SWAMP

Surface Water Ambient Monitoring Program

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

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

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1. ABSTRACT

In order to assess the ecological health of the Otay Hydrologic Unit (San Diego County, CA), water chemistry, water and sediment toxicity, benthic macroinvertebrate communities, and physical habitat were assessed at two sites—Poggi Creek and Jamul Creek. Water chemistry and toxicity were assessed by SWAMP multiple times in 2003, and bioassessment samples were collected between 2000 and 2001 under other programs. Although impacts to human health were also assessed, the goal of this monitoring program was to examine impacts to aquatic life in the watershed. Most of these ecological indicators showed evidence of impacts, although impacts were more severe at Poggi Creek than at Jamul Creek. For example, both sites exceeded aquatic life thresholds for several water chemistry constituents, but there were more exceedances at Poggi Creek (4) than Jamul (3), and more pesticides were detected at Poggi (5) than at Jamul (2). Nutrients, Selenium, and specific conductivity frequently exceeded thresholds at both sites. Toxicity was also evident at both sites. At Poggi Creek, 50% of tests for chronic toxicity were positive, but only 33% were positive at Jamul Creek. Bioassessment samples were only collected at sites near Jamul Creek, prior to sampling under SWAMP, but these bioassessment samples were in fair to poor condition. IBI scores ranged from 11 to 46, indicating that benthic macroinvertebrate communities were similar to communities at impaired sites. Physical habitat was degraded at Poggi Creek, where most components of physical habitat showed signs of major alterations. In contrast, Jamul Creek was moderately degraded, with only two components of physical habitat (embeddedness and channel flow) showing signs of severe alteration. At Poggi Creek, altered water chemistry, toxicity in the water column and sediments, and degraded physical habitat suggest that this site was impacted. At Jamul Creek, these same impacts appeared to be less severe, although bioassessment samples collected here suggested that benthic macroinvertebrate communities were also impacted. 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 these sites in the Otay watershed were in poor ecological condition.

2. INTRODUCTION

The Otay hydrologic unit (HU 910) is a watershed in the southern portion of San Diego County and is home to about 150,000 people and represents an important water resource in one of the most arid regions of the nation. Home to many endemic, rare, and endangered plants and animals, the ecological health of the Otay watershed is of increasing concern (Aspen Environmental Group 2006). Despite strong interest in the surface waters of the Otay HU, a comprehensive assessment of the ecological health of these waters has not been conducted. The purpose of this report is to provide such an analysis using data collected in 2003 under the Surface Waters Ambient Monitoring Program (SWAMP), and earlier data collected by the San Diego Regional Water Quality Control Board. SWAMP monitoring efforts rotated among sets of watersheds, ensuring that each HU is monitored once every 5 years (Table 1). These programs collected data to describe water chemistry, water and sediment toxicity, physical habitat, fish or invertebrate tissue, and macroinvertebrate community structure. By examining data from multiple sources, this report provides a measure of the ecological integrity of the Otay HU.

Table 1. Watersheds monitored under the SWAMP program.

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

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

At 154 mi^2, the Otay HU is one of the smaller watersheds in the San Diego Region. Located entirely within San Diego County, the Otay River drains the north-facing slopes of the San Ysidro Mountains (also known as the Otay Mountains), and the southerly slopes of the Jamul Mountains. White Mountain near Dulzura forms the interior boundary. The outlet of the Otay River is in the southernmost portion of San Diego Bay, which drains into the Pacific Ocean. The Otay HU also includes the Coronado Island peninsula, which has no streams (Figure 1).

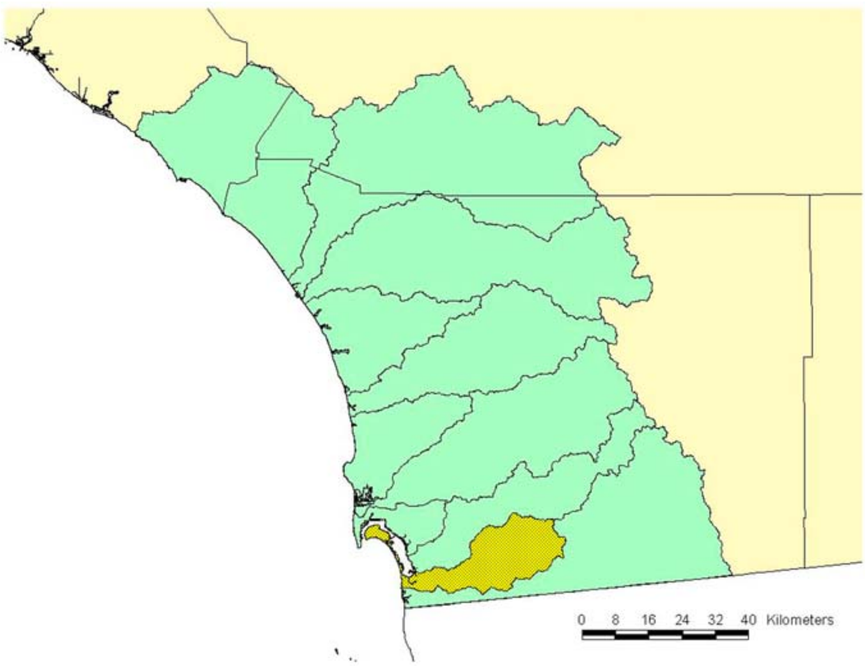

Figure 1. San Diego region (green) includes portions of San Diego, Riverside, and Orange counties. The Otay HU (yellow, shaded) is located entirely within San Diego County.

2.1.1 Climate

The Otay 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 Alpine (high elevation near the inland end of the watershed), La Mesa (near the middle of the watershed), and Sea World (near the coast, north of the watershed) shows considerable variability in rainfall throughout the HU (National Oceanic and Atmospheric Administration 2007) (Figure 2).

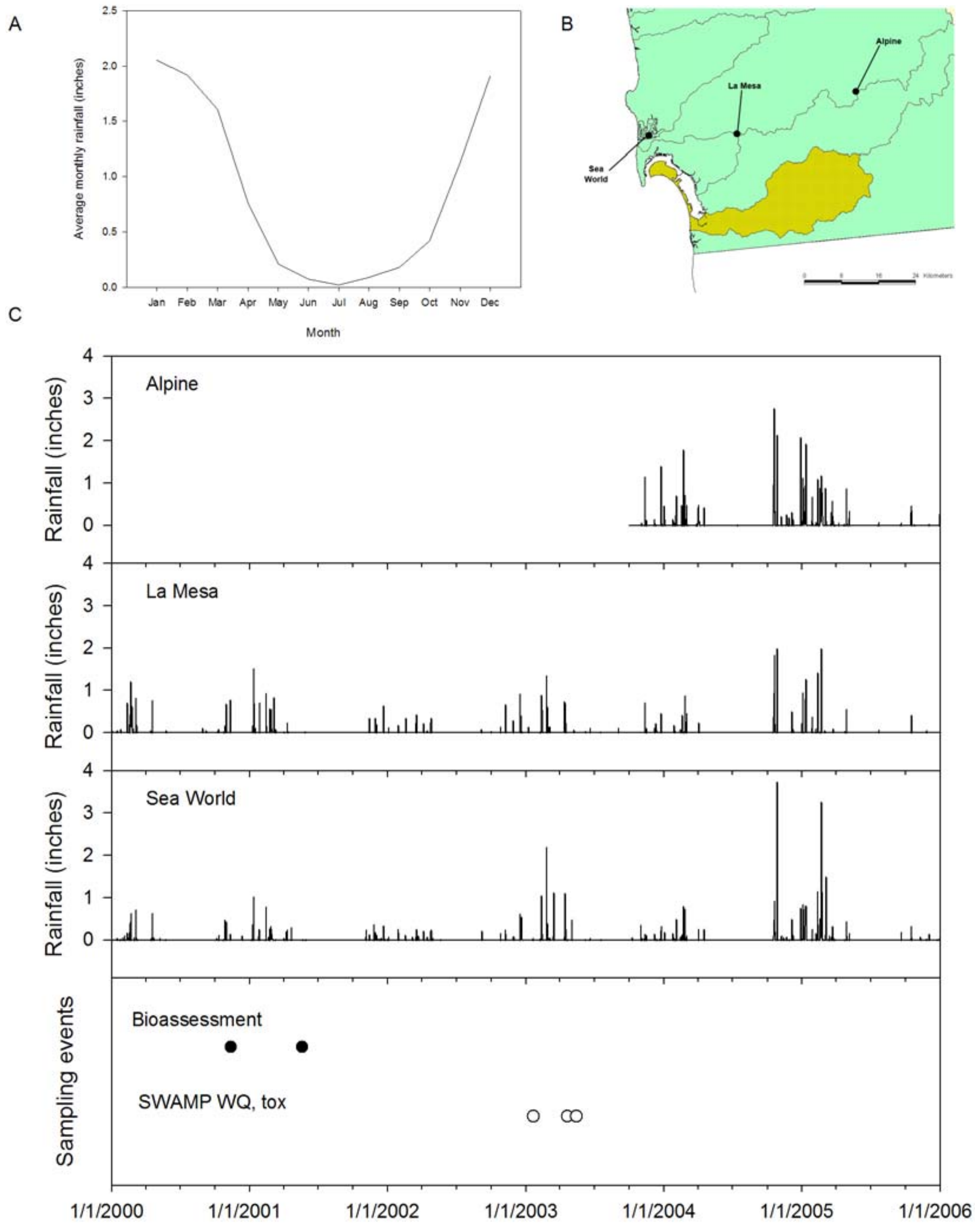

Figure 2. Rainfall and sampling events at three stations in the San Diego region. A. Average precipitation for each month at the Lindberg Station (DWR station code SDG), based on data collected between January 1905 and November 2006. B. Location of the Alpine, La Mesa, and Sea World gauges. C. Storm events and sampling events in the Otay HU. The top three 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 Otay HU consists of the Otay River and its major tributaries. The Otay River is the second largest river (after the Sweetwater) draining into San Diego Bay. Damming in the early part of the century created the Otay Reservoirs, which provide drinking water for southern San Diego County. Major tributaries of the Otay River include Jamul Creek, Dulzura Creek, and Poggi Creek (Figure 3). Water is diverted from Cottonwood Creek in the Tijuana HU into Dulzura Creek and into the Otay Reservoirs (City of San Diego Water Department, 2005). Coronado Island and its peninsula are part of the Otay HU, but this region does not drain into the Otay River.

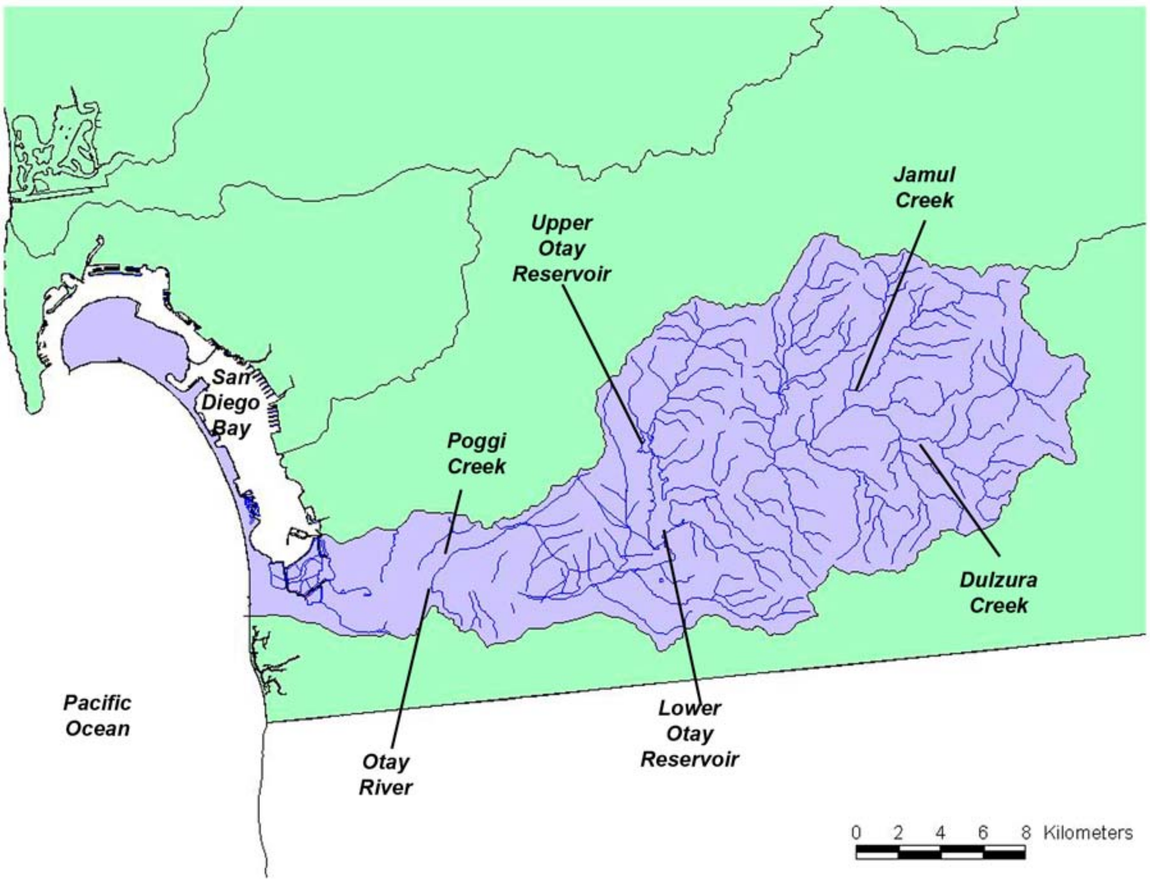

Figure 3. The Otay HU is made up of the Otay River and its tributaries, including Dulzura Creek and Jamul Creek.

2.1.3 Land Use within the Watershed

Several municipalities have jurisdiction over portions of the watershed. The County of San Diego controls the largest portion of the watershed (69.7%). Chula Vista is the largest municipality within the watershed, covering 17.6%. The cities of San Diego and Coronado occupy 6.7% and 5.2% respectively. The cities of Imperial Beach and National City each occupy less than 1% of the watershed.

About two-thirds (70%) of the watershed is open and undeveloped (Figure 4). Agriculture occurs in 10% of the watershed, and urban or industrial land uses occur in 20% (SANDAG 1998). Although the upper parts of the Otay watershed, there has been rapid growth in certain regions. For example, the Dulzura watershed has seen its population grow by 48% between 2000 and 2005 (City of San Diego 2005).

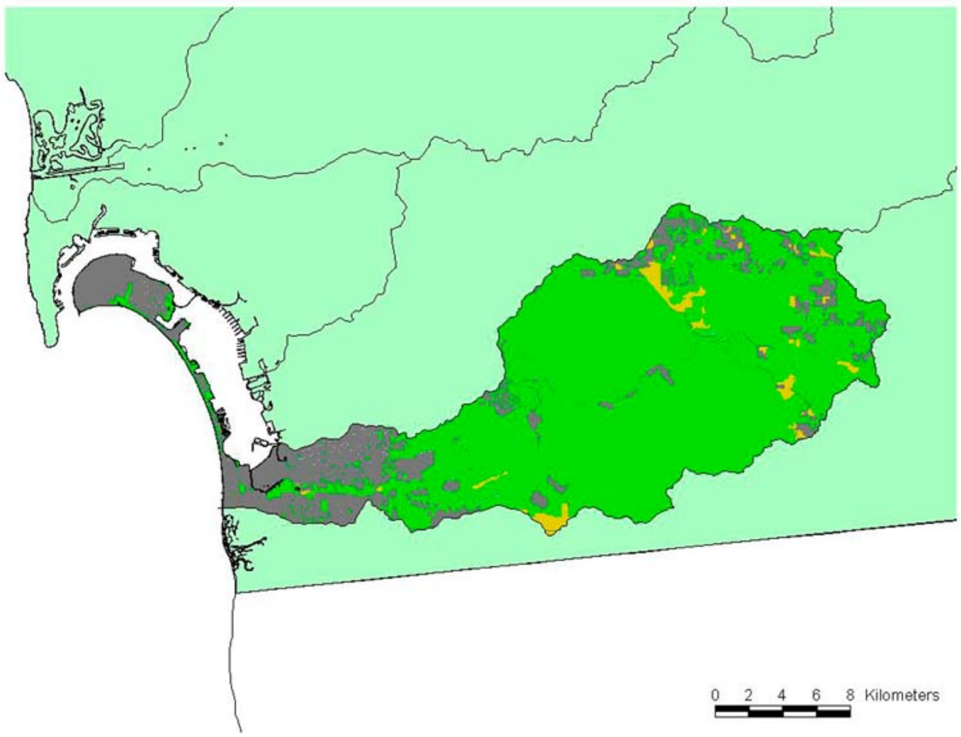

Figure 4. Land use within the Otay HU. Undeveloped open space is shown in green. Agricultural areas are shown in orange. Urban and developed lands are shown in dark gray.

Large areas within the watershed are protected by the San Diego National Wildlife Refuge (both the Sweetwater-Otay and Vernal Pools Units), the Rancho Jamul Ecological Reserve, and San Diego Water Department lands around the Otay Reservoirs. Other major landowners include Caltrans, with jurisdiction over all freeways and highways in the watershed, indigenous nations (e.g., the Jamul and Sycuan Indian reservations), and the US Navy. The Navy operates two bases on Coronado Island (Naval Air Station North Island and Naval Amphibious Base Coronado) that are within the Otay HU but outside the watershed of the Otay River (Aspen Environmental Group 2006).

2.1.4 Beneficial Uses and Known Impairments in the Watershed

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

One stream in the Otay HU, Poggi Creek, is listed as impaired on the 303(d) list of water quality limited segments, affecting a total of 7.8 stream miles. This stream is listed as impaired for DDT from unknown sources (Appendix I).

3. METHODS

This report analyzes water chemistry and toxicity data collected under SWAMP in the Otay watershed in 2003. Additional bioassessment data was collected by the San Diego Regional Board under other programs (Table 2). Two sites of interest were sampled under SWAMP: Jamul Creek (910OTJAM4) above the Otay Reservoir, and Poggi Creek (910OTPOG3) below the reservoir (Table 3; Figure 5). Water chemistry, water and sediment toxicity, and physical habitat was measured at each site. These samples were collected in January, April, and May of 2003. Bioassessment data was not collected as a part of SWAMP monitoring in the Otay HU, but data collected at two sites in Jamul Creek by the Regional Board in 2000 and 2001 was used in this report. These sites were very close to the SWAMP site in Jamul Creek (i.e., within 500 meters), and were used to estimate the health of benthic macroinvertebrate communities at 910OTJAM4 (Table 4, Figure 5).

Table 2. Sources of data used in this report.

Project	Indicators	Years
SWAMP	Water chemistry, toxicity	2003
San Diego Regional Board	Bioassessment	2000-2001

Table 3: SWAMP sampling site locations. Water chemistry and toxicity samples were assessed at these locations.

Site		Description	Latitude (°N)	Longitude (°E)
1	910OTJAM4	Jamul Creek 4	32.6365	-116.8842
2	910OTPOG3	Poggi Creek 3	32.6089	-117.0211

Table 4. Non-SWAMP sampling site locations. Bioassessment samples were collected at these locations.

Site	Description	SWAMP site within 500 m	Sources	Latitude (°N)	Longitude (°E)
1	Jamul Creek at gauging station	None	CDFG (910JCGSxx)	32.6336	-116.8860
2	Jamul Creek upstream of Otay Lakes Road	None	CDFG (910JCOLRx)	32.6370	-116.8844

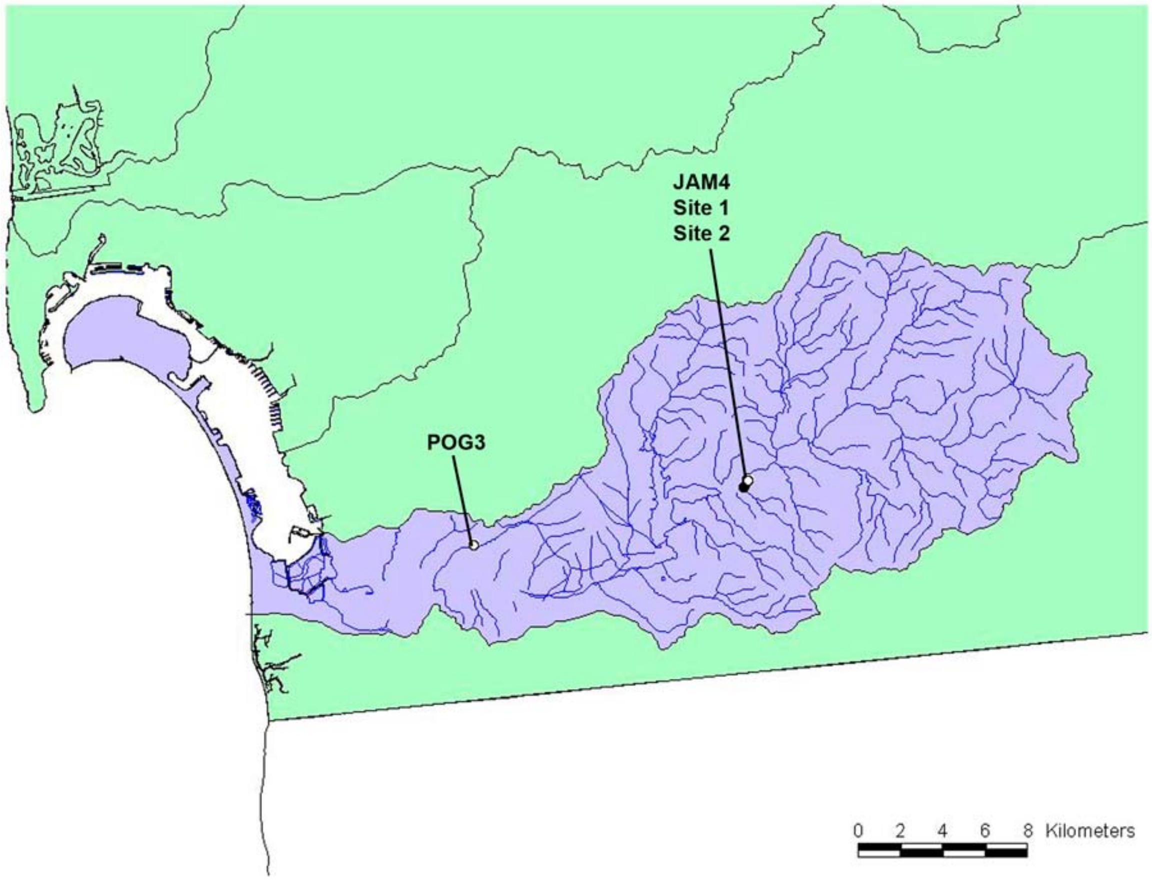

Figure 5. SWAMP (white circles) and non-SWAMP (black circles) sampling locations. The SWAMP site prefix designating the hydrologic unit (i.e., 910OT-) has been dropped to improve clarity.

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.

3.1.2 Toxicity

To evaluate water and sediment toxicity to aquatic life in the Otay HU, toxicity assays were conducted on samples from each site as per the SWAMP QAMP (EPA 1993, Puckett 2002). Water toxicity at both sites 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 at both sites 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 at Jamul Creek 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.

At Jamul Creek, toxicity to *C. dubia* was assessed on one date (January 21, 2003). Toxicity to *H. azteca* and *S. capricornutum* was assessed on three dates (January 21, 2003, April 21, 2003, and May 15, 2003). At Poggi Creek, toxicity to *C. dubia* and *S. capricornutum* was assessed on all three dates, but toxicity to *H. azteca* was never assessed.

3.1.3 Tissue

Fish tissues were not analyzed in the Otay HU.

3.1.4 Bioassessment

To assess the ecological health of the streams in Otay HU, benthic macroinvertebrate samples were collected at 2 sites. These sites were in Jamul Creek, and both were located close to the SWAMP site, but sampled more than one year before SWAMP sampling (Figure 2C). 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. Jamul Creek was assessed on August 30, 2001, and Poggi Creek was assessed on December 31, 2002.

3.2 Data Analysis

To evaluate the extent of human impacts to water chemistry in streams in the Otay 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. 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.

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, 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 Otay 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.
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 Otay 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).

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

Table 6, continued. Water chemistry thresholds.

		Aquatic life			Human health		
Category	Constituent	Threshold	Unit	Source	Threshold	Unit	Source
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	µS/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 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, and toxicity. No chemistry or toxicity were excluded as a result of QA/QC violations. Non-SWAMP bioassessment samples were screened for samples containing fewer than 450 individuals. No bioassessment sample was excluded from this analysis.

4. RESULTS

4.1 Water Chemistry

Analysis of water chemistry at SWAMP sites indicated impacts from a small number of constituents. Poggi Creek had more impacts than Jamul Creek. A total of two PAHs (C1- and C-2 dibenzothiophenes) and five pesticides (atrazine, p,p'-DDE, p,p'-DDT, diazinon, and oxadiazon) were detected in the watershed (Table 7). All of these anthropogenic organic constituents were detected in Poggi Creek; in contrast, only the PAHs, p,p'-DDT, and oxadiazon were detected in Jamul Creek (Table 8). Means and standard deviations of all constituents are presented in Appendix II.

Table 7. Number of anthropogenic organic compounds detected at each site in the Otay HU.

	PAHs		PCBs		Pesticides	
Site	Tested	Detected	Tested	Detected	Tested	Detected
910OTJAM4	43	2	50	0	91	2
910OTPOG3	43	2	50	0	91	5
Entire watershed	43	2	50	0	91	5

Table 8. Frequency of detection of anthropogenic organic compounds in the Otay HU. Constituent not detected at any site (--).

Category	Constituent	Tested	Detected	Frequency
PAHs	Acenaphthene	2	0	--
PAHs	Acenaphthylene	2	0	--
PAHs	Anthracene	2	0	--
PAHs	Benz(a)anthracene	2	0	--
PAHs	Benzo(a)pyrene	2	0	--
PAHs	Benzo(b)fluoranthene	2	0	--
PAHs	Benzo(e)pyrene	2	0	--
PAHs	Benzo(g,h,i)perylene	2	0	--
PAHs	Benzo(k)fluoranthene	2	0	--
PAHs	Biphenyl	2	0	--
PAHs	Chrysene	2	0	--
PAHs	Chrysenes, C1 -	2	0	--
PAHs	Chrysenes, C2 -	2	0	--
PAHs	Chrysenes, C3 -	2	0	--

Table 8, continued. Frequency of detection of anthropogenic organic water chemistry constituents.

Category	Constituent	Tested	Detected	Frequency
PAHs	Dibenz(a,h)anthracene	2	0	--
PAHs	Dibenzothiophene	2	0	--
PAHs	Dibenzothiophenes, C1 -	2	2	1.00
PAHs	Dibenzothiophenes, C2 -	2	2	1.00
PAHs	Dibenzothiophenes, C3 -	2	0	--
PAHs	Dimethylnaphthalene, 2,6-	2	0	--
PAHs	Fluoranthene	2	0	--
PAHs	Fluoranthene/Pyrenes, C1 -	2	0	--
PAHs	Fluorene	2	0	--
PAHs	Fluorenes, C1 -	2	0	--
PAHs	Fluorenes, C2 -	2	0	--
PAHs	Fluorenes, C3 -	2	0	--
PAHs	Indeno(1,2,3-c,d)pyrene	2	0	--
PAHs	Methylnaphthalene, 1-	2	0	--
PAHs	Methylnaphthalene, 2-	2	0	--
PAHs	Methylphenanthrene, 1-	2	0	--
PAHs	Naphthalene	2	0	--
PAHs	Naphthalenes, C1 -	2	0	--
PAHs	Naphthalenes, C2 -	2	0	--
PAHs	Naphthalenes, C3 -	2	0	--
PAHs	Naphthalenes, C4 -	2	0	--
PAHs	Perylene	2	0	--
PAHs	Phenanthrene	2	0	--
PAHs	Phenanthrene/Anthracene, C1 -	2	0	--
PAHs	Phenanthrene/Anthracene, C2 -	2	0	--
PAHs	Phenanthrene/Anthracene, C3 -	2	0	--
PAHs	Phenanthrene/Anthracene, C4 -	2	0	--
PAHs	Pyrene	2	0	--
PAHs	Trimethylnaphthalene, 2,3,5-	2	0	--
PCBs	PCB 005	2	0	--
PCBs	PCB 008	2	0	--
PCBs	PCB 015	2	0	--
PCBs	PCB 018	2	0	--
PCBs	PCB 027	2	0	--
PCBs	PCB 028	2	0	--
PCBs	PCB 029	2	0	--
PCBs	PCB 031	2	0	--
PCBs	PCB 033	2	0	--
PCBs	PCB 044	2	0	--
PCBs	PCB 049	2	0	--
PCBs	PCB 052	2	0	--
PCBs	PCB 056	2	0	--
PCBs	PCB 060	2	0	--
PCBs	PCB 066	2	0	--
PCBs	PCB 070	2	0	--
PCBs	PCB 074	2	0	--
PCBs	PCB 087	2	0	--
PCBs	PCB 095	2	0	--
PCBs	PCB 097	2	0	--

Table 8, continued. Frequency of detection of anthropogenic organic water chemistry constituents.

Category	Constituent	Tested	Detected	Frequency
PCBs	PCB 099	2	0	--
PCBs	PCB 101	2	0	--
PCBs	PCB 105	2	0	--
PCBs	PCB 110	2	0	--
PCBs	PCB 114	2	0	--
PCBs	PCB 118	2	0	--
PCBs	PCB 128	2	0	--
PCBs	PCB 137	2	0	--
PCBs	PCB 138	2	0	--
PCBs	PCB 141	2	0	--
PCBs	PCB 149	2	0	--
PCBs	PCB 151	2	0	--
PCBs	PCB 153	2	0	--
PCBs	PCB 156	2	0	--
PCBs	PCB 157	2	0	--
PCBs	PCB 158	2	0	--
PCBs	PCB 170	2	0	--
PCBs	PCB 174	2	0	--
PCBs	PCB 177	2	0	--
PCBs	PCB 180	2	0	--
PCBs	PCB 183	2	0	--
PCBs	PCB 187	2	0	--
PCBs	PCB 189	2	0	--
PCBs	PCB 194	2	0	--
PCBs	PCB 195	2	0	--
PCBs	PCB 200	2	0	--
PCBs	PCB 201	2	0	--
PCBs	PCB 203	2	0	--
PCBs	PCB 206	2	0	--
PCBs	PCB 209	2	0	--
Pesticides	Aldrin	2	0	--
Pesticides	Ametryn	2	0	--
Pesticides	Aspon	2	0	--
Pesticides	Atraton	2	0	--
Pesticides	Atrazine	2	1	0.50
Pesticides	Azinphos ethyl	2	0	--
Pesticides	Azinphos methyl	2	0	--
Pesticides	Bolstar	2	0	--
Pesticides	Carbophenothion	2	0	--
Pesticides	Chlordane, cis-	2	0	--
Pesticides	Chlordane, trans-	2	0	--
Pesticides	Chlordene, alpha-	2	0	--
Pesticides	Chlordene, gamma-	2	0	--
Pesticides	Chlorfenvinphos	2	0	--
Pesticides	Chlorpyrifos	2	0	--
Pesticides	Chlorpyrifos methyl	2	0	--
Pesticides	Ciodrin	2	0	--
Pesticides	Coumaphos	2	0	--
Pesticides	Dacthal	2	0	--

Table 8, continued. Frequency of detection of anthropogenic organic water chemistry constituents.

Category	Constituent	Tested	Detected	Frequency
Pesticides	DDD(o,p')	2	0	--
Pesticides	DDD(p,p')	2	0	--
Pesticides	DDE(o,p')	2	0	--
Pesticides	DDE(p,p')	2	1	0.50
Pesticides	DDMU(p,p')	2	0	--
Pesticides	DDT(o,p')	2	0	--
Pesticides	DDT(p,p')	2	2	1.00
Pesticides	Demeton-s	2	0	--
Pesticides	Diazinon	2	1	0.50
Pesticides	Dichlofenthion	2	0	--
Pesticides	Dichlorvos	2	0	--
Pesticides	Dicrotophos	2	0	--
Pesticides	Dieldrin	2	0	--
Pesticides	Dimethoate	2	0	--
Pesticides	Dioxathion	2	0	--
Pesticides	Disulfoton	2	0	--
Pesticides	Endosulfan I	2	0	--
Pesticides	Endosulfan II	2	0	--
Pesticides	Endosulfan sulfate	2	0	--
Pesticides	Endrin	2	0	--
Pesticides	Endrin Aldehyde	2	0	--
Pesticides	Endrin Ketone	2	0	--
Pesticides	Ethion	2	0	--
Pesticides	Ethoprop	2	0	--
Pesticides	Famphur	2	0	--
Pesticides	Fenchlorphos	2	0	--
Pesticides	Fenitrothion	2	0	--
Pesticides	Fensulfothion	2	0	--
Pesticides	Fenthion	2	0	--
Pesticides	Fonofos	2	0	--
Pesticides	HCH, alpha	2	0	--
Pesticides	HCH, beta	2	0	--
Pesticides	HCH, delta	2	0	--
Pesticides	HCH, gamma	2	0	--
Pesticides	Heptachlor	2	0	--
Pesticides	Heptachlor epoxide	2	0	--
Pesticides	Hexachlorobenzene	2	0	--
Pesticides	Leptophos	2	0	--
Pesticides	Malathion	2	0	--
Pesticides	Merphos	2	0	--
Pesticides	Methidathion	2	0	--
Pesticides	Methoxychlor	2	0	--
Pesticides	Mevinphos	2	0	--
Pesticides	Mirex	2	0	--
Pesticides	Molinate	2	0	--
Pesticides	Naled	2	0	--
Pesticides	Nonachlor, cis-	2	0	--
Pesticides	Nonachlor, trans-	2	0	--
Pesticides	Oxadiazon	2	2	1.00

Table 8, continued. Frequency of detection of anthropogenic organic water chemistry constituents.

Category	Constituent	Tested	Detected	Frequency
Pesticides	Oxychlordane	2	0	--
Pesticides	Parathion, Ethyl	2	0	--
Pesticides	Parathion, Methyl	2	0	--
Pesticides	Phorate	2	0	--
Pesticides	Phosmet	2	0	--
Pesticides	Phosphamidon	2	0	--
Pesticides	Prometon	2	0	--
Pesticides	Prometryn	2	0	--
Pesticides	Propazine	2	0	--
Pesticides	Secbumeton	2	0	--
Pesticides	Simazine	2	0	--
Pesticides	Simetryn	2	0	--
Pesticides	Sulfotep	2	0	--
Pesticides	Tedion	2	0	--
Pesticides	Terbufos	2	0	--
Pesticides	Terbuthylazine	2	0	--
Pesticides	Terbutryn	2	0	--
Pesticides	Tetrachlorvinphos	2	0	--
Pesticides	Thiobencarb	2	0	--
Pesticides	Thionazin	2	0	--
Pesticides	Tokuthion	2	0	--
Pesticides	Trichlorfon	2	0	--
Pesticides	Trichloronate	2	0	--

Comparison with applicable aquatic life thresholds support the conclusion that water quality is slightly impacted (Table 9; Figure 6). A total of 3 constituents exceeded aquatic life thresholds at Jamul Creek, and 4 did so at Poggi Creek. Ammonia-N exceeded aquatic life thresholds at both sites on the most sampling dates. In addition, At Poggi Creek, selenium and specific conductivity exceeded aquatic life thresholds on all sampling dates, and a single exceedance of pH was also detected. At Jamul Creek, manganese and specific conductivity exceeded aquatic life thresholds on one sampling date (Table 10).

Table 9. 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. Frequency = Frequency of samples exceeding applicable thresholds at each site. -- = Constituent never exceeded threshold. NA = No applicable thresholds at that site.

A. Aquatic life thresholds at SWAMP sites.

				910OTJAM4		910OTPOG3	
Category	Constituent	Threshold	Source	Frequency	n	Frequency	n
Inorganics	Alkalinity as CaCO3	20000 mg/l	EPA	--	3	--	3
Inorganics	Ammonia as N	0.025 mg/l	BP	0.67	3	0.67	3
Inorganics	Nitrate + Nitrite as N	10 mg/l	BP	--	3	--	3
Inorganics	Phosphorus as P,Total	0.1 mg/l	BP	--	3	--	3
Inorganics	Selenium,Dissolved	5 µg/l	CTR	--	3	1	3
Inorganics	Sulfate	250 mg/l	BP	--	3	--	3

Table 9, continued. Frequency of water chemistry threshold exceedances.
A, continued. Aquatic life thresholds at SWAMP sites.

Category	Constituent	Threshold	Source	910OTJAM4 Frequency	n	910OTPOG3 Frequency	n
Metals	Aluminum,Dissolved	1000 µg/l	BP	--	3	--	3
Metals	Arsenic,Dissolved	50 µg/l	BP	--	3	--	3
Metals	Cadmium,Dissolved	5 µg/l	BP	--	3	--	3
Metals	Chromium,Dissolved	50 µg/l	BP	--	3	--	3
Metals	Copper,Dissolved	9 µg/l	CTR	--	3	--	3
Metals	Lead,Dissolved	2.5 µg/l	CTR	--	3	--	3
Metals	Manganese,Dissolved	0.05 µg/l	BP	0.33	3	--	3
Metals	Nickel,Dissolved	52 µg/l	CTR	--	3	--	3
Metals	Silver,Dissolved	3.4 µg/l	CTR	--	3	--	3
Metals	Zinc,Dissolved	120 µg/l	CTR	--	3	--	3
PAHs	Benzo(a)pyrene	0.0002 µg/l	BP	--	3	--	3
PCBs	PCBs	0.014 µg/l	CTR	--	3	--	3
Pesticides	Aldrin	3 µg/l	CTR	--	3	--	3
Pesticides	Atrazine	3 µg/l	BP	--	3	--	3
Pesticides	Endrin	0.002 µg/l	BP	--	3	--	3
Pesticides	Heptachlor	0.0038 µg/l	CTR	--	3	--	3
Pesticides	Heptachlor epoxide	0.0038 µg/l	CTR	--	3	--	3
Pesticides	Hexachlorobenzene	1 µg/l	BP	--	3	--	3
Pesticides	Methoxychlor	40 µg/l	BP	--	3	--	3
Pesticides	Molinate	20 µg/l	BP	--	3	--	3
Pesticides	Simazine	4 µg/l	BP	--	3	--	3
Pesticides	Thiobencarb	70 µg/l	BP	--	3	--	3
Physical	pH	>6 or <8 pH units	BP	--	3	0.33	3
Physical	SpecificConductivity	1.6 mS/cm	CCR	0.33	3	1	3
Physical	Turbidity	20 NTU	BP	--	3	--	3

Table 9, continued. Frequency of water chemistry threshold exceedances.
B. Human health thresholds at SWAMP sites.

Category	Constituent	Threshold	Source	910OTJAM4 Frequency	n	910OTPOG3 Frequency	n
Metals	Arsenic,Dissolved	150 µg/l	CTR	--	3	--	3
Metals	Cadmium,Dissolved	2.2 µg/l	CTR	--	3	--	3
Metals	Copper,Dissolved	1300 µg/l	CTR	--	3	--	3
Metals	Nickel,Dissolved	610 µg/l	CTR	--	3	--	3
PAHs	Acenaphthene	1200 µg/l	CTR	--	3	--	3
PAHs	Anthracene	9600 µg/l	CTR	--	3	--	3
PAHs	Benz(a)anthracene	0.0044 µg/l	CTR	--	3	--	3
PAHs	Benzo(a)pyrene	0.0044 µg/l	CTR	--	3	--	3
PAHs	Benzo(b)fluoranthene	0.0044 µg/l	CTR	--	3	--	3
PAHs	Benzo(k)fluoranthene	0.0044 µg/l	CTR	--	3	--	3
PAHs	Chrysene	0.0044 µg/l	CTR	--	3	--	3
PAHs	Dibenz(a,h)anthracene	0.0044 µg/l	CTR	--	3	--	3
PAHs	Fluoranthene	300 µg/l	CTR	--	3	--	3
PAHs	Indeno(1,2,3-c,d)pyrene	0.0044 µg/l	CTR	--	3	--	3
PAHs	Pyrene	960 µg/l	CTR	--	3	--	3
PCBs	PCBs	0.00017 µg/l	CTR	--	3	--	3
Pesticides	Aldrin	0.00000013 µg/l	CTR	--	3	--	3
Pesticides	Ametryn	60 µg/l	EPA	--	3	--	3

Table 9, continued. Frequency of water chemistry threshold exceedances.
B, continued. Human health thresholds at SWAMP sites.

				910OTJAM4		910OTPOG3	
Category	Constituent	Threshold	Source	Frequency	n	Frequency	n
Pesticides	Atrazine	0.2 µg/l	OEHHA	--	3	--	3
Pesticides	Azinphos ethyl	87.5 µg/l	NASHA	--	3	--	3
Pesticides	Azinphos methyl	87.5 µg/l	NASHA	--	3	--	3
Pesticides	DDD(p,p')	0.00083 µg/l	CTR	--	3	--	3
Pesticides	DDE(p,p')	0.00059 µg/l	CTR	--	3	0.67	3
Pesticides	DDT(p,p')	0.00059 µg/l	CTR	0.33	3	0.33	3
Pesticides	Dieldrin	0.00014 µg/l	CTR	--	3	--	3
Pesticides	Dimethoate	1.4 µg/l	IRIS	--	3	--	3
Pesticides	Endosulfan sulfate	110 µg/l	CTR	--	3	--	3
Pesticides	Endrin	0.76 µg/l	CTR	--	3	--	3
Pesticides	Endrin Aldehyde	0.76 µg/l	CTR	--	3	--	3
Pesticides	Endrin Ketone	0.85 µg/l	CTR	--	3	--	3
Pesticides	Heptachlor	0.00021 µg/l	CTR	--	3	--	3
Pesticides	Heptachlor epoxide	0.0001 µg/l	CTR	--	3	--	3
Pesticides	Hexachlorobenzene	0.00075 µg/l	CTR	--	3	--	3
Pesticides	Oxychlordane	0.000023 µg/l	CTR	--	3	--	3

Table 10. Number of constituents exceeding thresholds at each SWAMP site.

Site	Aquatic life	Human health
910OTJAM4	3	1
910OTPOG3	4	2

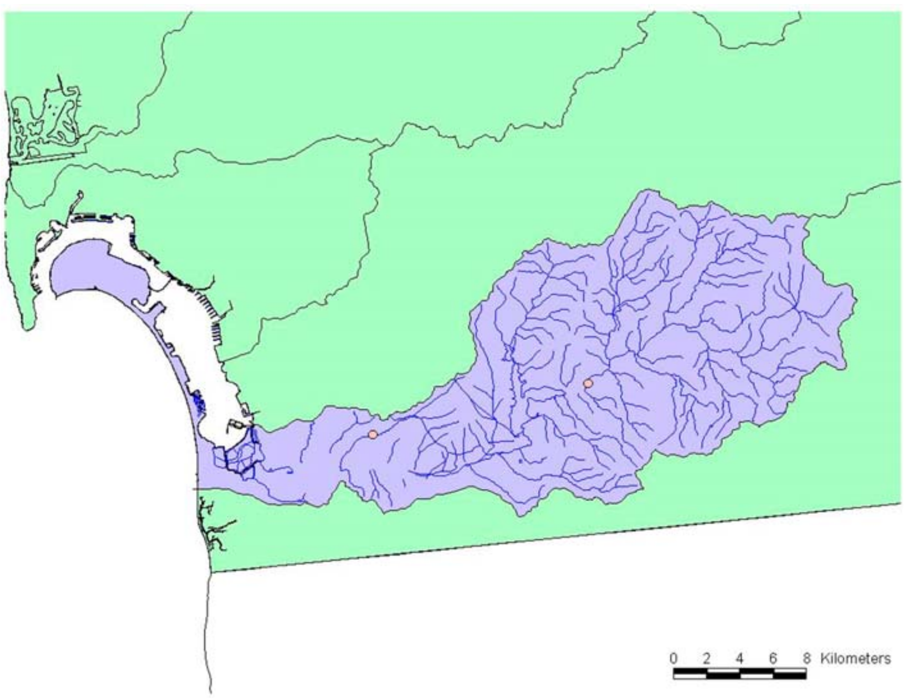

Figure 6. Map of aquatic life threshold exceedances for water chemistry at SWAMP sites. White circles indicate sites with one or fewer exceedances (this value did not occur in this watershed). Pink circles indicate sites with 2 to 5 exceedances. Red circles indicate sites with 6 to 9 exceedances (this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

Human health exceedances were rare in the Otay HU (Table 9; Figure 7). Apart from two DDT-related chemicals (p,p'-DDE and p,p'-DDT) , no constituents exceeded these thresholds. The constituent p,p'-DDE exceeded thresholds at Poggi Creek twice, and p,p'-DDT exceeded thresholds at both sites once (Table 10).

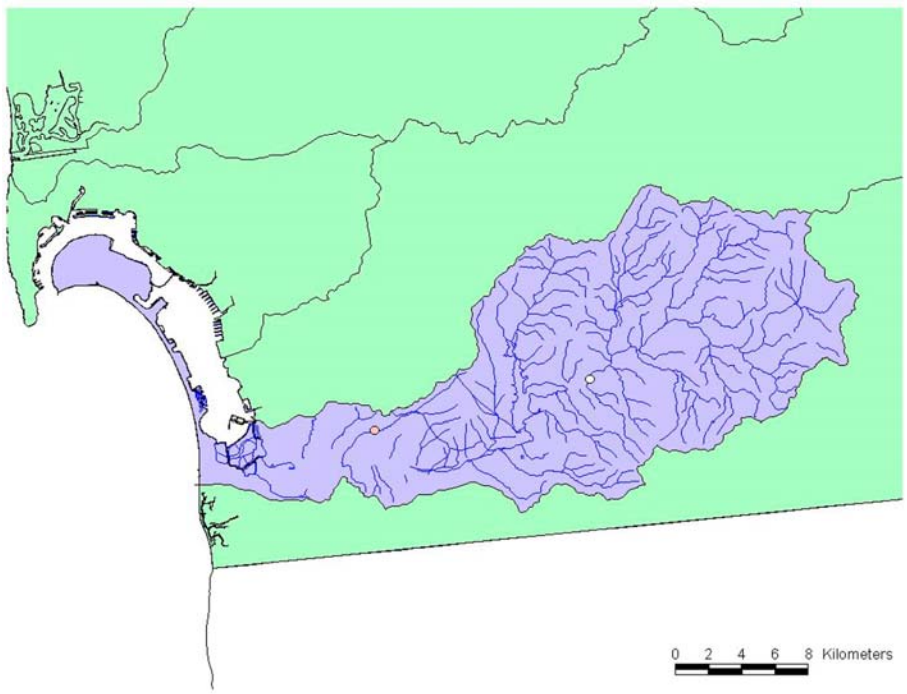

Figure 7. Map of human health exceedances for water chemistry at SWAMP sites. White circles indicate sites with one or fewer exceedances. Pink circles indicate sites with 2 to 5 exceedances. Red circles indicate sites with 6 to 9 exceedances (this value did not occur in this watershed). At both sites,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

4.2 Toxicity

Toxicity was evident at both sites in the Otay HU. (Table 11; Figure 8; Appendix III). Toxicity to *S. capricornutum* was detected in almost every sample (5 of 6) from both sites; the magnitude of the toxic effect at the two sites was similar, with the mean percent control total cell count slightly higher at Jamul Creek (66 ± 37, mean ± standard deviation) than at Poggi Creek (56 ± 8). In contrast to *S. capricornutum*, toxicity to *C. dubia* was never detected at either site. Sediments from Jamul Creek were acutely toxic to *H. azteca* once; toxicity of sediments from Poggi Creek was not assessed. Across the watershed, 42% of samples showed evidence of chronic toxicity to multiple indicators.

Table 11. 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 (--).

	Ceriodaphnia dubia				*Hyalella azteca*				*Selenastrum*		Multiple indicators	
Site	Surival	n	Young/Female	n	Survival	n	Growth	n	Total cell count	n	Frequency	n
910OTJAM4	--	1	--	1	0.33	3	--	2	0.67	3	0.33	6
910OTPOG3	--	3	--	3	not tested	0	not tested	0	1	3	0.5	6
Mean of all sites	--	4	--	4	0.33	3	--	2	0.83	6	0.42	12

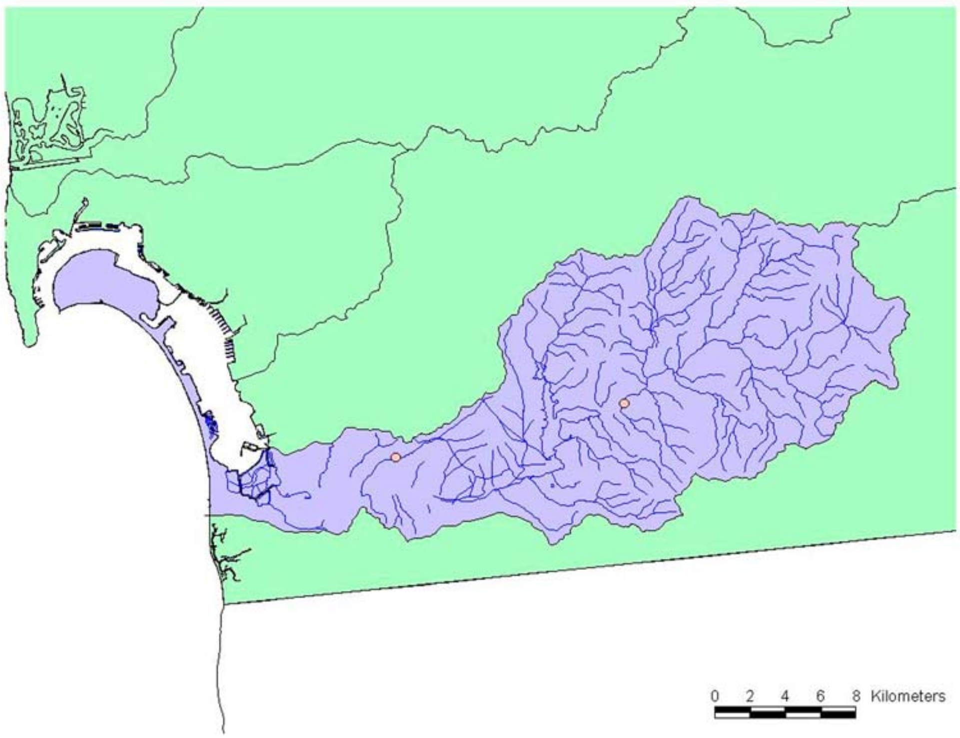

Figure 8. Frequency of toxicity (*C. dubia* fecundity, *H. azteca* growth, and *S. capricornutum* total cell count) at SWAMP sites. White circles indicate low frequency (0.0 to 0.1) of toxicity (this value did not occur in this watershed) . Pink circles indicate moderate frequency (0.1 to 0.5) of toxicity.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

4.3 Bioassessment

Biological health was very poor at both sites 1 and 2 in the spring, but fair at site 2 in the Fall (Table 12; Figure9; Appendix IV). The season-weighted average at Jamul Creek was 30.5, indicating that the stream was in poor condition. The Coleoptera taxa and predator taxa metrics showed little variability among the sites and seasons (Figure 10). However, most other metrics scored much higher in the Fall sample at site 1, especially % Collectors, EPT taxa, and % Intolerant. Although the metric % Tolerant taxa varied as well, this variability did not appear to relate to season or site.

Table 12. Mean and standard deviation of IBI scores at bioassessment sites within the Otay HU. Number of samples collected within each season (n). Range from first to last year of sampling at each site (Years). The average IBI is weighted by season.

Site	Season	Year	n	IBI	Condition
Site 1	Spring	2001	1	19.0	Very poor
Site 2	Average	2001-2002	2	38.5	Poor
Site 2	Fall	2001	1	46.0	Fair
Site 2	Spring	2002	1	11.0	Very poor
Mean of all sites	Average	2001-2002	3	30.5	Poor

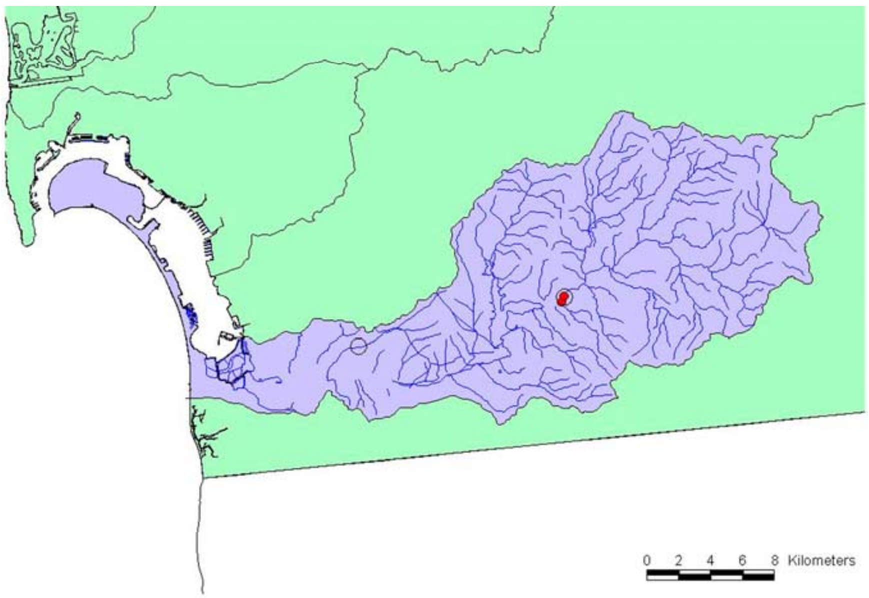

Figure 9. IBI scores at sites in the Otay HU. White circles indicate good or very good (60 to 100) IBI scores (this value did not occur in this watershed). Pink circles indicate fair (40 to 60) IBI scores (this value did not occur in this watershed). Red circles indicate poor (0 to 40) IBI scores. Open circles represent 500-m buffers around SWAMP sites; one of these buffers (at 910OTJAM4) included bioassessment sites, and the other buffer did not.

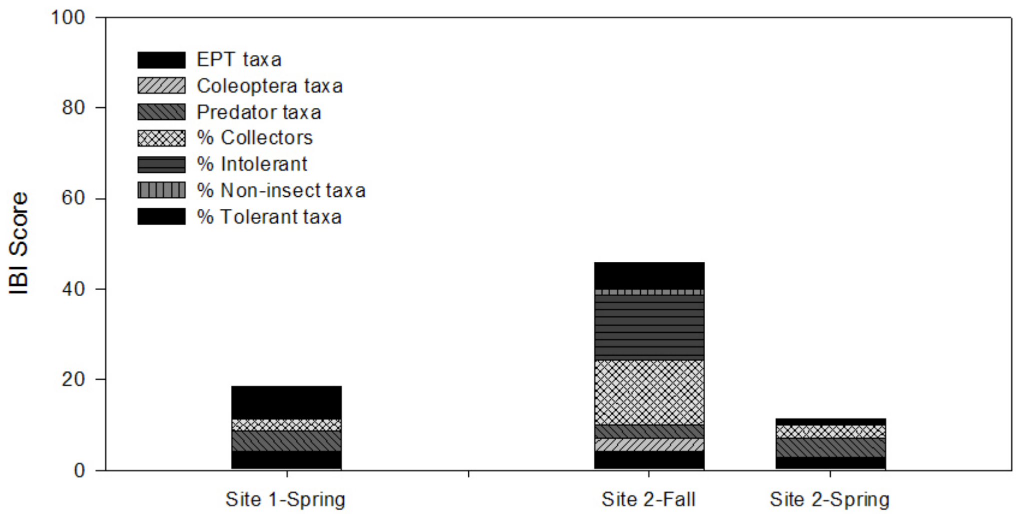

Figure 10. IBI scores at each bioassessment site and season. The height of the bar indicates the mean IBI score, and the size of each component of the bar represents the contribution of each metric to the IBI.

None of these sites were monitored under SWAMP, and all bioassessment data came from monitoring efforts by the San Diego Regional Board. No bioassessment data were collected from Poggi Creek.

4.4 Physical Habitat

Physical habitat was severely degraded at Poggi Creek, and moderately degraded at Jamul Creek. For example, at Jamul Creek, only two components of physical habitat were severely degraded (embeddedness and channel flow) and received scores under 5. In contrast, seven components were severely degraded at Poggi Creek. Although alteration was evident at both sites (e.g., only three components received scores above 15 at Jamul Creek, and none did so at Poggi Creek), impacts at Poggi Creek were more severe (Table 13; Figure 11).

Table 13. Score and mean for each component of physical habitat. Component range: 0 (heavily impacted habitat) to 20 (unimpacted habitat).

Sitecode	Date	Phab 1 Epifaunal cover	Phab 2 Embeddedness	Phab 3 Velocity-depth regime	Phab 4 Sediment deposition	Phab 5 Channel flow	Phab 6 Channel alteration	Phab 7 Riffle frequency	Phab 8 Bank stability	Phab 9 Vegetation protection	Phab 10 Riparian zone	Mean score
910OTJAM4	8/30/2001	13	2	8	14	4	13	15	19	18	14	12
910OTPOG3	12/31/2002	4	4	3	3	12	0	2	14	10	2	5.4
Mean of all sites		8.5	3	5.5	8.5	8	6.5	8.5	16.5	14	8	8.7

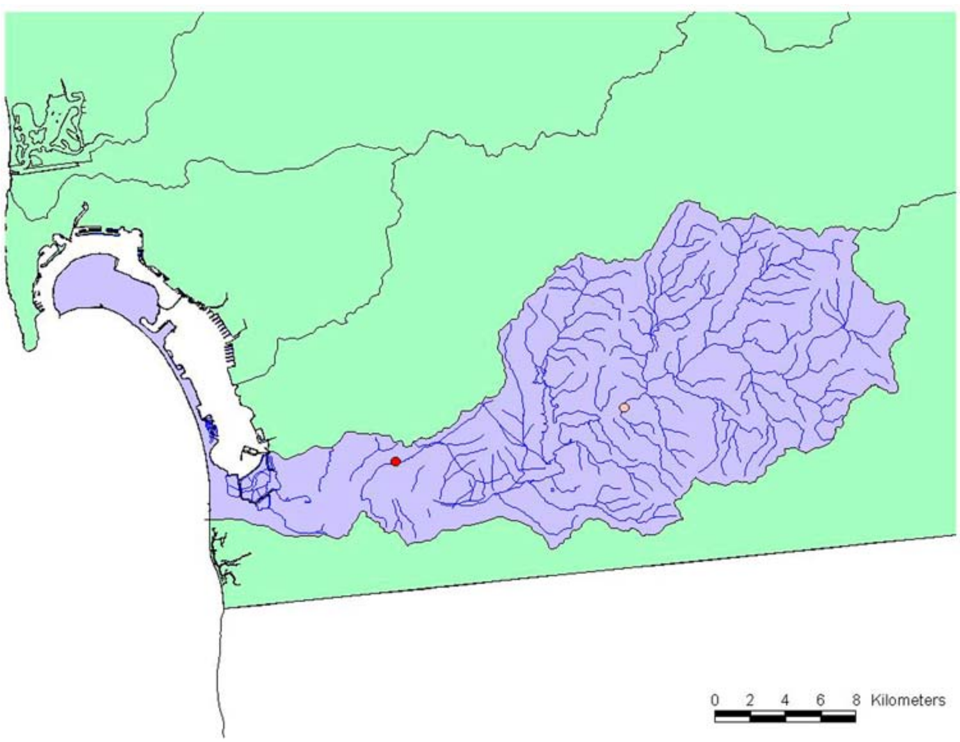

Figure 11. Assessment of physical habitat at SWAMP sites. White circles indicate sites with a mean physical habitat scores between 15 and 20 (this value did not occur in this watershed). Pink circles indicate mean scores between 10 and 15. Red circles indicate mean scores between 0 and 10.

5. DISCUSSION

The data collected by this study cannot be used to evaluate the overall health of the Otay HU because only two sites in the watershed were sampled. Although the data are inadequate to infer confidently about the condition of the entire watershed, they are sufficient to evaluate the two sites selected for monitoring.

The two sites in Otay HU showed evidence of impact from multiple indicators, and for most indicators impacts were more severe at Poggi Creek (Table 14; Figure 12). For example, more pesticides (5 vs. 2) were detected, and more constituents exceeded aquatic life (4 vs. 3) and human health thresholds (2 vs. 1) in water from Poggi Creek, compared to Jamul Creek. At both sites, Ammonia-N frequently exceeded aquatic life thresholds, and several anthropogenic constituents were frequently detected (e.g., dibenzothiphenes, oxadiazon, and p,p'-DDT). In Poggi Creek, selenium, specific conductivity, DDT-related constituents also exceeded thresholds. These data are consistent with the listing of Poggi Creek as impaired by DDT on the 303(d) list.

Table 14. Summary of the ecological health for two SWAMP sites in the Otay 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. Biology data were collected in 2000-2001, and all other data were collected in 2003.

	Water chemistry		Tissue	Toxicity	Biology	Physical habitat
Site	# constituents (AL)	# constituents (HH)	# constituents (OEHHA)	Frequency	Frequency	Mean score
910OTJAM4	3	1	Not tested	0.33	0.67*	12.0
904CBSAM6	4	2	Not tested	0.50	Not tested	5.4

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

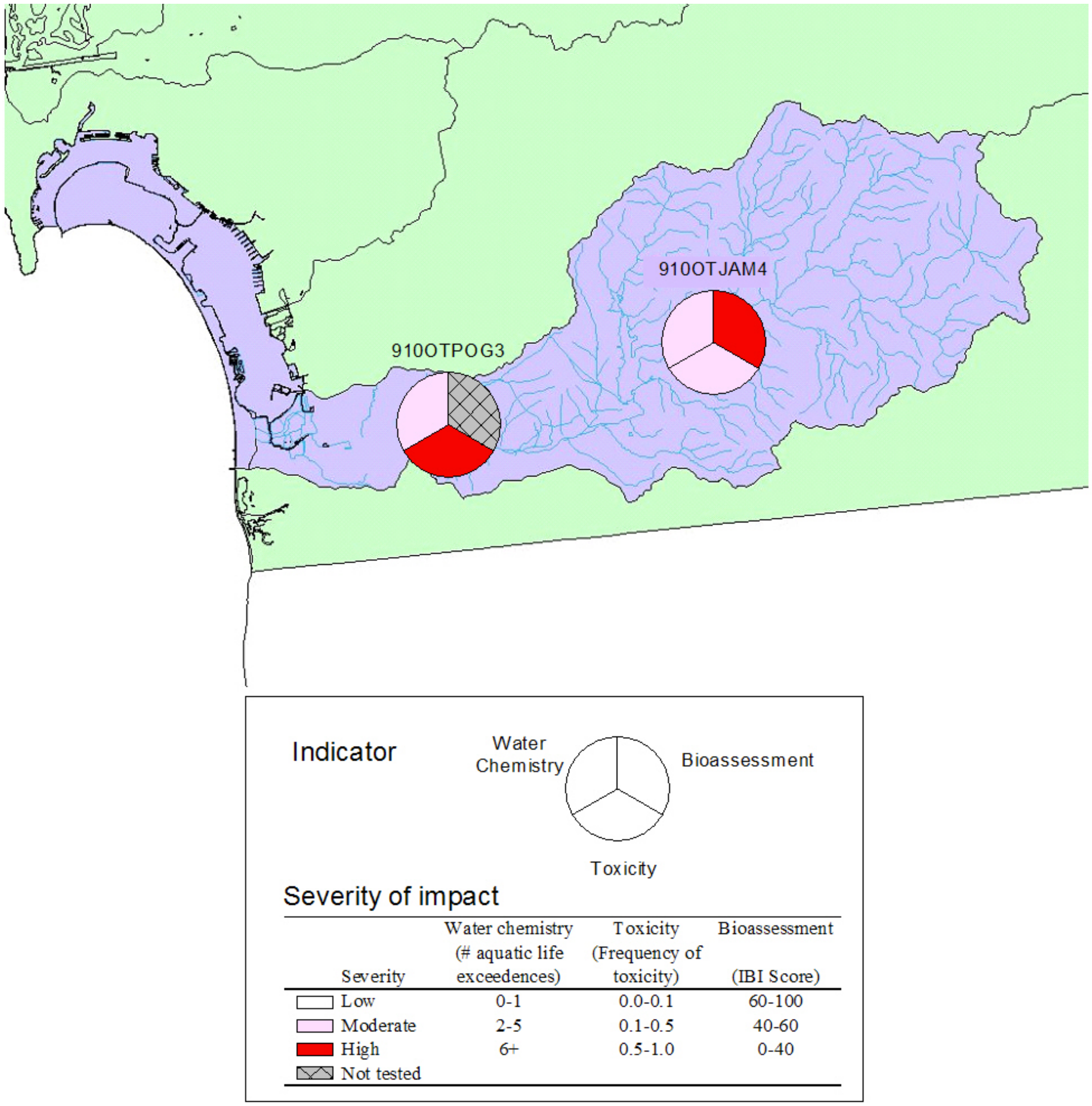

Figure 12. Summary of the ecological health of SWAMP sites in the Otay HU, as determined by water chemistry, toxicity, and bioassessment indicators. Each pie slice corresponds to a specific indicator, as described in the inset, with darker colors corresponding to more degraded conditions (unmeasured 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.

Toxicity tests also revealed differences between the sites. Half of all samples from Poggi Creek indicated chronic toxicity Poggi Creek, compared to only a third of samples from Jamul Creek. However, at both sites water samples were frequently toxic to *S. capricornutum*, with 83% of samples indicating toxicity. Although sampling efforts with arthropod indicators were uneven, neither site appeared to be toxic to *C. dubia.*

Despite the fact that water chemistry was better and toxicity lower at Jamul Creek, bioassessment data suggested that this site did not support a healthy community of benthic macroinvertebrates. Two samples collected nearby in the Spring over two years were in very poor condition (IBIs < 20), and one sample collected in Fall was in fair condition. Although no data are available from Poggi Creek, the fact that all other indicators show evidence of greater impairment there than at Jamul Creek suggests that benthic communities are in very poor condition at Poggi Creek as well.

Physical habitat was severely degraded at Poggi Creek, with most components of physical habitat showing evidence of extensive alteration. In contrast, physical habitat at Jamul Creek was moderately degraded, with only a couple of components showing extensive alteration (i.e., embeddedness and channel flow). Impacts from embeddedness were evident at both sites, suggesting that this impact may be widespread throughout the watershed.

Despite the apparent healthier condition of Jamul Creek, it is perhaps surprising that bioassessment samples from that site were in poor condition. However, the lack of bioassessment data from Poggi Creek makes comparison of benthic communities at these sites impossible. Furthermore, impacts from altered water chemistry, toxicity, and degraded physical habitat may be severe enough to affect IBI scores. The relationship between these factors and IBI scores, as well as the identification of threshold responses in IBI scores, is an active subject of research in Southern California and other parts of the country.

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

Despite the strength of the evidence, limitations of this study affect the assessment. These limitations include difficulties integrating data from SWAMP and Regional Board data, the non-randomization of sample sites, small sample size, and the lack of applicable thresholds for several indicators.

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

Johnson 2000, Bêche et al. 2006).In this study, bioassessment data were observed to be highly variable, and the use of data collected many years before water chemistry data is questionable.

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

The small number of sites monitored under SWAMP also limits the certainty of this study's assessment. The low level of replication (i.e., 2) of sites in the Otay watershed severely limits the ability to infer about the condition about the watershed as a whole. Although SWAMP has produced a wealth of data about the Otay watershed using limited resources, some indicators (especially those with high variability) require more extensive sampling to produce more precise and accurate assessments. A larger number of sites will be necessary to evaluate the health of the Otay watershed with greater certainty.

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

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7. APPENDICES

APPENDIX I

A. Beneficial uses of streams in the Otay HU (California Regional Water Quality Control Board, San Diego Region 1994). B. Streams on the 303(d) list of impaired water bodies in the Otay. HUC = Hydrologic Unit Code. MUN = Municipal and domestic supply. AGR = Agricultural supply. IND = Industrial service supply. PROC = Industrial process 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 Otay HU.

Otay HU (910)	HUC	MUN	AGR	IND	PROC	REC1	REC2	WARM	COLD	WILD	RARE	SPWN
San Diego County Coastal Streams												
Unnamed intermittent coastal streams	910.10	X				P		E				
Otay River Watershed												
Jamul Creek	910.34	E	E	E	E	E	E	E		E		
Jamul Creek	910.33	E	E		E	E	E	E		E		
Jamul Creek	910.36	E	E	E	E	E	E	E		E		
Dulzura Creek	910.37	E	E	E	E	E	E	E		E		
Dulzura Creek	910.36	E	E	E	E	E	E	E		E	E	
Dutchman Canyon	910.36	E	E	E	E	E	E	E		E		
Pringle Canyon	910.36	E	E	E	E	E	E	E		E		
Sycamore Canyon	910.36	E	E	E	E	E	E	E		E		
Hollenbeck Canyon	910.36	E	E	E	E	E	E	E		E		
Lyons Valley	910.36	E	E	E	E	E	E	E		E		
Cedar Canyon	910.36	E	E	E	E	E	E	E	E	E		E
Little Cedar Canyon	910.36	E	E	E	E	E	E	E	E	E		
Jamul Creek	910.31	E	E	E	E	E	E	E		E	E	
Unnamed tributary	910.31	E	E	E	E	E	E	E		E	E	
Proctor Valley	910.32	E	E	E	E	E	E	E		E		
Otay River	910.2	X	E	P		P	E	E		E	E	
O'Neal Canyon	910.2	X	E	P		P	E	E		E		
Salt Creek	910.2	X	E	P		P	E	E		E		
Johnson Canyon	910.2	X	E	P		P	E	E		E		
Wolf Canyon	910.2	X	E	P		P	E	E		E		
Dennery Canyon	910.2	X	E	P		P	E	E		E		
Poggi Canyon	910.2	X	E	P		P	E	E		E		

Appendix I, continued.
B. 303(d)-listed streams in the Otay HU.

Name	HUC	Stressor	Potential source	Affected length
Pogi Canyon Creek	910.2	DDT	Sources unknown	7.8 miles

APPENDIX II

Means, standard deviations (SD), and number of samples (n) of water chemistry constituents in SWAMP 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 2003.

			910OTJAM4			910OTPOG3			Entire watershed		
Category	**Constituent**	**Units**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**
Inorganics	Alkalinity as CaCO3	mg/l	246	6	3	216	20	3	231	21	2
Inorganics	Ammonia as N	mg/l	0.04	0.04	3	0.04	0.04	3	0.04	0	2
Inorganics	Nitrate + Nitrite as N	mg/l	0.06	0.01	3	3.81	1.45	3	1.93	2.65	2
Inorganics	Nitrate as N	mg/l	0.06	0.01	3	3.74	1.41	3	1.9	2.6	2
Inorganics	Nitrite as N	mg/l	--	--	3	0.07	0.04	3	0.03	0.05	2
Inorganics	Nitrogen, Total Kjeldahl	mg/l	0.37	0.03	3	1.07	0.19	3	0.72	0.5	2
Inorganics	OrthoPhosphate as P	mg/l	0.02	0	3	0.01	0	3	0.01	0	2
Inorganics	Phosphorus as P,Total	mg/l	--	--	3	0.02	0.02	3	0.01	0.02	2
Inorganics	Selenium,Dissolved	µg/L	2.8	0.5	3	15.5	3.3	3	9.2	9	2
Inorganics	Sulfate	mg/l	189	6	3	235	51	3	212	32	2
Metals	Aluminum,Dissolved	µg/L	0.5	0.9	3	0.7	0.7	3	0.6	0.1	2
Metals	Arsenic,Dissolved	µg/L	1.3	0.2	3	11.9	0.7	3	6.6	7.5	2
Metals	Cadmium,Dissolved	µg/L	0.02	0	3	0.03	0.01	3	0.02	0.01	2
Metals	Chromium,Dissolved	µg/L	0.1	0.04	3	0.67	0.16	3	0.38	0.4	2
Metals	Copper,Dissolved	µg/L	2.02	0.34	3	4.11	0.38	3	3.06	1.48	2
Metals	Lead,Dissolved	µg/L	0.01	0.01	3	0.03	0.01	3	0.02	0.01	2
Metals	Manganese,Dissolved	µg/L	85	91	3	10	9	3	47	53	2
Metals	Nickel,Dissolved	µg/L	0.4	0.6	3	0.9	1.6	3	0.7	0.4	2
Metals	Silver,Dissolved	µg/L	--	--	3	--	--	3	--	--	2
Metals	Zinc,Dissolved	µg/L	1.7	1	3	2.4	0.5	3	2	0.5	2
PAHs	Acenaphthene	µg/L	--	--	3	--	--	3	--	--	2
PAHs	Acenaphthylene	µg/L	--	--	3	--	--	3	--	--	2
PAHs	Anthracene	µg/L	--	--	3	--	--	3	--	--	2
PAHs	Benz(a)anthracene	µg/L	--	--	3	--	--	3	--	--	2
PAHs	Benzo(a)pyrene	µg/L	--	--	3	--	--	3	--	--	2
PAHs	Benzo(b)fluoranthene	µg/L	--	--	3	--	--	3	--	--	2
PAHs	Benzo(e)pyrene	µg/L	--	--	3	--	--	3	--	--	2
PAHs	Benzo(g,h,i)perylene	µg/L	--	--	3	--	--	3	--	--	2
PAHs	Benzo(k)fluoranthene	µg/L	--	--	3	--	--	3	--	--	2
PAHs	Biphenyl	µg/L	--	--	3	--	--	3	--	--	2
PAHs	Chrysene	µg/L	--	--	3	--	--	3	--	--	2
PAHs	Chrysenes, C1 -	µg/L	--	--	3	--	--	3	--	--	2
PAHs	Chrysenes, C2 -	µg/L	--	--	3	--	--	3	--	--	2
PAHs	Chrysenes, C3 -	µg/L	--	--	3	--	--	3	--	--	2
PAHs	Dibenz(a,h)anthracene	µg/L	--	--	3	--	--	3	--	--	2
PAHs	Dibenzothiophene	µg/L	--	--	3	--	--	3	--	--	2
PAHs	Dibenzothiophenes, C1 -	µg/L	0.004	0.006	3	0.004	0.006	3	0.004	0	2
PAHs	Dibenzothiophenes, C2 -	µg/L	0.008	0.007	3	0.007	0.011	3	0.007	0.001	2
PAHs	Dibenzothiophenes, C3 -	µg/L	--	--	3	--	--	3	--	--	2
PAHs	Dimethylnaphthalene, 2,6-	µg/L	--	--	3	--	--	3	--	--	2
PAHs	Fluoranthene	µg/L	--	--	3	--	--	3	--	--	2
PAHs	Fluoranthene/Pyrenes, C1 -	µg/L	--	--	3	--	--	3	--	--	2
PAHs	Fluorene	µg/L	--	--	3	--	--	3	--	--	2
PAHs	Fluorenes, C1 -	µg/L	--	--	3	--	--	3	--	--	2
PAHs	Fluorenes, C2 -	µg/L	--	--	3	--	--	3	--	--	2
PAHs	Fluorenes, C3 -	µg/L	--	--	3	--	--	3	--	--	2
PAHs	Indeno(1,2,3-c,d)pyrene	µg/L	--	--	3	--	--	3	--	--	2
PAHs	Methylnaphthalene, 1-	µg/L	--	--	3	--	--	3	--	--	2
PAHs	Methylnaphthalene, 2-	µg/L	--	--	3	--	--	3	--	--	2
PAHs	Methylphenanthrene, 1-	µg/L	--	--	3	--	--	3	--	--	2
PAHs	Naphthalene	µg/L	--	--	3	--	--	3	--	--	2
PAHs	Naphthalenes, C1 -	µg/L	--	--	3	--	--	3	--	--	2
PAHs	Naphthalenes, C2 -	µg/L	--	--	3	--	--	3	--	--	2
PAHs	Naphthalenes, C3 -	µg/L	--	--	3	--	--	3	--	--	2
PAHs	Naphthalenes, C4 -	µg/L	--	--	3	--	--	3	--	--	2
PAHs	Perylene	µg/L	--	--	3	--	--	3	--	--	2

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

			910OTJAM4			910OTPOG3			Entire watershed		
Category	**Constituent**	**Units**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**
PAHs	Phenanthrene	µg/L	--	--	3	--	--	3	--	--	2
PAHs	Phenanthrene/Anthracene, C1 -	µg/L	--	--	3	--	--	3	--	--	2
PAHs	Phenanthrene/Anthracene, C2 -	µg/L	--	--	3	--	--	3	--	--	2
PAHs	Phenanthrene/Anthracene, C3 -	µg/L	--	--	3	--	--	3	--	--	2
PAHs	Phenanthrene/Anthracene, C4 -	µg/L	--	--	3	--	--	3	--	--	2
PAHs	Pyrene	µg/L	--	--	3	--	--	3	--	--	2
PAHs	Trimethylnaphthalene, 2,3,5-	µg/L	--	--	3	--	--	3	--	--	2
PCBs	PCB 005	µg/L	--	--	3	--	--	3	--	--	2
PCBs	PCB 008	µg/L	--	--	3	--	--	3	--	--	2
PCBs	PCB 015	µg/L	--	--	3	--	--	3	--	--	2
PCBs	PCB 018	µg/L	--	--	3	--	--	3	--	--	2
PCBs	PCB 027	µg/L	--	--	3	--	--	3	--	--	2
PCBs	PCB 028	µg/L	--	--	3	--	--	3	--	--	2
PCBs	PCB 029	µg/L	--	--	3	--	--	3	--	--	2
PCBs	PCB 031	µg/L	--	--	3	--	--	3	--	--	2
PCBs	PCB 033	µg/L	--	--	3	--	--	3	--	--	2
PCBs	PCB 044	µg/L	--	--	3	--	--	3	--	--	2
PCBs	PCB 049	µg/L	--	--	3	--	--	3	--	--	2
PCBs	PCB 052	µg/L	--	--	3	--	--	3	--	--	2
PCBs	PCB 056	µg/L	--	--	3	--	--	3	--	--	2
PCBs	PCB 060	µg/L	--	--	3	--	--	3	--	--	2
PCBs	PCB 066	µg/L	--	--	3	--	--	3	--	--	2
PCBs	PCB 070	µg/L	--	--	3	--	--	3	--	--	2
PCBs	PCB 074	µg/L	--	--	3	--	--	3	--	--	2
PCBs	PCB 087	µg/L	--	--	3	--	--	3	--	--	2
PCBs	PCB 095	µg/L	--	--	3	--	--	3	--	--	2
PCBs	PCB 097	µg/L	--	--	3	--	--	3	--	--	2
PCBs	PCB 099	µg/L	--	--	3	--	--	3	--	--	2
PCBs	PCB 101	µg/L	--	--	3	--	--	3	--	--	2
PCBs	PCB 105	µg/L	--	--	3	--	--	3	--	--	2
PCBs	PCB 110	µg/L	--	--	3	--	--	3	--	--	2
PCBs	PCB 114	µg/L	--	--	3	--	--	3	--	--	2
PCBs	PCB 118	µg/L	--	--	3	--	--	3	--	--	2
PCBs	PCB 128	µg/L	--	--	3	--	--	3	--	--	2
PCBs	PCB 137	µg/L	--	--	3	--	--	3	--	--	2
PCBs	PCB 138	µg/L	--	--	3	--	--	3	--	--	2
PCBs	PCB 141	µg/L	--	--	3	--	--	3	--	--	2
PCBs	PCB 149	µg/L	--	--	3	--	--	3	--	--	2
PCBs	PCB 151	µg/L	--	--	3	--	--	3	--	--	2
PCBs	PCB 153	µg/L	--	--	3	--	--	3	--	--	2
PCBs	PCB 156	µg/L	--	--	3	--	--	3	--	--	2
PCBs	PCB 157	µg/L	--	--	3	--	--	3	--	--	2
PCBs	PCB 158	µg/L	--	--	3	--	--	3	--	--	2
PCBs	PCB 170	µg/L	--	--	3	--	--	3	--	--	2
PCBs	PCB 174	µg/L	--	--	3	--	--	3	--	--	2
PCBs	PCB 177	µg/L	--	--	3	--	--	3	--	--	2
PCBs	PCB 180	µg/L	--	--	3	--	--	3	--	--	2
PCBs	PCB 183	µg/L	--	--	3	--	--	3	--	--	2
PCBs	PCB 187	µg/L	--	--	3	--	--	3	--	--	2
PCBs	PCB 189	µg/L	--	--	3	--	--	3	--	--	2
PCBs	PCB 194	µg/L	--	--	3	--	--	3	--	--	2
PCBs	PCB 195	µg/L	--	--	3	--	--	3	--	--	2
PCBs	PCB 200	µg/L	--	--	3	--	--	3	--	--	2
PCBs	PCB 201	µg/L	--	--	3	--	--	3	--	--	2
PCBs	PCB 203	µg/L	--	--	3	--	--	3	--	--	2
PCBs	PCB 206	µg/L	--	--	3	--	--	3	--	--	2
PCBs	PCB 209	µg/L	--	--	3	--	--	3	--	--	2
PCBs	PCBs	µg/L	--	--	3	--	--	3	--	--	2

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

			910OTJAM4			910OTPOG3			Entire watershed		
Category	**Constituent**	**Units**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**
Pesticides	Aldrin	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Ametryn	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Aspon	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Atraton	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Atrazine	µg/L	--	--	3	0.014	0.024	3	0.007	0.01	2
Pesticides	Azinphos ethyl	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Azinphos methyl	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Bolstar	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Carbophenothion	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Chlordane, cis-	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Chlordane, trans-	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Chlordene, alpha-	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Chlordene, gamma-	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Chlorfenvinphos	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Chlorpyrifos	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Chlorpyrifos methyl	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Ciodrin	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Coumaphos	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Dacthal	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	DDD(o,p')	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	DDD(p,p')	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	DDE(o,p')	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	DDE(p,p')	µg/L	--	--	3	0.003	0.003	3	0.002	0.002	2
Pesticides	DDMU(p,p')	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	DDT(o,p')	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	DDT(p,p')	µg/L	0.001	0.001	3	0.001	0.001	3	0.001	--	2
Pesticides	DDTs	µg/L	0.001	0.001	3	0.004	0.003	3	0.002	0.002	2
Pesticides	Demeton-s	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Diazinon	µg/L	--	--	3	0.042	0.021	3	0.021	0.029	2
Pesticides	Dichlofenthion	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Dichlorvos	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Dicrotophos	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Dieldrin	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Dimethoate	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Dioxathion	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Disulfoton	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Endosulfan I	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Endosulfan II	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Endosulfan sulfate	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Endrin	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Endrin Aldehyde	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Endrin Ketone	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Ethion	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Ethoprop	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Famphur	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Fenchlorphos	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Fenitrothion	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Fensulfothion	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Fenthion	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Fonofos	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	HCH, alpha	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	HCH, beta	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	HCH, delta	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	HCH, gamma	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Heptachlor	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Heptachlor epoxide	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Hexachlorobenzene	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Leptophos	µg/L	--	--	3	--	--	3	--	--	2

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

			910OTJAM4			910OTPOG3			Entire watershed		
Category	**Constituent**	**Units**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**
Pesticides	Malathion	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Merphos	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Methidathion	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Methoxychlor	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Mevinphos	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Mirex	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Molinate	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Naled	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Nonachlor, cis-	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Nonachlor, trans-	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Oxadiazon	µg/L	0.002	0.004	3	0.054	0.04	3	0.028	0.037	2
Pesticides	Oxychlordane	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Parathion, Ethyl	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Parathion, Methyl	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Phorate	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Phosmet	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Phosphamidon	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Prometon	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Prometryn	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Propazine	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Secbumeton	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Simazine	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Simetryn	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Sulfotep	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Tedion	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Terbufos	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Terbuthylazine	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Terbutryn	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Tetrachlorvinphos	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Thiobencarb	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Thionazin	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Tokuthion	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Trichlorfon	µg/L	--	--	3	--	--	3	--	--	2
Pesticides	Trichloronate	µg/L	--	--	3	--	--	3	--	--	2
Physical	Fine-ASTM	%									
Physical	Fine-ASTM,Passing No. 200 Sieve	%	2.3	--	1				2.3	--	1
Physical	Oxygen, Saturation	%	103	22	3	142	19	3	122	28	2
Physical	pH	pH	7.7	0.3	3	7.9	0.1	3	7.8	0.2	2
Physical	Salinity	ppt	0.8	0.3	3	2	0.6	3	1.4	0.9	2
Physical	SpecificConductivity	mS/cm	1528	534	3	3841	1041	3	2685	1635	2
Physical	Temperature	ºC	14.6	1.5	3	16.6	1.8	3	15.6	1.4	2
Physical	Total Suspended Solids	mg/L	5.6	2.1	3	46.5	50.7	3	26.1	28.9	2
Physical	Turbidity	NTU	2.1	0.9	3	2.4	2.1	3	2.3	0.2	2
Physical	Velocity	ft/s	0.1	0.1	3	1.1	1.1	3	0.6	0.7	2

APPENDIX III

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

	C. dubia						*H. azteca*						*S. capricornutum*		
	Survival			Young / female			Survival			Growth			Total cell count		
StationCode	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n
910OTJAM4	100		1	106		1	90	18	3	124	26	2	66	37	3
910OTPOG3	93	12	3	81	36	3			0			0	56	8	3
Entire watershed	95	10	4	88	32	4	86	18	3	124	26	2	61	25	6

APPENDIX IV

Mean IBI and metric scores for bioassessment sites in the Otay 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.

Site	Site 1	Site 2	
Date	5/19/2001	11/12/2000	5/19/2001
Season	Spring	Fall	Spring
IBI	19	46	11
Condition	Very poor	Fair	Very poor
EPT Taxa	3	3	2
Coleoptera Taxa	0	2	0
Predator Taxa	3	2	3
% Collectors	2	10	2
% Intolerant	0	10	0
% Non-Insect Taxa	0	1	0
% Tolerant Taxa	5	4	1