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

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

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1. ABSTRACT

In order to assess the ecological health of the Peñasquitos Hydrologic Unit (San Diego County, CA), water chemistry, water and sediment toxicity, crayfish tissues, benthic macroinvertebrate communities, and physical habitat were assessed at multiple sites. Water chemistry, toxicity, and fish tissues were assessed under SWAMP in 2002, and bioassessment samples were collected between 1998 and 2005 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 widespread impacts to the watershed. For example, all 5 sites monitored in 2002 under the Surface Water Ambient Monitoring Program (SWAMP) exceeded aquatic life thresholds for several water chemistry constituents (up to eight at one site). These stressors included pesticides, as well as nutrients. Toxicity to *Selenastrum capricornutum* was also observed at every site; nearly 40% of sediment samples were toxic to *Hyallela azteca*. Bioassessment samples collected from 7 sites in Spring and Fall between 1998 and 2005 indicated widespread degradation, as all samples (n = 59) were in poor or very poor condition (i.e., Index of Biotic Integrity <40). Therefore, benthic macroinvertebrate communities were similar to communities expected at impaired sites. Physical habitat varied among sites, with mean physical habitat scores ranging from 4.8 to 15.4 out of 20. Multiple stressors, such as pollution of water and sediment, and alteration of physical habitat, were likely responsible for the poor health of the watershed. Despite limitations of this assessment (e.g., uncertain spatial and temporal variability, low levels of replication, non-probabilistic sampling, and lack of thresholds for several indicators), multiple lines of evidence support the conclusion that the Peñasquitos watershed is in poor ecological condition.

2. INTRODUCTION

The Peñasquitos hydrologic unit (HU 906) is in San Diego County and is home to more than 400,000 people and represents an important water resource in one of the most arid regions of the nation. Despite strong interest in the surface waters of the Peñasquitos HU, a comprehensive assessment of the ecological health of these waters has not been conducted. The purpose of this report was to assess watershed health using data collected under the Surface Waters Ambient Monitoring Program (SWAMP) in 2002, and data collected by National Pollution Discharge Elimination System (NPDES) permittees. The SWAMP program was undertaken to evaluate the ecological health of the 11 HUs in the San Diego Region. 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 Peñasquitos HU.

Table 1. Watersheds monitored under the SWAMP program.

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

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

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

2.1 Background

The Peñasquitos HU is a collection of coastal watersheds in southern San Diego county draining into Mission Bay, Los Peñasquitos Lagoon, and the Pacific Ocean (Figure 1). Located entirely within San Diego County, the watershed covers 162 mi^2 and ranges from Iron Mountain in the interior to the Pacific Coast.

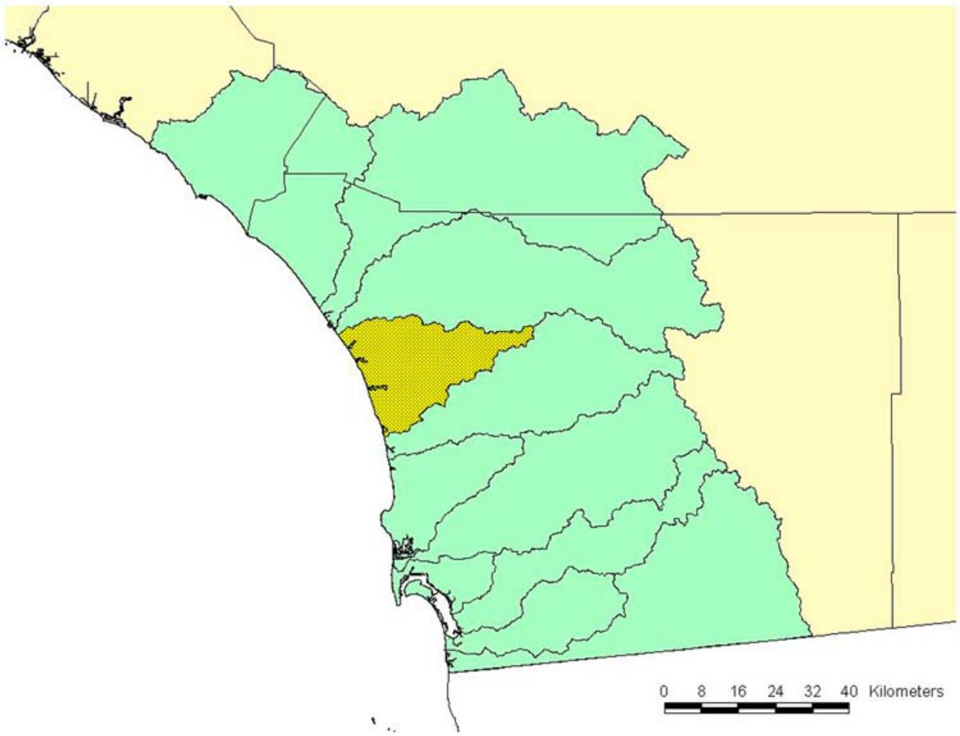


Figure 1. San Diego region (green) includes portions of San Diego, Riverside, and Orange counties. The Peñasquitos watershed (yellow, shaded) is located entirely within San Diego County.

2.1.1 Climate

The Peñasquitos 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 Miramar (at the interior of the HU) and at Sea World (near the coast within the HU) shows considerable variability in rainfall throughout the HU (National Oceanic and Atmospheric Administration 2007) (Figure 2).

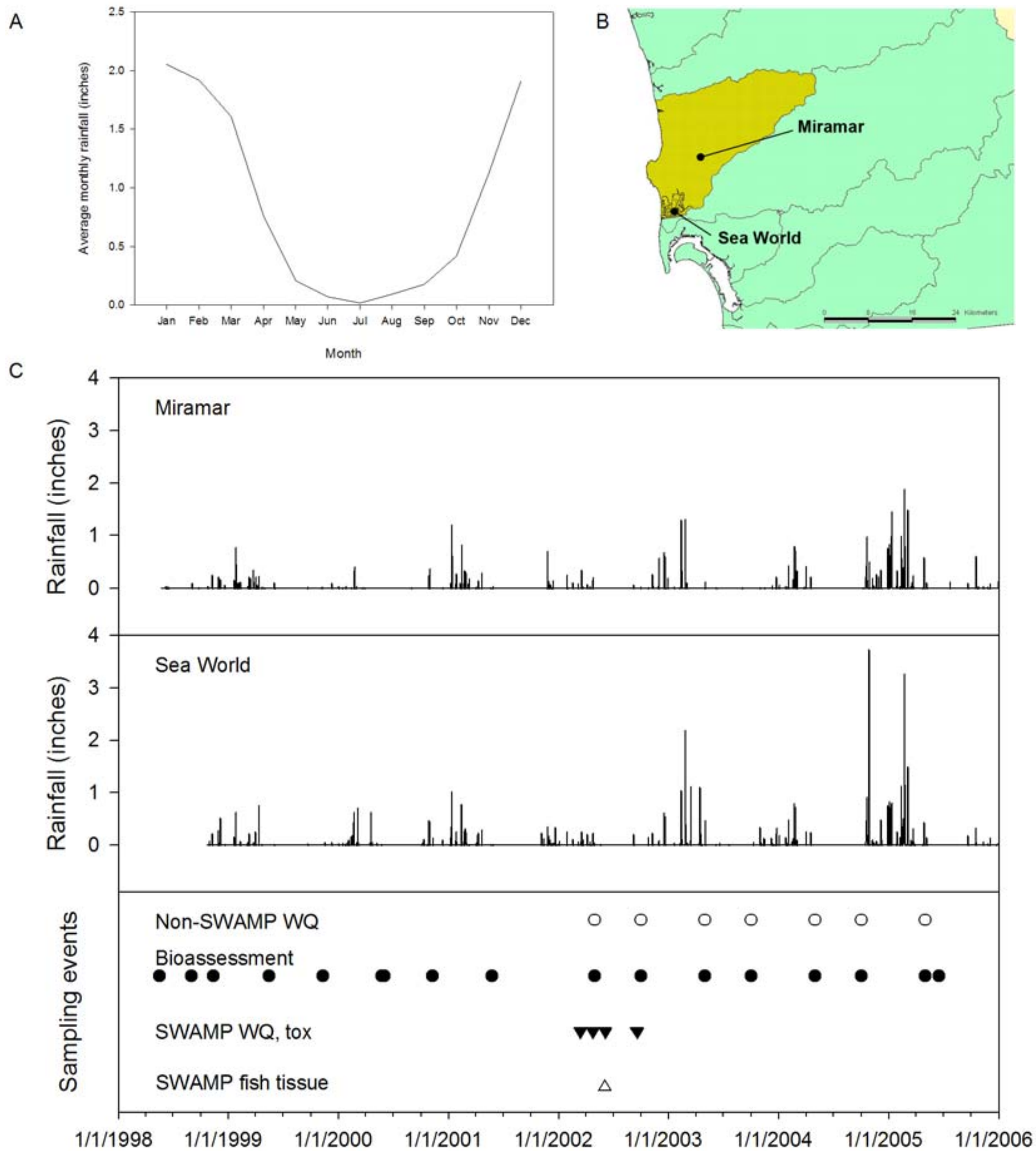


Figure 2. Rainfall and sampling events at two stations in the San Diego region. A. Average precipitation for each month at the Lindberg Station (DWR station code SDG), based on data collected between January 1905 and November 2006. B. Location of the Miramar and Sea World gauges. C. Storm events and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

2.1.2 Hydrology

Los Peñasquitos Creek is the largest stream in the 162 mi^2 HU; Beeler Creek, Rattlesnake Creek, Sabre Springs, Chicarita Creek, Soledad Canyon, Poway Creek and Lopez Creek are major tributaries of Los Peñasquitos, which empties into Los Peñasquitos Lagoon. Other streams in the Peñasquitos HU include Tecolote Creek, Rose Creek (both tributaries of Mission Bay), Carroll Canyon Creek, Carmel Creek (both tributaries of Los Peñasquitos Lagoon), and several unnamed tributaries that drain into the Pacific Ocean. The Miramar Reservoir, created in 1960 by the City of San Diego, is the largest standing body of water in the Peñasquitos HU, and is located within the watershed of Los Peñasquitos Creek. The California Department of Water Resources does not maintain data for stream gauges within this watershed (Figure 3).

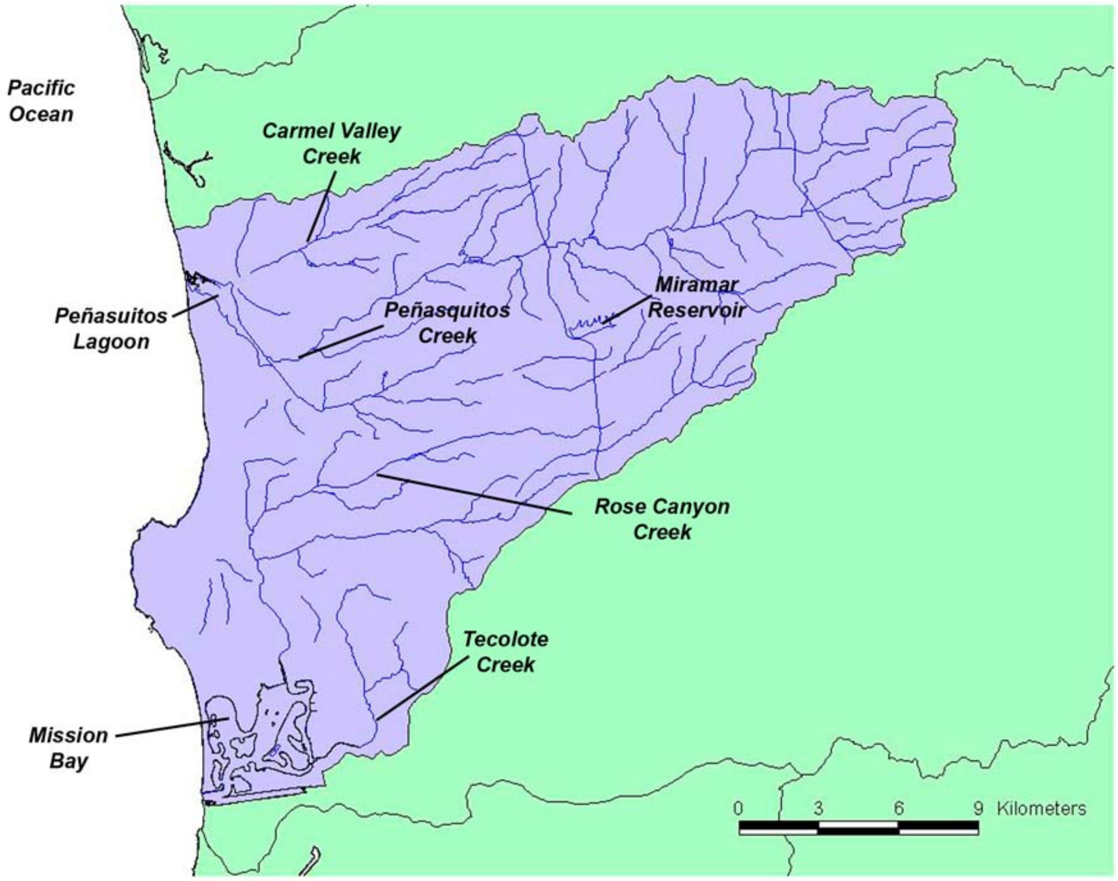


Figure 3. The Peñasquitos watershed, including five sub-basins and three major waterways: Los Peñasquitos Creek, Tecolote Creek, and Rose Canyon Creek. Los Peñasquitos Creek drains into Los Peñasquitos Lagoon, and Tecolote and Rose Canyon Creeks drain into Mission Bay.

2.1.3 Land Use within the Watershed

Several municipalities have jurisdiction over portions of the watershed, although the city of San Diego governs the majority (83.2%). Other cities include Poway (14.9%) and Del Mar (0.1%). The remainder of the watershed (1.8%) is comprised of unincorporated areas under the jurisdiction of the county of San Diego. Most of the watershed (53%) is developed urban land (residential and industrial). Parks or undeveloped land (43%) and agriculture (4%) account for the remainder of the land use within the watershed (Figure 4). The two largest parks protecting portions of the watershed are Tecolote Canyon Natural Park (1.4 mi^2) and Marian Bear Memorial Natural Park (0.7 mi^2); both parks are managed by the City of San Diego (SANDAG 1998). Other major landowners within the hydrologic unit include the US Marines (Miramar Marine Corps Air Station), Caltrans (freeways, highways, and the Kearney Mesa Maintenance Yard), and the Regents of the University of California (University of California at San Diego).

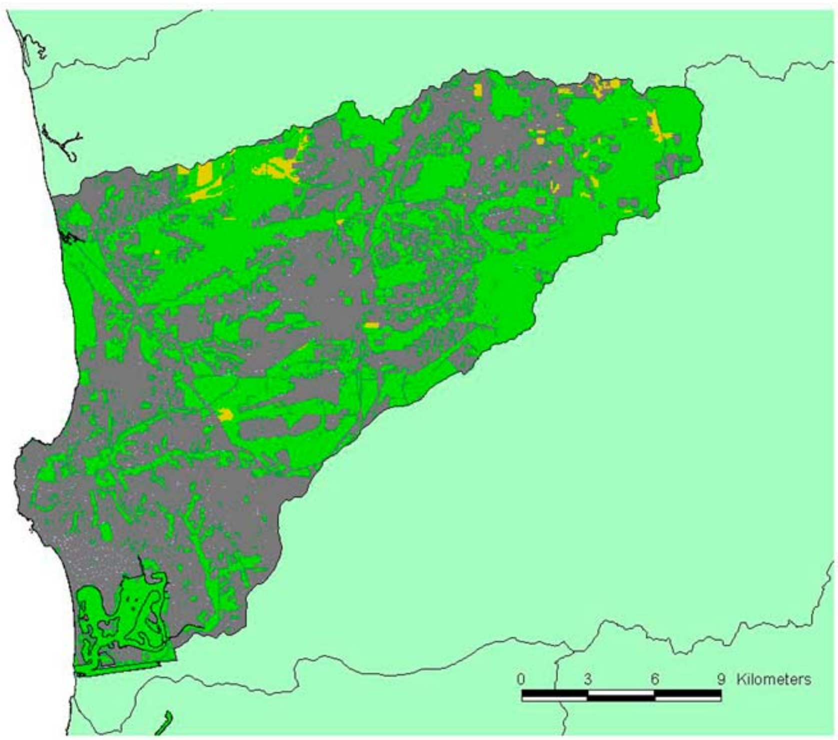


Figure 4. Land use within the Peñasquitos HU. Undeveloped open space is shown as green. Agricultural areas are shown as orange. Urban and developed lands are shown as dark gray.

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 Peñasquitos HU have been exempted from municipal uses (Appendix I)

Several streams in the Peñasquitos HU are listed as impaired on the 303(d) list of water quality limited segments, affecting a total of 20.3 stream miles. These streams include Los Peñasquitos Creek, Soledad Canyon, and Tecolote Creek. Known stressors include cadmium, copper, lead, phosphate, phosphorus, indicator bacteria, total dissolved solids, and water and sediment toxicity (Appendix I).

3. METHODS

This report analyzes data collected under SWAMP in the Los Peñasquitos HU in 2002 and supplements it with data from California Department of Fish and Game (CDFG) and NPDES monitoring (Table 2). Five sites of interest were sampled under SWAMP in the Peñasquitos HU in 2002 (Table 3; Figure 5). Water chemistry, water and sediment toxicity, and physical habitat was measured at each site. Fish tissues were collected at two sites (Rose Canyon Creek and Los Peñasquitos Creek) to assess bioaccumulation. Bioassessment was not included as part of SWAMP monitoring in the Peñasquitos HU, but bioassessment data collected by the CDFG Aquatic Bioassessment Laboratory (ABL) and the County of San Diego as part of its NPDES permit (from 2002 to 2005) was used in this report. In addition to bioassessment, conventional water chemistry (e.g., temperature, conductivity, dissolved oxygen) was also measured at sites sampled by San Diego County NPDES. When two non-SWAMP sites were located within 500 meters of each other, they were treated as a single site to minimize pseudoreplication and to associate indicators measured at slightly different locations. This distance of 500 meters was based on published measures of spatial correlation of benthic communities in streams (Gebler 2004). Non-SWAMP samples (i.e., samples collected by NPDES permittees or CDFG) were collected between 1998 and 2005; in some cases, non-SWAMP sites were very close to SWAMP sites (Table 4; Figure 5).

Table 2. Sources of data used in this report.

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

Table 3. SWAMP sampling site locations. Crayfish tissue measured at this location (*).

Site		Description	Latitude (°N)	Longitude (°E)
1	906LPLPC6	Los Peñasquitos Creek 6*	32.9032	-117.2263
2	906LPPOW2	Poway Creek 2	32.9524	-117.0453
3	906LPRSC4	Rose Canyon Creek 4*	32.8370	-117.2330
4	906LPSOL2	Soledad Canyon Creek 2	32.8912	-117.2126
5	906LPTEC3	Tecolote Creek 3	32.7754	-117.1885

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

Site	Description	SWAMP site within 500 m	Non-SWAMP Data Sources (site name)	W	B	Lat (°N)	Long (°E)
1	Carroll Creek west of I-805	906LPLPC6	CDFG (906CCC805)	X	X	32.8901	-117.2150
			SD NPDES (CCC-805)		X		
2	Chicarita Creek downstream of Evening Creek Road	None	CDFG (906CCECRx)		X	32.9621	-117.0934
3	Los Peñasquitos Creek above Black Mountain Road	None	CDFG (906LPCBMR)		X	32.9392	-117.1311
			SD NPDES (LPC-BMR)	X	X		
4	Los Peñasquitos Creek above Cobblestone Creek Road	None	CDFG (906LPCCCR)		X	32.9489	-117.0702
			SD NPDES (LPC-CCR)	X	X		
5	Rattlesnake Creek in Hilleary Park	None	CDFG (905RCHPxx)		X	32.9600	-117.0420
6	Tecolote Creek in Tecolote Nature Park	906LPTEC3	CDFG (906TCTCNP)		X	32.7752	-117.1890
			SD NPDES (TC-TCNP)	X	X		
7	Rose Canyon Creek	906LPRSC4	SD NPDES (MB-RC)	X	X	32.8343	-117.2315

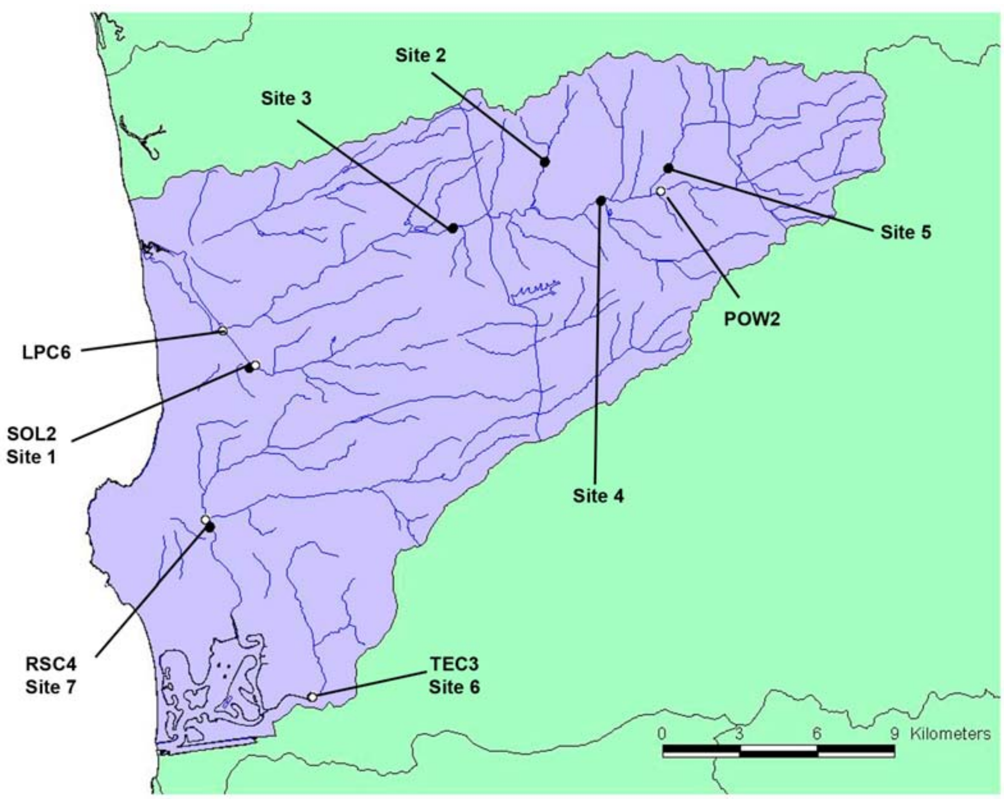


Figure 5. SWAMP (white circles) and non-SWAMP (black circles) sampling locations. The SWAMP site prefix designating the hydrologic unit (i.e., 906LP-) has been dropped to improve clarity.

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.

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

3.1.3 Tissue

To detect contamination in fish tissues in the Peñasquitos HU, crayfish tissues were collected at two sites (Los Peñasquitos Creek and Rose Canyon Creek). Crayfish were used for analysis because fish were not available for collection. Samples were not combined so that variability among individual organisms could be estimated. Two replicate crayfish were collected at each site.

Tissues were analyzed for metals, pesticides, PCBs, and PAHs as per the SWAMP QAMP (Puckett 2002). Wet-weight concentrations of each constituent were recorded.

3.1.4 Bioassessment

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

3.1.5 Physical Habitat

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

3.2 Data Analysis

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

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

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

3.2.1 Thresholds

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

Water chemistry data from this study were compared to water quality objectives established by state and federal agencies to protect the most sensitive beneficial uses designated in the Peñasquitos 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.

Table 5, continued. Threshold sources

Indicator	Source	Citation
Water chemistry	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 Peñasquitos HU. When multiple thresholds were applicable to a single constituent, the most stringent threshold was used. Water chemistry thresholds for aquatic life and human health standards used in this study are presented in Table 6. Impacts were assessed as the total number of constituents exceeding threshold, as opposed to the fraction of constituents. The fraction of constituents exceeding thresholds is not an ecologically meaningful statistic because the number of constituents below thresholds does not degrade or improve the ecological health of a site.

Table 6. Water chemistry thresholds for aquatic life and human health standards. San Diego Basin Plan (BP); California Toxics Rule (CTR); Environmental Protection Agency National Aquatic Life Standards (EPA); National Academy of Science Health Advisory (NASHA); Environmental Protection Agency Integrated Risk Information System (IRIS); California Code of Regulations §64449 (CCR). Threshold does not apply to Tecolote Creek - HSU 906.5 (*).

		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

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

		Aquatic life			Human health		
Category	Constituent	Threshold	Unit	Source	Threshold	Unit	Source
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
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 per indicator was used (*C. dubia*: fecundity, *H. azteca*: growth, and *S. capricornutum*: total cell count).

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

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

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

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

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

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

3.2.2 Quality Assurance and Quality Control (QA/QC)

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

4. RESULTS

4.1 Water Chemistry

Analysis of water chemistry for SWAMP sites indicated widespread impact to water quality for multiple constituents. Analysis of organic compounds showed that pesticides were a common contaminant in Peñasquitos HU, but PCBs and PAHs were rare. For example, 43 different pesticides were detected in the watershed, but only 4 PAHs and no PCBs (Table 8). The most widespread organic compounds were the pesticides atrazine, p,p'-DDE, diazinon, dimethoate, dioxathion, disulfoton, oxadiazon, propazine, secbumeton, and terbuthylazine, as well as the PAH C2-flourene. These compounds were found at every site (Table 9). Means and standard deviations of all constituents are presented in Appendix II.

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

	PAHs		PCBs		Pesticides	
	Tested	Detected	Tested	Detected	Tested	Detected
906LPLPC6	43	2	50	0	91	25
906LPPOW2	43	1	50	0	91	17
906LPRSC4	43	3	50	0	91	25
906LPSOL2	43	1	50	0	91	30
906LPTEC3	24	0	50	0	91	14
All sites	43	4	50	0	91	43

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

Category	Constituent	Tested	Detected	Frequency
PAHs	Acenaphthene	5	--	--
PAHs	Acenaphthylene	5	--	--
PAHs	Anthracene	5	--	--
PAHs	Benz(a)anthracene	5	--	--
PAHs	Benzo(a)pyrene	5	--	--
PAHs	Benzo(b)fluoranthene	5	--	--
PAHs	Benzo(e)pyrene	5	--	--
PAHs	Benzo(g,h,i)perylene	5	--	--
PAHs	Benzo(k)fluoranthene	5	--	--
PAHs	Biphenyl	5	--	--
PAHs	Chrysene	5	--	--
PAHs	Chrysenes, C1 -	4	--	--
PAHs	Chrysenes, C2 -	4	--	--
PAHs	Chrysenes, C3 -	4	--	--
PAHs	Dibenz(a,h)anthracene	5	--	--
PAHs	Dibenzothiophene	4	--	--
PAHs	Dibenzothiophenes, C1 -	4	--	--
PAHs	Dibenzothiophenes, C2 -	4	--	--
PAHs	Dibenzothiophenes, C3 -	4	--	--
PAHs	Dimethylnaphthalene, 2,6-	5	--	--
PAHs	Fluoranthene	5	--	--
PAHs	Fluoranthene/Pyrenes, C1 -	4	--	--
PAHs	Fluorene	5	--	--
PAHs	Fluorenes, C1 -	4	--	--
PAHs	Fluorenes, C2 -	4	4	1
PAHs	Fluorenes, C3 -	4	1	0.25
PAHs	Indeno(1,2,3-c,d)pyrene	5	--	--
PAHs	Methylnaphthalene, 1-	5	--	--
PAHs	Methylnaphthalene, 2-	5	--	--
PAHs	Methylphenanthrene, 1-	5	--	--
PAHs	Naphthalene	5	1	0.2
PAHs	Naphthalenes, C1 -	4	--	--
PAHs	Naphthalenes, C2 -	4	--	--
PAHs	Naphthalenes, C3 -	4	1	0.25
PAHs	Naphthalenes, C4 -	4	--	--
PAHs	Perylene	5	--	--
PAHs	Phenanthrene	5	--	--
PAHs	Phenanthrene/Anthracene,C1-	4	--	--
PAHs	Phenanthrene/Anthracene,C2-	4	--	--
PAHs	Phenanthrene/Anthracene,C3-	4	--	--
PAHs	Phenanthrene/Anthracene,C4-	4	--	--
PAHs	Pyrene	5	--	--
PAHs	Trimethylnaphthalene, 2,3,5-	5	--	--
PCBs	PCBs	5	--	--
Pesticides	Aldrin	5	1	0.2
Pesticides	Ametryn	5	--	--
Pesticides	Aspon	5	--	--
Pesticides	Atraton	5	1	0.2
Pesticides	Atrazine	5	5	1

Table 9. Continued. Frequency of detection of anthropogenic organic constituents.

Category	Constituent	Tested	Detected	Frequency
Pesticides	Azinphos ethyl	5	--	--
Pesticides	Azinphos methyl	5	2	0.4
Pesticides	Bolstar	5	--	--
Pesticides	Carbophenothion	5	4	0.8
Pesticides	Chlordane, cis-	5	--	--
Pesticides	Chlordane, trans-	5	--	--
Pesticides	Chlordene, alpha-	5	1	0.2
Pesticides	Chlordene, gamma-	5	2	0.4
Pesticides	Chlorfenvinphos	5	--	--
Pesticides	Chlorpyrifos	5	--	--
Pesticides	Chlorpyrifos methyl	5	--	--
Pesticides	Ciodrin	5	--	--
Pesticides	Coumaphos	5	1	0.2
Pesticides	Dacthal	5	3	0.6
Pesticides	DDD(o,p')	5	--	--
Pesticides	DDD(p,p')	5	1	0.2
Pesticides	DDE(o,p')	5	--	--
Pesticides	DDE(p,p')	5	5	1
Pesticides	DDMU(p,p')	5	--	--
Pesticides	DDT(o,p')	5	--	--
Pesticides	DDT(p,p')	5	2	0.4
Pesticides	Demeton-s	5	--	--
Pesticides	Diazinon	5	5	1
Pesticides	Dichlofenthion	5	--	--
Pesticides	Dichlorvos	5	--	--
Pesticides	Dicrotophos	5	3	0.6
Pesticides	Dieldrin	5	--	--
Pesticides	Dimethoate	5	5	1
Pesticides	Dioxathion	5	5	1
Pesticides	Disulfoton	5	5	1
Pesticides	Endosulfan I	5	1	0.2
Pesticides	Endosulfan II	5	3	0.6
Pesticides	Endosulfan sulfate	5	1	0.2
Pesticides	Endrin	5	1	0.2
Pesticides	Endrin Aldehyde	5	1	0.2
Pesticides	Endrin Ketone	5	--	--
Pesticides	Ethion	5	--	--
Pesticides	Ethoprop	5	1	0.2
Pesticides	Famphur	5	--	--
Pesticides	Fenchlorphos	5	--	--
Pesticides	Fenitrothion	5	--	--
Pesticides	Fensulfothion	5	--	--
Pesticides	Fenthion	5	2	0.4
Pesticides	Fonofos	5	--	--
Pesticides	HCH, alpha	5	2	0.4
Pesticides	HCH, beta	5	2	0.4
Pesticides	HCH, delta	5	1	0.2
Pesticides	HCH, gamma	5	1	0.2

Table 9. Continued. Frequency of detection of anthropogenic organic constituents.

Category	Constituent	Tested	Detected	Frequency
Pesticides	Heptachlor	5	--	--
Pesticides	Heptachlor epoxide	5	--	--
Pesticides	Hexachlorobenzene	5	3	0.6
Pesticides	Leptophos	5	--	--
Pesticides	Malathion	5	1	0.2
Pesticides	Merphos	5	--	--
Pesticides	Methidathion	5	--	--
Pesticides	Methoxychlor	5	1	0.2
Pesticides	Mevinphos	5	4	0.8
Pesticides	Mirex	5	--	--
Pesticides	Molinate	5	3	0.6
Pesticides	Naled	5	3	0.6
Pesticides	Nonachlor, cis-	5	--	--
Pesticides	Nonachlor, trans-	5	--	--
Pesticides	Oxadiazon	5	5	1
Pesticides	Oxychlordane	5	--	--
Pesticides	Parathion, Ethyl	5	1	0.2
Pesticides	Parathion, Methyl	5	3	0.6
Pesticides	Phorate	5	--	--
Pesticides	Phosmet	5	--	--
Pesticides	Phosphamidon	5	--	--
Pesticides	Prometon	5	--	--
Pesticides	Prometryn	5	--	--
Pesticides	Propazine	5	5	1
Pesticides	Secbumeton	5	5	1
Pesticides	Simazine	5	--	--
Pesticides	Simetryn	5	--	--
Pesticides	Sulfotep	5	--	--
Pesticides	Tedion	5	--	--
Pesticides	Terbufos	5	--	--
Pesticides	Terbuthylazine	5	5	1
Pesticides	Terbutryn	5	--	--
Pesticides	Tetrachlorvinphos	5	--	--
Pesticides	Thiobencarb	5	3	0.6
Pesticides	Thionazin	5	--	--
Pesticides	Tokuthion	5	1	0.2
Pesticides	Trichlorfon	5	--	--
Pesticides	Trichloronate	5	1	0.2

Comparison with applicable aquatic life and human health thresholds support the conclusion that water quality is impacted by these constituents (Table 10). Most sites showed similar results, suggesting that impact was not restricted to specific regions within the watershed (Figures 6 and 7). The most widespread exceedances were for ammonia-N, selenium, sulfate, manganese, p,p'-DDE, and specific conductivity (Tables 10 and 11). These constituents exceeded applicable thresholds for every site in the watershed. Total phosphorus as P and pH were nearly as widespread, affecting all sites except Tecolote Creek. Exceedances were less common for aldrin, p,p'-DDD, p,p'-DDT, and turbidity. All other constituents were below applicable thresholds at all sites.

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

A. Aquatic life thresholds at SWAMP sites.

		Aquatic life		906LPLPC6		906LPPOW2		906LPRSC4		906LPSOL2		906LPTEC3	
Category	Constituent	Threshold	Source	Freq	n	Freq	n	Freq	n	Freq	n	Freq	n
Inorganics	Alkalinity as CaCO3	20000 mg/l	EPA	--	4	--	4	--	4	--	4	--	3
Inorganics	Ammonia as N	0.025 mg/l	BP	1	4	1	4	1	4	1	4	1	3
Inorganics	Nitrate + Nitrite as N	10 mg/l	BP	--	4	--	4	--	4	--	4	--	3
Inorganics	Phosphorus as P,Total	0.1 mg/l	BP	0.5	4	0.25	4	0.25	4	0.25	4	--	3
Inorganics	Selenium,Dissolved	5 µg/l	CTR	0.75	4	1	4	0.75	4	0.75	4	1	3
Inorganics	Sulfate	250 mg/l*	BP	0.75	4	0.75	4	1	4	0.75	4	NA	3
Metals	Aluminum,Dissolved	1000 µg/l	BP	--	4	--	4	--	4	--	4	--	3
Metals	Arsenic,Dissolved	50 µg/l	BP	--	4	--	4	--	4	--	4	--	3
Metals	Cadmium,Dissolved	5 µg/l	BP	--	4	--	4	--	4	--	4	--	3
Metals	Chromium,Dissolved	50 µg/l	BP	--	4	--	4	--	4	--	4	--	3
Metals	Copper,Dissolved	9 µg/l	CTR	--	4	--	4	--	4	--	4	--	3
Metals	Lead,Dissolved	2.5 µg/l	CTR	--	4	--	4	--	4	--	4	--	3
Metals	Manganese,Dissolved	0.05 µg/l*	BP	0.25	4	1	4	0.25	4	1	4	NA	3
Metals	Nickel,Dissolved	52 µg/l	CTR	--	4	--	4	--	4	--	4	--	3
Metals	Silver,Dissolved	3.4 µg/l	CTR	--	4	--	4	--	4	--	4	--	3
Metals	Zinc,Dissolved	120 µg/l	CTR	--	4	--	4	--	4	--	4	--	3
PAHs	Benzo(a)pyrene	0.0002 µg/l	BP	--	4	--	4	--	4	--	4	--	3
PCBs	PCBs	0.014 µg/l	CTR	--	4	--	4	--	4	--	4	--	3
Pesticides	Aldrin	3 µg/l	CTR	--	4	--	4	--	4	--	4	--	3
Pesticides	Atrazine	3 µg/l	BP	--	4	--	4	--	4	--	4	--	3
Pesticides	Endrin	0.002 µg/l	BP	--	4	--	4	--	4	--	4	--	3
Pesticides	Heptachlor	0.0038 µg/l	CTR	--	4	--	4	--	4	--	4	--	3
Pesticides	Heptachlor epoxide	0.0038 µg/l	CTR	--	4	--	4	--	4	--	4	--	3
Pesticides	Hexachlorobenzene	1 µg/l	BP	--	4	--	4	--	4	--	4	--	3
Pesticides	Methoxychlor	40 µg/l	BP	--	4	--	4	--	4	--	4	--	3
Pesticides	Molinate	20 µg/l	BP	--	4	--	4	--	4	--	4	--	3
Pesticides	Simazine	4 µg/l	BP	--	4	--	4	--	4	--	4	--	3
Pesticides	Thiobencarb	70 µg/l	BP	--	4	--	4	--	4	--	4	--	3
Physical	pH	>6 or <8 pH units	BP	0.75	4	0.25	4	0.5	4	0.25	4	--	3
Physical	Specific Conductivity	1.6 mS/cm	CCR	0.75	4	1	4	0.75	4	0.75	4	1	3
Physical	Turbidity	20 NTU	BP	0.25	4	--	4	0.5	4	0.25	4	--	3

* Sulfate and Magnesium thresholds do not apply to sites in the Tecolote hydrologic sub-basin (906.5).

B. Human health thresholds at SWAMP sites.

				906LPLPC6		906LPPOW2		906LPRSC4		906LPSOL2		906LPTEC3	
Category	Constituent	Threshold	Source	Freq	n	Freq	n	Freq	n	Freq	n	Freq	n
Metals	Arsenic,Dissolved	150 µg/l	CTR	--	4	--	4	--	4	--	4	--	3
Metals	Cadmium,Dissolved	2.2 µg/l	CTR	--	4	--	4	--	4	--	4	--	3
Metals	Copper,Dissolved	1300 µg/l	CTR	--	4	--	4	--	4	--	4	--	3
Metals	Nickel,Dissolved	610 µg/l	CTR	--	4	--	4	--	4	--	4	--	3
PAHs	Acenaphthene	1200 µg/l	CTR	--	4	--	4	--	4	--	4	--	3
PAHs	Anthracene	9600 µg/l	CTR	--	4	--	4	--	4	--	4	--	3
PAHs	Benz(a)anthracene	0.0044 µg/l	CTR	--	4	--	4	--	4	--	4	--	3
PAHs	Benzo(a)pyrene	0.0044 µg/l	CTR	--	4	--	4	--	4	--	4	--	3
PAHs	Benzo(b)fluoranthene	0.0044 µg/l	CTR	--	4	--	4	--	4	--	4	--	3
PAHs	Benzo(k)fluoranthene	0.0044 µg/l	CTR	--	4	--	4	--	4	--	4	--	3
PAHs	Chrysene	0.0044 µg/l	CTR	--	4	--	4	--	4	--	4	--	3
PAHs	Dibenz(a,h)anthracene	0.0044 µg/l	CTR	--	4	--	4	--	4	--	4	--	3
PAHs	Fluoranthene	300 µg/l	CTR	--	4	--	4	--	4	--	4	--	3

Table 10, continued. Water chemistry exceedances.
B, continued. Human health thresholds at SWAMP sites.

				906LPLPC6		906LPPOW2		906LPRSC4		906LPSOL2		906LPTEC3	
Category	Constituent	Threshold	Source	Freq	n	Freq	n	Freq	n	Freq	n	Freq	n
PAHs	Indeno(1,2,3-c,d)pyrene	0.0044 µg/l	CTR	--	4	--	4	--	4	--	4	--	3
PAHs	Pyrene	960 µg/l	CTR	--	4	--	4	--	4	--	4	--	3
PCBs	PCBs	0.00017 µg/l	CTR	--	4	--	4	--	4	--	4	--	3
Pesticides	Aldrin	0.00000013 µg/l	CTR	--	4	--	4	0.25	4	--	4	--	3
Pesticides	Ametryn	60 µg/l	EPA	--	4	--	4	--	4	--	4	--	3
Pesticides	Atrazine	0.2 µg/l	OEHHA	--	4	--	4	--	4	--	4	--	3
Pesticides	Azinphos ethyl	87.5 µg/l	NASHA	--	4	--	4	--	4	--	4	--	3
Pesticides	Azinphos methyl	87.5 µg/l	NASHA	--	4	--	4	--	4	--	4	--	3
Pesticides	DDD(p,p')	0.00083 µg/l	CTR	0.25	4	--	4	--	4	--	4	--	3
Pesticides	DDE(p,p')	0.00059 µg/l	CTR	0.25	4	0.25	4	0.25	4	0.25	4	0.33	3
Pesticides	DDT(p,p')	0.00059 µg/l	CTR	--	4	--	4	0.25	4	0.25	4	--	3
Pesticides	Dieldrin	0.00014 µg/l	CTR	--	4	--	4	--	4	--	4	--	3
Pesticides	Dimethoate	1.4 µg/l	IRIS	--	4	--	4	--	4	--	4	--	3
Pesticides	Endosulfan sulfate	110 µg/l	CTR	--	4	--	4	--	4	--	4	--	3
Pesticides	Endrin	0.76 µg/l	CTR	--	4	--	4	--	4	--	4	--	3
Pesticides	Endrin Aldehyde	0.76 µg/l	CTR	--	4	--	4	--	4	--	4	--	3
Pesticides	Endrin Ketone	0.85 µg/l	CTR	--	4	--	4	--	4	--	4	--	3
Pesticides	Heptachlor	0.00021 µg/l	CTR	--	4	--	4	--	4	--	4	--	3
Pesticides	Heptachlor epoxide	0.0001 µg/l	CTR	--	4	--	4	--	4	--	4	--	3
Pesticides	Hexachlorobenzene	0.00075 µg/l	CTR	--	4	--	4	--	4	--	4	--	3
Pesticides	Oxychlordane	0.000023 µg/l	CTR	--	4	--	4	--	4	--	4	--	3

C. Aquatic life thresholds at non-SWAMP sites.

Constituent	Dissolved oxygen		pH		Specific conductivity		Turbidity	
Threshold	5	mg/l	>6 or <8		1.6	mS/cm	20	NTU
Site	Frequency	n	Frequency	n	Frequency	n	Frequency	n
Site 1	--	7	0.71	7	1	7	--	1
Site 3	--	2	0.5	2	1	2	n.t.	0
Site 4	--	6	--	6	0.83	6	--	1
Site 7	--	6	0.33	6	1	6	--	1
Site 6	0.43	7	--	7	1	7	--	1

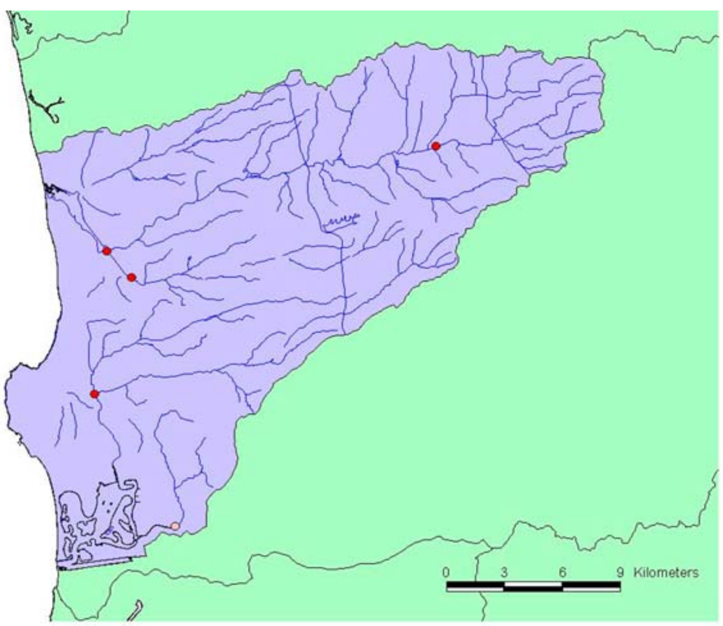


Figure 6. Map of aquatic life threshold exceedances for water chemistry at SWAMP sites. White circles indicate sites with one or fewer exceedances (this value did not occur in this watershed). Pink circles indicate sites with 2 to 5 exceedances. Red circles indicate sites with 6 to 9 exceedances. At Tecolote Creek (906LPTEC3), 29 constituents were assessed; at all other sites, 31 constituents were assessed.

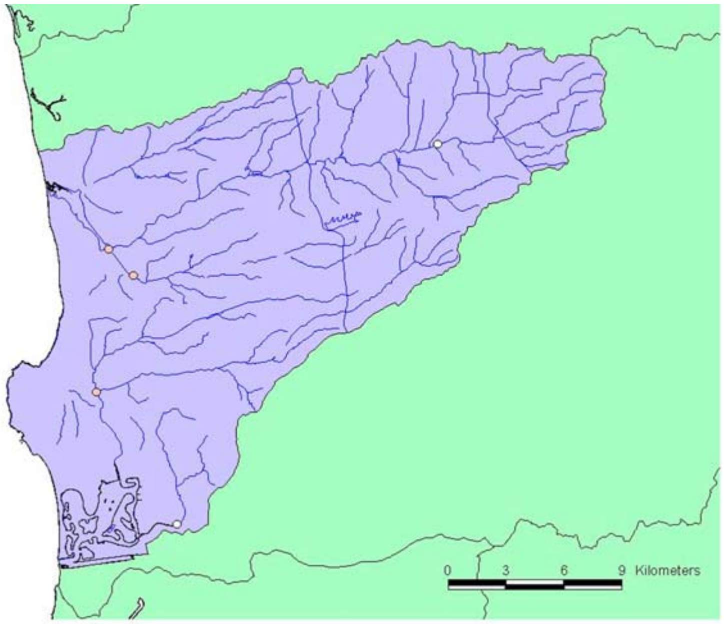


Figure 7. Map of human health exceedances for water chemistry at SWAMP sites. White circles indicate sites with one or fewer exceedances. Pink circles indicate sites with 2 to 5 exceedances. Red circles indicate sites with 6 to 9 exceedances (this value did not occur in this watershed). At all sites,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

All sites in Peñasquitos HU failed to achieve certain aquatic life and human health thresholds (Tables 11 and 12; Figures 6 and 7). Tecolote Creek had the fewest aquatic life exceedances, with only three constituents exceeding thresholds (i.e., ammonia as N, selenium and specific conductivity; Tables 10). The other sites exceeded aquatic life thresholds for manganese, sulfate, pH, total phosphorus as P, and (except Poway Creek) turbidity. However, Tecolote Creek lacks applicable thresholds for manganese and sulfate, and these constituents were found at concentrations similar to other sites within the watershed. Therefore, Tecolote Creek did not appear to have distinct water chemistry from the other sites. In general, impacts to water quality were found throughout Peñasquitos HU, affecting most streams in the watershed.

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	5	--	NA
Inorganics	Ammonia as N	5	1.0	NA
Inorganics	Nitrate + Nitrite as N	5	--	NA
Inorganics	Phosphorus as P,Total	5	0.8	NA
Inorganics	Selenium,Dissolved	5	1.0	NA
Inorganics	Sulfate	5	1.0	NA
Metals	Aluminum,Dissolved	5	--	NA
Metals	Arsenic,Dissolved	5	--	--
Metals	Cadmium,Dissolved	5	--	--
Metals	Chromium,Dissolved	5	--	NA

Table 11, continued, Frequency of SWAMP sites exceeding water chemistry thresholds.

Category	Constituent	n	Aquatic life	Human health
Metals	Copper,Dissolved	5	--	--
Metals	Lead,Dissolved	5	--	NA
Metals	Manganese,Dissolved	5	1.0	NA
Metals	Nickel,Dissolved	5	--	--
Metals	Silver,Dissolved	5	--	NA
Metals	Zinc,Dissolved	5	--	NA
PAHs	Acenaphthene	5	NA	--
PAHs	Anthracene	5	NA	--
PAHs	Benz(a)anthracene	5	NA	--
PAHs	Benzo(a)pyrene	5	--	--
PAHs	Benzo(b)fluoranthene	5	NA	--
PAHs	Benzo(k)fluoranthene	5	NA	--
PAHs	Chrysene	5	NA	--
PAHs	Dibenz(a,h)anthracene	5	NA	--
PAHs	Fluoranthene	5	NA	--
PAHs	Indeno(1,2,3-c,d)pyrene	5	NA	--
PAHs	Pyrene	5	NA	--
PCBs	PCBs	5	--	--
Pesticides	Aldrin	5	--	0.2
Pesticides	Ametryn	5	NA	--
Pesticides	Atrazine	5	--	--
Pesticides	Azinphos ethyl	5	NA	--
Pesticides	Azinphos methyl	5	NA	--
Pesticides	DDD(p,p')	5	NA	0.2
Pesticides	DDE(p,p')	5	NA	1.0
Pesticides	DDT(p,p')	5	NA	0.4
Pesticides	Dieldrin	5	NA	--
Pesticides	Dimethoate	5	NA	--
Pesticides	Endosulfan sulfate	5	NA	--
Pesticides	Endrin	5	--	--
Pesticides	Endrin Aldehyde	5	NA	--
Pesticides	Endrin Ketone	5	NA	--
Pesticides	Heptachlor	5	--	--
Pesticides	Heptachlor epoxide	5	--	--
Pesticides	Hexachlorobenzene	5	--	--
Pesticides	Methoxychlor	5	--	NA
Pesticides	Molinate	5	--	NA
Pesticides	Oxychlordane	5	NA	--
Pesticides	Simazine	5	--	NA
Pesticides	Thiobencarb	5	--	NA
Physical	pH	5	0.8	NA
Physical	SpecificConductivity	5	1.0	NA
Physical	Turbidity	5	0.6	NA

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

Site	Aquatic life	Human health
906LPLPC6	8	2
906LPPOW2	7	1
906LPRSC4	8	3
906LPSOL2	8	2
906LPTEC3	3	1

Results from NPDES water chemistry monitoring were similar to results from SWAMP. For example, specific conductivity exceeded aquatic life thresholds at all sites, and at almost every sampling date. In addition, NPDES monitoring frequently detected low dissolved oxygen levels in Tecolote Creek (site 6), and high pH at Carroll Canyon Creek and Rose Canyon Creek (sites 1 and 3, respectively) (Table 10C).

4.2 Toxicity

Toxicity was evident at all sites within the watershed, although results varied among sites and indicators (Table 13; Appendix III). Toxicity was most severe at Rose Creek and Soledad Canyon, where four of the five endpoints indicated toxicity. Toxicity was least severe in Los Peñasquitos Creek, where only one endpoint indicated toxicity. The geographic dispersion of sites with high and low toxicity suggested that local factors may contribute to toxicity, as opposed to watershed-scale factors (Figure 8).

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

	C. dubia				*H. azteca*				*S. capricornutum*		Multiple indicators	
Site	Survival	n	Young/Female	n	Survival	n	Growth	n	Total cell count	n	Frequency	n
906LPLPC6	--	4	--	4	--	4	--	4	0.75	4	0.25	12
906LPPOW2	--	4	--	4	0.50	4	0.25	4	1.00	4	0.42	12
906LPRSC4	0.25	4	--	3	0.50	2	1.00	2	0.75	4	0.56	9
906LPSOL2	--	4	0.25	4	0.75	4	0.25	4	0.75	4	0.42	12
906LPTEC3	0.67	3	--	3	--	2	--	2	1.00	3	0.38	8
All sites	0.16	19	0.06	18	0.38	16	0.25	16	0.84	19	0.40	53

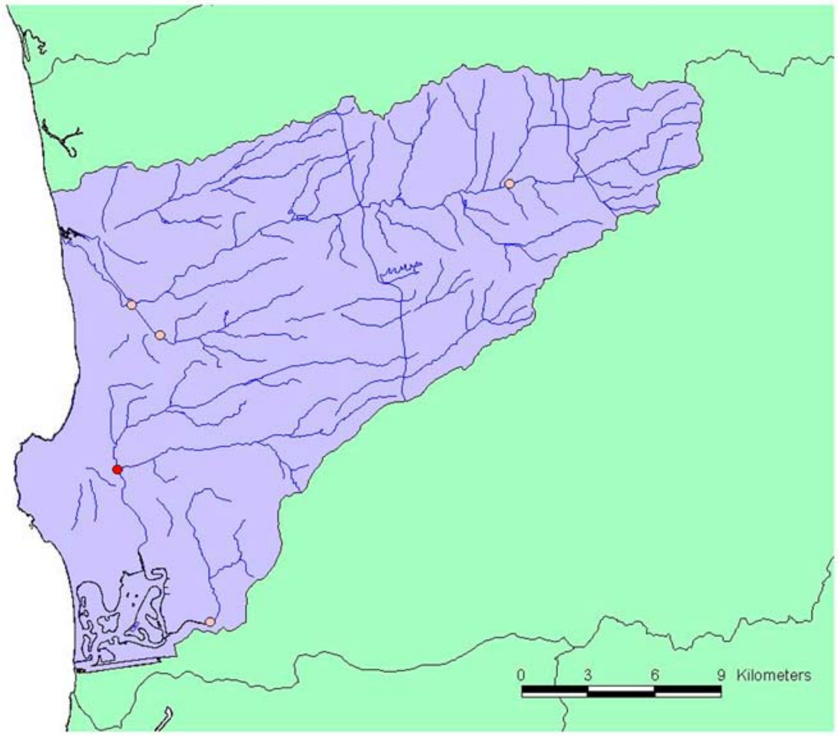


Figure 8. Frequency of toxicity (*C. dubia* fecundity, *H. azteca* growth, and *S. capricornutum* total cell count) at SWAMP sites. White circles indicate low frequency (0.0 to 0.1) of toxicity (this value did not occur in this watershed) . Pink circles indicate moderate frequency (0.1 to 0.5) of toxicity.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

S. capricornutum was the most sensitive toxicity indicator, with a total cell count less than 80% of control at all sites in nearly every sample. Toxicity to *S. capricornutum* was particularly severe in Tecolote Creek, where the mean percent of control of total cell count was only 18%. Across the entire watershed, 84% of tests using *S. capricornutum* indicated toxicity.

Toxicity tests using arthropod indicators provided more mixed results. For example, both *C. dubia* and *H. azteca* indicated toxicity at three of the five sites, but the set of sites were not identical for both indicators. Although Rose Canyon Creek and Soledad Canyon were toxic to both indicators, Poway Creek was only toxic to the sediment indicator (*H. azteca*), and Tecolote Creek was only toxic to the water indicator (*C. dubia*). Across the entire watershed, *H. azteca* indicated toxicity more frequently (38% of tests) than *C. dubia* (16% of tests). These results suggest that sediment is more frequently toxic than water to arthropods.

4.3 Tissue

Analysis of crayfish tissues at Los Peñasquitos Creek and Rose Canyon Creek showed little evidence of tissue contamination by metals, PCBs, and pesticides. The majority of constituents did not occur at detectable concentrations according to OEHHA thresholds (Appendix IV). Only one constituent (Selenium) in one sample from Rose Canyon Creek exceeded thresholds established by OEHHA (Table 14; Figure 9).

Table 14. Concentrations of contaminants in crayfish tissues, compared with OEHHA thresholds. A full list of analyzed constituents is presented in Appendix IV.

				906LPLPC6		906LPRSC4	
Category		Threshold	Unit	Sample 1	Sample 2	Sample 1	Sample 2
Inorganics	Se (ppm)	1.94	ppm	1.82	not tested	1.98	not tested
PCBs	PCBs	20	ng/g	17.27	16.18	8.39	not tested
Pesticides	Chlordane (ng/g)	200	ng/g	0	0	0	not tested
Pesticides	DDTs (ng/g)	560	ng/g	0	0	1.3	not tested
Pesticides	Dieldrin (ng/g)	16	ng/g	0	0	0	not tested
Pesticides	Toxaphene (ng/g)	220	ng/g	0	0	0	not tested
Metals	Mercury (ppm)	0.08	ppm	0.023	0.025	not tested	not tested

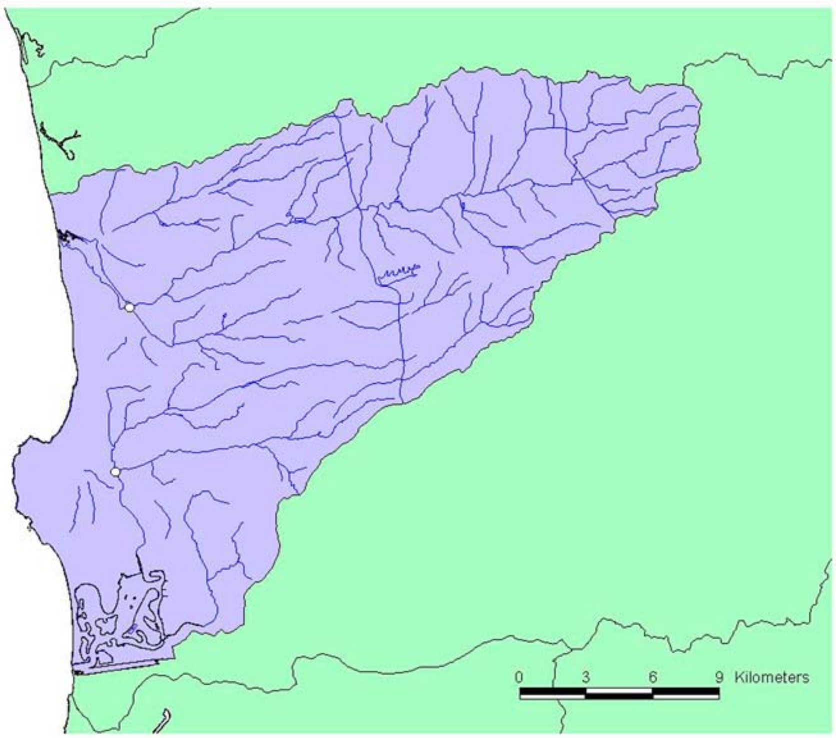


Figure 9. Crayfish tissue exceedances at SWAMP sites. White circles indicate 1 or fewer exceedances. Pink circles indicate 2 to 3 exceedances (this value did not occur in this watershed). Red circles indicate 4 to 5 exceedances (this value did not occur in this watershed).

Approximately one-half of the 48 PCBs analyzed were detected in crayfish samples (Table 15). Despite this accumulation, PCBs did not exceed the OEHHA threshold of 20 ng/g. In contrast, only two pesticides (p,p'-DDE and trans-Nonachlor) were detected in any sample, indicating that crayfish did not accumulate detectable levels for many of the pesticides found in the water samples (Table 11). Mercury was detected in samples from Rose Canyon Creek, but below the OEHHA thresholds for methylmercury.

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

Site	Sample	PCBs detected	PCBs tested	Pesticides detected	Pesticides tested
906LPLPC6	1	28	48	--	39
	2	29	48	--	39
906LPRSC4	1	26	48	2	39
	2	None tested		None tested	

4.4 Bioassessment

Biological health was poor or very poor for all sites and all seasons in the Peñasquitos HU. Mean IBI scores ranged from 9.1 at Los Peñasquitos Creek (site 3) to 29.5 at Rose Canyon Creek (site 7; Table 16; Figure 10). Sites in poor or very poor condition were found throughout the watershed (Figure 10). In general, samples collected in spring were in worse condition than those collected in fall, although the differences between seasons were slight for most sites (Table 16; Figure 11). Therefore, poor biological condition persisted during all seasons sampled.

Table 16. Mean and standard deviation of IBI scores at bioassessment sites within the Peñasquitos 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	20.8	0.9	Poor	1.00
1	Fall	6	1998-2004	21.4	3.8	Poor	1.00
1	Spring	7	1998-2005	20.2	10.8	Poor	1.00
2	Average	4	2000-2005	12.4	2.7	Very poor	1.00
2	Fall	1	2000-2000	14.3		Very poor	1.00
2	Spring	3	2000-2005	10.5	2.2	Very poor	1.00
3	Average	9	1998-2002	13.5	6.2	Very poor	1.00
3	Fall	4	1998-2002	17.9	5.5	Very poor	1.00
3	Spring	5	1998-2002	9.1	5.4	Very poor	1.00
4	Average	11	1998-2005	17.2	0.1	Very poor	1.00
4	Fall	4	1998-2004	17.1	2.3	Very poor	1.00
4	Spring	7	1998-2005	17.3	8.1	Very poor	1.00
5	Average	5	1998-2000	15	7.1	Very poor	1.00
5	Fall	1	1998-1998	20		Poor	1.00
5	Spring	4	1998-2000	10	6.2	Very poor	1.00
6	Average	11	1998-2005	16.2	9.8	Very poor	1.00
6	Fall	5	1998-2004	23.1	6.7	Poor	1.00
6	Spring	6	1999-2005	9.3	10.1	Very poor	1.00
7	Average	6	2002-2005	21.2	11.8	Poor	1.00
7	Fall	3	2002-2004	29.5	0.8	Poor	1.00
7	Spring	3	2003-2005	12.9	2.5	Very poor	1.00

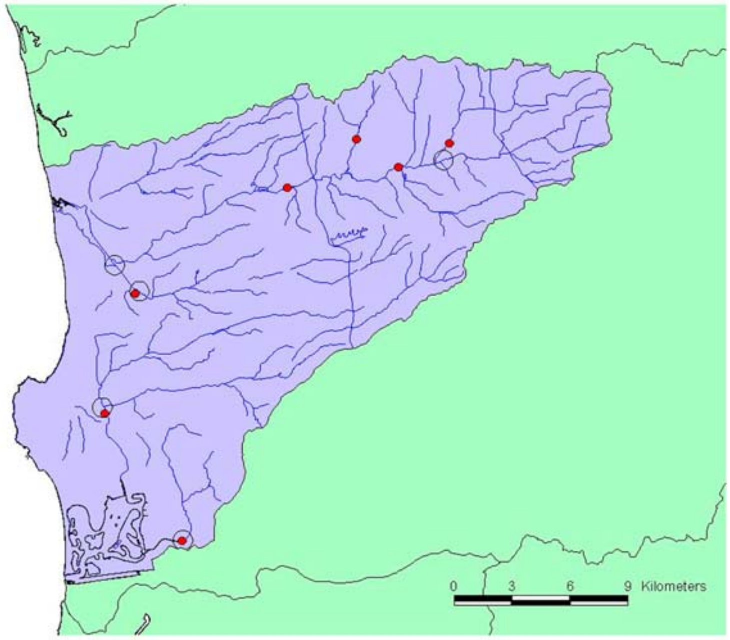


Figure 10. IBI scores at sites in the Peñasquitos HU. White circles indicate good or very good (60 to 100) IBI scores (this value did not occur in this watershed). Pink circles indicate fair (40 to 60) IBI scores (this value did not occur in this watershed). Red circles indicate poor (0 to 40) IBI scores.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

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

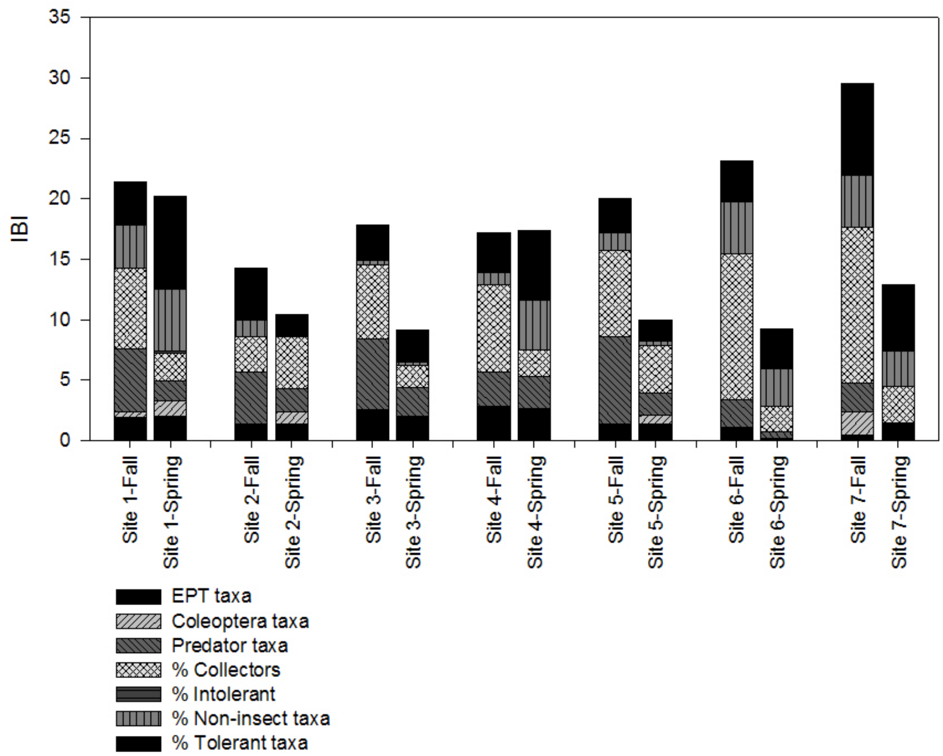


Figure 11. Mean IBI scores at each bioassessment site and each season. The height of the bar indicates the mean IBI score (averaged over multiple years), and the size of each component of the bar represents the contribution of each metric to the IBI.

Examination of IBI scores over time did not indicate a trend towards improving or deteriorating biological condition (Figure 12). Samples collected in Spring 2001-2002 had lower IBI scores than previous years, although this decline reversed by Fall 2002. 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.

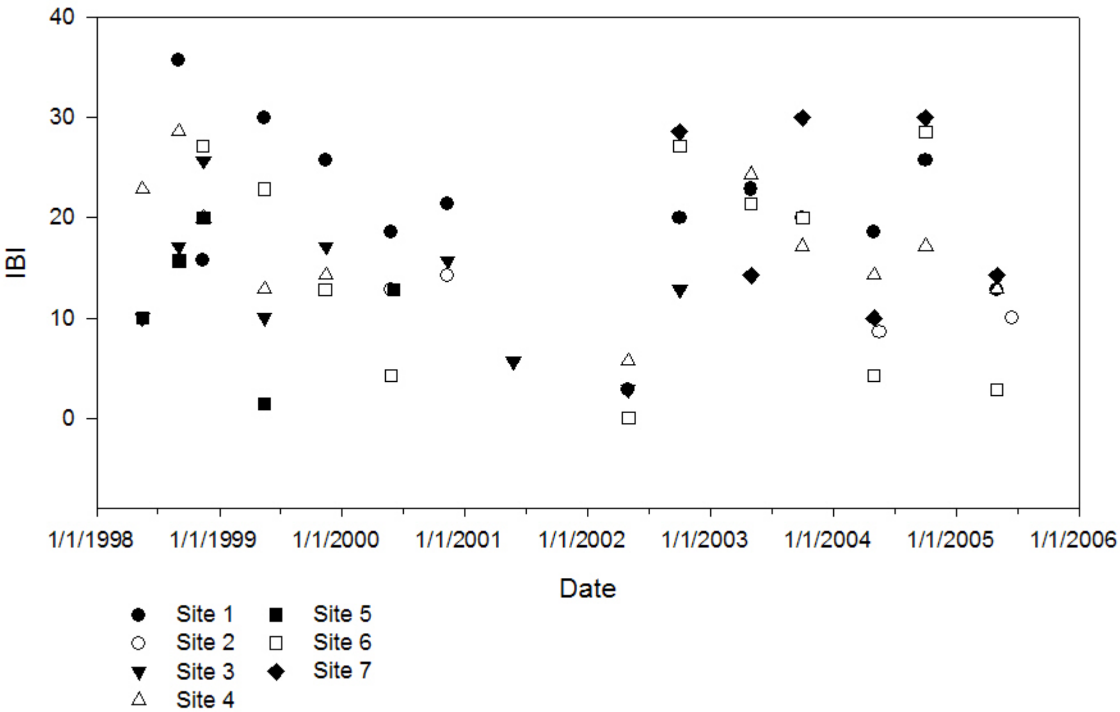


Figure 12. IBI values for each year and site. Each symbol represents a single sample.

None of these sites were monitored under SWAMP, and all bioassessment data came from monitoring efforts by NPDES permittees or the California Department of Fish and Game.

4.5 Physical Habitat

Physical habitat varied among sites throughout the watershed, although human alteration was evident at every site. Good habitat (mean physical habitat score >15) was found at only one site, Soledad Valley; Tecolote Creek had moderately altered habitat, with two physical habitat components (channel flow and vegetation protection) scoring below 10. Poorer condition was evident at the remaining sites: Los Peñasquitos Creek, Poway Creek, and Rose Creek had mean physical habitat scores less than 10 (Table 17; Figure 13).

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

Site Sampled sites:	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
906LPLPC6	2/8/2002	1	0	6	0	16	0	6	10	8	1	4.8
906LPPOW2	2/4/2002	3	0	6	20	13	6	1	20	19	1	8.9
906LPRSC4	2/15/2002	10	5	7	5	5	11	8	4	8	5	6.8
906LPSOL2	2/8/2002	17	17	15	16	15	10	19	14	17	14	15.4
906LPTEC3	2/15/2002	15	16	13	16	8	16	16	14	8	11	13.3
Mean of all sites		9.2	7.6	9.4	11.4	11.4	8.6	10	12.4	12	6.4	9.8

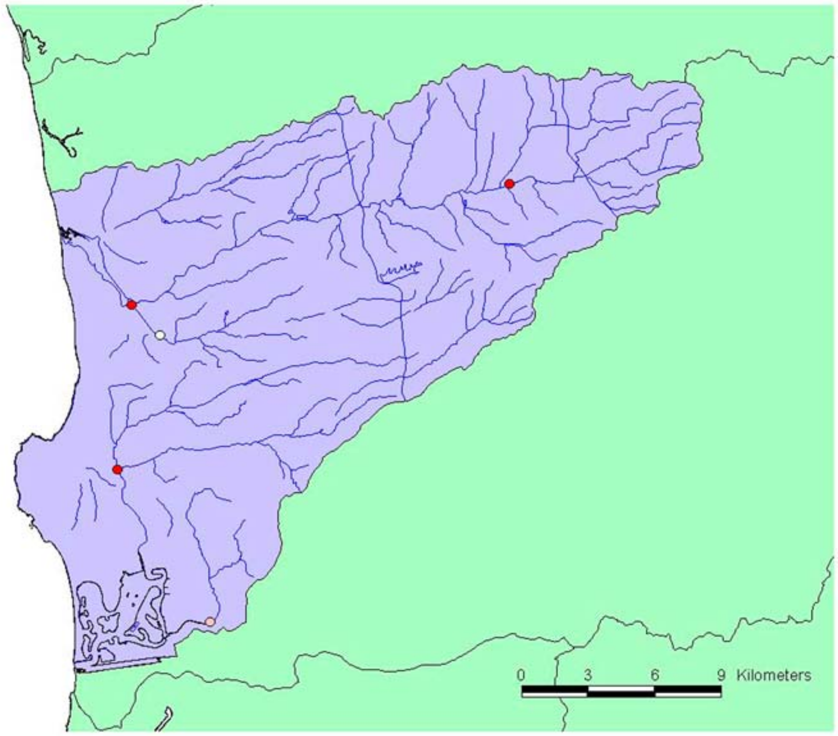
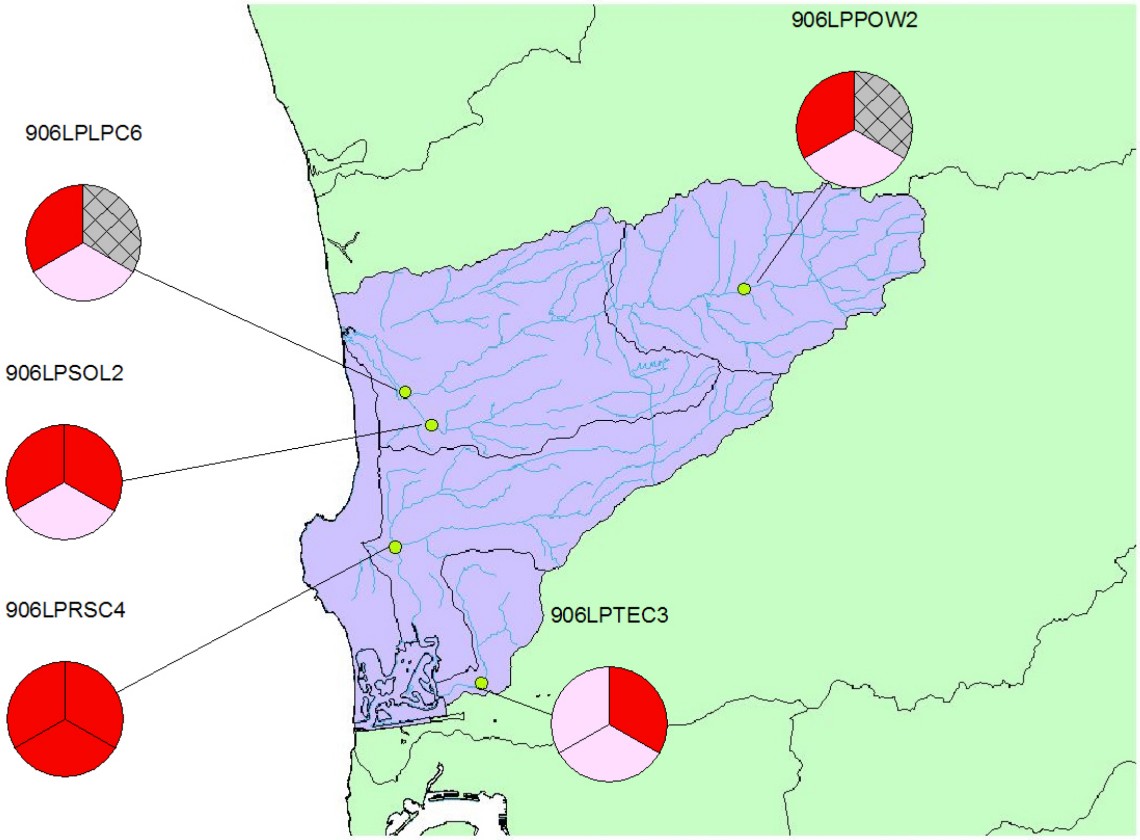


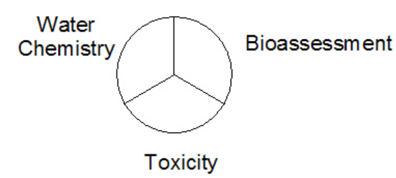
Figure 13. Assessment of physical habitat at SWAMP sites. White circles indicate sites with a mean physical habitat scores between 15 and 20. Pink circles indicate mean scores between 10 and 15. Red circles indicate mean scores between 0 and 10.

5. DISCUSSION

Every site sampled in the Peñasquitos HU showed evidence of impact for multiple indicators (Table 18; Figure 14). For example, Rose Canyon Creek had severe impacts to water chemistry (with 8 constituents exceeding aquatic life thresholds), toxicity to multiple endpoints, and low IBI scores. Toxicity, in fact, was more severe here than at any other site, with all sediment samples reducing growth of *H. azteca.* Additionally, crayfish tissues indicated slight impacts, with Selenium exceeding OEHHA standards in one sample. Physical habitat was poor, with a mean physical habitat score of 6.8. In fact, only one component of physical habitat (channel alteration) scored above 10 for this site.



Indicator



Severity of impact

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

Figure 14. Summary of the ecological health of SWAMP sites in the Peñasquitos 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.

Table 18. Summary of the ecological health for five SWAMP sites in Peñasquitos HU. Aquatic life (AL). Human health (HH). Toxicity frequency is frequency of toxicity for three endpoints: *C. dubia* (fecundity), *H. azteca* (growth), and *S. capricornutum* (total cell count). Biology frequency is the frequency of IBIs below 40.

	Water chemistry		Tissue			Physical habitat
Site	# constituents (AL)	# constituents (HH)	# constituents (OEHHA)	Toxicity frequency	Biology frequency	Mean score
906LPLPC6	8	2	0	0.25	n.t.	4.8
906LPPOW2	7	1	n.t.	0.42	n.t.	8.9
906LPRSC4	8	3	1	0.56	1.00*	6.8
906LPSOL2	8	2	n.t.	0.42	1.00*	15.4
906LPTEC3	3	1	n.t.	0.38	1.00*	13.3

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

Soledad Canyon also showed severe impacts to water chemistry and macroinvertebrate communities. Eight water chemistry constituents exceeded aquatic life thresholds. Toxicity was moderate at this site, as some of the samples collected did not strongly affect certain toxic endpoints. However, sediment toxicity was observed in 3 of 4 samples from Soledad Canyon; this result is consistent with the inclusion of sediment toxicity as a known impairment on the 303(d) list. Tissue samples were not collected in Soledad Canyon. In contrast to other sites, physical habitat was good, with a mean physical habitat score of 15.4 (higher than any other site assessed in the watershed), suggesting that the poor ecological health observed at this site may have been caused by other disturbances in the watershed, such as altered land use.

Los Peñasquitos Creek, like other sites in the watershed, had severe impacts to water chemistry, with eight constituents exceeding aquatic life thresholds. Although phosphate is listed a known stressor at Los Peñasquitos Creek on the 303(d) list, levels of Orthophosphate as P were lower at this site than any other in the HU. Toxicity was moderate. Although water samples were frequently toxic to *S. capricornutum*, none of the other species exhibited signs of toxicity. Crayfish tissue samples showed no signs of impact, although total PCBs in one replicate approached OEHHA thresholds. Macroinvertebrate communities were not assessed for this site. Physical habitat was more altered at Los Peñasquitos Creek than at any other site, with a mean physical habitat score of 4.8. Although channel flow was good at this site, with a score of 16, no other component of physical habitat achieved a score greater than 10.

Poway Creek, the most inland site assessed in this watershed, was in a condition similar to Los Peñasquitos Creek. Water chemistry was severely impacted, with seven constituents exceeding aquatic life thresholds. Toxicity was moderate at Poway Creek, although sediments showed more frequent signs of toxicity to *H. azteca* than did sediments from Los Peñasquitos Creek. *S. capricornutum* cultures were also very sensitive to water samples collected from Poway Creek. Neither crayfish tissues nor bioassessment samples were collected at this site. Physical habitat was poor, with a mean score of 8.9; six of the ten physical habitat components assessed here received scores below 10.

Tecolote Creek was the only site to show moderate impacts to water quality, with only three constituents exceeding aquatic life thresholds. However, Manganese and Sulfate thresholds did not apply to this sub-basin, and these constituents were detected in concentrations that would exceed thresholds at other sites. Several stressors listed as impairments on the 303(d) list never exceeded thresholds at Tecolote Creek; for example, Cadmium, Copper, Lead, and Phosphorus were always within applicable aquatic life and human health thresholds. Toxicity was moderate in Tecolote creek, with most water samples affecting both *S. capricornutum* and *C. dubia* endpoints; these results were consistent with the 303(d) list. Physical habitat was better at this site than at most sites in the watershed, with a mean score of 13.3. Only two physical habitat components received scores below 10.

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

Although these impacts were widespread, and in some cases severe, this study showed that, at least for water chemistry indicators, impacts were limited to certain constituents, such as inorganics (i.e., ammonia, phosphorus, sulfate, and selenium) and physical parameters (i.e., specific conductivity, pH, turbidity). In contrast, all metals (except manganese) were below applicable thresholds at every site, as were nearly all pesticides (with p,p'-DDE being a notable exception).

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

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

The targeted selection of sites monitored under the SWAMP program facilitated integration of pre-existing data from non-SWAMP sources, but this non-probabilistic approach severely limits the extrapolation of data from these sites to the rest of the watershed. Non-random sampling violates assumptions underlying most statistical analyses, and the sites selected in this study cannot be assumed to represent the entire watershed (Olsen et al. 1999, Stevens Jr. and Olsen 2004). The site selection process targeted sites of interest to watershed managers and the community, and these sites may be more likely than random to be impacted. No sites in the Peñasquitos HU were selected to represent reference conditions.

The small number of sites monitored under SWAMP also limits the certainty of this study's assessment. For example, tissue samples were collected at only two sites; therefore, tissue contamination may have gone undetected in unsampled regions of the watershed. Although SWAMP has produced a wealth of data about the Peñasquitos watershed using limited resources, some indicators (especially those with high variability, the IBI) 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 portions of the Peñasquitos HU are in poor ecological health. Some of these limitations (such as the lack of applicable thresholds and the small sample size) may in fact have caused this assessment to underestimate the severity of degradation in the watershed. All indicators showed signs of human impacts. Multiple stressors, including degraded water quality, sediment, and physical habitat are the likely cause of the impact. Future research (see final report on the SWAMP monitoring program for further study recommendations) is necessary to determine which stressors are responsible for the impacts seen in the watershed.

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7. APPENDICES

APPENDIX I

A. Beneficial uses of streams in the Peñasquitos HU (California Regional Water Quality Control Board, San Diego Region 1994). B. Streams on the 303(d) list of impaired water bodies in the Peñasquitos HUC. 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 in the Peñasquitos HU

Los Peñasquitos HU (906)	HUC	MUN	AGR	IND	REC1	REC2	WARM	COLD	WILD	RARE	SPWN
Los Peñasquitos Creek Watershed											
Soledad Canyon	906.1	X	E	E	P	E	E	E	E		
Carol Canyon	906.1	X	E	E	P	E	E	E	E	E	
Los Peñasquitos Creek	906.2	X	E	P	E	E	E	E	E		
Rattlesnake Creek	906.2	X	E	P	E	E	E	E	E		
Poway Creek	906.2	X	E	P	E	E	E		E		
Beeler Creek	906.2	X	E	P	E	E	E		E		
Chicarita Creek	906.2	X	E	P	E	E	E		E		
Cypress Canyon	906.2	X	E	P	E	E	E		E		
Los Peñasquitos Creek	906.1	X	E	E	P	E	E		E		
Unnamed tributary	906.1	X	E	E	P	E	E		E	E	
Carmel Valley	906.1	X	E	E	P	E	E		E		
Deer Canyon	906.1	X	E	E	P	E	E		E		
McGonigle Canyon	906.1	X	E	E	P	E	E		E		
Bell Valley	906.1	X	E	E	P	E	E		E		
Shaw Valley	906.1	X	E	E	P	E	E		E		
San Diego County Coastal Streams											
Unnamed intermittent coastal sterams	906.3	X			P	E	E		E		
Rose Canyon Watershed											
Rose Canyon	906.4	X		P	E	E	E		E		
San Clemente Canyon	906.4	X		P	E	E	E	E	E	E	E
Tecolote Creek Watershed											
Tecolote Creek	906.5				P	E	E		E		

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

Name	HUC	Stressor	Potential source	Affected length
Los Peñasquitos Creek	906.1	Phosphate	Sources unknown	12 miles
		Total Dissolved Solids	Sources unknown	12 miles
Soledad Canyon	906.1	Sediment toxicity	Sources unknown	1.7 miles
Tecolote Creek	906.5	Cadmium	Nonpoint/point source	6.6 miles
		Copper	Nonpoint/point source	6.6 miles
		Indicator bacteria	Nonpoint/point source	6.6 miles
		Lead	Nonpoint/point source	6.6 miles
		Phosphorus	Sources unknown	6.6 miles
		Toxicity	Nonpoint/point source	6.6 miles

APPENDIX II

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

A. SWAMP sites.

			906LPLPC6			906LPPOW2			906LPRSC4			906LPSOL2			906LPTEC3			Watershed average		
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	158	100	4	312	4	4	179	36	4	166	79	4	303	52	3	224	77	5
Inorganics	Ammonia as N	mg/l	0.08	0.02	4	0.08	0.02	4	0.12	0.09	4	0.11	0.08	4	0.1	0.05	3	0.1	0.02	5
Inorganics	Nitrate + Nitrite as N	mg/l	0.3	0.46	4	1.35	0.71	4	0.55	0.96	4	0.31	0.43	4	0.09	0.04	3	0.52	0.49	5
Inorganics	Nitrogen, Total Kjeldahl	mg/l	0.48	0.14	4	0.55	0.04	4	0.97	1.17	4	0.5	0.53	4	0.37	--	3	0.57	0.23	5
Inorganics	OrthoPhosphate as P	mg/l	0.04	0.04	4	0.06	0.01	4	0.05	0.06	4	0.03	0.04	4	0.02	0.01	3	0.04	0.02	5
Inorganics	Phosphorus as P,Total	mg/l	0.1	0.06	4	0.08	0.03	4	0.23	0.35	4	0.08	0.11	4	0.05	0.01	3	0.11	0.07	5
Inorganics	Selenium,Dissolved	µg/L	6.9	3.8	4	7	1.1	4	6.3	1	4	6.4	3.8	4	13.5	3.8	3	8	3.1	5
Inorganics	Sulfate	mg/l	596	364	4	254	30	4	667	248	4	657	385	4	1229	378	3	681	350	5
Metals	Aluminum,Dissolved	µg/L	3.8	4.6	4	3.5	2.3	4	12	13.2	4	4.2	5.1	4	1	0.8	3	4.9	4.1	5
Metals	Arsenic,Dissolved	µg/L	3.6	1.2	4	3.1	0.3	4	3.3	0.5	4	3.1	0.5	4	4.4	0.9	3	3.5	0.6	5
Metals	Cadmium,Dissolved	µg/L	0.01	0.01	4	0.01	0.01	4	0.04	0	4	0.02	0	4	0.01	0.01	3	0.02	0.01	5
Metals	Chromium,Dissolved	µg/L	0.77	0.57	4	1.32	1.95	4	0.85	0.64	4	0.84	0.71	4	0.88	0.79	3	0.93	0.22	5
Metals	Copper,Dissolved	µg/L	4.21	0.88	4	1.96	0.48	4	5.74	1.43	4	4.23	0.49	4	4.79	0.77	3	4.18	1.39	5
Metals	Lead,Dissolved	µg/L	0.07	0.08	4	0.02	0.02	4	0.09	0.14	4	0.04	0.07	4	0	0	3	0.05	0.04	5
Metals	Manganese,Dissolved	µg/L	56	55	4	131	30	4	62	106	4	83	18	4	274	115	3	121	90	5
Metals	Nickel,Dissolved	µg/L	2.3	1.3	4	2.1	1.5	4	4.3	1.4	4	2.1	1.3	4	2.5	1.8	3	2.7	0.9	5
Metals	Silver,Dissolved	µg/L	--	--	4	0.01	0.01	4	0	0.01	4	0	0.01	4	0	0.01	3	0	0	5
Metals	Zinc,Dissolved	µg/L	6.9	5.9	4	4.8	2.3	4	14.2	16	4	9.4	9.1	4	6	0.3	3	8.3	3.7	5
PAHs	Acenaphthene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PAHs	Acenaphthylene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PAHs	Anthracene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PAHs	Benz(a)anthracene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PAHs	Benzo(a)pyrene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PAHs	Benzo(b)fluoranthene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PAHs	Benzo(e)pyrene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PAHs	Benzo(g,h,i)perylene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PAHs	Benzo(k)fluoranthene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PAHs	Biphenyl	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PAHs	Chrysene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PAHs	Chrysenes, C1 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1				--	--	4
PAHs	Chrysenes, C2 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1				--	--	4
PAHs	Chrysenes, C3 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1				--	--	4
PAHs	Dibenz(a,h)anthracene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PAHs	Dibenzothiophene	µg/L	--	--	1	--	--	1	--	--	1	--	--	1				--	--	4
PAHs	Dibenzothiophenes, C1 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1				--	--	4
PAHs	Dibenzothiophenes, C2 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1				--	--	4
PAHs	Dibenzothiophenes, C3 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1				--	--	4
PAHs	Dimethylnaphthalene, 2,6-	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PAHs	Fluoranthene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PAHs	Fluoranthene/Pyrenes, C1 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1				--	--	4
PAHs	Fluorene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PAHs	Fluorenes, C1 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1				--	--	4
PAHs	Fluorenes, C2 -	µg/L	0.027	--	1	0.026	--	1	0.032	--	1	0.027	--	1				0.028	0.003	4
PAHs	Fluorenes, C3 -	µg/L	--	--	1	--	--	1	0.033	--	1	--	--	1				0.008	0.017	4
PAHs	Indeno(1,2,3-c,d)pyrene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PAHs	Methylnaphthalene, 1-	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PAHs	Methylnaphthalene, 2-	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PAHs	Methylphenanthrene, 1-	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PAHs	Naphthalene	µg/L	0.009	0.018	4	--	--	4	--	--	4	--	--	4	--	--	3	0.002	0.004	5
PAHs	Naphthalenes, C1 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1				--	--	4
PAHs	Naphthalenes, C2 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1				--	--	4
PAHs	Naphthalenes, C3 -	µg/L	--	--	1	--	--	1	0.022	--	1	--	--	1				0.005	0.011	4
PAHs	Naphthalenes, C4 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1				--	--	4

Appendix IIa, continued.

			906LPLPC6			906LPPOW2			906LPRSC4			906LPSOL2			906LPTEC3			Watershed average		
Category	Constituent	Units	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n
PAHs	Perylene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PAHs	Phenanthrene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PAHs	Phenanthrene/Anthracene, C1 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1				--	--	4
PAHs	Phenanthrene/Anthracene, C2 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1				--	--	4
PAHs	Phenanthrene/Anthracene, C3 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1				--	--	4
PAHs	Phenanthrene/Anthracene, C4 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1				--	--	4
PAHs	Pyrene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PAHs	Trimethylnaphthalene, 2,3,5-	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PCBs	PCB 005	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PCBs	PCB 008	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PCBs	PCB 015	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PCBs	PCB 018	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PCBs	PCB 027	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PCBs	PCB 028	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PCBs	PCB 029	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PCBs	PCB 031	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PCBs	PCB 033	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PCBs	PCB 044	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PCBs	PCB 049	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PCBs	PCB 052	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PCBs	PCB 056	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PCBs	PCB 060	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PCBs	PCB 066	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PCBs	PCB 070	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PCBs	PCB 074	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PCBs	PCB 087	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PCBs	PCB 095	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PCBs	PCB 097	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PCBs	PCB 099	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PCBs	PCB 101	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PCBs	PCB 105	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PCBs	PCB 110	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PCBs	PCB 114	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PCBs	PCB 118	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PCBs	PCB 128	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PCBs	PCB 137	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PCBs	PCB 138	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PCBs	PCB 141	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PCBs	PCB 149	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PCBs	PCB 151	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PCBs	PCB 153	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PCBs	PCB 156	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PCBs	PCB 157	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PCBs	PCB 158	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PCBs	PCB 170	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PCBs	PCB 174	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PCBs	PCB 177	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PCBs	PCB 180	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PCBs	PCB 183	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PCBs	PCB 187	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PCBs	PCB 189	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PCBs	PCB 194	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PCBs	PCB 195	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PCBs	PCB 200	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PCBs	PCB 201	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PCBs	PCB 203	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PCBs	PCB 206	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PCBs	PCB 209	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
PCBs	PCBs	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5

Appendix IIa, continued.

			906LPLPC6			906LPPOW2			906LPRSC4			906LPSOL2			906LPTEC3			Watershed average		
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	--	--	4	0.001	0.002	4	--	--	4	--	--	3	0	0	5
Pesticides	Ametryn	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
Pesticides	Aspon	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
Pesticides	Atraton	µg/L	--	--	4	--	--	4	0.033	0.065	4	--	--	4	--	--	3	0.007	0.015	5
Pesticides	Atrazine	µg/L	0.018	0.02	4	0.034	0.047	4	0.034	0.047	4	0.018	0.02	4	0.045	0.051	3	0.03	0.012	5
Pesticides	Azinphos ethyl	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
Pesticides	Azinphos methyl	µg/L	0.01	0.02	4	--	--	4	--	--	4	0.01	0.02	4	--	--	3	0.004	0.005	5
Pesticides	Bolstar	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
Pesticides	Carbophenothion	µg/L	0.015	0.029	4	--	--	4	0.01	0.02	4	0.01	0.02	4	0.013	0.023	3	0.01	0.006	5
Pesticides	Chlordane, cis-	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
Pesticides	Chlordane, trans-	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
Pesticides	Chlordene, alpha-	µg/L	--	--	4	--	--	4	--	--	4	0.003	0.006	4	--	--	3	0.001	0.001	5
Pesticides	Chlordene, gamma-	µg/L	--	--	4	0	0.001	4	0.002	0.002	4	--	--	4	--	--	3	0	0.001	5
Pesticides	Chlorfenvinphos	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
Pesticides	Chlorpyrifos	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
Pesticides	Chlorpyrifos methyl	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
Pesticides	Ciodrin	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
Pesticides	Coumaphos	µg/L	--	--	4	--	--	4	--	--	4	0.013	0.025	4	--	--	3	0.003	0.006	5
Pesticides	Dacthal	µg/L	0	0.001	4	--	--	4	0	0.001	4	0	0.001	4	--	--	3	0	0	5
Pesticides	DDD(o,p')	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
Pesticides	DDD(p,p')	µg/L	0	0.001	4	--	--	4	--	--	4	--	--	4	--	--	3	0	0	5
Pesticides	DDE(o,p')	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
Pesticides	DDE(p,p')	µg/L	0.01	0.019	4	0	0.001	4	0.009	0.018	4	0.008	0.016	4	0	0.001	3	0.005	0.005	5
Pesticides	DDMU(p,p')	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
Pesticides	DDT(o,p')	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
Pesticides	DDT(p,p')	µg/L	--	--	4	--	--	4	0.001	0.002	4	0.001	0.002	4	--	--	3	0	0	5
Pesticides	DDTs	µg/L	0.01	0.02	4	0	0.001	4	0.01	0.017	4	0.009	0.015	4	0	0.001	3	0.006	0.005	5
Pesticides	Demeton-s	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
Pesticides	Diazinon	µg/L	0.037	0.041	4	0.04	0.018	4	0.096	0.088	4	0.041	0.045	4	0.037	0.036	3	0.05	0.026	5
Pesticides	Dichlofenthion	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
Pesticides	Dichlorvos	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
Pesticides	Dicrotophos	µg/L	0.015	0.03	4	0.01	0.02	4	--	--	4	--	--	4	0.013	0.023	3	0.008	0.007	5
Pesticides	Dieldrin	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
Pesticides	Dimethoate	µg/L	0.034	0.04	4	0.033	0.043	4	0.016	0.031	4	0.025	0.05	4	0.013	0.023	3	0.024	0.01	5
Pesticides	Dioxathion	µg/L	0.01	0.02	4	0.01	0.02	4	0.01	0.02	4	0.01	0.02	4	0.013	0.023	3	0.011	0.001	5
Pesticides	Disulfoton	µg/L	0.069	0.099	4	0.023	0.015	4	0.052	0.047	4	0.07	0.101	4	0.05	0.035	3	0.053	0.019	5
Pesticides	Endosulfan I	µg/L	--	--	4	--	--	4	--	--	4	0	0.001	4	--	--	3	0	0	5
Pesticides	Endosulfan II	µg/L	--	--	4	0.001	0.002	4	0.001	0.003	4	--	--	4	0	0.001	3	0.001	0.001	5
Pesticides	Endosulfan sulfate	µg/L	--	--	4	--	--	4	--	--	4	0	0.001	4	--	--	3	0	0	5
Pesticides	Endrin	µg/L	--	--	4	0	0.001	4	--	--	4	--	--	4	--	--	3	0	0	5
Pesticides	Endrin Aldehyde	µg/L	0.001	0.002	4	--	--	4	--	--	4	--	--	4	--	--	3	0	0	5
Pesticides	Endrin Ketone	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
Pesticides	Ethion	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
Pesticides	Ethoprop	µg/L	0.01	0.02	4	--	--	4	--	--	4	--	--	4	--	--	3	0.002	0.004	5
Pesticides	Famphur	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
Pesticides	Fenchlorphos	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
Pesticides	Fenitrothion	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
Pesticides	Fensulfothion	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
Pesticides	Fenthion	µg/L	--	--	4	--	--	4	0.01	0.02	4	0.01	0.02	4	--	--	3	0.004	0.005	5
Pesticides	Fonofos	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
Pesticides	HCH, alpha	µg/L	--	--	4	--	--	4	0.01	0.019	4	0	0.001	4	--	--	3	0.002	0.004	5
Pesticides	HCH, beta	µg/L	--	--	4	0	0.001	4	--	--	4	0.002	0.003	4	--	--	3	0	0.001	5
Pesticides	HCH, delta	µg/L	--	--	4	0	0.001	4	--	--	4	--	--	4	--	--	3	0	0	5
Pesticides	HCH, gamma	µg/L	--	--	4	--	--	4	--	--	4	0	0.001	4	--	--	3	0	0	5
Pesticides	Heptachlor	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
Pesticides	Heptachlor epoxide	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
Pesticides	Hexachlorobenzene	µg/L	0	0	4	--	--	4	0	0	4	0	0	4	--	--	3	0	0	5

Appendix IIa, continued.

Category	Constituent	Units	906LPLPC6 Mean	SD	n	906LPPOW2 Mean	SD	n	906LPRSC4 Mean	SD	n	906LPSOL2 Mean	SD	n	906LPTEC3 Mean	SD	n	Watershed average Mean	SD	n
Pesticides	Leptophos	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
Pesticides	Malathion	µg/L	0.09	0.18	4	--	--	4	--	--	4	--	--	4	--	--	3	0.018	0.04	5
Pesticides	Merphos	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
Pesticides	Methidathion	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
Pesticides	Methoxychlor	µg/L	0	0.001	4	--	--	4	--	--	4	--	--	4	--	--	3	0	0	5
Pesticides	Mevinphos	µg/L	0.01	0.02	4	--	--	4	0.013	0.025	4	0.01	0.02	4	0.013	0.023	3	0.009	0.005	5
Pesticides	Mirex	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
Pesticides	Molinate	µg/L	0.025	0.05	4	--	--	4	0.025	0.05	4	0.025	0.05	4	--	--	3	0.015	0.014	5
Pesticides	Naled	µg/L	0.02	0.023	4	--	--	4	0.02	0.023	4	0.01	0.02	4	--	--	3	0.01	0.01	5
Pesticides	Nonachlor, cis-	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
Pesticides	Nonachlor, trans-	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
Pesticides	Oxadiazon	µg/L	0.031	0.031	4	0.005	0.005	4	0.1	0.055	4	0.038	0.017	4	0.067	0.029	3	0.048	0.036	5
Pesticides	Oxychlordane	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
Pesticides	Parathion, Ethyl	µg/L	--	--	4	--	--	4	--	--	4	0.01	0.02	4	--	--	3	0.002	0.004	5
Pesticides	Parathion, Methyl	µg/L	0.024	0.049	4	0.008	0.015	4	--	--	4	0.008	0.015	4	--	--	3	0.008	0.01	5
Pesticides	Phorate	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
Pesticides	Phosmet	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
Pesticides	Phosphamidon	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
Pesticides	Prometon	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
Pesticides	Prometryn	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
Pesticides	Propazine	µg/L	0.009	0.018	4	0.029	0.058	4	0.009	0.018	4	0.026	0.053	4	0.012	0.02	3	0.017	0.01	5
Pesticides	Secbumeton	µg/L	0.171	0.183	4	0.103	0.127	4	0.163	0.236	4	0.09	0.105	4	0.128	0.113	3	0.131	0.036	5
Pesticides	Simazine	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
Pesticides	Simetryn	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
Pesticides	Sulfotep	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
Pesticides	Tedion	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
Pesticides	Terbufos	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
Pesticides	Terbuthylazine	µg/L	0.293	0.355	4	0.121	0.14	4	0.884	0.439	4	0.2	0.042	4	0.412	0.15	3	0.382	0.301	5
Pesticides	Terbutryn	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
Pesticides	Tetrachlorvinphos	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
Pesticides	Thiobencarb	µg/L	0.231	0.463	4	--	--	4	0.075	0.15	4	0.025	0.05	4	--	--	3	0.066	0.097	5
Pesticides	Thionazin	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
Pesticides	Tokuthion	µg/L	--	--	4	--	--	4	--	--	4	0.01	0.02	4	--	--	3	0.002	0.004	5
Pesticides	Trichlorfon	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	3	--	--	5
Pesticides	Trichloronate	µg/L	--	--	4	--	--	4	0.01	0.02	4	--	--	4	--	--	3	0.002	0.004	5
Physical	Fine-ASTM	%	37.4	37.9	3	64.6	31.8	3	30.7	31.2	2	2.4	0.9	3	29.1	18.7	2	32.8	22.2	5
Physical	Fine-ASTM,Passing No. 200 Sieve	%	93.4	--	1	0.8	--	1				2.2	--	1				32.2	53	3
Physical	Oxygen, Saturation	%	123	27	4	77	21	4	118	22	4	130	44	4	84	18	3	106	24	5
Physical	pH	pH	8.1	0.5	4	7.7	0.2	4	8	0.6	4	7.9	0.2	4	7.5	0.3	3	7.8	0.2	5
Physical	SpecificConductivity	mS/cm	2704	1414	4	2793	152	4	2654	834	4	2505	1361	4	4673	1468	3	3065	905	5
Physical	Temperature	ºC	23.4	4.6	4	16.4	3.2	4	19.9	5.8	4	20.4	2.4	4	16.3	1.2	3	19.3	3	5
Physical	Turbidity	NTU	11.9	15.8	4	3.8	3.1	4	33.6	52	4	14.1	20.7	4	7.5	6.7	3	14.2	11.6	5
Physical	Velocity	ft/s	0.5	0.5	4	0.7	0.9	4	0.9	0.9	4	1.4	1.1	4	0.4	0.8	3	0.8	0.4	5

B. Non-SWAMP sites.

Constituent		Site 1 Mean	SD	N	Site 3 Mean	SD	N	Site 4 Mean	SD	N	Site 6 Mean	SD	N	Site 7 Mean	SD	N
Dissolved Oxygen	mg/L	11.1	2.8	7	7.2	0	2	8.6	0.7	6	6.2	2	7	9.7	3.8	6
pH	pH	8.1	0.2	7	7.9	0.5	2	7.7	0.2	6	7.5	0.3	7	7.8	0.3	6
Specific conductivity	mS/cm	3.2	0.6	7	2.3	0.9	2	2.1	0.8	6	5.6	1.5	7	3.6	0.6	6
Turbidity	NTU	7.4		1			0	7.9		1	8.1		1	8.9		1
Water temperature	ºC	22.2	2.9	7	16.7	0.8	2	17.8	1.9	6	18	2	7	18.8	2.2	6

APPENDIX III

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

	C. dubia						*H. azteca*						*S. capricornutum*		
	Survival			Young / female			Survival			Growth			Total cell count		
Site	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n
906LPLPC6	104	19	4	116	54	4	100	3	4	141	58	4	64	26	4
906LPPOW2	113	14	4	112	57	4	65	26	4	146	116	4	48	19	4
906LPRSC4	84	57	4	120	67	3	90	16	2	70	8	2	76	20	4
906LPSOL2	108	22	4	95	54	4	70	22	4	146	103	4	66	19	4
906LPTEC3	59	25	3	72	75	3	93	8	2	93	5	2	18	18	3
Mean of all sites	95	34	19	104	56	18	80	22	16	128	80	16	56	27	19

APPENDIX IV

Concentrations of metals, PCBs, and pesticides in each replicate crayfish collected from two sites in the Los Peñasquitos HU. -- = Constituent not detected. Blank cells indicate that the constituent concentration was not analyzed. Constituents exceeding OEHHA thresholds are indicated in bold.

	Site	OEHHA	906LPLPC6		906LPRSC4	
Category	Constituent	Threshold	Sample 1	Sample 2	Sample 1	Sample 2
Metals	Ag (ppm)		0.36		0.36	
Metals	Al (ppm)		503.99		2189.25	
Metals	As (ppm)		3.18		2.41	
Metals	Cd (ppm)		0.09		0.16	
Metals	Cr (ppm)		0.84		2.16	
Metals	Cu (ppm)		125.4		138.9	
Metals	Hg (ppm)				0.023	0.025
Metals	Mn (ppm)		158.8		1024.9	
Metals	Ni (ppm)		0.047		0.658	
Metals	Pb (ppm)		0.68		3.99	
Metals	Se (ppm)	1.94	1.82		**1.98**	
Metals	Zn (ppm)		71.3		80.7	
Pesticides	Aldrin (ng/g)		--	--	--	
Pesticides	Chlordane (ng/g)	200	--	--	--	
Pesticides	Chlordane, cis (ng/g)		--	--	--	
Pesticides	Chlordane, trans (ng/g)		--	--	--	
Pesticides	Chlordene, alpha (ng/g)		--	--	--	
Pesticides	Chlordene, gamma (ng/g)		--	--	--	
Pesticides	Chlorpyrifos (ng/g)		--	--	--	
Pesticides	Dacthal (ng/g)		--	--	--	
Pesticides	DCBP(p,p') (ng/g)		--	--	--	
Pesticides	DDD(o,p') (ng/g)		--	--	--	
Pesticides	DDD(p,p') (ng/g)		--	--	--	
Pesticides	DDE(o,p') (ng/g)		--	--	--	
Pesticides	DDE(p,p') (ng/g)		--	--	1.3	
Pesticides	DDMU(p,p') (ng/g)		--	--	--	
Pesticides	DDT(o,p') (ng/g)		--	--	--	
Pesticides	DDT(p,p') (ng/g)		--	--	--	
Pesticides	DDTs (ng/g)	560	--	--	1.3	
Pesticides	Diazinon (ng/g)		--	--	--	
Pesticides	Dieldrin (ng/g)	16	--	--	--	
Pesticides	Endosulfan I (ng/g)		--	--	--	
Pesticides	Endosulfan II (ng/g)		--	--	--	
Pesticides	Endosulfan sulfate (ng/g)		--	--	--	
Pesticides	Endrin (ng/g)		--	--	--	
Pesticides	HCH, alpha (ng/g)		--	--	--	
Pesticides	HCH, beta (ng/g)		--	--	--	
Pesticides	HCH, delta (ng/g)		--	--	--	
Pesticides	HCH, gamma (ng/g)		--	--	--	
Pesticides	Heptachlor (ng/g)		--	--	--	
Pesticides	Heptachlor epoxide (ng/g)		--	--	--	
Pesticides	Hexachlorobenzene (ng/g)		--	--	--	
Pesticides	Methoxychlor (ng/g)		--	--	--	
Pesticides	Mirex (ng/g)		--	--	--	
Pesticides	Nonachlor, cis (ng/g)		--	--	--	
Pesticides	Nonachlor, trans (ng/g)		--	--	0.58	
Pesticides	Oxadiazon (ng/g)		--	--	--	
Pesticides	Oxychlordane (ng/g)		--	--	--	
Pesticides	Parathion, Ethyl (ng/g)		--	--	--	
Pesticides	Parathion, Methyl (ng/g)		--	--	--	
Pesticides	Tedion (ng/g)		--	--	--	
Pesticides	Toxaphene (ng/g)	220	--	--	--	

Appendix IV, continued.

Category	Site Constituent	OEHHA Threshold	906LPLPC6 Sample 1	 Sample 2	906LPRSC4 Sample 1	 Sample 2
PCBs	PCB 008 (ng/g)		--	--	--	
PCBs	PCB 018 (ng/g)		--	--	0.112	
PCBs	PCB 027 (ng/g)		--	--	--	
PCBs	PCB 028 (ng/g)		0.144	0.1	0.245	
PCBs	PCB 029 (ng/g)		--	--	--	
PCBs	PCB 031 (ng/g)		--	--	0.16	
PCBs	PCB 033 (ng/g)		--	--	--	
PCBs	PCB 044 (ng/g)		0.138	0.126	0.157	
PCBs	PCB 049 (ng/g)		--	--	--	
PCBs	PCB 052 (ng/g)		0.434	0.364	0.435	
PCBs	PCB 056 (ng/g)		--	--	--	
PCBs	PCB 060 (ng/g)		--	--	--	
PCBs	PCB 066 (ng/g)		0.324	0.27	0.353	
PCBs	PCB 070 (ng/g)		0.251	0.183	0.257	
PCBs	PCB 074 (ng/g)		0.124	--	0.161	
PCBs	PCB 087 (ng/g)		0.144	0.114	0.137	
PCBs	PCB 095 (ng/g)		0.525	0.468	0.492	
PCBs	PCB 097 (ng/g)		0.139	0.11	0.154	
PCBs	PCB 099 (ng/g)		0.222	0.192	0.212	
PCBs	PCB 101 (ng/g)		1.1	1.01	0.647	
PCBs	PCB 105 (ng/g)		0.384	0.259	0.283	
PCBs	PCB 110 (ng/g)		0.341	0.198	0.323	
PCBs	PCB 114 (ng/g)		--	--	--	
PCBs	PCB 118 (ng/g)		0.807	0.685	0.668	
PCBs	PCB 128 (ng/g)		--	--	--	
PCBs	PCB 137 (ng/g)		--	--	--	
PCBs	PCB 138 (ng/g)		2.35	2.32	0.826	
PCBs	PCB 141 (ng/g)		0.764	0.745	0.171	
PCBs	PCB 149 (ng/g)		1.03	0.978	0.256	
PCBs	PCB 151 (ng/g)		0.613	0.568	0.133	
PCBs	PCB 153 (ng/g)		2.09	2	0.651	
PCBs	PCB 156 (ng/g)		0.166	0.155	--	
PCBs	PCB 157 (ng/g)		--	--	--	
PCBs	PCB 158 (ng/g)		--	0.103	--	
PCBs	PCB 170 (ng/g)		0.605	0.607	--	
PCBs	PCB 174 (ng/g)		0.779	0.771	0.169	
PCBs	PCB 177 (ng/g)		0.459	0.471	--	
PCBs	PCB 180 (ng/g)		1.65	1.65	0.541	
PCBs	PCB 183 (ng/g)		0.288	0.264	--	
PCBs	PCB 187 (ng/g)		0.956	0.904	0.447	
PCBs	PCB 189 (ng/g)		--	--	--	
PCBs	PCB 194 (ng/g)		0.188	0.18	--	
PCBs	PCB 195 (ng/g)		--	0.133	--	
PCBs	PCB 200 (ng/g)		--	--	--	
PCBs	PCB 201 (ng/g)		0.256	0.254	0.261	
PCBs	PCB 203 (ng/g)		--	--	0.134	
PCBs	PCB 206 (ng/g)		--	--	--	
PCBs	PCB 209 (ng/g)		--	--	--	
PCBs	PCBs	20	17.27	16.18	8.39	
Other	Lipid (%)		1.3	1.3	1	

APPENDIX V

Mean IBI and metric scores for bioassessment sites in the Peñasquitos 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		% Tolerant taxa	
Site	Season	n	Years	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Site 1	Average	13	1998-2005	20.8	0.9	0.6	0.4	1.4	0.1	2.4	1.8	3.1	2.2	0.1	0.1	3	0.8	3.9	2
	Fall	6	1998-2004	21.4	3.8	0.3	0.8	1.3	0.8	3.7	1.9	4.7	3.2	0	0	2.5	1.5	2.5	1.8
	Spring	7	1998-2005	20.2	10.8	0.9	1.1	1.4	0.5	1.1	1.5	1.6	3.4	0.1	0.4	3.6	3.2	5.3	3
Site 2	Average	4	2000-2005	12.4	2.7	0.3	0.5	1	0	2.2	1.2	2.5	0.7	0	0	0.5	0.7	2.2	1.2
	Fall	1	2000-2000	14.3		0		1		3		2		0		1		3	
	Spring	3	2000-2005	10.5	2.2	0.7	1.2	1	0	1.3	0.6	3	0	0	0	0	0	1.3	0.6
Site 3	Average	9	1998-2002	13.5	6.2	0	0	1.6	0.2	2.8	1.7	2.7	2.2	0	0	0.2	0	1.9	0.1
	Fall	4	1998-2002	17.9	5.5	0	0	1.8	1	4	2.2	4.3	2.1	0	0	0.3	0.5	2	1.4
	Spring	5	1998-2002	9.1	5.4	0	0	1.4	0.5	1.6	1.8	1.2	2.2	0	0	0.2	0.4	1.8	1.5
Site 4	Average	11	1998-2005	17.2	0.1	0	0	1.9	0.1	1.9	0.1	3.3	2.4	0	0	1.8	1.5	3.1	1.2
	Fall	4	1998-2004	17.1	2.3	0	0	2	0.8	2	1.6	5	1.6	0	0	0.8	1.5	2.3	1.9
	Spring	7	1998-2005	17.3	8.1	0	0	1.9	0.4	1.9	1.8	1.6	1.9	0	0	2.9	1.6	4	1.6
Site 5	Average	5	1998-2000	15	7.1	0.3	0.4	1	0	3.1	2.7	3.9	1.6	0	0	0.6	0.5	1.6	0.5
	Fall	1	1998-1998	20		0		1		5		5		0		1		2	
	Spring	4	1998-2000	10	6.2	0.5	1	1	0	1.3	2.5	2.8	2.5	0	0	0.3	0.5	1.3	1
Site 6	Average	11	1998-2005	16.2	9.8	0	0	0.5	0.4	1	0.9	5	4.9	0	0	2.6	0.6	2.4	0
	Fall	5	1998-2004	23.1	6.7	0	0	0.8	1.3	1.6	1.5	8.4	2.2	0	0	3	2.5	2.4	2.3
	Spring	6	1999-2005	9.3	10.1	0	0	0.2	0.4	0.3	0.8	1.5	2.7	0	0	2.2	2.4	2.3	4.1
Site 7	Average	6	2002-2005	21.2	11.8	0.7	0.9	0.7	0.5	0.8	1.2	5.5	4.9	0	0	2.5	0.7	4.5	1.2
	Fall	3	2002-2004	29.5	0.8	1.3	2.3	0.3	0.6	1.7	1.2	9	1.7	0	0	3	1	5.3	2.1
	Spring	3	2003-2005	12.9	2.5	0	0	1	0	0	0	2	2	0	0	2	2	3.7	1.5