Bioassessment and Water Quality Monitoring in the San Pedro Creek Watershed San Mateo County, California

San Mateo Countywide
Stormwater Pollution
Prevention Program

March 2005

Bioassessment and Water Quality Monitoring in the San Pedro Creek Watershed San Mateo County, California

San Mateo Countywide Stormwater Pollution Prevention Program

Prepared for the

San Mateo Countywide Stormwater Pollution Prevention Program

by

EOA, Inc.
1410 Jackson St.
Oakland, CA 94612

March 2005

TABLE OF CONTENTS

Tables

Figures

Appendices

SUMMARY

The San Mateo Countywide Stormwater Pollution Prevention Program (STOPPP) conducts watershed assessment and monitoring activities in compliance with its municipal stormwater NPDES permit. Field programs include assessing creek water quality in representative urban watersheds in San Mateo County. The overall goal is to begin identifying and solving any water quality impairment problems in San Mateo County creeks based on a watershed management approach. This report documents the results of STOPPP's recent screening-level/baseline biological and chemical water quality monitoring in the San Pedro Creek watershed. San Pedro Creek is on the coastal side of San Mateo County and receives stormwater runoff from urban and open space areas. Field activities were conducted over an approximate two-year period (May 2002 through February 2004) and included analysis of benthic macroinvertebrate assemblages, physical habitat assessment, chemical analysis and bioassay of grab water samples, and field instrument measurements of general water quality parameters.

The bioassessment helped characterize aquatic ecosystem health in San Pedro Creek. Two years of bioassessment yielded similar results and indicated that benthic macroinvertebrate assemblages sampled from various sites in the watershed were highly dissimilar, reflecting upstream land use. The data suggested that most of the variation in the assemblages was due to factors associated with the urbanized North Fork of San Pedro Creek and the main stem. Assemblages sampled from sites receiving flow from the less urbanized Middle and South Forks had consistently higher richness and diversity and included species less tolerant to stressors (e.g., pollutants) than assemblages sampled from the other sites. Elevation and substrate quality did not appear to have a large influence on assemblage quality and composition.

In addition to providing an indication of current creek ecosystem health, the bioassessment data may contribute to future evaluations of long-term trends in creek health and management practice effectiveness, and may also assist development of a regional Index of Biological Integrity.

General water quality parameters measured in the field included dissolved oxygen and pH. Dissolved oxygen measurements exceeded 7.0 milligrams per liter, meeting the Water Quality Control Plan for the San Francisco Bay Basin (Basin Plan) nontidal water objectives for cold water habitat (7.0 milligrams per liter minimum) and warm water habitat (5.0 milligrams per liter minimum). Measurements of pH varied from 7.80 to 8.27, which is within the acceptable range of 6.5 to 8.5 specified for San Francisco Bay Basin waters in the Basin Plan.

Organophosphate pesticides, including diazinon, were not detected in grab water samples. The detection limit for diazinon was lower than targets proposed by San Francisco Bay Regional Water Quality Control Board (Water Board) staff, indicating that the proposed targets were not exceeded in the study samples.

Grab water samples were also tested for chronic toxicity, using a standard three-species bioassay. The test species were *Ceriodaphnia dubia* (water flea), *Pimephales promelas* (fathead minnow) and *Selenastrum capricornutum* (green alga). The bioassays revealed water column toxicity in a limited number of samples. With the exception of one test, only sublethal effects (reduced growth or reproduction) were observed. The cause(s) of the toxicity is unknown, but there was no indication that diazinon or other organophosphate pesticides were involved, since these pesticides were not detected. Temporal or spatial patterns were not apparent in the bioassay data. Toxicity was found in samples from each sampling episode and

each sample location, including a location that primarily drains open space (other sampling locations receive substantial stormwater runoff from urbanized areas).

At this time, STOPPP does not have plans to perform more detailed investigations in the San Pedro Creek watershed, since budget constraints limit the scope of investigation that STOPPP can perform in any single watershed. However, STOPPP plans to prepare a new multi-year watershed assessment program plan in coordination with the regional municipal stormwater group permit currently under development. The tradeoff between the number of watersheds assessed and the level of investigation in each watershed will be carefully considered during development of the new multi-year plan.

Bioassessment and Water Quality Monitoring in the San Pedro Creek Watershed
San Mateo County, California

1.0 INTRODUCTION

The San Mateo Countywide Stormwater Pollution Prevention Program (STOPPP) conducts watershed assessment and monitoring activities in compliance with its municipal stormwater NPDES permit. This report documents the results of STOPPP's screening-level/baseline biological and chemical water quality monitoring in the San Pedro Creek watershed. Sampling episodes took place over an approximate two-year period (May 2002 through February 2004). STOPPP's objectives in performing this field monitoring program included:

- Performing a bioassessment to help characterize aquatic ecosystem health in San Pedro Creek, a creek on the coastal side of San Mateo County that receives stormwater runoff from urban and open space areas. The bioassessment data may also contribute to future evaluations of long-term trends in creek health and management practice effectiveness, and may assist development of a regional Index of Biological Integrity.

- Testing water samples from San Pedro Creek for toxicity and organophosphate pesticides, including diazinon. This data will contribute to the Water Quality Attainment Strategy and Total Maximum Daily Load (TMDL) under development for diazinon and pesticide-related toxicity in Bay Area urban creeks (Johnson 2004).

The field monitoring program in the San Pedro Creek watershed is part of STOPPP's efforts to assess creek water quality in representative urban watersheds in San Mateo County. Assessments typically focus on using environmental indicators such as benthic macroinvertebrate assemblages to help evaluate creek function and characteristics that are potentially impacted by urban runoff. Physical, biological and chemical water quality data are collected as appropriate. The overall goal is to begin identifying and solving any water quality impairment problems in San Mateo County creeks based on a watershed management approach.

2.0 BACKGROUND

2.1 Description of Study Area

San Pedro Creek is a perennial stream that flows westward to the Pacific Ocean through the City of Pacifica in San Mateo County, California (Figure 1). The creek drains roughly eight square miles of the western side of Montara Mountain and has five major tributaries, all of which contain perennial flows fed by springs. The North, Middle and South Forks extend into the upper reaches of the watershed. The North Fork headwaters are comprised of several steep first order streams that drain into an extensive network of underground culverts flowing through an urbanized valley. The Middle and South Fork tributaries also drain steep hillsides into a low gradient stream flowing through the upper end of San Pedro Valley. The North Fork and combined Middle/South Fork drainages are roughly equal in size, about 2.4 square miles each. There are two smaller tributaries in the watershed, Sanchez Creek and an unnamed tributary flowing through Shamrock Ranch, which drain into the lower reaches of the main stem. The main stem of San Pedro Creek flows for about 2.5 miles through a broad valley floor, which is mostly developed to the banks of the creek. About one-fifth of the total watershed area is urbanized with the remainder comprised mainly of open space and recreational uses. The overall imperviousness of the watershed is approximately 15 percent and about 64 percent of the creek channel is unmodified (STOPPP 2001 and 2002).

2.2 Regulatory Information

The San Francisco Bay Regional Water Quality Control Board (Water Board) has developed a Water Quality Control Plan for the San Francisco Bay Basin (SFBRWQCB 1995). This document is usually referred to as the “Basin Plan” and serves as a master policy document that contains descriptions of the legal, technical, and programmatic bases of water quality regulation in the San Francisco Bay Region, including water quality standards. The Basin Plan designates six existing beneficial uses for San Pedro Creek: cold water habitat, warm water habitat, fish migration, fish spawning, non-contact water recreation and municipal water supply.

The 2002 Clean Water Act Section 303(d) list designates San Pedro Creek as impaired due to high coliform levels. Water Board staff also reviewed information on San Pedro Creek regarding potential impairment due to excessive sedimentation, but concluded that there was insufficient basis for listing (SFBRWQCB 2001). The State Water Resources Control Board 2002 “Monitoring List” designates that trash threatens to impair water quality in all Bay Area urban creeks.

2.3 Previous Work by STOPPP

STOPPP (2001) initially completed a summary and evaluation of existing data on the San Pedro Creek watershed. The study compiled readily available existing information related to the health of the creek and water quality, including:

- the physical setting of the San Pedro Creek watershed,
- the history of urbanization in the watershed and current land uses,
- hydrologic and geomorphological conditions,
- biological conditions, including descriptions of aquatic biota, aquatic habitat and riparian vegetation, and
- water chemistry.

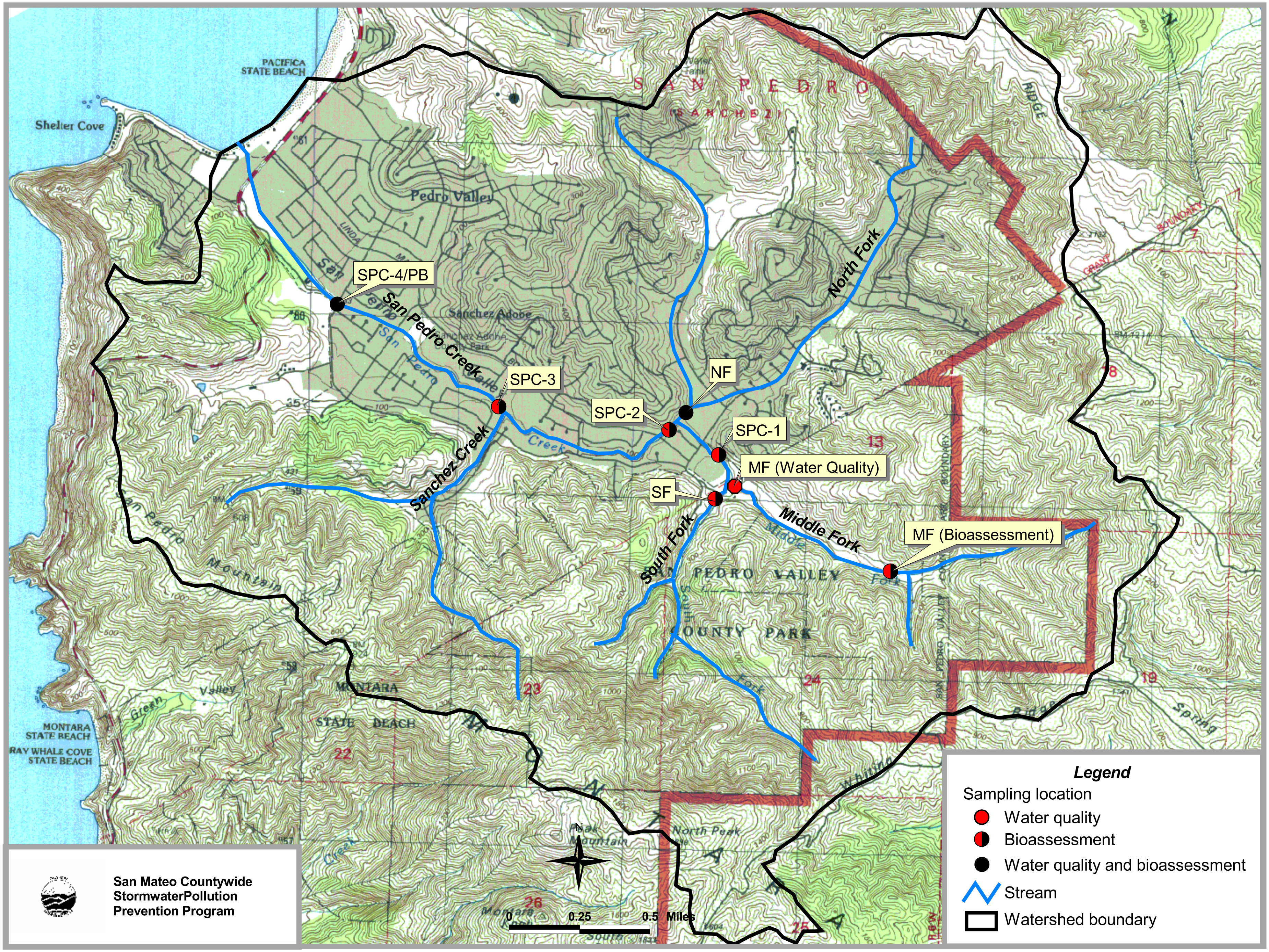

Figure 1. STOPPP bioassessment and water quality sampling locations in the San Pedro Creek watershed.

3.0 METHODS

Table 1 summarizes the field activities that STOPPP performed in the San Pedro Creek watershed: analysis of benthic macroinvertebrate assemblages, physical habitat assessment, chemical analysis and bioassay of grab water samples, and field instrument measurements (pH, temperature, conductivity, dissolved oxygen and velocity).

Table 1. Summary of STOPPP's Field Monitoring Activities in the San Pedro Creek Watershed

Type of Monitoring	Activity	Number of Sample Sites	Parameters	Frequency/Interval
Watershed characterization, assessment of receiving waters, and assessment of impacts to beneficial uses.	Bioassessment.	6-7	Macroinvertebrate assemblages and visual physical habitat characteristics.	Two episodes: • May 2002 • April/May 2003
	Creek water quality testing.	3	Temperature, pH, conductivity, dissolved oxygen, velocity, organophosphate pesticides, and water column toxicity (three-species bioassay).	Three episodes: • April 2003 • August 2003 • February 2004

3.1 Bioassessment

STOPPP collected two consecutive years of bioassessment data in the San Pedro Creek watershed: May 2002 (Bioassessment Services 2002) and April/May 2003 (see the report prepared by BioAssessment Services of Folsom, California in Appendix A). Benthic macroinvertebrate assemblages were characterized using protocols outlined in the California Stream Bioassessment Procedure (CSBP). The CSBP was developed by Harrington (1999) and the California Department of Fish and Game for assessing biotic integrity in wadeable streams. Physical habitat quality was assessed using USEPA's Rapid Bioassessment Protocols (Barbour et al. 1999).

Benthic macroinvertebrates were collected and visual assessments of physical habitat were conducted at six sites in the watershed during the first year and seven sites during year two (an additional site on the South Fork designated SF was added the second year). The selected sites (Figure 1) represent a range of subwatersheds, ecoregion subsections, elevations, stream characteristics and land use.

The San Pedro Creek Watershed Coalition and local volunteers assisted with the fieldwork (some persons assisted with both years of the bioassessment). STOPPP previously trained the volunteers during a two-day field workshop in May 2002 that was facilitated by the Sustainable Land Stewardship International Institute.

3.2 Water Testing

STOPPP collected grab water samples from San Pedro Creek and its tributaries on April 27, 2003, August 19, 2003 and February 17, 2004. These sampling dates were selected to correspond to three hydrologic seasons: decreasing hydrograph/spring, the dry season and the wet season, respectively. Samples were collected at three sites during each episode (Figure 1): on the Middle Fork near the confluence of the Middle and South Forks (designated MF), the downstream end of the North Fork (designated NF), and a main stem location (designated PB for "Peralta Bridge"). The water quality sampling sites were in the same general location as three of the seven bioassessment sites, and represent a range of creek conditions. Conventional water quality parameters (temperature, pH, conductivity, and dissolved oxygen) and stream velocity were measured using field instruments at each sampling site during each sampling episode.

A sample from each location was tested for organophosphate pesticides, including diazinon, using EPA Method 8141A. Samples from each location were also tested for chronic toxicity, using a standard three-species bioassay. The test species were *Ceriodaphnia dubia* (water flea), *Pimephales promelas* (fathead minnow) and *Selenastrum capricornutum* (green alga). The bioassay exposed the test organisms to the water samples for a specific duration[1] and their responses were compared to those of control organisms exposed to control water.

Appendix B contains a report prepared by Kinnetic Laboratories of Santa Cruz, California with a detailed description of the water sampling methods.

---

[1]The *Ceriodaphnia dubia* and *Pimephales* tests were seven days in duration and the *Selenastrum* test was four days in duration.

4.0 RESULTS

4.1 Bioassessment

Bioassessment Services (2002) and Appendix A contain a detailed presentation of the year one and two bioassessment data, respectively. These data are summarized below.

4.1.1 Benthic Macroinvertebrate Assemblages

Both years of bioassessment yielded similar results and indicated that benthic macroinvertebrate assemblages sampled from various sites in the San Pedro Creek watershed were highly dissimilar. Composite metric scores[2] were consistently higher for sites MF, SF and SPC-1 when compared to the other sites due to higher richness and diversity and higher proportion of stressor-intolerant and EPT taxa.[3] This is illustrated by the year two composite scores (Figure 2), which were similar to the year one scores.

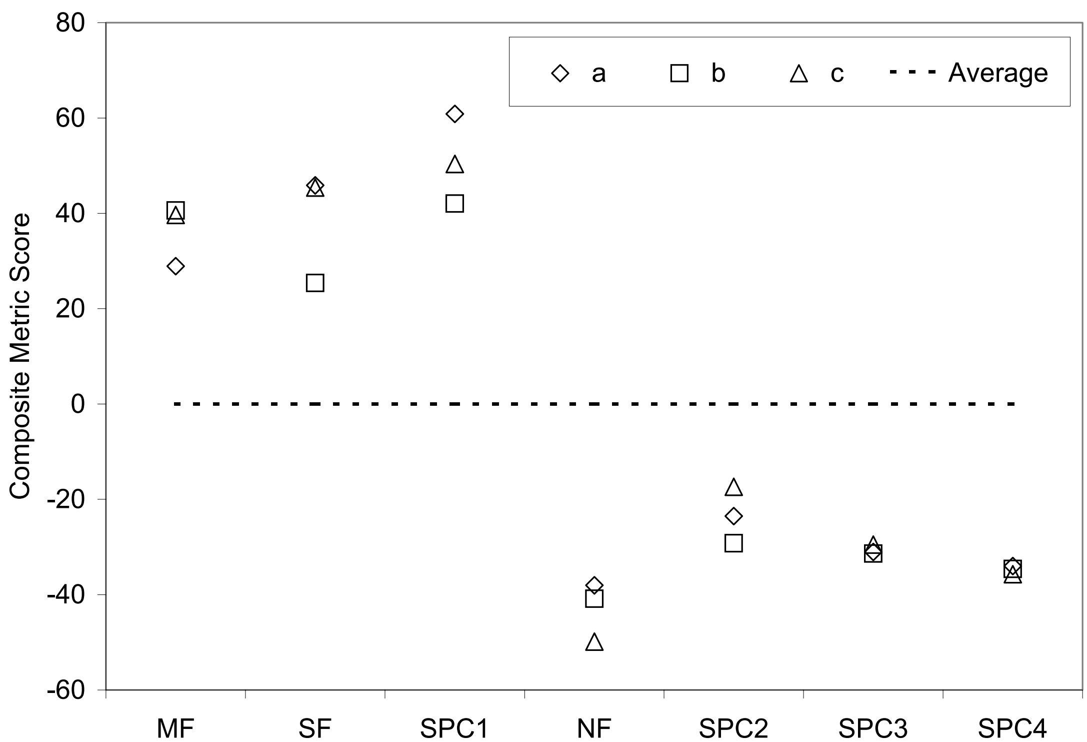

Figure 2. Year Two Composite Metric Scores (from BioAssessment Services report in Appendix A). The three sub-samples collected at each sample site are denoted a, b and c (See Appendix A for more details).

---

[2]Higher composite metric scores indicate better aquatic ecosystem health. However, limitations of the composite metric score include 1) scores are a relative rather than absolute measure of ecosystem health and cannot be used out of the context of the group of sites being compared, and 2) some of the metrics used in the composite metric score measure related attributes of the benthic macroinvertebrate assemblage, which results in amplified responses.
[3]Number of taxa in the orders Ephemeroptera (mayfly), Plecoptera (stonefly) and Trichoptera (caddisfly). EPT taxa are indicative of a healthly aquatic ecosystem.

4.1.2 Physical Habitat Assessment

Physical habitat assessment scores are presented in Table 2. Barbour et al. (1999) has described scores of 50 or less to imply poor habitat, scores greater than 50 to 100 to imply marginal habitat, scores greater than 100 to 150 to imply suboptimal habitat, and scores greater than 150 to imply optimal habitat. Based on this classification, all scores from this study imply suboptimal habitat, with the exception of the year two score at location MF, which implies optimal habitat.

Table 2. Physical Habitat Scores

Habitat Parameter	MF	NF	SF	SPC-1	SPC-2	SPC-3	SPC-4
Epifaunal Substrate/Available Cover	13/17	9/9	NA/9	9/12	12/16	17/15	8/10
Embeddedness	18/18	7/13	NA/7	18/17	12/12	12/13	14/13
Velocity/Depth Regime	11/12	15/8	NA/10	14/15	14/14	18/16	10/16
Sediment Deposition	15/19	6/14	NA/9	9/10	10/13	6/11	6/7
Channel Flow Status	18/18	18/18	NA/18	18/18	18/18	18/18	18/18
Channel Alteration	18/19	16/14	NA/15	13/14	12/16	13/15	8/11
Frequency of Riffles	13/19	19/20	NA/18	16/16	19/16	19/16	18/20
Bank Stability	9/17	10/14	NA/11	7/12	14/15	10/14	13/16
Vegetative Protection	17/18	11/16	NA/8	6/10	12/14	11/15	7/12
Riparian Vegetative Zone Width	14/13	6/14	NA/11	7/12	6/12	8/12	4/8
Total Score	**146/170**	**117/140**	**NA/116**	**117/136**	**129/146**	**132/145**	**106/131**

Notes:
See Figure 1 for sampling locations.
Scores are shown for both years of physical habitat assessment: May 2002 / April-May 2003.
NA – Not Applicable (Site SF was included in the second year bioassessment only).

4.2 Water Testing

Table 3 summarizes the results of the chemical analyses and the field probe conventional water quality parameter and velocity measurements. Organophosphate pesticides, including diazinon, were not detected in any of the samples. The report in Appendix B contains additional information on the water sampling results and quality control measures, including the organophosphorous pesticide analytes and method detection limits. Laboratory reports prepared by the analytical laboratory, ToxScan, Inc. of Watsonville, California, are not included in this report due to their large size, but are available upon request.

Table 3. Organophosphorous Pesticides and Field Instrument Measurement Results

Date Collected	Water Sample	Organo-phosphorous Pesticides	pH	Temp-erature (°C)	Con-ductivity (µS/cm)	Dissolved Oxygen (mg/L)	Velocity (ft/sec)
4-27-03	PB	Not Detected*	8.27	11.0	268.9	10.43	1.26
	MF	Not Detected	7.94	10.2	264.2	10.78	0.45
	NF	Not Detected	7.92	14.1	488	10.09	0.38
8-19-03	PB	Not Detected	8.06	15.8	336.4	8.85	0.42
	MF	Not Detected	8.06	15.1	303.6	8.80	0.03
	NF	Not Detected	7.94	16.8	626	7.08	0.07
2-17-04	PB	Not Detected	7.80	12.9	323.7	10.04	0.82
	MF	Not Detected	8.03	12.0	236	10.04	0.80
	NF	Not Detected	7.82	13.8	475	9.22	1.18

Notes:
See Figure 1 for sampling locations.
*The detection limit for all organophosphorous pesticide analytes in all samples was 50 nanograms per liter, except diazinon (10 nanograms per liter) and azinphos methyl (100 nanograms per liter).

Table 4 presents a very simplified summary of the results of the three species bioassays. A total of 27 toxicity tests was performed. Samples with any indication of toxicity (including relatively little indication), are shown in bold italics. Reduced *Pimephales* survival was found in one sample. Reduced *Ceriodaphnia* reproduction was found in six samples and inhibition of *Selenastrum* growth was found in one sample.

Appendix B includes a more detailed description of the bioassay results, including additional information on the magnitude of observed toxicity. Quantified parameters include No Observed Effect Concentration (NOEC) values (the highest test concentration not producing a statistically significant reduction in survival, reproduction, or growth), Lowest Observed Effect Concentration (LOEC) values (the lowest test concentration producing a statistically significant reduction in survival, reproduction or growth), LC_{50} values (median lethal concentrations), and IC_{50}, IC_{25} and IC_{10} values (concentrations inhibitory to reproduction or growth by 50, 25 and 10 percent, respectively). These values are expressed as the percentage of a sample in a test container (an undiluted sample has a concentration of 100%).

Table 4. Three Species Bioassay Results

Date Collected	Water Sample Designation	Organism	Summary of Bioassay Results[4]	
			Survival Endpoint	Sub-lethal Endpoint (Reproduction/Growth)
4-27-03	PB	*Ceriodaphnia*	Survival not reduced.	Reproduction not reduced.
		Pimephales	Survival not reduced.	Growth not reduced.
		Selenastrum	NA	Growth not inhibited.
	MF	*Ceriodaphnia*	Survival not reduced.	***Reduced reproduction***
		Pimephales	Survival not reduced.	Growth not reduced.
		Selenastrum	NA	Growth not inhibited.
	NF	*Ceriodaphnia*	Survival not reduced.	Reproduction not reduced.
		Pimephales	Survival not reduced.	Growth not reduced.
		Selenastrum	NA	***Inhibited growth.***
8-19-03	PB	*Ceriodaphnia*	Survival not reduced.	***Reduced reproduction.***
		Pimephales	Survival not reduced.	Growth not reduced.
		Selenastrum	NA	Growth not inhibited.
	MF	*Ceriodaphnia*	Survival not reduced.	Reproduction not reduced.
		Pimephales	Survival not reduced.	Growth not reduced.
		Selenastrum	NA	Growth not inhibited.
	NF	*Ceriodaphnia*	Survival not reduced.	***Reduced reproduction.***
		Pimephales	Survival not reduced.	Growth not reduced.
		Selenastrum	NA	Growth not inhibited.
2-17-04	PB	*Ceriodaphnia*	Survival not reduced.	***Reduced reproduction.***
		Pimephales	***Reduced survival.***	Growth not reduced.
		Selenastrum	NA	Growth not inhibited.
	MF	*Ceriodaphnia*	Survival not reduced.	***Reduced reproduction.***
		Pimephales	Survival not reduced.	Growth not reduced.
		Selenastrum	NA	Growth not inhibited.
	NF	*Ceriodaphnia*	Survival not reduced.	***Reduced reproduction***
		Pimephales	Survival not reduced.	Growth not reduced.
		Selenastrum	NA	Growth not inhibited.

Notes:
NA – Not Applicable.
See Figure 1 for sampling locations.
Samples with any indication of toxicity are shown in bold italics.
Appendix B includes a more detailed description of the bioassay results.

[4]During the bioassay of samples PB collected on 4-27-03 and MF and NF collected on 8-19-03, not all *Selenastrum* tests met test acceptability criteria. These quality control results increase the uncertainty of the corresponding test results.

5.0 DISCUSSION

5.1 Bioassessment

Benthic macroinvertebrate abundance and taxonomic diversity typically show a wide range of response to changes in their aquatic environment and therefore are a good indicator biota to monitor the quality of water resources. Thus the bioassessment results helped characterize aquatic ecosystem health in San Pedro Creek. Results were similar both years and indicated that benthic macroinvertebrate assemblages sampled from various sites in the watershed were highly dissimilar. Assemblages sampled from sites receiving flow from the less urbanized Middle and South Forks had consistently higher richness and diversity and included species less tolerant to stressors (e.g., pollutants) than assemblages sampled from the other sites. The data suggested that most of the variation in the assemblages was due to factors associated with the urbanized North Fork of San Pedro Creek and the main stem.

Based on composite metric scores, there was a consistent trend of benthic macroinvertebrate response relative to the extent of urbanization within the upstream drainage area. Sites MF, SF and SPC-1 are located in a less urbanized section of the San Pedro Creek watershed while sites NF, SPC-2, SPC-3 and SPC-4 all receive runoff from urban land uses (Figure 1). While sites MF, SF and SPC-1 had similar composite metric scores, site MF had the highest physical habitat quality ranking both years and sites SF and SPC-1 had relatively low habitat quality scores (Table 2). This suggests that habitat quality was not a primary factor contributing to the differences in benthic macroinvertebrate assemblages at these sites.

Factors other than urbanization could contribute to the dissimilarity of benthic macroinvertebrate assemblage quality and composition. Vannotte et al. (1980) describes factors associated with elevation such as gradient, canopy cover, stream width, substrate composition, allocthonous input, depth and temperature regime that influence the composition of benthic fauna along elevational gradients. Other investigators (e.g., Allan 1995 and Merritt and Cummins 1996) have shown these factors, individually and in various combinations, to be important influences on benthic fauna.

Elevation differences, however, did not appear to substantially contribute to the variation in benthic macroinvertebrate assemblage quality and composition observed during this study. The elevation range of the sites was only 200 feet and the elevation difference of two sites (NF and SPC-1) with highly dissimilar assemblage quality and composition was only about 20 feet. Substrate quality also did not appear to have a strong influence on benthic macroinvertebrate assemblage quality and composition.

In addition to providing an indication of current creek ecosystem health, the bioassessment data may contribute to future evaluations of long-term trends in creek health and management practice effectiveness. The data from this study may also assist development of a regional Index of Biological Integrity (IBI). A regional IBI would potentially help STOPPP evaluate attainment of beneficial uses in San Mateo County creeks, identify stressors to creeks, and establish water quality goals. To help refine the use of bioassessment techniques in the Bay Area, STOPPP is continuing to provide in-kind staff assistance to the Bay Area Macroinvertebrate Bioassessment Information Network (BAMBI). This regional program will help stormwater management agencies interpret bioassessment data collected in the Bay Area and use the results to inform development of urban runoff management strategies. BAMBI's goals include:

- standardizing rapid bioassessment protocols in the Bay Area, including quality assurance and control in field sampling and laboratory analyses;
- establishing reference conditions for Bay Area creeks;
- facilitating regional coordination, and data management and sharing;
- refining physical habitat assessment protocols; and
- developing a Bay Area IBI.

5.2 Water Testing

General water quality parameters measured in the field included dissolved oxygen and pH.[5] Dissolved oxygen measurements exceeded 7.0 milligrams per liter, meeting Basin Plan (SFBRWQCB 1995) nontidal water objectives for cold water habitat (7.0 milligrams per liter minimum) and warm water habitat (5.0 milligrams per liter minimum). Measurements of pH varied from 7.80 to 8.27, within the acceptable range of 6.5 to 8.5 specified for San Francisco Bay Basin waters in the Basin Plan.

Organophosphate pesticide analytes, including diazinon, were not detected in any of the grab water samples collected during this study. Water Board staff recently released a staff report on diazinon and pesticide-related toxicity in Bay Area urban creeks (Johnson 2004). Proposed diazinon concentration targets are 50 nanograms per liter (four-day average) and 80 nanograms per liter (one-hour average). None of these targets is to be exceeded more than once every three years. The detection limit for diazinon during this study was 10 nanograms per liter, which is lower than the proposed targets, indicating that the targets were not exceeded in the study samples.

The bioassays revealed water column toxicity in a limited number of samples. With the exception of one test, only sublethal effects (reduced growth or reproduction) were observed. The cause(s) of the toxicity is unknown, but there was no indication that diazinon or other organophosphate pesticides were involved, since these pesticides were not detected. Temporal or spatial patterns were not apparent in the bioassay data. Toxicity was found in samples from each sampling episode and each sample location (Table 4), including location MF, which primarily drains open space. The other two test locations, NF and PB, receive substantial stormwater runoff from urbanized areas.

In addition to the diazinon targets, the staff report proposes a quantitative toxicity target that does not allow any acute or chronic pesticide-related toxicity in Bay Area waters, consistent with a narrative toxicity objective in the Basin Plan (SFBRWQCB 1995). The staff report states "substantial exceedances of the toxicity target may trigger the need for Toxicity Identification Evaluations (TIE) to determine the causes of the toxicity (unless the toxicity can be attributed to diazinon)." A practical consideration is that a sample must have sufficient toxicity to perform a TIE. Staff of the laboratory that performed the bioassays believes that there was insufficient toxicity in any of the samples to perform acute TIEs. Two samples (NF – August 19, 2003 and MF – February 17, 2004) potentially showed enough toxicity to *Ceriodaphnia* reproduction to perform chronic TIEs (Lewis 2005, personal communication).

---

[5]General water quality measurements from this study do not capture natural variability due to daily photosynthesis cycles.

It is important to note that implementing aquatic toxicity testing in urban creeks and interpreting test results are not straightforward. Laboratory test conditions differ from conditions found in nature, potentially confounding test results. In addition, test results are variable and subject to interpretation. For example, USEPA (2000a) recommends the use of the concentration-response concept to assist in determining the validity of toxicity test results. When unexpected concentration-response relationships are encountered, a thorough review of test performance, test conditions, and the particular concentration-response pattern exhibited should be conducted to determine whether the derived effect concentrations are reliable or anomalous. USEPA (2000b) discusses identifying and minimizing potential sources of toxicity test method variability. STOPPP and other Bay Area Stormwater Management Agencies Association (BASMAA) agencies plan to work with Water Board staff to address uncertainties associated with implementing toxicity testing in urban creeks. Addressing these uncertainties is particularly relevant to the Water Quality Attainment Strategy and TMDL under development for diazinon and pesticide-related toxicity in Bay Area urban creeks.

5.3 Next Steps

STOPPP's watershed assessment program currently focuses on performing *screening-level/baseline* biological and chemical water quality monitoring in representative urban watersheds in San Mateo County. Environmental indicators such as benthic macroinvertebrate assemblages are used to help evaluate creek function and characteristics that are potentially impacted by urban runoff. At this time, STOPPP does not have plans to perform more detailed investigations in the San Pedro Creek watershed or other San Mateo County watersheds, since budget constraints limit the scope of investigation that STOPPP can perform in any single watershed. However, STOPPP plans to prepare a new multi-year watershed assessment program plan in coordination with the regional municipal stormwater group permit currently under development. The tradeoff between the number of watersheds assessed and the level of investigation in each watershed will be carefully considered during development of the new multi-year plan. The lessons learned during STOPPP's recent watershed assessments will inform this planning process.

6.0 REFERENCES

Allan, J. D. 1995. *Stream Ecology-Structure and function of running waters*. 1st edition. Chapman & Hall.

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. *Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition*. EPA 841-B-99-002. U.S. Environmental Protection Agency, Office of Water; Washington, D.C.

Bioassessment Services. 2002. *Benthic Macroinvertebrate Assemblages of San Pedro Creek, San Mateo County, Spring 2002.* Prepared for the San Mateo Countywide Stormwater Pollution Prevention Program by Bioassessment Services, Folsom, California, in association with EOA, Inc., Oakland, California. November.

Harrington, J.M. 1999. *California Stream Bioassessment Procedures*. California Department of Fish and Game, Water Pollution Control Laboratory. Rancho Cordova, CA.

Johnson, B. 2004. *Diazinon and Pesticide-Related Toxicity in Bay Area Urban Creeks, Water Quality Attainment Strategy and Total Maximum Daily Load (TMDL), Final Project Report*. Staff report of the San Francisco Bay Regional Water Quality Control Board. March.

Lewis, D. 2005. ToxScan, Inc., Watsonville, California. Personal Communication. January.

Merritt, R.W. and K.W. Cummins. 1996. *An Introduction to the Aquatic Insects of North America.* Second Edition. Dendall/Hunt Publishing Co., Dubuque, Iowa.

San Francisco Bay Regional Water Quality Control Board (SFBRWQCB). 1995. *Water Quality Control Plan, San Francisco Bay Basin (Region 2).* June 21.

San Francisco Bay Regional Water Quality Control Board (SFBRWQCB). 2001. *Staff Report, Proposed Revisions to Section 303(d) List and Priorities for Development of Total Maximum Daily Loads (TMDLs) for the San Francisco Bay Region.* November 14.

STOPPP. 2001. *San Pedro Creek Watershed Pilot Assessment.* Prepared for the San Mateo Countywide Stormwater Pollution Prevention Program by EOA, Inc., Oakland, California. December 17.

STOPPP. 2002. *Characterization of Impervious and Creek Channel Modifications for Seventeen Watersheds in San Mateo County.* Prepared for the San Mateo Countywide Stormwater Pollution Prevention Program by EOA, Inc., Oakland, California. January 1.

U.S. Environmental Protection Agency. 2000a. *Method Guidance and Recommendations for Whole Effluent Toxicity (WET) Testing (40 CFR Part 136).* EPA 821-B-00-004. U.S. Environmental Protection Agency, Office of Wastewater Management, Washington, D.C. July.

U.S. Environmental Protection Agency. 2000b. *Understanding and Accounting for Method Variability in Whole Effluent Toxicity Applications Under the National Pollutant Discharge Elimination System Program.* EPA/833/R-00/003. U.S. Environmental Protection Agency, Office of Wastewater Management, Washington, D.C. June.

Vannote, R.L., Minshall, G.W., Cummins, K.W., Sedell, J.R. and Cushing, C.E. 1980. *The River Continuum Concept*. Can. J. Fish. Aquat. Sci. 37: 130-137.

APPENDIX A

Bioassessment Report Prepared by BioAssessment Services

ONLY RAIN IN THE STORM DRAIN

San Mateo Countywide
Stormwater Pollution
Prevention Program

Benthic Macroinvertebrate Assemblages of San Pedro Creek, San Mateo County

- Spring 2003 -

Prepared by:
BIOASSESSMENT SERVICES
Folsom, California

Prepared for:
EOA, INC.
Oakland, California

September 2004

SUMMARY

The San Mateo Countywide Stormwater Pollution Prevention Program initiated biological monitoring and assessment in May of 2002 to help evaluate the biotic condition of the San Pedro Creek watershed. This report provides the results and analyses for the second year of the biological assessment that was conducted in May 2003. The assessments for both years were conducted using protocols outlined in the California Stream Bioassessment Procedure (CSBP), which uses the benthic macroinvertebrate assemblage as an indicator of water and habitat quality. Benthic macroinvertebrate abundance and taxonomic diversity typically show a wide range of response to changes in their aquatic environment, and as a result, are good indicator biota to monitor the quality of water resources.

Bioassessment monitoring was conducted at seven sites within the San Pedro Creek system: one site on each of the middle, south, and north forks and four sites in the mainstem; the mainstem was defined as the section of creek between the middle and south fork confluence and the mouth at Pacifica State Beach. The south fork site was not assessed the previous year, while the remaining six sites were assessed both years. Each assessment consisted of collecting three benthic samples and a qualitative visual physical habitat assessment.

The benthic samples were processed by subsampling 300 organisms from each sample and identifying the organisms to a standard taxonomic level. Biological metrics were used to describe characteristics of the benthic macroinvertebrate assemblages and cluster analysis was used to assess the degree of site and sample similarity based on the composition of benthic macroinvertebrate assemblages.

Results of the assessment indicated that benthic macroinvertebrate assemblages sampled from the sites were highly dissimilar. While the sites were distributed along an elevational gradient, the data suggested that most of the variation in the benthic macroinvertebrate assemblages was due to factors associated with both the urbanized north fork branch of San Pedro Creek and the mainstem. Benthic macroinvertebrate assemblages sampled from sites receiving flow from the less urbanized middle and south forks had consistently higher taxonomic richness and diversity and were less tolerant than benthic macroinvertebrate assemblages sampled from the other sites, which received north fork and mainstem flow. The results of this assessment were similar to results of the assessment conducted in year 2002.

Streams that receive runoff from urban watersheds with impervious landscape surfaces may have altered flow and temperature regimes and may contain petroleum hydrocarbons, fine sediment, pesticides, fertilizers and detergents. These characteristics of the urban stream have been shown to affect the composition of the benthic macroinvertebrate community.

TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF TABLES AND FIGURES

INTRODUCTION

Bioassessment Services was contracted by EOA, Inc. to provide laboratory services for processing 21 stream benthos samples collected from seven sites in late April and early May 2003 from San Pedro Creek, San Mateo County. This report provides the results and analyses of the benthic macroinvertebrate (BMI) community assemblages that were collected from the San Pedro Creek sampling sites in 2003, as well as a comparison with the 2002 assessment results. This work was performed as part of the San Mateo Countywide Stormwater Pollution Prevention Program's (STOPPP's) efforts to assess the health of creeks in representative urban watersheds in San Mateo County. STOPPP's overall goal is to help solve water quality impairment problems in creeks using a watershed-based approach.

BMIs are an essential component of the food web in aquatic habitats. They cycle nutrients in their aquatic environment by feeding on algae and organic detritus and by preying on a wide range of small organisms. They are an important food resource for fishes, amphibians, reptiles, birds and mammals. Because of BMI abundance, taxonomic diversity and range of response to changes in their aquatic environment, they are commonly the resident biota used to monitor the quality of water resources throughout the United States (Davis et al. 1996). Justifications for their use as indicators of water and habitat quality have been described by Hutchinson (1993), Karr and Chu (1999), Resh and Jackson (1993), Rosenburg and Resh (1993) and others. Additional advantages of BMI-based biological assessment include long holding times for preserved samples and the establishment of BMI voucher collections.

METHODS

Benthic Sampling and Habitat Assessment

EOA, Inc., members of the San Pedro Creek Watershed Coalition, and local volunteers performed the benthic sampling and habitat assessment for the project using methods outlined in the California Stream Bioassessment Procedures (CSBP). The field crew consisted of the same persons that conducted the May 2002 bioassessment in San Pedro Creek. Volunteers were previously trained on implementing the CSBP protocols during a two-day field workshop (May 4 and 5, 2002). The Sustainable Land Stewardship International Institute (SLSII) facilitated the training workshop.

The CSBP was developed by Harrington (1999) and the California Department of Fish and Game (DFG) for assessing biotic integrity in wadeable streams. The non-point source pollution BMI sampling methodology in the CSBP was applied to this assessment for documenting and describing BMI assemblages and physical habitat within the selected sites. Table 1 provides location descriptions of the sampling sites; a map of the sites is shown in Figure 1. The fieldwork was conducted on April 27th, May 2nd and May 5th, 2003.

Five riffle habitat units were identified within each site and three were randomly chosen for sampling. Riffle length was determined at each randomly selected riffle and a transect was randomly established within the upper third of the riffle. Three samples were collected along the transect and composited. Samples were collected by rubbing cobble and boulder substrates and disturbing finer substrates within a 2 ft^2 (0.19 m^2) area upstream of a D-frame kicknet fitted with a 0.02 inch (0.5 mm) mesh net. The total area sampled per transect was 6 ft^2 (0.56 m^2) Each sample was transferred to a plastic jar, preserved with 95 percent ethanol and labeled, and chain-of-custody forms were completed. Three samples were collected in this manner at each of seven sites for a total of 21 samples.

At each site water quality measurements were taken and physical characteristics of the riparian zone were documented using the US EPA's Rapid Bioassessment Protocols for high gradient streams (Barbour et al. 1999). Criteria for scoring the habitat parameters are shown in Appendix A. Specific conductance, pH and dissolved oxygen were measured with portable meters at one location per site after instrument calibration.

Table 1. Site location data for the San Pedro Creek biological assessment.

Stream Name	Site Code	Elevation (ft)	Coordinates		No. of Samples
			Latitude	Longitude	
Middle Fork San Pedro Creek	MF	230	N 37° 34' 31"	W 122° 27' 49"	3
South Fork San Pedro Creek	SF	170	N 37° 34' 44"	W 122° 28' 27"	3
San Pedro Creek	SPC-1	150	N 37° 34' 49"	W 122° 28' 26"	3
North Fork San Pedro Creek	NF	130	N 37° 35' 00"	W 122° 28' 34"	3
San Pedro Creek	SPC-2	120	N 37° 34' 55"	W 122° 28' 40"	3
San Pedro Creek	SPC-3	80	N 37° 34' 55"	W 122° 29' 12"	3
San Pedro Creek	SPC-4	40	N 37° 35' 17"	W 122° 29' 54"	3
	7 sites				21 samples

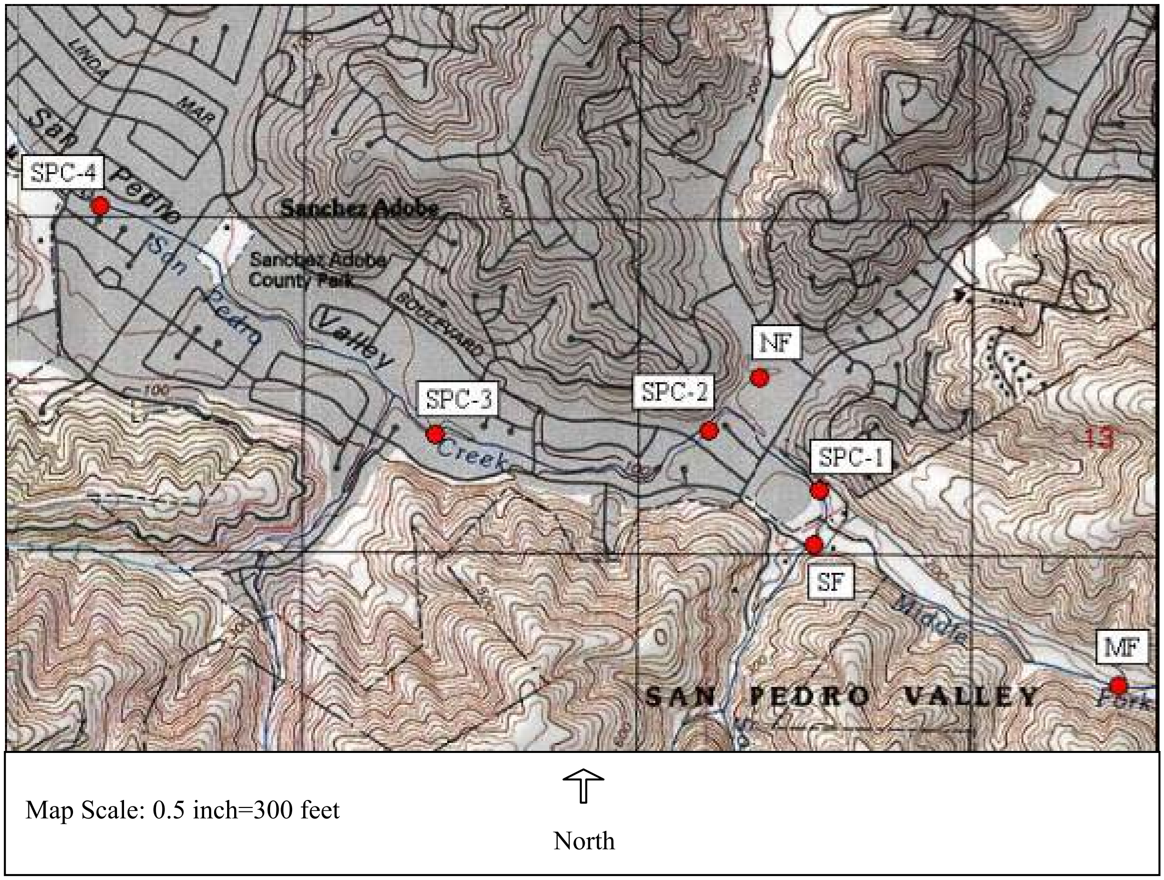

Figure 1. Site locations where benthic samples were collected in April/May 2003.

Sample Processing
At the laboratory, each sample was rinsed in a standard no. 35 sieve (0.02 inch; 0.5 mm) and transferred to a tray with twenty, 4 in^2 (26 cm^2) grids for subsampling. Benthic material in the subsampling tray was transferred from randomly selected grids (or half grids if BMI densities were high) to petri dishes where the BMIs were removed systematically with the aid of a stereomicroscope and placed in vials containing 70 percent ethanol and 2 percent glycerol. At least 300 BMIs were subsampled from a minimum of three grids or all grids were processed if there were less than 300 BMIs. If there were more BMIs remaining in the last grid after 300 were archived, then the remaining BMIs were tallied and archived in a separate vial. This was done to assure a reasonably accurate estimate of BMI abundance based on the portion of benthos in the tray that was subsampled. These "extra" BMIs were not included in the taxonomic lists and metric calculations.

Subsampled BMIs were identified using taxonomic keys (Merritt and Cummins 1996; Stewart and Stark 1993; Thorp and Covich 2001 and Wiggins 1996) and unpublished references. A standard level of taxonomic effort was used as specified in the January 2003 revision

California Aquatic Macroinvertebrate Laboratory Network (CAMLnet) List of Taxonomic Effort. Exceptions were made for some early instar taxonomic groups. The subsampled BMIs identified from each sample were archived in labeled vials with a mixture of 70 percent ethanol and 2 percent glycerol.

Data Processing and Analysis

The identified taxa and the numbers of BMIs comprising each taxonomic group were entered into a Microsoft Access® database. A taxonomic list and a table of the five most numerically abundant (dominant) taxa for each site were generated using Microsoft Excel®. Cumulative site totals were determined by pooling the BMIs from the three replicate samples collected at each site.

Cluster analysis is a multivariate procedure for detecting natural groupings in data. PC-ORD® (version 4) software (McCune and Mefford 1999) was used for performing cluster analysis on taxa lists. The cluster distance measure used was Sorenson (Bray Curtis) and the Group Average method was used for group linking; both are frequently used in ecological studies (Magurran 1988). Dendrograms are scaled by the percentage of information remaining, which is based on information loss as agglomeration (linking of groups) proceeds during the analysis and is conceptually similar to coefficient of determination (McCune and Mefford 1999). The output of the cluster analysis is a dendrogram, which shows relative site and sample similarity based on BMI composition.

Biological metrics (numerical attributes of biotic assemblages) suggested by the DFG were generated using Excel® and are described in Appendix B. Tolerance values and functional feeding group designations were obtained from the January 2003 revision of CAMLnet list of taxonomic effort. Biological metric values were tabulated by sample and summarized by site using mean, standard deviation and cumulative site totals.

Each of the samples (transects) was given a relative ranking score based on a set of BMI assemblage metric values. The metrics used for the scores were Taxonomic Richness, Ephemeroptera Taxa, Plecoptera Taxa, Trichoptera Taxa, Shannon Diversity, Tolerance Value, Percent Intolerant Organisms, Percent Tolerant Organisms, Percent Dominant Taxon and Percent Predators. The ranking score was an integrative index of these 10 metrics. Nine of the 10 metrics used for the ranking score were found to be reliable responders to disturbance by Karr and Chu (1999). Shannon Diversity, although not identified by Karr and Chu, was incorporated into the suite of metrics because it integrates richness and evenness (Shannon and Weaver 1963, Magurran 1988).

Sites that score high in this integrative index have better than average scores for most or all of the metrics, while sites that score low have poorer scores for most or all of the component metrics. Average ranking sites either have average scores for the component metrics or have a combination of high and low scores. This ranking method was developed by the DFG Aquatic Bioassessment Laboratory.

The formula for computing the ranking scores is as follows:

$$\text{Ranking Score} = \sum \pm(\mathbf{x}_i - x_i)/\text{sem}_i$$

where: $\mathbf{x}_i$ = sample value for the i-th metric; x_i = overall mean for the i-th metric; sem_i = standard error of the mean for the i-th metric; ±: a plus sign denotes a metric that decreases with response to impairment (e.g. Taxonomic Richness) while a minus sign denotes a metric that increases with response to impairment (e.g. Tolerance Value).

Two-Year BMI Comparison

Several representative metrics were used to compare the BMI assemblages from the year 2002 assessment with the year 2003 assessment. These metrics were: Taxa Richness, Shannon Diversity, EPT Taxa, Percent Intolerant Organisms, Mean Tolerance and Percent Predators.

Quality Control

Two processed BMI samples were randomly selected from the voucher collection and submitted to the DFG's Aquatic Bioassessment Laboratory for independent assessment of taxonomic accuracy, enumeration of organisms and conformance to standard taxonomic level.

RESULTS

Benthic Macroinvertebrates

Of the 21 samples collected, 5,675 BMIs were processed comprising 87 distinct taxa. Table 2 shows the five numerically abundant (dominant) taxa at each site. Figure 2 is a cluster dendrogram that shows the relative similarity of samples based on the composition of BMIs while Figure 3 shows relative site similarity based on the cumulative composition of BMIs in the samples collected from the sites. A complete taxonomic list including California Tolerance Value (CTV) and functional feeding group (FFG) designations is presented in Appendix C.

Table 2 and Figures 2 and 3 indicate high similarity of BMI composition for sites SPC3 and SPC4. At the highest level of grouping, as shown as (1) in Figure 2, BMI composition of sites MF, SF and SPC1 were dissimilar from BMI composition from the other sites. This grouping pattern of sites is supported in Table 2 and Figure 3. The mayfly *Baetis* was numerically dominant at all sites but comprised half or more of the BMIs at sites SPC2, SPC3 and SPC4. Representative genera within the EPT taxonomic orders were numerically dominant at sites MF and SPC1 while only one Ephemeroptera taxon (*Baetis*) was dominant at sites NF, SPC2, SPC3 and SPC4. Two EPT orders were dominant at site SF. Oligochaetes, including naidids and enchytraeids, comprised 26 percent of the BMIs at site NF.

Table 2. Numerically dominant benthic macroinvertebrate taxa and their percent contribution by site from samples collected from San Pedro Creek in April/May 2003.

Site	Dominant Taxa				
	1	2	3	4	5
MF	*Baetis* 19%	*Parthina* 14%	*Suwallia* 12%	Orthocladiinae 10%	*Neophylax* 9%
SF	Orthocladiinae 12%	*Drunella* 11%	Tanypodinae 8%	Ostracoda 8%	*Baetis* 7%
SPC1	*Baetis* 14%	Orthocladiinae 12%	*Suwallia* 9%	*Calineuria californica* 7%	*Parthina* 6%
NF	*Baetis* 40%	Orthocladiinae 26%	Naididae 23%	Enchytraeidae 3%	Planariidae 2%
SPC2	*Baetis* 49%	Orthocladiinae 17%	Naididae 9%	Tanypodinae 7%	*Antocha* 4%
SPC3	*Baetis* 63%	Orthocladiinae 13%	*Narpus* 6%	Tanypodinae 5%	*Antocha* 3%
SPC4	*Baetis* 60%	*Simulium* 14%	Orthocladiinae 13%	*Narpus* 5%	*Antocha* 4%

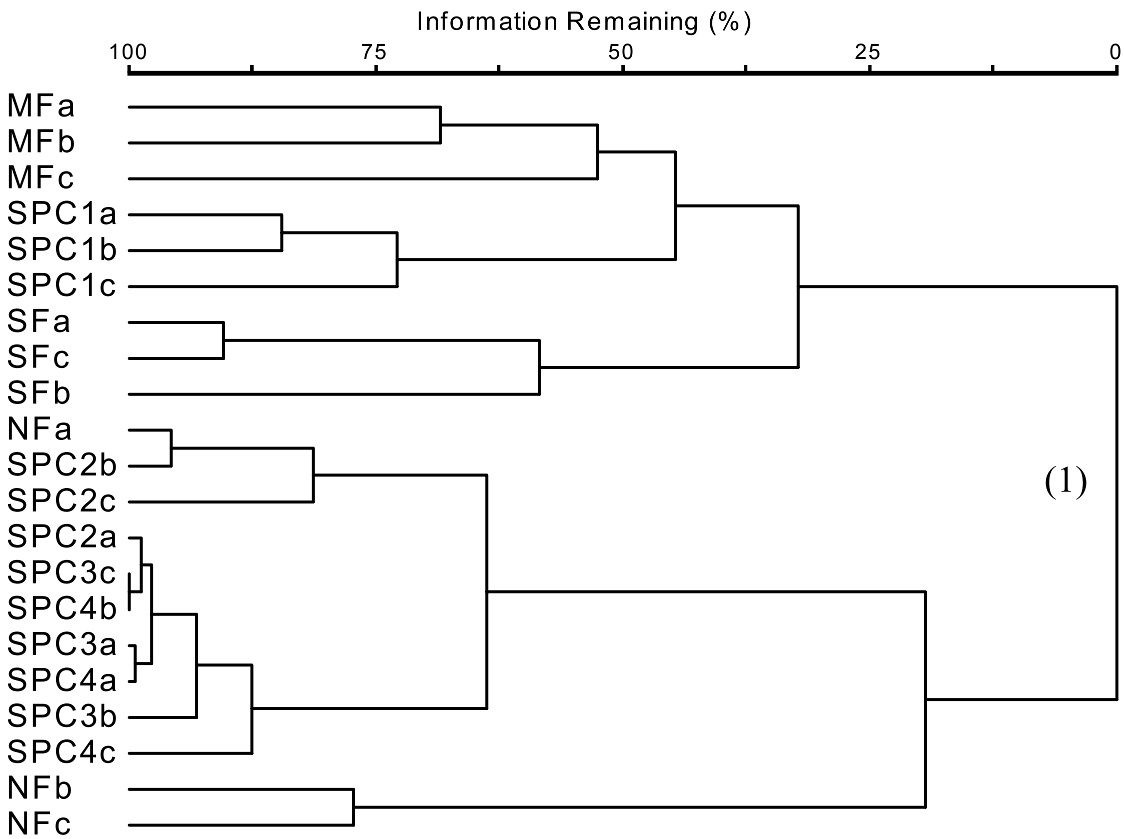

Figure 2. **Dendrogram showing degree of site and sample (denoted as a, b and c) similarity based on the composition of benthic macroinvertebrates sampled from San Pedro Creek in April/May 2003. Site dissimilarity increases as links are made from left to right.**

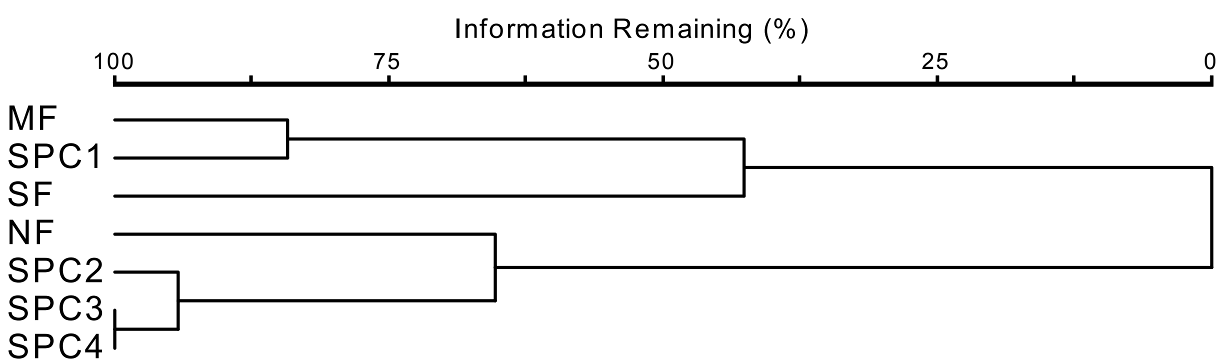

Figure 3. **Dendrogram showing degree of site similarity based on the composition of benthic macroinvertebrates sampled from San Pedro Creek in April/May 2003. Site dissimilarity increases as links are made from left to right.**

BMI Metrics and Composite Metric Scores

BMI metric values are summarized in Table 3 and tabulated by transect in Appendix D. Functional feeding groups and composite metric scores are presented in Figures 4 and 5, respectively.

Richness and Composition Metrics - Mean Taxonomic Richness values ranged from 12 at site NF to 36 at site SF. Mean EPT Taxa values ranged from two at sites NF, SPC3 and SPC4 to 18 at sites SF and SPC1. Large magnitude differences were also documented for mean Sensitive EPT Index and Shannon Diversity but the magnitude of differences in mean EPT Index values were less due to the high abundance of the moderately tolerant mayfly, *Baetis*, at all sites.

Tolerance Metrics – Mean Tolerance values ranged from 3.2 at sites MF and SPC1 to 5.9 at site NF. Mean Percent Intolerant Organism metric values ranged from one at site NF to 46 at site MF. BMI taxa contributing to sites with higher intolerance included the mayfly *Drunella*, the stoneflies *Malenka*, *Suwallia* and *Calineuria californica,* and the caddisflies *Neophylax* and *Parthina*. Mean Percent Tolerant Organisms metric values ranged from two at site SPC4 to 30 at site NF.

Functional Feeding Groups (FFG) – Figure 4 indicates that sites MF, SF and SPC1 had a more even distribution of FFGs than the other sites. Shredders comprised one percent or less of the FFGs while collectors comprised over 80 percent of the FFGs at sites NF, SPC2, SPC3 and SPC4.

Abundance – Estimated mean abundance values were relatively low at the sites, compared to other streams that are similar in size, and ranged from 200 at site NF to 820 at site SF.

Composite Metric Scores – Mean metric values for the sites, described above, suggest a trend that is supported by the Composite Metric Scores (Figure 5). Composite metric scores show consistently higher scores for sites MF, SF and SPC1 when compared to the other sites. The higher scores for sites MF, SF and SPC1 were due to higher richness and diversity, lower tolerance and higher proportion of intolerant and EPT taxa when compared to the other sites.

Table 3. Site mean, standard deviation (SD) and cumulative site total (CST) metric values for benthic macroinvertebrate assemblages sampled from San Pedro Creek in April/May 2003.

	Middle Fork			South Fork			SPC1			North Fork			SPC2			SPC3			SPC4		
Metrics	Mean	SD	CST	Mean	SD	CST	Mean	SD	CST	Mean	SD	CST	Mean	SD	CST	Mean	SD	CST	Mean	SD	CST
Taxonomic Richness	27	4.7	43	36	1.5	49	34	2.5	47	12	4.0	18	18	2.5	30	16	0.6	22	11	2.1	17
EPT Taxa	14	1.0	21	18	3.6	23	18	4.4	24	2	0.6	5	5	1.0	10	2	1.0	3	2	1.0	3
Ephemeroptera Taxa	5.0	1.0	7	6.3	0.6	7	7.0	0.0	8	1.0	0.0	1	3.3	0.6	6	1.7	0.6	2	1.3	0.6	2
Plecoptera Taxa	2.3	0.6	3	3.3	0.6	5	2.7	1.2	4	1.0	0.0	3	1.0	1.0	2	0.0	0.0	0	0.0	0.0	0
Trichoptera Taxa	5.7	0.6	10	6.7	2.3	9	7.0	2.6	10	0.3	0.6	1	0.7	1.2	2	0.3	0.6	1	0.7	0.6	1
EPT Index (%)	74	6.1	73	56	13	56	66	4.6	66	39	6.5	54	52	11	52	64	4.2	64	61	6.5	61
Sensitive (<4) EPT Index (%)	45	9.5	44	29	9.7	29	39	6.7	39	1	0.2	1	3	0.4	3	1	0.8	1	0	0.2	0
Shannon Diversity	2.5	0.2	2.7	3.0	0.1	3.1	2.9	0.2	3.0	1.5	0.1	1.2	1.7	0.3	1.8	1.4	0.1	1.4	1.3	0.1	1.4
Tolerance Value	3.2	0.3	3.2	4.0	0.6	4.0	3.2	0.4	3.2	5.9	0.3	5.2	5.2	0.3	5.3	5.0	0.1	5.0	5.1	0.1	5.1
Intolerant Organisms (%)	46	9.4	45	30	9.7	30	39	7.2	39	1	0.0	1	7	2.0	7	4	1.2	4	4	1.6	4
Tolerant Organisms (%)	4	1.6	4	11	1.0	11	3	1.5	3	30	11	7	10	7.8	10	2	0.9	2	2	1.1	2
Dominant Taxon (%)	21	8.9	19	16	5.5	12	16	4.6	14	41	3.5	53	49	11	49	63	3.6	63	60	6.3	60
Collector-Gatherers (%)	46	13		55	5.1		46	6.5		93	2.8		88	3.3		89	1.6		83	12	
Collector-Filterers (%)	3	3.5		6	3.0		4	2.0		1	0.7		1	0.2		3	0.5		14	12	
Scrapers (%)	16	12		14	4.0		16	3.6		0	0.4		1	0.9		1	0.3		0	0.6	
Predators (%)	20	2.0		22	2.7		24	6.2		5	4.1		9	2.8		5	2.2		2	0.7	
Shredders (%)	16	4.0		2	0.8		9	4.1		0	0.4		0	0.2		0	0.2		0	0.0	
Other (%)	0	0.8		1	0.3		1	0.5		0	0.8		1	0.6		1	0.3		1	0.8	
Estimated Abundance	270	127	820	820	511	2450	370	85	1120	200	98	590	670	544	2020	480	246	1430	490	59	1480

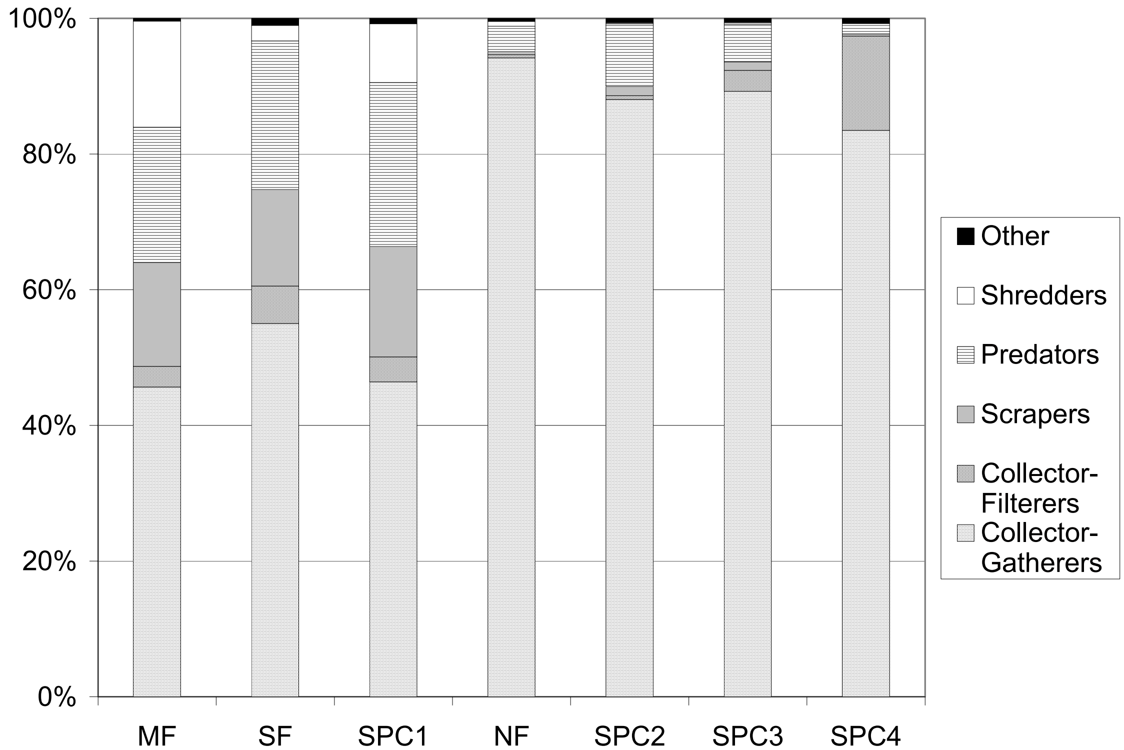

Figure 4. **Percentages of benthic macroinvertebrate functional feeding groups sampled from San Pedro Creek in April/May 2003.**

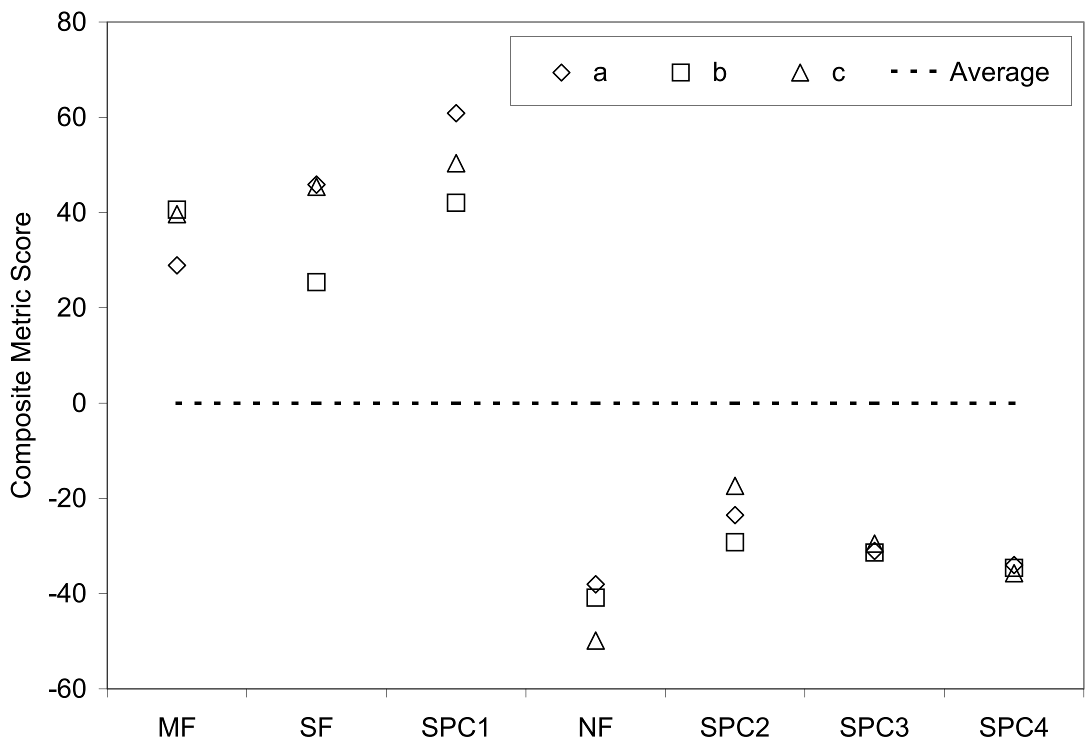

Figure 5. **Composite metric scores based on integrated metric values for samples (denoted as a, b and c) collected from San Pedro Creek in April/May 2003.**

Two-Year BMI Comparison

Trends in variation of cumulative site total metric values were consistent for the assessments conducted in years 2002 and 2003. Annual variation of metric values was relatively small when compared to variation of metric values among sites as shown in Figure 6. The upper three sites (MF, SF and SPC1) had consistently higher Taxa Richness, Shannon Diversity, EPT Taxa, Percent Predator and Intolerant Organism values than sites in the mainstem that are downstream of the north fork confluence. Mean cumulative site Taxa Richness values from sites not receiving north fork flow were more than twice as high as cumulative site Taxa Richness values for sites receiving flow from the north fork. Also notable was the consistency of cumulative site total Taxa Richness values of sites for both years: values were within 10 percent for all sites and within five percent for three sites when compared by year.

There were however, notable differences in BMI assemblages between the two years. Stonefly taxa were absent from site NF in year 2002 but three taxa were sampled in year 2003. Conversely, one stonefly taxon was sampled from site SPC3 in year 2002 but none was sampled in year 2003. There were decreases in both stonefly and caddisfly taxa at site SPC3 in year 2003 when compared to year 2002. There was substantial variability in percent predator and tolerance for site SPC1 when compared by year. Finally, the mayfly, *Baetis*, was consistently more abundant in year 2003 when compared to year 2002.

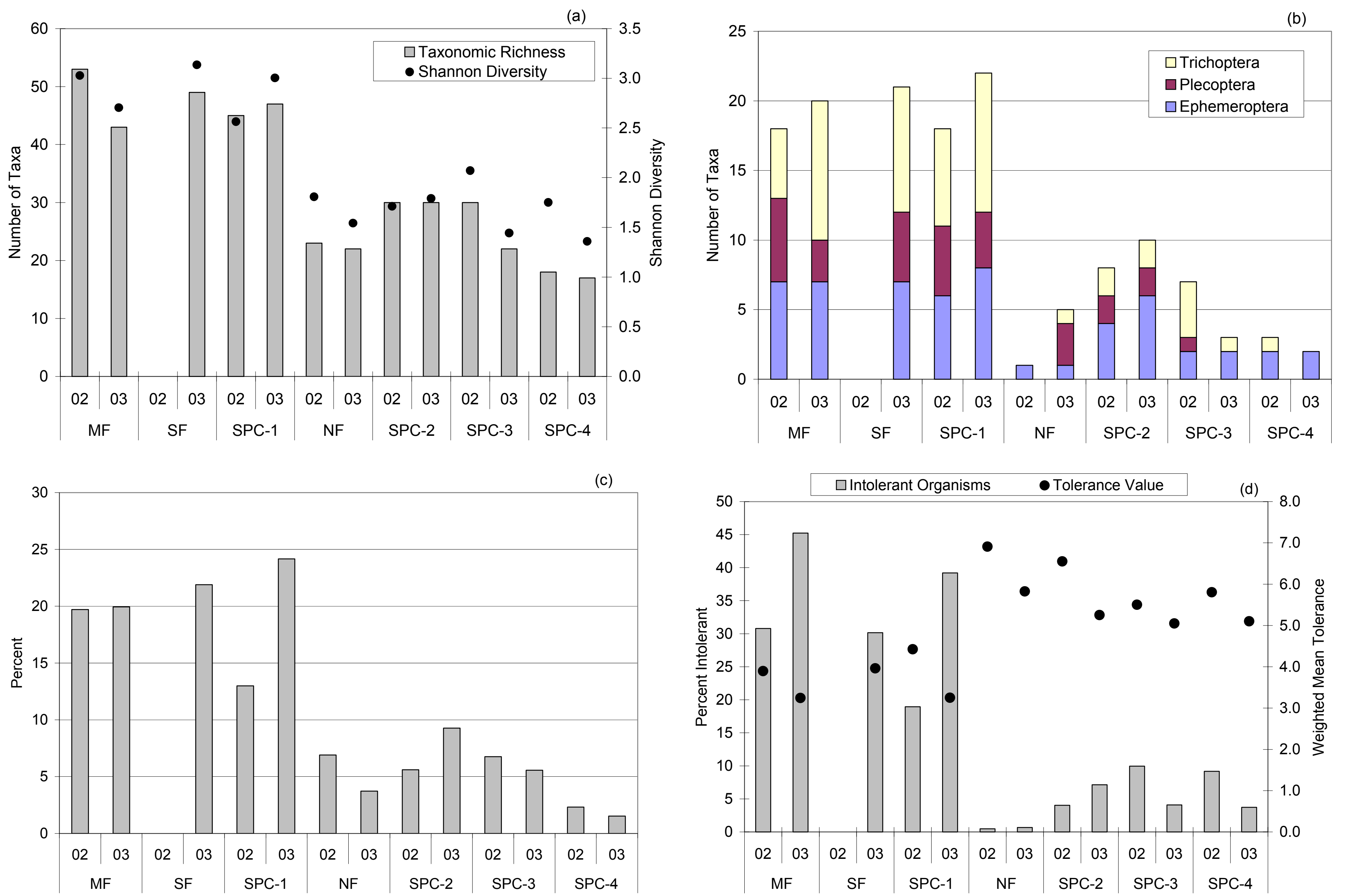

Figure 6. **Cumulative site total biological metrics including Taxa Richness and Shannon Diversity (a), EPT Taxa (b), Percent Predators (c) and Intolerant Organisms and Mean Tolerance (c) for samples collected in the San Pedro Creek drainage in the spring of 2002 and 2003. Site SF was not sampled in year 2002.**

Quality Control
Results of DFG's independent review of the voucher collection are summarized in Appendix E. Quality control results revealed minor errors but no consistent or systematic errors and identifications conformed to standard taxonomic effort.

Habitat Assessment
Site scale habitat assessment results are presented in Table 4; other supplemental habitat data are shown in Appendix F. Habitat scores ranged from 116 at site SF to 170 at site MF. According to Barbour et al. (1999) these scores would imply suboptimal habitat for all sites except site MF, which scored in the optimal range. For reference, scores less than 50 would imply poor habitat, scores between 50 and 100 would imply marginal habitat and scores greater than 150 would imply optimal habitat.

Table 4. Site scale habitat scores and water quality constituents measured for San Pedro Creek in April/May 2003 (determined by EOA, Inc.).

Habitat Parameter	MF	SF	SPC1	NF	SPC2	SPC3	SPC4
Epifaunal Substrate/ Available Cover	17	9	12	9	16	15	10
Embeddedness	18	7	17	13	12	13	13
Velocity/Depth Regime	12	10	15	8	14	16	16
Sediment Deposition	19	9	10	14	13	11	7
Channel Flow Status	18	18	18	18	18	18	18
Channel Alteration	19	15	14	14	16	15	11
Frequency of Riffles	19	18	16	20	16	16	20
Bank Stability	17	11	12	14	15	14	16
Vegetative Protection	18	8	10	16	14	15	12
Riparian Vegetative Zone Width	13	11	12	14	12	12	8
Total Score	170	116	136	140	146	145	131
Water Quality							
Water Temperature (°C)	11	12	12	14	12	13	11
Specific Conductance (μmho/cm @ 25ºC)	270	220	250	490	300	300	270
pH	8.0	7.9	7.9	7.9	8.1	8.2	8.3
Dissolved Oxygen (mg/l)	10.4	10.4	10.5	10.1	10.4	10.5	10.4

DISCUSSION

Evaluating Influences on Benthic Fauna

Since reference conditions have not been established in California, it is difficult to identify the range of biotic metric values that would be expected for different stream types within a given region that are undisturbed from anthropogenic activities. Until reference conditions are established on a regional basis, investigators must use best professional judgment and empirical methods on a project-by-project basis to evaluate effects of habitat and/or water quality impairment on benthic fauna.

The composite metric score, used for this assessment, is one method for evaluating relative site quality as a function of BMI assemblage quality. However, there are limitations of the composite metric scores. One limitation is that scores cannot be used out of the context of the group of sites being compared. Also, some of the metrics used in the composite metric score measure related attributes of the BMI assemblage, which results in amplified responses. While amplified responses are useful for screening relative site quality, metrics that incorporate distinct attributes of biotic assemblages would yield a more representative description of the BMI assemblages. It should be noted that the metrics used for this assessment are widely used but are not necessarily the most responsive to stressors affecting streams in the Central California Coast ecological region. More BMI data from nearby regions for multiple years with a range of water year types would be required for conducting a metric analysis.

Despite limitations of the composite metric scores, there was a consistent trend of BMI response relative to the extent of urbanization within upstream drainage area. Sites MF, SF and SPC1 are located in a less urbanized section of the San Pedro Creek watershed while sites NF, SPC2, SPC3 and SPC4 are all impacted by runoff from urban land uses. While sites MF, SF and SPC1 had similar composite metric scores, site MF had the highest habitat quality ranking and site SF had the lowest habitat quality ranking, which suggests that habitat quality was not a primary factor contributing the differences in BMI assemblages. While the cluster dendrogram does not infer a qualitative measure of biotic integrity, it does support the composite metric scores by showing that the BMI assemblages of sites receiving flow from the North Fork San Pedro Creek were dissimilar from the BMI assemblages sampled from sites upstream of the north fork's influence.

Other factors, in addition to urbanization, could be contributing to the dissimilarity of BMI assemblage quality and composition. Factors associated with elevation such as gradient, canopy cover, stream width, substrate composition, allocthonous input, depth and temperature regime have been described by Vannotte et al. (1980) in the River Continuum Concept to influence the composition of benthic fauna along elevational gradients. Other investigators (e.g., Allan 1995 and Merritt and Cummins 1996) have shown these factors, individually and in various combinations, to be important influences on benthic fauna.

It is unlikely, however, that elevation differences were contributing to the variation in BMI assemblage quality and composition. The elevation range of the sites was only 200 feet and the elevation difference of two sites (NF and SPC1), with highly dissimilar BMI assemblage quality and composition, was approximately 20 feet. Substrate quality did not appear to have a strong influence on BMI assemblage quality and composition. While coarse substrate may have been limiting at site NF, coarse substrate was present at other sites with relatively low composite metric scores (Appendix F and Figure 5). Also, despite the high substrate complexity score for site SPC2, the site had a relatively low composite metric score (Appendix F and Figure 5).

Although additional data are needed to better characterize the stressors affecting BMI assemblages in San Pedro Creek, these data suggest that factors associated with the urbanized north fork drainage were influencing the composition and quality BMI assemblages at the sites receiving north fork flow. Furthermore, metric values for the year 2002 assessment were similar to the metric values determined for the year 2003 assessment despite a late season rain event, which occurred prior to sampling in year 2003.

Effects of Urbanization

Factors contributing to streams with productive and diverse benthic fauna include mixtures of loosely consolidated coarse substrate, a natural hydrograph, allochthonous inputs and good water quality. These conditions become altered in urban areas where upstream impervious landscape surfaces affect the natural hydrograph and interfere with the production and transport of allocthonous material (Williams and Feltmate 1992, Schueler 1995, and Karr and Chu 1999). While bank sloughing is a natural phenomenon of stream systems, urban streams are characterized as having higher and more frequent peak flows, which contribute to increases in bank instability, increasing channel cross-sectional area and sediment discharge (Trimble 1997). Excessive sediment input occludes interstitial space and thereby decreases the variation of area within the substrate for insect colonization (Allan 1995). Often, a shift in benthic fauna occurs with increases in sedimentation resulting in increases in burrowing forms such as oligochaetes. Furthermore, altered hydrographs may affect benthic fauna such as uni/ semi-voltine (long-lived) taxa that are dependent on cyclic thermal cues for their development (Ward and Stanford 1979). Benthic fauna of urban streams may also be affected by constituents that may be found in storm water runoff such as petroleum hydrocarbons, fine sediment, pesticides, fertilizers and detergents (Schueler 1987).

LITERATURE CITED

Allan, J. D. 1995. Stream Ecology- Structure and function of running waters. 1st ed. Chapman & Hall. xii, 388pp.

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

Davis, W.S., B.D. Syder, J.B. Stribling and C. Stoughton. 1996. Summary of State Biological Assessment Program for Streams and Wadeable Rivers. EPA 230-R-96-007. U.S. Environmental Protection Agency; Office of Policy, Planning and Evaluation, Washington D.C.

Harrington, J.M. 1999. California Stream Bioassessment Procedures. California Department of Fish and Game, Water Pollution Control Laboratory. Rancho Cordova, CA.

Hutchinson, G. E. 1993. A Treatise on Limnology. Vol. IV, The Zoobenthos. (Ed.) Y.H. Edmondson. John Wiley & Sons, Inc.

Karr, J.R. and E.W. Chu. 1999. Restoring Life in Running Waters. Island Press, Covelo, CA.

Magurran, A.E. 1988. Ecological Diversity and Its Measurement. Princeton University Press, Princeton, New Jersey.

McCune, B., and M. J. Mefford. 1999. PC-ORD. Multivariate Analysis of Ecological Data, Version 4. MjM Software Design, Gleneden Beach, Oregon, USA.

Merritt, R.W. and K.W. Cummins. 1996. An Introduction to the Aquatic Insects of North America. Second Edition. Dendall/Hunt Publishing Co., Dubuque, Iowa
Resh, V.H. and J.K. Jackson. 1993. Rapid Assessment Approaches to Biomonitoring and Benthic Macroinvertebrates. Chapman and Hall, New York.

Rosenburg, D.M. and V.H. Resh (eds). 1993. Freshwater Biomonitoring and Benthic Macroinvertebrates. Chapman and Hall, New York.

Schueler, T. 1987. Controlling urban runoff: a practical manual for planning and designing urban best management practices. Metropolitan Washington Council of Governments, Washington, DC.

Schueler, T. 1995. The importance of imperviousness. Watershed Protection Techniques 1(3): 100-111.

Shannon, C.E. and W. Weaver. 1963. The Mathematical Theory of Communication. Univ. Illinois Press, Urbana, IL.

Stewart, K.W. and B.P. Stark. 1993. Nymphs of North American Stonefly Genera (Plecoptera). University of North Texas Press, Denton, Texas.

Thorp, J.H. and A.P. Covich (eds.). 2001. Ecology and Classification of North American Invertebrates, second ed. Academic Press, San Diego, CA.

Trimble S. 1997. Contribution of stream channel erosion to sediment yield from an urbanizing watershed. Science 278: 1442-1444.

Vannote, R.L., Minshall, G.W., Cummins, K.W., Sedell, J.R. and Cushing, C.E. 1980. The River Continuum Concept. Can. J. Fish. Aquat. Sci. 37: 130-137.

Ward, J. V. and J. A. Stanford. 1979. Ecological factors controlling stream zoobenthos with emphasis on thermal modification of regulated streams. International Symposium on Regulated Streams (Ecology of Regulated Streams), Eds. J. V. Ward and J. A. Stanford, Erie, Pennsylvania, USA, Plenum Press, New York. 35-55.

Wiggins, G.B. 1996. Larva of North American Caddisfly Genera (Trichoptera), 2nd ed. University of Toronto Press, Toronto.

Williams, D.D., and B.W. Feltmate. 1992. Aquatic Insects. CAB International. xiii, 358pp.

APPENDIX A

Habitat ranking criteria used for the San Pedro Creek biological assessment in April/May 2003

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate sand: <0.08" gravel: 0.08-2.5" sm cobble: 2.5-5" lg cobble: 5-10" boulder: >10"	Small and large cobble comprises >70% of substrate. Range of substrate types present from sand to boulder but sand, gravel and/or boulder comprise <30% of substrate. Substrate provides ample and variably sized interstitial space.	Small and large cobble ranges from 40 to 70%. Range of substrate types more limited or present from sand to boulder but amount of sand, gravel and/or boulder accounts for >30-60% of substrate.	Small and large cobble comprises between 20-40% of available substrate. Substrate complexity and ranges of interstitial space limited. Sand, gravel and/or boulder accounts for 60-80% of substrate.	Substrate with little complexity and interstitial space; substrate >90% silt, sand, boulder, bedrock or rip-rap; or, channel is impervious due to concrete or asphalt lining
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Embeddedness	Gravel, cobble and boulder particles are 25% surrounded by fine sediment. Layering of cobble provides diversity of niche space.	Gravel, cobble and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble and boulder particles are >75% surrounded by fine sediment. May be completely covered.
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Velocity/ Depth Regime	All four velocity depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow).	Only 3 of 4 of the regimes present (if fast-shallow is missing, score lower than if missing other regimes).	Only 2 of 4 of the regimes present (if fast-shallow or slow-shallow are missing, score low).	Dominated by 1 velocity/ depth regime (usually slow-deep)
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of point bars just above or below riffle. Less than 5% of the bottom of riffle affected by fine sediment.	Some new increases in bar formation just above or below riffle. 5 - 30% of the bottom of the riffle affected by fine sediment.	Moderate deposition of new gravel, sand or fine sediment on bars just above or below riffle. 50-80% of the bottom of the riffle affected by fine sediment.	Heavy deposition of new gravel, sand or fine sediment on bars just above or below riffle. >80% of the bottom of the riffle affected by fine sediment.
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches both banks; wetted channel width is equal to bankfull width.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel; or most of channel substrate is exposed.	Very little water present in channel and mostly present as standing pools.
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

6. Channel Alteration	No channel alteration; no dredging, levees, rip-rap, gabion structures or bridge abutments	Some channelization present, usually in areas of bridge abutments; evidence of past channelization from dredging	Channelization extensive; embankments or shoring structures present on both banks and 40 to 80% of riffle channelized and disrupted.	Banks shored with gabion or cement; entire riffle affected by channelization.
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Frequency of Riffles (or bends)	Occurrence of riffles relatively frequent: ratio of distance between riffles divided by stream width <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important.	Occurrence of riffles infrequent; distance between riffles divided by stream width is between 7 to 15.	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by stream width is between 15 to 25.	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio >25.
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability	Both banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of banks adjacent to riffle and just upstream affected.	Banks moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of banks adjacent to riffle and just upstream affected.	Banks moderately unstable; 30-60% of banks adjacent to riffle and just upstream affected.	Unstable banks; 60-80% of banks adjacent to riffle and just upstream affected having Araw≅ areas and erosional scars.
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
9. Bank Vegetation	Optimal	Suboptimal	Marginal	Poor
	More than 90% of the streambank surfaces adjacent to and near riffle covered by native vegetation including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption by livestock grazing or mowing not evident.	70 - 90% of the streambank surfaces adjacent to and near riffle covered by native vegetation including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption by livestock grazing or mowing not evident.	50-70% of the stream bank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 cm or less in average stubble height.
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
10. Riparian Zone Width	Optimal	Suboptimal	Marginal	Poor
	Width of riparian zone >18 m; human activities (eg. Parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 m; human activities have impacted zone only minimally.	Width of riparian zone 6-12 m; human activities have impacted zone substantially.	Width of riparian zone <6 m; little or no riparian zone due to human activities
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

APPENDIX B

Metrics used to describe characteristics of benthic macroinvertebrate assemblages as described in the California Stream Bioassessment Procedures

BMI Metric	Description	Response to Impairment
Richness Measures		
1. Taxonomic Richness	Total number of individual taxa.	decrease
2. EPT Taxa	Number of taxa in the orders Ephemeroptera (mayfly), Plecoptera (stonefly) and Trichoptera (caddisfly)	decrease
3. Ephemeroptera Taxa	Number of mayfly taxa	decrease
4. Plecoptera Taxa	Number of stonefly taxa	decrease
5. Trichoptera Taxa	Number of caddisfly taxa	decrease
Composition Measures		
6. EPT Index	Percent composition of mayfly, stonefly and caddisfly larvae	decrease
7. Sensitive EPT Index	Percent composition of mayfly, stonefly and caddisfly larvae with Tolerance Values less than 4.	decrease
8. Shannon Diversity Index	General measure of sample diversity that incorporates richness and evenness (Shannon and Weaver 1963).	decrease
Tolerance/Intolerance Measures		
9. Tolerance Value (TV)	TVs between 0 and 10 weighted for abundance of individuals designated as pollution tolerant (higher values) and intolerant (lower values).	increase
10. Percent Intolerant Organisms	Percentage of organisms that are highly intolerant to water and/ or habitat quality impairment as indicated by TVs of 0, 1, 2 or 3.	decrease
11. Percent Tolerant Organisms	Percentage of organisms that are highly tolerant to water and/ or habitat quality impairment as indicated by TVs of 8, 9 or 10.	increase
12. Percent Dominant Taxon	The highest percentage of organisms represented by one taxon.	increase
Functional Feeding Groups (FFG)		
13. % Collector-gatherers (cg)	Percent of macroinvertebrates that collect or gather material	increase
14. % Collector-filterers (cf)	Percent of macroinvertebrates that filter suspended material from the water column	increase
15. % Scrapers (sc)	Percent of macroinvertebrates that graze upon periphyton	variable
16. % Predators (p)	Percent of macroinvertebrates that prey on living organisms	decrease
17. % Shredders (sh)	Percent of macroinvertebrates that shred leaf litter	decrease
18. % Others (ot)	Percent of macroinvertebrates that occupy an FFG not described above	variable
Other		
19. Abundance	Estimate of the number of BMIs in a sample based on the proportion of BMIs subsampled.	variable

APPENDIX C

Taxonomic list of benthic macroinvertebrates sampled from San Pedro Creek in April/May 2003

		Site:	Middle Fork			South Fork			SPC-1			North Fork			SPC-2			SPC-3			SPC-4		
		Transect:	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c
		Lab No.:	1579	1580	1581	1582	1583	1584	1576	1577	1578	1585	1586	1587	1573	1574	1575	1570	1571	1572	1567	1568	1569
Final ID	CTV	FFG																					
Arthropoda																							
Insecta																							
Coleoptera																							
Dytiscidae																							
Ametor	5	p					1																
Elmidae																							
Cleptelmis addenda	4	cg				1		8		2													
Narpus	4	cg	5	10	15	4	5	3	4	1					4	6	8	22	10	13	25	4	18
Narpus (adult)	4	sc				1																	
Optioservus	4	sc		5	3	17	11	8	28	9	17					2	4	1	2	2	2		
Optioservus (adult)	4	cg								1													
Zaitzevia	4	sc	3	1	8	6	6	2	14	5	17				1			1					
Zaitzevia (adult)	4	cg	1		1	1					2												
Diptera																							
Ceratopogonidae																							
Bezzia/ Palpomyia	6	p	2	1	2		2	2	1	3	1				1		2	1		1			2
Ceratopogonidae	6	p																	1				
Chironomidae																							
Chironomini	6	cg		1		1	3	1	4	2	2				3	4	30	8	3	7	2	3	1
Orthocladiinae	5	cg	25	37	5	21	61	21	34	46	31	92	41	23	52	41	60	40	29	35	42	53	20
Tanypodinae	7	p	2	1		19	33	20	4	11	1	3	1		15	28	24	19	7	11	3	3	5
Tanytarsini	6	cg	1	1		2	1	2	3	1	1	4	2	1	2	1	3		2				
Dixidae																							
Dixa	2	cg		3		1	1																
Empididae																							
Chelifera/	6	p								1					1	1					1		
Clinocera	6	p					1																
Empididae	6	p					1									1				1			
Muscidae																							
Muscidae	6	p										1											
Pelecorhynchidae																							
Glutops	3	p									1												
Psychodidae																							
Pericoma/	4	cg		2			2																
Psychoda	10	cg		1						1					2				1	1		1	
Simuliidae																							
Simulium	6	cf	1	17		4	2		5	12	2	2	2			1		8	7	10	29	13	84

		Site:	Middle Fork			South Fork			SPC-1			North Fork			SPC-2			SPC-3			SPC-4		
		Transect:	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c
		Lab No.:	1579	1580	1581	1582	1583	1584	1576	1577	1578	1585	1586	1587	1573	1574	1575	1570	1571	1572	1567	1568	1569
Final ID	CTV	FFG																					
Arthropoda																							
Tipulidae																							
Antocha	3	cg	1		1						1	1			17	17	5	11	3	13	10	16	7
Dicranota	3	p				1	1	1															
Hexatoma	2	p		1				2	2		1												
Limonia	6	sh																1					
Tipula	4	om			3				3	1	1		2		3		2	1	2	2			
Ephemeroptera																							
Ameletidae																							
Ameletus	0	cg		1	1																		
Baetidae																							
Baetis	5	cg	62	40	31	28	11	25	32	40	54	139	54	43	182	140	117	181	127	203	176	207	167
Diphetor hageni	5	cg	13	28	3	3	29	17	20	23	9						1						
Ephemerellidae																							
Drunella	0	cg	2			46	16	30	18	22	17				6	5	4		3	2		1	
Serratella	2	cg		1																			
Heptageniidae																							
Cinygmula	4	sc	4	3	8		1	1	2	10	10												
Epeorus	0	sc				8		4							1								
Ironodes	4	sc		3	1	9	7	23	2	8	2					1							
Rhithrogena	0	sc							1		3												
Heptageniidae	4	sc								2													
Leptophlebiidae																							
Paraleptophlebia	4	cg				19	19	25	10	15	2				1								
Odonata																							
Coenagrionidae																							
Argia	7	p																2					
Plecoptera																							
Capniidae																							
Capniidae	1	sh							1														
Chloroperlidae																							
Chloroperlidae	1	p												1									
Suwallia	1	p	18	32	30		5	6	9	11	60					3	3						
Sweltsa	1	p				4	2	4	3							1							
Leuctridae																							
Leuctridae	0	sh	1		1			1															

		Site:	Middle Fork			South Fork			SPC-1			North Fork			SPC-2			SPC-3			SPC-4		
		Transect:	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c
		Lab No.:	1579	1580	1581	1582	1583	1584	1576	1577	1578	1585	1586	1587	1573	1574	1575	1570	1571	1572	1567	1568	1569
Final ID	CTV	FFG																					
Nemouridae																							
Malenka	2	sh	2	2		2	8	5	5	5	3		1										
Soyedina	2	sh										1											
Zapada	2	sh				1																	
Perlidae																							
Calineuria	1	p	5	13	6	10	1	2	24	20	15												
Hesperoperla	2	p				3		2	1														
Trichoptera																							
Apataniidae																							
Apatania	1	sc						1															
Brachycentridae																							
Brachycentrus	1	om				3	2	4	1	1													
Micrasema	1	mh															1						
Calamoceratidae																							
Heteroplectron	1	sh							4														
Glossosomatidae																							
Agapetus	0	sc				3	3	4	7	2	2												
Anagapetus	0	sc			1																		
Glossosoma	1	sc	1																				
Glossosomatidae	0	sc		4																			
Hydropsychidae																							
Hydropsyche	4	cf			1	8		11	3	3	2												
Parapsyche	0	p				6			1														
Hydroptilidae																							
Hydroptila	6	ph																			5	1	
Lepidostomatidae																							
Lepidostoma	1	sh	1	1					2														
Limnephilidae																							
Amphicomoecus	1	sh															1						
Limnephilidae	4	sh										1											
Odontoceridae																							
Parthina	0	sh	35	30	34	1		2	28	12	18									1			
Odontoceridae	0	sh		1																			
Philopotamidae																							
Wormaldia	3	cf				1	2	6	1														
Rhyacophilidae																							
Rhyacophila	0	p	8	13	2	17	16	16	12	22	11												

		Site:	Middle Fork			South Fork			SPC-1			North Fork			SPC-2			SPC-3			SPC-4		
		Transect:	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c
		Lab No.:	1579	1580	1581	1582	1583	1584	1576	1577	1578	1585	1586	1587	1573	1574	1575	1570	1571	1572	1567	1568	1569
Final ID	CTV	FFG																					
Uenoidae																							
Neophylax	3	sc	2	20	38	4		5	2	1	2												
Uenoidae	0	sc			1																		
Arachnoidea																							
Acari																							
Hygrobatidae																							
Hygrobates	8	p					1																
Lebertiidae																							
Lebertia	8	p		1		2	1						1				1						
Sperchontidae																							
Sperchon	8	p				1	3			1		1						2					
Torrenticolidae																							
Torrenticola	5	p			1	2	2	1			1												
Malacostraca																							
Amphipoda																							
Crangonyctidae																							
Crangonyctidae	4	cg		1																			
Ostracoda																							
Ostracoda	8	cg	4	11	7	15	25	27	5	7	3	2	1										
Annelida																							
Hirudinea																							
Pharyngobdellida																							
Erpobdellidae																							
Erpobdellidae	8	p										1		1									
Rhyncobdellida																							
Glossiphoniidae																							
Helobdella	6	pa																				1	
Oligochaeta																							
Tubificida																							
Enchytraeidae																							
Enchytraeidae	8	cg			1							5	11										
Tubificidae																							
Tubificidae	10	cg												1									
Naididae																							
Naididae	8	cg				3	3			3	1	57	26	56	2	54	21	5	1	2	6	5	1

		Site:	Middle Fork			South Fork			SPC-1			North Fork			SPC-2			SPC-3			SPC-4		
		Transect:	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c
		Lab No.:	1579	1580	1581	1582	1583	1584	1576	1577	1578	1585	1586	1587	1573	1574	1575	1570	1571	1572	1567	1568	1569
Final ID	CTV	FFG																					
Mollusca																							
Bivalvia																							
Pelecypoda																							
Corbiculacea	9	cf		2		8	2	4	4	1					2		2					1	
Gastropoda																							
Prosobranchia																							
Hydrobiidae																							
Hydrobiidae	8	sc															2	2	1	1	1		
Pulmonata																							
Lymnaeidae																							
Fossaria	8	sc										1											
Physidae																							
Physa/ Physella	8	sc										1					1						
Platyhelminthes																							
Turbellaria																							
Tricladida																							
Planariidae																							
Planariidae	4	p											2	11	1		1						

APPENDIX D

Transect scale biological metrics for benthic macroinvertebrates sampled from San Pedro Creek in April/May 2003

Site:	Middle Fork			South Fork			SPC1			North Fork			SPC2			SPC3			SPC4		
Transect:	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c
Taxonomic Richness	23	32	25	38	36	35	36	34	31	16	12	8	18	16	21	16	15	16	12	13	9
EPT Taxa	13	15	14	19	14	21	23	16	15	3	2	2	4	5	6	1	2	3	2	3	1
Ephemeroptera Taxa	4	6	5	6	6	7	7	7	7	1	1	1	4	3	3	1	2	2	1	2	1
Plecoptera Taxa	3	2	2	3	3	4	4	2	2	1	1	1	0	2	1	0	0	0	0	0	0
Trichoptera Taxa	5	6	6	8	4	8	10	6	5	1	0	0	0	0	2	0	0	1	1	1	0
EPT Index	77	67	77	62	42	66	63	65	72	45	38	32	64	49	43	59	65	68	60	68	55
Sensitive EPT Index	38	41	56	38	19	31	40	31	45	0	1	1	2	3	3	0	2	1	0	0	0
Shannon Diversity	2.3	2.7	2.5	3.1	2.8	3.1	3.0	2.9	2.6	1.4	1.6	1.4	1.4	1.7	1.9	1.5	1.4	1.3	1.4	1.2	1.3
Tolerance Value	3.3	3.5	2.9	3.5	4.6	3.8	3.2	3.7	2.9	5.7	5.8	6.2	4.9	5.5	5.3	5.1	5.0	5.0	5.1	5.0	5.2
Intolerant Organisms (%)	38	42	56	39	20	32	41	31	46	1	1	1	8	8	5	4	3	5	3	6	2
Tolerant Organisms (%)	2	5	4	10	12	10	3	4	1	22	27	42	2	18	9	3	2	1	2	2	0
Dominant Taxon (%)	31	14	19	16	21	10	11	15	20	45	38	41	61	46	40	59	64	67	58	67	55
Collector-Gatherers (%)	57	48	32	51	61	54	43	54	42	96	94	91	92	88	85	88	90	90	86	94	70
Collector-Filterers (%)	1	7	0	7	2	7	4	5	1	1	1	0	1	0	1	3	4	3	10	5	28
Scrapers (%)	5	13	29	17	10	16	19	12	18	1	0	0	1	1	2	1	2	1	1	0	0
Predators (%)	18	22	20	23	24	19	19	23	31	2	3	9	6	11	11	8	4	4	1	1	2
Shredders (%)	20	12	17	1	3	3	13	6	7	1	1	0	0	0	0	0	0	0	0	0	0
Other (%)	0	0	1	1	1	1	1	1	0	0	1	0	1	0	1	0	1	1	2	1	0
Estimated Abundance	200	420	200	450	1400	600	370	460	290	310	140	140	320	1300	400	560	200	670	470	560	450

APPENDIX E

Quality control results for San Pedro Creek benthic macroinvertebrate samples

Comparative Taxonomic Listing of all Submitted Samples

Samples submitted by Bioassessment Services for Project: EOA 2003, reference date:

Report prepared by Andrew Rehn, WPCL, 9/4/2003

Taxonomist	Sample #	Vial #	Original ID	Original Count	Stage	ABL Count	ABL ID
JTK	SPC-02						
		1	Baetis	181		182	Baetis
		2	Narpus	22		22	Narpus
		3	Simulium	8		8	Simulium
		4	Zaitzevia	1		1	Zaitzevia
		5	Orthocladiinae	40		40	Orthocladiinae
		6	Limonia	1		1	Limonia
		7	Optioservus	1		1	Optioservus
		8	Naididae	5		4	Naididae
		9	Bezzia/ Palpomyia	1		1	Bezzia/ Palpomyia
		10	Sperchon	2		2	Sperchon
		11	Hydrobiidae	2		2	Hydrobiidae
		12	Tanypodinae	19		19	Tanypodinae
		13	Tipula	1		1	Tipula
		14	Argia	2		2	Argia
		15	Antocha	11		12	Antocha
		16	Chironomini	8		8	Chironomini

Taxonomist	Sample #	Vial #	Original ID	Original Count	Stage	ABL Count	ABL ID
JTK	SPC-04						
		1	Tipula	1		1	Tipula
		2	Agapetus	2		2	Agapetus
		3	Chironomini	2		2	Chironomini
		4	Diphetor hageni	23		23	Diphetor hageni
		5	Psychoda	1		1	Pericoma/ Telmatoscopus
		6	Calineuria californica	20		20	Calineuria californica
		7	Drunella	22		22	Drunella
		8	Neophylax	1		1	Neophylax
		9	Parthina	12		12	Parthina
		10	Corbiculacea	1		1	Corbiculacea
		11	Heptageniidae	2		2	Heptageniidae
		12	Cinygmula	10		10	Cinygmula
		13	Tanytarsini	1		1	Tanytarsini

Taxonomist	Sample #	Vial #	Original ID	Original Count	Stage	ABL Count	ABL ID
JTK	**SPC-04**	14	Cleptelmis addenda	2		2	Cleptelmis addenda
		15	Orthocladiinae	46		46	Orthocladiinae
		16	Brachycentrus	1		1	Brachycentrus
		17	Rhyacophila	22		22	Rhyacophila
		18	Simulium	12		12	Simulium
		19	Tanypodinae	11		11	Tanypodinae
		20	Zaitzevia	5		5	Zaitzevia
		21	Chelifera/ Metachela	1		1	Chelifera/ Metachela
		22	Malenka	5		5	Malenka
		23	Hydropsyche	3		3	Hydropsyche
		24	Suwallia	11		10	Suwallia
		24	Suwallia	11		1	Calineuria californica
		25	Sperchon	1		1	Sperchon
		26	Narpus	1		1	Narpus
		27	Optioservus	9		9	Optioservus
		28	Naididae	3		3	Naididae
		29	Paraleptophlebia	15		15	Paraleptophlebia
		30	Ostracoda	7		7	Ostracoda
		31	Optioservus	1	A	1	Optioservus
		32	Bezzia/ Palpomyia	1		1	Bezzia/ Palpomyia
		33	Ironodes	8		8	Ironodes
		34	Baetis	1		1	Baetis

APPENDIX F

Supplemental habitat data collected during benthic sampling of San Pedro Creek in April/May 2003

	BMI Sampling Stations in San Pedro Creek Watershed						
Riffle Characteristics	**SPC-4**	**SPC-3**	**SPC-2**	**SPC-1**	**MF-1**	**SF-1**	**NF-1**
Mean Length (ft)	47	27	21	47	25	39	15
Mean Width (ft)	14	16	13	8.7	5.2	7.5	8.0
Mean Depth (ft)	0.4	0.5	0.4	0.3	0.6	0.5	0.3
Mean Velocity (ft/sec)	2.6	1.7	2.4	3.0	2.1	2.2	1.4
Subjective Assessment							
(site mean values)							
% Canopy	18	52	47	80	43	80	60
Substrate Complexity (1-10)	4.0	7.0	7.7	4.7	5.3	4.5	4.0
Embeddedness (1-10)	3.3	4.7	6.3	7.7	8.0	3.5	3.3
% Fines (<2 mm)	23	13	15	10	5.0	20	17
% Gravel (2-50 mm)	35	25	28	45	40	33	18
% Cobble (50-256 mm)	40	33	40	43	53	40	15
% Boulder (>256 mm)	1.7	28	17	1.7	1.7	7.5	50
Substrate Consolidation	Low	Mod	Mod	Low	Mod	Mod	Mod
Reach Characteristics							
Total Length (ft)	229	370	300	349	182	253	83
% Gradient	0.7	1.12	1.55	1.28	2	1.6	1.5
Habitat Quality Score	131	145	146	136	170	116	140
Water Quality Conditions							
Time of Sampling	950	1600	1230	1200	930	200	1430
Water Temperature	11	13.3	12.5	11.8	11.1	12.5	14.1
Specific Conductance (uS/cm)	270	300	300	250	270	220	490
pH	8.3	8.2	8.1	7.9	8	7.9	7.9
Dissolved Oxygen (mg/l)	10.4	10.5	10.4	10.5	10.4	10.4	10.1

APPENDIX B

Water Quality Testing Report Prepared by Kinnetic Laboratories, Incorporated

ONLY RAIN IN THE STORM DRAIN

San Mateo Countywide
Stormwater Pollution
Prevention Program

KINNETIC LABORATORIES INCORPORATED

OCEANOGRAPHIC & ENVIRONMENTAL CONSULTING

307 Washington Street, Santa Cruz, CA 95060
Tel: (831) 457-3950 Fax: (831) 426-0405

July 28, 2004

Mr. Jon Konnan
EOA, Inc.
1410 Jackson Street
Oakland, CA 94612-4010

Re: San Pedro Creek Watershed Monitoring Report

Water samples were collected from three stream sites in the San Pedro Creek watershed. (Figure 1). Station IDs (identifications), descriptions, and locations are listed in Table 1. Three sampling events were performed with each representing one of three hydrological cycles. The three hydrological cycles were defined as: wet season (January-March), decreasing hydrograph/spring (April-May), and the dry season (June-October). The decreasing hydrograph/spring sampling event was performed on 27 April 2003. The dry season sampling event was performed on 19 August 2003. The wet season sampling event was performed on 17 February 2004. Organophosphate Pesticides and Toxicity were tested at all three sites for each event.

Conventional water quality parameters of temperature, pH, conductivity, and dissolved oxygen (D.O.) were measured with portable field instruments. Temperature, pH, and, conductivity were measured with a YSI Model 63 handheld instrument. D.O. was measured with a YSI Model 58 portable D.O. meter. In addition, water velocity was measured in feet/second with a portable ultrasonic velocity meter. Water quality samples were collected directly into sample bottles as close to midstream as possible. General water quality field measurements are presented in Table 2. Water quality field measurements were successfully performed at all sites during all sampling events.

Water quality analytical laboratory results are presented for the decreasing hydrograph/spring event (27 April 2003) in Table 3, for the dry season event (19 August 2003) in Table 4, and for the wet season event (17 February 2004) in Table 5. No organophosphorus pesticide analytes were detected in any of the samples during all sampling events.

Water samples were tested for toxicity during all three sampling events. Three species bioassays were performed using the water flea (*Ceriodaphnia dubia*), the fathead minnow (*Pimephales promelas*), and the green algae (*Selenastrum capricornutum*). Results for the decreasing hydrograph/spring sampling event are shown in Table 6. Results for the dry season sampling event are shown in Table 7. The wet season sampling event results are shown in Table 8.

All Quality Assurance/Quality Control (QA/QC) activities associated with the laboratory analyses were within QA/QC limits. Analytical quality assurance for this program included the following:

- Employing analytical chemists trained in the procedures to be followed.
- Adherence to documented procedures, USEPA methods and written Standard Operating Procedures (SOPs).
- Calibration of analytical instruments.
- Use of quality control samples including method blanks, laboratory control samples (LCS), surrogate spikes, and matrix spike/matrix spike duplicates (MS/MSD)
- Complete documentation of sample tracking and analysis.

Data validation was performed in accordance with the National Functional Guidelines for Organic Data Review (EPA540/R-99/008) and Inorganic Data Review (EPA540/R-01/008).

Please give me a call (831 457-3950) if you have any questions or need further information.

Sincerely,

Jonathan Toal

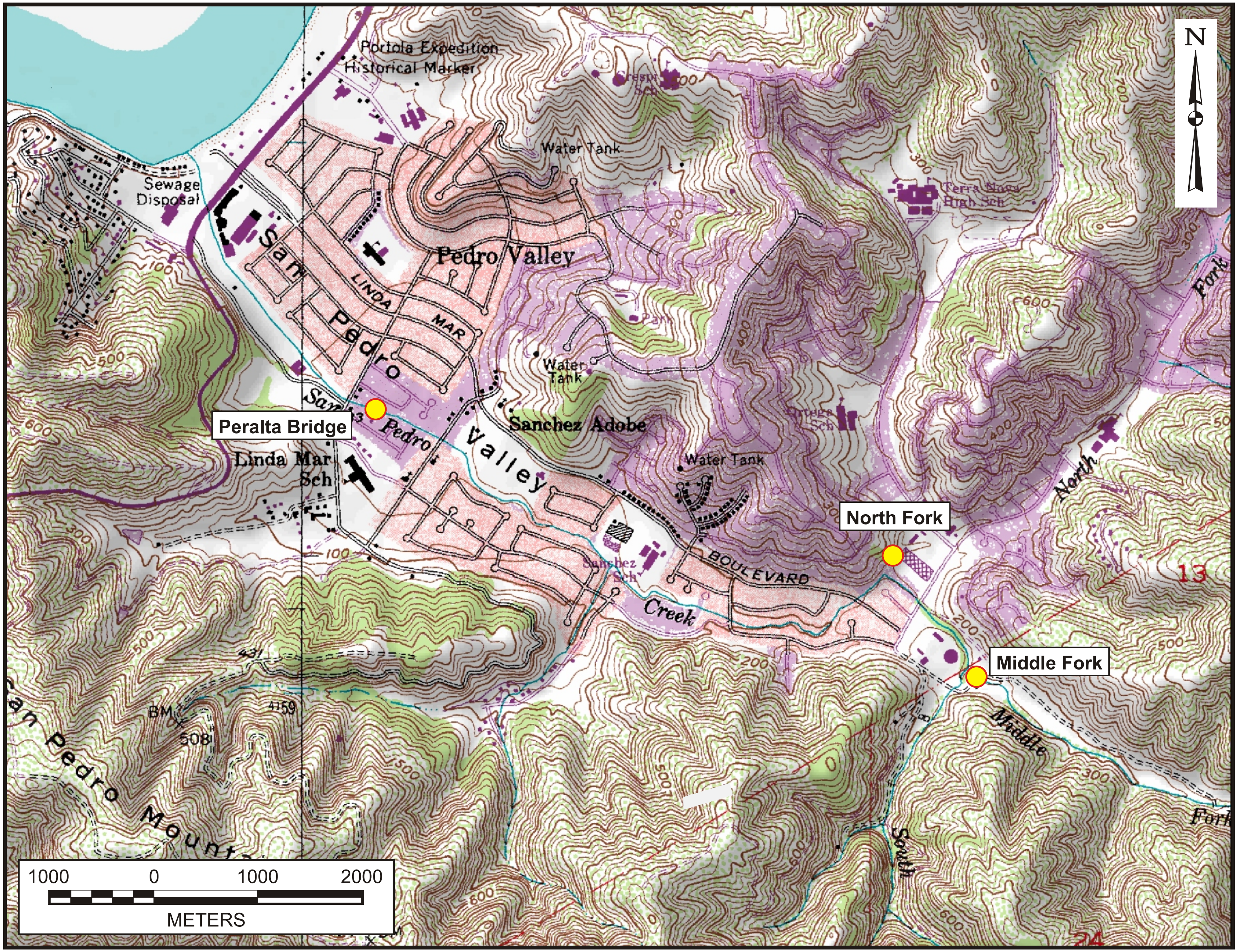

Figure 1. San Pedro Creek Sampling Sites: Peralta Bridge (San Pedro Creek upstream of Peralta Bridge), Middle Fork of San Pedro Creek, and North Fork of San Pedro Creek.

Table 1. Sampling Locations (September 2002, January and April 2003).

Station ID and Description		Latitude	Longitude
PB	San Pedro Creek Upstream of Peralta Bridge	37° 35' 18.1"	122° 29' 53.6"
MF	San Pedro Creek - Middle Fork	37° 34' 45.2"	122° 28' 24.3"
NF	San Pedro Creek - North Fork	37° 34' 58.9"	122° 28' 35.5"

Table 2. General Water Quality Measurements for Each Sampling Event (April 2003, August 2003, and February 2004).

Station ID and Station Description		DATE	pH	Temp. (°C)	Cond. (μS/cm)	D.O. (mg/L)	Velocity (ft/sec)
Decreasing Hydrograph/Spring Event (27 April 2003)							
PB	Peralta Bridge	4/27/03	8.27	11.0	268.9	10.43	1.26
MF	Middle Fork	4/27/03	7.94	10.2	264.2	10.78	0.45
NF	North Fork	4/27/03	7.92	14.1	488	10.09	0.38
Dry Season Event (19 August 2003)							
PB	Peralta Bridge	8/19/03	8.06	15.8	336.4	8.85	0.42
MF	Middle Fork	8/19/03	8.06	15.1	303.6	8.80	0.03
NF	North Fork	8/19/03	7.94	16.8	626	7.08	0.07
Wet Season Event (17 February 2004)							
PB	Peralta Bridge	2/17/04	7.8	12.9	323.7	10.04	0.82
MF	Middle Fork	2/17/04	8.03	12.0	236	10.04	0.80
NF	North Fork	2/17/04	7.82	13.8	475	9.22	1.18

Table 3. Water Quality Results for Decreasing Hydrograph/Spring Sampling Event (27 April 2003).

	Stations		
	PB	MF	NF
ORGANOPHOSPHORUS PESTICIDES (ug/L)			
Azinphos methyl	0.10U	0.10U	0.10U
Bolstar	0.050U	0.050U	0.050U
Chlorpyrifos	0.050U	0.050U	0.050U
Coumaphos	0.050U	0.050U	0.050U
Demeton, o and s	0.050U	0.050U	0.050U
Diazinon	0.010U	0.010U	0.010U
Dichlorvos	0.050U	0.050U	0.050U
Disulfoton	0.050U	0.050U	0.050U
Ethion	0.050U	0.050U	0.050U
Ethoprop	0.050U	0.050U	0.050U
Fensulfothion	0.050U	0.050U	0.050U
Fenthion	0.050U	0.050U	0.050U
Malathion	0.050U	0.050U	0.050U
Merphos	0.050U	0.050U	0.050U
Mevinphos	0.050U	0.050U	0.050U
Parathion-ethyl	0.050U	0.050U	0.050U
Parathion-methyl	0.050U	0.050U	0.050U
Phorate	0.050U	0.050U	0.050U
Ronnel	0.050U	0.050U	0.050U
Stirophos	0.050U	0.050U	0.050U
Tokuthion (Prothiofos)	0.050U	0.050U	0.050U
Trichloronate	0.050U	0.050U	0.050U

PB = Peralta Bridge
MF = Middle Fork
NF = North Fork
U = Not measured above reported sample method detection limit

Table 4. Water Quality Results for Dry Season Sampling Event (19 August 2003).

	Stations		
	PB	MF	NF
ORGANOPHOSPHORUS PESTICIDES (ug/L)			
Azinphos methyl	0.10U	0.10U	0.10U
Bolstar	0.050U	0.050U	0.050U
Chlorpyrifos	0.050U	0.050U	0.050U
Coumaphos	0.050U	0.050U	0.050U
Demeton, o and s	0.050U	0.050U	0.050U
Diazinon	0.010U	0.010U	0.010U
Dichlorvos	0.050U	0.050U	0.050U
Disulfoton	0.050U	0.050U	0.050U
Ethion	0.050U	0.050U	0.050U
Ethoprop	0.050U	0.050U	0.050U
Fensulfothion	0.050U	0.050U	0.050U
Fenthion	0.050U	0.050U	0.050U
Malathion	0.050U	0.050U	0.050U
Merphos	0.050U	0.050U	0.050U
Mevinphos	0.050U	0.050U	0.050U
Parathion-ethyl	0.050U	0.050U	0.050U
Parathion-methyl	0.050U	0.050U	0.050U
Phorate	0.050U	0.050U	0.050U
Ronnel	0.050U	0.050U	0.050U
Stirophos	0.050U	0.050U	0.050U
Tokuthion (Prothiofos)	0.050U	0.050U	0.050U
Trichloronate	0.050U	0.050U	0.050U

PB = Peralta Bridge
MF = Middle Fork
NF = North Fork
U = Not measured above reported sample method detection limit

Table 5 Water Quality Results for Wet Season Sampling Event (27 February 2004).

	Stations		
	PB	MF	NF
ORGANOPHOSPHORUS PESTICIDES (ug/L)			
Azinphos methyl	0.10U	0.10U	0.10U
Bolstar	0.050U	0.050U	0.050U
Chlorpyrifos	0.050U	0.050U	0.050U
Coumaphos	0.050U	0.050U	0.050U
Demeton, o and s	0.050U	0.050U	0.050U
Diazinon	0.010U	0.010U	0.010U
Dichlorvos	0.050U	0.050U	0.050U
Disulfoton	0.050U	0.050U	0.050U
Ethion	0.050U	0.050U	0.050U
Ethoprop	0.050U	0.050U	0.050U
Fensulfothion	0.050U	0.050U	0.050U
Fenthion	0.050U	0.050U	0.050U
Malathion	0.050U	0.050U	0.050U
Merphos	0.050U	0.050U	0.050U
Mevinphos	0.050U	0.050U	0.050U
Parathion-ethyl	0.050U	0.050U	0.050U
Parathion-methyl	0.050U	0.050U	0.050U
Phorate	0.050U	0.050U	0.050U
Ronnel	0.050U	0.050U	0.050U
Stirophos	0.050U	0.050U	0.050U
Tokuthion (Prothiofos)	0.050U	0.050U	0.050U
Trichloronate	0.050U	0.050U	0.050U

PB = Peralta Bridge
MF = Middle Fork
NF = North Fork
U = Not measured above reported sample method detection limit

Table 6. San Pedro Creek Summary of Bioassay Results (27 April 2003).

Sample	*Survival* *NOEC*	*LOEC*	*LC_{50}*	*Reproduction* *NOEC*	*LOEC*	*IC_{50}*	*IC_{25}*	*IC_{10}*
Ceriodaphnia dubia								
PB	100	>100	>100	100	>100	>100	>100	>100
MF	100	>100	>100	100	>100	>100	>100	91.3
NF	100	>100	>100	100	>100	>100	>100	>100
Pimephales promelas								
PB	100	>100	>100	100	>100	>100	>100	>100
MF	100	>100	>100	100	>100	>100	>100	>100
NF	100	>100	>100	100	>100	>100	>100	>100
Selenastrum capricornutum								
PB	NA	NA	NA	100	>100	>100	>100	>100
MF	NA	NA	NA	100	>100	>100	>100	>100
NF	NA	NA	NA	50	100	>100	64.0	39.6

Values are percent sample
PB= Peralta Bridge
MF= Middle Fork
NF= North Fork
NOEC= Highest Test Concentration Not Producing a Statistically Significant Reduction in Survival or Fertilization
LOEC= Lowest Test Concentration Producing a Statistically Significant Reduction in Survival or Fertilization
LC_{50}= Median (50%) Lethal Concentration
IC_{50}= Concentration Inhibitory to Reproduction by 50% (Median)
IC_{25}= Concentration Inhibitory to Reproduction by 25%
IC_{10}= Concentration Inhibitory to Reproduction by 10%
NA= Not Applicable

Table 7. San Pedro Creek Summary of Bioassay Results (19 August 2003).

Sample	*Survival* *NOEC*	*LOEC*	*LC_{50}*	*Reproduction* *NOEC*	*LOEC*	*IC_{50}*	*IC_{25}*	*IC_{10}*
Ceriodaphnia dubia								
PB	100	>100	>100	12.5	25	>100	63.5	12.6
MF	100	>100	>100	100	>100	>100	>100	>100
NF	100	>100	>100	25	50	58.9	11.9	8.5
Pimephales promelas								
PB	100	>100	>100	100	>100	>100	>100	>100
MF	100	>100	>100	100	>100	>100	>100	>100
NF	100	>100	>100	100	>100	>100	>100	>100
Selenastrum capricornutum								
PB	NA	NA	NA	100	>100	>100	>100	>100
MF	NA	NA	NA	100	>100	>100	>100	>100
NF	NA	NA	NA	100	>100	>100	>100	>100

Values are percent sample
PB= Peralta Bridge
MF= Middle Fork
NF= North Fork
NOEC= Highest Test Concentration Not Producing a Statistically Significant Reduction in Survival or Fertilization
LOEC= Lowest Test Concentration Producing a Statistically Significant Reduction in Survival or Fertilization
LC_{50}= Median (50%) Lethal Concentration
IC_{50}= Concentration Inhibitory to Reproduction by 50% (Median)
IC_{25}= Concentration Inhibitory to Reproduction by 25%
IC_{10}= Concentration Inhibitory to Reproduction by 10%
NA= Not Applicable

Table 8. San Pedro Creek Summary of Bioassay Results (17 February 2004).

	Survival			*Reproduction*				
Sample	*NOEC*	*LOEC*	*LC_{50}*	*NOEC*	*LOEC*	*IC_{50}*	*IC_{25}*	*IC_{10}*
Ceriodaphnia dubia								
PB	100	>100	>100	<6.25	6.25	>100	>100	3.9
MF	100	>100	>100	6.25	12.5	>100	8.0	4.1
NF	100	>100	>100	100	>100	>100	>100	21.4
Pimephales promelas								
PB	25	50	>100	100	>100	>100	>100	>100
MF	100	>100	>100	100	>100	>100	>100	>100
NF	100	>100	>100	100	>100	>100	>100	>100
Selenastrum capricornutum								
PB	NA	NA	NA	100	>100	>100	>100	>100
MF	NA	NA	NA	100	>100	>100	>100	>100
NF	NA	NA	NA	100	>100	>100	>100	>100

Values are percent sample
PB= Peralta Bridge
MF= Middle Fork
NF= North Fork
NOEC= Highest Test Concentration Not Producing a Statistically Significant Reduction in Survival or Fertilization
LOEC= Lowest Test Concentration Producing a Statistically Significant Reduction in Survival or Fertilization
LC_{50}= Median (50%) Lethal Concentration
IC_{50}= Concentration Inhibitory to Reproduction by 50% (Median)
IC_{25}= Concentration Inhibitory to Reproduction by 25%
IC_{10}= Concentration Inhibitory to Reproduction by 10%
NA= Not Applicable