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

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1. ABSTRACT

In order to assess the ecological health of the San Juan Hydrologic Unit (San Diego, Orange, and Riverside Counties, 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, and bioassessment samples were collected under other programs between 1998 and 2006. Most indicators showed evidence of widespread impact, especially in the northern and coastal areas of the watershed. For example, all sites in the Laguna Creek hydrologic subarea, as well as sites in the lower portions of the San Juan Creek watershed exceeded aquatic life thresholds for many (8) water chemistry constituents. Toxicity was moderate at most sites, and not observed at a few sites in the interior of the San Juan Creek watershed. Fish tissue collected from Aliso Creek did not indicate impairment, although no organic constituents were measured, and only one constituent (Selenium) had an applicable threshold. IBIs were poor or very poor at almost every coastal site, as well as at all sites in the Laguna Creek hydrologic subarea, meaning that biological communities characteristic of impairment were found at these sites. Sites with fair, good, or very good IBI scores were located in the interior or southern portions of the watershed. Physical habitat was very degraded at coastal and northern sites, but in moderate to good condition at interior sties. Some designated reference sites (e.g., 901SJMCC2, REF-CS, and 901SJATC2) did not appear to conform to expectations of reference condition. However, other reference sites appeared to be in good ecological health, as were sites that had not been designated as reference (e.g., 901SJBEL2). 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 parts of the San Juan HU are in poor ecological condition.

2. INTRODUCTION

The San Juan hydrologic unit (HU 901) is in Orange, Riverside, and San Diego Counties. The hydrologic unit represents an important water resource in one of the most arid regions of the nation. Despite strong interest in the surface waters of the San Juan HU, a comprehensive assessment of the ecological health of these waters has not been conducted at this time. The purpose of this report is to provide such an analysis using data collected in 2002-2003 under the Surface Waters Ambient Monitoring Program (SWAMP), as well as additional sources, such as including data collected by National Pollution Discharge Elimination System (NPDES) permittees and by the Camp Pendleton Marine Corps Base. 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, fish tissues, physical habitat, and macroinvertebrate community structure. By examining these data from multiple sources, this report provides a measure of the ecological integrity of the San Juan HU.

Table 1. Watersheds monitored under the SWAMP program.

Project	Indicators	Years
SWAMP	Water chemistry, toxicity, fish tissue	2002-2003
CA Department of Fish and Game	Bioassessment	1998-2000
Orange County NPDES	Water chemistry, bioassessment, toxicity, physical habitat	2002-2006
Camp Pendleton	Water chemistry, bioassessment	2004-2005
Laguna Niguel grant-funded projects	Water chemistry	2004-2006

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 San Juan HU is a collection of coastal watersheds in Orange, Riverside, and San Diego counties draining into the Pacific Ocean (Figure 1). The watershed covers 496 mi^2 and ranges from the Santa Margarita mountains in the interior to the Pacific Coast.

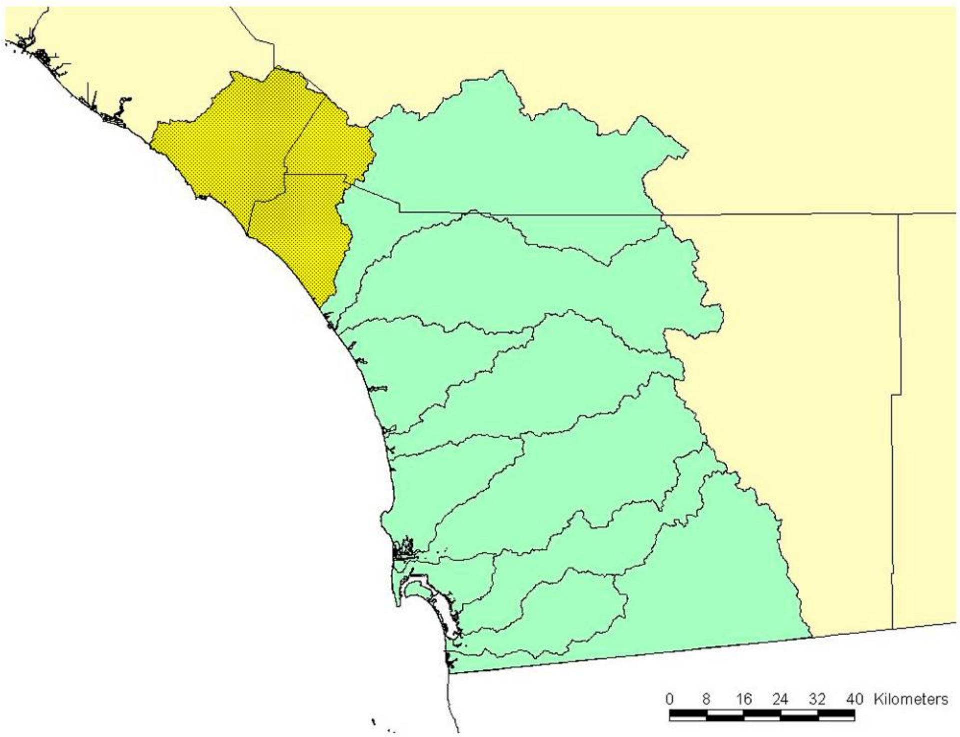


Figure 1. San Diego region (green) includes portions of San Diego, Riverside, and Orange counties. The San Juan HU (yellow, shaded) is located within Orange, Riverside, and San Diego Counties

2.1.1 Climate

The San Juan 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 John Wayne Airport (north of the HU and near the coast) and at San Juan Canyon (in the Santa Ana mountains within the HU) shows considerable variability in rainfall throughout the HU (National Oceanic and Atmospheric Administration 2007) (Figure 2).

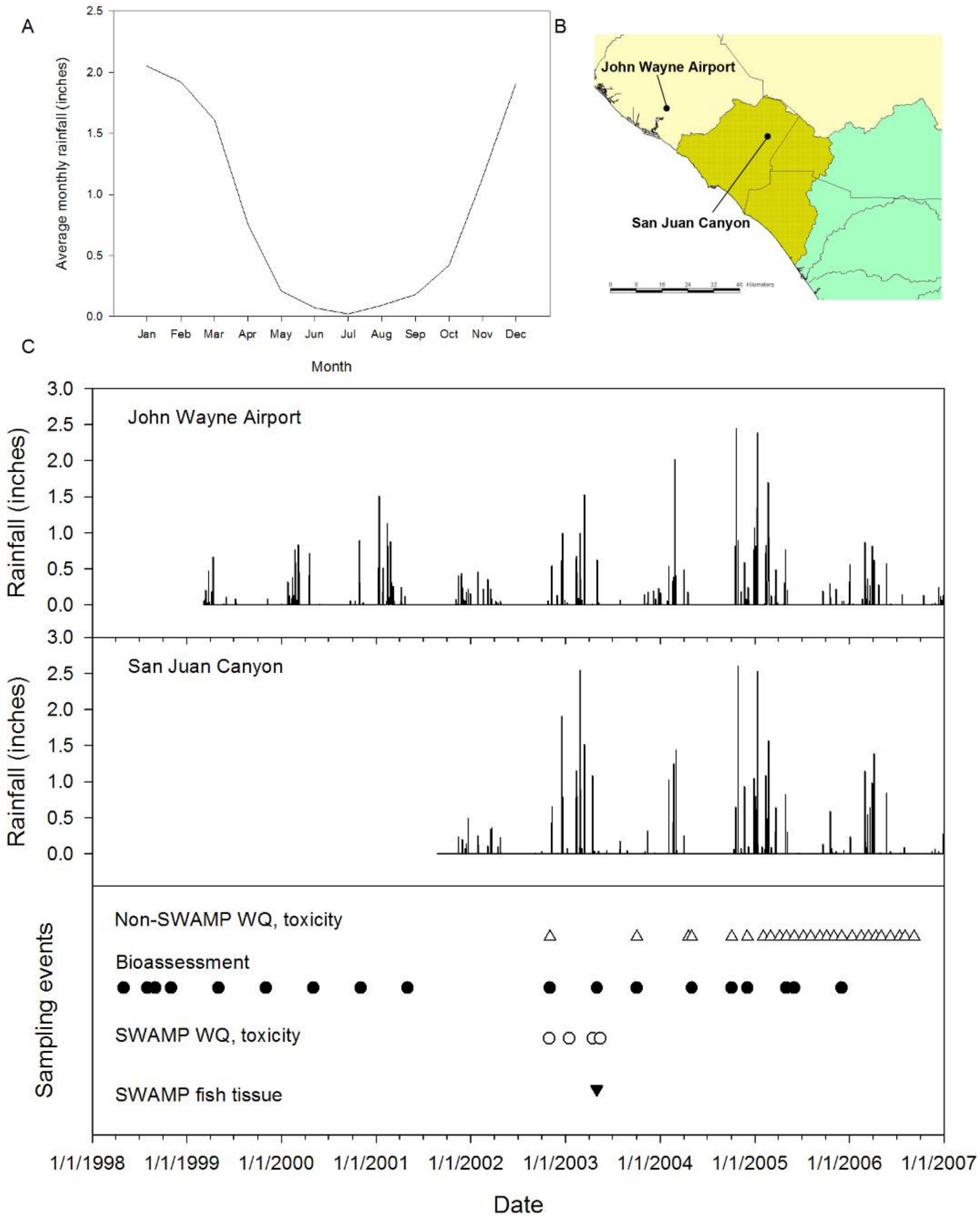


Figure 2. Rainfall and sampling events at two stations in the San Diego region. A. Average precipitation for each month at the Lindberg Station (DWR station code SDG), based on data collected between January 1905 and November 2006. B. Location of the John Wayne Airport and San Juan Canyon gauges. C. Storm events and sampling events in the San Juan HU. The top two plots show daily precipitation between 1998 and 2007 at the three stations. The bottom plot shows the timing of sampling events. SWAMP water chemistry and toxicity samples are shown as white circles. Bioassessment samples are shown as black circles.

2.1.2 Hydrology

The San Juan HU consists of several watersheds that drain directly into the Pacific Ocean. The largest watershed is San Juan Creek; its major tributaries are Bell Canyon, Arroyo Trabuco, and Oso Creeks. The second largest creek is San Mateo Creek, with Christianitos Creek as the largest major tributary. Smaller in size are Aliso, San Onofre, and Las Pulgas Creeks. Smaller still are numerous coastal streams, including Morro Canyon, Laguna Canyon, Salt Creek, Prima Deshecha, Segunda Deshecha, and several unnamed drainages (Figure 3).

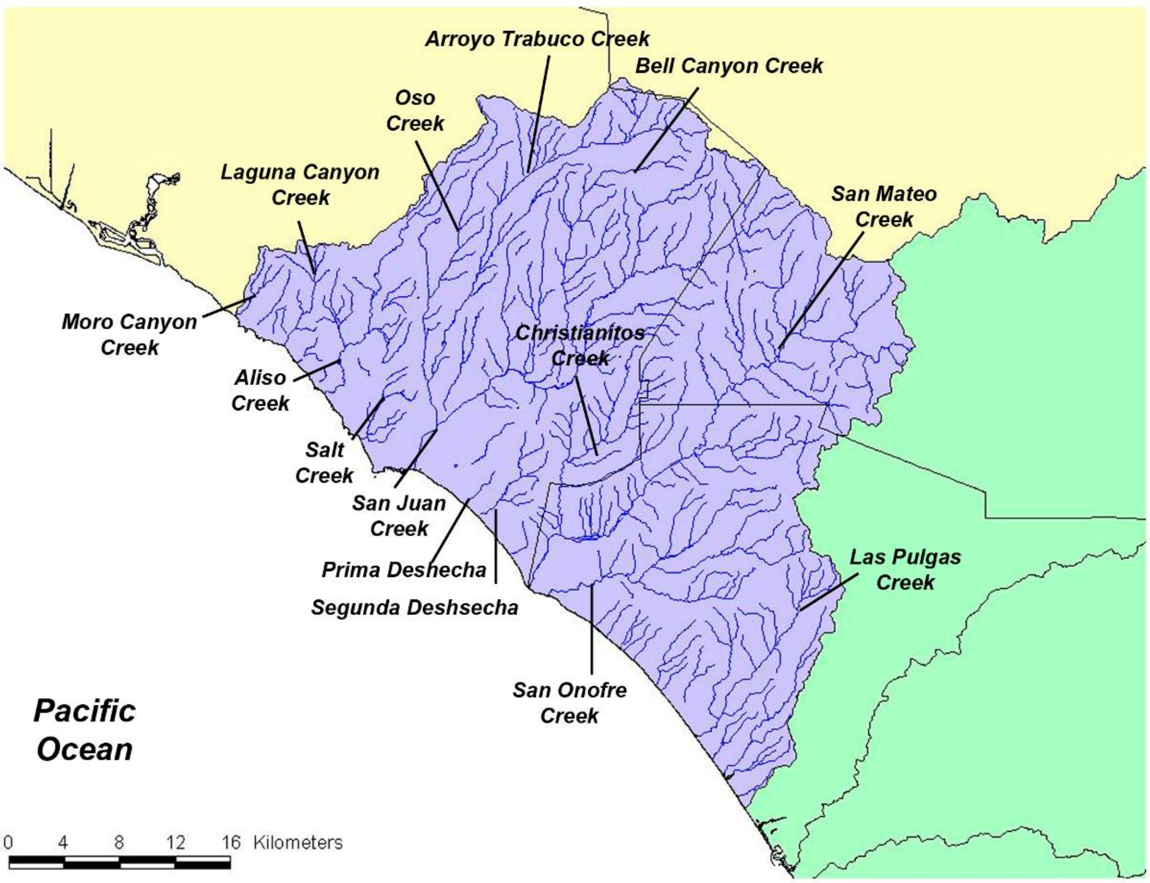


Figure 3. The San Juan HU, including major waterways.

2.1.3 Land Use within the Watershed

Three counties and several municipalities have jurisdiction over portions of the watershed. Riverside County includes a small portion (17.8%) of the San Juan HU, and no municipalities are found within this portion. More than half the watershed (51.7%) is located within Orange County, and the remainder (30.5%) is in San Diego County. In Orange County, the cities of Aliso Viejo, Mission Viejo, Laguna Beach, Laguna Woods, Laguna Niguel, Dana Point, Lake Forest, Rancho Santa Margarita, San Juan Capistrano, and San Clemente occur within the HU. Although a small portion (7.2%) of the HU is developed, most of this development is concentrated within the northern portion of the watershed. The undeveloped portion, the southern and interior portions, occupies 91.8% of the watershed. Agricultural land use occupies less than 1% of the land (Figure 4). A very large and mostly undeveloped portion of the watershed is encompassed by the Camp Pendleton Marine Corps Base in northern San Diego County. Other large areas of open space are found within the Cleveland National Forest. Caltrans is another major landowner, and it has jurisdiction over the major freeways that traverse the watershed (SANDAG 1998).

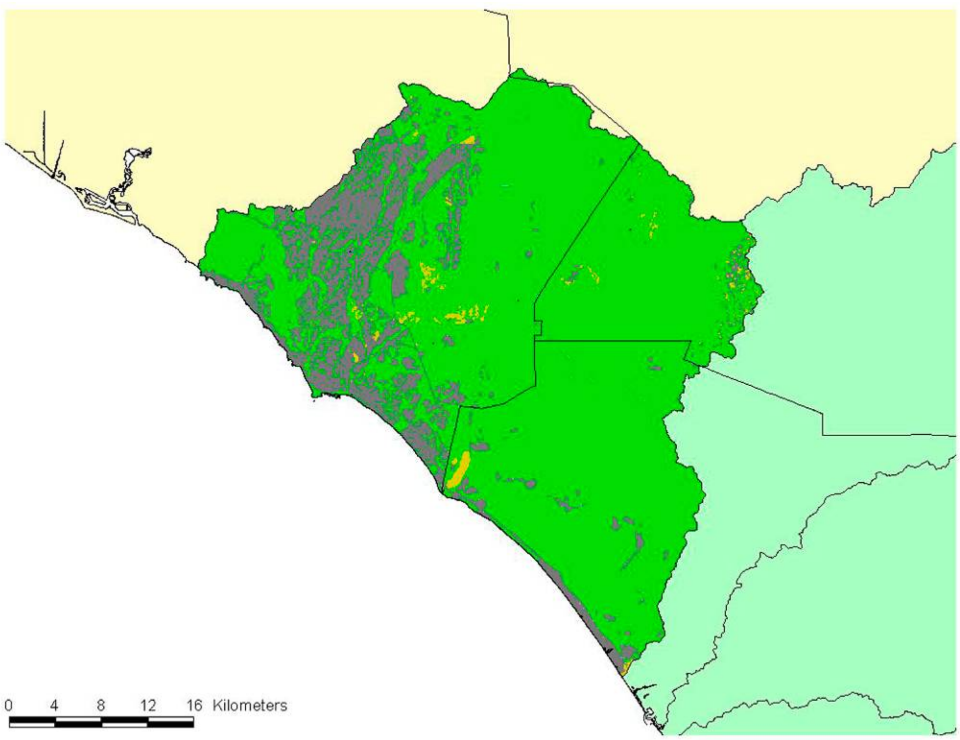


Figure 4. Land use within the San Juan HU. Undeveloped open space is shown as green. Agricultural areas are shown as orange. Urban and developed lands are shown as dark gray.

2.1.4 Beneficial Uses and Known Impairments in the Watershed

Beneficial uses in the watershed include agriculture; industrial service supply; recreation; warm and cold freshwater habitat; wildlife habitat; rare, threatened, or endangered species; and spawning habitat. All streams in the San Juan HU have been exempted from municipal uses (Appendix I).

Several streams in the San Juan HU are listed as impaired on the 303(d) list of water quality limited segments, affecting a total of 26.7 stream miles. These streams include Aliso Creek, English Creek, Laguna Canyon Channel, Oso Creek, San Juan Creek, Prima Deshecha Creek, and Segunda Deshecha Creek. Known stressors include indicator bacteria, total dissolved solids, turbidity, benzo(b)fluoranthene, DDE, dieldrin, sulfates, chloride, phosphorus, and sediment toxicity (Appendix I).

3. METHODS

This report combines data collected under SWAMP with data from California Department of Fish and Game (CDFG), Camp Pendleton, and NPDES monitoring (Table 2). Eleven sites of interest were sampled under SWAMP in the San Juan HU in 2003 (Table 3; Figure 5). Water chemistry, water and sediment toxicity, and physical habitat was measured at each site. Three of these sites were designated reference sites (i.e., Upper Arroyo Trabuco, Morro Canyon, and San Mateo Creek). Water chemistry, water and sediment toxicity, and physical habitat was measured at each of the eleven sites.

Table 2. Sources of data used in this report.

Project	Indicators	Years
SWAMP	Water chemistry, toxicity, fish tissue	2002-2003
CA Department of Fish and Game	Bioassessment	1998-2000
Orange County NPDES	Water chemistry, bioassessment, toxicity, physical habitat	2002-2006
Camp Pendleton	Water chemistry, bioassessment	2004-2005
Laguna Niguel grant-funded projects	Water chemistry	2004-2006

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

Site		Description	Latitude (°N)	Longitude (°E)
1	901SJALC6	Aliso Creek 6 (mouth)	33.5119	-117.7519
2	901SJATC2	Upper Arroyo Trabuco Creek 2 (reference)	33.6717	-117.5575
3	901SJATC5*	Lower Arroyo Trabuco Creek 5	33.5266	-117.6701
4	901SJBEL2	Bell Canyon Creek 2	33.6327	-117.5553
5	901SJENG2	English Creek 2	33.6278	-117.6806
6	901SJLAG2	Laguna Canyon Creek 2	33.5726	-117.7629
7	901SJMCC2	Morro Canyon Creek 2 (reference)	33.5622	-117.8188
8	901SJOSO3	Oso Creek 3	33.5348	-117.6762
9	901SJSJC5	Upper San Juan Creek 5	33.5879	-117.5164
10	901SJSJC9	Lower San Juan Creek 9	33.4847	-117.6746
11	901SJSMT2	San Mateo Creek 2 (reference)	33.5497	-117.3962

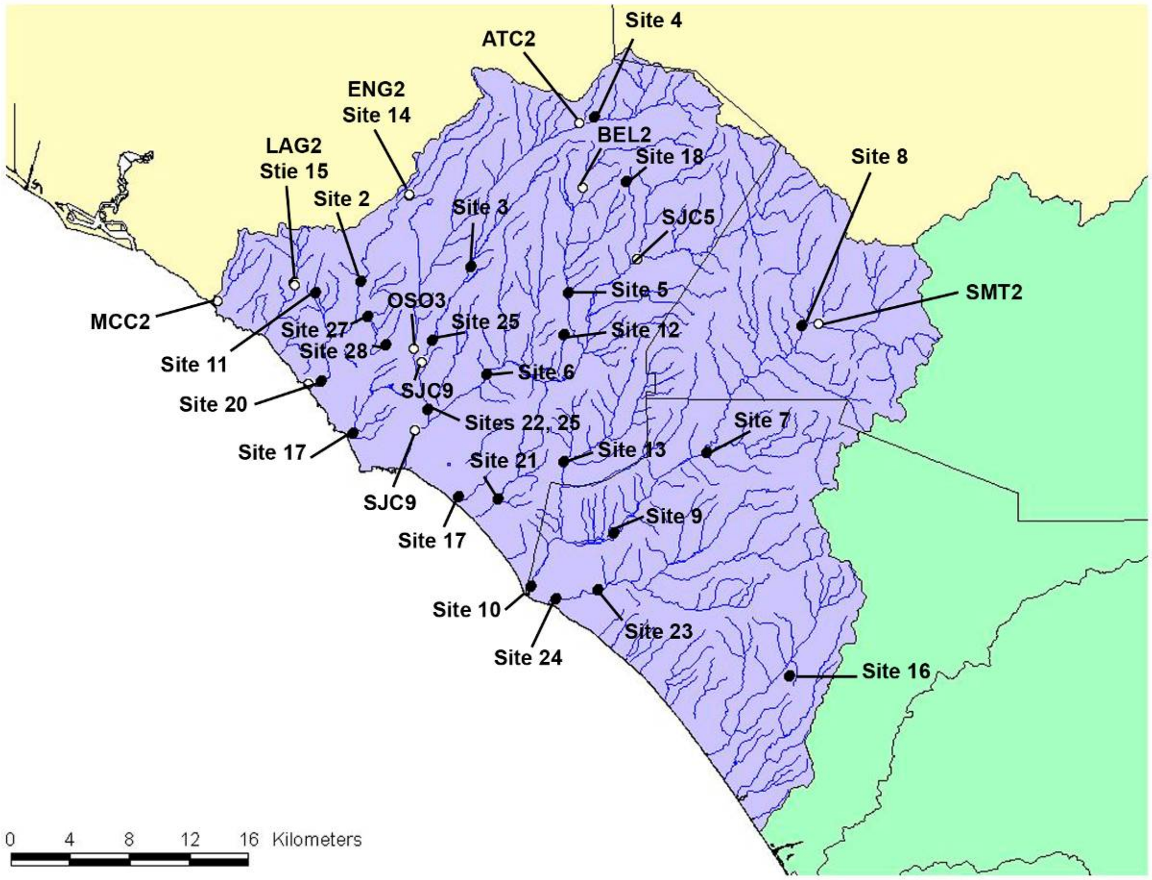


Figure 5. SWAMP (white circles) and non-SWAMP (black circles) sampling locations. Black triangles indicate two non-SWAMP sites were bioassessment samples were not collected. The SWAMP site prefix designating the hydrologic unit (i.e., 901SJ-) has been dropped to improve clarity.

Data from several non-SWAMP monitoring were included in this report. Twenty-eight sites were sampled under programs other than SWAMP. Orange County NPDES monitoring at 18 sites included conventional water chemistry, toxicity, bioassessment, and physical habitat. Monitoring at 3 sites at Camp Pendleton included conventional water chemistry and bioassessment. Monitoring at grant-funded projects by the city of Laguna Niguel included conventional water chemistry, nutrients and bacteria (at Upper Sulphur Creek and Narco Channel), as well as metals and organic compounds (at Narco Channel). Additional bioassessment data was collected at 10 sites by the CDFG Aquatic Bioassessment Laboratory (ABL); of these 10 sites, 5 were also sampled by Orange 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 2006; in some cases, non-SWAMP sites were very close to SWAMP sites (Table 4; Figure 5).

Table 4. Non-SWAMP sampling site locations. W = sites where water chemistry was sampled. T = sites where samples were collected for toxicity assays. B = sites where benthic macroinvertebrates were sampled. P = sites where physical habitat was assessed.

Site	Description	SWAMP site	W	T	B	P	Sources	Lat (°N)	Long (°E)
1	Aliso Creek at Country Club Road	901SJALC6			X		CDFG (901ACCCRx)	33.5142	-117.7430
			X	X	X	X	OC NPDES (AC-CCR)		
2	Aliso Creek at Pacific Park Drive	None			X		CDFG (901ACPPDx)	33.5752	-117.7150
			X	X	X	X	OC NPDES (AC-PPD)		
3	Arroyo Trabuco Creek at Country Club Road	None			X		CDFG (901ATCAPx)	33.5842	-117.6358
4	Arroyo Trabuco Creek (reference)	None			X		CDFG (901ATCTCx)	33.6748	-117.5471
			X	X	X	X	OC NPDES (REF-TCAS, REF-AT2, REF-TAC, REF-ATC)		
5	Bell Canyon Creek at Bell Canyon Trail in Caspar Wilderness Park	None			X		CDFG (901BCCBCT, 901BCCSRT)	33.569	-117.5651
6	San Juan Creek at Highway 74	None			X		CDFG (901SJC74x)	33.5192	-117.6237
			X	X	X	X	OC NPDES (SJC-74)		
7	San Mateo Creek at Devil's Canyon	None			X		CDFG (901SMCDCx, 901DCCDCx)	33.4728	-117.4648
8	San Mateo Creek at San Mateo Canyon	901SJSMT2			X		CDFG (901SMCSMC)	33.5496	-117.3962
9	San Mateo Creek at San Mateo Road	None			X		CDFG (901SMCSMR)	33.4234	-117.5314
10	San Mateo Creek at I5	None	X		X		OC NPDES (SMC-I5)	33.3834	-117.5728
11	Wood Creek	None			X		CDFG (901WCCRTx, 901WCRMMx, 901WCEOTx)	33.5681	-117.7477
			X	X	X	X	OC NPDES (WC-WCT)		
12	Aliso Creek at Aliso Creek Park	None	X	X	X	X	OC NPDES (AC-ACP, ACJ01)	33.5435	-117.5681
13	Christianitos Creek at Christianitos Road	None	X	X	X	X	OC NPDES (CC-CR)	33.4666	-117.5681
14	English Creek at Madera Drive	901SJENG2	X	X	X	X	OC NPDES (EC-MD)	33.6275	-117.6804
15	Laguna Canyon Creek at Highway 133	901SJLAG2	X	X	X	X	OC NPDES (LC-133)	33.5737	-117.7631
16	Las Pulgas Creek	None	X		X		Camp Pendleton (LP-BR)	33.3376	-117.4044
17	Prima Descheca at Calle Grande Vista	None	X	X	X	X	OC NPDES (PD-CGV)	33.4453	-117.6441
18	Bell Creek (reference)	None	X	X	X	X	OC NPDES (REF-BC)	33.6361	-117.5235
19	Cold Spring Creek (reference)	None	X	X	X	X	OC NPDES (REF-CS)	33.0252	-116.6338
20	Salt Creek at Monarch Bay	None	X	X	X	X	OC NPDES (SC-MB)	33.4832	-117.7201
21	Segunda Descheca at Avenida Presidio	None	X	X	X	X	OC NPDES (SD-AP)	33.4436	-117.6153
22	San Juan Creek at Camino Capistrano	None	X	X	X	X	OC NPDES (SJC-CC)	33.4978	-117.6661
23	San Onofre Creek at Highway 2	None	X		X		Camp Pendleton (SOC-2)	33.3893	-117.5432
24	San Onofre Creek at Highway 5	None	X		X		Camp Pendleton (SOC-I5)	33.3834	-117.5728
25	Trabuco Creek at Avery Parkway	None	X	X	X	X	OC NPDES (TC-AP)	33.5398	-117.6631
26	Trabuco Creek at Del Obispo	None	x	x	x	x	OC NPDES (TC-DO)	33.4978	-117.6661
27	Narco Channel	None	X				Laguna Niguel NPDES (Downstream and Upstream)	33.5536	-117.7103
28	Sulphur Creek	None	X				Laguna Niguel NPDES (Downstream, Upstream, La Plaz, La Plata, and Nueva Vista)	33.5364	-117.6964

3.1 Indicators

Multiple indicators were used to assess the sites in the San Juan 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 San Juan 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.

Toxicity was assessed by Orange County NPDES as well (Weston Solutions Inc. 2006). Between 2003 and 2006, water and sediment samples were collected at all sites. Procedures were similar to those used in SWAMP monitoring, with the following differences: chronic toxicity to *C. dubia* was measured as decreased growth (mg per individual) relative to controls (as opposed to reduced fecundity), and chronic toxicity to *H. azteca* was not assessed. In addition, 7-day exposures of sample water to the fathead minnow (*Pimephales promelas*) was assessed as decreased survival (acute toxicity) and growth (chronic toxicity) relative to controls.

3.1.3 Tissue

To detect contamination in fish tissues in the San Juan HU, tissues from one red-ear sun fish and one crayfish were collected at Lower Arroyo Trabuco Creek. Samples were not combined so that variability among individual organisms could be estimated. Tissues were analyzed for metals and selenium 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 San Juan HU, benthic macroinvertebrate samples were collected at 26 sites. Three of these sites were designated reference sties (site 4, 18, and 19). 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.

Physical habitat was also assessed by Orange County NPDES, using methods identical to those used in SWAMP monitoring. Seventeen sites were monitored between 2002 and 2006 twice a year using the same protocols as the SWAMP program (Weston Solutions Inc. 2006).

3.2 Data Analysis

To evaluate the extent of human impacts to water chemistry in streams in the San Juan 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 one site. 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 San Juan 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 San Juan 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). Sulfate threshold of 500 mg/l applies to the Laguna Creek Hydrologic Sub Area (HSU 901.1) (*).

		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	1.3E-07	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
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 and for Camp Pendleton were similar to those used in SWAMP . Non-SWAMP bioassessment samples were screened for samples containing fewer than 450 individuals. No bioassessment sample was excluded from this analysis. Details on QA/QC and on sampling methods for San Diego County NPDES can be found in Weston Solutions Inc. (2006), for Orange County NPDES in Weston Solutions Inc (2006), and for Camp Pendleton in Weston Solutions Inc. (2007).

4. RESULTS

4.1 Water Chemistry

Analysis of water chemistry at SWAMP sites indicated widespread impact to water quality from multiple constituents (Table 8; Figure 6). Across the entire watershed, 31 PAHs, 8 PCBs, and 28 pesticides were detected. The number of PAHs detected ranged from two at a site (at the Upper San Juan Creek and San Mateo Creek) to more than twenty (at English Creek and Oso Creek). PCBs were not detected at two of the reference sites (Upper Arroyo Trabuco and San Mateo Creek), as well as at Bell Canyon Creek. Between 1 and 4 PCB constituents were found at all other sites, including the Morro Canyon Creek reference site. Few pesticides (i.e., between 1 and 3) were detected at reference sites and at the upper San Juan Creek. Furthermore, no pesticides were detected at Bell Canyon Creek. However, a high number of pesticides (i.e., between 12 and 14) were detected at all other sites in the watershed. Means and standard deviations of all constituents are presented in Appendix II.

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

	PAHs		PCBs		Pesticides	
Site	Tested	Detected	Tested	Detected	Tested	Detected
901SJALC6	43	12	50	2	91	13
901SJATC2	43	7	50	0	91	2
901SJATC5	43	17	50	1	91	14
901SJBEL2	43	3	50	0	91	0
901SJENG2	43	27	50	1	91	14
901SJLAG2	43	13	50	2	91	13
901SJMCC2	43	4	50	1	91	1
901SJOSO3	43	25	50	4	91	13
901SJSJC5	43	2	50	2	91	1
901SJSJC9	43	6	50	2	91	12
901SJSMT2	43	2	50	0	91	3
Ali sites	43	31	50	8	91	28

Several organic compounds were widespread throughout the watershed (Table 9). For example, C1- and C2-dibenzothiophenes were found at nearly every site, and many pesticides and PAHs were found at the majority of sites (the PAHs benzo(b)fluoranthene, C3-dibenzothiophene, C1-fluorene, C3- and C4-naphthalenes, C1-, C2- and C3-phenanthrene/anthracene; one PCB (PCB087); and the pesticides dacthal, p,p’-DDE, diazinon, disulfotan, delta HCH, heptachlor epoxide, hexachlorobenzene, and oxadiazon). Fifty-five additional constituents were detected at one or more sites in the San Juan HU.

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

Category	Constituent	Tested	Detected	Frequency
PAHs	Acenaphthene	11	0	--
PAHs	Acenaphthylene	11	0	--
PAHs	Anthracene	11	0	--
PAHs	Benz(a)anthracene	11	0	--
PAHs	Benzo(a)pyrene	11	1	0.1
PAHs	Benzo(b)fluoranthene	11	6	0.5
PAHs	Benzo(e)pyrene	11	2	0.2
PAHs	Benzo(g,h,i)perylene	11	3	0.3
PAHs	Benzo(k)fluoranthene	11	1	0.1
PAHs	Biphenyl	11	0	--
PAHs	Chrysene	11	2	0.2
PAHs	Chrysenes, C1 -	11	3	0.3
PAHs	Chrysenes, C2 -	11	4	0.4
PAHs	Chrysenes, C3 -	11	2	0.2
PAHs	Dibenz(a,h)anthracene	11	1	0.1
PAHs	Dibenzothiophene	11	3	0.3
PAHs	Dibenzothiophenes, C1 -	11	10	0.9
PAHs	Dibenzothiophenes, C2 -	11	10	0.9
PAHs	Dibenzothiophenes, C3 -	11	7	0.6
PAHs	Dimethylnaphthalene, 2,6-	11	0	--

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

Category	Constituent	Tested	Detected	Frequency
PAHs	Fluoranthene	11	2	0.2
PAHs	Fluoranthene/Pyrenes, C1 -	11	1	0.1
PAHs	Fluorene	11	0	--
PAHs	Fluorenes, C1 -	11	5	0.5
PAHs	Fluorenes, C2 -	11	3	0.3
PAHs	Fluorenes, C3 -	11	7	0.6
PAHs	Indeno(1,2,3-c,d)pyrene	11	2	0.2
PAHs	Methylnaphthalene, 1-	11	0	--
PAHs	Methylnaphthalene, 2-	11	0	--
PAHs	Methylphenanthrene, 1-	11	0	--
PAHs	Naphthalene	11	2	0.2
PAHs	Naphthalenes, C1 -	11	2	0.2
PAHs	Naphthalenes, C2 -	11	3	0.3
PAHs	Naphthalenes, C3 -	11	7	0.6
PAHs	Naphthalenes, C4 -	11	6	0.5
PAHs	Perylene	11	2	0.2
PAHs	Phenanthrene	11	0	--
PAHs	Phenanthrene/Anthracene, C1 -	11	7	0.6
PAHs	Phenanthrene/Anthracene, C2 -	11	5	0.5
PAHs	Phenanthrene/Anthracene, C3 -	11	5	0.5
PAHs	Phenanthrene/Anthracene, C4 -	11	1	0.1
PAHs	Pyrene	11	3	0.3
PAHs	Trimethylnaphthalene, 2,3,5-	11	0	--
PCBs	PCB 005	11	2	0.2
PCBs	PCB 008	11	1	0.1
PCBs	PCB 015	11	0	--
PCBs	PCB 018	11	0	--
PCBs	PCB 027	11	0	--
PCBs	PCB 028	11	0	--
PCBs	PCB 029	11	0	--
PCBs	PCB 031	11	1	0.1
PCBs	PCB 033	11	0	--
PCBs	PCB 044	11	0	--
PCBs	PCB 049	11	0	--
PCBs	PCB 052	11	1	0.1
PCBs	PCB 056	11	0	--
PCBs	PCB 060	11	0	--
PCBs	PCB 066	11	0	--
PCBs	PCB 070	11	0	--
PCBs	PCB 074	11	0	--
PCBs	PCB 087	11	6	0.5
PCBs	PCB 095	11	0	--
PCBs	PCB 097	11	0	--
PCBs	PCB 099	11	0	--
PCBs	PCB 101	11	0	--
PCBs	PCB 105	11	0	--
PCBs	PCB 110	11	0	--
PCBs	PCB 114	11	0	--
PCBs	PCB 118	11	0	--

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

Category	Constituent	Tested	Detected	Frequency
PCBs	PCB 128	11	0	--
PCBs	PCB 137	11	0	--
PCBs	PCB 138	11	0	--
PCBs	PCB 141	11	0	--
PCBs	PCB 149	11	0	--
PCBs	PCB 151	11	0	--
PCBs	PCB 153	11	0	--
PCBs	PCB 156	11	0	--
PCBs	PCB 157	11	0	--
PCBs	PCB 158	11	0	--
PCBs	PCB 170	11	0	--
PCBs	PCB 174	11	0	--
PCBs	PCB 177	11	0	--
PCBs	PCB 180	11	0	--
PCBs	PCB 183	11	0	--
PCBs	PCB 187	11	2	0.2
PCBs	PCB 189	11	0	--
PCBs	PCB 194	11	1	0.1
PCBs	PCB 195	11	1	0.1
PCBs	PCB 200	11	0	--
PCBs	PCB 201	11	0	--
PCBs	PCB 203	11	0	--
PCBs	PCB 206	11	0	--
PCBs	PCB 209	11	0	--
Pesticides	Aldrin	11	0	--
Pesticides	Ametryn	11	0	--
Pesticides	Aspon	11	0	--
Pesticides	Atraton	11	0	--
Pesticides	Atrazine	11	0	--
Pesticides	Azinphos ethyl	11	0	--
Pesticides	Azinphos methyl	11	0	--
Pesticides	Bolstar	11	0	--
Pesticides	Carbophenothion	11	0	--
Pesticides	Chlordane, cis-	11	2	0.2
Pesticides	Chlordane, trans-	11	1	0.1
Pesticides	Chlordene, alpha-	11	0	--
Pesticides	Chlordene, gamma-	11	4	0.4
Pesticides	Chlorfenvinphos	11	0	--
Pesticides	Chlorpyrifos	11	0	--
Pesticides	Chlorpyrifos methyl	11	0	--
Pesticides	Ciodrin	11	0	--
Pesticides	Coumaphos	11	0	--
Pesticides	Dacthal	11	5	0.5
Pesticides	DDD(o,p')	11	0	--
Pesticides	DDD(p,p')	11	1	0.1
Pesticides	DDE(o,p')	11	1	0.1
Pesticides	DDE(p,p')	11	6	0.5
Pesticides	DDMU(p,p')	11	0	--
Pesticides	DDT(o,p')	11	0	--
Pesticides	DDT(p,p')	11	3	0.3

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

Category	Constituent	Tested	Detected	Frequency
Pesticides	Demeton-s	11	0	--
Pesticides	Diazinon	11	6	0.5
Pesticides	Dichlofenthion	11	0	--
Pesticides	Dichlorvos	11	0	--
Pesticides	Dicrotophos	11	0	--
Pesticides	Dieldrin	11	3	0.3
Pesticides	Dimethoate	11	1	0.1
Pesticides	Dioxathion	11	0	--
Pesticides	Disulfoton	11	5	0.5
Pesticides	Endosulfan I	11	4	0.4
Pesticides	Endosulfan II	11	1	0.1
Pesticides	Endosulfan sulfate	11	4	0.4
Pesticides	Endrin	11	2	0.2
Pesticides	Endrin Aldehyde	11	0	--
Pesticides	Endrin Ketone	11	0	--
Pesticides	Ethion	11	0	--
Pesticides	Ethoprop	11	0	--
Pesticides	Famphur	11	0	--
Pesticides	Fenchlorphos	11	0	--
Pesticides	Fenitrothion	11	0	--
Pesticides	Fensulfothion	11	0	--
Pesticides	Fenthion	11	0	--
Pesticides	Fonofos	11	0	--
Pesticides	HCH, alpha	11	1	0.1
Pesticides	HCH, beta	11	0	--
Pesticides	HCH, delta	11	5	0.5
Pesticides	HCH, gamma	11	0	--
Pesticides	Heptachlor	11	0	--
Pesticides	Heptachlor epoxide	11	5	0.5
Pesticides	Hexachlorobenzene	11	5	0.5
Pesticides	Leptophos	11	0	--
Pesticides	Malathion	11	0	--
Pesticides	Merphos	11	0	--
Pesticides	Methidathion	11	0	--
Pesticides	Methoxychlor	11	0	--
Pesticides	Mevinphos	11	0	--
Pesticides	Mirex	11	0	--
Pesticides	Molinate	11	0	--
Pesticides	Naled	11	0	--
Pesticides	Nonachlor, cis-	11	1	0.1
Pesticides	Nonachlor, trans-	11	2	0.2
Pesticides	Oxadiazon	11	8	0.7
Pesticides	Oxychlordane	11	4	0.4
Pesticides	Parathion, Ethyl	11	0	--
Pesticides	Parathion, Methyl	11	0	--
Pesticides	Phorate	11	0	--
Pesticides	Phosmet	11	0	--
Pesticides	Phosphamidon	11	0	--
Pesticides	Prometon	11	0	--

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

Category	Constituent	Tested	Detected	Frequency
Pesticides	Prometryn	11	0	--
Pesticides	Propazine	11	0	--
Pesticides	Secbumeton	11	2	0.2
Pesticides	Simazine	11	1	0.1
Pesticides	Simetryn	11	0	--
Pesticides	Sulfotep	11	0	--
Pesticides	Tedion	11	2	0.2
Pesticides	Terbufos	11	0	--
Pesticides	Terbuthylazine	11	0	--
Pesticides	Terbutryn	11	0	--
Pesticides	Tetrachlorvinphos	11	0	--
Pesticides	Thiobencarb	11	1	0.1
Pesticides	Thionazin	11	0	--
Pesticides	Tokuthion	11	0	--
Pesticides	Trichlorfon	11	0	--
Pesticides	Trichloronate	11	0	--

Comparison with applicable aquatic life and human health thresholds support the conclusion that water quality is impacted by these constituents (Table 10, Figure 6, 7). Nutrients, sulfate, selenium, manganese, specific conductivity, pH, and turbidity frequently exceeded aquatic life thresholds at several sites (Table 11). At certain sites, copper, benzo(a)pyrene, and heptachlor epoxide also exceeded aquatic life standards. In general, fewer constituents exceeded human health standards, although exceedances of benzo(b)fluoranthene, p,p'-DDE, and heptachlor epoxide were widespread (Table 10; Figure 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. D) Frequency of human health thresholds 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. (*) Sulfate threshold of 500 mg/l was applied to the Laguna Creek Hydrologic Subarea (HSU 901.1). This sub area includes 901SJMCC2 and 901SJLAG2.

A. Aquatic life				901SJALC6		901SJATC2		901SJATC5		901SJBEL2		901SJENG2		901SJLAG2		901SJMCC2		901SJOSO3		901SJSJC5		901SJSJC9		901SJSMT2	
Category	Constituent	Threshold	Source	Freq	n	Freq	n	Freq	n	Freq	n	Freq	n	Freq	n	Freq	n	Freq	n	Freq	n	Freq	n	Freq	n
Inorganics	Alkalinity as CaCO3	20000 mg/l	EPA	--	4	--	2	--	4	--	2	--	4	--	4	--	4	--	4	--	4	--	4	--	2
Inorganics	Ammonia as N	0.025 mg/l	BP	0.50	4	0.50	2	0.25	4	0.50	2	0.75	4	0.50	4	1.00	4	0.75	4	--	4	0.50	4	--	2
Inorganics	Nitrate + Nitrite as N	10 mg/l	BP	--	4	--	2	--	4	--	2	--	4	--	4	--	4	--	4	--	4	--	4	--	2
Inorganics	Phosphorus as P,Total	0.1 mg/l	BP	1.00	4	0.50	2	0.25	4	0.50	2	0.75	4	1.00	4	1.00	4	0.75	4	--	4	0.25	4	--	2
Inorganics	Selenium,Dissolved	5 µg/l	CTR	0.75	4	--	2	--	4	--	2	0.75	4	--	4	1.00	4	0.75	4	--	4	0.50	4	--	2
Inorganics	Sulfate	250 mg/l*	BP	0.75	4	--	3	--	4	--	2	--	4	--	4	1.00	4	0.75	4	--	4	0.75	4	--	2
Metals	Aluminum,Dissolved	1000 µg/l	BP	--	4	--	2	--	4	--	2	--	4	--	4	--	4	--	4	--	4	--	4	--	2
Metals	Arsenic,Dissolved	50 µg/l	BP	--	4	--	2	--	4	--	2	--	4	--	4	--	4	--	4	--	4	--	4	--	2
Metals	Cadmium,Dissolved	5 µg/l	BP	--	4	--	2	--	4	--	2	--	4	--	4	--	4	--	4	--	4	--	4	--	2
Metals	Chromium,Dissolved	50 µg/l	BP	--	4	--	2	--	4	--	2	--	4	--	4	--	4	--	4	--	4	--	4	--	2
Metals	Copper,Dissolved	9 µg/l	CTR	--	4	--	2	--	4	--	2	--	4	--	4	0.25	4	0.50	4	--	4	--	4	--	2
Metals	Lead,Dissolved	2.5 µg/l	CTR	--	4	--	2	--	4	--	2	--	4	--	4	--	4	--	4	--	4	--	4	--	2
Metals	Manganese,Dissolved	0.05 µg/l	BP	0.75	4	--	2	--	4	--	2	--	4	0.75	4	1.00	4	0.50	4	--	4	0.50	4	--	2
Metals	Nickel,Dissolved	52 µg/l	CTR	--	4	--	2	--	4	--	2	--	4	--	4	--	4	--	4	--	4	--	4	--	2
Metals	Silver,Dissolved	3.4 µg/l	CTR	--	4	--	2	--	4	--	2	--	4	--	4	--	4	--	4	--	4	--	4	--	2
Metals	Zinc,Dissolved	120 µg/l	CTR	--	4	--	2	--	4	--	2	--	4	--	4	--	4	--	4	--	4	--	4	--	2
PAHs	Benzo(a)pyrene	0.0002 µg/l	BP	--	4	--	2	--	4	--	2	0.25	4	--	4	--	4	--	4	--	4	--	4	--	2
PCBs	PCBs	0.014 µg/l	CTR	--	4	--	2	--	4	--	2	--	4	--	4	--	4	--	4	--	4	--	4	--	2
Pesticides	Aldrin	3 µg/l	CTR	--	4	--	2	--	4	--	2	--	4	--	4	--	4	--	4	--	4	--	4	--	2
Pesticides	Atrazine	3 µg/l	BP	--	4	--	2	--	4	--	2	--	4	--	4	--	4	--	4	--	4	--	4	--	2
Pesticides	Endrin	0.002 µg/l	BP	--	4	--	2	--	4	--	2	--	4	--	4	--	4	--	4	--	4	--	4	--	2
Pesticides	Heptachlor	0.0038 µg/l	CTR	--	4	--	2	--	4	--	2	--	4	--	4	--	4	--	4	--	4	--	4	--	2
Pesticides	Heptachlor epoxide	0.0038 µg/l	CTR	--	4	--	2	--	4	--	2	0.25	4	--	4	--	4	--	4	--	4	--	4	--	2
Pesticides	Hexachlorobenzene	1 µg/l	BP	--	4	--	2	--	4	--	2	--	4	--	4	--	4	--	4	--	4	--	4	--	2
Pesticides	Methoxychlor	40 µg/l	BP	--	4	--	2	--	4	--	2	--	4	--	4	--	4	--	4	--	4	--	4	--	2
Pesticides	Molinate	20 µg/l	BP	--	4	--	2	--	4	--	2	--	4	--	4	--	4	--	4	--	4	--	4	--	2
Pesticides	Simazine	4 µg/l	BP	--	4	--	2	--	4	--	2	--	4	--	4	--	4	--	4	--	4	--	4	--	2
Pesticides	Thiobencarb	70 µg/l	BP	--	4	--	2	--	4	--	2	--	4	--	4	--	4	--	4	--	4	--	4	--	2
Physical	pH	>6 or <8 pH units	BP	0.50	4	0.50	2	0.33	3	--	2	0.75	4	--	4	--	4	0.75	4	0.25	4	0.25	4	0.50	2
Physical	SpecificConductivity	1.6 mS/cm	CCR	0.75	4	--	2	--	4	--	2	0.25	4	0.25	4	1.00	4	0.75	4	--	4	0.50	4	--	2
Physical	Turbidity	20 NTU	BP	0.25	4	0.50	2	0.25	4	0.50	2	0.25	4	--	4	0.50	4	--	4	--	4	0.25	4	--	2

Table 10, continued. Frequency of water chemistry threshold exceedances.

B. Human Health				901SJMCC2		901SJOSO3		901SJSJC5		901SJSJC9		901SJSMT2		901SJMCC2		901SJOSO3		901SJSJC5		901SJSJC9		901SJSMT2	
Category	Constituent	Threshold	Source	Freq	n	Freq	n	Freq	n	Freq	n	Freq	n	Freq	n	Freq	n	Freq	n	Freq	n	Freq	n
Metals	Arsenic,Dissolved	150 µg/l	CTR	--	4	--	4	--	4	--	4	--	2	--	4	--	4	--	4	--	4	--	2
Metals	Cadmium,Dissolved	2.2 µg/l	CTR	--	4	--	4	--	4	--	4	--	2	--	4	--	4	--	4	--	4	--	2
Metals	Copper,Dissolved	1300 µg/l	CTR	--	4	--	4	--	4	--	4	--	2	--	4	--	4	--	4	--	4	--	2
Metals	Nickel,Dissolved	610 µg/l	CTR	--	4	--	4	--	4	--	4	--	2	--	4	--	4	--	4	--	4	--	2
PAHs	Acenaphthene	1200 µg/l	CTR	--	4	--	4	--	4	--	4	--	2	--	4	--	4	--	4	--	4	--	2
PAHs	Anthracene	9600 µg/l	CTR	--	4	--	4	--	4	--	4	--	2	--	4	--	4	--	4	--	4	--	2
PAHs	Benz(a)anthracene	0.0044 µg/l	CTR	--	4	--	4	--	4	--	4	--	2	--	4	--	4	--	4	--	4	--	2
PAHs	Benzo(a)pyrene	0.0044 µg/l	CTR	--	4	--	4	--	4	--	4	--	2	--	4	--	4	--	4	--	4	--	2
PAHs	Benzo(b)fluoranthene	0.0044 µg/l	CTR	0.25	4	0.25	4	--	4	--	4	--	2	0.25	4	0.25	4	--	4	--	4	--	2
PAHs	Benzo(k)fluoranthene	0.0044 µg/l	CTR	--	4	--	4	--	4	--	4	--	2	--	4	--	4	--	4	--	4	--	2
PAHs	Chrysene	0.0044 µg/l	CTR	--	4	0.25	4	--	4	--	4	--	2	--	4	0.25	4	--	4	--	4	--	2
PAHs	Dibenz(a,h)anthracene	0.0044 µg/l	CTR	--	4	--	4	--	4	--	4	--	2	--	4	--	4	--	4	--	4	--	2
PAHs	Fluoranthene	300 µg/l	CTR	--	4	--	4	--	4	--	4	--	2	--	4	--	4	--	4	--	4	--	2
PAHs	Indeno(1,2,3-c,d)pyrene	0.0044 µg/l	CTR	--	4	0.25	4	--	4	--	4	--	2	--	4	0.25	4	--	4	--	4	--	2
PAHs	Pyrene	960 µg/l	CTR	--	4	--	4	--	4	--	4	--	2	--	4	--	4	--	4	--	4	--	2
PCBs	PCBs	0.00017 µg/l	CTR	--	4	--	4	--	4	--	4	--	2	--	4	--	4	--	4	--	4	--	2
Pesticides	Aldrin	0.00000013 µg/l	CTR	--	4	--	4	--	4	--	4	--	2	--	4	--	4	--	4	--	4	--	2
Pesticides	Ametryn	60 µg/l	EPA	--	4	--	4	--	4	--	4	--	2	--	4	--	4	--	4	--	4	--	2
Pesticides	Atrazine	0.2 µg/l	OEHHA	--	4	--	4	--	4	--	4	--	2	--	4	--	4	--	4	--	4	--	2
Pesticides	Azinphos ethyl	87.5 µg/l	NASHA	--	4	--	4	--	4	--	4	--	2	--	4	--	4	--	4	--	4	--	2
Pesticides	Azinphos methyl	87.5 µg/l	NASHA	--	4	--	4	--	4	--	4	--	2	--	4	--	4	--	4	--	4	--	2
Pesticides	DDD(p,p')	0.00083 µg/l	CTR	--	4	--	4	--	4	--	4	--	2	--	4	--	4	--	4	--	4	--	2
Pesticides	DDE(p,p')	0.00059 µg/l	CTR	--	4	0.25	4	--	4	0.50	4	--	2	--	4	0.25	4	--	4	0.50	4	--	2
Pesticides	DDT(p,p')	0.00059 µg/l	CTR	--	4	0.25	4	--	4	--	4	0.50	2	--	4	0.25	4	--	4	--	4	0.50	2
Pesticides	Dieldrin	0.00014 µg/l	CTR	--	4	--	4	--	4	0.25	4	--	2	--	4	--	4	--	4	0.25	4	--	2
Pesticides	Dimethoate	1.4 µg/l	IRIS	--	4	--	4	--	4	--	4	--	2	--	4	--	4	--	4	--	4	--	2
Pesticides	Endosulfan sulfate	110 µg/l	CTR	--	4	--	4	--	4	--	4	--	2	--	4	--	4	--	4	--	4	--	2
Pesticides	Endrin	0.76 µg/l	CTR	--	4	--	4	--	4	--	4	--	2	--	4	--	4	--	4	--	4	--	2
Pesticides	Endrin Aldehyde	0.76 µg/l	CTR	--	4	--	4	--	4	--	4	--	2	--	4	--	4	--	4	--	4	--	2
Pesticides	Endrin Ketone	0.85 µg/l	CTR	--	4	--	4	--	4	--	4	--	2	--	4	--	4	--	4	--	4	--	2
Pesticides	Heptachlor	0.00021 µg/l	CTR	--	4	--	4	--	4	--	4	--	2	--	4	--	4	--	4	--	4	--	2
Pesticides	Heptachlor epoxide	0.0001 µg/l	CTR	--	4	0.25	4	--	4	0.25	4	--	2	--	4	0.25	4	--	4	0.25	4	--	2
Pesticides	Hexachlorobenzene	0.00075 µg/l	CTR	--	4	0.25	4	--	4	--	4	--	2	--	4	0.25	4	--	4	--	4	--	2
Pesticides	Oxychlordane	0.000023 µg/l	CTR	--	4	0.25	4	--	4	0.25	4	--	2	--	4	0.25	4	--	4	0.25	4	--	2

Table 10, continued. Frequency of water chemistry threshold exceedances.

C. Aquatic life (non-SWAMP)		Cadmium		Copper		Dissolved oxygen		Nickel		pH		Specific conductivity		Total phosphorus		Turbidity	
	Threshold	5	ug/l	9	ug/l	5	mg/l	52	ug/l	>6 or <8		1.6	mS/cm	0.1	mg/l	20	NTU
Site	Specific location	BP	n	CTR	n	BP	n	CTR	n	BP	n	CCR	n	BP	n	BP	n
1	AC-CCR		0		0	--	6		0	0.33	6	1.00	6		0		0
2	AC-PPD		0		0	--	6		0	0.67	6	1.00	6		0		0
4	REF-AT2		0		0	--	4		0	0.50	4	--	4		0		0
6	SJC-74		0		0	--	5		0	0.60	5	0.40	5		0		0
10	SMC-I5		0		0	0.50	2		0	--	2	--	2		0	--	2
11	WC-WCT		0		0	--	2		0	1.00	2	1.00	2		0		0
12	AC-ACP		0		0	--	6		0	0.50	6	1.00	6		0		0
13	CC-CR		0		0	--	4		0	0.25	4	--	4		0		0
14	EC-MD		0		0	--	6		0	0.83	6	0.83	6		0		0
15	LC-133		0		0	--	6		0	0.83	6	0.50	6		0		0
16	LP-BR		0		0	--	4		0	0.25	4	--	4		0	--	2
17	PD-CGV		0		0	--	1		0	1.00	1	1.00	1		0		0
18	REF-BC		0		0	0.25	4		0	0.25	4	--	4		0		0
19	REF-CS		0		0	--	6		0	1.00	6	--	6		0		0
20	SC-MB		0		0	--	6		0	0.17	6	1.00	6		0		0
21	SD-AP		0		0	--	6		0	0.33	6	1.00	6		0		0
22	SJC-CC		0		0	0.17	6		0	0.33	6	0.83	6		0		0
23	SOC-2		0		0		0		0	1.00	1	--	1		0		0
24	SOC-I5		0		0	--	2		0	--	2	--	2		0	0.50	2
25	TC-AP		0		0	--	6		0	0.67	6	--	6		0		0
26	TC-DO		0		0	--	6		0	1.00	6	1.00	6		0		0
27	Narco Downstream	0.97	36	0.08	12		0	0.97	36		0	1.00	11	1.00	12		0
27	Narco Upstream	1.00	12	--	12		0	1.00	12		0	1.00	11	1.00	12		0
28	Lower Reach Downstream end		0		0		0		0		0		0		0		0
28	Lower Reach midreach (La Plata)		0		0		0		0		0		0		0		0
28	Middle Reach Downstream end (La Paz)-Post construction		0		0		0		0		0		0		0		0
28	Middle Reach Downstream end (La Paz)-Pre construction		0		0		0		0		0		0		0		0
28	Middle Reach upstream end (Nueva Vista) - Post construction		0		0		0		0		0		0		0		0
28	Middle Reach upstream end (Nueva Vista) - Pre construction		0		0		0		0		0		0		0		0
28	Upper Reach - Upper End		0		0		0		0		0		0		0		0

Table 10, continued. Frequency of water chemistry threshold exceedances.

D. Human health (non-SWAMP)		Cadmium		Copper		Dimethoate		Nickel	
		2.2	ug/l	1300	ug/l	1.4	ng/l	610	ug/l
Site	Specific location	CTR	n	CTR	n	EPA	n	CTR	n
27	Narco Channel (downstream)	1.00	36	--	12	--	4	0	36
	Narco Channel (upstream)	1.00	12	--	12	--	4	--	12

Table 11. Frequency of SWAMP sites with aquatic life and human health threshold exceedances of 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	11	--	NA
Inorganics	Ammonia as N	11	0.82	NA
Inorganics	Nitrate + Nitrite as N	11	--	NA
Inorganics	Phosphorus as P,Total	11	0.82	NA
Inorganics	Selenium,Dissolved	11	0.45	NA
Inorganics	Sulfate	11	0.36	NA
Metals	Aluminum,Dissolved	11	--	NA
Metals	Arsenic,Dissolved	11	--	--
Metals	Cadmium,Dissolved	11	--	--
Metals	Chromium,Dissolved	11	--	NA
Metals	Copper,Dissolved	11	0.18	--
Metals	Lead,Dissolved	11	--	NA
Metals	Manganese,Dissolved	11	0.45	NA
Metals	Nickel,Dissolved	11	--	--
Metals	Silver,Dissolved	11	--	NA
Metals	Zinc,Dissolved	11	--	NA
PAHs	Acenaphthene	11	NA	--
PAHs	Anthracene	11	NA	--
PAHs	Benz(a)anthracene	11	NA	--
PAHs	Benzo(a)pyrene	11	0.09	0.09
PAHs	Benzo(b)fluoranthene	11	NA	0.55
PAHs	Benzo(k)fluoranthene	11	NA	0.09
PAHs	Chrysene	11	NA	0.18
PAHs	Dibenz(a,h)anthracene	11	NA	0.09
PAHs	Fluoranthene	11	NA	--
PAHs	Indeno(1,2,3-c,d)pyrene	11	NA	0.18
PAHs	Pyrene	11	NA	--
PCBs	PCBs	11	--	--
Pesticides	Aldrin	11	--	--
Pesticides	Ametryn	11	NA	--
Pesticides	Atrazine	11	--	--
Pesticides	Azinphos ethyl	11	NA	--
Pesticides	Azinphos methyl	11	NA	--
Pesticides	DDD(p,p')	11	NA	0.09
Pesticides	DDE(p,p')	11	NA	0.55
Pesticides	DDT(p,p')	11	NA	0.27
Pesticides	Dieldrin	11	NA	0.27
Pesticides	Dimethoate	11	NA	--
Pesticides	Endosulfan sulfate	11	NA	--
Pesticides	Endrin	11	--	--
Pesticides	Endrin Aldehyde	11	NA	--
Pesticides	Endrin Ketone	11	NA	--
Pesticides	Heptachlor	11	--	--
Pesticides	Heptachlor epoxide	11	0.09	0.45
Pesticides	Hexachlorobenzene	11	--	0.09
Pesticides	Methoxychlor	11	--	NA
Pesticides	Molinate	11	--	NA
Pesticides	Oxychlordane	11	NA	0.36
Pesticides	Simazine	11	--	NA
Pesticides	Thiobencarb	11	--	NA
Physical	Oxygen, Dissolved	0	nt	NA
Physical	pH	11	0.73	NA
Physical	SpecificConductivity	11	0.55	NA
Physical	Turbidity	11	0.64	NA

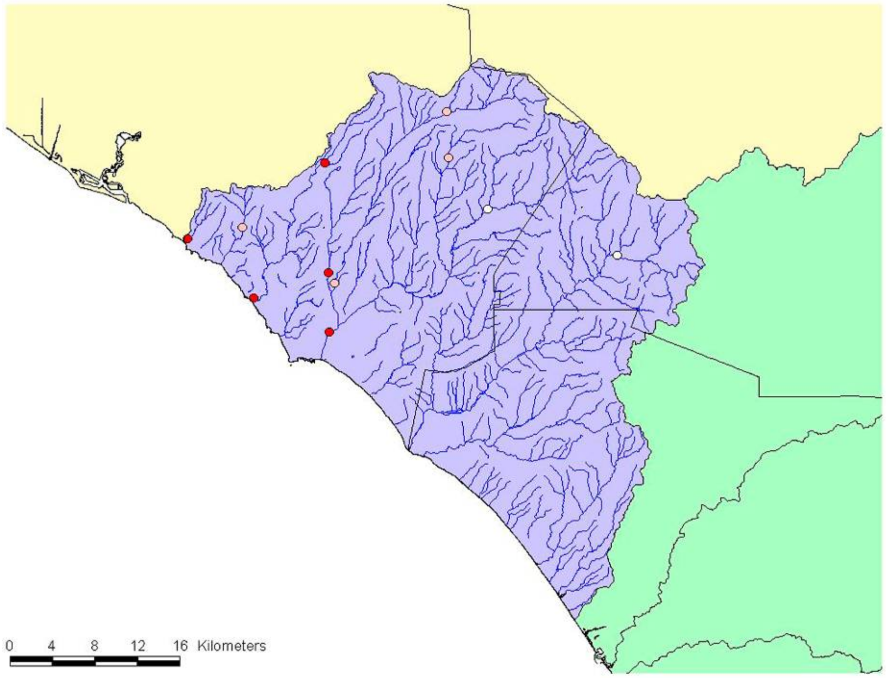


Figure 6. Map of aquatic life threshold exceedances for water chemistry at SWAMP sites. White circles indicate sites with one or fewer exceedances. Pink circles indicate sites with 2 to 5 exceedances. Red circles indicate sites with 6 to 9 exceedances. At all sites, 31 constituents were assessed.

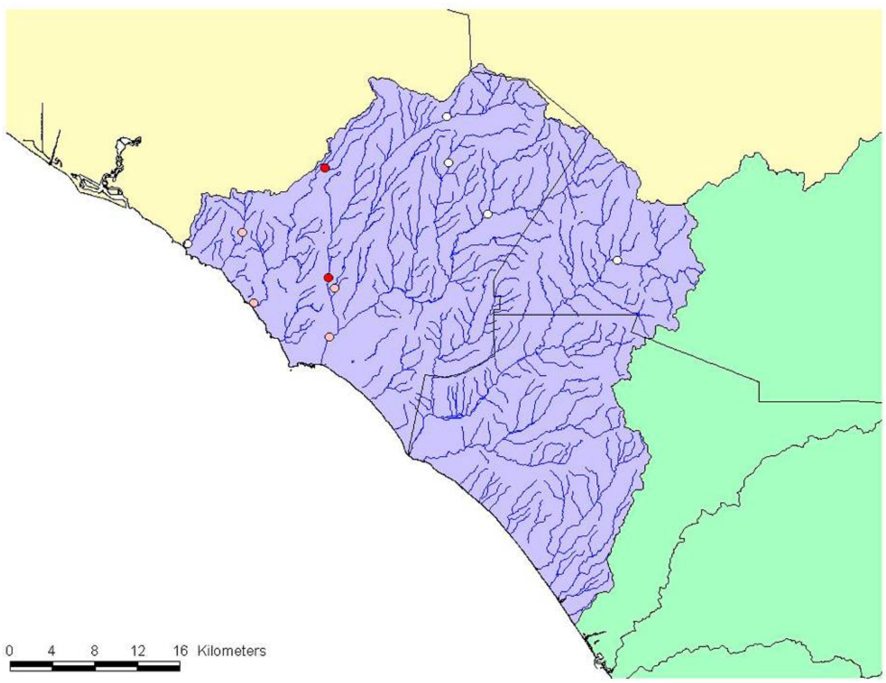


Figure 7. Map of human health exceedances for water chemistry at SWAMP sites. White circles indicate sites with one or fewer exceedances. Pink circles indicate sites with 2 to 5 exceedances. Red circles indicate sites with 6 to 9 exceedances. At all sites, 34 constituents were assessed.

All sites in San Juan HU exceeded certain aquatic life and human health thresholds (Table 12; Figure 6, 7). Aliso Creek (901SJALC6), English Creek, Morro Canyon Creek, Oso Creek, and the lower San Juan Creek (901SJSJC9) each had eight exceedances of aquatic life thresholds. Reference sites ranged from having few exceedances (one at San Mateo Creek), moderate (four at Upper Arroyo Trabuco Creek), to high (eight at Morro Canyon Creek) numbers of aquatic life threshold exceedances. A high number of human health exceedances (i.e., 8 or more) were observed at English Creek and Oso Creek.

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

Site	Aquatic life	Human health
901SJALC6	8	4
901SJATC2	4	1
901SJATC5	4	3
901SJBEL2	3	0
901SJENG2	8	10
901SJLAG2	4	4
901SJMCC2	8	1
901SJOSO3	8	8
901SJSJC5	1	0
901SJSJC9	8	4
901SJSMT2	1	1

Results from non-SWAMP water chemistry monitoring at 23 sites were similar to results from SWAMP (Table 10C and D, above). For example, specific conductivity and pH frequently exceeded aquatic life thresholds at nearly every site. In addition, non-SWAMP monitoring found that dissolved oxygen was generally within acceptable levels. However, cadmium and nickel exceeded thresholds at Narco Channel on nearly every sampling date.

4.2 Toxicity

Toxicity was evident at nearly every site within the watershed, although results varied among sites and indicators (Table 13; Figure 8; Appendix III). Severity was high at English Creek, Oso Creek, and Laguna Canyon Creek, which showed evidence of toxicity to all three indicator species on at least one sampling date. No toxicity was evident at Bell Canyon Creek, although sediment toxicity was not assessed at this site. Across the watershed, chronic toxicity was observed in 30% of 96 samples.

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 (--). A. Sites sampled under SWAMP. B. Sites sampled under OC NPDES.

A. SWAMP sites	*C. dubia*				*H. azteca*				*S. capricornutum*		Multiple indicators	
Site	Surival	n	Young/Female	n	Survival	n	Growth	n	Total cell count	n	Frequency	n
901SJALC6	--	3	--	3	0.25	4	--	3	0.75	4	0.30	10
901SJATC2	--	2	--	2	1.00	1	no survival	0	--	2	0.20	5
901SJATC5	--	4	--	4	--	3	0.33	3	0.75	4	0.36	11
901SJBEL2	--	2	--	2	not tested	0	not tested	0	--	2	0.00	4
901SJENG2	0.50	4	--	3	0.50	4	0.25	4	0.50	4	0.27	11
901SJLAG2	0.25	4	--	4	0.50	4	--	4	1.00	4	0.33	12
901SJMCC2	--	2	--	2	--	4	--	4	1.00	4	0.40	10
901SJOSO3	0.33	3	--	3	0.50	2	--	1	1.00	4	0.50	8
901SJSJC5	--	4	--	4	--	1	--	1	--	4	0.00	9
901SJSJC9	--	4	--	4	0.25	4	0.25	4	1.00	4	0.42	12
901SJSMT2	--	2	--	2	not tested	0	not tested	0	0.50	2	0.25	4
Mean of all sites	0.12	34	--	33	0.30	27	0.13	24	0.66	38	0.30	96

Table 13, continued. Frequency of toxicity.

B. Non-SWAMP sites	*C. dubia*				*H. azteca*		*S. capricornutum*		*P. promelas*			
Site	Survival	n	Growth	n	Survival	n	Total cell count	n	Survival	n	Growth	n
1	--	7	--	7	--	7	--	6	--	3	--	3
2	--	7	0.14	7	--	7	--	7	--	3	--	3
4	--	5	0.17	6	--	6	--	5		0		0
6	--	7	--	7	--	7	--	7		0		0
11	--	2	--	2	0.50	2	--	2	--	1	--	1
12	0.29	7	0.29	7	0.14	7	--	7	--	3	0.33	3
13	--	5	--	5	--	5	--	4		0		0
14	--	6	0.17	6	--	6	--	5	--	1	--	1
15	--	7	0.14	7	--	7	--	7		0		0
17	--	1	1.00	1	--	1	--	1		0		0
18	--	5	--	5	--	5	--	4		0		0
19	--	7	--	7	--	7	--	7		0		0
20	0.43	7	0.43	7	0.17	6	--	7		0		0
21	0.67	6	1.00	5	--	5	--	4		0		0
22	--	6	--	6	--	6	--	5		0		0
25	--	7	--	7	--	7	--	6		0		0
26	--	6	--	6	--	6	--	5		0		0

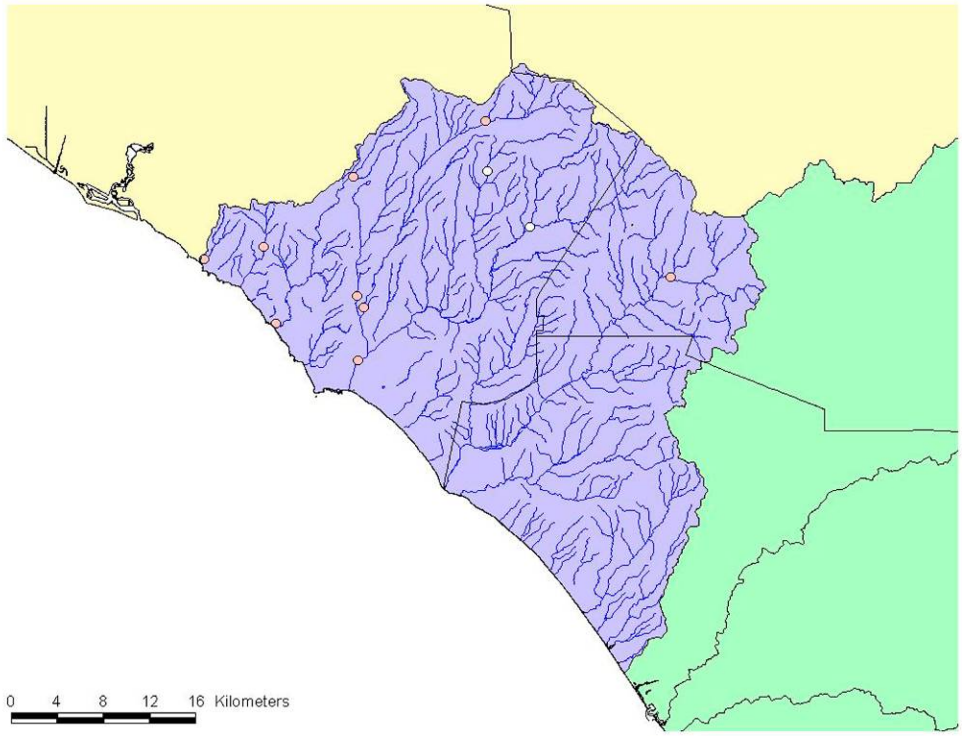


Figure 8. Frequency of toxicity (*C. dubia* fecundity, *H. azteca* growth, and *S. capricornutum* total cell count) at SWAMP sites. White circles indicate low frequency (0.0 to 0.1) of toxicity (this value did not occur in this watershed) . Pink circles indicate moderate frequency (0.1 to 0.5) of toxicity.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

S. capricornutum was the most sensitive 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 *S. capricornutum* at three sites, the Upper Arroyo Trabuco site (a designated reference site), the Upper San Juan Creek site, and Bell Canyon Creek. In contrast, at least half of all samples at all other sites were toxic to *S. capricornutum*, including the other two reference sites.

Toxicity tests using arthropod indicators showed widespread, but moderate toxicity to *H. azteca,* and more mild toxicity to *C. dubia.* Across the watershed, toxicity to *H. azteca* was observed at 7 sites. Although toxicity to *H. azteca* was not assessed at one of the reference sites (San Mateo Creek), no acute toxicity was observed at the other two. However, one sample from the Upper Arroyo Trabuco Creek reference site showed evidence of chronic toxicity in one sample. Across the entire watershed, 30% of samples were acutely toxic to *H. azteca.* Only three sites (Oso Creek, English Creek, and Laguna Canyon Creek) showed evidence of toxicity to *C. dubia.* Across the entire watershed, 12% of samples were acutely toxic to *C. dubia.*

4.3 Tissue

Analysis of fish tissue from Lower Arroyo Trabuco Creek did not find evidence of widespread impact (Table 14; Figure 9). Selenium did not exceed OEHHA thresholds. All other measured constituents lacked applicable thresholds. Every constituent occurred in higher concentration in crayfish tissue than sunfish tissue, particularly aluminum, cadmium, copper, and manganese. Nickel, which was not detected in either specimen, was an exception to this trend. Fish tissue concentrations of PCBs, PAHs, and pesticides were not assessed.

Table 14. Concentrations of contaminants in fish tissues collected at Aliso Creek (901SJALC6), compared with OEHHA thresholds.

Category	Constituent	Threshold	Unit	Red-ear sunfish	Crayfish
Metals	Ag		ppm	0.00	0.04
Metals	Al		ppm	0.22	96.10
Metals	As		ppm	0.12	0.44
Metals	Cd		ppm	0.01	0.18
Metals	Cr		ppm	0.10	0.18
Metals	Cu		ppm	0.35	13.10
Metals	Mn		ppm	1.6	55.1
Metals	Ni		ppm	0.00	0.00
Metals	Pb		ppm	0.00	0.04
Metals	Zn		ppm	11.2	15.3
Inorganics	Se	1.94	ppm	0.63	0.40

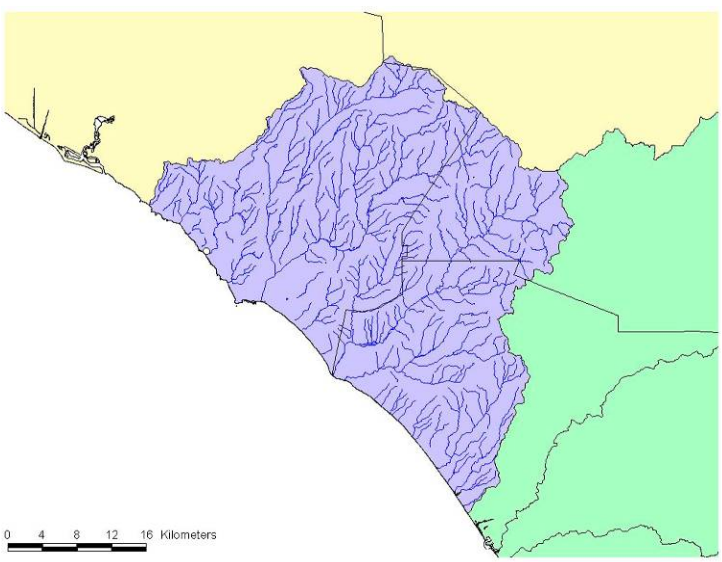


Figure 9. Fish tissue exceedances at SWAMP sites. White circles indicate 1 or fewer exceedances. Pink circles indicate 2 to 3 exceedances (this value did not occur in this watershed). Red circles indicate 4 to 5 exceedances (this value did not occur in this watershed).

4.4 Bioassessment

Biological health varied widely across the watershed. Mean annual IBI scores ranged from 7.1 (at Prima Deshecha, site 17) to 81.4 (Arroyo Trabuco Creek, site 4) (Table 15; Figure 10). Sites in poor or very poor condition were found throughout the watershed, including near designated SWAMP reference sites. However, high IBI scores were observed at most of the designated reference sites. In addition to site 4, Bell Canyon Creek (site 18) had IBI scores above 60 in both Spring and Fall. In general, headwater sites at the interior of the watersheds of San Juan and San Mateo Creeks had the highest IBI scores. In addition, a site in San Onofre Creek near the coast (site 23) also had a moderately high IBI score (50). There was no consistent effect of season in IBI scores, and the differences between seasons were slight for most sites (Table 15; Figure 11).

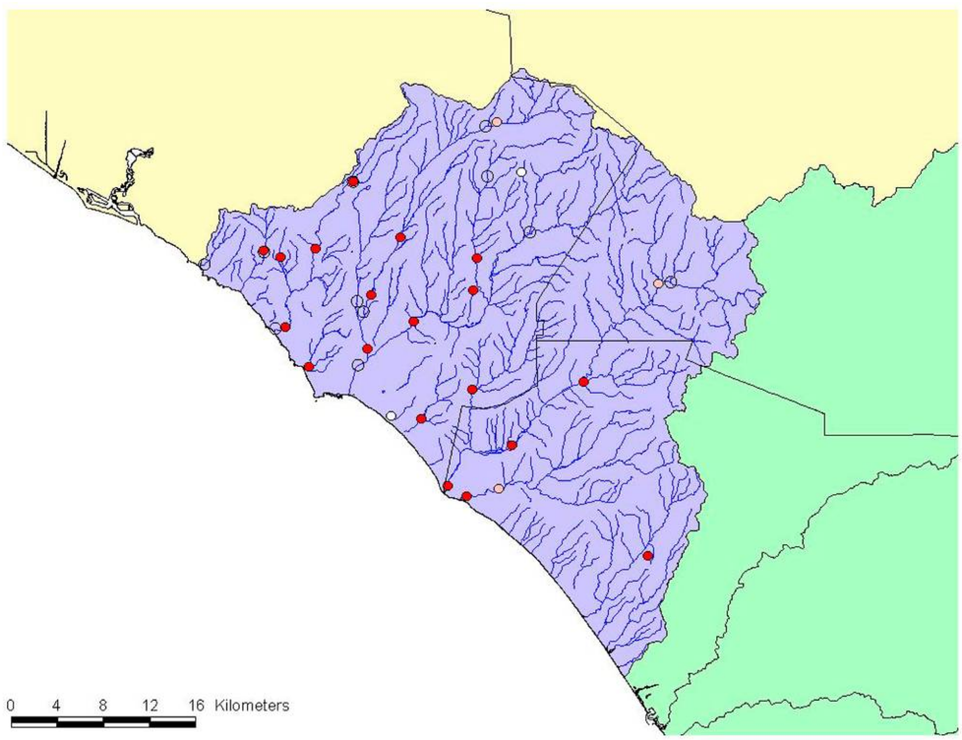


Figure 10. IBI scores at sites in the San Juan HU. White circles indicate good or very good (60 to 100) IBI scores. Pink circles indicate fair (40 to 60) IBI scores. Red circles indicate poor (0 to 40) IBI scores. Open circles represent 500-m buffers around SWAMP sites; five of these buffers included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

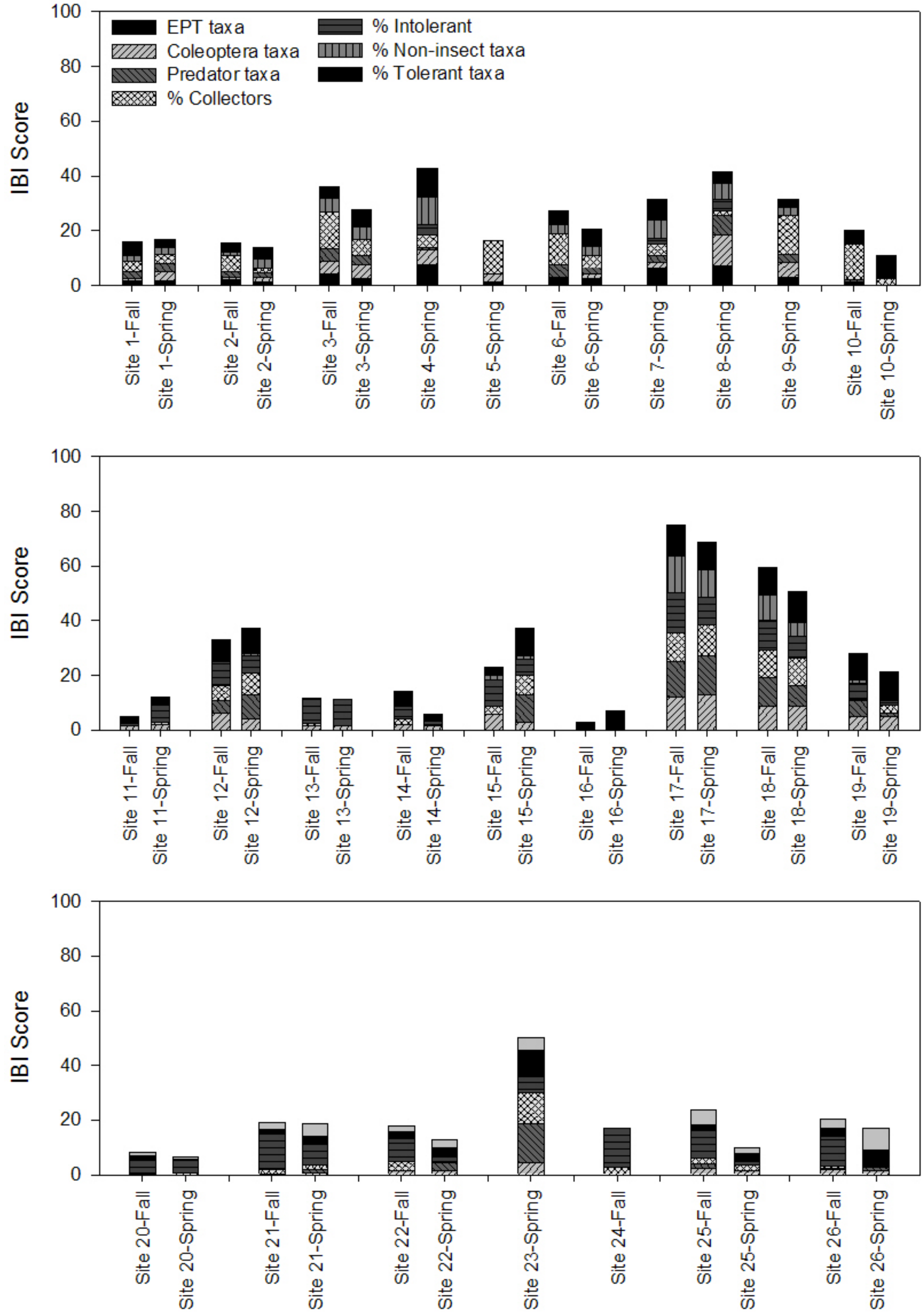


Figure 11. Mean IBI scores at each bioassessment site and each season. The height of the bar indicates the mean IBI score, and the size of each component of the bar represents the contribution of each metric to the IBI. Sites are split over three plots to improve clarity.

Table 15. Mean and standard deviation of IBI scores at bioassessment sites within the San Juan 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	13	1998-2005	16.4	0.4	Very poor	0.92
1	Fall	7	1998-2005	16.1	7.4	Very poor	1.00
1	Spring	6	1998-2005	16.7	17.8	Very poor	0.83
2	Average	12	1998-2005	14.9	1.2	Very poor	1.00
2	Fall	6	1998-2005	15.7	9.9	Very poor	1.00
2	Spring	6	1998-2005	14	8.6	Very poor	1.00
3	Average	6	1998-2000	31.9	6.1	Poor	0.67
3	Fall	3	1998-2000	36.2	3.6	Poor	0.67
3	Spring	3	1998-2000	27.6	14.5	Poor	0.67
4	Average	6	2001-2005	68	23	Good	0.17
4	Fall	2	2003-2005	84.3	12.1	Very good	0.00
4	Spring	4	2001-2005	51.8	18.6	Fair	0.25
5	Spring	2	2001-2001	16.4	3	Very poor	1.00
6	Average	12	1998-2005	23.8	4.8	Poor	1.00
6	Fall	5	1998-2005	27.1	3.4	Poor	1.00
6	Spring	7	1998-2005	20.4	4.8	Poor	1.00
7	Spring	4	2001-2005	31.4	13.7	Poor	0.75
8	Spring	1	2001-2001	41.4		Fair	0.00
9	Spring	1	2001-2001	31.4		Poor	1.00
10	Average	2	2005-2006	23.6	27.3	Poor	0.50
10	Fall	1	2005-2005	42.9		Fair	0.00
10	Spring	1	2006-2006	4.3		Very poor	1.00
11	Average	5	2001-2004	15.5	6.4	Very poor	1.00
11	Fall	2	2002-2004	20	2	Poor	1.00
11	Spring	3	2001-2001	11	3	Very poor	1.00
12	Average	6	2002-2005	12	3.3	Very poor	1.00
12	Fall	4	2002-2005	9.6	4.7	Very poor	1.00
12	Spring	2	2003-2005	14.3	2	Very poor	1.00
13	Average	4	2003-2005	39.6	4.5	Poor	0.50
13	Fall	2	2003-2005	36.4	13.1	Poor	0.50
13	Spring	2	2003-2005	42.9	6.1	Fair	0.50
14	Average	5	2002-2005	14.5	0.3	Very poor	1.00
14	Fall	4	2002-2005	14.6	6.6	Very poor	1.00
14	Spring	1	2005-2005	14.3		Very poor	1.00
15	Average	6	2002-2005	17	6.8	Very poor	1.00
15	Fall	4	2002-2005	21.8	6.2	Poor	1.00
15	Spring	2	2003-2005	12.1	3	Very poor	1.00
16	Average	4	2004-2006	36.8	0.5	Poor	0.50
16	Fall	2	2004-2005	36.4	9.1	Poor	0.50
16	Spring	2	2005-2006	37.1	14.1	Poor	0.50
17	Average	2	2002-2003	7.1	6.1	Very poor	1.00
17	Fall	1	2002-2002	2.9		Very poor	1.00
17	Spring	1	2003-2003	11.4		Very poor	1.00
18	Average	4	2003-2005	65.7	5.1	Good	0.00
18	Fall	2	2004-2005	69.3	9.1	Good	0.00
18	Spring	2	2003-2005	62.1	9.1	Good	0.00
19	Average	6	2002-2005	33.8	3.3	Poor	0.83
19	Fall	4	2002-2005	36.1	11.1	Poor	0.75
19	Spring	2	2003-2005	31.4	2	Poor	1.00

Table 15, continued. Mean and standard deviations of IBI scores.

Site	Season	n	Years	IBI Mean	SD	Condition	Frequency
20	Average	6	2002-2005	7.3	1.3	Very poor	1.00
20	Fall	4	2002-2005	8.2	7.9	Very poor	1.00
20	Spring	2	2003-2005	6.4	5.1	Very poor	1.00
21	Average	6	2002-2005	18.9	0.5	Very poor	1.00
21	Fall	4	2002-2005	19.3	5.5	Very poor	1.00
21	Spring	2	2003-2005	18.6	4	Very poor	1.00
22	Average	6	2002-2005	15.4	3.5	Very poor	1.00
22	Fall	4	2002-2005	17.9	12.4	Very poor	1.00
22	Spring	2	2003-2005	12.9	4	Very poor	1.00
23	Spring	1	2005-2005	50		Fair	0.00
24	Average	3	2004-2006	27.9	1	Poor	0.67
24	Fall	2	2004-2005	28.6	16.2	Poor	0.50
24	Spring	1	2006-2006	27.1		Poor	1.00
25	Average	6	2002-2005	17	9.8	Very poor	1.00
25	Fall	4	2002-2005	23.9	10.6	Poor	1.00
25	Spring	2	2003-2005	10	0	Very poor	1.00
26	Average	6	2002-2005	18.8	2.3	Very poor	1.00
26	Fall	4	2002-2005	20.4	2.1	Poor	1.00
26	Spring	2	2003-2005	17.1	0	Very poor	1.00

The EPT taxa metric appeared to be most sensitive component of the IBI, as it only contributed to the IBI at high scoring sites (Figure 11; Appendix IV). In contrast, the % collector and % tolerant taxa were a large component of the total IBI score at all sites, including those with very low IBI scores (e.g., Segunda Deshecha, site 21).

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, Camp Pendleton, or the California Department of Fish and Game.

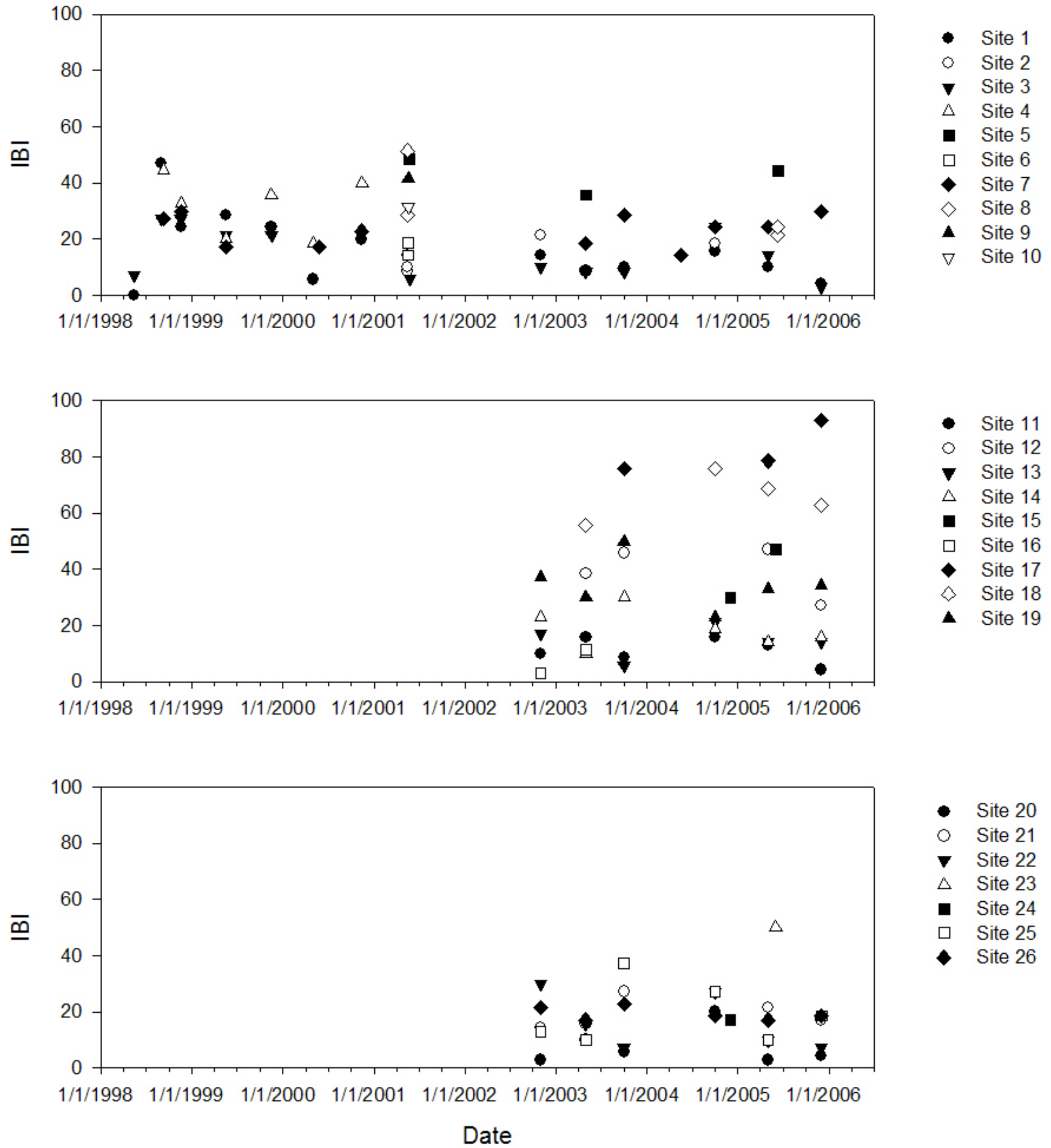


Figure 12. IBI values for each year and site. Each symbol represents a single sampling event. Sites are split over three plots to improve clarity.

4.5 Physical Habitat

Physical habitat varied among sites throughout the watershed, although human alteration was evident at every site visited. San Mateo Creek had very good physical habitat, with a mean physical habitat score of 19.6. Bell Canyon Creek also had very good physical habitat, receiving a score greater than 15 for every component of physical habitat. However, six sites in the San Juan HU received scores below 10, indicating that degraded physical habitat was widespread. More heavily degraded sites were concentrated in the northern and coastal portions of the HU. For example, Laguna Canyon Creek, Morro Canyon Creek, and Oso Creek all had mean physical habitat scores below 7. In contrast, sites at the interior or southern portions were less degraded. (Table 16; Figure 13).

Table 16. Score and mean for each component of physical habitat. Component range: 0 (heavily impacted habitat) to 20 (unimpacted habitat). A. SWAMP sites. B. Non-SWAMP sites.

A. SWAMP sites		Phab 1	Phab 2	Phab 3	Phab 4	Phab 5	Phab 6	Phab 7	Phab 8	Phab 9	Phab 10	
		Epifaunal		Velocity-	Sediment	Channel	Channel	Riffle	Bank	Vegetation	Riparian	Mean
Sitecode	Date	cover	Embeddedness	depth regime	deposition	flow	alteration	frequency	stability	protection	zone	score
901SJALC6	3/29/2002	8	8				10	7	13	13	13	10.3
901SJATC2	4/10/2003	15	17	14	18	15	14	18	7	9.5	8.5	13.6
901SJATC5	3/29/2002	13	8	9	4				1	10	13	8.3
901SJBEL2	2/1/2002	17	16	15	18	16	20	19	19	20	19	17.9
901SJENG2	10/11/2002	9	4	11	13	12	3	16	3	4	2	7.7
901SJLAG2	3/29/2002	5		5					8	5		5.8
901SJMCC2	3/29/2002	8		3	3	3	16	3	3	16		6.9
901SJOSO3	10/11/2002	3	0	6	6	17	0	3	19	9	0	6.3
901SJSJC5	10/4/2002	13	3	3	16	5	19	3	17	19	19	11.7
901SJSJC9	3/29/2002	10	15	8	10		5	12		0	0	7.5
901SJSMT2	10/4/2002	20	17				20	20	20	20	20	19.6
Mean of all sites		13.7	10.6	8.8	15.1	12.8	14.6	14.3	14.2	13.9	13.3	12.9

Table 16, continued. Mean scores and standard deviations for each component of physical habitat.

B. Non-SWAMP sites			Phab 1		Phab 2		Phab 3		Phab 4		Phab 5		Phab 6		Phab 7		Phab 8		Phab 9		Phab 10		
			Epifaunal				Velocity-		Sediment		Channel		Channel		Riffle		Bank		Vegetation		Riparian		
			cover		Embeddedness		depth regime		deposition		flow		alteration		frequency		stability		protection		zone		Mean
Site	n	Years	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Score
1	8	2002-2006	13.5	1.6	13.4	3.6	15.8	2	14.3	3.6	16.5	2.7	5.4	2.3	12.9	2.2	16.1	2	10.3	1.7	5.8	2.3	12.4
2	8	2002-2006	12.8	1.9	13.4	2.3	11.3	2.3	11.8	3.2	15.9	2.5	10	0.8	11.9	2.4	14.5	1.4	12.1	2.2	12	1.9	12.6
4	6	2003-2006	18.7	1.2	18.8	1	17	3.5	18.8	1	14.2	6	18.3	2.3	19.3	0.5	17.5	0.8	12.7	3.3	18.2	3.5	17.4
6	7	2003-2006	13.6	1.9	12.7	2.3	13.1	2.8	12.4	3.3	13.3	3.8	16.3	2.1	12	3.8	13.7	2.9	16.3	2.4	15.4	1.9	13.9
11	3	2002-2006	13.3	3.1	15	3	10.3	1.5	13	3.5	12.3	5.5	18.3	1.2	13.3	4.2	15.3	1.2	10.3	3.8	16	3	13.7
12	8	2002-2006	12.1	2.4	13.4	3	13.8	4.6	13.4	3.7	17.3	1.3	11.6	3.5	6.9	1.4	11.9	3.2	15.6	2.4	15.8	2.8	13.2
13	5	2003-2005	11	3	8.4	5.9	8.4	2.7	8	2.3	7.4	2.2	19.6	0.5	9.8	4.7	15	3	19.4	0.9	19.4	0.9	12.6
14	7	2002-2006	11.4	1.8	11.6	2.8	12.4	1.5	9.9	2.9	12.3	2.3	6.6	0.8	14.3	2.6	16.3	1.4	4.3	1.4	4.4	1.6	10.3
15	8	2002-2006	15.8	2.7	15.9	2.6	13.4	1.9	15.9	1.8	13.4	3.5	9.8	2.6	13.6	3.1	9.8	4.3	10	3.9	3.8	1.5	12.1
17	2	2002-2006	2	0	3	2.8	6.5	2.1	4	0	11	1.4	1	0	6.5	2.1	20	0	1	1.4	1	1.4	5.6
18	6	2003-2006	18.3	0.5	18.3	1	13.7	4.7	19	0	14.5	6.2	18.5	1.2	15.7	6.4	17.7	0.8	15.7	3.7	19	0	17
19	8	2002-2006	17	1.8	15.9	2.1	13.4	2.6	17.6	1.4	13.6	4.1	19.3	1.8	14.6	3.3	17.4	1.2	15.4	1.8	19.1	1.2	16.3
20	8	2002-2006	12.3	4.3	12.4	4.2	14.8	1.3	14.4	2.6	14.1	4.4	8	3	11	1.8	7.1	3.2	11.6	2.3	5	1.1	11.1
21	8	2002-2006	9.1	3.6	7.6	6.6	11.4	2.8	11.1	5.5	13.4	3.1	9.5	1.9	5.9	1.6	17.1	2.1	10	2.8	8.9	2.1	10.4
22	7	2002-2005	12.3	2.5	13.3	1.3	12.6	2.6	11.4	4.5	13.3	3.2	7.1	1.9	13	1	11.3	5.1	8	2	5.3	1	10.8
25	8	2002-2006	15.1	1.1	13.8	2.8	14.6	1.5	16.4	1.1	14.9	3	14.5	4	13.3	1.8	14.4	2.6	14.8	2.4	10.4	2.4	14.2
26	8	2002-2006	11.5	4	11.8	2.6	10.4	2.5	10	2.6	13.9	2	3.5	1.8	15	3.2	19.8	0.7	2.8	2.1	1.8	0.5	10

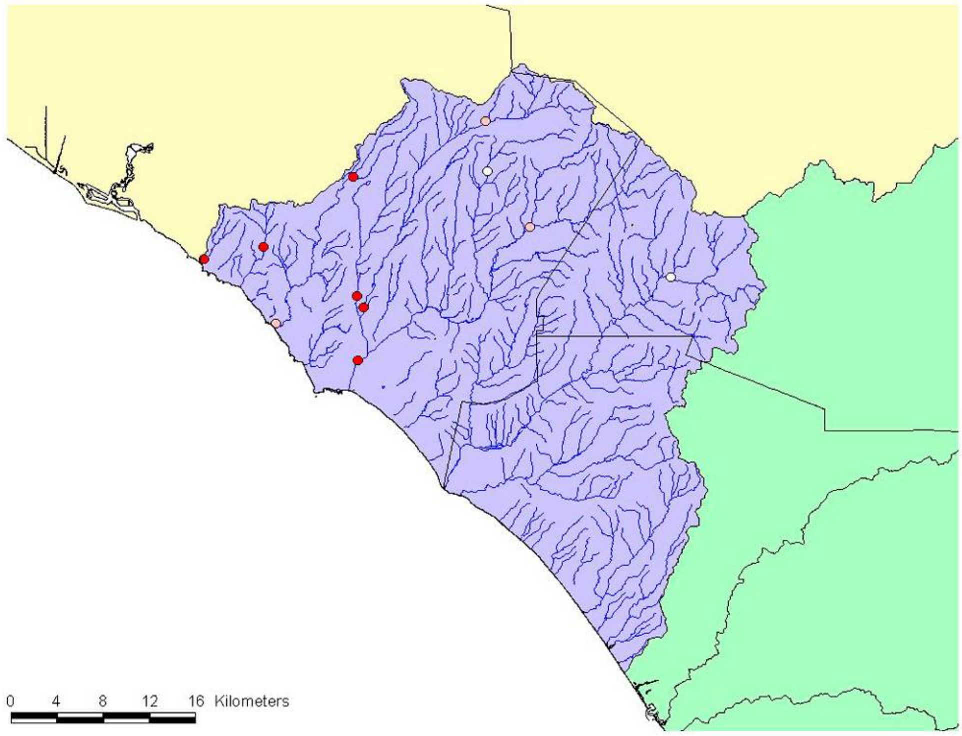


Figure 13. Assessment of physical habitat at SWAMP sites. White circles indicate sites with a mean physical habitat scores between 15 and 20. Pink circles indicate mean scores between 10 and 15. Red circles indicate mean scores between 0 and 10.

Embeddedness and poor velocity-depth regimes appeared to be the most widespread impacts to physical habitat. For example, although embeddedness was minimal at four of the sites (i.e., physical habitat component score was greater than 15), the remaining sites were strongly impacted (i.e. score was less than 10). Every component of physical habitat showed signs of severe degradation (i.e., score was 5 or less) at multiple sites in the watershed.

Results from monitoring by Orange County NPDES were similar, in that mean physical habitat scores were high (i.e., > 15) at reference sites (sites 4, 18, 19), and lowest (i.e., <10) at northern and coastal portions of the watershed (e.g., site 17, in Prima Deshecha). Although sites were monitored over several years (often 5), values changed little, and standard deviations were typically under 4.

5. DISCUSSION

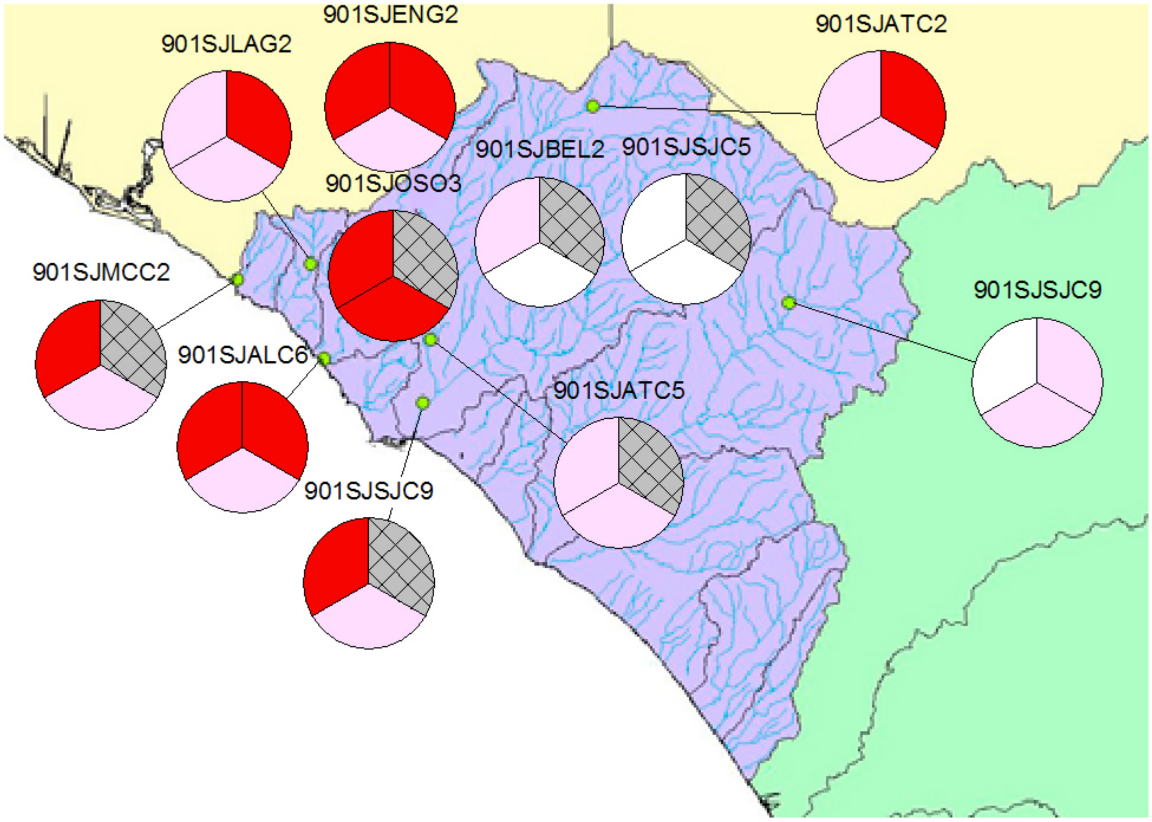
This analysis of the San Juan HU suggests that the northern and coastal portions of the watershed are in poor ecological health, but the condition of streams in the southern and interior portions are moderate to good. However, every site sampled under SWAMP in the San Juan HU showed evidence of impact from multiple indicators (Table 17; Figure 14). These impacts ranged from very sight (e.g., the Upper Arroyo Trabuco Creek reference site) to severe (e.g., English Creek).

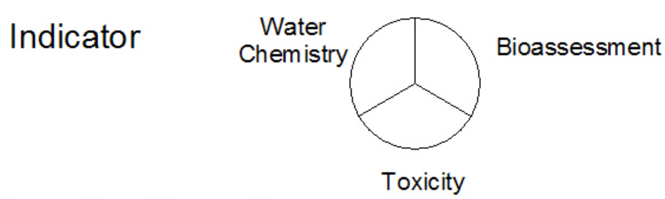
Table 17. Summary of the ecological health for five SWAMP sites in San Juan HU. Aquatic life (AL). Human health (HH). Toxicity frequency is frequency of toxicity for three chronic toxicity endpoints: *C. dubia* (fecundity), *H. azteca* (growth), and *S. capricornutum* (total cell count). Biology frequency is the frequency of IBIs below 40. n.t. = Indicator not tested.

	Water chemistry		Tissue	Toxicity	Biology	Physical habitat
Site	# constituents (AL)	# constituents (HH)	# constituents (OEHHA)	Frequency	Frequency	Mean score
901SJALC6	8	4	0	0.30	0.92*	10.3
901SJATC2	4	1	n.t.	0.20	1.00*	13.6
901SJATC5	4	3	n.t.	0.36	n.t.	8.3
901SJBEL2	3	0	n.t.	0.00	n.t.	17.9
901SJENG2	8	10	n.t.	0.27	1.00*	7.7
901SJLAG2	4	4	n.t.	0.33	1.00*	5.8
901SJMCC2	8	1	n.t.	0.40	n.t.	6.9
901SJOSO3	8	8	n.t.	0.50	n.t.	6.3
901SJSJC5	1	0	n.t.	0.00	n.t.	11.7
901SJSJC9	8	4	n.t.	0.42	n.t.	7.5
901SJSMT2	1	1	n.t.	0.25	0.00*	19.6

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

The Laguna Creek hydrologic subarea, in the northern portion of the hydrologic unit, contained several sites in poor ecological health, including the reference site at Morro Canyon Creek. Water chemistry at this site exceeded aquatic life thresholds for numerous constituents. Furthermore, toxicity to *S. capricornutum* was observed at every sampling date at this site. In addition, physical habitat received a very low score at this site (6.9). The data collected by SWAMP do not support the designation of Morro Canyon Creek as a reference site.





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 San Juan 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.

Other sites in the Laguna Creek hydrologic subarea were also in poor ecological health. Laguna Canyon Creek, Aliso Creek, and English Creek all had many (i.e., 8) water chemistry constituents in exceedance of aquatic life thresholds. Furthermore, English Creek also exceeded a high number of human health thresholds (8 and 10, respectively). These results were consistent with the inclusion of these streams on the 303(d) list of impaired water bodies; for example, known stressors like phosphorus, benzo(b)fluoranthene, and dieldrin exceeded thresholds at these sites. Toxicity was also evident throughout this region. Samples from all sites were toxic to *S. capricornutum*, and all but Morro Canyon Creek were toxic to *H. azteca* as well. Toxicity to *C. dubia* was observed at two sites in the Laguna Creek hydrologic subarea (i.e., English Creek and Laguna Canyon Creek), but at only one other site in the San Juan HU. These results are consistent with the listing of toxicity as a stressor at Aliso, English, and Laguna Canyon Creeks on the 303(d) list. All bioassessment samples collected within this area were in poor or very poor condition, and physical habitat ranged from moderately (i.e., Aliso Creek) to severely degraded (all other sites). Fish tissues collected from Aliso Creek did not show evidence of impact, although few constituents were measured, only one of which (i.e., Selenium) had an applicable threshold to detect impact. Water chemistry monitoring by NPDES permittees found additional water chemistry constituents, such as Cadmium, that exceed aquatic life thresholds in the watershed.

The Mission Viejo hydrologic area (i.e., San Juan Creek watershed) included many sites representing a wide range of ecological health. Oso Creek, a tributary to the San Juan Creek, was in very poor condition, comparable to many sites in the Laguna Creek hydrologic subarea. Eight water chemistry constituents exceeded both aquatic life and human health thresholds, and toxicity to all indicator species was observed on at least one sampling date. Physical habitat was also degraded at Oso Creek. Conditions were marginally less impacted at the downstream San Juan Creek site, which also had a high number (8) of aquatic life threshold exceedances. p,p’-DDE exceeded thresholds in half the samples at the downstream site, supporting the listing of DDE as a known stressor at San Juan Creek on the 303(d) list. Water and sediment samples from this site were toxic to both *S. capricornutum* and *H. azteca,* but not *C. dubia.* Physical habitat at the downstream San Juan Creek site, like Oso Creek, received one of the lowest scores in the HU. Ecological health was better at sites further inland. For example, the Upper San Juan Creek site had water chemistry comparable to reference sites, with only one constituent exceeding aquatic life thresholds. In addition, toxicity was never observed at this site. However, physical habitat was moderately degraded at this site, as embeddedness, velocity-depth regime, and channel flow all received physical habitat scores of 5 or lower. The health of other sites in the San Juan watershed was intermediate between the upper San Juan Creek site and Oso Creek. For example, toxicity was not observed at Bell Canyon Creek, but a moderate number (3) of water chemistry constituents exceeded aquatic life thresholds. This site also had very good physical habitat, with a mean score of 17.9. Bioassessment samples collected elsewhere from Bell Canyon Creek ranged from good (site 18) to very poor (site 5). Toxicity was moderately higher at other sites, such as those on Arroyo Trabuco Creek, and water chemistry slightly more impacted. Bioassessment samples collected nearby designated reference site on Arroyo Trabuco Creek (site 4) were in very good condition, although low IBI scores were sometimes observed, perhaps due to natural variability.

The reference site in the San Mateo watershed was in good ecological health. Only one water chemistry constituent exceeded aquatic life thresholds, and toxicity was not frequently observed. Physical habitat was extremely good at the San Mateo Creek site, with nearly all components of physical habitat receiving perfect scores (i.e. 20). However, the bioassessment sample collected near this site was in fair condition (IBI 41.4). This low IBI score may be caused by natural variability, and additional sampling may yield higher IBI scores, or it may indicate low-level impacts which have not yet caused major degradation of the site. All bioassessments in the lower part of the watershed were in poor or very poor ecological condition.

Bioassessment monitoring in other hydrologic areas of the San Juan HU (e.g., San Onofre hydrologic area) found poor ecological health at most sites. Apart from one site in San Onofre Creek (site 23), all bioassessment samples were in poor or very poor ecological condition, and had IBI scores below 40.

This study's assessment of the San Juan HU suggests that the northern and coastal portions of the watershed are in poor ecological health, but the inland and southern portions (particularly San Juan and San Mateo Creeks, and to a lesser extent San Onofre Creek) are in moderate to good health. Multiple lines of evidence support this conclusion. For example, several water chemistry constituents exceeded aquatic life and human health thresholds, in the northern and coastal portions. Toxicity was observed at every site in this area, but not at some sites in the interior of the San Juan Creek watershed. Bioassessment samples were in very poor ecological health along the northern and coastal regions, but fair or good at the interior. Physical habitat was degraded at coastal and northern sites but less so in the interior.

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 conclusion that portions of the San Juan HU are in poor ecological health.

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). Although three reference sites were designated for monitoring under SWAMP (and four for monitoring under NPDES permittees and Camp Pendleton), it is unclear if the proportion of reference sites sampled reflect the proportion of minimally degraded streams in the HU.

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 one site, and only a small number of constituents were evaluated; therefore, tissue contamination may have gone undetected in unsampled regions of the watershed. Although SWAMP has produced a wealth of data about the San Juan 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 northern and coastal portions San Juan HU are in poor ecological health, and that the southern and interior portions are in good 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.

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.

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. *Journal 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. 2006. Stream bioassessment December 2005 survey data summary report. County of Orange. Santa Ana, CA.

Weston Solutions Inc. 2007. Stream bioassessment of the Camp Pendleton Watersheds. 2005/2006 monitoring surveys. Final Report. US Navy—Naval Facilities Engineering Services Center. Camp Pendleton, CA.

7. APPENDICES

APPENDIX I

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

A. Beneficial uses of streams in the San Juan HU.

San Juan Watershed (901)	HUC	MUN	AGR	IND	REC1	REC2	WARM	COLD	WILD	RARE	SPWN
Orange County coastal streams											
Moro canyon	901.11	X	E		P	E	E		E		
Unnamed intermittent coastal streams	901.11	X	E		P	E	E		E		
Emerald Canyon	901.11	X	E		P	E	E		E		
Laguna Canyon	901.12	X	E		P	E	E		E		
Blue Bird Canyon	901.12	X	E		P	E	E		E		
Rim Rock Canyon	901.12	X	E		P	E	E		E		
Unnamed intermittent coastal streams	901.13	X	E		P	E	E		E		
Hobo Canyon	901.13	X	E		P	E	E		E		
Aliso Creek Watershed											
Aliso Creek											
English Canyon Creek	901.13	X	E		P	E	E				
Sulphur Creek	901.13	X	E		P	E	E				
Wood Canyon	901.13	X	E		P	E	E				
Dana Point Watershed											
Unnamed intermittent coastal streams	901.14	X	E		P	E	E		E		
Salt Creek	901.14	X	E		P	E	E		E		
San Juan Canyon	901.14	X	E		P	E	E		E		
Arroyo Salada	901.14	X	E		P	E	E		E		
San Juan Creek Watershed											
San Juan Creek	901.25	X	E	E	E	E	E	E	E		
Morrel Canyon	901.25	X	E	E	E	E	E	E	E		
Decker Canyon	901.25	X	E	E	E	E	E	E	E		
Long Canyon	901.25	X	E	E	E	E	E	E	E		
Lion Canyon	901.25	X	E	E	E	E	E	E	E		E
Hot Spring Canyon	901.25	X	E	E	E	E	E	E	E		E
Cold Spring Canyon	901.25	X	E	E	E	E	E	E	E		
Lucas Canyon	901.25	X	E	E	E	E	E	E	E		
Aliso Canyon	901.25	X	E	E	E	E	E	E	E		
Verdugo Canyon	901.25	X	E	E	E	E	E	E	E		
Bell Canyon	901.25	X	E	E	E	E	E	E	E		
Fox Canyon	901.25	X	E	E	E	E	E	E	E		
Dove Canyon	901.24	X	E	E	E	E	E	E	E		
Crow Canyon	901.25	X	E	E	E	E	E	E	E		
San Juan Creek	901.26	X	E	E	E	E	E	E	E		
Trampas Canyon	901.26	X	E	E	E	E	E	E	E		
Canada Gobernadora	901.24	X	E	E	E	E	E	E	E		
Canada Chiquita	901.24	X	E	E	E	E	E	E	E		
San Juan Creek	901.28	X	E	E	E	E	E	E	E		
San Juan Creek	901.27	X	E	E	E	E	E	E	E		
Horno Creek	901.27	X	E	E	E	E	E	E	E		
Arroyo Trabuco Creek	901.22	X	E	E	E	E	E	E	E		E
Holy Jim Canyon	901.22	X	E	E	E	E	E	E	E		E
Falls Canyon	901.22	X	E	E	E	E	E	E	E		
Rose Canyon	901.22	X	E	E	E	E	E	E	E		
Hickey Canyon	901.22	X	E	E	E	E	E	E	E		
Live Oak Canyon	901.22	X	E	E	E	E	E	E	E		
Arroyo Trabuco Creek	901.23	X	E	E	E	E	E	E	E		
Tijeras Canyon	901.23	X	E	E	E	E	E	E	E		
Arroyo Trabuco Creek	901.27	X	E	E	E	E	E	E	E		
Oso Creek	901.21	X	E	E	E	E	E	E	E		
La Paz Creek	901.21	X	E	E	E	E	E	E	E		

Appendix Ia, continued.

San Juan Watershed (901)	HUC	MUN	AGR	IND	REC1	REC2	WARM	COLD	WILD	RARE	SPWN
Orange County Coastal Streams											
Prima Deshecha Canada	901.31	X	E		P	E	E		E		
Unnamed intermittent coastal streams	901.3	X	E		P	E	E		E		
Segunda Deshecha Canada	901.32	X	E		P	E	E		E		
San Mateo Creek Watershed											
San Mateo Creek	901.4	X			P	E	E	E	E	E	E
Devil Canyon	901.4	X			P	E	E	E	E		E
Cold Spring Canyon	901.4	X			P	E	E	E	E		
San Mateo Canyon	901.4	X			P	E	E	E	E	E	E
Los Alamos Canyon	901.4	X			P	E	E	E	E		E
Wildhorse Canyon	901.4	X			P	E	E	E	E		
Tenaja Canyon	901.4	X			P	E	E	E	E		E
Bluewater Canyon	901.4	X			P	E	E	E	E		
Nickel Canyon	901.4	X			P	E	E	E	E		
Christanitos Creek	901.4	X			P	E	E	E	E		
Gabino Canyon	901.4	X			P	E	E	E	E		
La Paz Canyon	901.4	X			P	E	E	E	E		
Blind Canyon	901.4	X			P	E	E	E	E		
Talega Canyon	901.4	X			P	E	E	E	E		
San Onofre Creek Watershed											
San Onofre Creek	901.51	X	E		E	E	E	E	E		E
San Onofre Canyon North Fork	901.51	X	E		E	E	E	E	E		E
Jardine Canyon	901.51	X	E		E	E	E	E	E		
San Onofre Canyon	901.51	X	E		E	E	E	E	E		E
San Onofre Canyon South Fork	901.51	X	E		E	E	E	E	E	E	
Unnamed intermittent coastal streams	901.51	X	E		E	E	E		E		
Foley Canyon	901.51	X	E		E	E	E		E		
Horno Canyon	901.51	X	E		E	E	E		E		
Las Flores Creek	901.52	X	E		E	E	E	E	E	E	
Piedra de Lumbre Canyon	901.52	X	E		E	E	E	E	E	E	
Unnamed intermittent coastal streams	901.52	X	E		E	E	E		E		
Aliso Canyon	901.53	X	E		E	E	E	E	E	E	
French Canyon	901.53	X	E		E	E	E		E	E	
Cocklebur Canyon	901.53	X	E		E	E	E		E		

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

Name	HUC	Stressor	Potential source	Affected length
Aliso Creek	901.13	Indicator bactera	Urban runoff/storm sewers, unknown point source, and nonpoint/point source	19 miles
		Phosphorus	Urban runoff/storm sewers, unknown point source, and nonpoint/point source	19 miles
		Toxicity	Urban runoff/storm sewers, unknown point source, and nonpoint/point source	19 miles
English Canyon	901.13	Benzo(b)fluoranthene	Sources unknown	3.6 miles
		Dieldrin	Sources unknown	3.6 miles
		Sediment toxicity	Sources unknown	3.6 miles
Laguna Canyon Channel	901.12	Sediment toxicity	Sources unknown	1.6 miles
Oso Creek (at Mission Viejo Golf Course)	901.2	Chloride	Sources unknown	1 miles
		Sulfates	Sources unknown	1 miles
		Total dissolved solids	Sources unknown	1 miles
Prima Deshecha Creek	901.3	Phosphorus	Urban runoff/storm sewers, unknown point source, and nonpoint/point source	1.2 miles
		Turbidity	Urban runoff/storm sewers, unknown point source, and nonpoint/point source	1.2 miles
San Juan Creek	901.2	DDE	Sources unknown	1 miles
		Indicator bactera	Nonpoint/point source	1 miles
Segunda Deshecha Creek	901.3	Phosphorus	Urban runoff/storm sewers, unknown point source, and nonpoint/point source	0.92 miles
		Turbidity	Construction/land development, urban runoff/storm sewers, channelization, flow regulation/modifications, unknown nonpoint source, unknown point source	0.92 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 to 2003. Non-SWAMP sites were monitored in Spring and Fall between 2002 and 2006.

A. SWAMP sites

			901SJALC6			901SJATC2			901SJATC5			901SJBEL2			901SJENG2			901SJLAG2		
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	180	71	4	112	80	2	186	45	4	162	22	2	179	98	4	309	119	4
Inorganics	Ammonia as N	mg/l	0.09	0.11	4	0.1	0.14	2	0.02	0.03	4	0.03	0.04	2	0.48	0.72	4	0.03	0.03	4
Inorganics	Nitrate + Nitrite as N	mg/l	0.52	0.35	4	0.54	0.35	2	0.1	0.1	4	0.1	0.03	2	0.4	0.24	4	0.16	0.13	4
Inorganics	Nitrate as N	mg/l	0.51	0.34	4	0.53	0.34	2	0.1	0.1	4	0.1	0.03	2	0.37	0.22	4	0.16	0.12	4
Inorganics	Nitrite as N	mg/l	0.02	0.02	4	0.01	0.02	2	--	--	4	--	--	2	0.03	0.03	4	0.01	0.01	4
Inorganics	Nitrogen, Total Kjeldahl	mg/l	0.69	0.38	4	1.84	2.27	2	0.29	0.27	4	0.23	0.15	2	1.16	1.13	4	1.03	0.94	4
Inorganics	OrthoPhosphate as P	mg/l	0.17	0.07	4	0.1	0.11	2	0.04	0.02	4	0.03	0.01	2	0.17	0.08	4	0.19	0.05	4
Inorganics	Phosphorus as P,Total	mg/l	0.24	0.16	4	0.71	1	2	0.1	0.11	4	0.08	0.11	2	0.28	0.25	4	0.21	0.05	4
Inorganics	Selenium,Dissolved	µg/l	22	22.1	4	2.8	0.4	2	1.5	0.8	4	3.1	0.1	2	5.5	3.8	4	2	1.1	4
Inorganics	Sulfate	mg/l	943	513	4	105	59	3	183	47	4	151	16	2	298	191	4	212	90	4
Metals	Aluminum,Dissolved	µg/l	1.6	0.7	4	0.5	0.8	2	0.8	1.3	4	0.4	0.6	2	1.6	1.6	4	1.5	2.4	4
Metals	Arsenic,Dissolved	µg/l	7.7	5.3	4	1.4	0.4	2	2.9	0.8	4	0.9	0.2	2	3.1	1.2	4	3.2	0.3	4
Metals	Cadmium,Dissolved	µg/l	0.62	0.25	4	0.05	0.01	2	0.04	0.01	4	0.02	0.01	2	0.23	0.13	4	0.05	0.01	4
Metals	Chromium,Dissolved	µg/l	0.63	0.3	4	0.1	0.14	2	0.15	0.1	4	--	--	2	0.24	0.06	4	0.23	0.11	4
Metals	Copper,Dissolved	µg/l	6.94	2.21	4	1.83	0.12	2	2.1	0.52	4	1.51	0.24	2	4.27	0.81	4	2.55	0.73	4
Metals	Lead,Dissolved	µg/l	0.02	0.01	4	0.01	0.01	2	0.02	0.02	4	--	--	2	0.05	0.03	4	0.03	0.02	4
Metals	Manganese,Dissolved	µg/l	125	65	4	16	7	2	6	6	4	3	3	2	9	7	4	188	210	4
Metals	Nickel,Dissolved	µg/l	14.3	2.7	4	--	--	2	0.9	0.5	4	--	--	2	2.5	1.4	4	1.9	1.3	4
Metals	Silver,Dissolved	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	0	0.01	4
Metals	Zinc,Dissolved	µg/l	6.5	1.5	4	1.2	0.2	2	1.6	0.4	4	0.8	0	2	5.6	1.9	4	2.6	0.5	4
PAHs	Acenaphthene	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PAHs	Acenaphthylene	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PAHs	Anthracene	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PAHs	Benz(a)anthracene	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PAHs	Benzo(a)pyrene	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	0.017	0.034	4	--	--	4
PAHs	Benzo(b)fluoranthene	µg/l	0.003	0.006	4	--	--	2	0.004	0.007	4	--	--	2	0.018	0.024	4	0.003	0.005	4
PAHs	Benzo(e)pyrene	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	0.009	0.018	4	--	--	4
PAHs	Benzo(g,h,i)perylene	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	0.024	0.035	4	0.012	0.023	4
PAHs	Benzo(k)fluoranthene	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	0.014	0.028	4	--	--	4
PAHs	Biphenyl	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PAHs	Chrysene	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	0.003	0.007	4	--	--	4
PAHs	Chrysenes, C1 -	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	0.004	0.008	4	--	--	4
PAHs	Chrysenes, C2 -	µg/l	--	--	4	--	--	2	0.003	0.005	4	--	--	2	0.006	0.012	4	--	--	4
PAHs	Chrysenes, C3 -	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	0.178	0.339	4	--	--	4
PAHs	Dibenz(a,h)anthracene	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	0.024	0.047	4	--	--	4
PAHs	Dibenzothiophene	µg/l	--	--	4	--	--	2	0.003	0.007	4	--	--	2	0.008	0.016	4	--	--	4
PAHs	Dibenzothiophenes, C1 -	µg/l	0.007	0.014	4	0.009	0.012	2	0.014	0.021	4	0.006	0.008	2	0.028	0.055	4	0.005	0.01	4
PAHs	Dibenzothiophenes, C2 -	µg/l	0.013	0.025	4	0.02	0.005	2	0.024	0.035	4	0.017	0.004	2	0.052	0.103	4	0.009	0.018	4
PAHs	Dibenzothiophenes, C3 -	µg/l	0.008	0.016	4	0.008	0.011	2	0.012	0.024	4	--	--	2	0.03	0.061	4	0.006	0.012	4
PAHs	Dimethylnaphthalene, 2,6-	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PAHs	Fluoranthene	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	0.003	0.005	4	--	--	4
PAHs	Fluoranthene/Pyrenes, C1 -	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PAHs	Fluorene	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PAHs	Fluorenes, C1 -	µg/l	0.003	0.007	4	--	--	2	0.003	0.006	4	--	--	2	0.008	0.015	4	0.003	0.006	4
PAHs	Fluorenes, C2 -	µg/l	0.003	0.005	4	--	--	2	--	--	4	--	--	2	0.004	0.007	4	0.003	0.005	4
PAHs	Fluorenes, C3 -	µg/l	0.018	0.023	4	0.006	0.009	2	0.006	0.012	4	--	--	2	0.011	0.023	4	0.004	0.008	4
PAHs	Indeno(1,2,3-c,d)pyrene	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	0.032	0.053	4	--	--	4
PAHs	Methylnaphthalene, 1-	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PAHs	Methylnaphthalene, 2-	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PAHs	Methylphenanthrene, 1-	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4

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

			901SJALC6			901SJATC2			901SJATC5			901SJBEL2			901SJENG2			901SJLAG2		
Category	Constituent	Units	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n
PAHs	Naphthalene	µg/l	--	--	4	--	--	2	0.004	0.007	4	--	--	2	--	--	4	--	--	4
PAHs	Naphthalenes, C1 -	µg/l	--	--	4	--	--	2	0.003	0.005	4	--	--	2	--	--	4	--	--	4
PAHs	Naphthalenes, C2 -	µg/l	--	--	4	--	--	2	0.004	0.007	4	--	--	2	0.004	0.008	4	--	--	4
PAHs	Naphthalenes, C3 -	µg/l	0.005	0.011	4	0.006	0.008	2	0.008	0.016	4	--	--	2	0.008	0.016	4	0.003	0.007	4
PAHs	Naphthalenes, C4 -	µg/l	0.003	0.006	4	0.022	0.031	2	0.013	0.025	4	--	--	2	0.026	0.052	4	0.003	0.007	4
PAHs	Perylene	µg/l	--	--	4	--	--	2	0.007	0.014	4	--	--	2	0.01	0.021	4	--	--	4
PAHs	Phenanthrene	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PAHs	Phenanthrene/Anthracene, C1 -	µg/l	0.004	0.008	4	--	--	2	0.011	0.016	4	0.007	0.009	2	0.012	0.017	4	0.004	0.008	4
PAHs	Phenanthrene/Anthracene, C2 -	µg/l	0.004	0.008	4	0.006	0.008	2	0.004	0.009	4	--	--	2	0.007	0.015	4	--	--	4
PAHs	Phenanthrene/Anthracene, C3 -	µg/l	0.003	0.007	4	--	--	2	0.004	0.007	4	--	--	2	0.008	0.017	4	0.004	0.007	4
PAHs	Phenanthrene/Anthracene, C4 -	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	0.004	0.008	4
PAHs	Pyrene	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	0.004	0.009	4	--	--	4
PAHs	Trimethylnaphthalene, 2,3,5-	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PCBs	PCB 005	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PCBs	PCB 008	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PCBs	PCB 015	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PCBs	PCB 018	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PCBs	PCB 027	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PCBs	PCB 028	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PCBs	PCB 029	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PCBs	PCB 031	µg/l	0.001	0.002	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PCBs	PCB 033	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PCBs	PCB 044	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PCBs	PCB 049	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PCBs	PCB 052	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	0.003	0.006	4
PCBs	PCB 056	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PCBs	PCB 060	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PCBs	PCB 066	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PCBs	PCB 070	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PCBs	PCB 074	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PCBs	PCB 087	µg/l	0.002	0.004	4	--	--	2	0.001	0.002	4	--	--	2	0.001	0.002	4	0.001	0.002	4
PCBs	PCB 095	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PCBs	PCB 097	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PCBs	PCB 099	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PCBs	PCB 101	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PCBs	PCB 105	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PCBs	PCB 110	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PCBs	PCB 114	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PCBs	PCB 118	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PCBs	PCB 128	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PCBs	PCB 137	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PCBs	PCB 138	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PCBs	PCB 141	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PCBs	PCB 149	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PCBs	PCB 151	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PCBs	PCB 153	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PCBs	PCB 156	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PCBs	PCB 157	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PCBs	PCB 158	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PCBs	PCB 170	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PCBs	PCB 174	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PCBs	PCB 177	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PCBs	PCB 180	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PCBs	PCB 183	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PCBs	PCB 187	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PCBs	PCB 189	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PCBs	PCB 194	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PCBs	PCB 195	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PCBs	PCB 200	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PCBs	PCB 201	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PCBs	PCB 203	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PCBs	PCB 206	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PCBs	PCB 209	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
PCBs	PCBs	µg/l	0.003	0.006	4	--	--	2	0.001	0.002	4	--	--	2	0.001	0.002	4	0.004	0.008	4

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

			901SJALC6			901SJATC2			901SJATC5			901SJBEL2			901SJENG2			901SJLAG2		
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	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Ametryn	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Aspon	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Atraton	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Atrazine	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Azinphos ethyl	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Azinphos methyl	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Bolstar	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Carbophenothion	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Chlordane, cis-	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	0.002	0.005	4	--	--	4
Pesticides	Chlordane, trans-	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Chlordene, alpha-	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Chlordene, gamma-	µg/l	0.001	0.003	4	--	--	2	--	--	4	--	--	2	0	0.001	4	--	--	4
Pesticides	Chlorfenvinphos	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Chlorpyrifos	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Chlorpyrifos methyl	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Ciodrin	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Coumaphos	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Dacthal	µg/l	0	0.001	4	--	--	2	0	0.001	4	--	--	2	--	--	4	0.001	0.002	4
Pesticides	DDD(o,p')	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	DDD(p,p')	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	0	0.001	4
Pesticides	DDE(o,p')	µg/l	--	--	4	--	--	2	0	0.001	4	--	--	2	--	--	4	--	--	4
Pesticides	DDE(p,p')	µg/l	0.001	0.001	4	0.001	0.001	2	0.001	0.001	4	--	--	2	0	0.001	4	--	--	4
Pesticides	DDMU(p,p')	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	DDT(o,p')	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	DDT(p,p')	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	0.001	0.002	4	--	--	4
Pesticides	DDTs	µg/l	0.001	0.001	4	0.001	0.001	2	0.001	0.002	4	--	--	2	0.001	0.003	4	0	0.001	4
Pesticides	Demeton-s	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Diazinon	µg/l	0.049	0.027	4	--	--	2	0.044	0.058	4	--	--	2	0.204	0.286	4	0.029	0.036	4
Pesticides	Dichlofenthion	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Dichlorvos	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Dicrotophos	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Dieldrin	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	0.001	0.001	4	0	0.001	4
Pesticides	Dimethoate	µg/l	0.01	0.02	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Dioxathion	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Disulfoton	µg/l	0.008	0.015	4	--	--	2	0.008	0.015	4	--	--	2	0.008	0.015	4	0.008	0.015	4
Pesticides	Endosulfan I	µg/l	0	0.001	4	--	--	2	0	0.001	4	--	--	2	0.001	0.001	4	0	0.001	4
Pesticides	Endosulfan II	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	0	0.001	4	--	--	4
Pesticides	Endosulfan sulfate	µg/l	0	0.001	4	--	--	2	0	0.001	4	--	--	2	0	0.001	4	--	--	4
Pesticides	Endrin	µg/l	--	--	4	--	--	2	0	0.001	4	--	--	2	--	--	4	0	0.001	4
Pesticides	Endrin Aldehyde	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Endrin Ketone	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Ethion	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Ethoprop	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Famphur	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Fenchlorphos	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Fenitrothion	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Fensulfothion	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Fenthion	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Fonofos	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	HCH, alpha	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	0	0.001	4
Pesticides	HCH, beta	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	HCH, delta	µg/l	0	0.001	4	--	--	2	0	0.001	4	--	--	2	--	--	4	0	0.001	4
Pesticides	HCH, gamma	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Heptachlor	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Heptachlor epoxide	µg/l	0	0.001	4	--	--	2	--	--	4	--	--	2	0.001	0.002	4	0	0.001	4
Pesticides	Hexachlorobenzene	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	0	0	4	--	--	4
Pesticides	Leptophos	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Malathion	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Merphos	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Methidathion	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Methoxychlor	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Mevinphos	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4

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

			901SJALC6			901SJATC2			901SJATC5			901SJBEL2			901SJENG2			901SJLAG2		
Category	Constituent	Units	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n
Pesticides	Mirex	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Molinate	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Naled	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Nonachlor, cis-	µg/l	--	--	4	--	--	2	0	0.001	4	--	--	2	--	--	4	--	--	4
Pesticides	Nonachlor, trans-	µg/l	--	--	4	--	--	2	0	0.001	4	--	--	2	--	--	4	--	--	4
Pesticides	Oxadiazon	µg/l	0.012	0.009	4	0.001	--	2	0.046	0.061	4	--	--	2	0.006	0.007	4	0.052	0.034	4
Pesticides	Oxychlordane	µg/l	0	0.001	4	--	--	2	0	0.001	4	--	--	2	--	--	4	--	--	4
Pesticides	Parathion, Ethyl	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Parathion, Methyl	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Phorate	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Phosmet	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Phosphamidon	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Prometon	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Prometryn	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Propazine	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Secbumeton	µg/l	0.017	0.034	4	--	--	2	--	--	4	--	--	2	--	--	4	0.013	0.026	4
Pesticides	Simazine	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Simetryn	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Sulfotep	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Tedion	µg/l	--	--	4	--	--	2	0	0.001	4	--	--	2	0	0.001	4	--	--	4
Pesticides	Terbufos	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Terbuthylazine	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Terbutryn	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Tetrachlorvinphos	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Thiobencarb	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	0.038	0.075	4
Pesticides	Thionazin	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Tokuthion	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Trichlorfon	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Pesticides	Trichloronate	µg/l	--	--	4	--	--	2	--	--	4	--	--	2	--	--	4	--	--	4
Physical	Fine-ASTM,Passing No. 200 Sieve	%	7.2	9.3	3	22.9	--	1	33.3	17.5	3				11.1	9.2	4	28.8	31.7	4
Physical	Oxygen, Saturation	%	145	30	4	94	8	2	127	22	4	95	6	2	132	28	4	94	15	4
Physical	pH	pH	8.1	0.6	4	7.8	0.4	2	8.2	0.5	3	8	0	2	8.7	1.5	4	7.5	0.6	4
Physical	Salinity	ppt	3.8	4.1	4	0.2	0	2	0.4	0.3	4	0.2	0	2	0.6	0.5	3	0.6	0.4	3
Physical	SpecificConductivity	mS/cm	6756	6892	4	420	103	2	844	501	4	426	18	2	1330	805	4	1299	638	4
Physical	Suspended Sediment Concentration	%	3	--	1				1	--	1				4	--	1	321.1	--	1
Physical	Temperature	ºC	16.7	3.1	4	18.1	6.8	2	16.4	2.4	4	15.8	2.9	2	19.7	4.4	4	14.6	2.2	4
Physical	Total Suspended Solids	mg/l	46.4	76.1	3	139.2	190.7	2	420.2	724.7	3	112.5	159.1	2	121.3	199.9	3	10.9	4.7	3
Physical	Turbidity	NTU	22.9	38.1	4	95.3	125.4	2	73.8	142.9	4	140.3	197.6	2	58	108.1	4	4.2	4	4
Physical	Velocity	ft/s	--	--	4	1.3	0.7	2	0.6	0.6	4	1.8	1.4	2	0.6	0.6	4	0.2	0.3	4

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

			901SJMCC2			901SJOSO3			901SJSJC5			901SJSJC9			901SJSMT2			Watershed mean		
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	427	19	4	166	96	4	123	26	4	193	55	4	128	27	2	197	92	11
Inorganics	Ammonia as N	mg/l	0.32	0.24	4	0.81	1.41	4	--	--	4	0.08	0.1	4	--	--	2	0.18	0.26	11
Inorganics	Nitrate + Nitrite as N	mg/l	0.45	0.13	4	0.92	0.7	4	0.05	0.01	4	0.57	0.68	4	0.09	0.08	2	0.36	0.28	11
Inorganics	Nitrate as N	mg/l	0.42	0.12	4	0.87	0.66	4	0.05	0.01	4	0.55	0.66	4	0.09	0.07	2	0.34	0.26	11
Inorganics	Nitrite as N	mg/l	0.03	0.02	4	0.05	0.04	4	--	--	4	0.02	0.02	4	0	0	2	0.02	0.02	11
Inorganics	Nitrogen, Total Kjeldahl	mg/l	0.98	0.46	4	1.57	1.5	4	0.03	0.06	4	0.6	0.55	4	0.41	0.23	2	0.8	0.57	11
Inorganics	OrthoPhosphate as P	mg/l	0.13	0.01	4	0.22	0.18	4	0.01	0	4	0.1	0.13	4	0.04	0.03	2	0.11	0.07	11
Inorganics	Phosphorus as P,Total	mg/l	0.31	0.12	4	0.37	0.32	4	0.01	0.02	4	0.17	0.23	4	0.04	0.05	2	0.23	0.2	11
Inorganics	Selenium,Dissolved	µg/l	19.7	8	4	10.3	7.9	4	1.8	0.6	4	4.7	2	4	1.1	0	2	6.8	7.4	11
Inorganics	Sulfate	mg/l	1415	152	4	761	506	4	109	21	4	549	292	4	46	20	2	434	438	11
Metals	Aluminum,Dissolved	µg/l	1.4	1.1	4	8.3	6.1	4	1.5	2.1	4	1.1	0.9	4	1.3	0	2	1.8	2.2	11
Metals	Arsenic,Dissolved	µg/l	3.5	0.9	4	4.8	1.9	4	1.4	0.2	4	3.2	0.2	4	1.5	0.2	2	3.1	1.9	11
Metals	Cadmium,Dissolved	µg/l	0.29	0.05	4	0.73	0.7	4	0.03	0	4	0.26	0.15	4	0.03	0.01	2	0.21	0.25	11
Metals	Chromium,Dissolved	µg/l	0.37	0.18	4	0.43	0.09	4	--	--	4	0.26	0.06	4	0.05	0.07	2	0.22	0.2	11
Metals	Copper,Dissolved	µg/l	7.69	2.47	4	7.25	3.53	4	1.02	0.18	4	4.51	1.08	4	2.06	1.93	2	3.79	2.49	11
Metals	Lead,Dissolved	µg/l	0	0	4	0.06	0.02	4	0.01	0.01	4	0.02	0.01	4	0.02	0.01	2	0.02	0.02	11
Metals	Manganese,Dissolved	µg/l	902	643	4	50	44	4	2	1	4	87	82	4	22	23	2	128	264	11
Metals	Nickel,Dissolved	µg/l	15.6	1.5	4	8.7	4.8	4	0.1	0.1	4	3.7	1.4	4	0.2	0.2	2	4.4	5.8	11
Metals	Silver,Dissolved	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	0	0	11
Metals	Zinc,Dissolved	µg/l	8.1	1.4	4	7.9	3.4	4	0.9	0.5	4	4.1	1.6	4	1.1	1.4	2	3.7	2.9	11

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

			901SJMCC2			901SJOSO3			901SJSJC5			901SJSJC9			901SJSMT2			Watershed mean		
Category	Constituent	Units	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n
PAHs	Acenaphthene	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
PAHs	Acenaphthylene	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
PAHs	Anthracene	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
PAHs	Benz(a)anthracene	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
PAHs	Benzo(a)pyrene	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	0.002	0.005	11
PAHs	Benzo(b)fluoranthene	µg/l	0.003	0.005	4	0.005	0.01	4	--	--	4	--	--	4	--	--	2	0.003	0.005	11
PAHs	Benzo(e)pyrene	µg/l	--	--	4	0.004	0.007	4	--	--	4	--	--	4	--	--	2	0.001	0.003	11
PAHs	Benzo(g,h,i)perylene	µg/l	--	--	4	0.006	0.012	4	--	--	4	--	--	4	--	--	2	0.004	0.008	11
PAHs	Benzo(k)fluoranthene	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	0.001	0.004	11
PAHs	Biphenyl	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
PAHs	Chrysene	µg/l	--	--	4	0.004	0.009	4	--	--	4	--	--	4	--	--	2	0.001	0.002	11
PAHs	Chrysenes, C1 -	µg/l	--	--	4	0.004	0.009	4	0.01	0.02	4	--	--	4	--	--	2	0.002	0.003	11
PAHs	Chrysenes, C2 -	µg/l	--	--	4	0.005	0.01	4	0.012	0.024	4	--	--	4	--	--	2	0.002	0.004	11
PAHs	Chrysenes, C3 -	µg/l	--	--	4	0.008	0.015	4	--	--	4	--	--	4	--	--	2	0.017	0.054	11
PAHs	Dibenz(a,h)anthracene	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	0.002	0.007	11
PAHs	Dibenzothiophene	µg/l	--	--	4	0.005	0.011	4	--	--	4	--	--	4	--	--	2	0.002	0.003	11
PAHs	Dibenzothiophenes, C1 -	µg/l	0.006	0.006	4	0.017	0.025	4	--	--	4	0.005	0.01	4	0.02	0.011	2	0.011	0.008	11
PAHs	Dibenzothiophenes, C2 -	µg/l	0.007	0.008	4	0.033	0.052	4	--	--	4	0.008	0.017	4	0.015	0.008	2	0.018	0.014	11
PAHs	Dibenzothiophenes, C3 -	µg/l	--	--	4	0.024	0.041	4	--	--	4	0.005	0.01	4	--	--	2	0.008	0.01	11
PAHs	Dimethylnaphthalene, 2,6-	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
PAHs	Fluoranthene	µg/l	--	--	4	0.005	0.011	4	--	--	4	--	--	4	--	--	2	0.001	0.002	11
PAHs	Fluoranthene/Pyrenes, C1 -	µg/l	--	--	4	0.004	0.008	4	--	--	4	--	--	4	--	--	2	0	0.001	11
PAHs	Fluorene	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
PAHs	Fluorenes, C1 -	µg/l	--	--	4	0.003	0.005	4	--	--	4	--	--	4	--	--	2	0.002	0.002	11
PAHs	Fluorenes, C2 -	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	0.001	0.001	11
PAHs	Fluorenes, C3 -	µg/l	--	--	4	0.011	0.021	4	--	--	4	0.003	0.006	4	--	--	2	0.005	0.006	11
PAHs	Indeno(1,2,3-c,d)pyrene	µg/l	--	--	4	0.005	0.01	4	--	--	4	--	--	4	--	--	2	0.003	0.01	11
PAHs	Methylnaphthalene, 1-	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
PAHs	Methylnaphthalene, 2-	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
PAHs	Methylphenanthrene, 1-	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
PAHs	Naphthalene	µg/l	--	--	4	0.009	0.019	4	--	--	4	--	--	4	--	--	2	0.001	0.003	11
PAHs	Naphthalenes, C1 -	µg/l	--	--	4	0.01	0.02	4	--	--	4	--	--	4	--	--	2	0.001	0.003	11
PAHs	Naphthalenes, C2 -	µg/l	--	--	4	0.003	0.007	4	--	--	4	--	--	4	--	--	2	0.001	0.002	11
PAHs	Naphthalenes, C3 -	µg/l	--	--	4	0.004	0.007	4	--	--	4	0.003	0.007	4	--	--	2	0.003	0.003	11
PAHs	Naphthalenes, C4 -	µg/l	--	--	4	0.015	0.03	4	--	--	4	--	--	4	--	--	2	0.007	0.01	11
PAHs	Perylene	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	0.002	0.004	11
PAHs	Phenanthrene	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
PAHs	Phenanthrene/Anthracene, C1 -	µg/l	--	--	4	0.009	0.012	4	--	--	4	0.005	0.01	4	--	--	2	0.005	0.004	11
PAHs	Phenanthrene/Anthracene, C2 -	µg/l	--	--	4	0.006	0.012	4	--	--	4	--	--	4	--	--	2	0.002	0.003	11
PAHs	Phenanthrene/Anthracene, C3 -	µg/l	--	--	4	0.008	0.015	4	--	--	4	--	--	4	--	--	2	0.002	0.003	11
PAHs	Phenanthrene/Anthracene, C4 -	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	0	0.001	11
PAHs	Pyrene	µg/l	0.008	0.015	4	0.014	0.016	4	--	--	4	--	--	4	--	--	2	0.002	0.005	11
PAHs	Trimethylnaphthalene, 2,3,5-	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
PCBs	PCB 005	µg/l	0.001	0.002	4	0.003	0.005	4	--	--	4	--	--	4	--	--	2	0	0.001	11
PCBs	PCB 008	µg/l	--	--	4	0.004	0.008	4	--	--	4	--	--	4	--	--	2	0	0.001	11
PCBs	PCB 015	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
PCBs	PCB 018	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
PCBs	PCB 027	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
PCBs	PCB 028	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
PCBs	PCB 029	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
PCBs	PCB 031	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	0	0	11
PCBs	PCB 033	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
PCBs	PCB 044	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
PCBs	PCB 049	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
PCBs	PCB 052	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	0	0.001	11
PCBs	PCB 056	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
PCBs	PCB 060	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
PCBs	PCB 066	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
PCBs	PCB 070	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
PCBs	PCB 074	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
PCBs	PCB 087	µg/l	--	--	4	0.002	0.003	4	--	--	4	0.002	0.004	4	--	--	2	0.001	0.001	11
PCBs	PCB 095	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
PCBs	PCB 097	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11

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

			901SJMCC2			901SJOSO3			901SJSJC5			901SJSJC9			901SJSMT2			Watershed mean		
Category	Constituent	Units	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n
PCBs	PCB 099	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
PCBs	PCB 101	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
PCBs	PCB 105	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
PCBs	PCB 110	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
PCBs	PCB 114	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
PCBs	PCB 118	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
PCBs	PCB 128	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
PCBs	PCB 137	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
PCBs	PCB 138	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
PCBs	PCB 141	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
PCBs	PCB 149	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
PCBs	PCB 151	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
PCBs	PCB 153	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
PCBs	PCB 156	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
PCBs	PCB 157	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
PCBs	PCB 158	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
PCBs	PCB 170	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
PCBs	PCB 174	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
PCBs	PCB 177	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
PCBs	PCB 180	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
PCBs	PCB 183	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
PCBs	PCB 187	µg/l	--	--	4	0.001	0.002	4	--	--	4	0.001	0.001	4	--	--	2	0	0	11
PCBs	PCB 189	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
PCBs	PCB 194	µg/l	--	--	4	--	--	4	0.002	0.004	4	--	--	4	--	--	2	0	0.001	11
PCBs	PCB 195	µg/l	--	--	4	--	--	4	0.002	0.004	4	--	--	4	--	--	2	0	0.001	11
PCBs	PCB 200	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
PCBs	PCB 201	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
PCBs	PCB 203	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
PCBs	PCB 206	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
PCBs	PCB 209	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
PCBs	PCBs	µg/l	0.001	0.002	4	0.009	0.018	4	0.004	0.007	4	0.002	0.005	4	--	--	2	0.002	0.003	11
Pesticides	Aldrin	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	Ametryn	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	Aspon	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	Atraton	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	Atrazine	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	Azinphos ethyl	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	Azinphos methyl	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	Bolstar	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	Carbophenothion	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	Chlordane, cis-	µg/l	--	--	4	0.001	0.001	4	--	--	4	--	--	4	--	--	2	0	0.001	11
Pesticides	Chlordane, trans-	µg/l	--	--	4	0	0.001	4	--	--	4	--	--	4	--	--	2	0	0	11
Pesticides	Chlordene, alpha-	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	Chlordene, gamma-	µg/l	--	--	4	0.001	0.003	4	--	--	4	0	0.001	4	--	--	2	0	0	11
Pesticides	Chlorfenvinphos	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	Chlorpyrifos	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	Chlorpyrifos methyl	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	Ciodrin	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	Coumaphos	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	Dacthal	µg/l	--	--	4	0	0.001	4	--	--	4	0	0.001	4	--	--	2	0	0	11
Pesticides	DDD(o,p')	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	DDD(p,p')	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	0	0	11
Pesticides	DDE(o,p')	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	0	0	11
Pesticides	DDE(p,p')	µg/l	--	--	4	0	0.001	4	--	--	4	0.001	0.001	4	--	--	2	0	0	11
Pesticides	DDMU(p,p')	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	DDT(o,p')	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	DDT(p,p')	µg/l	--	--	4	0.001	0.002	4	--	--	4	--	--	4	0.001	0.001	2	0	0	11
Pesticides	DDTs	µg/l	--	--	4	0.001	0.003	4	--	--	4	0.001	0.001	4	0.001	0.001	2	0.001	0	11
Pesticides	Demeton-s	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	Diazinon	µg/l	--	--	4	0.056	0.029	4	--	--	4	0.036	0.032	4	--	--	2	0.038	0.059	11
Pesticides	Dichlofenthion	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	Dichlorvos	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	Dicrotophos	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11

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

			901SJMCC2			901SJOSO3			901SJSJC5			901SJSJC9			901SJSMT2			Watershed mean		
Category	Constituent	Units	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n
Pesticides	Dieldrin	µg/l	--	--	4	--	--	4	--	--	4	0	0.001	4	--	--	2	0	0	11
Pesticides	Dimethoate	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	0.001	0.003	11
Pesticides	Dioxathion	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	Disulfoton	µg/l	--	--	4	--	--	4	--	--	4	0.008	0.015	4	--	--	2	0.003	0.004	11
Pesticides	Endosulfan I	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	0	0	11
Pesticides	Endosulfan II	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	0	0	11
Pesticides	Endosulfan sulfate	µg/l	--	--	4	--	--	4	--	--	4	0	0.001	4	--	--	2	0	0	11
Pesticides	Endrin	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	0	0	11
Pesticides	Endrin Aldehyde	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	Endrin Ketone	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	Ethion	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	Ethoprop	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	Famphur	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	Fenchlorphos	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	Fenitrothion	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	Fensulfothion	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	Fenthion	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	Fonofos	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	HCH, alpha	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	0	0	11
Pesticides	HCH, beta	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	HCH, delta	µg/l	--	--	4	0	0.001	4	--	--	4	0	0.001	4	--	--	2	0	0	11
Pesticides	HCH, gamma	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	Heptachlor	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	Heptachlor epoxide	µg/l	--	--	4	0	0.001	4	--	--	4	0	0.001	4	--	--	2	0	0	11
Pesticides	Hexachlorobenzene	µg/l	0	0	4	0.001	0.002	4	0	0	4	0	0	4	--	--	2	0	0	11
Pesticides	Leptophos	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	Malathion	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	Merphos	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	Methidathion	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	Methoxychlor	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	Mevinphos	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	Mirex	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	Molinate	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	Naled	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	Nonachlor, cis-	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	0	0	11
Pesticides	Nonachlor, trans-	µg/l	--	--	4	0	0.001	4	--	--	4	--	--	4	--	--	2	0	0	11
Pesticides	Oxadiazon	µg/l	--	--	4	0.024	0.025	4	--	--	4	0.299	0.48	4	0.001	0.001	2	0.04	0.088	11
Pesticides	Oxychlordane	µg/l	--	--	4	0	0.001	4	--	--	4	0	0.001	4	--	--	2	0	0	11
Pesticides	Parathion, Ethyl	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	Parathion, Methyl	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	Phorate	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	Phosmet	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	Phosphamidon	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	Prometon	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	Prometryn	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	Propazine	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	Secbumeton	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	0.003	0.006	11
Pesticides	Simazine	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	0.017	0.024	2	0.002	0.005	11
Pesticides	Simetryn	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	Sulfotep	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	Tedion	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	0	0	11
Pesticides	Terbufos	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	Terbuthylazine	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	Terbutryn	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	Tetrachlorvinphos	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	Thiobencarb	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	0.003	0.011	11
Pesticides	Thionazin	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	Tokuthion	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	Trichlorfon	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11
Pesticides	Trichloronate	µg/l	--	--	4	--	--	4	--	--	4	--	--	4	--	--	2	--	--	11

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

			901SJMCC2			901SJOSO3			901SJSJC5			901SJSJC9			901SJSMT2			Watershed mean		
Category	**Constituent**	**Units**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**
Physical	Fine-ASTM,Passing No. 200 Sieve	%	42.9	37.6	4	66.4	--	1	7.9	--	1	18	16	4				26.5	19.2	9
Physical	Oxygen, Saturation	%	61	31	4	104	25	4	75	24	4	117	18	4	93	7	2	103	25	11
Physical	pH	pH	7.1	0.7	4	8	0.4	4	7	0.9	4	7.7	0.8	4	8	0.3	2	7.8	0.5	11
Physical	Salinity	ppt	2	0.5	3	0.9	0.7	3	0.2	0.1	3	0.7	0.4	3	0.2	0	2	0.9	1.1	11
Physical	SpecificConductivity	mS/cm	4015	833	4	2173	1418	4	473	184	4	1797	987	4	384	76	2	1811	1963	11
Physical	Suspended Sediment Concentration	%	50.7	--	1	5.3	--	1	173.6	--	1	4.9	--	1				70.5	117.2	8
Physical	Temperature	ºC	16.5	1.5	4	19.1	3.6	4	14.2	1.4	4	17.6	4.3	4	16.2	0.8	2	16.8	1.7	11
Physical	Total Suspended Solids	mg/l	81.2	96.8	3	127.2	212.9	3	5.1	8.2	3	57.9	97.1	3	2.7	1.4	2	102.2	116.9	11
Physical	Turbidity	NTU	21	19	4	1.8	1.7	4	2.8	4.4	4	29.9	53.4	4	9.4	12.8	2	41.8	45.1	11
Physical	Velocity	ft/s	0	0.1	4	0	0.1	4	0	0.1	4	0.3	0.4	4	--	--	2	0.4	0.6	11

Appendix IIb. Means and standard deviations of water chemistry constituents at non-SWAMP sites.

	27 (Narco Downstream)			27 (Narco Upstream)		
Constituent	Mean	SD	N	Mean	SD	N
Cadmium, dissolved (ug/l)	19.2	23	36	12.3	1.9	12
Chlorpyrifos (ng/l)	--	--	4	--	--	4
Copper, dissolved (ug/l)	1.3	4.3	12	--	--	12
Diazinon (ng/l)	5.8	11.5	4	6.3	12.7	4
Malathion (ng/l)	735	848.7	4	78.5	90.6	4
Nickel, dissolved (ug/l)	137.9	153.4	36	84.3	14.8	12
Dimethoate (ng/l)	--	--	4	--	--	4
Total phophorus (mg/l)	0.7	1	12	0.7	1	12

Appendix IIb, continued. Means and standard deviations of water chemistry constituents at non-SWAMP sites.

		Enteroccoccus (cfu / 100 ml)			Fecal Coliform (cfu / 100 ml)			Total Colilform (cfu / 100 ml)			TKN (mg/l)			Orthophosphate (mg/l)		
Site	Specific location	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N
27	NarcoDownstream	6608	4965	12	7905	12898	42	1E+05	114456	11	6.3	2.7	12			
27	NarcoUpstream	8236	6124	11	25075	42113	12	2E+05	93720	11	6	2.1	12			
28	Lower Reach Downstream end	1698	1438	56	1008	1572	56	8946	8231	56	6	27.8	56	0.4	0.1	56
28	Lower Reach midreach (La Plata)	2981	2790	67	1036	1358	67	15311	17776	67	2.6	0.9	67	0.4	0.2	67
28	Middle Reach Downstream end (La Paz)-Post construction	1559	2015	19	606	861	19	6589	5636	19	2.1	0.9	19	0.5	0.7	19
28	Middle Reach Downstream end (La Paz)-Pre construction	3778	3035	30	1672	2355	30	28023	36401	30	2.6	0.5	30	0.5	0.5	30
28	Middle Reach upstream end (Nueva Vista) - Post construction	1872	2677	19	498	627	19	9884	14492	19	2.4	0.7	19	0.4	0.1	19
28	Middle Reach upstream end (Nueva Vista) - Pre consrtuction	3179	2921	41	1248	1627	41	17541	18562	41	2.6	0.7	41	0.5	0.2	41
28	Upper Reach - Upper End	5660	7075	55	4761	6371	55	1E+05	107626	55	2.9	0.5	55	0.4	0.2	55

Appendix IIb, continued. Means and standard deviations of water chemistry constituents at non-SWAMP sites.

		Dissolved oxygen (mg/l)			pH			Temperature (C)			Relative chlorophyll (ug/l)			Specific conductivity (mS/cm)			Turbidity (NTU)		
Site	Specific location	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N
1	AC-CCR	9.6	1.9	6	8.0	0.3	6	16.5	4	6	7.9	5.1	5	3	0.3	6			
2	AC-PPD	9	1.6	6	8.1	0.2	6	17.8	2.2	6	2.3	0.7	5	2.6	0.4	6			
4	REF-AT2	10	2	4	8.0	0.3	4	14.6	2.4	4	0.2	0.3	4	0.5	0.3	4			
6	SJC-74	8.2	2.2	5	7.7	0.5	5	17.4	2.8	5	1	0.3	5	1.4	0.4	5			
10	SMC-I5	6	1.6	2	7.2	0.1	2	18.7	0.5	2	0.9	0.2	2	0.8	0.1	2	1.2	0.2	2
11	WC-WCT	12.3	6	2	8.2	0.2	2	13.1	1.2	2	2.5		1	2.2	0.7	2			
12	AC-ACP	8.7	2.7	6	8.0	0.2	6	18.5	2.9	6	2.5	1.7	5	3.2	0.4	6			
13	CC-CR	12.4	3.6	4	7.9	0.1	4	15.4	2.5	4	0.9	0.7	4	1	0.2	4			
14	EC-MD	11	2.2	6	8.4	0.6	6	18	4.2	6	3	1.1	5	1.9	0.2	6			
15	LC-133	8.9	2.9	6	8.2	0.2	6	15.8	2	6	3.2	0.9	5	1.6	0.4	6			
16	LP-BR	9.3	2.5	4	7.8	0.2	4	17.2	3.1	4	1.5	0.9	4	0.9	0.1	4	1.1	0.8	2
17	PD-CGV	10.4		1	8.8		1	15.2		1			0	3.8		1			
18	REF-BC	8.6	3.3	4	7.8	0.5	4	16	0.2	4	0.1	0.1	4	0.8	0.1	4			
19	REF-CS	11.6	0.9	6	8.4	0.3	6	15.5	2.6	6			0	0.6	0.1	6			
20	SC-MB	9.4	1.3	6	7.8	0.3	6	15.7	2.9	6	5.4	1.4	5	3.7	0.7	6			
21	SD-AP	9.8	3.4	6	8.0	0.5	6	14.1	3.3	6	7.6	2	5	4.5	0.9	6			
22	SJC-CC	8	2.5	6	7.8	0.5	6	17.5	4.1	6	2.5	1	5	2.2	0.8	6			
23	SOC-2				9.2		1	27.3		1	2.4		1	0.5		1			
24	SOC-I5	8.4	0.9	2	7.6	0.1	2	13.5	3.8	2	2	0.3	2	1	0.1	2	412	580.9	2
25	TC-AP	10.2	4.3	6	8.2	0.4	6	16.3	2.6	6	0.9	0.7	5	1.1	0.2	6			
26	TC-DO	12.8	2.4	6	8.4	0.2	6	20.2	7.2	6	9.4	10.1	5	2.2	0.5	6			
27	Narco Downstream	18.3							4	41			0	73.2	3.4	11			
27	Narco Upstream	22.7							1.1	11			0	72.9	2	11			
28	Lower Reach Downstream end	15							3.8	56									
28	Lower Reach midreach (La Plata)	16.2							5	67									
28	Middle Reach Downstream end (La Paz)-Post construction	13.4							5.1	19									
28	Middle Reach Downstream end (La Paz)-Pre construction	16.8							3.2	30									
28	Middle Reach upstream end (Nueva Vista) - Post construction	11.5							3.8	19									
28	Middle Reach upstream end (Nueva Vista) - Pre consrtuction	16.8							3.6	41									
28	Upper Reach - Upper End	18.2							2	55									

APPENDIX III

Results from toxicity assays for each endpoint at each site in the watershed. Mean = mean percent control. SD = standard deviation. A. SWAMP sites. B. Sites assessed by Orange County NPDES.

A. SWAMP-Sites

	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
901SJALC6	104	6	3	84	43	3	86	20	4	135	64	3	52	34	4
901SJATC2	95	7	2	71	5	2	0		1			0	95	8	2
901SJATC5	94	12	4	87	25	4	101	16	3	120	44	3	52	47	4
901SJBEL2	95	7	2	78	34	2			0			0	98	25	2
901SJENG2	60	49	4	94	18	3	67	34	4	88	36	4	84	15	4
901SJLAG2	78	45	4	91	36	4	66	41	4	123	34	4	49	11	4
901SJMCC2	101	15	2	79	10	2	97	6	4	338	478	4	10	8	4
901SJOSO3	77	40	3	102	38	3	52	71	2	82		1	52	24	4
901SJSJC5	93	10	4	102	17	4	109		1	221		1	106	15	4
901SJSJC9	98	5	4	111	22	4	93	23	4	119	45	4	53	21	4
901SJSMT2	100	0	2	102	24	2			0			0	78	15	2
Mean of all sites	87	30	34	93	26	33	79	34	27	155	197	24	99	35	38

B. Orange County NPDES

	C. dubia						*H. azteca*			*S. capricornutum*			*P. promelas*					
	Survival			Growth			Survival			Total cell count			Survival			Growth		
Site	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n
1	94	10	7	105	12	7	99	10	7	146	56	6	99	17	3	130	29	3
2	102	13	7	113	29	7	103	8	7	162	70	7	85	11	3	129	70	3
4	99	16	5	87	14	6	102	3	6	172	63	6						
6	105	10	7	110	19	7	98	4	7	168	60	7						
11	100	0	2	139	30	2	84	22	2	202	49	2	97		1	248		1
12	80	37	8	75	39	8	94	13	8	154	57	8	93	22	4	134	8	4
13	100	0	5	116	19	5	101	8	5	151	72	4						
14	95	11	6	103	29	6	105	7	6	148	47	5	83		1	150		1
15	105	8	7	516	1030	7	99	5	7	200	110	7						
17	0		1	0		1	100		1	179		1						
18	97	5	6	104	14	6	100	7	6	161	42	5						
19	102	4	7	124	29	7	100	10	7	185	66	7						
20	67	46	7	65	60	7	91	20	6	160	67	8						
21	38	44	6	9	8	5	100	0	5	129	48	4						
22	98	4	6	111	11	6	106	5	6	147	49	5						
25	124	62	7	131	25	7	113	21	7	157	68	6						
26	100	7	6	118	24	6	102	6	6	147	46	5						

APPENDIX IV

Mean IBI and metric scores for bioassessment sites in the San Juan 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	13	1998-2005	16.4	0.4	1.5	1.4	1.2	0.1	1.7	0.2	2.6	0.2	0	0	1.5	0.2	2.9	1.2
1	Fall	7	1998-2005	16.1	7.4	0.6	1	1.3	0.5	1.6	2.1	2.7	3.7	0	0	1.4	1.5	3.7	2.7
1	Spring	6	1998-2005	16.7	17.8	2.5	4.2	1.2	0.8	1.8	4	2.5	1.8	0	0	1.7	2.6	2	1.8
2	Average	12	1998-2005	14.9	1.2	0.8	0.2	1.2	0.2	1.3	0.2	2.8	2	0	0	1.7	0.9	2.7	0.5
2	Fall	6	1998-2005	15.7	9.9	0.7	1	1.3	0.8	1.5	2.8	4.2	3.9	0	0	1	0.9	2.3	1.9
2	Spring	6	1998-2005	14	8.6	1	1.7	1	0	1.2	2.9	1.3	1.4	0	0	2.3	1.9	3	1.8
3	Average	6	1998-2000	31.9	6.1	3.5	0.2	2.3	0.9	2.7	0.5	6.7	3.8	0	0	3.5	0.2	3.7	0.9
3	Fall	3	1998-2000	36.2	3.6	3.3	1.2	3	1	3	2	9.3	1.2	0	0	3.7	0.6	3	0
3	Spring	3	1998-2000	27.6	14.5	3.7	1.5	1.7	1.2	2.3	2.1	4	5.2	0	0	3.3	1.2	4.3	0.6
4	Average	6	2001-2005	68	23	7.1	2.7	7.4	1.6	5	3.5	7.1	4.1	6.6	4.1	7.5	0.7	6.9	0.5
4	Fall	2	2003-2005	84.3	12.1	9	1.4	8.5	2.1	7.5	2.1	10	0	9.5	0.7	8	1.4	6.5	0.7
4	Spring	4	2001-2005	51.8	18.6	5.3	3.4	6.3	1.9	2.5	3.7	4.3	2.2	3.8	2.8	7	0.8	7.3	0.5
5	Spring	2	2001-2001	16.4	3	2	0	1	0	0	0	8.5	2.1	0	0	0	0	0	0
6	Average	12	1998-2005	23.8	4.8	0.6	0.8	1.9	0.2	2.6	1.2	5.4	3.4	0	0	2.3	0.1	3.9	0.7
6	Fall	5	1998-2005	27.1	3.4	0	0	2	1.9	3.4	1.7	7.8	2.7	0	0	2.4	1.7	3.4	2.1
6	Spring	7	1998-2005	20.4	4.8	1.1	1.6	1.7	1	1.7	1	3	2.1	0	0	2.3	2.1	4.4	2.3
7	Spring	4	2001-2005	31.4	13.7	1.5	1.9	4.5	1.7	1.5	1.9	3	3.6	1.5	1.7	4.8	1	5.3	1
8	Spring	1	2001-2001	41.4		8		5		5		1		3		4		3	
9	Spring	1	2001-2001	31.4		4		2		2		10		0		2		2	
10	Average	2	2005-2006	23.6	27.3	4.5	3.5	1	0	2.5	3.5	5	7.1	0	0	1	1.4	1	1.4
10	Fall	1	2005-2005	42.9		7		1		5		10		0		2		2	
10	Spring	1	2006-2006	4.3		2		1		0		0		0		0		0	
11	Average	5	2001-2004	15.5	6.4	0	0	0.5	0.7	0.3	0.4	5.3	5.2	0	0	0	0	4.8	1.8
11	Fall	2	2002-2004	20	2	0	0	1	0	0.5	0.7	9	1.4	0	0	0	0	3.5	2.1
11	Spring	3	2001-2001	11	3	0	0	0	0	0	0	1.7	2.9	0	0	0	0	6	4
12	Average	6	2002-2005	12	3.3	0	0	1.3	0.4	0.3	0.4	2.6	2.7	0	0	1.9	0.2	2.4	1.2
12	Fall	4	2002-2005	9.6	4.7	0	0	1	0	0	0	0.8	1	0	0	1.8	1.7	3.3	2.5
12	Spring	2	2003-2005	14.3	2	0	0	1.5	0.7	0.5	0.7	4.5	0.7	0	0	2	1.4	1.5	0.7
13	Average	4	2003-2005	39.6	4.5	4.5	2.1	3.8	1.1	4.8	1.1	5.3	1.1	0.3	0.4	6	0.7	3.3	1.1
13	Fall	2	2003-2005	36.4	13.1	3	1.4	4.5	0.7	4	1.4	6	1.4	0	0	5.5	2.1	2.5	2.1
13	Spring	2	2003-2005	42.9	6.1	6	1.4	3	0	5.5	0.7	4.5	0.7	0.5	0.7	6.5	0.7	4	1.4
14	Average	5	2002-2005	14.5	0.3	0	0	1.1	0.2	0.3	0.4	6.5	0.7	0	0	0.3	0.4	2	0
14	Fall	4	2002-2005	14.6	6.6	0	0	1.3	0.5	0.5	0.6	6	3.9	0	0	0.5	0.6	2	1.4
14	Spring	1	2005-2005	14.3		0		1		0		7		0		0		2	
15	Average	6	2002-2005	17	6.8	0	0	1.3	0.4	1	0.7	2	1.4	0	0	2.8	1.8	4.9	0.5
15	Fall	4	2002-2005	21.8	6.2	0	0	1.5	0.6	1.5	1.3	3	2	0	0	4	0.8	5.3	2.2
15	Spring	2	2003-2005	12.1	3	0	0	1	0	0.5	0.7	1	0	0	0	1.5	0.7	4.5	0.7
16	Average	4	2004-2006	36.8	0.5	2.8	1.1	3.3	1.1	3.5	0.7	4.5	2.1	1	0	4.8	1.8	6	1.4
16	Fall	2	2004-2005	36.4	9.1	2	2.8	4	0	4	2.8	6	1.4	1	0	3.5	2.1	5	0
16	Spring	2	2005-2006	37.1	14.1	3.5	4.9	2.5	0.7	3	2.8	3	1.4	1	0	6	1.4	7	0
17	Average	2	2002-2003	7.1	6.1	0	0	0	0	0	0	0	0	0	0	3.5	2.1	1.5	2.1
17	Fall	1	2002-2002	2.9		0		0		0		0		0		2		0	
17	Spring	1	2003-2003	11.4		0		0		0		0		0		5		3	
18	Average	4	2003-2005	65.7	5.1	6.5	1.4	6	0	7	0	6.5	1.4	5	2.1	7.5	0.7	7.5	0.7
18	Fall	2	2004-2005	69.3	9.1	7.5	3.5	6	1.4	7	1.4	7.5	3.5	6.5	2.1	7	1.4	7	1.4
18	Spring	2	2003-2005	62.1	9.1	5.5	2.1	6	1.4	7	2.8	5.5	0.7	3.5	2.1	8	0	8	0

Appendix IV, continued. Mean IBI and metric scores.

				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
19	Average	6	2002-2005	33.8	3.3	2.5	2.1	3.5	0	1.3	1.1	2.5	2.1	0.6	0.2	6.9	0.2	6.4	0.9
19	Fall	4	2002-2005	36.1	11.1	4	3.6	3.5	1	0.5	1	4	3.8	0.8	0.5	6.8	1.5	5.8	2.1
19	Spring	2	2003-2005	31.4	2	1	1.4	3.5	0.7	2	1.4	1	0	0.5	0.7	7	1.4	7	1.4
20	Average	6	2002-2005	7.3	1.3	0	0	0.4	0.2	0.1	0.2	3.5	0	0	0	0.4	0.5	0.8	0.4
20	Fall	4	2002-2005	8.2	7.9	0	0	0.3	0.5	0.3	0.5	3.5	1.7	0	0	0.8	1.5	1	1.4
20	Spring	2	2003-2005	6.4	5.1	0	0	0.5	0.7	0	0	3.5	2.1	0	0	0	0	0.5	0.7
21	Average	6	2002-2005	18.9	0.5	0.5	0.7	0.4	0.2	1	0	7.5	2.8	0	0	1.4	0.9	2.5	0.7
21	Fall	4	2002-2005	19.3	5.5	0	0	0.3	0.5	1	1.4	9.5	1	0	0	0.8	1.5	2	0
21	Spring	2	2003-2005	18.6	4	1	1.4	0.5	0.7	1	0	5.5	6.4	0	0	2	1.4	3	4.2
22	Average	6	2002-2005	15.4	3.5	1	1.4	1	0	1.5	1.4	3.6	3	0	0	1.9	0.2	1.8	0.4
22	Fall	4	2002-2005	17.9	12.4	0	0	1	0	2.5	1.3	5.8	4.9	0	0	1.8	1	1.5	1.9
22	Spring	2	2003-2005	12.9	4	2	0	1	0	0.5	0.7	1.5	2.1	0	0	2	0	2	0
23	Spring	1	2005-2005	50		10		3		8		4		0		7		3	
24	Average	3	2004-2006	27.9	1	3.8	0.4	0.8	0.4	3.5	0.7	7.5	3.5	0	0	3	1.4	1	0
24	Fall	2	2004-2005	28.6	16.2	3.5	4.9	0.5	0.7	3	1.4	10	0	0	0	2	2.8	1	1.4
24	Spring	1	2006-2006	27.1		4		1		4		5		0		4		1	
25	Average	6	2002-2005	17	9.8	0.5	0.7	1.4	0.5	1.5	0	4.1	4.4	0	0	1.6	0.5	2.8	1.8
25	Fall	4	2002-2005	23.9	10.6	1	1.2	1.8	0.5	1.5	1.3	7.3	3.2	0	0	1.3	1	4	2.4
25	Spring	2	2003-2005	10	0	0	0	1	0	1.5	2.1	1	1.4	0	0	2	1.4	1.5	2.1
26	Average	6	2002-2005	18.8	2.3	0.8	0.4	1.1	0.2	0.3	0.4	3.9	5.5	0	0	3.3	1.8	3.9	2.3
26	Fall	4	2002-2005	20.4	2.1	0.5	1	1.3	0.5	0.5	0.6	7.8	4.5	0	0	2	2.7	2.3	1.7
26	Spring	2	2003-2005	17.1	0	1	1.4	1	0	0	0	0	0	0	0	4.5	0.7	5.5	2.1