16
Table 9. Frequency of detection of anthropogenic organic compounds 16
Table 10. Frequency of water chemistry threshold exceedances 20
Table 11. Frequency of SWAMP sites with aquatic life and human health threshold exceedances for each constituent 24
Table 12. Number of constituents exceeding thresholds at each SWAMP site. 26
Table 13. Frequency of toxicity detected for each endpoint and at each site .27
Table 14. Concentrations of contaminants in fish tissues 28
Table 15. Frequency of anthropogenic organic constituents detected in fish tissue. 29
Table 16. Mean and standard deviation of IBI scores at bioassessment sites within the Carlsbad HU 30
Table 17. Score and mean for each component of physical habitat 35
Table 18. Summary of the ecological health for five SWAMP sites in Carlsbad HU 36

1. ABSTRACT

In order to assess the ecological health of the Carlsbad Hydrologic Unit (San Diego County, CA), water chemistry, water and sediment toxicity, fish tissues, benthic macroinvertebrate communities, and physical habitat were assessed at multiple sites. Water chemistry, toxicity, and fish tissues were assessed under SWAMP between 2002 and 2003. Bioassessment samples were collected under other programs between 1998 and 2005. Although impacts to human health were also assessed, the goal of this monitoring program was to examine impacts to aquatic life in the watershed. Most of these ecological indicators showed evidence of widespread impacts to the watershed. For example, all sites (n = 10) exceeded aquatic life thresholds for several water chemistry constituents (up to eight at one site). Toxicity was evident at all sites, although severity varied from slight (e.g., at Escondido Creek) to moderate (e.g., at San Marcos Creek); chronic indicators of toxicity were evident at 8 to 40% of all samples, with *Selenastrum capricornutum* and *Hyallela azteca* being the most sensitive indicators of toxicity. Fish tissue collected at 2 sites did not indicate impairment, although accumulation of PCBs and pesticides was evident. Bioassessment samples collected at 21 sites (125 samples) were all in poor or very poor condition, with mean annual IBIs ranging from 4.3 to 31.4, meaning that benthic assemblages were typical of impacted communities. Physical habitat varied throughout the watershed, with mean physical habitat scores ranging from 8.3 to 16.5 (both in Escondido Creek). Embeddedness was a widespread and severe impact on physical habitat, receiving at average score of 3.3. Multiple stressors, such as pollution of water and sediment, and alteration of physical habitat, are likely responsible for the poor health of the watershed. Despite limitations of this assessment (e.g., uncertain spatial and temporal variability, low levels of replication, non-probabilistic sampling, and lack of thresholds for several indicators), multiple lines of evidence support the conclusion that the Carlsbad watershed is in poor ecological condition.

2. INTRODUCTION

The Carlsbad hydrologic unit (HU 904) is in San Diego County and is home to about 500,000 people and represents an important water resource in one of the most arid regions of the nation. Despite strong interest in the surface waters of the Carlsbad HU, a comprehensive assessment of the ecological health of these waters has not been conducted. The purpose of this study was assess the health of the watershed using data collected in 2002 under the Surface Waters Ambient Monitoring Program (SWAMP), and data collected by National Pollution Discharge Elimination System (NPDES) permittees. SWAMP monitoring efforts rotated among sets of watersheds, ensuring that each HU is monitored once every 5 years (Table 1). These programs collected data to describe water chemistry, water and sediment toxicity, physical habitat, fish or invertebrate tissue, and macroinvertebrate community structure. By examining data from multiple sources, this report provides a measure of the ecological integrity of the Carlsbad HU.

Table 1. Watersheds monitored under the SWAMP program.

Year (Fiscal year)	Sample collection	Hydrologic unit	HUC
1 (2000-2001)	2002	Carlsbad	904
	2002	Peñasquitos	906
2 (2001-2002)	2002-2003	San Juan	901
	2003	Otay	910
3 (2002-2003)	2003	Santa Margarita	902
	2003	San Dieguito	905
4 (2003-2004)	2004-2005	San Diego	907
	2004-2005	San Luis Rey	903
5 (2004-2005)	2005-2006	Pueblo San Diego	908
	2005-2006	Sweetwater	909
	2005-2006	Tijuana	911

There are two objectives for this assessment: 1) To evaluate the condition of SWAMP sites; and 2) To evaluate the overall condition of the watershed. Evaluations were based on multiple indicators of ecological integrity, including water chemistry, water and sediment toxicity, fish tissue bioaccumulation, biological assessment of benthic macroinvertebrate communities, and physical habitat assessment.

This report is organized into four sections. The first section (Introduction) describes the geographic setting in terms of climate, hydrology, and land use within the watershed. The second section (Methods) describes the approach to data collection, assessment indicators, and data analysis. The third section (Results) contains the results of these analyses. The fourth section (Discussion) integrates evidence of impact from multiple indicators, describes the limitations of this assessment, and summarizes the overall health of the watershed.

2.1 Geographic Setting

The Carlsbad HU is a collection of coastal watersheds in San Diego county draining into several coastal lagoons and the Pacific Ocean (Figure 1). Located entirely within San Diego County, the watershed covers 211 mi^2 and ranges from Paradise Mountains in the interior to the Pacific Coast.

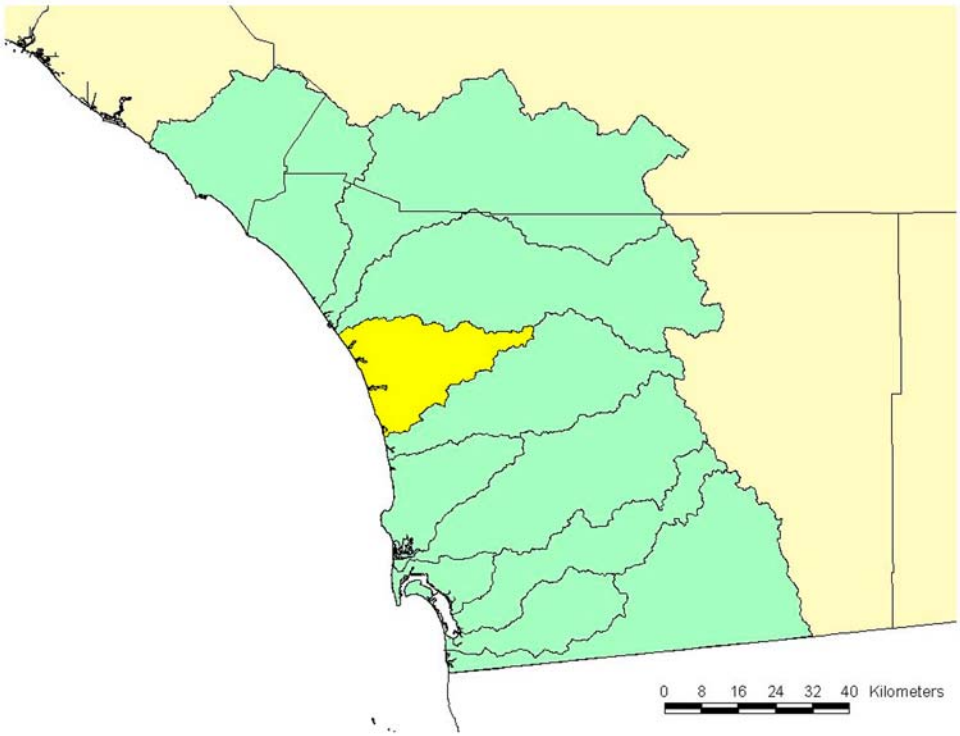


Figure 1. San Diego region (green) includes portions of San Diego, Riverside, and Orange counties. The Carlsbad HU (yellow, shaded) is located entirely within San Diego County.

2.1.1 Climate

The Carlsbad HU, like the entire San Diego region, is characterized by a mediterranean climate, with hot dry summers and cool wet winters. Average monthly rainfalls measured at the Lindberg Airport (SDG) in San Diego, California between 1905 and 2006 show that nearly all rain fell between the months of October and April, with hardly any falling between the months of May and September (California Department of Water Resources 2007). The wettest month was January, with an average rainfall of 2.05"). Average annual rainfall at this station was 10.37". Daily rainfall measured at Wild Animal Park (near the inland end of the HU) and at Carlsbad APT (near the coast within the HU) shows considerable variability in rainfall throughout the HU (National Oceanic and Atmospheric Administration 2007)) (Figure 2).

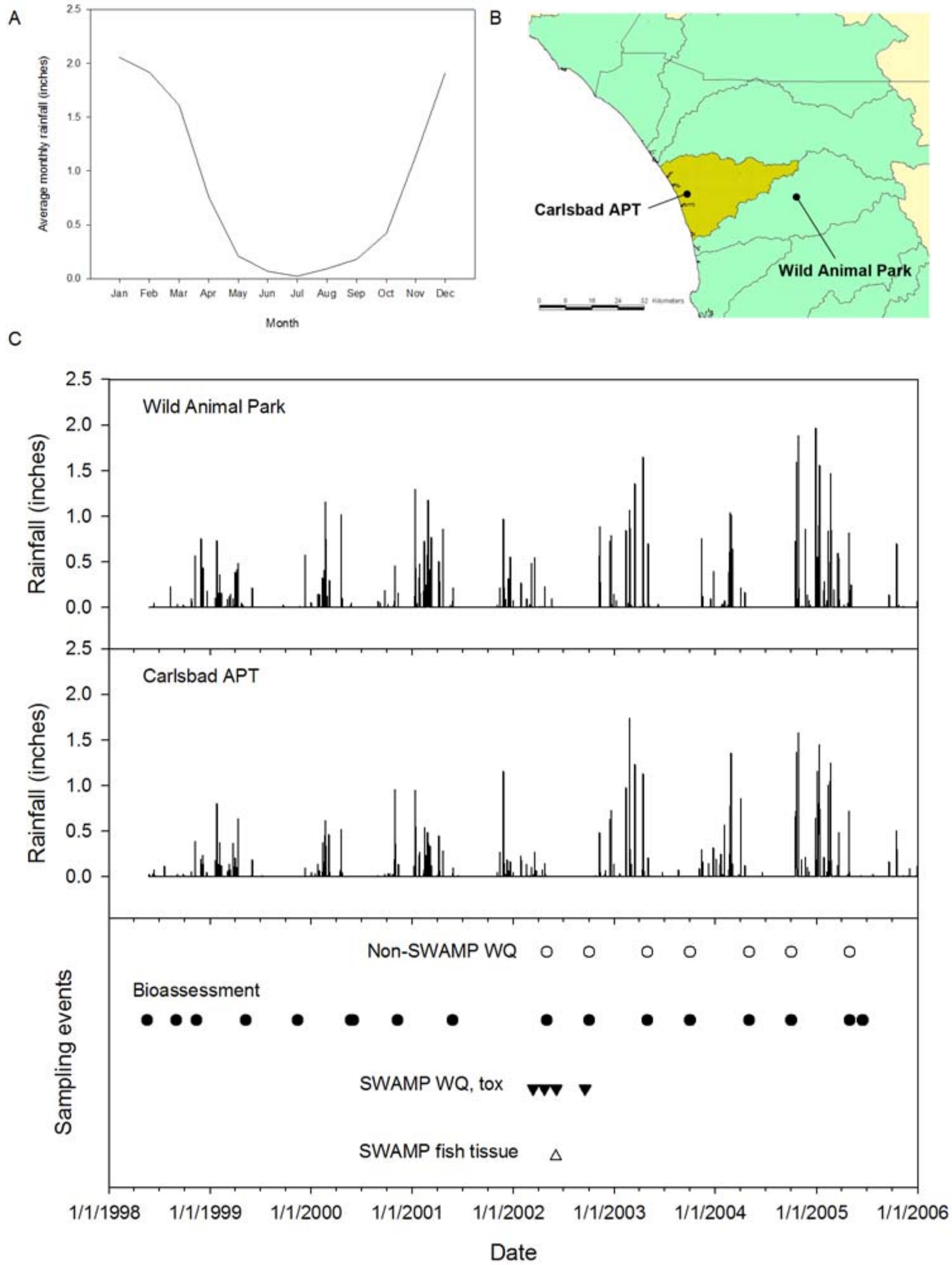


Figure 2. Rainfall and sampling events at two stations in the San Diego region. A. Average precipitation for each month at the Lindberg Station (DWR station code SDG), based on data collected between January 1905 and November 2006. B. Location of the Wild Animal Park and Carlsbad APT gauges. C. Storm events and sampling events in the Carlsbad HU. The top two plots show daily precipitation between 1998 and 2006 at the two stations. The bottom plot shows the timing of sampling events. SWAMP water chemistry and toxicity samples are shown as black downward triangles. SWAMP fish tissue samples are shown as upward white triangles. Non-SWAMP water chemistry samples are shown as white circles. Bioassessment samples are shown as black circles.

2.1.2 Hydrology

The Carlsbad HU consists of seven major watersheds, many of which drain to several coastal lagoons that provide abundant wetland habitat (Figure 3). Smaller watersheds drain directly into the Pacific Ocean. The largest watershed is Escondido Creek, which drains into San Elijo Lagoon. Major waterbodies within this watershed include Lake Wohlford and Dixon Reservoir, in the upper reaches of the watershed, and Olivenhain Reservoir in lower portions of the watershed. San Marcos Creek is the next largest watershed, draining into Batiquitos Lagoon. Further north, Agua Hedionda Creek and Buena Creek drain into Agua Hedionda Lagoon; this watershed include Squires Reservoir and Lake Calavera. Buena Vista Creek drains into Buena Vista Lagoon. Several smaller creeks drain directly into the Pacific Ocean; the largest of these are Loma Alta Creek, Encinas Creek, and Cottonwood Creek. During dry weather, water from Cottonwood Creek is diverted to a treatment facility to remove bacteria and other contaminants; this water is returned to the creek before it discharges to Moonlight Beach (City of Encinitas 2006)

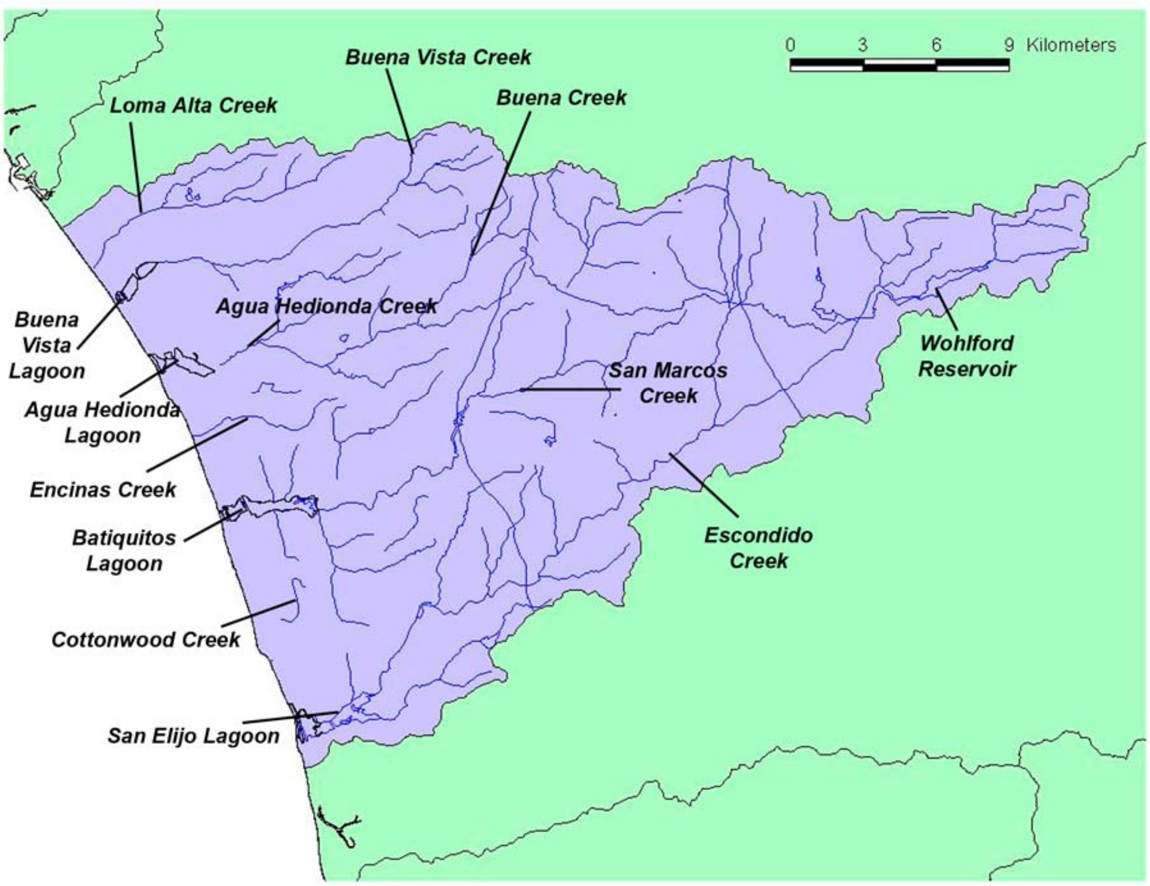


Figure 3. The Carlsbad watershed, including major waterways.

2.1.3 Land Use within the Watershed

Several municipalities have jurisdiction over portions of the watershed. Carlsbad occupies the largest portion of the watershed (18.5%), followed by Escondido (12.9%, and San Marcos (11.4%). The cities of Encinitas, Oceanside, and Vista cover between 8 and 10% of the watershed each, and the city of Solana Beach occupies less than 1%. The remainder of the watershed (31.3%) are unincorporated areas under the jurisdiction of the county of San Diego. Half of the watershed (50%) is developed urban land (residential and industrial). Parks or undeveloped land occupy 38%. Agriculture occurs in 12% of the watershed (Figure 4). The largest protected open space is the Daley Ranch, a 4.8 mi^2 conservation area operated by the City of Escondido; this preserve contains portions of Escondido Creek. Caltrans is a major landowner within the HU, and it has jurisdiction of all major freeways and highways (SANDAG 1998).

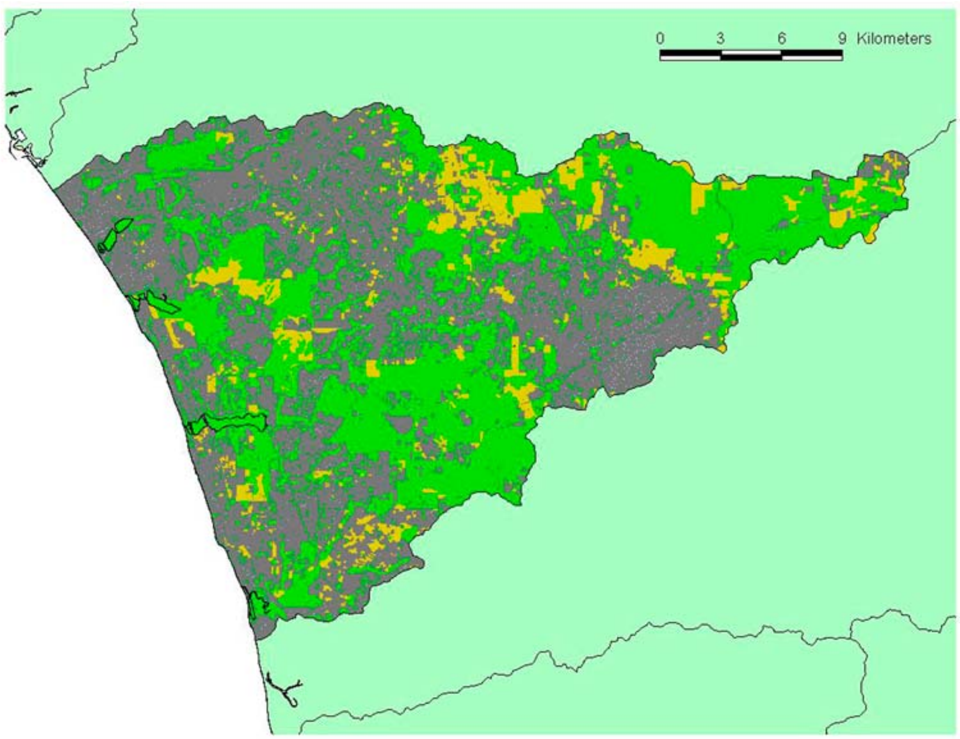


Figure 4. Land use within the Carlsbad HU. Undeveloped open space is shown as green. Agricultural areas are shown as orange. Urban and developed lands are shown as dark gray.

2.1.4 Beneficial Uses and Known Impairments in the Watershed

The Carlsbad HU is designated to support many beneficial uses. Beneficial uses in the watershed include municipal; agriculture; industrial service supply; power; recreation; warm and cold freshwater habitat; wildlife habitat; and rare, threatened, or endangered species. Some streams in the Calrsbad HU have been exempted from municipal uses (Appendix I).

Several streams in the Carlsbad HU are listed as impaired on the 303(d) list of water quality limited segments, affecting a total of 76.6 stream miles. These streams include Agua Hedionda Creek, Buena Vista Creek, Buena Creek, Cottonwood Creek, Encinitas Creek, Escondido Creek, Reidy Canyon Creek, and San Marcos Creek. Known stressors include pesticides (DDE and DDT), manganese, nitrate and nitrite, phosphate, phosphorus, selenium, sulfates, total dissolved solids, and sediment toxicity (Appendix I).

3. METHODS

This report combines data collected under SWAMP with data from California Department of Fish and Game (CDFG) and NPDES monitoring (Table 2). Ten sites of interest were sampled under SWAMP in the Carlsbad HU in 2002 (Table 3; Figure 5). Water chemistry, water and sediment toxicity, and physical habitat was measured at each site. Fish and invertebrate tissues were collected near two sites (Agua Hedionda Creek, 904CBAGH6, and San Marcos Creek, 904CBSAM6) to assess bioaccumulation. Bioassessment was not included as part of SWAMP monitoring in the Carlsbad HU, but bioassessment data collected by the CDFG Aquatic Bioassessment Laboratory (ABL) and the County of San Diego as part of its NPDES permit (from 2002 to 2005) was used in this report. In addition to bioassessment, conventional water chemistry (e.g., temperature, conductivity, dissolved oxygen) was also measured at sites sampled by San Diego County NPDES. When two non-SWAMP sites were located within 500 meters of each other, they were treated as a single site. This distance was based on published measures of spatial correlation of benthic communities in streams (Gebler 2004). Non-SWAMP samples were collected between 1998 and 2005; in some cases, non-SWAMP sites were very close to SWAMP sites (Table 4; Figure 5).

Table 2. Sources of data used in this report.

Project	Indicators	Years
SWAMP	Water chemistry, toxicity, fish tissue, bioassessment, and physical habitat.	2002
CA Department of Fish and Game	Bioassessment	1998-2000
San Diego County NPDES	Water chemistry, bioassessment	2002-2005

Table 3: SWAMP sampling site locations. Fish tissues were sampled at the locations marked with an asterisk (*).

	Site	Description	Latitude (°N)	Longitude (°E)
1	904CBAQH6*	Agua Hedionda Creek 6	33.149	-117.2977
2	904CBBUR1	Buena Creek 1	33.1726	-117.2084
3	904CBBVR4	Buena Vista Creek 4	33.1806	-117.3292
4	904CBCWC2	Cottonwood Creek 2	33.0487	-117.2955
5	904CBENC2	Encinitas Creek 2	33.0682	-117.2625
6	904CBESC5	Upper Escondido Creek 5	33.0865	-117.1451
7	904CBESC8	Lower Escondido Creek 8	33.0349	-117.2363
8	904CBLAC3	Loma Alta Creek 3	33.2001	-117.3307
9	904CBSAM3	Upper San Marcos Creek 3	33.1322	-117.1969
10	904CBSAM6*	Lower San Marcos Creek 6	33.0882	-117.2683

Table 4. Non-SWAMP sampling site locations. W = sites where conventional water chemistry was sampled. B = sites where benthic macroinvertebrates were sampled.

Site	Description	SWAMP site within 500 m	Sources (Sites)	W	B	Latitude (°N)	Longitude (°E)
1	Agua Hedionda Creek at El Camino Real	904CBAQH6	CDFG (904AHCECR)		X	33.1490	-117.2972
			SD NPDES (AHC-ECR)	X	X		
2	Agua Hedionda Creek at Sycamore Avenue	None	CDFG (904AHCSAx)		X	33.1563	-117.2261
3	Buena Vista Creek at Santa Fe Avenue	None	CDFG (904BVREDx)		X	33.1994	-117.2431
			SD NPDES (BVR-ED)	X	X		
4	Buena Vista Creek at South Vista Way	904CBBVR4	CDFG (904BVRSVW)		X	33.1802	-117.3281
5	Escondido Creek at Elfin Forest Resort	None	CDFG (904ECEFxx)		X	33.0736	-117.1642
			SD NPDES (ESC-EF)	X	X		
6	Escondido Creek upstream of Elfin Forest on Harmony Grove Rd.	None	CDFG (904ECHGxx)		X	33.0764	-117.1593
7	Escondido Creek at Harmony Grove Bridge	None	CDFG (904ECHRBx)		X	33.1092	-117.1115
			SD NPDES (ESC-HRB)	X	X		
8	Escondido Creek at Rancho Santa Fe Road	904CBESC8	CDFG (904ECRSFR)		X	33.0394	-117.2306
			SD NPDES (ESC-RSFR)	X	X		
9	Encinitas Creek SW of El Camino Real and La Costa Boulevard	904CBENC2	CDFG (904ENCGVR)		X	33.0783	-117.2667
			SD NPDES (ENC-GVR)	X	X		
10	Encinitas Creek at Rancho Santa Fe Road	None	CDFG (904ENCRSF)		X	33.0362	-117.2350
11	Loma Alta Creek at College Boulevard	None	CDFG (904LACCBx)		X	33.2061	-117.2848
			SD NPDES (LAC-CB)	X	X		
12	Loma Alta Creek at El Camino Real	904CBLAC3	CDFG (904LACECR)		X	33.1999	-117.3313
			SD NPDES (LAC-ECR)	X	X		
13	San Marcos Creek below Rancho Santa Fe Road	None	CDFG (904SMCLCC)		X	33.0885	-117.2454
14	San Marcos Creek at McMahr Road	904CBSAM3	CDFG (904SMCMxx)		X	33.1305	-117.1929
			SD NPDES (SMC-M)	X	X		
15	San Marcos Creek Above Rancho Santa Fe Road	None	CDFG (904SMCRSF)		X	33.1032	-117.2268
			SD NPDES (SMC-RSFR)	X	X		
16	San Marcos Creek at Santar Place	None	CDFG (904SMCSPx)		X	33.1417	-117.1457
			SD NPDES (SMC-SP)	X	X		
17	Agua Hedionda Creek at Melrose Road	None	SD NPDES (AHC-MR)	X	X	33.1522	-117.2409
18	Buena Vista Creek at College Boulevard	None	SD NPDES (BVR-CB)	X	X	33.1802	-117.2986
19	Cottonwood Creek at Highway 101	904CBCWC2	SD NPDES (CC-E)	X	X	33.0484	-117.2938
20	Escondido Creek at Country Club Road	None	SD NPDES (ESC-CC)	X	X	33.0988	-117.1306
21	Escondido Creek in Vista Canyon	None	SD NPDES (ESC-VC)	X	X	33.0603	-117.1800
22	San Marcos Creek	None	SD NPDES (SMC-LCCC)	X	X	33.0911	-117.2268

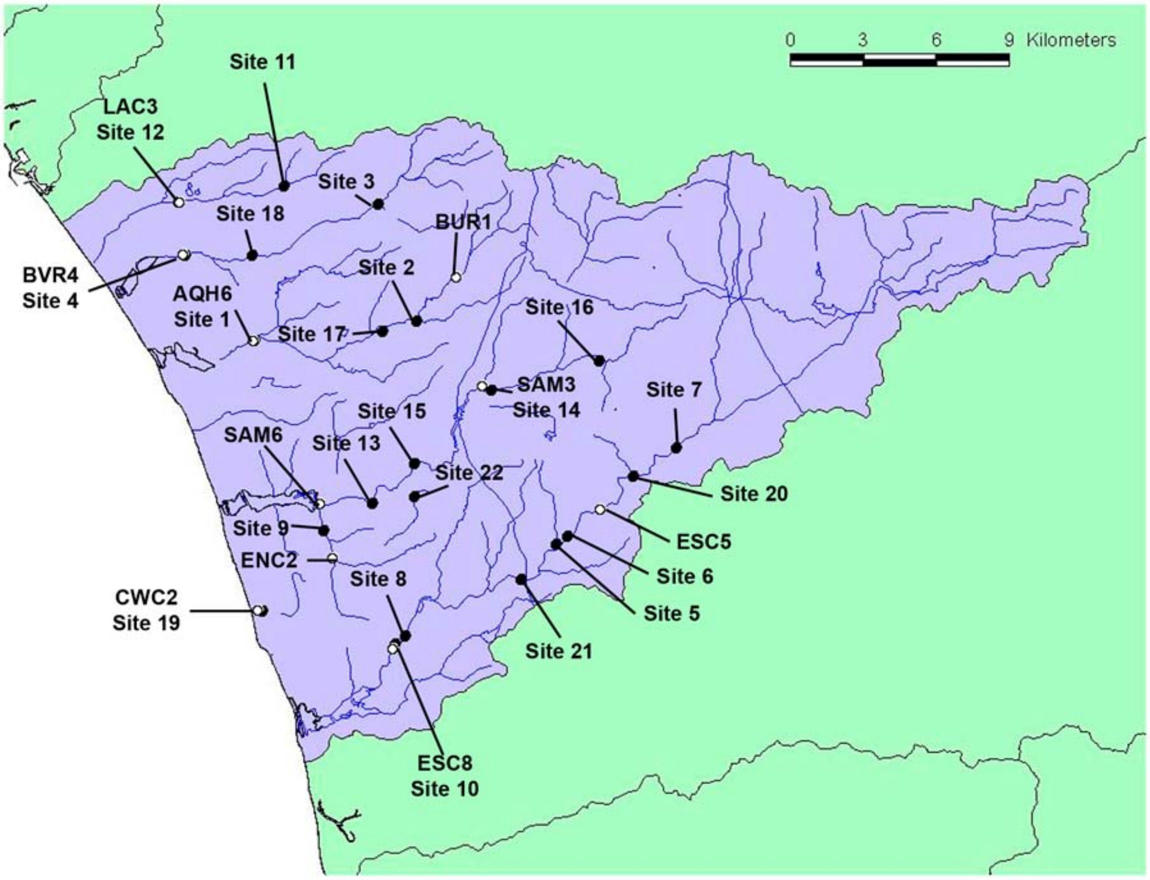


Figure 5. SWAMP (white circles) and non-SWAMP (black circles) sampling locations. The SWAMP site prefix designating the hydrologic unit (i.e., 904CB-) has been dropped to improve clarity.

3.1 Indicators

Multiple indicators were used to assess the sites in the Carlsbad HU. Water chemistry, water and sediment toxicity, fish tissues, benthic macroinvertebrate communities, and physical habitat.

3.1.1 Water chemistry

To assess water chemistry, samples were collected at each site. Water chemistry was measured as per the SWAMP Quality Assurance Management Plan (QAMP) (Puckett 2002). Measured indicators included conventional water chemistry (e.g., pH, temperature dissolved oxygen, etc.), inorganics, herbicides, pesticides, polycyclic aromatic hydrocarbons (PAHs), dissolved metals, pesticides, and polychlorinated biphenyls (PCBs). Appendix II contains a complete list of constituents that were measured.

Limited water chemistry was collected under non-SWAMP NPDES monitoring as well. This monitoring was restricted to physical parameters, and followed procedures described in annual reports to California Regional Water Quality Control Board, San Diego Region (e.g., Weston Solutions Inc. 2007).

3.1.2 Toxicity

To evaluate water and sediment toxicity to aquatic life in the Carlsbad HU, toxicity assays were conducted on samples from each site as per the SWAMP QAMP (EPA 1993, Puckett 2002). Water toxicity was evaluated with 7-day exposures on the water flea, *Ceriodaphnia dubia*, and 96-hour exposures to the alga *Selenastrum capricornutum.* Both acute and chronic toxicity to *C. dubia* was measured as decreased survival and fecundity (i.e., eggs per female) relative to controls, respectively. Chronic toxicity to *S. capricornutum* was measured as changes in total cell count relative to controls. Sediment toxicity was evaluated with 10-day exposures on the amphipod *Hyallela azteca.* Both acute and chronic toxicity to *H. azteca* was measured as decreased survival and growth (mg per individual) relative to controls, respectively. Chronic toxicity endpoints (i.e., *C. dubia* fecundity, *H. azteca* growth, and *S. capricornutum* total cell count) were used to develop a summary index of toxicity at each site.

3.1.3 Tissue

To detect contamination in fish tissues in the Carlsbad HU, fish tissues were collected at two sites (San Marcos Creek and Agua Hedionda Creek). Samples were not combined so that variability among individual organisms could be estimated. One bullhead and one crayfish were collected at each site; in addition, one red-ear sunfish was collected at San Marcos Creek. Tissues were analyzed for metals, pesticides, PCBs, and PAHs as per the SWAMP QAMP (Puckett 2002). Wet-weight concentrations of each constituent were recorded.

3.1.4 Bioassessment

To assess the ecological health of the streams in Carlsbad HU, benthic macroinvertebrate samples were collected at 21 sites. Samples were collected using SWAMP-comparable protocols, as per the SWAMP QAMP (Puckett 2002). Three replicate samples were collected from riffles at each site; 300 individuals were sorted and identified from each replicate, creating a total count of 900 individuals per site. Using a Monte Carlo simulation, all samples were reduced to 500 count for calculation of the Southern California Index of Biotic Integrity (IBI; Ode et al. 2005), a composite of seven metrics summed and scaled from 0 (poor condition) to 100 (good condition).

3.1.5 Physical Habitat

Physical habitat was assessed using semi-quantitative observations of 10 components relating to habitat quality, such as embeddedness, bank stability, and width of riparian zone. The assessment protocols are described in The California Stream Bioassessment Procedure (California Department of Fish and Game 2003). Each component was scored on a scale of 0 (highly degraded) to 20 (not degraded). Sites were assessed by the average component score.

3.2 Data Analysis

To evaluate the extent of human impacts to water chemistry in streams in the Carlsbad HU, two frequency-based approaches were employed to detecting impacts. First, established aquatic life and human health thresholds for individual constituents were evaluated for frequency of exceedances. Second, the frequency of detection for anthropogenic constituents (such as PCBs, pesticides, and PAHs) were also evaluated.

To evaluate the overall health of each site and of the watershed, three indicators were selected for analysis: number of constituents exceeding aquatic life water chemistry thresholds; frequency of chronic toxicity to *S. capricornutum, C. dubia,* and *H. azteca*; and mean IBI score. Tissue analysis was excluded because tissue samples were collected at only two sites. Physical habitat assessment was excluded due to lack of agreed-upon thresholds for evaluation of physical habitat scores. These results were plotted on a map of the watershed, indicating the severity and distribution of human impacts.

Although non-SWAMP sources of water chemistry data were used, this report focuses on SWAMP data in order to maintain consistency of sampling methods and parameters measured at each site. Analyses of non-SWAMP water chemistry data is presented separately. In contrast, bioassessment data from multiple sources is analyzed together because of the high compatibility of sampling protocols used in different programs, and because of the limited availability of bioassessment data from a single source. Toxicity, fish tissue, and physical habitat data were only available from SWAMP monitoring.

3.2.1 Thresholds

In order to use the data to assess the health of the watershed, thresholds were established for each indicator: water quality, toxicity, bioassessment, fish tissue, and physical habitat. Exceedance of appropriate thresholds was considered evidence for impact on watershed health.

Water chemistry data from this study were compared to water quality objectives established by state and federal agencies to protect the most sensitive beneficial uses designated in the Carlsbad HU. Therefore, the most stringent water quality objectives (e.g., municipal drinking water, aquatic life, etc.) for the measured constituents were used as thresholds points to evaluate the data.

The Water Quality Control Plan For the San Diego Basin (BP) was the primary source of water chemistry thresholds. Other sources for standards used in water chemistry thresholds included the California Toxics Rule (CTR), the Environmental Protection Agency National Aquatic Life Criteria (EPA), the National Academy of Sciences Health Advisory (NASHA), United States Environmental Protection Agency Integrated Risk Information System (IRIS), and the California Code of Regulations §64449 (CCR). The sources for thresholds used in this study are shown in Table 5.

Table 5. Threshold sources

Indicator	Source	Citation
Water chemistry	Water Quality Control Plan For the San Diego Basin (BP)	California Regional Water Quality Control Board, San Diego Region. 1994. Water quality control plan for the San Diego Region. San Diego, CA. http://www.waterboards.ca.gov/sandiego/programs/basinplan.html
	California Toxics Rule (CTR)	Environmental Protection Agency. 1997. Water quality standards: Establishment of numeric criteria for priority toxic pollutants for the state of California: Proposed Rule. *Federal Register* 62:42159-42208.
	EPA National Aquatic Life Criteria (EPA)	Environmental Protection Agency. 2002. National recommended water quality criteria. EPA-822-R-02-047. Office of Water. Washington, DC.
	National Academy of Sciences Health Advisory (NASHA)	National Academy of Sciences. 1977. Drinking Water and Health. Volume 1. Washington, DC.
	US Environmental Protection Agency Integrated Risk Information System (IRIS)	Environmental Protection Agency (EPA). 2007. Integrated Risk Information System. http://www.epa.gov/iris/index.html. Office of Research and Development. Washington, DC.
	California Code of Regulations §64449 (CCR)	California Code of Regulations. 2007. Secondary drinking water standards. Register 2007, No. 8. Title 22, division 4, article 16.
Fish tissue	Office of Environmental Health Hazard Assessment (OEHHA)	Office of Environmental Health Hazard Assessment. 2006. Draft development of guidance tissue levels and screening values for common contaminants in California Sports Fish: Chlordane, DDTs, Dieldrin, Methylmercury, PCBs, Selenium, and Toxaphene. Sacramento, CA.
Bioassessment	Ode et al. 2005	Ode, P.R., A.C. Rehn and J.T. May. 2005. A quantitative tool for assessing the integrity of southern California coastal streams. *Environmental Management* 35:493-504.

Although human health thresholds (e.g., drinking water standards) were applied to relevant water chemistry data, this report focuses on aquatic life, and does not address the risks to human health in the Carlsbad HU. When multiple thresholds were applicable to a single constituent, the most stringent threshold was used. Water chemistry thresholds for aquatic life and human health standards used in this study are presented in Table 6. Impacts were assessed as the total number of constituents exceeding threshold, as opposed to the fraction of constituents. The fraction of constituents exceeding thresholds is not an ecologically meaningful statistic because the number of constituents below thresholds does not degrade or improve the ecological health of a site.

Table 6. Water chemistry thresholds for aquatic life and human health standards. San Diego Basin Plan (BP); California Toxics Rule (CTR); Environmental Protection Agency National Aquatic Life Standards (EPA); National Academy of Science Health Advisory (NASHA); Environmental Protection Agency Integrated Risk Information System (IRIS); California Code of Regulations §64449 (CCR). Threshold does not apply to Loma Alta Creek - HSU 904.1 or Encinas Creek – HSU 904.4 (*).

		Aquatic life			Human health		
Category	Constituent	Threshold	Unit	Source	Threshold	Unit	Source
Inorganics	Alkalinity as CaCO3	20000	mg/l	EPA	none	mg/l	none
Inorganics	Ammonia as N	0.025	mg/l	BP	none	mg/l	none
Inorganics	Nitrate + Nitrite as N	10	mg/l	BP	none	mg/l	none
Inorganics	Phosphorus as P,Total	0.1	mg/l	BP	none	mg/l	none
Inorganics	Selenium,Dissolved	5	µg/L	CTR	none	µg/L	none
Inorganics	Sulfate	250*	mg/l	BP	none	mg/l	none
Metals	Aluminum,Dissolved	1000	µg/L	BP	none	µg/L	none
Metals	Arsenic,Dissolved	50	µg/L	BP	150	µg/L	CTR
Metals	Cadmium,Dissolved	5	µg/L	BP	2.2	µg/L	CTR
Metals	Chromium,Dissolved	50	µg/L	BP	none	µg/L	none
Metals	Copper,Dissolved	9	µg/L	CTR	1300	µg/L	CTR
Metals	Lead,Dissolved	2.5	µg/L	CTR	none	µg/L	none
Metals	Manganese,Dissolved	0.05*	µg/L	none	none	µg/L	none
Metals	Nickel,Dissolved	52	µg/L	CTR	610	µg/L	CTR
Metals	Silver,Dissolved	3.4	µg/L	CTR	none	µg/L	none
Metals	Zinc,Dissolved	120	µg/L	CTR	none	µg/L	none
PAHs	Acenaphthene	none	µg/L	none	1200	µg/L	CTR
PAHs	Anthracene	none	µg/L	none	9600	µg/L	CTR
PAHs	Benz(a)anthracene	none	µg/L	none	0.0044	µg/L	CTR
PAHs	Benzo(a)pyrene	0.0002	µg/L	BP	0.0044	µg/L	CTR
PAHs	Benzo(b)fluoranthene	none	µg/L	none	0.0044	µg/L	CTR
PAHs	Benzo(k)fluoranthene	none	µg/L	none	0.0044	µg/L	CTR
PAHs	Chrysene	none	µg/L	none	0.0044	µg/L	CTR
PAHs	Dibenz(a,h)anthracene	none	µg/L	none	0.0044	µg/L	CTR
PAHs	Fluoranthene	none	µg/L	none	300	µg/L	CTR
PAHs	Indeno(1,2,3-c,d)pyrene	none	µg/L	none	0.0044	µg/L	CTR
PAHs	Pyrene	none	µg/L	none	960	µg/L	CTR
PCBs	PCBs	0.014	µg/L	CTR	0.00017	µg/L	CTR
Pesticides	Aldrin	3	µg/L	CTR	0.00000013	µg/L	CTR
Pesticides	Ametryn	none	µg/L	none	60	µg/L	EPA
Pesticides	Atrazine	3	µg/L	BP	0.2	µg/L	OEHHA
Pesticides	Azinphos ethyl	none	µg/L	none	87.5	µg/L	NASHA
Pesticides	Azinphos methyl	none	µg/L	none	87.5	µg/L	NASHA

Table 6, continued. Water chemistry thresholds for aquatic life and human health.

		Aquatic life			Human health		
Category	Constituent	Threshold	Unit	Source	Threshold	Unit	Source
Pesticides	DDD(p,p')	none	µg/L	none	0.00083	µg/L	CTR
Pesticides	DDE(p,p')	none	µg/L	none	0.00059	µg/L	CTR
Pesticides	DDT(p,p')	none	µg/L	none	0.00059	µg/L	CTR
Pesticides	Dieldrin	none	µg/L	none	0.00014	µg/L	CTR
Pesticides	Dimethoate	none	µg/L	none	1.4	µg/L	IRIS
Pesticides	Endosulfan sulfate	none	µg/L	none	110	µg/L	CTR
Pesticides	Endrin	0.002	µg/L	BP	0.76	µg/L	CTR
Pesticides	Endrin Aldehyde	none	µg/L	none	0.76	µg/L	CTR
Pesticides	Endrin Ketone	none	µg/L	none	0.85	µg/L	CTR
Pesticides	Heptachlor	0.0038	µg/L	CTR	0.00021	µg/L	CTR
Pesticides	Heptachlor epoxide	0.0038	µg/L	CTR	0.0001	µg/L	CTR
Pesticides	Hexachlorobenzene	1	µg/L	BP	0.00075	µg/L	CTR
Pesticides	Methoxychlor	40	µg/L	BP	none	µg/L	none
Pesticides	Molinate	20	µg/L	BP	none	µg/L	none
Pesticides	Oxychlordane	none	µg/L	none	0.000023	µg/L	CTR
Pesticides	Simazine	4	µg/L	BP	none	µg/L	none
Pesticides	Thiobencarb	70	µg/L	BP	none	µg/L	none
Physical	Oxygen, Dissolved	5	mg/L	BP	none	mg/L	none
Physical	pH	>6 and <8	pH	BP	none	pH	none
Physical	Specific Conductivity	1600	µS/cm	CCR	none	mS/cm	none
Physical	Turbidity	20	NTU	BP	none	NTU	none

Several anthropogenic water chemistry constituents had no applicable threshold (e.g., malathion), and impacts from these constituents would not be detected using the threshold-based approach described above. To assess the impact from these constituents, the number of organic constituents (i.e., PAHs, PCBs, and pesticides) detected at each site were calculated. The total number of sites at which these compounds were detected was recorded.

Thresholds for toxicity assays were determined by comparing study samples to control samples(non-toxic reference samples). Samples meeting the following criteria were considered toxic: 1) treatment responses significantly different from controls, as determined by a statistical t-test; and 2) endpoints less than 80% of controls. To summarize the toxicity at a site using multiple endpoints, the frequency of toxic samples was calculated. To assign equal weight to all three indicators, a single endpoint of chronic toxicity per indicator was used (*C. dubia*: fecundity, *H. azteca*: growth, and *S. capricornutum*: total cell count).

Thresholds for tissue samples shown in Table 7 were derived from the Draft Development of Guidance Tissue Levels and Screening Values for Common Contaminant in California Sport Fish: Chlordane, DDTs, Dieldrin, Methylmercury, PCBs, Selenium, and Toxaphene (OEHHA 2006). Several constituents, including total mercury, had no applicable threshold. Because methylmercury accounts for more than 95% of mercury in fish tissues, the threshold for methylmercury was applied to mercury concentrations (OEHHA 2006).

Table 7. Threshold concentrations for fish tissue contaminants established by OEHHA. All thresholds apply to wet-weight concentrations.

Category	Constituent	Source	Threshold	Unit
Inorganics	Selenium	OEHHA	1.94	ppm
PCBs	PCBs	OEHHA	20	ppm
Pesticides	Chlordane	OEHHA	200	ng/g
Pesticides	DDTs	OEHHA	560	ng/g
Pesticides	Dieldrin	OEHHA	16	ng/g
Pesticides	Toxaphene	OEHHA	220	ng/g
Metals	Mercury*	OEHHA	0.08	ppm

*The threshold for methylmercury was used as a threshold for total mercury concentrations.

Thresholds for bioassessment samples were based on a benthic macroinvertebrate index of biological integrity (IBI) that was developed specifically for southern California (Ode et al. 2005). The results of the IBI produces a measure of impairment with scores scaled from 0 to 100, 0 representing the poorest health and 100 the best health. Based on the IBI, samples with scores equal to or below 40 are considered to be in “poor” condition, and samples below 20 are considered to be in “very poor” condition. Therefore, in this study samples with an IBI below 40 were considered impacted.

Thresholds for the evaluation of physical habitat have not been established. Therefore, measurements of physical habitat were excluded from the overall assessment of ecological health. However, because the protocol used to evaluate physical habitat qualitatively assigns scores lower than 10 (out of 20) to streams in poor condition, this number was used to determine sites with severely degraded habitat. Sites with scores below 15 were considered moderately degraded, and those with scores greater than 15 were considered unimpacted (California Department of Fish and Game 2003).

3.2.2 Quality Assurance and Quality Control (QA/QC)

The SWAMP QAMP guided QA/QC for all data collected under SWAMP (See SWAMP QAMP for detailed descriptions of QA/QC protocols, Puckett 2002). QA/QC officers flagged non-compliant physical habitat, water chemistry, toxicity, and tissue results. No chemistry, toxicity, or tissue data were excluded as a result of QA/QC violations. QA/QC procedures for NPDES water chemistry data were similar to those used in SWAMP (Weston Solutions Inc. 2007) Non-SWAMP bioassessment samples were screened for samples containing fewer than 450 individuals. No bioassessment sample was excluded from this analysis.

4. RESULTS

4.1 Water Chemistry

Analysis of water chemistry at SWAMP sites indicated widespread impact to water quality for multiple constituents. Across the entire watershed, 41 pesticides and 6 PAHs were detected (Table 8). Buena Creek had the highest number of pesticides (24), and Lower San Marcos Creek had the highest number of PAHs (6). Every site had at least 1 PAH and 14 pesticides. In contrast, PCBs were never detected at any site. Means and standard deviations of all constituents are presented in Appendix II.

Table 8. Number of anthropogenic organic compounds detected at each site in Carlsbad HU.

	PAHs		PCBs		Pesticides	
Site	Tested	Detected	Tested	Detected	Tested	Detected
904CBAQH6	43	4	50	0	91	14
904CBBUR1	43	4	50	0	91	24
904CBBVR4	43	2	50	0	91	19
904CBCWC2	43	1	50	0	91	16
904CBENC2	43	1	50	0	91	14
904CBESC5	43	1	50	0	91	19
904CBESC8	43	1	50	0	91	16
904CBLAC3	43	1	50	0	91	20
904CBSAM3	43	1	50	0	91	20
904CBSAM6	43	6	50	0	91	14
All sites	43	6	50	0	91	41

Several organic compounds were widespread throughout the watershed (Table 9). For example, the PAH C2-Fluorene was detected at every site. The pesticides p,p'-DDE, diazinon, disulfotan, oxadiazon, secbumeton, and terbuthylazine were also detected at every site. Other frequently detected pesticides include atrazine, dacthal, p,p'-DDT, demeton-s, dimethoate, endosulfan II, alpha-HCH, delta-HCH, hexachlorobenzene, mevinphos, naled, and propazine, all of which were detected in at least half of the sites.

Table 9. Frequency of detection of anthropogenic organic compounds in the Carlsbad HU. Constituent not detected at any site (--).

Category	Constituent	Tested	Detected	Frequency
PAHs	Acenaphthene	10	1	0.1
PAHs	Acenaphthylene	10	0	--
PAHs	Anthracene	10	3	0.3
PAHs	Benz(a)anthracene	10	0	--
PAHs	Benzo(a)pyrene	10	0	--
PAHs	Benzo(b)fluoranthene	10	0	--
PAHs	Benzo(e)pyrene	10	0	--
PAHs	Benzo(g,h,i)perylene	10	0	--
PAHs	Benzo(k)fluoranthene	10	0	--

Table 9, continued. Frequency of detection of anthropogenic organic compounds.

Category	Constituent	Tested	Detected	Frequency
PAHs	Biphenyl	10	0	--
PAHs	Chrysene	10	0	--
PAHs	Chrysenes, C1 -	10	0	--
PAHs	Chrysenes, C2 -	10	0	--
PAHs	Chrysenes, C3 -	10	0	--
PAHs	Dibenz(a,h)anthracene	10	0	--
PAHs	Dibenzothiophene	10	0	--
PAHs	Dibenzothiophenes, C1 -	10	0	--
PAHs	Dibenzothiophenes, C2 -	10	0	--
PAHs	Dibenzothiophenes, C3 -	10	0	--
PAHs	Dimethylnaphthalene, 2,6-	10	0	--
PAHs	Fluoranthene	10	0	--
PAHs	Fluoranthene/Pyrenes, C1 -	10	0	--
PAHs	Fluorene	10	1	0.1
PAHs	Fluorenes, C1 -	10	0	--
PAHs	Fluorenes, C2 -	10	10	1.0
PAHs	Fluorenes, C3 -	10	0	--
PAHs	Indeno(1,2,3-c,d)pyrene	10	0	--
PAHs	Methylnaphthalene, 1-	10	0	--
PAHs	Methylnaphthalene, 2-	10	0	--
PAHs	Methylphenanthrene, 1-	10	0	--
PAHs	Naphthalene	10	4	0.4
PAHs	Naphthalenes, C1 -	10	0	--
PAHs	Naphthalenes, C2 -	10	0	--
PAHs	Naphthalenes, C3 -	10	0	--
PAHs	Naphthalenes, C4 -	10	0	--
PAHs	Perylene	10	0	--
PAHs	Phenanthrene	10	3	0.3
PAHs	Phenanthrene/Anthracene, C1 -	10	0	--
PAHs	Phenanthrene/Anthracene, C2 -	10	0	--
PAHs	Phenanthrene/Anthracene, C3 -	10	0	--
PAHs	Phenanthrene/Anthracene, C4 -	10	0	--
PAHs	Pyrene	10	0	--
PAHs	Trimethylnaphthalene, 2,3,5-	10	0	--
PCBs	PCBs	10	0	--
Pesticides	Aldrin	10	2	0.2
Pesticides	Ametryn	10	0	--
Pesticides	Aspon	10	0	--
Pesticides	Atraton	10	0	--
Pesticides	Atrazine	10	7	0.7
Pesticides	Chlordene, alpha-	10	0	--
Pesticides	Chlordene, gamma-	10	3	0.3
Pesticides	Chlorfenvinphos	10	0	--
Pesticides	Chlorpyrifos	10	0	--
Pesticides	Chlorpyrifos methyl	10	0	--
Pesticides	Ciodrin	10	0	--
Pesticides	Coumaphos	10	0	--
Pesticides	Dacthal	10	7	0.7
Pesticides	DDD(o,p')	10	2	0.2

Table 9, continued. Frequency of detection of anthropogenic organic compounds.

Category	Constituent	Tested	Detected	Frequency
Pesticides	DDD(p,p')	10	2	0.2
Pesticides	DDE(o,p')	10	0	--
Pesticides	DDE(p,p')	10	10	1.0
Pesticides	DDMU(p,p')	10	0	--
Pesticides	DDT(o,p')	10	0	--
Pesticides	DDT(p,p')	10	5	0.5
Pesticides	Demeton-s	10	5	0.5
Pesticides	Diazinon	10	10	1.0
Pesticides	Dichlofenthion	10	0	--
Pesticides	Dichlorvos	10	0	--
Pesticides	Dicrotophos	10	1	0.1
Pesticides	Dieldrin	10	1	0.1
Pesticides	Dimethoate	10	6	0.6
Pesticides	Dioxathion	10	4	0.4
Pesticides	Disulfoton	10	10	1.0
Pesticides	Endosulfan I	10	2	0.2
Pesticides	Endosulfan II	10	5	0.5
Pesticides	Endosulfan sulfate	10	1	0.1
Pesticides	Endrin	10	2	0.2
Pesticides	Endrin Aldehyde	10	4	0.4
Pesticides	Endrin Ketone	10	0	--
Pesticides	Ethion	10	0	--
Pesticides	Ethoprop	10	0	--
Pesticides	Famphur	10	0	--
Pesticides	Fenchlorphos	10	0	--
Pesticides	Fenitrothion	10	0	--
Pesticides	Fensulfothion	10	0	--
Pesticides	Fenthion	10	0	--
Pesticides	Fonofos	10	0	--
Pesticides	HCH, alpha	10	7	0.7
Pesticides	HCH, beta	10	3	0.3
Pesticides	HCH, delta	10	5	0.5
Pesticides	HCH, gamma	10	2	0.2
Pesticides	Heptachlor	10	0	--
Pesticides	Heptachlor epoxide	10	0	--
Pesticides	Hexachlorobenzene	10	5	0.5
Pesticides	Leptophos	10	0	--
Pesticides	Malathion	10	1	0.1
Pesticides	Merphos	10	0	--
Pesticides	Methidathion	10	1	0.1
Pesticides	Methoxychlor	10	1	0.1
Pesticides	Mevinphos	10	5	0.5
Pesticides	Mirex	10	0	--
Pesticides	Molinate	10	0	--
Pesticides	Naled	10	5	0.5
Pesticides	Nonachlor, cis-	10	0	--
Pesticides	Nonachlor, trans-	10	2	0.2
Pesticides	Oxadiazon	10	10	1.0
Pesticides	Oxychlordane	10	0	--

Table 9, continued. Frequency of detection of anthropogenic organic compounds.

Category	Constituent	Tested	Detected	Frequency
Pesticides	Parathion, Ethyl	10	0	--
Pesticides	Parathion, Methyl	10	1	0.1
Pesticides	Phorate	10	0	--
Pesticides	Phosmet	10	0	--
Pesticides	Phosphamidon	10	0	--
Pesticides	Prometon	10	4	0.4
Pesticides	Prometryn	10	0	--
Pesticides	Propazine	10	8	0.8
Pesticides	Secbumeton	10	10	1.0
Pesticides	Simazine	10	0	--
Pesticides	Simetryn	10	0	--
Pesticides	Sulfotep	10	0	--
Pesticides	Tedion	10	0	--
Pesticides	Terbufos	10	0	--
Pesticides	Terbuthylazine	10	10	1.0
Pesticides	Terbutryn	10	0	--
Pesticides	Tetrachlorvinphos	10	1	0.1
Pesticides	Thiobencarb	10	0	--
Pesticides	Thionazin	10	0	--
Pesticides	Tokuthion	10	0	--
Pesticides	Trichlorfon	10	0	--
Pesticides	Trichloronate	10	0	--

Comparison with applicable aquatic life and human health thresholds support the conclusion that water quality is impacted by these constituents (Table 10). Most sites showed similar results, suggesting that impacts are not restricted to specific regions within the watershed (Figure 6, 7). Ammonia-N, sulfate, specific conductivity, and p,p'-DD, exceeded thresholds at every site where thresholds applied (Table 10, 11). Total phosphorus, selenium, manganese, pH, and p,p'-DDT also exceeded thresholds at most sites. Nitrate + nitrite-N, aldrin, and p,p'-DDD exceeded thresholds at two sites, and dieldrin, endrin and turbidity each exceeded thresholds at a single site. Overall, human health thresholds were exceeded less frequently than aquatic life thresholds (Figure 6, 7)

Table 10. Frequency of water chemistry threshold exceedances. A) Frequency of aquatic life threshold exceedances at SWAMP sites. B) Frequency of human health threshold exceedances at SWAMP sites. C) Frequency of aquatic life threshold exceedances at non-SWAMP sites. No human health thresholds applied to constituents measured at non-SWAMP sites. Freq = Frequency of samples exceeding applicable thresholds at each site. AL = Aquatic life. HH = Human health. -- = Constituent never exceeded threshold. NA = No applicable thresholds at that site. Empty cells indicate that the constituent was not measured at the site.

A. Aquatic life thresholds at SWAMP sites.

				904CBAQH6		904CBBUR1		904CBBVR4		904CBCWC2		904CBENC2	
Category	Constituent	Threshold	Source	Freq	n	Freq	n	Freq	n	Freq	n	Freq	n
Inorganics	Alkalinity as CaCO3	20000 mg/l	EPA	--	4	--	4	--	4	--	4	--	4
Inorganics	Ammonia as N	0.025 mg/l	BP	1.00	4	1.00	4	1.00	4	1.00	4	1.00	4
Inorganics	Nitrate + Nitrite as N	10 mg/l	BP	--	4	1.00	4	--	4	1.00	4	--	4
Inorganics	Phosphorus as P,Total	0.1 mg/l	BP	--	4	1.00	4	--	4	1.00	4	1.00	4
Inorganics	Selenium,Dissolved	5 µg/l	CTR	1.00	4	--	4	1.00	4	1.00	4	1.00	4
Inorganics	Sulfate	250 mg/l*	BP	1.00	4	1.00	4	0.50	4	1.00	4	1.00	4
Metals	Aluminum,Dissolved	1000 µg/l	BP	--	4	--	4	--	4	--	4	--	4
Metals	Arsenic,Dissolved	50 µg/l	BP	--	4	--	4	--	4	--	4	--	4
Metals	Cadmium,Dissolved	5 µg/l	BP	--	4	--	4	--	4	--	4	--	4
Metals	Chromium,Dissolved	50 µg/l	BP	--	4	--	4	--	4	--	4	--	4
Metals	Copper,Dissolved	9 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Metals	Lead,Dissolved	2.5 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Metals	Manganese,Dissolved	0.05 µg/l*	BP	0.50	4	--	4	0.50	4	0.25	4	1.00	4
Metals	Nickel,Dissolved	52 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Metals	Silver,Dissolved	3.4 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Metals	Zinc,Dissolved	120 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
PAHs	Benzo(a)pyrene	0.0002 µg/l	BP	--	4	--	4	--	4	--	4	--	4
PCBs	PCBs	0.014 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Pesticides	Aldrin	3 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Pesticides	Atrazine	3 µg/l	BP	--	4	--	4	--	4	--	4	--	4
Pesticides	Endrin	0.002 µg/l	BP	--	4	0.25	4	--	4	--	4	--	4
Pesticides	Heptachlor	0.0038 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Pesticides	Heptachlor epoxide	0.0038 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Pesticides	Hexachlorobenzene	1 µg/l	BP	--	4	--	4	--	4	--	4	--	4
Pesticides	Methoxychlor	40 µg/l	BP	--	4	--	4	--	4	--	4	--	4
Pesticides	Molinate	20 µg/l	BP	--	4	--	4	--	4	--	4	--	4
Pesticides	Simazine	4 µg/l	BP	--	4	--	4	--	4	--	4	--	4
Pesticides	Thiobencarb	70 µg/l	BP	--	4	--	4	--	4	--	4	--	4
Physical	pH	>6 or <8 pH units	BP	0.25	4	0.50	4	0.75	4	0.25	4	0.25	4
Physical	Specific conductivity	1.6 mS/cm	CCR	1.00	4	1.00	4	1.00	4	1.00	4	1.00	4
Physical	Turbidity	20 NTU	BP	--	4	--	4	--	4	--	4	--	4

* Sulfate and Magnesium thresholds do not apply to sites in the Loma Alta and Encinitas hydrologic sub-basin (904.1 and 904.4).

Table 10, continued. Frequency of water chemistry threshold exceedances.
A, continued. Aquatic life thresholds at SWAMP sites.

				904CBESC5		904CBESC8		904CBLAC3		904CBSAM3		904CBSAM6	
Category	Constituent	Threshold	Source	Freq	n	Freq	n	Freq	n	Freq	n	Freq	n
Inorganics	Alkalinity as CaCO3	20000 mg/l	EPA	--	4	--	4	--	4	--	4	--	4
Inorganics	Ammonia as N	0.025 mg/l	BP	1.00	4	1.00	4	1.00	4	1.00	4	1.00	4
Inorganics	Nitrate + Nitrite as N	10 mg/l	BP	--	4	--	4	--	4	--	4	--	4
Inorganics	Phosphorus as P,Total	0.1 mg/l	BP	0.50	4	1.00	4	--	4	1.00	4	1.00	4
Inorganics	Selenium,Dissolved	5 µg/l	CTR	0.75	4	1.00	4	1.00	4	0.75	4	0.75	4
Inorganics	Sulfate	250 mg/l*	BP	1.00	4	1.00	4	NA	4	0.75	4	1.00	4
Metals	Aluminum,Dissolved	1000 µg/l	BP	--	4	--	4	--	4	--	4	--	4
Metals	Arsenic,Dissolved	50 µg/l	BP	--	4	--	4	--	4	--	4	--	4
Metals	Cadmium,Dissolved	5 µg/l	BP	--	4	--	4	--	4	--	4	--	4
Metals	Chromium,Dissolved	50 µg/l	BP	--	4	--	4	--	4	--	4	--	4
Metals	Copper,Dissolved	9 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Metals	Lead,Dissolved	2.5 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Metals	Manganese,Dissolved	0.05 µg/l*	BP	--	4	1.00	4	NA	4	0.75	4	0.75	4
Metals	Nickel,Dissolved	52 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Metals	Silver,Dissolved	3.4 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Metals	Zinc,Dissolved	120 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
PAHs	Benzo(a)pyrene	0.0002 µg/l	BP	--	4	--	4	--	4	--	4	--	4
PCBs	PCBs	0.014 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Pesticides	Aldrin	3 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Pesticides	Atrazine	3 µg/l	BP	--	4	--	4	--	4	--	4	--	4
Pesticides	Endrin	0.002 µg/l	BP	--	4	--	4	--	4	--	4	--	4
Pesticides	Heptachlor	0.0038 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Pesticides	Heptachlor epoxide	0.0038 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Pesticides	Hexachlorobenzene	1 µg/l	BP	--	4	--	4	--	4	--	4	--	4
Pesticides	Methoxychlor	40 µg/l	BP	--	4	--	4	--	4	--	4	--	4
Pesticides	Molinate	20 µg/l	BP	--	4	--	4	--	4	--	4	--	4
Pesticides	Simazine	4 µg/l	BP	--	4	--	4	--	4	--	4	--	4
Pesticides	Thiobencarb	70 µg/l	BP	--	4	--	4	--	4	--	4	--	4
Physical	pH	>6 or <8 pH units	BP	0.75	4	0.33	3	0.25	4	0.75	4	--	4
Physical	Specific conductivity	1.6 mS/cm	CCR	1.00	4	1.00	4	1.00	4	1.00	4	1.00	4
Physical	Turbidity	20 NTU	BP	--	4	--	4	--	4	--	4	0.25	4

* Sulfate and Magnesium thresholds do not apply to sites in the Loma Alta and Encinitas hydrologic sub-basin (904.1 and 904.4).

Table 10, continued. Frequency of water chemistry threshold exceedances.
B. Human health thresholds at SWAMP sites

				904CBAQH6		904CBBUR1		904CBBVR4		904CBCWC2		904CBENC2	
Category	Constituent	Threshold	Source	Freq	n	Freq	n	Freq	n	Freq	n	Freq	n
Metals	Arsenic,Dissolved	150 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Metals	Cadmium,Dissolved	2.2 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Metals	Copper,Dissolved	1300 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Metals	Nickel,Dissolved	610 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
PAHs	Acenaphthene	1200 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
PAHs	Anthracene	9600 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
PAHs	Benz(a)anthracene	0.0044 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
PAHs	Benzo(a)pyrene	0.0044 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
PAHs	Benzo(b)fluoranthene	0.0044 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
PAHs	Benzo(k)fluoranthene	0.0044 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
PAHs	Chrysene	0.0044 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
PAHs	Dibenz(a,h)anthracene	0.0044 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
PAHs	Fluoranthene	300 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
PAHs	Indeno(1,2,3-c,d)pyrene	0.0044 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
PAHs	Pyrene	960 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
PCBs	PCBs	0.00017 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Pesticides	Aldrin	0.00000013 µg/l	CTR	--	4	0.25	4	--	4	--	4	--	4
Pesticides	Ametryn	60 µg/l	EPA	--	4	--	4	--	4	--	4	--	4
Pesticides	Atrazine	0.2 µg/l	OEHHA	--	4	--	4	--	4	--	4	--	4
Pesticides	Azinphos ethyl	87.5 µg/l	NASHA	--	4	--	4	--	4	--	4	--	4
Pesticides	Azinphos methyl	87.5 µg/l	NASHA	--	4	--	4	--	4	--	4	--	4
Pesticides	DDD(p,p')	0.00083 µg/l	CTR	--	4	0.25	4	--	4	--	4	--	4
Pesticides	DDE(p,p')	0.00059 µg/l	CTR	0.25	4	1	4	0.25	4	0.5	4	0.25	4
Pesticides	DDT(p,p')	0.00059 µg/l	CTR	--	4	0.25	4	--	4	0.5	4	--	4
Pesticides	Dieldrin	0.00014 µg/l	CTR	--	4	0.25	4	--	4	--	4	--	4
Pesticides	Dimethoate	1.4 µg/l	IRIS	--	4	--	4	--	4	--	4	--	4
Pesticides	Endosulfan sulfate	110 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Pesticides	Endrin	0.76 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Pesticides	Endrin Aldehyde	0.76 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Pesticides	Endrin Ketone	0.85 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Pesticides	Heptachlor	0.00021 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Pesticides	Heptachlor epoxide	0.0001 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Pesticides	Hexachlorobenzene	0.00075 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Pesticides	Oxychlordane	0.000023 µg/l	CTR	--	4	--	4	--	4	--	4	--	4

Table 10, continued. Frequency of water chemistry threshold exceedances.
B, continued. Human health thresholds at SWAMP sites.

				904CBESC5		904CBESC8		904CBLAC3		904CBSAM3		904CBSAM6	
Category	Constituent	Threshold	Source	Freq	n	Freq	n	Freq	n	Freq	n	Freq	n
Metals	Arsenic,Dissolved	150 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Metals	Cadmium,Dissolved	2.2 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Metals	Copper,Dissolved	1300 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Metals	Nickel,Dissolved	610 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
PAHs	Acenaphthene	1200 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
PAHs	Anthracene	9600 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
PAHs	Benz(a)anthracene	0.0044 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
PAHs	Benzo(a)pyrene	0.0044 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
PAHs	Benzo(b)fluoranthene	0.0044 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
PAHs	Benzo(k)fluoranthene	0.0044 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
PAHs	Chrysene	0.0044 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
PAHs	Dibenz(a,h)anthracene	0.0044 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
PAHs	Fluoranthene	300 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
PAHs	Indeno(1,2,3-c,d)pyrene	0.0044 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
PAHs	Pyrene	960 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
PCBs	PCBs	0.00017 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Pesticides	Aldrin	0.00000013 µg/l	CTR	0.25	4	--	4	--	4	--	4	--	4
Pesticides	Ametryn	60 µg/l	EPA	--	4	--	4	--	4	--	4	--	4
Pesticides	Atrazine	0.2 µg/l	OEHHA	--	4	--	4	--	4	--	4	--	4
Pesticides	Azinphos ethyl	87.5 µg/l	NASHA	--	4	--	4	--	4	--	4	--	4
Pesticides	Azinphos methyl	87.5 µg/l	NASHA	--	4	--	4	--	4	--	4	--	4
Pesticides	DDD(p,p')	0.00083 µg/l	CTR	--	4	0.25	4	--	4	--	4	--	4
Pesticides	DDE(p,p')	0.00059 µg/l	CTR	0.25	4	0.25	4	0.25	4	0.75	4	0.25	4
Pesticides	DDT(p,p')	0.00059 µg/l	CTR	0.25	4	0.25	4	--	4	0.25	4	--	4
Pesticides	Dieldrin	0.00014 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Pesticides	Dimethoate	1.4 µg/l	IRIS	--	4	--	4	--	4	--	4	--	4
Pesticides	Endosulfan sulfate	110 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Pesticides	Endrin	0.76 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Pesticides	Endrin Aldehyde	0.76 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Pesticides	Endrin Ketone	0.85 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Pesticides	Heptachlor	0.00021 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Pesticides	Heptachlor epoxide	0.0001 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Pesticides	Hexachlorobenzene	0.00075 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Pesticides	Oxychlordane	0.000023 µg/l	CTR	--	4	--	4	--	4	--	4	--	4

Table 10, continued. Frequency of water chemistry threshold exceedances.
C. Aquatic life thresholds at non-SWAMP sites.

Constituent	Dissolved Oxygen		pH		Specific Conductivity		Turbidity	
Threshold	5 mg/L		> 6 or < 8		1.6 mS/cm		20 NTU	
Source	BP		BP		CCR		BP	
Site	Frequency	n	Frequency	n	Frequency	n	Frequency	n
1	--	7	0.57	7	1.00	7	--	1
3	--	1	1.00	1	1.00	1	n.t.	0
5	--	7	1.00	7	1.00	7	--	1
7	0.14	7	0.86	7	1.00	7	--	1
8	--	1	--	1	1.00	1	n.t.	0
9	--	1	--	1	1.00	1	n.t.	0
11	--	1	--	1	1.00	1	n.t.	0
12	--	2	0.50	2	1.00	2	n.t.	0
14	--	1	--	1	1.00	1	n.t.	0
15	--	1	--	1	1.00	1	n.t.	0
16	--	1	--	1	--	1	n.t.	0
17	--	7	--	7	0.86	7	--	1
18	--	3	0.33	3	0.67	3	n.t.	0
19	--	1	--	1	1.00	1	n.t.	0
20	--	1	--	1	1.00	1	n.t.	0
21	--	1	1.00	1	--	1	n.t.	0
22	--	3	0.67	3	0.67	3	n.t.	0

Table 11. Frequency of SWAMP sites with aquatic life and human health threshold exceedances for each constituent. Number of SWAMP sites included in evaluation (n). Constituent never exceeded threshold at any site (--). No applicable threshold for constituent (NA).

Category	Constituent	n	Aquatic life	Human health
Inorganics	Alkalinity as CaCO3	10	--	NA
Inorganics	Ammonia as N	10	1.00	NA
Inorganics	Nitrate + Nitrite as N	10	0.20	NA
Inorganics	Phosphorus as P,Total	10	0.70	NA
Inorganics	Selenium,Dissolved	10	0.90	NA
Inorganics	Sulfate	9	1.00	NA
Metals	Aluminum,Dissolved	10	--	NA
Metals	Arsenic,Dissolved	10	--	--
Metals	Cadmium,Dissolved	10	--	--
Metals	Chromium,Dissolved	10	--	NA
Metals	Copper,Dissolved	10	--	--
Metals	Lead,Dissolved	10	--	NA
Metals	Manganese,Dissolved	9	0.78	NA
Metals	Nickel,Dissolved	10	--	--
Metals	Silver,Dissolved	10	--	NA
Metals	Zinc,Dissolved	10	--	NA
PAHs	Acenaphthene	10	NA	--
PAHs	Anthracene	10	NA	--
PAHs	Benz(a)anthracene	10	NA	--
PAHs	Benzo(a)pyrene	10	--	--
PAHs	Benzo(b)fluoranthene	10	NA	--
PAHs	Benzo(k)fluoranthene	10	NA	--
PAHs	Chrysene	10	NA	--
PAHs	Dibenz(a,h)anthracene	10	NA	--
PAHs	Fluoranthene	10	NA	--
PAHs	Indeno(1,2,3-c,d)pyrene	10	NA	--
PAHs	Pyrene	10	NA	--
PCBs	PCBs	10	--	--
Pesticides	Aldrin	10	--	0.2
Pesticides	Ametryn	10	NA	--
Pesticides	Atrazine	10	--	--
Pesticides	Azinphos ethyl	10	NA	--
Pesticides	Azinphos methyl	10	NA	--
Pesticides	DDD(p,p')	10	NA	0.2
Pesticides	DDE(p,p')	10	NA	1
Pesticides	DDT(p,p')	10	NA	0.5
Pesticides	Dieldrin	10	NA	0.1
Pesticides	Dimethoate	10	NA	--
Pesticides	Endosulfan sulfate	10	NA	--
Pesticides	Endrin	10	0.10	--
Pesticides	Endrin Aldehyde	10	NA	--
Pesticides	Endrin Ketone	10	NA	--
Pesticides	Heptachlor	10	--	--
Pesticides	Heptachlor epoxide	10	--	--
Pesticides	Hexachlorobenzene	10	--	--
Pesticides	Methoxychlor	10	--	NA
Pesticides	Molinate	10	--	NA
Pesticides	Oxychlordane	10	NA	--
Pesticides	Simazine	10	--	NA
Pesticides	Thiobencarb	10	--	NA
Physical	pH	10	0.90	NA
Physical	Specific conductivity	10	1.00	NA
Physical	Turbidity	10	0.10	NA

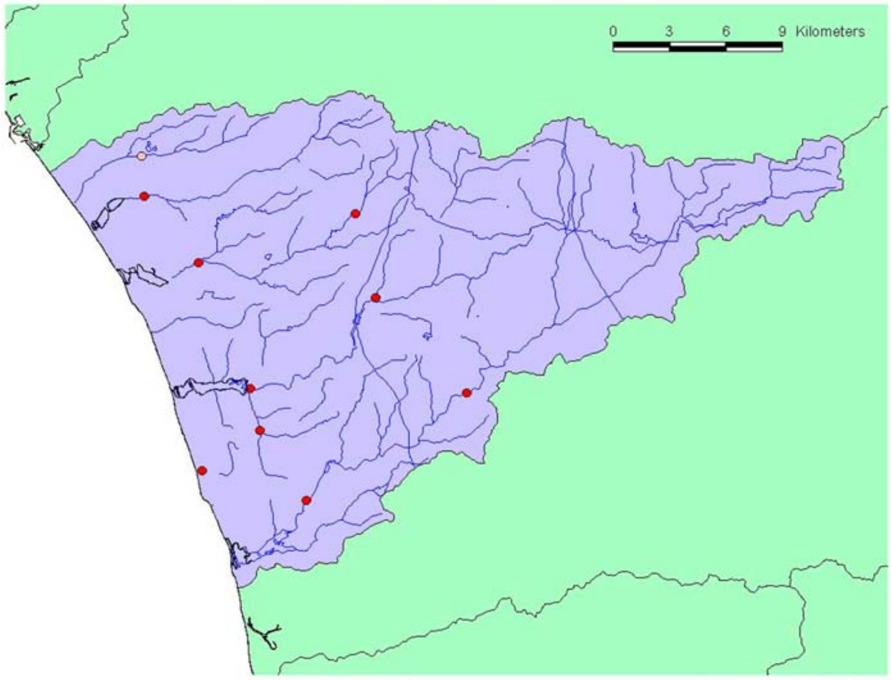


Figure 6. Map of aquatic life threshold exceedances for water chemistry at SWAMP sites. White circles indicate sites with one or fewer exceedances (this value did not occur in this watershed). Pink circles indicate sites with 2 to 5 exceedances. Red circles indicate sites with 6 to 9 exceedances. At Loma Alta Creek (904CBLAC3), 29 constituents were assessed; at all other sites, 31 constituents were assessed.

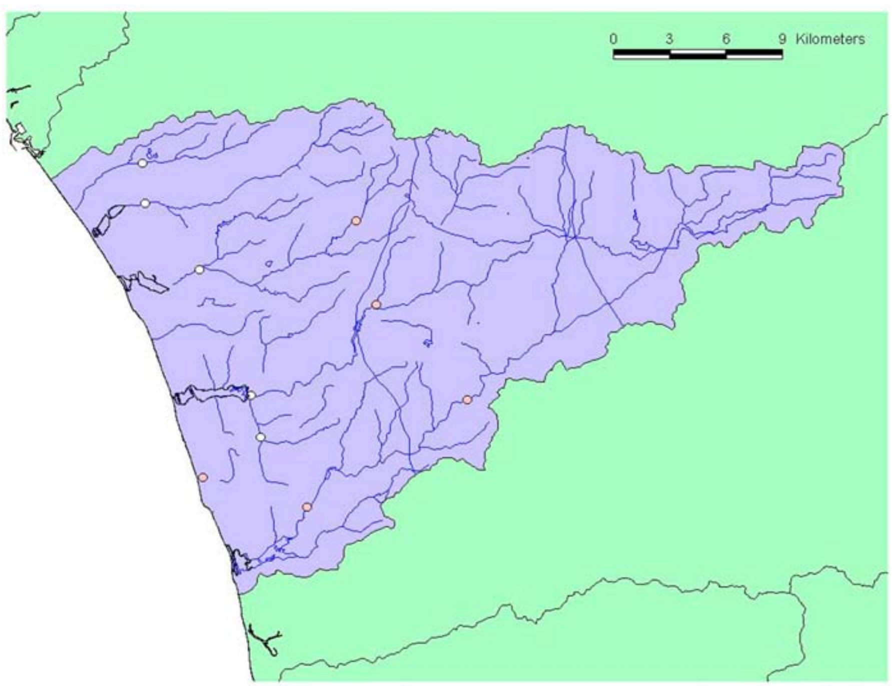


Figure 7. Map of human health exceedances for water chemistry at SWAMP sites. White circles indicate sites with one or fewer exceedances. Pink circles indicate sites with 2 to 5 exceedances. Red circles indicate sites with 6 to 9 exceedances (this value did not occur in this watershed). At all sites, 34 constituents were assessed.

All sites in Carlsbad HU failed to achieve certain aquatic life and human health thresholds (Table 12). Cottonwood Creek had the highest number of exceedances of aquatic life thresholds (8), and Buena Creek had the highest number of exceedances of human health thresholds (5). Loma Alta Creek had the fewest exceedances of aquatic life thresholds, with four constituents exceeding thresholds. However, Loma Alta Creek lacks applicable thresholds for manganese and sulfate, and that these constituents were found at concentrations similar to other sites within the watershed. Therefore, Loma Alta Creek does not appear to have distinct water chemistry from the other sites. Impacts do not appear to be localized and affect most streams in the watershed.

Table 12. Number of constituents exceeding thresholds at each SWAMP site.

Site	Aquatic life	Human health
904CBAQH6	6	1
904CBBUR1	7	5
904CBBVR4	6	1
904CBCWC2	8	2
904CBENC2	7	1
904CBESC5	6	3
904CBESC8	7	3
904CBLAC3	4	1
904CBSAM3	7	2
904CBSAM6	7	1

Results from NPDES water chemistry monitoring at 17 sites were similar to results from SWAMP (Table 10C). For example, specific conductivity exceeded aquatic life thresholds at nearly every site, and at almost every sampling date; at only two sites (San Marcos Creek, site 16, and Escondido Creek, site 21) was specific conductivity below aquatic life thresholds at all sampling dates. NPDES monitoring detected exceedances of pH at eight sites. Dissolved oxygen was high at all times in most sites, falling below threshold at Escondido Creek (site 7) on one occasion. Turbidity never exceeded aquatic life thresholds where it was measured.

4.2 Toxicity

Toxicity was evident at all sites within the watershed, although results varied among sites and indicators (Table 13; Appendix III). Toxicity was most severe at Buena Vista Creek, Cottonwood Creek, and both sites on San Marcos Creek, where a majority of samples were toxic to at least two indicators (generally, *S. capricornutum* and *H. azteca*). Toxicity was least severe at the Lower Escondido Creek site, where only one sample was toxic to a single indicator (Figure 8).

Table 13. Frequency of toxicity detected for each endpoint and at each site. A sample was considered toxic if the percent control of the endpoint was less than 80% of reference samples, and the difference was considered significant at 0.05. Number of samples where the endpoint was evaluated (n). Toxicity not detected in any sample (--).

	C. dubia				*H. azteca*				*S. capricornutum*		Multiple indicators	
Site	Surival	n	Young/Female	n	Survival	n	Growth	n	Total cell count	n	Frequency	n
904CBAQH6	--	4	--	4	0.25	4	--	4	1.00	4	0.33	12
904CBBUR1	--	4	0.25	4	0.25	4	0.25	4	0.25	4	0.25	12
904CBBVR4	--	4	--	4	1.00	4	0.25	4	0.75	4	0.33	12
904CBCWC2	--	4	--	4	1.00	4	--	4	0.75	4	0.25	12
904CBENC2	0.25	4	0.25	4	0.25	4	0.25	4	0.25	4	0.25	12
904CBESC5	0.25	4	--	4	--	4	0.25	4	--	4	0.08	12
904CBESC8	--	4	--	4	--	4	0.25	4	--	4	0.08	12
904CBLAC3	--	4	--	4	0.25	4	--	4	1.00	4	0.33	12
904CBSAM3	0.25	4	0.25	4	0.75	4	--	4	0.5	4	0.18	11
904CBSAM6	0.33	3	0.25	3	0.75	4	--	4	1.00	4	0.40	10
Entire watershed	0.10	39	0.10	39	0.45	40	0.13	40	0.55	40	0.24	116

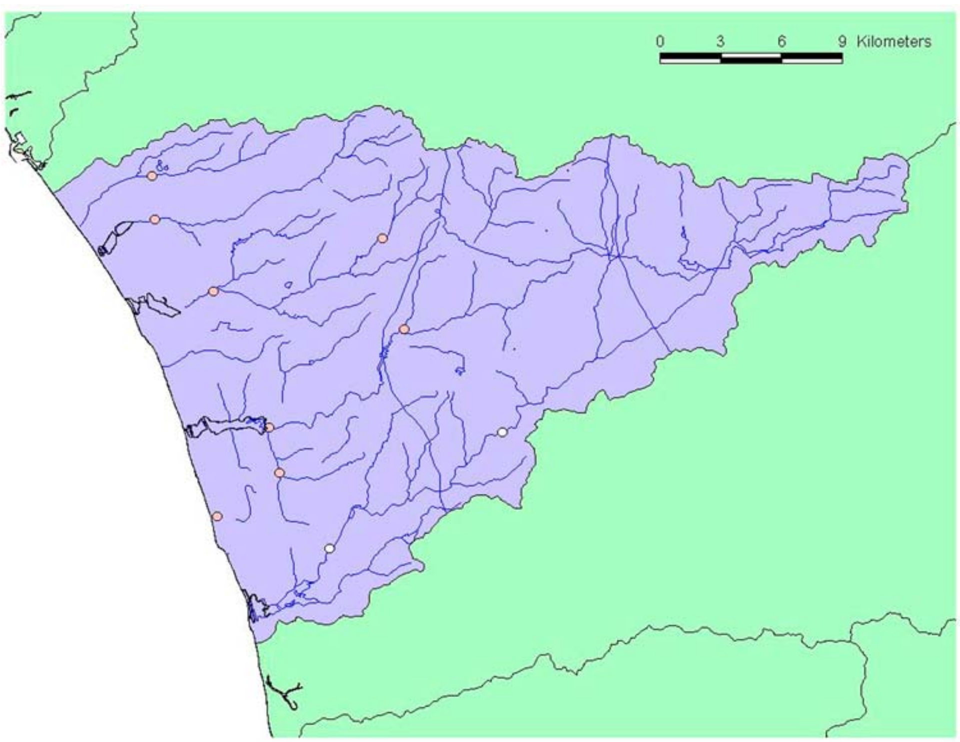


Figure 8. Frequency of toxicity (*C. dubia* fecundity, *H. azteca* growth, and *S. capricornutum* total cell count) at SWAMP sites. White circles indicate low frequency (0.0 to 0.1) of toxicity (this value did not occur in this watershed) . Pink circles indicate moderate frequency (0.1 to 0.5) of toxicity. Red circles indicate high (0.5 to 1.0) frequency of toxicity (this value did not occur in this watershed).

S. capricornutum was the most sensitive toxicity indicator, as total cell count was less than 80% of control at most sites in most samples. However, there was no evidence of toxicity to *Selenastrum* at the two sites in Escondido Creek, and toxicity was only observed once each at Buena Creek and Encinitas

Creek. Across the entire watershed, 55% of tests using *Selenastrum* indicated toxicity.

Toxicity tests using arthropod indicators provided more mixed results. For example, all sites showed acute or chronic toxicity to *H. azteca* in at least one sample, but only half the sites were toxic to *C. dubia.* Every sediment sample from Buena Vista Creek and Cottonwood Creek was acutely toxic to *H. azteca*, but water samples from these sites had no observable effect on *C. dubia.* In general, sediment toxicity appeared to be more persistent over the period of study, as multiple samples from certain sites were toxic to *H. azteca;* in contrast, water toxicity to *C. dubia* was never evident in more than one sample from a site, suggesting that water column toxicity may be transient. Across the entire watershed, *H. azteca* indicated toxicity more frequently (45% of tests) than did *C. dubia* (10% of tests).

4.3 Tissue

Analysis of fish tissues from Agua Hedionda Creek and the lower San Marcos Creek site showed little evidence of tissue contamination by PCBs and pesticides, although mercury exceeded thresholds for methylmercury at both sites. The majority of constituents did not occur at detectable concentrations (Table 14; Figure 9; Appendix IV).

Table 14. Concentrations of contaminants in fish tissues, compared with OEHHA thresholds. A full list of analyzed constituents is presented in Appendix-III. Bold face indicates constituents exceeding threshold. Dashes (--) indicate that the constituent was not detected.

				904CBAQH6		904CBSAM6		
Category	Constituent	Threshold	Unit	Bullhead	Crayfish	Bullhead	Crayfish	Red-ear sunfish
Inorganics	Selenium	1.94	ppm	0.17			1.53	0.37
PCBs	PCBs	20	ng/g		2.79	2.51		
Pesticides	Chlordane	200	ng/g	--			--	
Pesticides	DDTs	560	ng/g	22.9			1.1	
Pesticides	Dieldrin	16	ng/g	--			--	
Pesticides	Toxaphene	220	ng/g	--			--	
Metals	Mercury	0.08	ppm	**0.39**				**1.96**

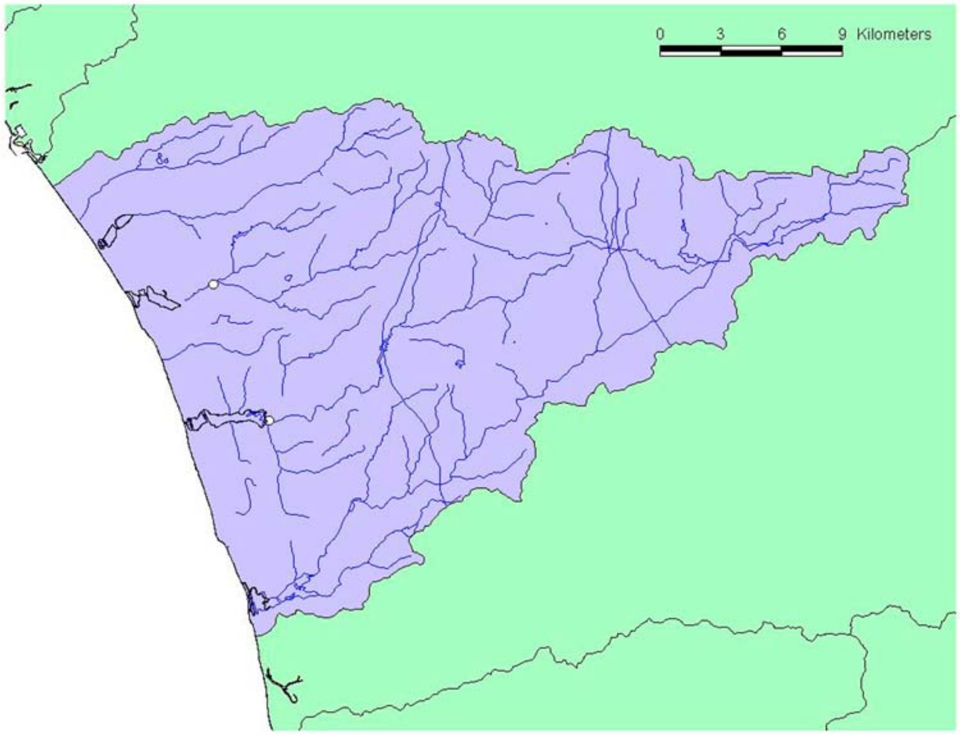


Figure 9. Fish tissue exceedances at SWAMP sites. White circles indicate 1 or fewer exceedances. Pink circles indicate 2 to 3 exceedances (this value did not occur in this watershed). Red circles indicate 4 to 5 exceedances (this value did not occur in this watershed).

Approximately one-quarter of the 48 PCBs analyzed were detected in fish samples (Table 15). Despite this evident accumulation, PCBs were well below the OEHHA threshold of 20 ng/g. In contrast, only three pesticides (i.e., p,p'-DDD, p,p'-DDE and trans-nonachlor) were detected in samples, indicating that fish did not accumulate detectable levels of many of the pesticides found in the water samples (see Table 11).

Table 15. Frequency of anthropogenic organic constituents detected in fish tissue.

		PCBs		Pesticides	
Site	Species	Detected	Tested	Detected	Tested
904CBAQH6	Bullhead	None tested		3	39
	Crayfish	14	48	None tested	
904CBSAM6	Bullhead	11	48	None tested	
	Crayfish	None tested		2	39

4.4 Bioassessment

Biological health was poor or very poor for all sites and all seasons in the Carlsbad HU. Mean IBI scores ranged from 4.3 at Escondido Creek (sites 8 and 21) and Buena Vista Creek (Site 18) to a high of 31.4, also at Escondido Creek (Site 6) (Table 16; Figure 10). Sites in poor or very poor condition were found throughout the watershed (Figure 10). Most creeks had sites with IBI scores of 10 or lower. There was no consistent affect of season in IBI scores, and the differences between seasons were slight for most sites (Table 16; Figure 11). Therefore, poor biological condition persisted during all seasons sampled.

Table 16. Mean and standard deviation of IBI scores at bioassessment sites within the Carlsbad HU. Number of samples collected within each season (n). Range from first to last year of sampling at each site (Years). Frequency of poor or very poor IBI scores (IBI <40) at each site and season (Frequency).

				IBI			
Site	Season	n	Years	Mean	SD	Condition	Frequency
1	Average	15	1998-2005	14.7	4.4	Very poor	1.0
1	Fall	6	1998-2004	17.9	7.5	Very poor	1.0
1	Spring	9	1998-2005	11.6	9.3	Very poor	1.0
2	Spring	2	1998-1998	14.3	2	Very poor	1.0
3	Average	5	1998-2002	15.5	4.3	Very poor	1.0
3	Fall	1	1999-1999	18.6		Very poor	1.0
3	Spring	4	1998-2002	12.5	10.2	Very poor	1.0
4	Average	7	1998-2000	6	1.1	Very poor	1.0
4	Fall	3	1998-2000	5.2	3	Very poor	1.0
4	Spring	4	1998-2000	6.8	8.2	Very poor	1.0
5	Average	15	1998-2005	20.7	1	Poor	1.0
5	Fall	5	1998-2004	20	4.7	Poor	1.0
5	Spring	10	1998-2005	21.4	6	Poor	1.0
6	Fall	1	2000-2000	31.4		Poor	1.0
7	Average	12	1998-2005	11.4	2	Very poor	1.0
7	Fall	5	1998-2004	12.9	6	Very poor	1.0
7	Spring	7	1998-2005	10	5.5	Very poor	1.0
8	Spring	2	1998-2002	4.3	4	Very poor	1.0
9	Average	7	1998-2002	6.9	0.4	Very poor	1.0
9	Fall	2	1998-1999	7.1	2	Very poor	1.0
9	Spring	5	1998-2002	6.6	4.1	Very poor	1.0
10	Spring	1	2000-2000	7.1		Very poor	1.0
11	Average	6	1998-2002	10	0	Very poor	1.0
11	Fall	2	1998-1999	10	6.1	Very poor	1.0
11	Spring	4	1998-2002	10	9.5	Very poor	1.0
12	Average	8	1998-2002	12.4	3.4	Very poor	1.0
12	Fall	3	1998-2002	10	3.8	Very poor	1.0
12	Spring	5	1998-2002	14.9	8.5	Very poor	1.0
13	Average	7	1998-2000	16	1.1	Very poor	1.0
13	Fall	3	1998-2000	15.2	3.6	Very poor	1.0
13	Spring	4	1998-2000	16.8	10.2	Very poor	1.0
14	Average	8	1998-2002	9.6	0.6	Very poor	1.0
14	Fall	3	1998-2000	10	2.9	Very poor	1.0
14	Spring	5	1998-2002	9.1	6.4	Very poor	1.0
15	Average	7	1998-2002	12.3	1.3	Very poor	1.0
15	Fall	3	1998-2000	11.4	3.8	Very poor	1.0
15	Spring	4	1998-2002	13.2	4.7	Very poor	1.0
16	Average	5	1998-2002	15.7	6.1	Very poor	1.0
16	Fall	1	1998-1998	20		Poor	1.0
16	Spring	4	1998-2002	11.4	4.2	Very poor	1.0

Table 16, continued. Mean and standard deviation of IBI scores.

				IBI			
Site	Season	n	Years	Mean	SD	Condition	Frequency
17	Average	7	2002-2005	14.6	9	Very poor	1.0
17	Fall	3	2002-2004	21	5.4	Poor	1.0
17	Spring	4	2002-2005	8.2	4.3	Very poor	1.0
18	Average	4	2002-2004	11.9	10.8	Very poor	1.0
18	Fall	3	2002-2004	19.5	2.2	Very poor	1.0
18	Spring	1	2002-2002	4.3		Very poor	1.0
19	Spring	1	2002-2002	7.1		Very poor	1.0
20	Spring	1	2002-2002	11.4		Very poor	1.0
21	Spring	1	2002-2002	4.3		Very poor	1.0
22	Average	3	2002-2004	26.8	2.5	Poor	1.0
22	Fall	2	2002-2004	25	5.1	Poor	1.0
22	Spring	1	2002-2002	28.6		Poor	1.0

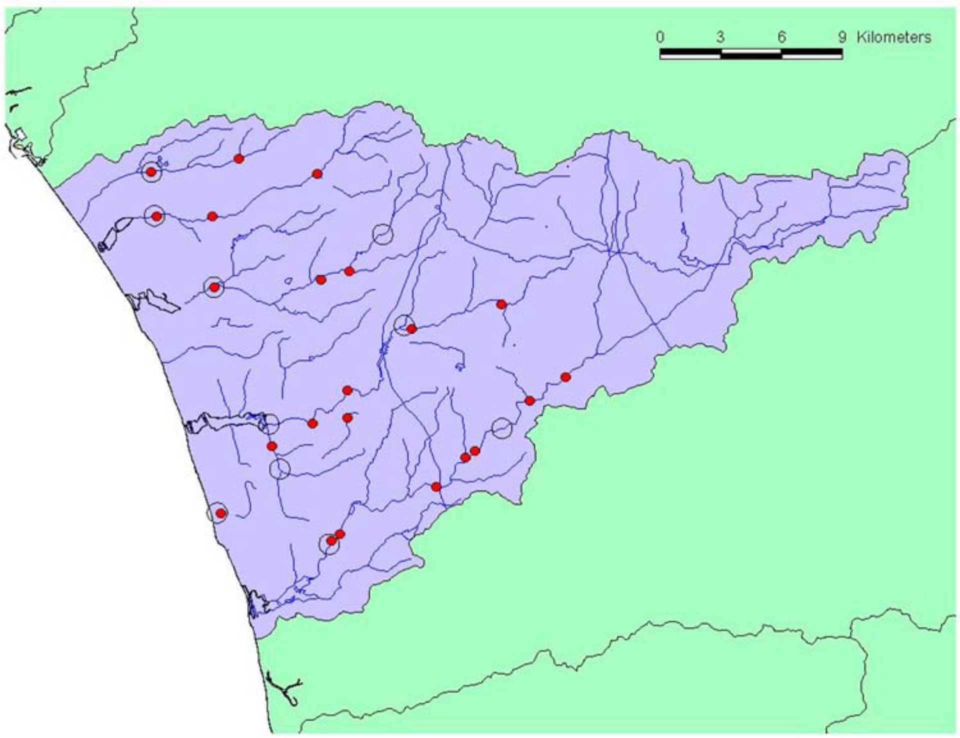


Figure 10. IBI scores at sites in the Carlsbad HU. White circles indicate good or very good (60 to 100) IBI scores (this value did not occur in this watershed). Pink circles indicate fair (40 to 60) IBI scores (this value did not occur in this watershed). Red circles indicate poor (0 to 40) IBI scores. Open circles represent 500-m buffers around SWAMP sites; six of these buffers included bioassessment sites, and three of these buffers did not.

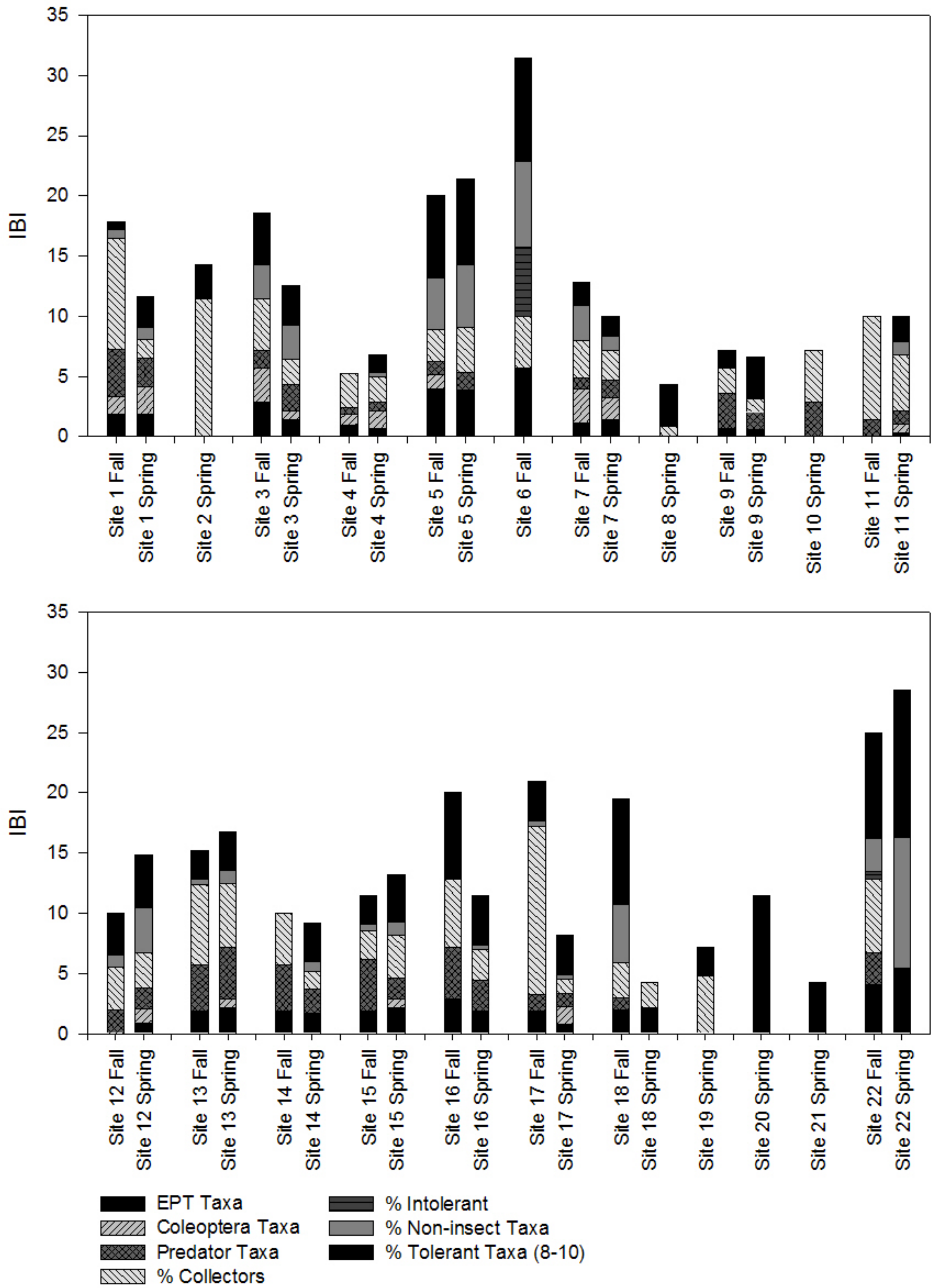


Figure 11. Mean IBI scores at each bioassessment site and each season. The height of the bar indicates the mean IBI score, and the size of each component of the bar represents the contribution of each metric to the IBI. Sites are split over two plots to improve clarity.

Mean values of the metrics that make up the IBI indicated very poor biological health. For example, pollution-sensitive taxa (used to calculate the % Intolerant metric) and beetles (used to calculate the Coleoptera Taxa metric) were nearly absent from all samples. The % Collectors, % Non-insect Taxa , and % Tolerant Taxa metrics also indicated impact, although to a lesser degree than the other metrics. (Appendix V; Figure 11).

Examination of IBI scores over time did not indicate a trend towards improving or deteriorating biological condition (Figure 12). Variability among years was high, which may obscure trends in the data. Furthermore, a different set of sites were sampled in the early and late periods of study, increasing spatial variability and obscuring trends. None of these sites were monitored under SWAMP, and all bioassessment data came from monitoring efforts by NPDES permittees or the California Department of Fish and Game.

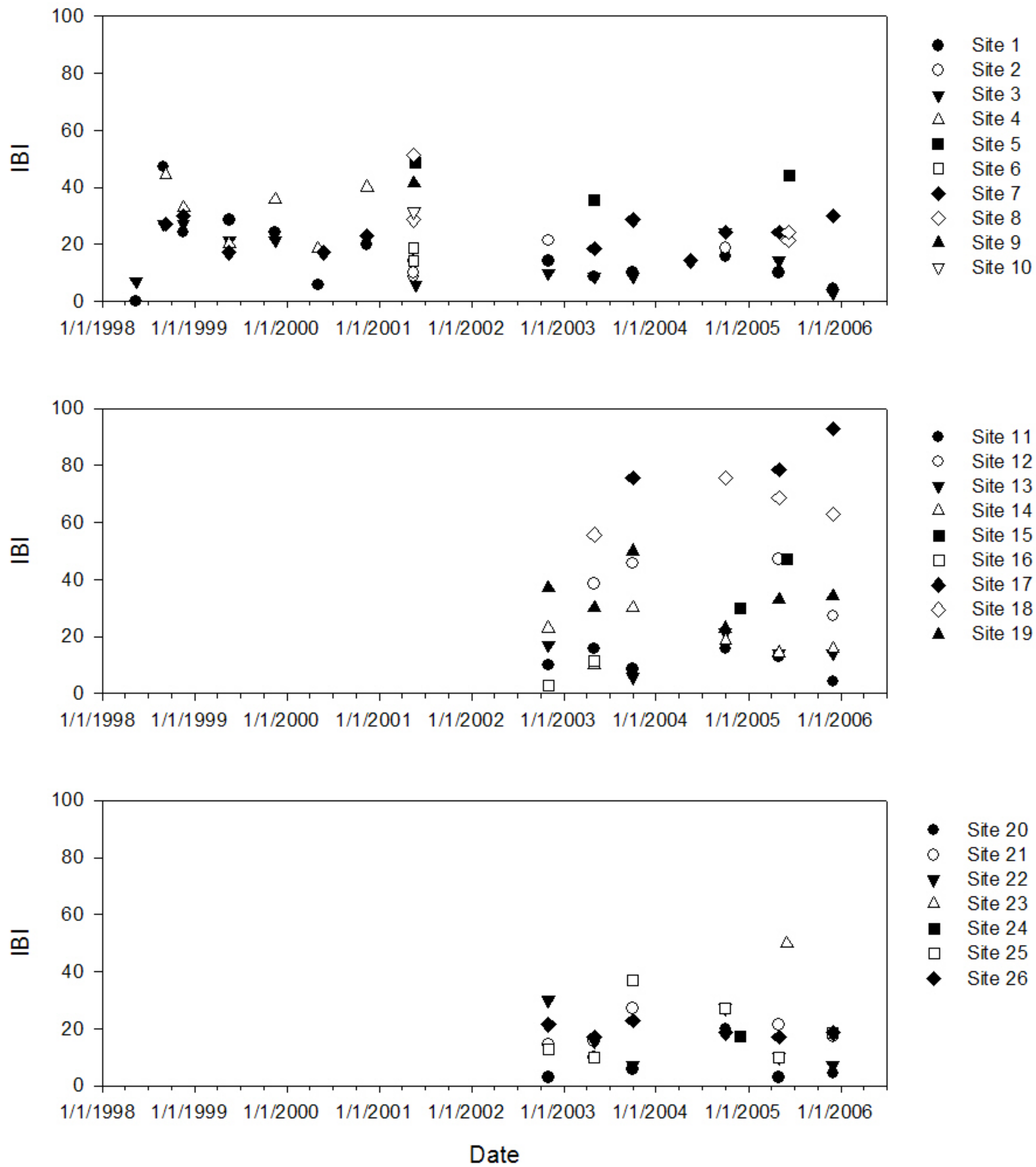


Figure 12. IBI values for each year and site. Each symbol represents a single sample. Sites are split over three plots to improve clarity.

4.5 Physical Habitat

Physical habitat varied among sites throughout the watershed, although human alteration was evident at every site visited. Good habitat (i.e., mean physical habitat score > 15) was found at only the Upper Escondido Creek site. Moderately altered habitat (i.e., mean physical habitat score > 10) was found at several sites throughout the watershed, including Buena Vista Creek, Cottonwood Creek, Encinitas Creek, Loma Alta Creek, and both sites in San Marcos Creek. The most altered habitat was found in Agua Hedionda Creek, Buena Creek, and the Lower Escondido Creek site (Table 17; Figure 13).

Table 17. Score and mean for each component of physical habitat. Component range: 0 (heavily impacted habitat) to 20 (unimpacted habitat).

Site	Date	Phab 1- Epifaunal cover	Phab 2- Embeddedness	Phab 3- Velocity-depth regime	Phab 4- Sediment deposition	Phab 5- Channel flow	Phab 6- Channel alteration	Phab 7- Riffle frequency	Phab 8- Bank stability	Phab 9- Vegetation protection	Phab 10 Riparian Zone	Mean score
904CBAQH6	2/21/2002	9	1	3	3	8	10	5	16	14	10	8.5
904CBBUR1	2/25/2002	6	0	12	13	13	13	16	6	6	0	8.5
904CBBVR4	2/21/2002	11	10	18	13	13	9	6	17	14	7	11.8
904CBCWC2	2/8/2002	16	3	15	14	18	3	19	17	15	8	12.8
904CBENC2	2/25/2002	16	2	13	15	19	2	8	20	20	11	12.6
904CBESC5	2/4/2002	19	3	17	9	20	20	18	20	20	19	16.5
904CBESC8	2/25/2002	1	0	6	18	3	3	2	20	20	10	8.3
904CBLAC3	2/21/2002	16	12	13	16	13	14	14	7	7	8	12.0
904CBSAM3	2/4/2002	11	2	11	20	19	2	6	20	18	6	11.5
904CBSAM6	2/25/2002	16	2	13	17	13	2	8	20	20	10	12.1
Mean of all sites		11.3	3.3	11.1	13.6	13.8	8.5	9.2	15.3	13.9	8.8	10.8

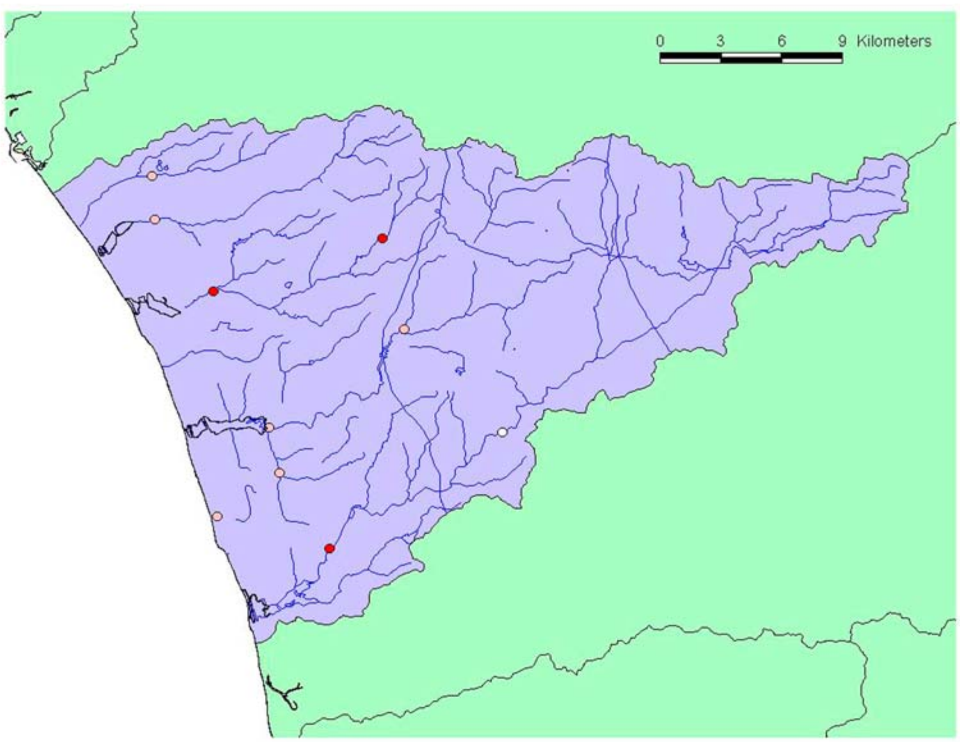


Figure 13. Assessment of physical habitat at SWAMP sites. White circles indicate sites with a mean physical habitat scores between 15 and 20. Pink circles indicate mean scores between 10 and 15. Red circles indicate mean scores between 0 and 10.

Agua Hedionda Creek stood out as having the most severely degraded physical habitat, as every component of physical habitat was impacted (i.e., ≤10). Such severe degradation was rare, and the majority of physical habitat components were in good condition (i.e., ≥ 10) at eight of the ten sites. In fact, the upper site in Escondido Creek received very high physical habitat scores (i.e., > 15) for eight components.

Some components of physical habitat suggested very severe degradation in the watershed. For example embeddedness was severely impacted throughout the Carlsbad HU, receiving scores below four at all but two sites (Buena Vista Creek and Loma Alta Creek). The average embeddedness score in the Carlsbad HU was 3.3 Channel alteration, riffle frequency, and riparian zone also showed signs of degradation throughout the watershed, as these components received average scores of 8.5, 9.2, and 8.8, respectively. In contrast, bank stability was good at most sites, receiving scores above 15 at 7 sites. Vegetation protection and channel flow similarly received high scores at most sites.

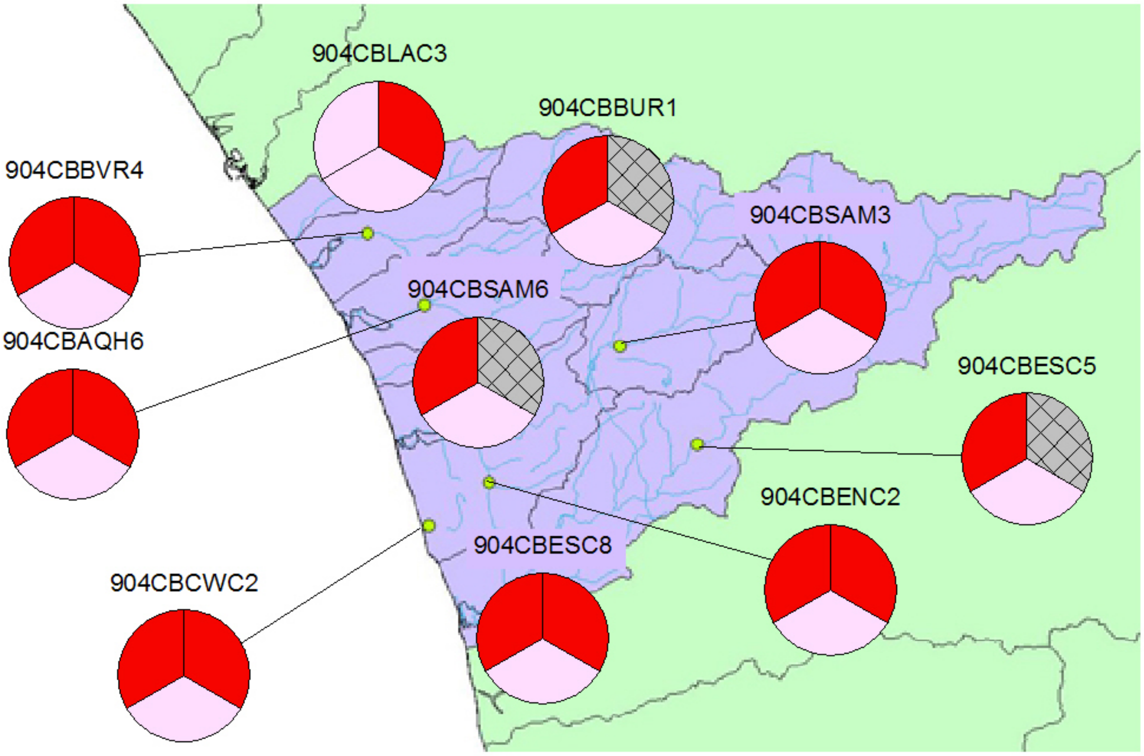
5. DISCUSSION

Every site sampled in the Carlsbad HU showed evidence of impact from multiple indicators (Table 18; Figure 14). For example, severe impacts at Agua Hedionda Creek were detected by numerous aquatic life threshold exceedances in water chemistry, and by low IBI scores. Toxicity indicated moderate impacts as well, because all water samples were toxic to *S. capricornutum*. Physical habitat was degraded, with one of the lowest mean physical habitat scores (i.e., 8.5) of any site in the Carlsbad HU. Constituents in fish tissue collected near this site contained mercury exceeding OEHHA standards for methylmercury, although 14 PCBs and 3 pesticides were detected in low concentrations.

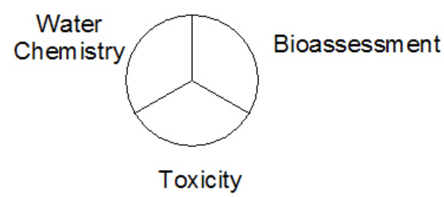
Table 18. Summary of the ecological health for five SWAMP sites in Carlsbad HU. Aquatic life (AL). Human health (HH). Toxicity frequency is frequency of toxicity for three chronic toxicity endpoints: *C. dubia* (fecundity), *H. azteca* (growth), and *S. capricornutum* (total cell count). Biology frequency is the frequency of IBIs below 40. n.t. = Indicator not tested.

Site	Water chemistry # constituents (AL)	# constituents (HH)	Tissue # constituents (OEHHA)	Toxicity Frequency	Biology Frequency	Physical habitat Mean score
904CBAQH6	6	1	0	0.33	1.00*	5.9
904CBBUR1	7	5	n.t.	0.25	n.t.	8.5
904CBBVR4	6	1	n.t.	0.33	1.00*	11.8
904CBCWC2	8	2	n.t.	0.25	1.00*	12.8
904CBENC2	7	1	n.t.	0.25	1.00*	12.6
904CBESC5	6	3	n.t.	0.08	n.t.	16.5
904CBESC8	7	3	n.t.	0.08	1.00*	8.3
904CBLAC3	4	1	n.t.	0.33	1.00*	12
904CBSAM3	7	2	n.t.	0.18	1.00*	11.5
904CBSAM6	7	1	0	0.40	n.t.	12.1

* = Estimated from data collected at nearby (within 500 meters) non-SWAMP sites



Indicator



Severity of impact

Severity	Water chemistry (# aquatic life exceedences)	Toxicity (Frequency of toxicity)	Bioassessment (IBI Score)
Low	0-1	0.0-0.1	60-100
Moderate	2-5	0.1-0.5	40-60
High	6+	0.5-1.0	0-40
Not tested			

Figure 14. Summary of the ecological health of SWAMP sites in the Carlsbad HU, as determined by water chemistry, toxicity, and bioassessment indicators. Each pie slice corresponds to a specific indicator, as described in the inset, with darker colors corresponding to more degraded conditions (unmeasured indicators are shown in cross-hatched gray). The top-left slice corresponds to the number of water chemistry constituents exceeding aquatic life thresholds. The bottom slice corresponds to the frequency of toxicity among three endpoints: *C. dubia* (fecundity), *H. azteca* (growth), and *S. capricornutum* (total cell count). The top-right slice corresponds to the IBI of bioassessment samples.

Buena Creek had many impacts to water chemistry (mainly from nutrients and physical parameters, such as pH) and toxicity. Buena Creek was distinct by having five water chemistry constituents exceed human health thresholds—more than any other site in the Carlsbad HU. All of these constituents were pesticides, with p,p'-DDE having the most frequent exceedances. These results are consistent with the inclusion of Buena Creek on the 303(d) list of impaired water bodies, which identifies DDT, nitrate and nitrite, and phosphate as known stressors. Although several endpoints indicated toxicity, one sampling date (April 23, 2002) accounted for 75% of the toxic hits at this site. Half the sampling dates were not toxic to any endpoint, suggesting that sediment and water toxicity was not persistent. Physical habitat was degraded at Buena Creek, with half of the components of physical habitat receiving scores below 10. Bioassessment samples were not collected at this site.

Buena Vista Creek also had impacts to water chemistry, toxicity to multiple endpoints, and benthic communities. Ammonia, selenium, and specific conductivity exceeded aquatic life thresholds at every sampling event, indicating that these constituents were persistent impacts. Sediment from this site was acutely toxic to *H. azteca* at all times of the year, and all water samples were toxic to *S. capricornutum* as well. These results are consistent with the inclusion of Buena Vista Creek on the 303(d) list, which lists sediment toxicity as a known stressor. Physical habitat showed signs of degradation, particularly in terms of riffle frequency and an altered riparian zone.

Impacts to ecological health at both SWAMP sites in San Marcos Creek were similar. For example, both sites had numerous water chemistry constituents exceed aquatic life thresholds, particularly nutrients (such as ammonia-N and phosphorus), sulfate, selenium, and specific conductivity. The two sites differed in that pH at the downstream site was always within the bound of the aquatic life thresholds, but at the upstream site, pH was frequently above the threshold. Toxicity was similar at these sites. Water and sediment samples exhibited acute toxicity to both *C. dubia* and *H. azteca*. Toxicity to *S. capricornutum* was observed at all sampling dates at the downstream site, but only half as frequently upstream. Both water chemistry and toxicity data are consistent with the inclusion of San Marcos Creek on the 303(d), which specifies DDE, phosphate, and sediment toxicity as known stressors. Bioassessment samples, collected at the upstream site, were in very poor condition, as indicated by extremely low IBI scores (mean ≤ 10) from samples collected in both Spring and Fall. Bioassessment at other sites on San Marcos Creek had slightly higher IBI scores, although still indicating poor or very poor condition. The highest IBI scores in this creek were found at site 22, where the annual mean score was 26.8. Physical habitat was similarly degraded at the two sites, with embeddedness, channel alteration, riffle frequency, and riparian zone components indicating the most severe impacts. Mercury in fish tissues collected in Lower San Marcos Creek were high, exceeding OEHHA thresholds for methylmercury. Mercury detected in concentrations five times greater here than at Agua Hedionda Creek. However, 11 PCBs and 2 pesticides were detected in low concentrations in fish tissues.

Encinitas Creek also showed evidence of impacts from multiple indicators. Water chemistry was severely impacted, with six constituents exceeding aquatic life thresholds at every sampling date. Like other sites in the Carlsbad HU, these constituents included nutrients (such as ammonia-N and phosphorus), selenium, manganese, sulfate, and specific conductivity. These results are consistent with the inclusion of Encinitas Creek on the 303(d) list, which specifies Phosphorus as a known stressor in Encinitas Creek. All toxicity endpoints indicated toxicity in one sampling event. Bioassessment samples collected nearby (site 9) had extremely low IBI scores (annual mean of 6.9), suggesting that benthic communities are severely impacted. A bioassessment sample collected upstream (site 10) also had an extremely low IBI score (7.1). Physical habitat was moderately impacted. Embeddedness, channel alteration, and riffle frequency all received physical habitat scores under 10.

Cottonwood Creek, was similar to the other sites in the watershed. Water chemistry and bioassessment indicators suggested severe impacts to aquatic health, and toxicity indicators suggested moderate impacts. For example, eight water chemistry constituents exceeded aquatic life thresholds, 6 of which did so at every sampling date. Nutrients (i.e., ammonia-N, total phosphorus, and nitrate + nitrite–N), selenium, sulfate, and specific conductivity caused the most frequent exceedances. Water and sediment samples from most dates indicated chronic toxicity in Cottonwood Creek, and samples from all dates resulted in acute toxicity to *H. azteca.* Although only one bioassessment sample was collected near this site (site 19), it was in very poor ecological condition (IBI = 7.1). Physical habitat was good for most components. For example, 6 of 10 components received scores greater than 15. However, embeddedness, channel alteration, and riparian zone all indicated severe degradation, receiving scores of 3, 3, and 8 respectively.

Escondido Creek was in poor ecological condition as indicated by multiple indicators at both sites. For example, six water chemistry constituents exceeded aquatic life thresholds at every sampling date at the downstream site; exceedances were less frequent for some constituents at the upstream site, where only 3 constituents exceeded thresholds at all sampling dates. At both sites, nutrients (ammonia-N and total phosphorus), selenium, sulfate, pH, and specific conductivity caused most exceedances; in addition, manganese exceeded thresholds at all samples in the downstream site, but never at the upstream site. Toxicity was less severe in Escondido Creek than at other sites in Carlsbad HU. For example, water samples from either site did not indicate toxicity to *S. capricornutum*. In contrast, at least one sample from all other sites in the Carlsbad HU were toxic to this indicator. Furthermore, only samples collected on April 24, 2002 were toxic to *C. dubia* or *H. azteca*, suggesting that toxicity levels were usually low in Escondido Creek. Bioassessment samples collected in

Spring near the downstream site (site 8) were in extremely poor ecological condition, with an average IBI of only 4.3. A sample collected several miles upstream (site 21) was also extremely low (IBI of 4.3), although the middle reaches of Escondido Creek (sites 5 and 6) were in better (but still poor) condition, (with mean annual IBI scores of 20.7 and 31.4, respectively). Samples collected further upstream (sites 7 and 20) had IBI scores between those of the downstream and middle reaches (mean annual IBI scores of 11.4 at both sites). Physical habitat was severely degraded at the downstream SWAMP site, where the mean physical habitat score was lower than any other site in the Carlsbad HU. Half the components of physical habitat (i.e., epifaunal cover, embeddedness, channel flow, channel alteration, and riffle frequency) received scores below 5. Physical habitat at the upstream SWAMP site was better, receiving the highest mean physical habitat score in the Carlsbad HU. Eight components of physical habitat received scores above 15 at this site. The only component that was severely impacted was embeddedness, which received a score of 3.

Loma Alta Creek differed from the other sites in the Carlsbad HU by having the lowest number (i.e., 4) of water chemistry exceedances of aquatic life thresholds. However, thresholds for sulfate and manganese do not apply to the Loma Alta hydrologic sub-area (HSU 904.1). Both these constituents occurred in concentrations comparable to other sites in the watershed, suggesting that water chemistry is not better in Loma Alta Creek, despite the lower number of exceedances. Ammonia-N, selenium, and specific conductivity exceeded thresholds at every sampling date, and pH did so once. Toxicity was moderate, with water samples collected on every sampling date producing toxicity to *S. capricornutum.* Samples were never toxic to *C. dubia*, but one sample reduced survival of *H. azteca*. Bioassessment samples collected near this site were in very poor ecological condition, as indicated by low IBI scores (annual mean IBI 12.4). Samples collected upstream in Loma Alta Creek (site 11) were also in very poor condition (mean annual IBI 10.0). Physical habitat was moderately degraded, with only 3 components (i.e., bank stability, vegetation protection, and riparian zone) receiving scores below 10. Embeddedness, which received very low scores at most sites in the Carlsbad HU, was only moderately degraded, receiving a score of 12.

This study's assessment of the Carlsbad HU suggests that the watershed is in poor ecological health. Multiple lines of evidence support this conclusion. For example, several water chemistry constituents exceeded aquatic life thresholds, toxicity was observed at every site, and bioassessment of macroinvertebrate communities were in poor or very poor condition at every sampling event.

Although these impacts were widespread, and in some cases severe, this study showed that, at least for water chemistry indicators, impacts were limited to certain constituents, such as nutrients and physical parameters. In contrast, all metals (except manganese) were below applicable thresholds at every site, as were nearly all pesticides (with p,p'-DDE and p,p'-DDT being exceptions). Furthermore, fish tissues did not exceed any thresholds apart from methylmercury, and they was little evidence of accumulation of pesticides.

Despite the strength of the evidence, limitations of this study affect the assessment. These limitations include difficulties integrating data from SWAMP and non-SWAMP sources, the non-randomization of sample sites, small sample size, and the lack of applicable thresholds for several indicators. Although these limitations require that results be interpreted with caution, it is unlikely that they would alter the fundamental finding that the Carlsbad watershed is in poor health, as explained at the end of this section.

The geographical approach to integrating SWAMP and non-SWAMP data relies on assumptions about the spatial and temporal variability of the variables measured by these programs. For example, bioassessment data may have been collected up to 500 meters away and up to 4 years before or 3 years after water chemistry, toxicity, and tissue data were collected. This study assumes that anthropogenic impacts do not change across these distances or over these spans of time. There is little published research on either of these assumptions, although there may be greater support for the assumptions about spatial variability (e.g., Gebler 2004) than for temporal variability (e.g., Sandin and Johnson 2000, Bêche et al. 2006).In this study, bioassessment data were observed to be highly variable, and the use of data collected many years before water chemistry data is questionable.

The targeted selection of sites monitored under the SWAMP program facilitated integration of pre-existing data from non-SWAMP sources, but this non-probabilistic approach severely limits the extrapolation of data from these sites to the rest of the watershed. Non-random sampling violates assumptions underlying most statistical analyses, and the sites selected in this study cannot be assumed to represent the entire watershed (Olsen et al. 1999, Stevens Jr. and Olsen 2004).

The small number of sites monitored under SWAMP also limits the certainty of this study's assessment. For example, tissue samples were collected at only two sites; therefore, tissue contamination may have gone undetected in unsampled regions of the watershed. Although SWAMP has produced a wealth of data about the Carlsbad watershed using limited resources, some indicators (especially those with high variability) may require more extensive sampling to produce more precise and accurate assessments.

Thresholds are an essential tool for assessing water quality and ecological health. However, their use is limited to indicators that have been well studied, and they cannot provide a holistic view watershed health. This limitation is exacerbated by the fact that many constituents and indicators lack applicable thresholds. For example, of the 54 water chemistry constituents, 20 (37%) had no applicable water quality objectives that could be used as thresholds for water quality. No thresholds exist for physical habitat scores. Furthermore, thresholds applied to IBI scores and toxicity were based on statistical distributions and professional judgment (respectively), rather than on risks to ecological health. For example, the 80% threshold used to identify toxic samples is based on the assumption that this level is ecologically meaningful, although this assumption has not been verified in the field. The development of biocriteria to establish meaningful thresholds for bioassessment is subject of active interest in California (Bernstein and Schiff 2002).

Despite these limitations, the data gathered under SWAMP and other programs strongly support the conclusion that the Carlsbad HU is in poor ecological health. Some of these limitations (such as the lack of applicable thresholds and the small sample size) may in fact have caused this assessment to underestimate the severity of degradation in the watershed. All indicators showed signs of human impacts. Multiple stressors, including degraded water quality, sediment, and physical habitat are the likely cause of the impact. Future research (see final report on the SWAMP monitoring program for further study recommendations) is necessary to determine which stressors are responsible for the impacts seen in the watershed.

6. LITERATURE CITED

Bêche, L.A., E.P. McElravy and V.H. Resh. 2005. Long-term seasonal variation in the biological traits of benthic-macroinvertebrates in two Mediterranean climate streams in California, USA. *Freshwater Biology* 51:56-75.

Bernstien, B. and Schiff, K. 2002. Stormwater research needs in Southern California. Technical Report 358. Southern California Coastal Water Research Project. Westminster, CA.

California Code of Regulations. 2007. Barclay's Official California Code of Regulations. Title 22. Social Security Division 4. Environmental Health Chapter 15. Domestic Water Quality and Monitoring Regulations Article 16. Secondary Drinking Water Standards. §64449.

California Department of Fish and Game. 2003. California Stream Bioassessment Procedure: Protocol for Biological and Physical/Habitat Assessment in Wadeable Streams. Available from www.dfg.ca.gov/cabw/cabwhome.html.

California Department of Water Resources. 2007. http://www.water.ca.gov/.
Environmental Protection Agency (EPA). 1993. Methods for measuring acute toxicity of effluents and receiving waters to freshwater and marine organisms, Fourth Edition. EPA 600/4-90/027. US Environmental Protection Agency, Environmental Research Laboratory. Duluth, MN.

City of Encinitas. 2006. Moonlight Beach Urban Runoff Treatment. Final Report. Encinas, CA. Available from http://www.ci.encinitas.ca.us/Resident/Environment/CleanWP/

Environmental Protection Agency (EPA). 1997. Water quality standards: Establishment of numeric criteria for priority toxic pollutants for the state of California: Proposed Rule. *Federal Register* 62:42159-42208.

Environmental Protection Agency (EPA). 2002. National recommended water quality criteria. EPA-822-R-02-047. Environmental Protection Agency Office of Water. Washington, DC.

Environmental Protection Agency (EPA). 2007. Integrated Risk Information System. http://www.epa.gov/iris/index.html. Office of Research and Development. Washington, DC.

Gebler, J.B. 2004. Mesoscale spatial variability of selected aquatic invertebrate community metrics from a minimally impaired stream segment. J*ournal of the North American Benthological Society* 23:616-633.

National Academy of Sciences. 1977. Drinking Water and Health. Volume 1. Washington, DC.

National Oceanic and Atmospheric Administration. 2007. National Weather Service data. Available from http://www.wrh.noaa.gov/sgx/obs/rtp/rtpmap.php?wfo=sgx

Ode, P.R., A.C. Rehn and J.T. May. 2005. A quantitative tool for assessing the integrity of southern California coastal streams. *Environmental Management* 35:493-504.

Office of Environmental Health Hazard Assessment (OEHHA). 2006. Draft development of guidance tissue levels and screening values for common contaminants in California Sports Fish: Chlordane, DDTs, Dieldrin, Methylmercury, PCBs, Selenium, and Toxaphene. OEHHA. Sacramento, CA.

Olsen, A.R., J. Sedransk, D. Edwards, C.A. Gotway, W. Liggett, S. Rathburn, K.H. Reckhow and L.J. Young. 1999. Statistical issues for monitoring ecological and natural resources in the United States. *Environmental Management and Assessment* 54:1-45.

Puckett, M. 2002. Quality Assurance Management Plan for the State of California's Surface Water Ambient Monitoring Program: Version 2. California Department of Fish and Game, Monterey, CA. Prepared for the State Water Resources Control Board. Sacramento, CA.

California Regional Water Quality Control Board, San Diego Region. 1994. Water quality control plan for the San Diego Region. San Diego, CA. http://www.waterboards.ca.gov/sandiego/programs/basinplan.html

SANDAG. 1998. Watersheds of the San Diego Region. SANDAG INFO.

Sandin, L. and R.K. Johnson. 2000. The statistical power of selected indicator metrics using macroinvertebrates for assessing acidification and eutrophication of running waters. *Hydrobiologia* 422/423:233-243.

Stevans, Jr., D.L. and A.R. Olsen. 2004. Spatially balanced sampling of natural resources. *Journal of the American Statistical Association: Theory and Methods* 99:262-278.

Weston Solutions, Inc. 2007. San Diego County Municipal Copermittees 2005-2006 Urban Runoff Monitoring. Final Report. County of San Diego. San Diego, CA. Available at http://www.projectcleanwater.org/html/wg_monitoring_05-06report.html.

7. APPENDICES

APPENDIX I

A. Beneficial uses of streams in the Carlsbad HU (California Regional Water Quality Control Board, San Diego Region 1994). B. Streams on the 303(d) list of impaired water bodies in the Carlsbad HUC. HUC = Hydrologic Unit Code. MUN = Municipal and domestic supply. AGR = Agricultural supply. IND = Industrial service supply. POW = Hydropower generation. REC1 = Contact recreation. REC2 = Non-contact recreation. WARM = Warm freshwater habitat. COLD = Cold freshwater habitat. WILD = Wildlife habitat. RARE = Rare, threatened, or endangered species. X = Exempted from municipal supply. E = Existing beneficial use. P = Potential beneficial use.

A. Beneficial uses of streams in the Carlsbad HU.

Carlsbad HU (904)	HUC	MUN	AGR	IND	POW	REC1	REC2	WARM	COLD	WILD	RARE
San Diego County Coastal Streams											
Loma Alta Creek	904.10	X				P	E	E		E	
Buena Vista Creek	904.22	X	E	E		E	E	E		E	
Buena Vista Creek	904.21	X	E	E		E	E	E		E	E
Agua Hedionda Creek	904.32	E	E	E		E	E	E		E	
Buena Creek	904.32	E	E	E		E	E	E		E	
Agua Hedionda Creek	904.31	E	E	E		E	E	E		E	
Letterbox Canyon	904.31	E	E	E		E	E	E		E	
Canyon de las Encinas	904.40	X				P	E	E		E	
San Marcos Creek Watershed											
San Marcos Creek	904.52	X	E			E	E	E		E	
Unnamed intermittent streams	904.53	X	E			E	E	E		E	
San Marcos Creek	904.51	X	E			E	E	E		E	
Encinitas Creek	904.51	X	E			E	E	E		E	
Escondido Creek Watershed											
Escondido Creek	904.63	E	E	P	E	E	E	E	E	E	
Escondido Creek	904.62	E	E	P		E	E	E	E	E	
Reidy Canyon	904.62	E	E	P		E	E	E	E	E	
Escondido Crek	904.61	E	E	P		E	E	E	E	E	

B. 303(d)-listed streams in the Carlsbad HU.

Name	HUC	Stressor	Potential source	Affected length
Agua Hedionda Creek	904.31	Manganese	Sources unknown	7 miles
		Selenium	Sources unknown	7 miles
		Sulfates	Sources unknown	7 miles
		Total Dissolved Solids	Urban runoff/storm sewers; unknown nonpoint source; unknown point source	7 miles
Buena Creek	904.32	DDT	Sources unknown	4.8 miles
		Nitrate and Nitrite	Sources unknown	4.8 miles
		Phosphate	Sources unknown	4.8 miles
Buena Vista Creek	904.21	Sediment toxicity	Sources unknown	11 miles
Cottonwood Creek (Sar	904.51	DDT	Sources unknown	1.9 miles
		Phosphorus	Sources unknown	1.9 miles
		Sediment toxicity	Sources unknown	1.9 miles
Encinitas Creek	904.51	Phosphorus	Sources unknown	3 miles
Escondido Creek	904.62	DDT	Sources unknown	26 miles
		Manganese	Sources unknown	26 miles
		Phosphate	Sources unknown	26 miles
		Selenium	Sources unknown	26 miles
		Sulfates	Sources unknown	26 miles
		Total Dissolved Solids	Sources unknown	26 miles
Reidy Canyon Creek	904.62	Phosphorus	Sources unknown	3.9 miles
San Marcos Creek	904.51	DDE	Sources unknown	19 miles
		Phosphorus	Sources unknown	19 miles
		Sediment toxicity	Sources unknown	19 miles

APPENDIX II

Means, standard deviations (SD), and number of samples (n) of water chemistry constituents in (A) SWAMP sites and (B) Non-SWAMP (NPDES) sites. The watershed average was calculated as the mean of the site averages. Blank cells indicate that the constituent was not analyzed at that site. -- = Constituent not detected at that site. SWAMP sites were monitored in 2002. Non-SWAMP sites were monitored in Spring and Fall between 2002 and 2005.

A. SWAMP sites.

			904CBAQH6			904CBBUR1			904CBBVR4			904CBCWC2			904CBENC2			904CBESC5		
Category	Constituent	Units	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n
Inorganics	Alkalinity as CaCO3	mg/l	232	4	4	282	23	4	254	17	4	155	2	4	266	7	4	285	19	4
Inorganics	Ammonia as N	mg/l	0.09	0.03	4	0.15	0.16	4	0.16	0.17	4	0.18	0.15	4	0.13	0.12	4	0.08	0.02	4
Inorganics	Nitrate + Nitrite as N	mg/l	1.09	0.42	4	15.38	3.92	4	0.37	0.28	4	37.63	4.33	4	0.42	0.09	4	6.37	0.38	4
Inorganics	Nitrogen, Total Kjeldahl	mg/l	0.4	0.08	4	0.66	0.52	4	0.39	0.03	4	0.56	0.22	4	0.53	0.18	4	0.39	0.04	4
Inorganics	OrthoPhosphate as P	mg/l	0.04	0.01	4	0.15	0.02	4	0.08	0.03	4	0.14	0.01	4	0.2	0.09	4	0.08	0.04	4
Inorganics	Phosphorus as P,Total	mg/l	0.04	0.01	4	0.15	0.03	4	0.08	0.02	4	0.17	0.02	4	0.28	0.09	4	0.09	0.04	4
Inorganics	Selenium,Dissolved	µg/L	7	1	4	3.7	0.4	4	5.9	0.6	4	17.9	2.3	4	10.3	1.1	4	5.1	0.6	4
Inorganics	Sulfate	mg/l	433	80	4	373	62	4	237	32	4	517	73	4	854	118	4	376	49	4
Metals	Aluminum,Dissolved	µg/L	0.7	0.5	4	3.2	3.2	4	2.2	2	4	2.3	0.7	4	1.7	1.4	4	0.6	0.5	4
Metals	Arsenic,Dissolved	µg/L	4.2	0.3	4	4.4	0.3	4	7.2	0.2	4	5.2	0.8	4	4.4	0.6	4	1.8	0.2	4
Metals	Cadmium,Dissolved	µg/L	0.06	0.02	4	0.01	0.01	4	0.06	0.01	4	0.08	0.02	4	0.01	0.01	4	0.04	0.01	4
Metals	Chromium,Dissolved	µg/L	0.61	0.53	4	0.7	0.97	4	0.59	0.53	4	1.15	0.84	4	1.38	1.74	4	2.08	1.68	4
Metals	Copper,Dissolved	µg/L	2.75	0.35	4	5.77	2.21	4	2.29	0.14	4	4.07	0.45	4	3.72	0.44	4	3.19	0.42	4
Metals	Lead,Dissolved	µg/L	0	0	4	0.01	0.02	4	0.02	0.02	4	0.06	0.05	4	0.03	0.02	4	0.02	0.02	4
Metals	Manganese,Dissolved	µg/L	50	19	4	26	12	4	54	35	4	45	53	4	258	42	4	8	7	4
Metals	Nickel,Dissolved	µg/L	2	1.2	4	1.1	0.4	4	1.3	0.6	4	2.9	1.1	4	3.8	1.3	4	1.1	0.5	4
Metals	Silver,Dissolved	µg/L	0	0.01	4	0	0.01	4	--	--	4	0.01	0.01	4	0.01	0.01	4	0	0.01	4
Metals	Zinc,Dissolved	µg/L	1.9	1	4	2	0.6	4	3.7	2.2	4	10.7	3	4	13.1	2.4	4	6	2.5	4
PAHs	Acenaphthene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PAHs	Acenaphthylene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PAHs	Anthracene	µg/L	0.009	0.018	4	0.009	0.018	4	--	--	4	--	--	4	--	--	4	--	--	4
PAHs	Benz(a)anthracene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PAHs	Benzo(a)pyrene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PAHs	Benzo(b)fluoranthene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PAHs	Benzo(e)pyrene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PAHs	Benzo(g,h,i)perylene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PAHs	Benzo(k)fluoranthene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PAHs	Biphenyl	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PAHs	Chrysene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PAHs	Chrysenes, C1 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1	--	--	1	--	--	1
PAHs	Chrysenes, C2 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1	--	--	1	--	--	1
PAHs	Chrysenes, C3 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1	--	--	1	--	--	1
PAHs	Dibenz(a,h)anthracene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PAHs	Dibenzothiophene	µg/L	--	--	1	--	--	1	--	--	1	--	--	1	--	--	1	--	--	1
PAHs	Dibenzothiophenes, C1 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1	--	--	1	--	--	1
PAHs	Dibenzothiophenes, C2 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1	--	--	1	--	--	1
PAHs	Dibenzothiophenes, C3 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1	--	--	1	--	--	1
PAHs	Dimethylnaphthalene, 2,6-	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PAHs	Fluoranthene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PAHs	Fluoranthene/Pyrenes, C1 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1	--	--	1	--	--	1
PAHs	Fluorene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PAHs	Fluorenes, C1 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1	--	--	1	--	--	1
PAHs	Fluorenes, C2 -	µg/L	0.028	--	1	0.027	--	1	0.027	--	1	0.028	--	1	0.029	--	1	0.026	--	1
PAHs	Fluorenes, C3 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1	--	--	1	--	--	1
PAHs	Indeno(1,2,3-c,d)pyrene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PAHs	Methylnaphthalene, 1-	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PAHs	Methylnaphthalene, 2-	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PAHs	Methylphenanthrene, 1-	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PAHs	Naphthalene	µg/L	0.009	0.018	4	0.009	0.018	4	0.009	0.018	4	--	--	4	--	--	4	--	--	4
PAHs	Naphthalenes, C1 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1	--	--	1	--	--	1
PAHs	Naphthalenes, C2 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1	--	--	1	--	--	1
PAHs	Naphthalenes, C3 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1	--	--	1	--	--	1
PAHs	Naphthalenes, C4 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1	--	--	1	--	--	1

Appendix IIa, continued. Means and standard deviations of water chemistry constituents.

			904CBAQH6			904CBBUR1			904CBBVR4			904CBCWC2			904CBENC2			904CBESC5		
Category	Constituent	Units	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n
PAHs	Perylene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PAHs	Phenanthrene	µg/L	0.009	0.018	4	0.009	0.018	4	--	--	4	--	--	4	--	--	4	--	--	4
PAHs	Phenanthrene/Anthracene, C1 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1	--	--	1	--	--	1
PAHs	Phenanthrene/Anthracene, C2 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1	--	--	1	--	--	1
PAHs	Phenanthrene/Anthracene, C3 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1	--	--	1	--	--	1
PAHs	Phenanthrene/Anthracene, C4 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1	--	--	1	--	--	1
PAHs	Pyrene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PAHs	Trimethylnaphthalene, 2,3,5-	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PCBs	PCB 005	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PCBs	PCB 008	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PCBs	PCB 015	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PCBs	PCB 018	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PCBs	PCB 027	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PCBs	PCB 028	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PCBs	PCB 029	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PCBs	PCB 031	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PCBs	PCB 033	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PCBs	PCB 044	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PCBs	PCB 049	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PCBs	PCB 052	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PCBs	PCB 056	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PCBs	PCB 060	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PCBs	PCB 066	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PCBs	PCB 070	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PCBs	PCB 074	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PCBs	PCB 087	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PCBs	PCB 095	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PCBs	PCB 097	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PCBs	PCB 099	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PCBs	PCB 101	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PCBs	PCB 105	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PCBs	PCB 110	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PCBs	PCB 114	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PCBs	PCB 118	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PCBs	PCB 128	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PCBs	PCB 137	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PCBs	PCB 138	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PCBs	PCB 141	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PCBs	PCB 149	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PCBs	PCB 151	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PCBs	PCB 153	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PCBs	PCB 156	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PCBs	PCB 157	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PCBs	PCB 158	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PCBs	PCB 170	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PCBs	PCB 174	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PCBs	PCB 177	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PCBs	PCB 180	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PCBs	PCB 183	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PCBs	PCB 187	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PCBs	PCB 189	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PCBs	PCB 194	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PCBs	PCB 195	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PCBs	PCB 200	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PCBs	PCB 201	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PCBs	PCB 203	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PCBs	PCB 206	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PCBs	PCB 209	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
PCBs	PCBs	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4

Appendix IIa, continued. Means and standard deviations of water chemistry constituents.

			904CBAQH6			904CBBUR1			904CBBVR4			904CBCWC2			904CBENC2			904CBESC5		
Category	Constituent	Units	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n
Pesticides	Aldrin	µg/L	--	--	4	0	0.001	4	--	--	4	--	--	4	--	--	4	0	0.001	4
Pesticides	Ametryn	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	Aspon	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	Atraton	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	Atrazine	µg/L	0.009	0.018	4	--	--	4	0.009	0.018	4	--	--	4	--	--	4	0.009	0.018	4
Pesticides	Azinphos ethyl	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	Azinphos methyl	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	Bolstar	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	Carbophenothion	µg/L	--	--	4	--	--	4	0.01	0.02	4	0.01	0.02	4	--	--	4	--	--	4
Pesticides	Chlordane, cis-	µg/L	--	--	4	0	0.001	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	Chlordane, trans-	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	Chlordene, alpha-	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	Chlordene, gamma-	µg/L	0.002	0.004	4	0	0.001	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	Chlorfenvinphos	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	Chlorpyrifos	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	Chlorpyrifos methyl	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	Ciodrin	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	Coumaphos	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	Dacthal	µg/L	--	--	4	0.001	0.001	4	0	0.001	4	0	0.001	4	0	0.001	4	0	0.001	4
Pesticides	DDD(o,p')	µg/L	--	--	4	0	0.001	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	DDD(p,p')	µg/L	--	--	4	0	0.001	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	DDE(o,p')	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	DDE(p,p')	µg/L	0.001	0.002	4	0.003	0.002	4	0.001	0.002	4	0.001	0.001	4	0.003	0.005	4	0.001	0.002	4
Pesticides	DDMU(p,p')	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	DDT(o,p')	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	DDT(p,p')	µg/L	--	--	4	0.001	0.002	4	--	--	4	0.002	0.002	4	--	--	4	0.001	0.002	4
Pesticides	DDTs	µg/L	0.001	0.002	4	0.005	0.005	4	0.001	0.002	4	0.002	0.002	4	0.003	0.005	4	0.002	0.002	4
Pesticides	Demeton-s	µg/L	0.01	0.02	4	0.01	0.02	4	0.01	0.02	4	--	--	4	--	--	4	--	--	4
Pesticides	Diazinon	µg/L	0.011	0.015	4	0.011	0.007	4	0.067	0.064	4	0.031	0.016	4	0.139	0.175	4	0.107	0.145	4
Pesticides	Dichlofenthion	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	Dichlorvos	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	Dicrotophos	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	Dieldrin	µg/L	--	--	4	0	0.001	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	Dimethoate	µg/L	0.01	0.02	4	0.01	0.02	4	--	--	4	0.01	0.02	4	0.01	0.02	4	0.01	0.02	4
Pesticides	Dioxathion	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	0.01	0.02	4	0.01	0.02	4
Pesticides	Disulfoton	µg/L	0.015	0.017	4	0.008	0.015	4	0.023	0.015	4	0.023	0.015	4	0.071	0.05	4	0.023	0.015	4
Pesticides	Endosulfan I	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	0	0.001	4	--	--	4
Pesticides	Endosulfan II	µg/L	--	--	4	--	--	4	0.001	0.001	4	--	--	4	0	0.001	4	0.001	0.002	4
Pesticides	Endosulfan sulfate	µg/L	--	--	4	--	--	4	--	--	4	0	0.001	4	--	--	4	--	--	4
Pesticides	Endrin	µg/L	--	--	4	0.001	0.001	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	Endrin Aldehyde	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	0.002	0.004	4	--	--	4
Pesticides	Endrin Ketone	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	Ethion	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	Ethoprop	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	Famphur	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	Fenchlorphos	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	Fenitrothion	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	Fensulfothion	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	Fenthion	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	Fonofos	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	HCH, alpha	µg/L	0	0.001	4	0	0.001	4	0	0.001	4	0.001	0.001	4	--	--	4	0	0.001	4
Pesticides	HCH, beta	µg/L	--	--	4	--	--	4	0	0.001	4	--	--	4	--	--	4	0.004	0.008	4
Pesticides	HCH, delta	µg/L	0	0.001	4	0	0.001	4	--	--	4	0	0.001	4	--	--	4	0.001	0.001	4
Pesticides	HCH, gamma	µg/L	--	--	4	--	--	4	0.001	0.001	4	--	--	4	--	--	4	--	--	4
Pesticides	Heptachlor	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	Heptachlor epoxide	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	Hexachlorobenzene	µg/L	--	--	4	0	0	4	0	0	4	--	--	4	--	--	4	0	0	4

Appendix IIa, continued. Means and standard deviations of water chemistry constituents.

			904CBAQH6			904CBBUR1			904CBBVR4			904CBCWC2			904CBENC2			904CBESC5		
Category	Constituent	Units	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n
Pesticides	Leptophos	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	Malathion	µg/L	--	--	4	--	--	4	--	--	4	0.009	0.019	4	--	--	4	--	--	4
Pesticides	Merphos	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	Methidathion	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	0.01	0.02	4	--	--	4
Pesticides	Methoxychlor	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	Mevinphos	µg/L	0.01	0.02	4	0.01	0.02	4	0.01	0.02	4	--	--	4	--	--	4	--	--	4
Pesticides	Mirex	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	Molinate	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	Naled	µg/L	0.01	0.02	4	0.01	0.02	4	0.01	0.02	4	--	--	4	--	--	4	--	--	4
Pesticides	Nonachlor, cis-	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	Nonachlor, trans-	µg/L	--	--	4	0	0.001	4	--	--	4	0	0.001	4	--	--	4	--	--	4
Pesticides	Oxadiazon	µg/L	0.003	0.003	4	0.005	0.003	4	0.005	0.005	4	0.484	0.918	4	0.063	0.059	4	0.013	0.01	4
Pesticides	Oxychlordane	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	Parathion, Ethyl	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	Parathion, Methyl	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	Phorate	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	Phosmet	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	Phosphamidon	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	Prometon	µg/L	--	--	4	--	--	4	0.009	0.018	4	--	--	4	0.01	0.019	4	--	--	4
Pesticides	Prometryn	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	Propazine	µg/L	--	--	4	0.009	0.018	4	0.009	0.018	4	0.009	0.018	4	--	--	4	0.009	0.018	4
Pesticides	Secbumeton	µg/L	0.009	0.018	4	0.009	0.018	4	0.05	0.1	4	0.009	0.018	4	0.071	0.12	4	0.067	0.082	4
Pesticides	Simazine	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	Simetryn	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	Sulfotep	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	Tedion	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	Terbufos	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	Terbuthylazine	µg/L	0.076	0.09	4	0.009	0.018	4	0.134	0.156	4	0.009	0.018	4	0.684	0.685	4	0.056	0.089	4
Pesticides	Terbutryn	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	Tetrachlorvinphos	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	0.01	0.02	4
Pesticides	Thiobencarb	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	Thionazin	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	Tokuthion	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	Trichlorfon	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
Pesticides	Trichloronate	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4
Physical	Fine-ASTM	%	12.2	8.1	3	22.3	17.8	3	55.4	23	3	8.1	12.6	3	3.8	3.3	3	0.9	0.9	3
Physical	Fine-ASTM,Passing No. 200 Sieve	%	3.4	--	1	16.2	--	1	20.8	--	1	53.7	--	1	2.8	--	1	18.5	--	1
Physical	Oxygen, Saturation	%	101	9	4	96	8	4	135	54	4	101	17	4	79	9	4	118	21	4
Physical	pH	pH	7.8	0.3	4	7.6	0.7	4	8.4	0.3	4	8	0.7	4	7.9	0.7	4	8.1	0.8	4
Physical	Specific conductivity	mS/cm	2823	133	4	1839	152	4	2278	72	4	4691	159	4	4072	516	4	1889	62	4
Physical	Temperature	ºC	17.3	2.9	4	17.7	1.7	4	20.8	3.2	4	20	1.1	4	15.7	2	4	17.3	4.2	4
Physical	Total Organic Carbon	mg/L																		
Physical	Turbidity	NTU	0.8	0.5	4	1.4	1.5	4	2.3	1.2	4	2.6	2	4	5.6	1.3	4	1.1	0.9	4
Physical	Velocity	ft/s	1	0.7	4	0.6	0.9	4	0.5	1	4	0.6	0.5	4	0.1	0.1	4	0.9	0.6	4

Appendix IIa, continued. Means and standard deviations of water chemistry constituents.

			904CBESC8			904CBLAC3			904CBSAM3			904CBSAM6			Entire watershed		
Category	Constituent	Units	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n
Inorganics	Alkalinity as CaCO3	mg/l	265	18	4	309	15	4	246	26	4	225	16	4	252	42	10
Inorganics	Ammonia as N	mg/l	0.07	0	4	0.16	0.15	4	0.12	0.1	4	0.14	0.07	4	0.13	0.04	10
Inorganics	Nitrate + Nitrite as N	mg/l	1.96	0.86	4	0.13	0.04	4	0.5	0.37	4	0.27	0.04	4	6.41	11.96	10
Inorganics	Nitrogen, Total Kjeldahl	mg/l	0.45	0.09	4	0.43	0.07	4	0.43	0.12	4	0.69	0.09	4	0.49	0.11	10
Inorganics	OrthoPhosphate as P	mg/l	0.11	0.02	4	0.03	0.01	4	0.14	0.05	4	0.2	0.02	4	0.12	0.06	10
Inorganics	Phosphorus as P,Total	mg/l	0.14	0.02	4	0.03	0.02	4	0.19	0.13	4	0.26	0.02	4	0.14	0.08	10
Inorganics	Selenium,Dissolved	µg/L	5.5	0.3	4	12.2	1.8	4	14.3	16.5	4	24.2	22.8	4	10.6	6.6	10
Inorganics	Sulfate	mg/l	433	73	4	221	28	4	312	70	4	941	517	4	470	243	10
Metals	Aluminum,Dissolved	µg/L	12	14	4	2	2.6	4	6.6	6.3	4	4.5	4.9	4	3.6	3.5	10
Metals	Arsenic,Dissolved	µg/L	2.1	0.1	4	5.4	0.7	4	5.4	4.7	4	7.4	4.7	4	4.7	1.8	10
Metals	Cadmium,Dissolved	µg/L	0.05	0.01	4	0.01	0.01	4	0.05	0.02	4	0.05	0.05	4	0.04	0.02	10
Metals	Chromium,Dissolved	µg/L	1.48	1.58	4	0.75	0.65	4	0.82	0.71	4	1.17	0.71	4	1.07	0.48	10
Metals	Copper,Dissolved	µg/L	3	0.42	4	2.12	0.39	4	3.17	0.19	4	5.31	2.54	4	3.54	1.21	10
Metals	Lead,Dissolved	µg/L	0.01	0.02	4	0	0.01	4	0.03	0.03	4	0.14	0.24	4	0.03	0.04	10
Metals	Manganese,Dissolved	µg/L	137	37	4	120	63	4	175	221	4	381	238	4	125	119	10
Metals	Nickel,Dissolved	µg/L	1.4	0.6	4	2.5	1.5	4	2	0.7	4	2.6	1.3	4	2.1	0.9	10
Metals	Silver,Dissolved	µg/L	--	--	4	--	--	4	0	0.01	4	0.01	0.01	4	0	0	10
Metals	Zinc,Dissolved	µg/L	2.8	0.4	4	1.2	0.8	4	7.7	4.8	4	16.1	12.5	4	6.5	5.2	10
PAHs	Acenaphthene	µg/L	--	--	4	--	--	4	--	--	4	0.009	0.018	4	0.001	0.003	10
PAHs	Acenaphthylene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PAHs	Anthracene	µg/L	--	--	4	--	--	4	--	--	4	0.02	0.04	4	0.004	0.007	10
PAHs	Benz(a)anthracene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PAHs	Benzo(a)pyrene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PAHs	Benzo(b)fluoranthene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PAHs	Benzo(e)pyrene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PAHs	Benzo(g,h,i)perylene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PAHs	Benzo(k)fluoranthene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PAHs	Biphenyl	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PAHs	Chrysene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PAHs	Chrysenes, C1 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1	--	--	10
PAHs	Chrysenes, C2 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1	--	--	10
PAHs	Chrysenes, C3 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1	--	--	10
PAHs	Dibenz(a,h)anthracene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PAHs	Dibenzothiophene	µg/L	--	--	1	--	--	1	--	--	1	--	--	1	--	--	10
PAHs	Dibenzothiophenes, C1 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1	--	--	10
PAHs	Dibenzothiophenes, C2 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1	--	--	10
PAHs	Dibenzothiophenes, C3 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1	--	--	10
PAHs	Dimethylnaphthalene, 2,6-	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PAHs	Fluoranthene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PAHs	Fluoranthene/Pyrenes, C1 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1	--	--	10
PAHs	Fluorene	µg/L	--	--	4	--	--	4	--	--	4	0.006	0.013	4	0.001	0.002	10
PAHs	Fluorenes, C1 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1	--	--	10
PAHs	Fluorenes, C2 -	µg/L	0.044	--	1	0.026	--	1	0.028	--	1	0.026	--	1	0.029	0.005	10
PAHs	Fluorenes, C3 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1	--	--	10
PAHs	Indeno(1,2,3-c,d)pyrene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PAHs	Methylnaphthalene, 1-	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PAHs	Methylnaphthalene, 2-	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PAHs	Methylphenanthrene, 1-	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PAHs	Naphthalene	µg/L	--	--	4	--	--	4	--	--	4	0.018	0.02	4	0.004	0.006	10
PAHs	Naphthalenes, C1 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1	--	--	10
PAHs	Naphthalenes, C2 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1	--	--	10
PAHs	Naphthalenes, C3 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1	--	--	10
PAHs	Naphthalenes, C4 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1	--	--	10

Appendix IIa, continued. Means and standard deviations of water chemistry constituents.

			904CBESC8			904CBLAC3			904CBSAM3			904CBSAM6			Entire watershed		
Category	Constituent	Units	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n
PAHs	Perylene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PAHs	Phenanthrene	µg/L	--	--	4	--	--	4	--	--	4	0.02	0.04	4	0.004	0.007	10
PAHs	Phenanthrene/Anthracene, C1 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1	--	--	10
PAHs	Phenanthrene/Anthracene, C2 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1	--	--	10
PAHs	Phenanthrene/Anthracene, C3 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1	--	--	10
PAHs	Phenanthrene/Anthracene, C4 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1	--	--	10
PAHs	Pyrene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PAHs	Trimethylnaphthalene, 2,3,5-	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PCBs	PCB 005	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PCBs	PCB 008	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PCBs	PCB 015	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PCBs	PCB 018	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PCBs	PCB 027	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PCBs	PCB 028	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PCBs	PCB 029	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PCBs	PCB 031	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PCBs	PCB 033	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PCBs	PCB 044	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PCBs	PCB 049	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PCBs	PCB 052	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PCBs	PCB 056	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PCBs	PCB 060	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PCBs	PCB 066	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PCBs	PCB 070	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PCBs	PCB 074	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PCBs	PCB 087	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PCBs	PCB 095	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PCBs	PCB 097	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PCBs	PCB 099	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PCBs	PCB 101	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PCBs	PCB 105	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PCBs	PCB 110	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PCBs	PCB 114	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PCBs	PCB 118	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PCBs	PCB 128	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PCBs	PCB 137	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PCBs	PCB 138	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PCBs	PCB 141	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PCBs	PCB 149	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PCBs	PCB 151	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PCBs	PCB 153	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PCBs	PCB 156	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PCBs	PCB 157	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PCBs	PCB 158	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PCBs	PCB 170	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PCBs	PCB 174	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PCBs	PCB 177	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PCBs	PCB 180	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PCBs	PCB 183	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PCBs	PCB 187	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PCBs	PCB 189	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PCBs	PCB 194	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PCBs	PCB 195	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PCBs	PCB 200	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PCBs	PCB 201	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PCBs	PCB 203	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PCBs	PCB 206	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PCBs	PCB 209	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PCBs	PCBs	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10

Appendix IIa, continued. Means and standard deviations of water chemistry constituents.

			904CBESC8			904CBLAC3			904CBSAM3			904CBSAM6			Entire watershed		
Category	Constituent	Units	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n
Pesticides	Aldrin	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	0	0	10
Pesticides	Ametryn	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
Pesticides	Aspon	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
Pesticides	Atraton	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
Pesticides	Atrazine	µg/L	0.009	0.018	4	0.025	0.05	4	0.041	0.061	4	0.018	0.02	4	0.012	0.013	10
Pesticides	Azinphos ethyl	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
Pesticides	Azinphos methyl	µg/L	--	--	4	0.01	0.02	4	--	--	4	--	--	4	0.001	0.003	10
Pesticides	Bolstar	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
Pesticides	Carbophenothion	µg/L	--	--	4	0.01	0.02	4	0.01	0.02	4	--	--	4	0.004	0.005	10
Pesticides	Chlordane, cis-	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	0	0	10
Pesticides	Chlordane, trans-	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
Pesticides	Chlordene, alpha-	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
Pesticides	Chlordene, gamma-	µg/L	0.002	0.003	4	--	--	4	--	--	4	--	--	4	0	0.001	10
Pesticides	Chlorfenvinphos	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
Pesticides	Chlorpyrifos	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
Pesticides	Chlorpyrifos methyl	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
Pesticides	Ciodrin	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
Pesticides	Coumaphos	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
Pesticides	Dacthal	µg/L	0	0.001	4	--	--	4	0	0.001	4	--	--	4	0	0	10
Pesticides	DDD(o,p')	µg/L	--	--	4	--	--	4	0.001	0.001	4	--	--	4	0	0	10
Pesticides	DDD(p,p')	µg/L	0	0.001	4	--	--	4	--	--	4	--	--	4	0	0	10
Pesticides	DDE(o,p')	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
Pesticides	DDE(p,p')	µg/L	0.001	0.001	4	0.001	0.003	4	0.003	0.003	4	0.001	0.001	4	0.001	0.001	10
Pesticides	DDMU(p,p')	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
Pesticides	DDT(o,p')	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
Pesticides	DDT(p,p')	µg/L	0.001	0.002	4	--	--	4	0.001	0.002	4	--	--	4	0	0.001	10
Pesticides	DDTs	µg/L	0.002	0.001	4	0.001	0.003	4	0.004	0.004	4	0.001	0.001	4	0.002	0.001	10
Pesticides	Demeton-s	µg/L	--	--	4	0.01	0.02	4	0.01	0.02	4	--	--	4	0.005	0.005	10
Pesticides	Diazinon	µg/L	0.079	0.1	4	0.033	0.027	4	0.172	0.172	4	0.035	0.017	4	0.068	0.055	10
Pesticides	Dichlofenthion	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
Pesticides	Dichlorvos	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
Pesticides	Dicrotophos	µg/L	--	--	4	--	--	4	0.01	0.02	4	--	--	4	0.001	0.003	10
Pesticides	Dieldrin	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	0	0	10
Pesticides	Dimethoate	µg/L	0.01	0.02	4	--	--	4	--	--	4	--	--	4	0.006	0.005	10
Pesticides	Dioxathion	µg/L	0.01	0.02	4	--	--	4	--	--	4	0.01	0.02	4	0.004	0.005	10
Pesticides	Disulfoton	µg/L	0.023	0.015	4	0.073	0.069	4	0.044	0.059	4	0.033	0.03	4	0.033	0.022	10
Pesticides	Endosulfan I	µg/L	--	--	4	0	0.001	4	--	--	4	--	--	4	0	0	10
Pesticides	Endosulfan II	µg/L	0.001	0.002	4	--	--	4	--	--	4	0.002	0.003	4	0	0.001	10
Pesticides	Endosulfan sulfate	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	0	0	10
Pesticides	Endrin	µg/L	--	--	4	--	--	4	0	0.001	4	--	--	4	0	0	10
Pesticides	Endrin Aldehyde	µg/L	--	--	4	0.001	0.002	4	0.002	0.004	4	0.001	0.002	4	0.001	0.001	10
Pesticides	Endrin Ketone	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
Pesticides	Ethion	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
Pesticides	Ethoprop	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
Pesticides	Famphur	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
Pesticides	Fenchlorphos	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
Pesticides	Fenitrothion	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
Pesticides	Fensulfothion	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
Pesticides	Fenthion	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
Pesticides	Fonofos	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
Pesticides	HCH, alpha	µg/L	--	--	4	0	0.001	4	--	--	4	0.001	0.003	4	0	0	10
Pesticides	HCH, beta	µg/L	--	--	4	0	0.001	4	--	--	4	--	--	4	0	0.001	10
Pesticides	HCH, delta	µg/L	--	--	4	0	0.001	4	--	--	4	--	--	4	0	0	10
Pesticides	HCH, gamma	µg/L	--	--	4	0	0.001	4	--	--	4	--	--	4	0	0	10
Pesticides	Heptachlor	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
Pesticides	Heptachlor epoxide	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
Pesticides	Hexachlorobenzene	µg/L	--	--	4	--	--	4	0	0	4	0	0	4	0	0	10

Appendix IIa, continued. Means and standard deviations of water chemistry constituents.

			904CBESC8			904CBLAC3			904CBSAM3			904CBSAM6			Entire watershed		
Category	Constituent	Units	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n
Pesticides	Leptophos	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
Pesticides	Malathion	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	0.001	0.003	10
Pesticides	Merphos	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
Pesticides	Methidathion	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	0.001	0.003	10
Pesticides	Methoxychlor	µg/L	--	--	4	--	--	4	--	--	4	0	0.001	4	0	0	10
Pesticides	Mevinphos	µg/L	--	--	4	0.01	0.02	4	0.01	0.02	4	--	--	4	0.005	0.005	10
Pesticides	Mirex	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
Pesticides	Molinate	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
Pesticides	Naled	µg/L	--	--	4	0.01	0.02	4	0.01	0.02	4	--	--	4	0.005	0.005	10
Pesticides	Nonachlor, cis-	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
Pesticides	Nonachlor, trans-	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	0	0	10
Pesticides	Oxadiazon	µg/L	0.011	0.008	4	0.004	0.005	4	0.05	0.049	4	0.01	0.008	4	0.065	0.149	10
Pesticides	Oxychlordane	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
Pesticides	Parathion, Ethyl	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
Pesticides	Parathion, Methyl	µg/L	--	--	4	--	--	4	0.008	0.015	4	--	--	4	0.001	0.002	10
Pesticides	Phorate	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
Pesticides	Phosmet	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
Pesticides	Phosphamidon	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
Pesticides	Prometon	µg/L	0.006	0.011	4	0.048	0.047	4	--	--	4	--	--	4	0.007	0.015	10
Pesticides	Prometryn	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
Pesticides	Propazine	µg/L	0.009	0.018	4	0.009	0.018	4	0.009	0.018	4	0.009	0.018	4	0.007	0.004	10
Pesticides	Secbumeton	µg/L	0.065	0.075	4	0.116	0.21	4	0.338	0.311	4	0.117	0.119	4	0.085	0.098	10
Pesticides	Simazine	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
Pesticides	Simetryn	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
Pesticides	Sulfotep	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
Pesticides	Tedion	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
Pesticides	Terbufos	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
Pesticides	Terbuthylazine	µg/L	0.084	0.078	4	0.153	0.305	4	0.856	1.118	4	0.365	0.423	4	0.242	0.299	10
Pesticides	Terbutryn	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
Pesticides	Tetrachlorvinphos	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	0.001	0.003	10
Pesticides	Thiobencarb	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
Pesticides	Thionazin	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
Pesticides	Tokuthion	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
Pesticides	Trichlorfon	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
Pesticides	Trichloronate	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
Physical	Fine-ASTM	%	40.8	30.5	3	8.3	3.8	3	15.6	6.1	3	76.3	7.9	3	24.4	25.1	10
Physical	Fine-ASTM,Passing No. 200 Sieve	%	30.5	--	1	4.8	--	1	42.9	--	1	55.3	--	1	24.9	20	10
Physical	Oxygen, Saturation	%	84	14	4	144	31	4	95	2	4	71	43	4	102	23	10
Physical	pH	pH	9.1	2.2	3	8.3	1.1	4	8	0.4	4	7.7	0.1	4	8.1	0.4	10
Physical	Specific conductivity	mS/cm	2204	151	4	4415	332	4	2219	371	4	11570	11354	4	3800	2933	10
Physical	Temperature	ºC	16.9	1.9	4	20.2	3.2	4	18.3	1.5	4	21.2	3.7	4	18.5	1.9	10
Physical	Turbidity	NTU	0.8	0.5	4	1.4	1.5	4	2.3	1.2	4	2.6	2	4	5.6	1.3	4
Physical	Velocity	ft/s	1	0.7	4	0.6	0.9	4	0.5	1	4	0.6	0.5	4	0.1	0.1	4

Appendix II, continued. Means and standard deviations of water chemistry constituents.
B. Non-SWAMP sites.

	Dissolved Oxygen (mg/l)			pH			Specific Conductance (mS/cm)			Turbidity (NTU)			Water Temperature (C)		
Site	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n
Site 1	10.3	2.1	7	8.1	0.3	7	2.6	0.2	7	7.2		1	20.9	4.3	7
Site 3	18.2		1	8.5		1	1.8		1			0	19.0		1
Site 5	10.1	1.7	7	8.5	0.2	7	1.9	0.1	7	7.3		1	18.3	1.6	7
Site 7	10.5	3.4	7	8.3	0.2	7	1.9	0.1	7	8.1		1	20.2	4.4	7
Site 8	8.5		1	7.9		1	2.0		1			0	16.2		1
Site 9	11.1		1	7.8		1	4.3		1			0	18.1		1
Site 11	9.5		1	7.6		1	4.1		1			0	16.0		1
Site 12	9.7	2.3	2	8.0	0.4	2	3.2	0.1	2			0	15.3	1.6	2
Site 14	7.2		1	7.8		1	1.7		1			0	15.5		1
Site 15	9.4		1	7.9		1	1.8		1			0	16.3		1
Site 16	7.1		1	7.7		1	1.5		1			0	15.7		1
Site 17	8.1	1.3	7	7.7	0.2	7	2.1	0.4	7	14.7		1	17.4	1.9	7
Site 18	8.2	2.3	3	8.1	0.5	3	1.8	0.4	3			0	17.7	1.5	3
Site 19	8.2		1	7.4		1	4.7		1			0	15.1		1
Site 20	10.5		1	8.0		1	1.7		1			0	17.0		1
Site 21	12.4		1	8.2		1	1.6		1			0	16.6		1
Site 22	11.6	5.7	3	8.0	0.5	3	1.6	0.5	3			0	17.2	2.3	3

APPENDIX III

Results from toxicity assays for each endpoint at each site in the watershed. Mean = mean percent control. SD = standard deviation.

	C. dubia						*H. azteca*						*S. capricornutum*		
	Survival			Young / female			Survival			Growth			Total cell count		
Site	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n
904CBAQH6	109	12	4	65	8	4	80	38	4	119	28	4	49	7	4
904CBBUR1	106	7	4	84	16	4	90	21	4	125	61	4	88	26	4
904CBBVR4	106	7	4	88	18	4	29	24	4	83	46	4	72	10	4
904CBCWC2	113	14	4	57	36	4	36	27	4	102	56	4	71	34	4
904CBENC2	79	55	4	80	46	3	91	10	4	94	52	4	90	11	4
904CBESC5	95	45	4	121	50	4	93	11	4	115	44	4	97	14	4
904CBESC8	105	23	4	139	42	4	90	9	4	144	79	4	94	14	4
904CBLAC3	83	16	4	68	47	4	91	18	4	162	91	4	20	6	4
904CBSAM3	84	56	4	115	27	3	44	34	4	121	26	4	83	22	4
904CBSAM6	71	62	3	23	12	2	40	32	4	145	112	4	35	4	4
Mean of all sites	96	34	39	87	43	36	66	34	40	116	65	40	70	30	40

APPENDIX IV

Concentrations of metals, PCBs, and pesticides in each replicate fish collected from two sites in the Carlsbad HU. -- = Constituent not detected. Blank cells indicate that the constituent concentration was not analyzed. No constituent exceeded OEHHA standards.

		OEHHA	904CBAQH6		904CBSAM6		
Category	Constituent	Treshold	Bullhead	Crayfish	Bullhead	Crayfish	Red-ear sunfish
Metals	Ag (ppm)		--			0.22	--
Metals	Al (ppm)		0.59			300.3	--
Metals	As (ppm)		0.03			1.12	--
Metals	Cd (ppm)		--			0.13	--
Metals	Cr (ppm)		0.1			0.72	0.09
Metals	Cu (ppm)		0.18			91.11	0.25
Metals	Hg (ppm)		0.385				1.96
Metals	Mn (ppm)		0.1			529	0.2
Metals	Ni (ppm)		--				--
Metals	Pb (ppm)		--			0.21	--
Inorganics	Se (ppm)	1.94	0.17			1.53	0.37
Metals	Zn (ppm)		3.6			63.1	4.8
Pesticides	Aldrin (ng/g)		--			--	
Pesticides	Chlordane (ng/g)	200	--			--	
Pesticides	Chlordane, cis (ng/g)		--			--	
Pesticides	Chlordane, trans (ng/g)		--			--	
Pesticides	Chlordene, alpha (ng/g)		--			--	
Pesticides	Chlordene, gamma (ng/g)		--			--	
Pesticides	Chlorpyrifos (ng/g)		--			--	
Pesticides	Dacthal (ng/g)		--			--	
Pesticides	DCBP(p,p') (ng/g)		--			--	
Pesticides	DDD(o,p') (ng/g)		--			--	
Pesticides	DDD(p,p') (ng/g)		1.5			--	
Pesticides	DDE(o,p') (ng/g)		--			--	
Pesticides	DDE(p,p') (ng/g)		21.4			1.1	
Pesticides	DDMU(p,p') (ng/g)		--			--	
Pesticides	DDT(o,p') (ng/g)		--			--	
Pesticides	DDT(p,p') (ng/g)		--			--	
Pesticides	DDTs (ng/g)	560	22.9			1.1	
Pesticides	Diazinon (ng/g)		--			--	
Pesticides	Dieldrin (ng/g)	16	--			--	
Pesticides	Endosulfan I (ng/g)		--			--	
Pesticides	Endosulfan II (ng/g)		--			--	
Pesticides	Endosulfan sulfate (ng/g)		--			--	
Pesticides	Endrin (ng/g)		--			--	
Pesticides	HCH, alpha (ng/g)		--			--	
Pesticides	HCH, beta (ng/g)		--			--	
Pesticides	HCH, delta (ng/g)		--			--	
Pesticides	HCH, gamma (ng/g)		--			--	
Pesticides	Heptachlor (ng/g)		--			--	
Pesticides	Heptachlor epoxide (ng/g)		--			--	
Pesticides	Hexachlorobenzene (ng/g)		--			--	
Pesticides	Methoxychlor (ng/g)		--			--	
Pesticides	Mirex (ng/g)		--			--	
Pesticides	Nonachlor, cis (ng/g)		--			--	
Pesticides	Nonachlor, trans (ng/g)		1.43			1.35	
Pesticides	Oxadiazon (ng/g)		--			--	
Pesticides	Oxychlordane (ng/g)		--			--	
Pesticides	Parathion, Ethyl (ng/g)		--			--	
Pesticides	Parathion, Methyl (ng/g)		--			--	
Pesticides	Tedion (ng/g)		--			--	
Pesticides	Toxaphene (ng/g)	220	--			--	
Other	Lipid (%)		0.4	0.4	1.7	1.7	

Appendix IV. Concentrations of metals, PCBs, and pesticides in fish tissues.

		OEHHA	904CBAQH6		904CBSAM6		
Category	Constituent	Treshold	Bullhead	Crayfish	Bullhead	Crayfish	Red-ear sunfish
PCBs	PCB 008 (ng/g)			--	--		
PCBs	PCB 018 (ng/g)			--	--		
PCBs	PCB 027 (ng/g)			--	--		
PCBs	PCB 028 (ng/g)			--	--		
PCBs	PCB 029 (ng/g)			--	--		
PCBs	PCB 031 (ng/g)			--	--		
PCBs	PCB 033 (ng/g)			--	--		
PCBs	PCB 044 (ng/g)			--	--		
PCBs	PCB 049 (ng/g)			--	--		
PCBs	PCB 052 (ng/g)			0.187	0.235		
PCBs	PCB 056 (ng/g)			--	--		
PCBs	PCB 060 (ng/g)			--	--		
PCBs	PCB 066 (ng/g)			0.23	0.425		
PCBs	PCB 070 (ng/g)			--	0.153		
PCBs	PCB 074 (ng/g)			--	--		
PCBs	PCB 087 (ng/g)			0.13	--		
PCBs	PCB 095 (ng/g)			0.124	0.13		
PCBs	PCB 097 (ng/g)			--	--		
PCBs	PCB 099 (ng/g)			--	--		
PCBs	PCB 101 (ng/g)			0.208	0.29		
PCBs	PCB 105 (ng/g)			0.102	0.146		
PCBs	PCB 110 (ng/g)			0.171	0.225		
PCBs	PCB 114 (ng/g)			--	--		
PCBs	PCB 118 (ng/g)			0.175	0.274		
PCBs	PCB 128 (ng/g)			--	--		
PCBs	PCB 137 (ng/g)			--	--		
PCBs	PCB 138 (ng/g)			0.36	0.285		
PCBs	PCB 141 (ng/g)			--	--		
PCBs	PCB 149 (ng/g)			0.189	0.155		
PCBs	PCB 151 (ng/g)			--	--		
PCBs	PCB 153 (ng/g)			0.294	0.196		
PCBs	PCB 156 (ng/g)			--	--		
PCBs	PCB 157 (ng/g)			0.297	--		
PCBs	PCB 158 (ng/g)			--	--		
PCBs	PCB 170 (ng/g)			--	--		
PCBs	PCB 174 (ng/g)			--	--		
PCBs	PCB 177 (ng/g)			--	--		
PCBs	PCB 180 (ng/g)			0.13	--		
PCBs	PCB 183 (ng/g)			--	--		
PCBs	PCB 187 (ng/g)			0.19	--		
PCBs	PCB 189 (ng/g)			--	--		
PCBs	PCB 194 (ng/g)			--	--		
PCBs	PCB 195 (ng/g)			--	--		
PCBs	PCB 200 (ng/g)			--	--		
PCBs	PCB 201 (ng/g)			--	--		
PCBs	PCB 203 (ng/g)			--	--		
PCBs	PCB 206 (ng/g)			--	--		
PCBs	PCB 209 (ng/g)			--	--		
PCBs	PCBs	20		2.79	2.51		

APPENDIX V

Mean IBI and metric scores for bioassessment sites in the Carlsbad HU. Note that the number listed under IBI is the mean IBI for each site, and not the IBI calculated from the mean metric values.

				IBI		Coleoptera taxa		EPT taxa		Predator taxa		% Collectors		% Intolerant		% Non-insect taxa		% Tolerant taxa	
Site	Season	n	Years	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1	Average	15	1998-2005	15	4	1.33	0	1.28	0.39	2.25	0.82	3.81	3.81	0	0	0.58	0.12	1.14	0.9
1	Fall	6	1998-2004	18	7	1.33	0.82	1	1.67	2.83	2.14	6.5	2.26	0	0	0.5	0.84	0.5	0.84
1	Spring	9	1998-2005	12	9	1.33	0.71	1.56	1.67	1.67	1.66	1.11	1.76	0	0	0.67	0.87	1.78	1.56
2	Spring	2	1998-1998	14	2	0	0	0	0	0	0	8	1.41	0	0	0	0	2	2.83
3	Average	5	1998-2002	16	4	1.5	0.71	1.25	1.06	1.25	0.35	2.25	1.06	0	0	2	0	2.63	0.53
3	Fall	1	1999-1999	19		2		2		1		3		0		2		3	
3	Spring	4	1998-2002	13	10	1	0	0.5	1	1.5	3	1.5	1.73	0	0	2	1.41	2.25	3.3
4	Average	7	1998-2000	6	1	0.58	0.12	0.83	0.24	0.42	0.12	1.75	0.35	0	0	0.13	0.18	0.5	0.71
4	Fall	3	1998-2000	5	3	0.67	0.58	0.67	1.15	0.33	0.58	2	1	0	0	0	0	0	0
4	Spring	4	1998-2000	7	8	0.5	0.58	1	2	0.5	1	1.5	1.73	0	0	0.25	0.5	1	1.15
5	Average	15	1998-2005	21	1	2.75	0.07	0.4	0.57	0.9	0.14	2.2	0.57	0	0	3.3	0.42	4.9	0.14
5	Fall	5	1998-2004	20	5	2.8	0.45	0.8	1.79	0.8	0.84	1.8	0.45	0	0	3	1	4.8	1.79
5	Spring	10	1998-2005	21	6	2.7	0.67	0	0	1	1.49	2.6	3.34	0	0	3.6	1.96	5	2.58
6	Fall	1	2000-2000	31		4		0		0		3		4		5		6	
7	Average	12	1998-2005	11	2	0.9	0.14	1.64	0.51	0.8	0.28	1.96	0.34	0	0	1.43	0.81	1.27	0.18
7	Fall	5	1998-2004	13	6	0.8	0.45	2	2	0.6	0.55	2.2	1.92	0	0	2	1.22	1.4	1.14
7	Spring	7	1998-2005	10	6	1	0	1.29	1.89	1	1.53	1.71	1.6	0	0	0.86	0.9	1.14	1.07
8	Spring	2	1998-2002	4	4	0	0	0	0	0	0	0.5	0.71	0	0	0	0	2	2.83
9	Average	7	1998-2002	7	0	0.45	0.07	0	0	1.5	0.71	1.15	0.49	0	0	0	0	1.7	0.99
9	Fall	2	1998-1999	7	2	0.5	0.71	0	0	2	1.41	1.5	0.71	0	0	0	0	1	0
9	Spring	5	1998-2002	7	4	0.4	0.55	0	0	1	1.41	0.8	1.3	0	0	0	0	2.4	2.7
10	Spring	1	2000-2000	7		0		0		2		3		0		0		0	
11	Average	6	1998-2002	10	0	0.13	0.18	0.25	0.35	0.88	0.18	4.63	1.94	0	0	0.38	0.53	0.75	1.06
11	Fall	2	1998-1999	10	6	0	0	0	0	1	1.41	6	2.83	0	0	0	0	0	0
11	Spring	4	1998-2002	10	10	0.25	0.5	0.5	1	0.75	1.5	3.25	4.27	0	0	0.75	0.5	1.5	1.29
12	Average	8	1998-2002	12	3	0.3	0.42	0.4	0.57	1.27	0.09	2.17	0.24	0	0	1.63	1.37	2.67	0.47
12	Fall	3	1998-2002	10	4	0	0	0	0	1.33	0.58	2.33	1.53	0	0	0.67	1.15	2.33	1.53
12	Spring	5	1998-2002	15	9	0.6	0.55	0.8	1.1	1.2	1.64	2	2.55	0	0	2.6	1.82	3	3
13	Average	7	1998-2000	16	1	1.42	0.12	0.25	0.35	2.83	0.24	4.21	0.65	0	0	0.54	0.29	1.96	0.41
13	Fall	3	1998-2000	15	4	1.33	0.58	0	0	2.67	1.15	4.67	2.08	0	0	0.33	0.58	1.67	1.53
13	Spring	4	1998-2000	17	10	1.5	0.58	0.5	1	3	4.24	3.75	4.5	0	0	0.75	0.96	2.25	2.06
14	Average	8	1998-2002	10	1	1.27	0.09	0	0	2.03	0.9	2	1.41	0	0	0.3	0.42	1.1	1.56
14	Fall	3	1998-2000	10	3	1.33	0.58	0	0	2.67	1.53	3	1	0	0	0	0	0	0
14	Spring	5	1998-2002	9	6	1.2	0.45	0	0	1.4	1.95	1	1.73	0	0	0.6	0.89	2.2	1.64
15	Average	7	1998-2002	12	1	1.42	0.12	0.25	0.35	2.13	1.24	2.08	0.59	0	0	0.54	0.29	2.21	0.77
15	Fall	3	1998-2000	11	4	1.33	0.58	0	0	3	2.65	1.67	1.15	0	0	0.33	0.58	1.67	1.53
15	Spring	4	1998-2002	13	5	1.5	0.58	0.5	1	1.25	1.89	2.5	3.11	0	0	0.75	1.5	2.75	3.1
16	Average	5	1998-2002	16	6	1.63	0.53	0	0	2.38	0.88	2.88	1.59	0	0	0.13	0.18	3.88	1.59
16	Fall	1	1998-1998	20		2		0		3		4		0		0		5	
16	Spring	4	1998-2002	11	4	1.25	0.5	0	0	1.75	2.87	1.75	2.06	0	0	0.25	0.5	2.75	2.5
17	Average	7	2002-2005	15	9	0.92	0.59	0.5	0.71	0.88	0.18	5.38	6.54	0	0	0.29	0.06	2.29	0.06
17	Fall	3	2002-2004	21	5	1.33	0.58	0	0	1	1	10	0	0	0	0.33	0.58	2.33	3.21
17	Spring	4	2002-2005	8	4	0.5	0.58	1	1.15	0.75	0.5	0.75	1.5	0	0	0.25	0.5	2.25	1.5
18	Average	4	2002-2004	12	11	1.17	0.24	0	0	0.33	0.47	1.5	0.71	0	0	1.67	2.36	3	4.24
18	Fall	3	2002-2004	20	2	1.33	0.58	0	0	0.67	1.15	2	1.73	0	0	3.33	3.06	6	1.73
18	Spring	1	2002-2002	4		1		0		0		1		0		0		0	
19	Spring	1	2002-2002	7		0		0		0		4		0		0		2	
20	Spring	1	2002-2002	11		1		0		0		0		0		0		6	
21	Spring	1	2002-2002	4		2		0		0		0		0		0		2	
22	Average	3	2002-2004	27	3	3.5	0.71	0	0	1	1.41	2.25	3.18	0.25	0.35	5	4.24	7.75	1.77
22	Fall	2	2002-2004	25	5	3	0	0	0	2	1.41	4.5	4.95	0.5	0.71	2	1.41	6.5	0.71
22	Spring	1	2002-2002	29		4		0		0		0		0		8		9	