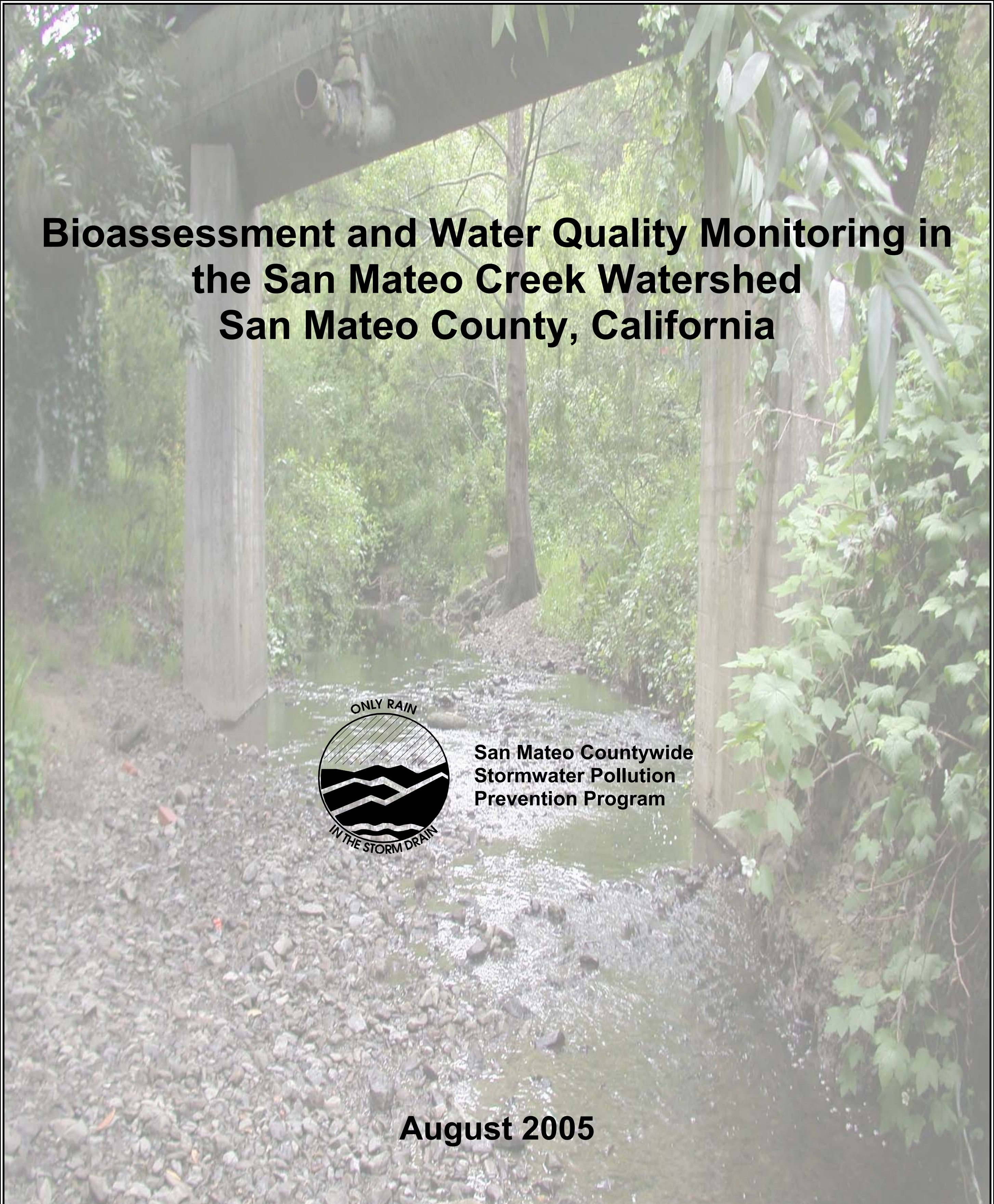
Bioassessment and Water Quality Monitoring in the San Mateo Creek Watershed San Mateo County, California



San Mateo Countywide Stormwater Pollution Prevention Program

ONLY RAIN IN THE STORM DRAIN

August 2005

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

ONLY RAIN IN THE STORM DRAIN

San Mateo Countywide Stormwater Pollution Prevention Program

Prepared for the

San Mateo Countywide Stormwater Pollution Prevention Program

by

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August 2005

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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. This report documents the results of an assessment of the San Mateo Creek watershed, which drains about 33 square miles and includes parts of unincorporated San Mateo County, the City of San Mateo and the Town of Hillsborough. Below the Crystal Springs reservoir dam, the watershed encompasses approximately five square miles and is mostly urbanized.

During FY 2002/03, STOPPP providing funding for the Water Board to supplement water quality testing performed in the San Mateo Creek watershed by the statewide Surface Water Ambient Monitoring Program (SWAMP).[1] As a follow-up, STOPPP performed the additional screening-level biological and chemical water quality monitoring documented in this report.

Field activities 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. STOPPP collected a second year of bioassessment data from the San Mateo Creek watershed in April 2004, as a follow-up to the first year bioassessment conducted during spring 2003 by the SWAMP. The two years of bioassessment data showed negligible annual variation and indicated that benthic macroinvertebrate assemblages sampled from various sites in the watershed were highly dissimilar. Three sites on San Mateo Creek downstream of Crystal Springs reservoir and a tributary site (Polhemus Creek) had relatively poor quality benthic macroinvertebrate assemblages when compared to two sites upstream of Crystal Springs reservoir. Site quality was likely influenced by the degree of upstream urbanization, including the Crystal Springs reservoir dam. However, variations in habitat quality associated with elevation differences may also have impacted the quality of benthic macroinvertebrate assemblages.

General water quality parameters measured in the field included dissolved oxygen and pH. All dissolved oxygen measurements equaled or exceeded 9.0 milligrams per liter, meeting the 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 7.47 to 8.56 and, with the exception of the 8.56 measurement, were within the acceptable range of 6.5 to 8.5 specified for San Francisco Bay Basin waters in the Basin Plan.[2]

STOPPP collected grab water samples from four San Mateo Creek watershed sites during February 2004. Organophosphorous pesticides, including diazinon, were not detected in the samples. The detection limit for diazinon was lower than a TMDL target proposed by Water Board staff, indicating that the target was not exceeded in the study samples. The water samples were also tested for toxicity using a three-species bioassay. Toxicity was not observed in any of the samples with the exception of relatively minor inhibition of *Ceriodaphnia dubia* reproduction in one sample.

[1] Water Board staff plans to prepare a report that will interpret the results of the monitoring performed by the SWAMP in the Bay Area, including the supplemental San Mateo Creek results.
[2] Another pH measurement was made on a different date at the same station where a pH of 8.56 was measured. The other pH measurement (7.89) was within the acceptable range specified in the Basin Plan.

At this time, STOPPP does not have plans to perform more detailed investigations in the San Mateo Creek watershed, since budget constraints limit the scope of investigation that STOPPP can perform in any single watershed. However, STOPPP will evaluate its current watershed assessment and monitoring program after adoption of the Municipal Regional Permit currently under development. The lessons learned during STOPPP's recent watershed assessments will inform this planning process.

Bioassessment and Water Quality Monitoring in the San Mateo 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 biological and chemical water quality monitoring in the San Mateo Creek watershed. STOPPP's objectives in performing this field-monitoring program included:

- Performing a bioassessment to help characterize aquatic ecosystem health in San Mateo Creek, an urban creek in San Mateo County. 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 Mateo Creek for toxicity and organophosphorous 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, 2005).

The field program in the San Mateo 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 (e.g., bioassessment and toxicity testing) to help evaluate the health of receiving waters and thereby help assess the overall effectiveness of STOPPP's stormwater pollution prevention and control Best Management Practices (BMPs).

2.0 BACKGROUND

2.1 Description of Study Area

The San Mateo Creek watershed drains about 33 square miles and includes parts of unincorporated San Mateo County, the City of San Mateo and the Town of Hillsborough. The creek headwaters originate near Sweeney Ridge in the Santa Cruz Mountains. The upper watershed is undeveloped and drains into Crystal Springs reservoir. Below the Crystal Springs reservoir dam, the watershed encompasses approximately five square miles (Figure 1) and is mostly urbanized, with the densest urbanization east of El Camino Real, where the creek enters a 2,000-foot culvert. The creek flows to San Francisco Bay at Ryder Park, just south of Coyote Point (City of San Mateo, 1988 and SFRWQCB, 2002). The overall watershed imperviousness below the dam is approximately 38 percent with 51 percent of the creek channel unmodified (STOPPP, 2002). SFRWQCB (2002) includes further information about the geologic and geomorphic setting, biota, climate, land uses and water quality issues in the watershed.

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 (SFRWQCB, 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 beneficial uses for Bay Area surface waters, including four existing beneficial uses for San Mateo Creek: fresh water replenishment, preservation of rare and endangered species, fish spawning and wildlife habitat. Three potential beneficial uses are also designated: cold water habitat, non-contact water recreation and water contact recreation.

The 2002 Clean Water Act Section 303(d) list designates San Mateo Creek and all other Bay Area urban creeks as impaired by diazinon. In addition, all Bay area urban creeks, lakes and shorelines were placed on the State Water Resources Control Board 2002 "Monitoring List" due to the potential of trash to impair water quality.

2.3 Previous Water Quality Investigations

Katznelson and Mumley (1997) reported diazinon was found in two samples from San Mateo creek during a spring 1995 survey of diazinon in Bay Area urban creeks. Diazinon was detected at 0.068 micrograms per liter (µg/L) in a sample collected from the creek near Norfolk Street and Beacon Avenue (located in the lower watershed near Highway 101) and at 0.048 µg/L in a sample collected near Crystal Springs Road (a cross street is not provided, but this road is in the upper watershed).

The statewide Surface Water Ambient Monitoring Program (SWAMP) performed baseline water quality monitoring in the San Mateo Creek watershed during January, April and June 2003. This field program included analysis of benthic macroinvertebrate assemblages, physical habitat assessment, chemical analysis and bioassay of grab water and sediment samples, and field instrument measurements. STOPPP supplemented the April and June monitoring episodes by funding collection and analysis of samples for organophosphorous pesticides and water column toxicity at three of the SWAMP stations. The methods used during the supplemental monitoring were similar to those described below (Section 3.0). Water Board staff plans to prepare a report that will interpret the results of the Bay Area monitoring performed by the SWAMP, including the supplemental San Mateo Creek results.

3.0 METHODS

Table 1 summarizes the field activities that STOPPP performed in the San Mateo 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).

3.1 Bioassessment

STOPPP collected a second year of bioassessment data from the San Mateo Creek watershed in April 2004, as a follow-up to the previously mentioned spring 2003 bioassessment conducted by the SWAMP. 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).

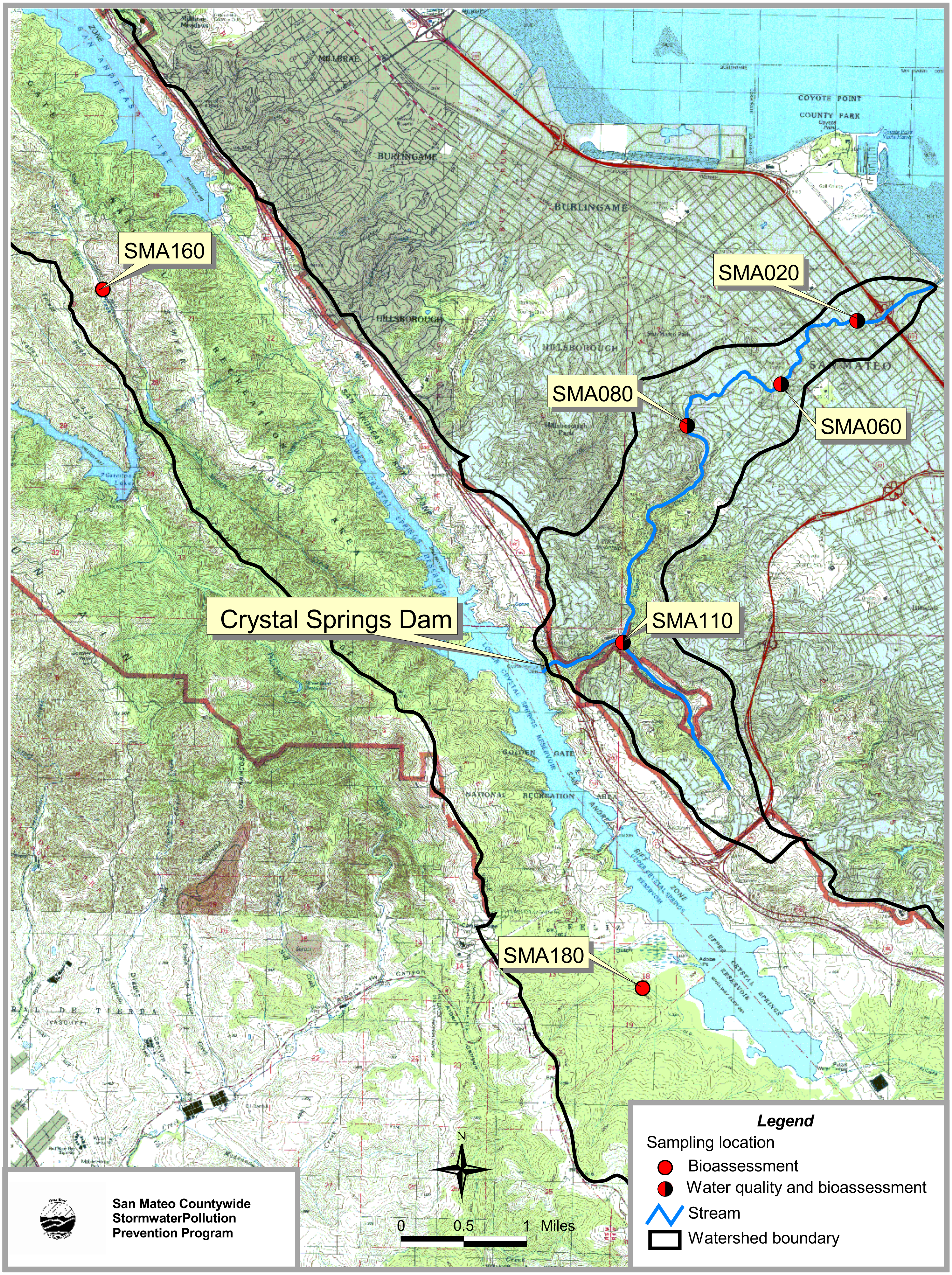

Figure 1. STOPPP bioassessment and water quality sampling locations in the San Mateo Creek watershed.

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

Type of Monitoring	Activity	Number of Sample Sites	Parameters	Frequency/Interval
Watershed characterization and assessment of receiving waters.	Bioassessment.	6	Macroinvertebrate assemblages, visual physical habitat characteristics, temperature, pH, conductivity, and dissolved oxygen,	One episode in April 2004.
	Creek water quality testing.	4	Temperature, pH, conductivity, dissolved oxygen, velocity, organophosphorous pesticides, and water column toxicity (three-species bioassay).	One episode in February 2004.

Note: In addition to the above activities, STOPPP supplemented water quality monitoring in San Mateo Creek previously performed by the SWAMP. STOPPP funded collection and analysis of water samples for organophosphorous pesticides and toxicity at three SWAMP stations during April and June 2003. Water Board staff plans to prepare a report that will interpret the results of the Bay Area monitoring performed by the SWAMP, including the supplemental San Mateo Creek results.

Benthic macroinvertebrates were collected and visual assessments of physical habitat were conducted at six sites in the watershed (Table 2 and Figure 1). These same six sites were sampled previously during the SWAMP, and represent a range of subwatersheds, ecoregion subsections, elevations, stream characteristics and land use.

STOPPP General Program staff performed the bioassessment fieldwork. Conventional water quality parameters (temperature, pH, conductivity, and dissolved oxygen) were measured using field instruments at each sampling site. The macroinvertebrate samples were submitted to BioAssessment Services of Folsom, California for analysis. Appendix A contains a report prepared by BioAssessment Services of Folsom, California that documents the bioassessment methodology in detail.

3.2 Water Testing

STOPPP collected grab water samples from San Mateo Creek and its tributaries on February 24, 2004. Samples were collected at the same four stations (Figure 1) where STOPPP funded supplemental testing in April and June 2003 during the SWAMP monitoring. The February sampling, in conjunction with the April and June SWAMP sampling, comprised three hydrologic seasons: the wet season, decreasing hydrograph (spring), and the dry season. The water quality sampling sites were in the same general location as four of the six 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.

Each water sample was tested for organophosphorous pesticides, including diazinon, using EPA Method 8141A and 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[3] 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.

Table 2. Descriptions of Site Locations (from BioAssessment Services report in Appendix A)

Sample Station[1]	Elevation (ft)	Stream Reach Location Description	Predominant Land Use	Ecoregion Subsection	Channel Slope (%)	Stream Channel Condition
SMA020[2]	10	Gateway Park (upstream of Humbolt St.)	Commercial, residential	Santa Clara Valley	0.4	Channelized by earthen levee
SMA060[2]	25	Arroyo Court Park at Dartmouth Rd.	Commercial, residential	Santa Clara Valley	0.4	Modified channel
SMA080[2]	50	Sierra Dr. crossing	Residential	Leeward Hills	0.5	Modified channel
SMA110[2]	180	Polhemus Cr. above confluence with San Mateo Cr.	Mixed uses	Leeward Hills	4.2	Unmodified
SMA160[3]	700	One mile above Mud Dam along Pilarcitos Ridge Rd.	Open space	Santa Cruz Mountain	1.2	Unmodified
SMA180[3]	360	Upstream Old Canada Rd. past Adobe Gulch	Open space	Santa Cruz Mountain	3.6	Unmodified

[1]See Figure 1 for sample station locations.
[2]Water quality and bioassessment station.
[3]Bioassessment only station.

4.0 RESULTS

4.1 Bioassessment

The results of the bioassessment are presented below and discussed in Section 5.0 of this report. Appendix A contains a detailed analysis of the bioassessment data.

4.1.1 Benthic Macroinvertebrate Assemblages

Results were similar to the first year of work, and indicated that benthic assemblages sampled from various sites in the San Mateo Creek watershed were highly dissimilar. Composite metric

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

scores[4] (Figure 2) were consistently higher for the two sites upstream of Crystal Springs reservoir (SMA160 and SMA180) when compared to the other sites, due to higher richness and diversity, lower tolerance and higher proportion of stressor-intolerant and EPT taxa[5].

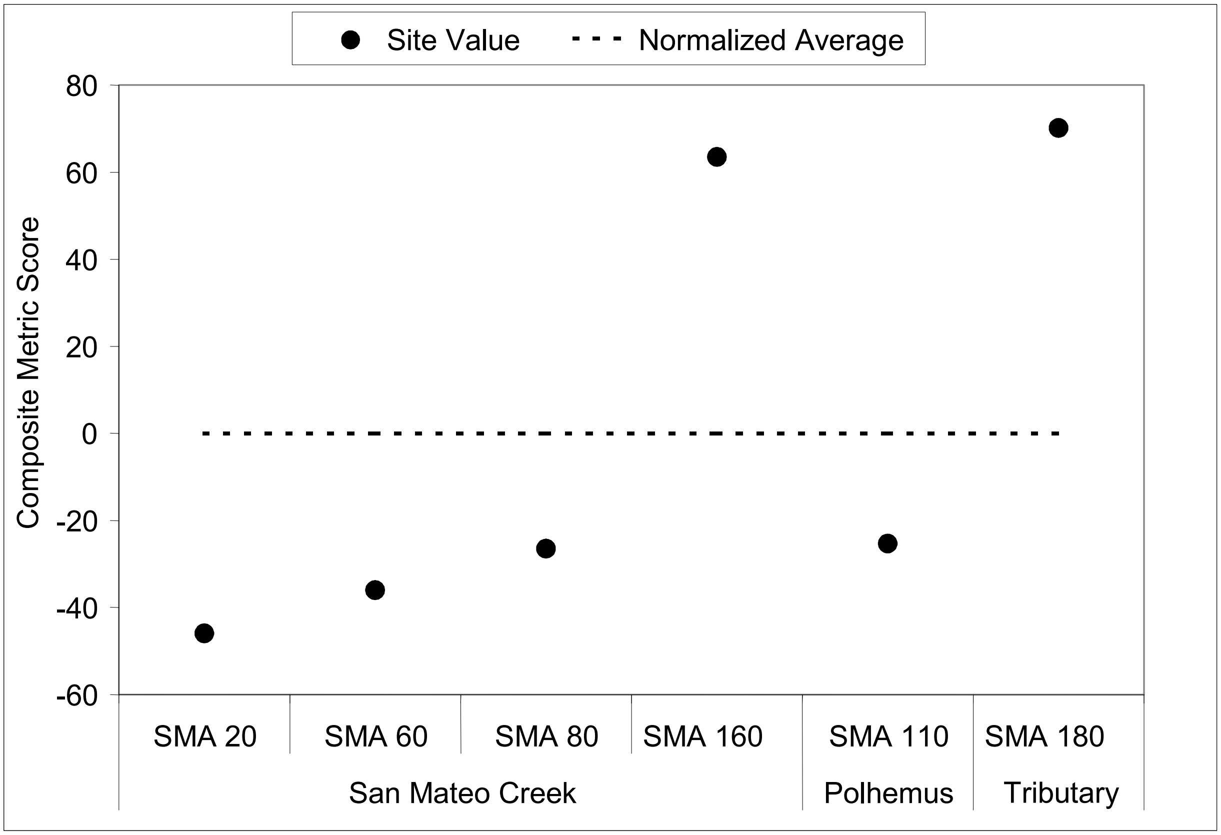

Figure 2. Composite Metric Scores (from BioAssessment Services report in Appendix A)

4.1.2 Physical Habitat Assessment

Habitat quality scores ranged from 71 at site SMA020 to 181 at site SMA180 (Table 3). According to Barbour et al. (1999), scores of 50 or less imply poor habitat, scores greater than 50 to 100 imply marginal habitat, scores greater than 100 to 150 imply suboptimal habitat, and scores greater than 150 imply optimal habitat. Based on this classification, the habitat quality scores would imply marginal habitat for site SMA020, suboptimal habitat for sites SMA060 and SMA080 and optimal habitat for sites SMA110, SMA160 and SMA180.

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[4] 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.
[5]Number of taxa in the orders Ephemeroptera (mayfly), Plecoptera (stonefly) and Trichoptera (caddisfly). EPT taxa are indicative of a healthy aquatic ecosystem.

Table 3. Physical Habitat Scores

Sample Station[1]	Habitat Quality Score	Implied Habitat Quality (Barbour et al., 1999)
SMA020	71	Marginal
SMA060	101	Suboptimal
SMA080	112	Suboptimal
SMA110	155	Optimal
SMA160	162	Optimal
SMA180	181	Optimal

[1]See Figure 1 for sample station locations.

4.2 Water Testing

Table 4 summarizes the results of the chemical analyses and the field probe conventional water quality parameter and velocity measurements. Organophosphorous 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 4. Organophosphorous Pesticides and Field Instrument Measurement Results

Date Collected	Sample Station[1]	Organo-phosphorous Pesticides	pH	Temp-erature (°C)	Con-ductivity (µS/cm)	Dissolved Oxygen (mg/L)	Velocity (ft/sec)
2-24-04	SMA020	Not Detected[2]	7.89	11.8	447.8	9.22	0.84
	SMA060	Not Detected	8.09	12.0	461.0	10.59	0.35
	SMA080	Not Detected	8.03	12.0	438.5	11.01	0.24
	SMA110	Not Detected	8.31	12.0	400.6	11.32	0.28
4/14/04 - 4/16/04	SMA020	NA[3]	8.56	13.2	640	10.9	NA
	SMA060	NA	8.06	12.1	650	9.0	NA
	SMA080	NA	8.12	12.2	635	10.0	NA
	SMA110	NA	8.36	11.5	1120	10.0	NA
	SMA160	NA	7.47	10.5	268	9.3	NA
	SMA180	NA	7.92	10.6	1242	9.2	NA

Notes:
[1]See Figure 1 for sample station locations.
[2]The detection limit for all organophosphorous pesticide analytes in all samples was 0.05 µg/L, except diazinon (0.01 µg/L) and azinphos methyl (0.1 µg/L).
[3]NA – Not Applicable.

Table 5 presents a simplified summary of the results of the three species bioassays. A total of 12 toxicity tests was performed. SMA080 was the only sample with any indication of toxicity. When this sample was diluted to a concentration of about 56% (an undiluted sample has a concentration of 100%), *Ceriodaphnia* reproduction was reduced by 10%.

Table 5. Three Species Bioassay Results

Date Collected	Sample Station[1]	Organism	Summary of Bioassay Results[2,3]	
			Survival Endpoint	Sub-lethal Endpoint (Reproduction/Growth)
2-24-04	SMA020	*Ceriodaphnia*	Survival not reduced.	Reproduction not reduced.[4]
		Pimephales	Survival not reduced.	Growth not reduced.
		Selenastrum	NA[5]	Growth not inhibited.
	SMA060	*Ceriodaphnia*	Survival not reduced.	Reproduction not reduced.
		Pimephales	Survival not reduced.	Growth not reduced.
		Selenastrum	NA	Growth not inhibited.
	SMA080	*Ceriodaphnia*	Survival not reduced.	***Reduced reproduction.***
		Pimephales	Survival not reduced.	Growth not reduced.
		Selenastrum	NA	Growth not inhibited.
	SMA110	*Ceriodaphnia*	Survival not reduced.	Reproduction not reduced.
		Pimephales	Survival not reduced.	Growth not reduced.
		Selenastrum	NA	Growth not inhibited.

Notes:
[1]See Figure 1 for sample station locations.
[2]Appendix B includes a more detailed description of the bioassay results.
[3]Samples with any indication of toxicity are shown in bold italics.
[4]During the bioassay of sample SMA020, the *Ceriodaphnia* test did not meet Test Acceptability Criteria for the reproduction endpoint, introducing some uncertainty into this test result.
[5]NA – Not Applicable.

Appendix B includes a more detailed description of the bioassay results. 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%).

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 Mateo Creek. The results of STOPPP's spring 2004 bioassessment were similar to the SWAMP bioassessment in spring 2003 and indicated that benthic macroinvertebrate assemblages sampled from various sites in the watershed were highly dissimilar.

Three sites on San Mateo Creek downstream of Crystal Springs reservoir and a tributary site (Polhemus Creek) had relatively poor quality benthic macroinvertebrate assemblages when compared to two sites upstream of the reservoir. Site quality was likely influenced by the degree of upstream urbanization, including the Crystal Springs reservoir dam. However, variations in habitat quality associated with elevation differences may also have impacted the quality of benthic macroinvertebrate assemblages. Vannotte et al. (1980) describes factors associated with elevation such as gradient, canopy cover, stream width, substrate composition, allocthonous[6] input, depth and temperature regime that influence the composition of benthic fauna along elevation gradients. Other investigators (e.g., Allan, 1995 and Merritt and Cummins, 1996) have demonstrated that these factors, individually and in various combinations, are important influences on benthic fauna.

The Polhemus Creek site (SMA110) is an example of a site with good habitat quality but a considerably lower composite metric score (Figure 2) than sites upstream of Crystal Springs reservoir (SMA160 and SMA180) with similar habitat quality (Table 3). This suggests that factors associated with urbanization, in addition to local habitat quality, impacted macroinvertebrate assemblages at the Polhemus Creek site.

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). BAMBI is a regional program that helps coordinate Bay Area benthic macroinvertebrate bioassessment efforts. BAMBI will help Bay Area stormwater management agencies interpret local bioassessment data and use the results to inform evaluation and selection of pollution prevention and control BMPs. BAMBI's specific 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 regional IBI, which would potentially help with evaluation of attainment of beneficial uses in creeks, identify stressors to creeks, and establish water quality goals.

5.2 Water Testing

General water quality parameters measured in the field included dissolved oxygen and pH.[7] Dissolved oxygen measurements equaled or exceeded 9.0 milligrams/liter (mg/L), meeting Basin Plan (SFRWQCB, 1995) nontidal water objectives for cold water habitat (7.0 mg/L minimum) and warm water habitat (5.0 mg/L minimum). Measurements of pH varied from 7.47 to 8.56 and, with the exception of the 8.56 measurement, were within the acceptable range of

[6]Material originating from a location other than where it is presently found (e.g., sediment from upstream sources).
[7]General water quality measurements from this study are a snapshot and do not capture natural variability due to daily photosynthesis cycles.

6.5 to 8.5 specified for San Francisco Bay Basin waters in the Basin Plan.[8]

Organophosphorous pesticide analytes, including diazinon, were not detected in the grab water samples collected during this study. A recent Water Board staff report proposed a diazinon concentration target of 0.1 µg/L, to be evaluated as a one-hour average (Johnson, 2005). The detection limit for diazinon during this study was 0.01 µg/L, which is lower than the proposed target, indicating that the target was not exceeded in the study samples.

SMA080 was the only sample with any indication of toxicity. When this sample was diluted to a concentration of about 56% (an undiluted sample has a concentration of 100%), *Ceriodaphnia* reproduction was reduced by 10%, a relatively minor sublethal effect. The cause(s) of the toxicity is unknown, but there was no indication that diazinon or other organophosphorous pesticides were involved, since these pesticides were not detected.

In addition to the diazinon targets, the Water Board staff report (Johnson, 2005) 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 (SFRWQCB, 1995). The staff report also states "Substantial exceedances of the toxicity target may trigger the need for Toxicity Identification Evaluations or other studies to determine the causes of the toxicity (unless the toxicity can be attributed to a specific pesticide based on other information)." 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 sample SMA080 to perform a TIE (Lewis, 2005 - personal communication).

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 interpretation of the 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* 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 health and characteristics that are potentially impacted by stormwater runoff. At this time, STOPPP does not have plans to perform more detailed investigations in the San Mateo Creek watershed, since budget constraints limit the scope of investigation that STOPPP can perform in any single watershed. However, STOPPP will

[8]Another pH measurement was made on a different date at the same station where a pH of 8.56 was measured. The other pH measurement (7.89) was within the acceptable range specified in the Basin Plan.

evaluate its current watershed assessment and monitoring program after adoption of the Municipal Regional Permit currently under development. 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.

City of San Mateo 1988. *San Mateo Creek Study Staff Summary Report*. September 15, 1988.

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

Johnson, B. 2005. *Diazinon and Pesticide-Related Toxicity in Bay Area Urban Creeks, Water Quality Attainment Strategy and Total Maximum Daily Load (TMDL), Proposed Basin Plan Amendment and Staff Report*. San Francisco Bay Regional Water Quality Control Board. August 5, 2005.

Katznelson, R. and Mumley, T. 1997. *Diazinon in Surface Waters in the San Francisco Bay Area: Occurence and Potential Impact*. Prepared for the California State Water Resources Control Board, the Alameda County Flood Control and Water Conservation District and the Alameda Countywide Clean Water Program. June 30, 1997.

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

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

San Francisco Bay Regional Water Quality Control Board (SFRWQCB) 2002. *Surface Water Ambient Monitoring Program (SWAMP) Final Workplan 2002-2003*. June 2002.

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, 2002.

U.S. Environmental Protection Agency (USEPA) 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 2000.

U.S. Environmental Protection Agency (USEPA) 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 2000.

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.

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APPENDIX A

Bioassessment Report Prepared by BioAssessment Services

ONLY RAIN IN THE STORM DRAIN

San Mateo Countywide
Stormwater Pollution
Prevention Program

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Biological Assessment of San Mateo Creek

- Spring 2004 -

Prepared by:
BIOASSESSMENT SERVICES
Folsom, California

Prepared for:
EOA, INC.
Oakland, California

September 2004

SUMMARY

The San Mateo Countywide Stormwater Pollution Prevention Program (STOPPP) conducted a biological assessment of San Mateo Creek in April of 2004 to help evaluate the water and physical habitat quality in this watershed. The assessment was conducted using protocols outlined in the California Stream Bioassessment Procedure, which is a standardized procedure for characterizing benthic macroinvertebrate assemblages in wadeable streams. Because of benthic macroinvertebrate 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.

Six stream sites were assessed within the San Mateo Creek system; four sites were distributed along an elevation gradient within San Mateo Creek and two sites were located on two tributaries. Three of the four San Mateo Creek sites were located within a predominantly urban area downstream of Crystal Springs Reservoir while the furthest site upstream was located in a relatively undisturbed drainage area above the reservoir. One tributary site was located in the Polhemus Creek drainage, which is within an area of mixed open space and urban land use. An un-named tributary site was located in an undisturbed drainage area above Crystal Springs Reservoir. The two sites above the Crystal Springs Reservoir were considered reference sites as they both occur in protected watershed areas owned and managed by the San Francisco Public Utilities Commission. Bioassessments were also conducted at the same six sites by the California Department of Fish and Game (CDFG) and the San Francisco Regional Water Quality Control Board (Regional Board) in April of 2003.

Fieldwork consisted of collecting three benthic samples per site and documenting characteristics of instream and riparian habitat. The benthic samples were processed in the laboratory by compositing the three samples collected at each site, subsampling 500 randomly selected organisms from each composite and identifying the subsampled 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 relative site similarity based on the taxonomic composition of benthic macroinvertebrates sampled from the sites. Biological assessment data compiled by the Regional Board and CDFG in year 2003 were used to assess annual variation (years 2003 and 2004) of BMI assemblage quality at the sites.

Results of the San Mateo Creek assessment indicated that benthic macroinvertebrate assemblages sampled from the sites were highly dissimilar. The three sites on San Mateo Creek downstream of Crystal Springs Reservoir and the Polhemus Creek site had relatively poor quality benthic macroinvertebrate assemblages when compared to the two sites upstream of Crystal Springs Reservoir. There was negligible annual variation in biological assessment results for years 2003 and 2004. Site quality based on the benthic macroinvertebrate assemblages and habitat assessments was likely influenced by the degree of urbanization in the subwatersheds. However, natural habitat changes, which occur along elevation gradients, may have contributed to differences in the quality of benthic macroinvertebrate assemblages.

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1.0 INTRODUCTION

During FY 2003/04, the San Mateo Countywide Stormwater Pollution Prevention Program (STOPPP) initiated a water quality monitoring program in the San Mateo Creek watershed. Monitoring activities included conducting rapid bioassessments at selected locations in San Mateo Creek using benthic macroinvertebrate (BMI) assemblages and physical habitat assessments. This report documents the results of the bioassessments and compares the results to previous bioassessments conducted by the San Francisco Regional Water Quality Control Board (Regional Board).

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.

1.1 Study Objectives

The objectives of the bioassessment were to:

- Assess biological integrity and overall "health" of San Mateo Creek watershed using BMI assemblages at selected stream locations;

- Measure inter-annual variability in BMI community assemblages at stream locations that were previously sampled in 2003 by the California Department of Fish and Game (CDFG) and the Regional Board; and

- Contribute data to Bay-wide data set intended to characterize watershed "health" and development of an Index of Biological Integrity (IBI).

1.2 Study Area Description

San Mateo Creek watershed drains approximately 33.2 square miles, with 28.7 square miles accounting for the drainage area above Crystal Springs Dam and 4.5 square miles below the dam. The drainage area above the dam is predominantly steep forested terrain that is relatively undisturbed by urbanization. Three reservoirs occur in this drainage area, including San Andreas Lake, and the Upper and Lower Crystal Spring Reservoirs. The area draining into all three reservoirs is a protected watershed that is owned by the San Francisco Public Utilities Commission (SFPUC) and managed for water supply.

San Mateo Creek flows approximately 5.5 miles below Crystal Springs Dam into San Francisco Bay just south of Coyote Point. The upper 3 miles of the creek below the dam flows through a narrow valley that is moderately urbanized. Polhemus Creek tributary confluence is located about 0.75 mile downstream of the dam. The last 2.5 miles flow through highly urbanized areas within the alluvial plain. The creek is tidally influenced downstream of Highway 101.

2.0 METHODS

2.1 Site Selection

The six BMI sampling sites in the San Mateo Creek watershed represent a range of ecoregion subsections, elevations, stream gradients, channel characteristics and land use (Table 1 and Figure 1). Ecoregion information in Table 1 was obtained from the National Hierarchical Framework of Ecological Units GIS database (Bailey 1995). Elevation and channel slope were obtained from USGS 7.5 minute Topographic Maps. Land use information was obtained from Association for Bay Area Governments (ABAG) 1995 Land Use GIS database. Stream channel condition was identified from existing channel survey information (STOPPP 2002).

Table 1. Site location descriptions for the San Mateo Creek biological assessment.

Sampling Station ID	Elevation (FT)	Stream Reach Location Description	Predominant Land Use	Ecoregion Subsection	Channel Slope (%)	Stream Channel Condition
SMA 020	10	Gateway Park upstream Humbolt	Commercial; residential	Santa Clara Valley	0.4	Channelized by earthen levee
SMA 060	25	Arroyo Court Park at Dartmouth	Commercial; residential	Santa Clara Valley	0.4	Modified channel
SMA 080	50	Downstream Sierra Dr	Residential	Leeward Hills	0.5	Modified channel
SMA 110	180	Polhemus Cr above confluence with San Mateo Cr	Mixed	Leeward Hills	4.2	Unmodified
SMA 160	700	1 mile above Mud Dam along Pilarcitos Ridge Rd	Open space	Santa Cruz Mtn	1.2	Unmodified
SMA 180	360	Upstream Old Canada Rd past Adobe Gulch	Open space	Santa Cruz Mtn	3.6	Unmodified

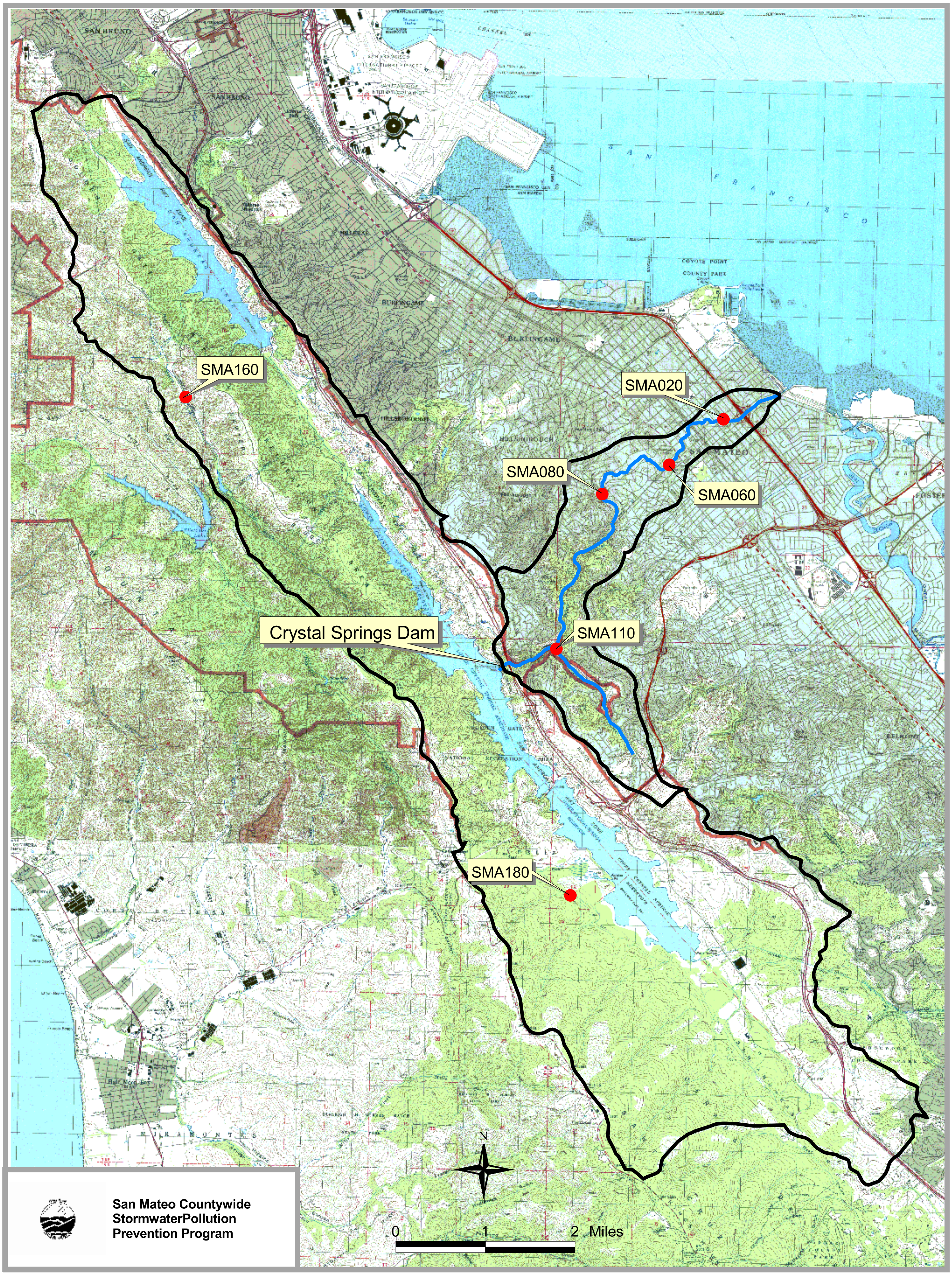


Figure 1. Benthic macroinvertebrate sampling stations in San Mateo Creek watershed.

2.2 Bioassessment Field Study

STOPPP General Program staff collected BMI samples, measured water quality constituents, and conducted physical habitat assessments between April 14 and April 16, 2004. Benthic sampling and habitat assessment were conducted using methods outlined in the California Stream Bioassessment Procedures (CSBP) December 2003 revision (http://www.dfg.ca.gov/cabw/csbp_2003.pdf). The CSBP was developed by Harrington (1999) and the CDFG for assessing biotic integrity in wadeable streams. The non-point source portion of the CSBP was applied to this assessment for documenting and describing BMI assemblages and physical habitat within the selected sites.

2.2.1 Macroinvertebrate Sampling

Macroinvertebrate sampling was conducted following the CSBP protocols for both low and high gradient streams. The high gradient sites consisted of a 100 meter reach of the channel with at least 3 riffle habitats, each greater than 1 meter wide and 1 meter long. If more than three riffles occurred within the reach, 3 riffles were randomly selected using a random number table. When a selected riffle was of sufficient length and width, a transect location for sampling was randomly chosen from the upper third of the riffle. This was accomplished by laying a tape measure along the length of the upper third of the riffle, assigning sequential numbers to each meter or 3-foot length on the tape measure, then using a random number table to select the transect to be sampled in each riffle.

Starting with the downstream riffle, the benthos within a 1 ft^2 area was disturbed upstream of a 1 ft (0.305 m) wide, 0.02 in. (0.5 mm) mesh D-frame kick net. Sampling of the benthos was performed by manually rubbing cobble and boulder substrates followed by 'kicking' the upper layers of substrate to dislodge any remaining invertebrates. Duration of sampling ranged from 60-180 seconds, depending on the amount of boulder and cobble-sized substrates that required rubbing by hand; more and larger substrates required more time to process. Samples were collected at three locations representing the habitats along each transect (usually the two margins and the mid-point). The samples were combined into a composite sample in the field (representing a 3 ft^2 area) and transferred into a 500-ml wide-mouth jar containing approximately 200 ml of 95% ethanol. This technique was repeated for each of the three riffles in each monitoring sampling station (site).

The low gradient stream protocol was used for the farthest downstream sampling site (Gateway Park) and the high gradient protocol was used for all other sampling sites. The low gradient protocol was used due to a lack of riffle habitat in the reach. For the low gradient site, three transects were randomly selected within a 100 meter section of stream. BMIs were sampled at three locations along each transect by placing a D-shaped kick-net on the substrate and disturbing a 1 square foot of habitat upstream of the net. The three sampling locations for each transect were selected to represent the general habitat types that occur within the reach (e.g., submerged vegetation, soft substrate, woody debris). Similar to the protocols used for high gradient sites, the three samples collected for each transect were combined into a composite sample.

Using a permanent marker, each sample jar was labeled with a station code and transect number, date, and sampler's name. Using a small piece of Rite-in-the Rain paper and a pencil, a second label was prepared and included inside each sample jar. Each sampled BMI station produced three benthic samples, which were composited at the laboratory prior to subsampling and identification of organisms. Six composite samples were collected from six stations in the San Mateo Creek watershed during the April 2004 sampling effort.

2.2.2 Chemical and Physical Habitat Parameters

Ambient water chemistry (dissolved oxygen, temperature, pH and conductivity) was recorded at each site using a Yellow Springs Instruments (YSI) 600 XL-BO sonde coupled to a model 650 MDS (multi-parameter display system). Stream velocity was determined at each riffle using a Global Water FP101 flow meter. An example of the field sheet used to record most of the field data is provided in Appendix A.

Physical habitat quality was assessed for each monitoring reach using the U.S. Environmental Protection Agency (EPA) Rapid Bioassessment Protocol (Barbour et al. 1999). These qualitative habitat assessments were recorded for each sampling station during field sampling. Note that the estimate of substrate size percent composition addressed only the riffle habitat sampled and not all other instream habitat types (e.g., pools). Therefore, qualitative and quantitative substrate composition measurements taken during this study should only be used to characterize riffle substrate at stations sampled, and should not be extrapolated to the entire stream system. The percent fines in riffles are expected to be less than the other instream habitats due to gradient and current velocities. An example of a Physical Habitat Quality Bioassessment Work Sheet is provided in Appendix A.

Photographs of the BMI sampling sites were taken with a digital camera. Field notes were taken to describe the photo point. Photographs are included in Appendix B.

2.3 Macroinvertebrate Sample Processing and Analysis

At the laboratory, each of the three samples collected at each site were composited, rinsed in a standard no. 35 sieve (0.02 in; 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% ethanol and 2% glycerol. At least 500 BMIs were subsampled from a minimum of three grids. If there were more BMIs remaining in the last grid after 500 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. The subsampled BMIs identified from each sample were archived in labeled vials with a mixture of 70% ethanol and 2% glycerol. A standard taxonomic effort (STE) was used as specified in the California Aquatic Macroinvertebrate Laboratory Network (CAMLnet) short list of taxonomic effort, January 2003 revision. Exceptions were made for some early instar/ young organisms and organisms in poor condition. Other exceptions included: 1) the identification of midges to subfamily/tribe; 2) the identification of Oligochaeta to family when feasible and 3) a tolerance value of 6 was applied to all Oligochaeta (Adams 2004).

2.3.1 Quality Control

One processed BMI sample from the voucher collection was submitted to CDFG's Aquatic Bioassessment Laboratory for independent assessment of taxonomic accuracy, enumeration of organisms and conformance to standard taxonomic level.

2.3.2 Macroinvertebrate Metrics

BMI 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®.

Biological metrics (numerical attributes of biotic assemblages) suggested by the CDFG were generated using Excel® and are described in Appendix C. Tolerance values and functional feeding group designations were obtained from the CAMLnet short list of taxonomic effort, January 2003 revision. The taxonomic list was adjusted to the Level I STE prior to all metric calculations.

The various metrics can be categorized into five main types:

- Richness Measures (reflects the total number of distinct taxa);
- Composition Measures (reflects the distribution of individuals among taxonomic groups and includes measures of diversity);
- Tolerance/Intolerance Measures (reflects the relative sensitivity of the assemblage to disturbance);
- Functional Feeding Groups (shows the balance of feeding strategies in the aquatic assemblage);
- Abundance (estimate total number of organisms in sample based on a nine sq. ft. sampling area)

2.3.3 Composite Metric Score

Finding a consistent pattern in all metrics is overwhelming due to the volume of data, and sometimes metrics can provide conflicting results. Consequently, to better assess the biological integrity of a given site, ten metrics were integrated into a single ranking score for relative comparison to a large regional data set. A regional data set is necessary to develop an Index of

Biological Integrity (IBI); however, at this time, an IBI for the San Francisco Bay Area has not been developed. Therefore, single BMI composite metric scores are calculated for each site to provide a relative ranking of the various sampling stations. This process serves as a placeholder for the eventual development of a regional IBI (P. Ode, CDFG, personal communication).

The composite metric score approach to evaluating BMI metric data is to normalize and sum the means for ten metrics, and then compare the resulting score between the various sampling sites. 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 Predator Richness. The composite metric 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.

The formula for computing the composite metric scores is as follows:

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

> 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).

In addition to plotting composite metric scores by site, composite metric scores were also plotted against substrate quality. Substrate quality scores were determined by adding substrate complexity and substrate embeddedness scores that were assessed qualitatively during benthic sampling. The substrate quality categories are: 0 – 5 (poor); >5 to 10 (marginal); >10 to 15 (suboptimal) and >15 to 20 (optimal).

2.3.4 Macroinvertebrate Composition Analyses

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 until all links are made and no information remains. For example, sites that group at 95% information remaining means that they grouped early in the agglomeration process and are closely related while a link that occurs at 20% information remaining means that the link was made toward the end of the agglomeration process and the group that was linked is relatively dissimilar. The output of the cluster analysis is a tree-like dendrogram, which shows relative site similarity based on BMI composition.

For the farthest downstream site (Gateway Park), the low gradient protocol was used while the high gradient protocol was used for other sites. The data collected from the Gateway Park site is therefore not directly comparable to other sites; however, for the purposes of this study, the Gateway Park data were used in the composition analyses.

2.3.5 Two-Year BMI Data Comparison

In April of 2003, biological assessments were conducted at the same sites shown in Table 1 by the Regional Board and CDFG. The April 2003 data were integrated with April 2004 data for the composite metric score analysis and selected metric comparisons emphasizing taxonomic richness and diversity. For the year 2004 assessment, a 500 organism subsample was used to represent each site while a 900 organism subsample was used to represent each site for the 2003 assessment data. In addition, for the farthest downstream site (Gateway Park), the 2004 assessment used the CDFG low gradient protocol while the 2003 assessment used the CDFG high gradient protocol. The data collected from the Gateway Park site are not directly comparable to data from other sites sampled in 2004 or with data collected at the same site from the previous year; however, for the purposes of this study, the Gateway Park data were used in the two-year comparison. All other aspects of the data set are comparable due to the utilization of the same sampling technique, habitat type sampled, sampling net, net mesh size, area of benthos, subsampling procedure (except for the number of organisms subsampled) and taxonomic level.

3.0 RESULTS

3.1 Macroinvertebrate Metrics

Complete metric results for the San Mateo Creek BMI data set are provided in Table 2.

Richness and Composition Measures

Taxonomic Richness values ranged from 8 at site SMA080 to 33 at the San Mateo Creek reference site (SMA160-R). EPT Taxa values ranged from 1 at sites SMA20 and SMA80 to 16 at the SMA 160-R reference site. Similar differences among sites occurred with EPT Index metric values and there were no sensitive EPT taxa sampled from non-reference sites. Shannon Diversity values ranged from 1.5 or less for the non-reference sites to 2.5 or greater for the reference sites.

Tolerance Measures

Weighted mean tolerance values were 5.6 or greater for non-reference sites and 3.2 or less for reference sites. Percent Intolerant Organism metric values ranged from zero for non-reference sites to 63 for the San Mateo Creek reference site (SMA160-R). Percent Tolerant Organism metric values were low for all sites and ranged from 0.2 percent at the Un-named tributary reference site (SMA180-R) to 3.0 percent at the San Mateo Creek reference site (SMA160-R). Although present in low numbers, the cumulative abundance of the amphipod *Hyalella*, ostracods and sphaeriid clams contributed to the relatively high percentage of tolerant organisms sampled from site SMA160-R.

Functional Feeding Groups (FFG)

Plots of functional feeding groups are presented in Figure 2. Reference sites had more FFGs represented and a more even distribution of individuals within the FFGs when compared to the other sites. In particular, the percentages of predators and shredders were considerably higher at reference sites when compared to the other sites. Relatively high numerical abundance of individuals represented by several stonefly taxa contributed to the high percentage of predators in the reference site samples while caddisfly individuals represented by the genera *Lepidostoma* and *Parthina* contributed to the relatively high percentages of shredders in the reference site samples.

Abundance

Estimated abundance values ranged from 2,100 at site SMA160-R to 7,700 at site SMA020. On average, abundance values were 2.5 times higher at non-reference sites when compared to reference sites.

Table 2. Biological metric values based on the level I standard taxonomic effort for benthic macroinvertebrate assemblages sampled from San Mateo Creek and tributaries, San Mateo County.

	San Mateo Cr.				Polhemus Cr.	Un-named Tributary
Metrics	**SMA 20**	**SMA 60**	**SMA 80**	**SMA 160-R**	**SMA 110**	**SMA 180-R**
Taxonomic Richness	11	11	8	33	12	28
EPT Taxa	1	2	1	16	3	14
Ephemeroptera Taxa	1	1	1	7	2	4
Plecoptera Taxa	0	0	0	4	0	6
Trichoptera Taxa	0	1	0	5	1	4
EPT Index	5.5	40	24	74	25	70
Sensitive EPT Index	0.0	0.0	0.0	64	0.0	44
Shannon Diversity	1.1	1.5	1.3	2.6	1.4	2.5
Dominant Taxon (%)	47	40	38	25	43	19
Tolerance Value	6.0	5.6	5.8	2.7	5.8	3.2
Intolerant Organisms (%)	0.0	0.0	0.0	63	0.0	47
Tolerant Organisms (%)	2.5	2.4	0.2	3.0	0.6	0.2
Collector-Gatherers (%)	98	85	90	44	75	67
Collector-Filterers (%)	0.4	11	9.4	3.6	23	5.3
Scrapers (%)	1.4	2.8	0.2	16	0.2	2.2
Predators (%)	0.2	0.4	0.4	29	0.2	18
Shredders (%)	0.0	0.0	0.2	6.9	0.2	7.7
Other (%)	0.0	0.2	0.0	0.4	1.4	0.0
Estimated Abundance	7,700	4,200	6,500	2,100	4,800	2,500

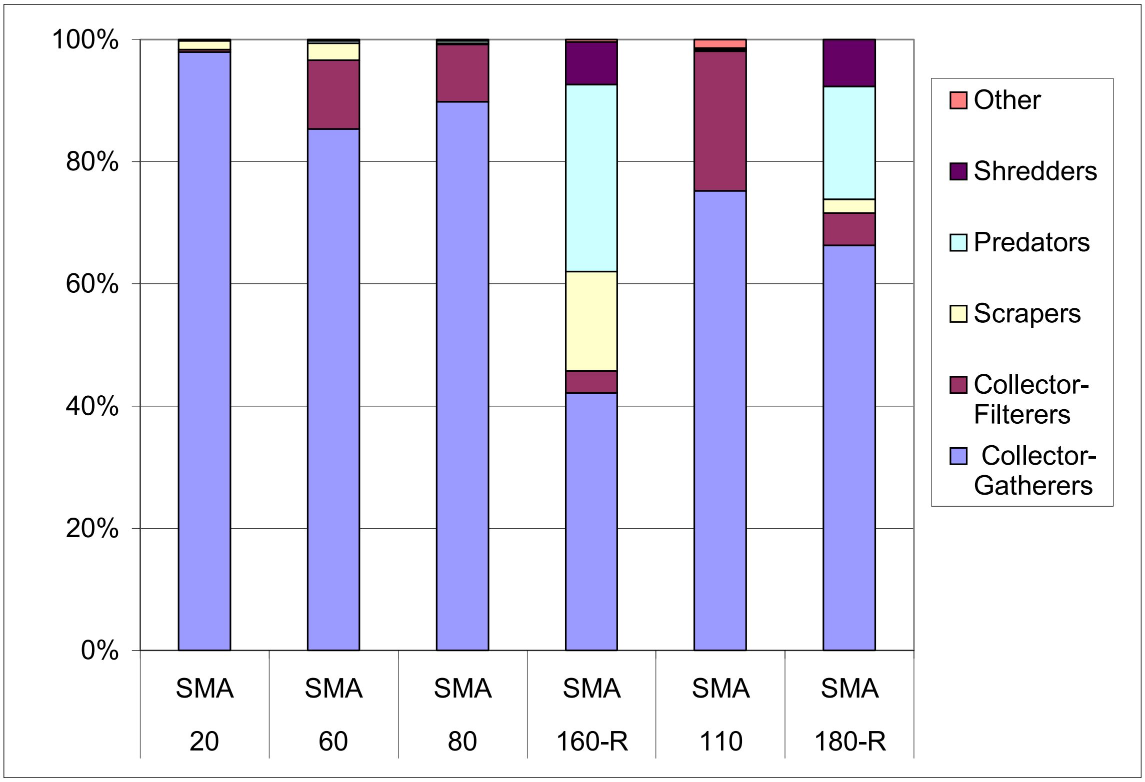


Figure 2. Macroinvertebrate functional feeding groups sampled from San Mateo Creek and tributaries, San Mateo County. Reference sites denoted "R".

3.2 Composite Metric Scores

Metric values for the sites, described above, indicate a trend that is supported by the composite metric scores (Figure 3). Composite metric scores show consistently higher scores for the reference sites when compared to non-reference sites.

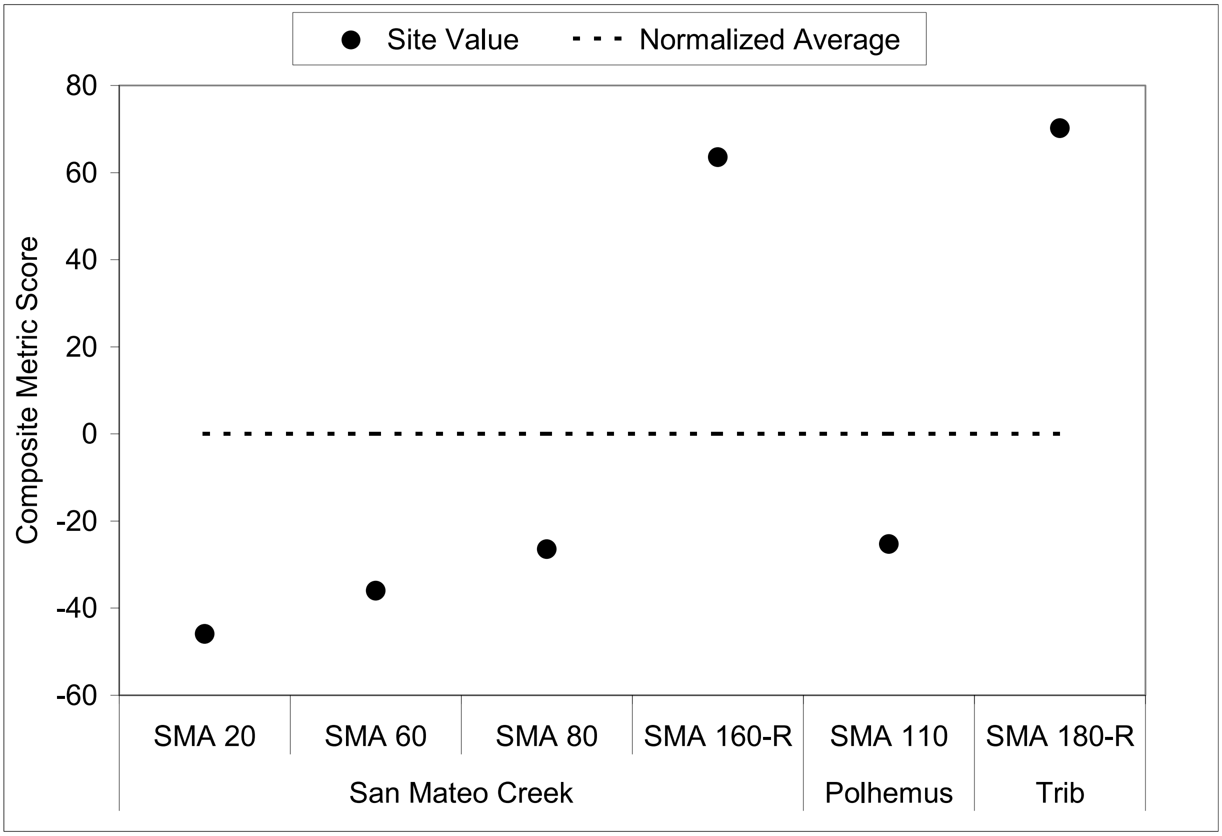


Figure 3. **Composite metric scores for San Mateo Creek and tributaries, San Mateo County; reference sites denoted "R".**

3.3 Dominant Taxa Composition and Taxonomic Similarity

Of the six samples collected in 2004, 3,024 BMIs were processed comprising 62 distinct taxa. Table 3 shows the five most numerically abundant (dominant) taxa at each site based on the modified level 1 STE. Figure 4 is a cluster dendrogram that shows the relative similarity of sites based on the composition of BMIs. A complete taxonomic list including California Tolerance Value (CTV) and functional feeding group (FFG) designations is presented in Appendix D.

Table 3. Numerically dominant benthic macroinvertebrate taxa and their percent contribution by site for San Mateo Creek and tributary sites, San Mateo County. Reference sites denoted "R".

Stream	Site Code	Dominant Taxa 1	2	3	4	5
San Mateo Creek	SMA 20	Naididae 44%	Orthocladiinae 41%	*Baetis* 6%	Chironomini 2%	Enchytraeidae 1%
San Mateo Creek	SMA 60	*Baetis* 40%	Orthocladiinae 24%	Naididae 13%	*Simulium* 10%	Lumbriculidae 4%
San Mateo Creek	SMA 80	Orthocladiinae 34%	Naididae 27%	*Baetis* 24%	*Simulium* 9%	Tanytarsini 4%
San Mateo Creek	SMA 160-R	*Serratella* 25%	Chloroperlidae 15%	Orthocladiinae 9%	*Optioservus* 6%	*Cinygmula/ Parthina* 6%
Polhemus Creek	SMA 110	Orthocladiinae 38%	*Baetis* 24%	*Simulium* 23%	Naididae 6%	Tanytarsini 5%
Un-named Tributary	SMA 180-R	Orthocladiinae 17%	*Ameletus* 17%	*Baetis* 15%	Chloroperlidae 11%	*Paraleptophlebia* 10%

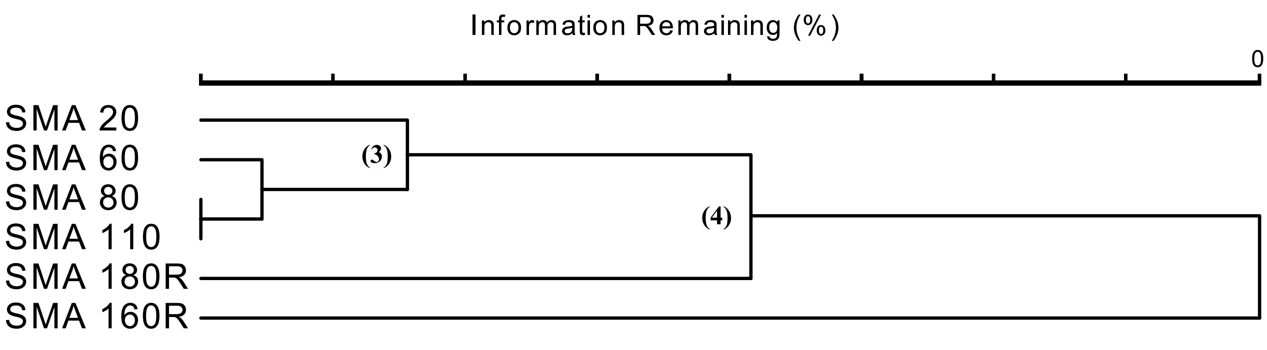


Figure 4. Dendrogram showing degree of site similarity based on taxonomic composition of benthic macroinvertebrates sampled from San Mateo Creek and tributaries, San Mateo County. Site dissimilarity increases as links are made from left to right. Reference sites denoted "R".

Table 3 and Figure 4 indicate distinct dissimilarity of BMI taxonomic composition for reference sites when compared to non-reference sites. Four of the five dominant taxa at the reference sites were comprised of EPT taxa while one EPT taxon, the mayfly (Ephemeroptera) *Baetis*, was dominant at the non-reference sites. Over 40% of individuals sampled from non-reference sites were oligochaetes and midges, while oligochaetes and midges comprised less than 20% of individuals sampled from the reference sites.

At the third level of grouping depicted on the cluster dendrogram (Figure 4), non-reference sites formed one group and non-reference sites formed another group based on taxonomic composition. At the fourth level of grouping, taxonomic composition of site SMA180-R fell within an intermediate level between the non-reference sites and site SMA160-R.

3.4 Quality Control

Results of CDFG's independent review of one sample from the voucher collection is shown in Appendix E. According to CDFG, the taxonomy was very good and performed in accordance with the CSBP level 1 STE. The errors shown in Appendix E were mostly associated with immature specimens, which had not fully developed characteristics used in their identification.

3.5 Habitat and Water Quality Assessment

Habitat assessment results are summarized by site in Table 4; transect scale habitat and supplemental site scale habitat assessment data are presented in Appendix F. Sites were sparsely (8%) to densely (80%) canopied with intact to moderately impaired riparian zones (Table 4; Appendix F). Substrate composition of the sites ranged from fines/gravel dominant to gravel/cobble dominant. Substrate quality scores integrate embeddedness and substrate complexity for estimating epifaunal colonization potential and range from 0 (poor quality) to 20 (high quality). Substrate quality scores ranged from 3.3 at site SMA020 to 15 at site SMA180-R. Stream gradients for the sites ranged from 0.4% to 4.2%.

Site scale habitat scores ranged from 71 at site SMA020 to 181 at site SMA180-R. According to Barbour et al. (1999) the total habitat scores for site SMA020 would imply marginal habitat; sites SMA060, SMA080 would imply suboptimal habitat and sites SMA160-R, SMA110 and SMA180-R would imply optimal habitat. For reference, scores less than 50 would imply poor habitat, scores between >50 and 100 would imply marginal habitat, scores between >100 and 150 would imply suboptimal habitat, and scores greater than 150 would imply optimal habitat.

Water quality conditions fell within ranges typical for the region but these water quality data are of limited value since most of the parameters (pH, dissolved oxygen and temperature) fluctuate on a daily basis due to cycles of photosynthesis associated with primary production. However, specific conductance values suggest differences in water quality of the sites. Specific conductance values for San Mateo Creek sites downstream of Crystal Springs Reservoir were consistent (range: 635 to 650 µS/cm) and over two times the conductance value measured for the site upstream of Crystal Springs Reservoir. Both tributary streams had similar conductance values (1120 and 1240 µS/cm), which were nearly two times the mean conductance of the San Mateo Creek sites downstream of Crystal Springs Reservoir.

Table 4. Physical habitat and water quality constituents documented for San Mateo Creek and tributaries, San Mateo County. Reference sites denoted "R".

	San Mateo Creek				Polhemus Creek	Un-named tributary
Habitat Parameters	**SMA 020**	**SMA 060**	**SMA 080**	**SMA 160-R**	**SMA 110**	**SMA 180-R**
Riffle Characteristics						
Mean Length (ft)	34.7	4.7	5.3	8.7	9.0	19.3
Mean Width (ft)	16.8	11.0	12.1	2.2	7.2	3.6
Mean Depth (ft)	0.4	0.2	0.2	0.1	0.2	0.2
Mean Velocity (ft/sec)		4.2	3.2			
Subjective Assessment						
% Canopy	8.3	75	47	73	73	80
Substrate Complexity (1-10)	1.3	2.0	2.7	3.3	4.3	8.0
Embeddedness (1-10)	2.0	4.7	4.7	5.0	4.7	7.0
Substrate Quality Score	3.3	6.7	7.3	8.3	9.0	15.0
% Fines (<2 mm)	47	18	12	37	8.3	5.0
% Gravel (2-50 mm)	48	47	32	60	42	28
% Cobble (50-256 mm)	3.3	33	57	3.3	42	50
% Boulder (>256 mm)	1.7	1.7	0.0	0.0	6.7	17
% Bedrock (soild)	0.0	0.0	0.0	0.0	1.7	0.0
Substrate Consolidation	low	low	low	low	low	high
Reach Characteristics						
Total Length (ft)	175	113	72	108	77	126
% Gradient	0.4	0.4	0.4	1.2	4.2	3.6
Habitat Quality Score	71	101	112	162	155	181
Water Quality Conditions						
Time of Sampling	1100	0845	1145	1315	0900	1025
Water Temperature (ºC)	13.2	12.1	12.2	10.47	11.5	10.6
Specific Conductance (uS/cm)	640	650	635	268	1120	1242
pH	8.56	8.06	8.12	7.47	8.36	7.92
Dissolved Oxygen (mg/l)	10.9	9.0	10.0	9.3	10.0	9.2

3.6 Habitat Quality and Benthic Macroinvertebrates

While site scale habitat and substrate quality may have contributed to differences in BMI assemblages (Figures 5 and 6), other factors may have been more important influences on BMI assemblage quality. The Polhemus non-reference site, with good habitat quality (score of 155) and moderate substrate quality, had a substantially lower composite metric score (-22) when compared to reference site composite metric scores (Figures 6 and 7).

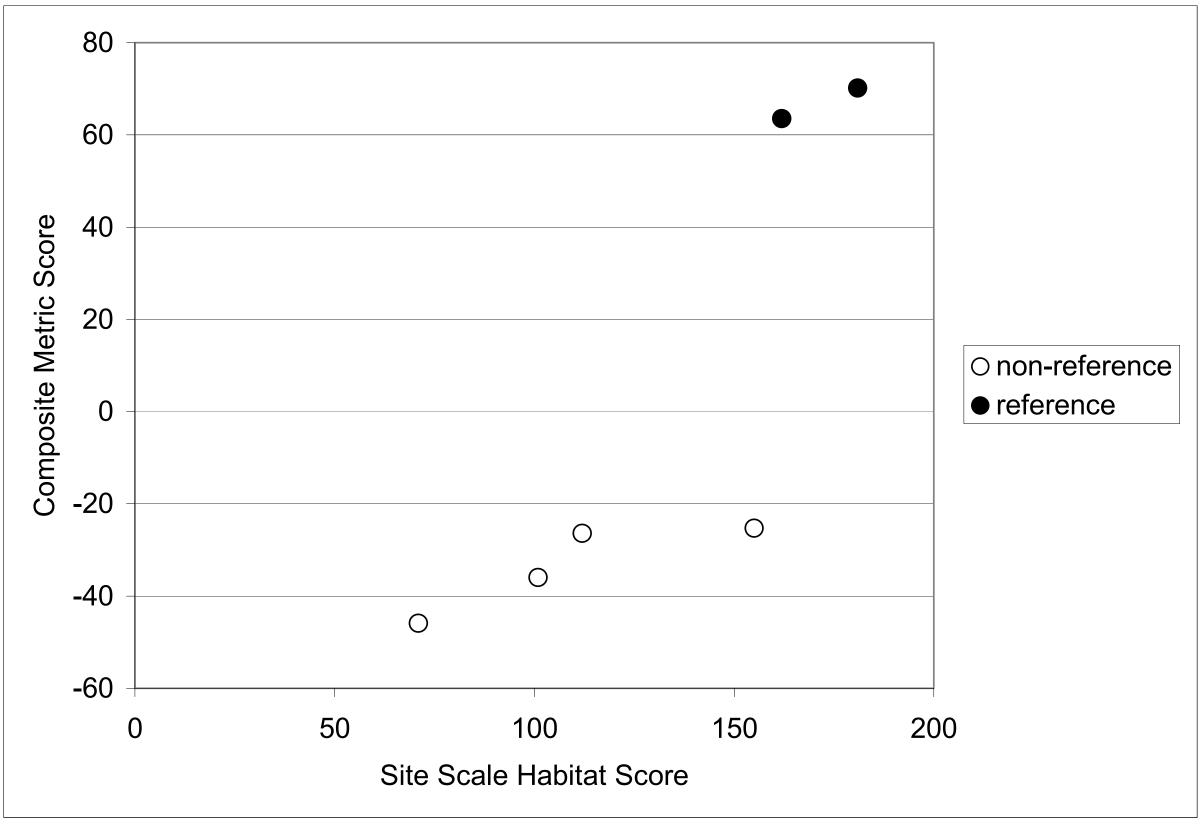


Figure 5. Site scale habitat scores vs. composite metric scores for the San Mateo Creek biological assessment project, San Mateo County.

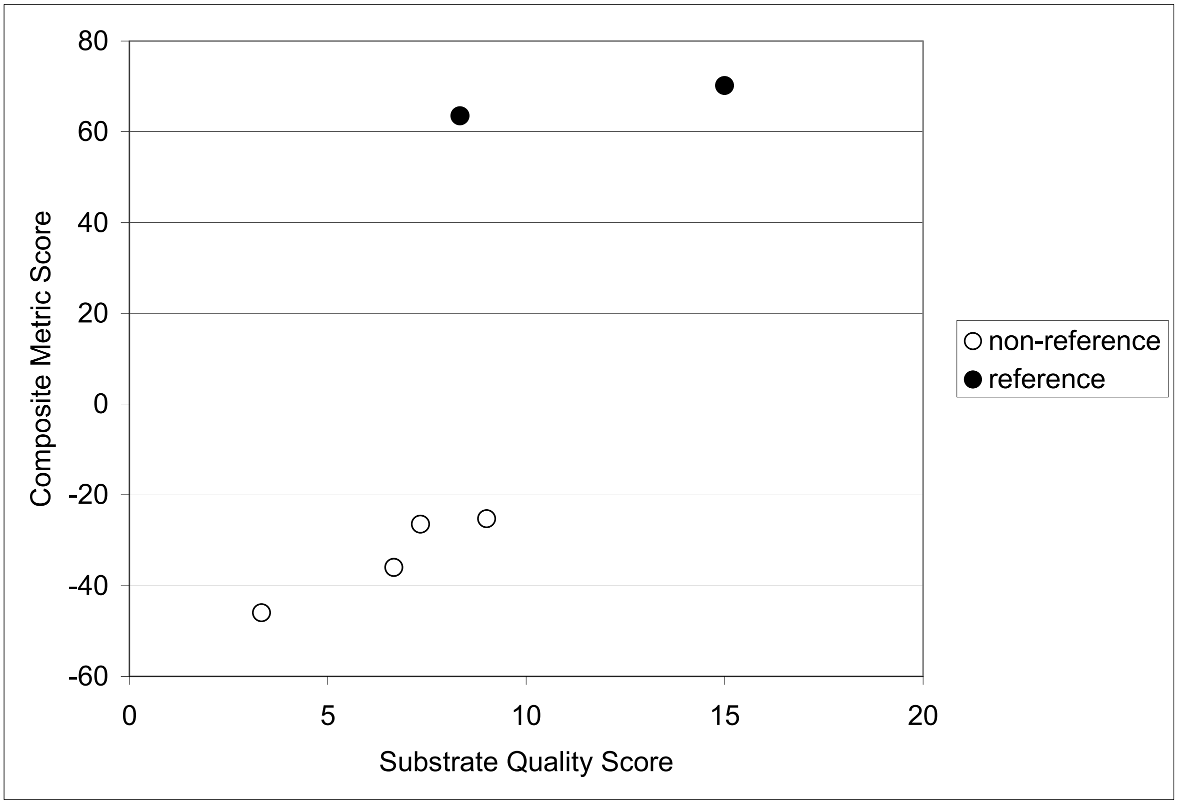


Figure 6. **Substrate quality scores vs. composite metric scores for the San Mateo Creek biological assessment project, San Mateo County.**

3.7 Two-Year BMI Comparison

Trends in variation of composite metric scores were consistent for the assessments conducted in years 2003 by the Regional Board and 2004 by Program staff (Figure 7). Annual variation of metric values was relatively small when compared to variation of metric values between reference sites and non-reference sites. Several metrics associated with richness and diversity, which were used for generating the composite metric score plot, are shown in Figure 8. As would be expected, the plots of individual metric values (Figure 8) follow the same trends shown in Figure 7. Note that site SMA 160-R shows some variation in richness and diversity between years but overall metric value results, as reflected in the composite metric score plot, shows high annual consistency.

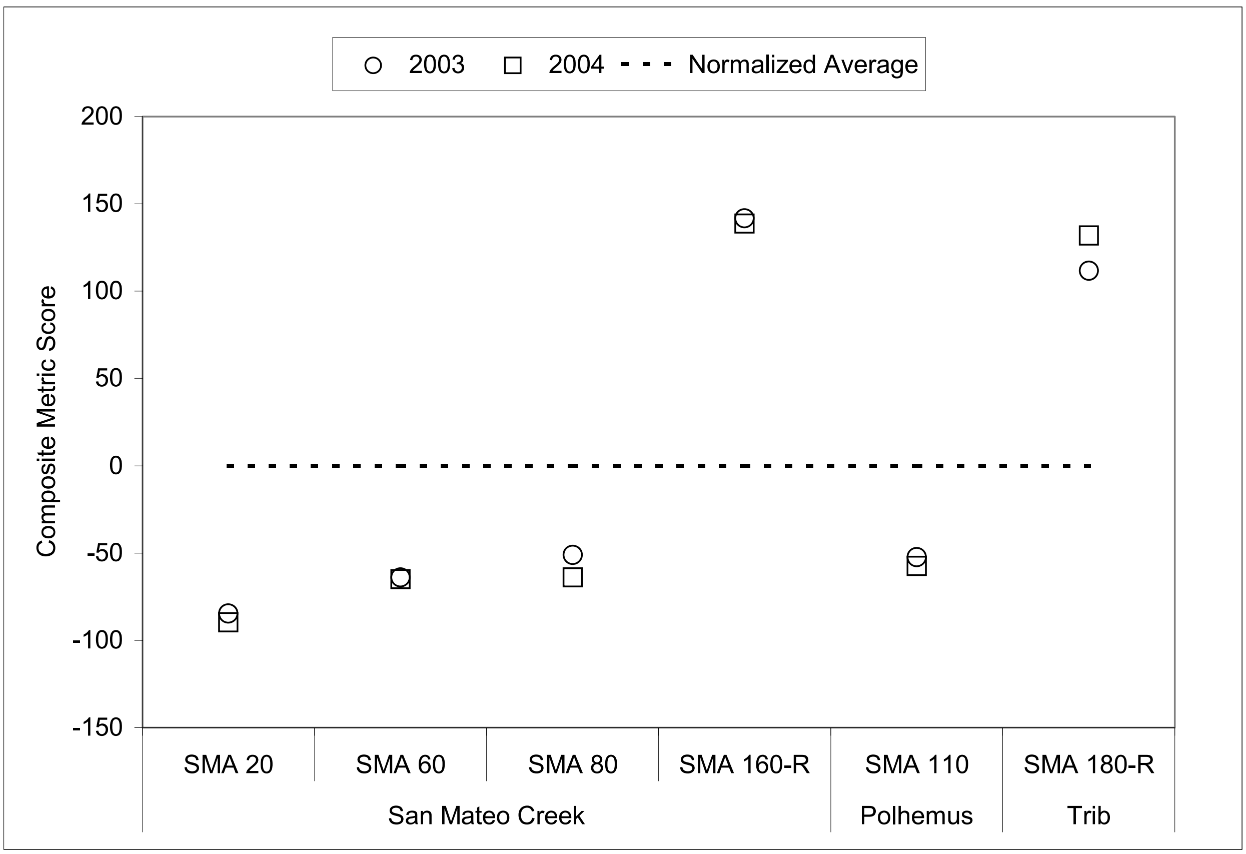


Figure 7. Composite metric scores for San Mateo Creek and tributaries for years 2003 and 2004, San Mateo County; reference sites denoted "R". Year 2003 data were obtained from the Regional Board.

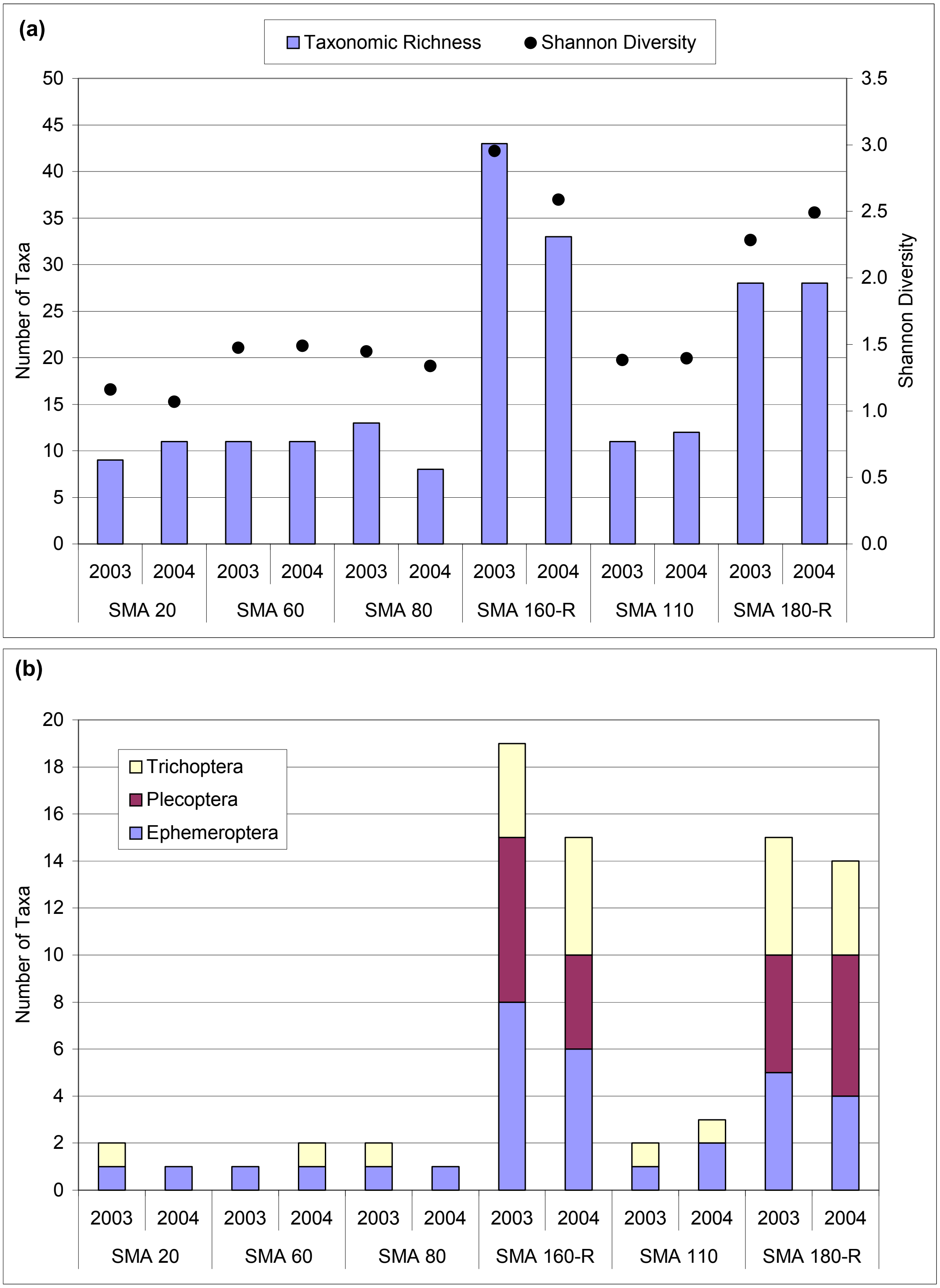


Figure 8. Biological metrics associated with taxonomic richness/ diversity (a) and EPT richness (b) for San Mateo Creek and tributaries for years 2003 and 2004, San Mateo County; reference sites denoted "R". Year 2003 data were obtained from the CDFG and Regional Board.

4.0 DISCUSSION

4.1 Evaluating Influences on Benthic Fauna

Since reference conditions have not been established in California, it is difficult to know what range of biotic metric values would be considered typical for a given region. 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 assemblage quality. It should be noted that the metrics used for this assessment are widely used (Karr and Chu 1999) 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 the limitations of the composite metric scores, a consistent partitioning of sites by BMI assemblage quality was clearly evident: The reference sites (SMA160-R and SMA180-R) had considerably higher composite metric scores when compared to the non-reference sites and annual variation between two years (2003 and 2004) was negligible. The yearly consistency in composite metric scores is noteworthy because samples were collected by different sampling crews and samples were processed by different laboratories. However, sampling and sample processing was performed using the same procedure except for the number of organisms subsampled.

4.2 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 peak discharges, 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 and clams. 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).

Several factors could be contributing to the variation in BMI assemblage quality observed for San Mateo Creek sites. Factors associated with elevation such as gradient, canopy cover, stream width, substrate composition, allochthonous input, depth and temperature regime have been shown to influence the composition of benthic fauna along elevational gradients as described by Vannote et al. (1980) in the River Continuum Concept. Other investigators, as described by Allan (1995) and Merritt and Cummins (1996) have shown these factors, individually and in various combinations, to be important influences on benthic fauna. Localized substrate quality and overall habitat quality, perhaps influenced by site elevation, appeared to have had an effect on BMI assemblages for sites within the San Mateo watershed as shown by Figures 5 and 6.

The extent of urbanization in the San Mateo Creek watershed is described in Table 1 and shown in Figure 1 by the higher density of paved road surfaces. As the extent of urbanization decreases with increasing elevation within the watershed, BMI assemblage quality increased with the highest quality assemblages occurring at the sites upstream of most urbanization. Additional urban impacts caused by downstream effects of the Crystal Springs Reservoir also influence the three lower San Mateo Creek sites. While factors associated with local habitat may have influenced the BMI assemblages, the data suggest that urbanization, including the dam, had a substantial effect on BMI assemblage quality. For example, one non-reference site (SMA 110) with good habitat quality and moderate substrate quality had a considerably lower composite metric score when compared to the reference sites with similar habitat quality. This suggests that factors associated with urbanization, in addition to local habitat quality, were affecting BMI assemblages.

It is difficult to separate natural factors associated with elevation from factors associated with urbanization because urbanization can alter, to varying degrees, some habitat features that change with elevation such as channel shape and substrate quality. However, as more standardized data are compiled through time and locale, factors influencing the quality of BMI assemblages may be more clearly differentiated and consistent patterns of BMI distribution and assemblage quality may emerge.

5.0 LITERATURE CITED

Adams, JW. 2004. Stream bugs as biomonitors: Guide to Pacific Northwest macroinvertebrate monitoring and identification. CD-ROM.

Allan, J. D. 1995. Stream Ecology- Structure and Function of Running Waters. 1st ed. Chapman & Hall. xii, 388pp.

Bailey, R. G. 1995. Descriptions of the Ecoregions of the United States, 2nd edition. Miscellaneous Publication No. 1391, U. S. Department of Agriculture, Forest Service, Washington D. C., 108 pp.

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.

San Mateo Countywide Stormwater Pollution Prevention Program (STOPPP). 2002. Characterization of imperviousness and creek channel modifications for seventeen watersheds in San Mateo County. January 1, 2002.

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

Field data sheets used for recording habitat quality during biological assessments in April 2004

CALIFORNIA STREAM BIOASSESSMENT WORKSHEET

WATERSHED/ STREAM: ____________________ DATE/ TIME: ____________________

COMPANY/ AGENCY: ____________________ SAMPLE ID#: ____________________

SITE DESCRIPTION: ____________________

SAMPLING CREW

____

____

SITE INFORMATION

GPS Coordinates

Latitude: ____________________

Longitude: ____________________

Elevation: ____________________

Ecoregion: ____________________

COMMENTS:

____

____

____

____

CHEMICAL CHARACTERISTICS

Water Temperature: ____________

Specific Conductance: ____________

pH: ____________

Dissolved Oxygen: ____________

SITE PHOTOGRAPHS

RIFFLE/ REACH CHARACTERISTICS

Point Source Sampling Design

Riffle Length: ______

Transect 1: ______

Transect 2: ______

Transect 3: ______

(Record Physical Habitat Characterization in riffle 1 column)

Non-Point Source Sampling Design

Reach Length: ______

Physical Habitat Quality Score: ______

Physical / Habitat Characteristics

Units: ________

	Riffle 1	Riffle 2	Riffle 3
Riffle Length:	______	______	______
Transect Location:	______	______	______
Avg. Riffle Width:	______	______	______
Avg. Riffle Depth:	______	______	______
Riffle Velocity:	______	______	______
% Canopy Cover:	______	______	______
Substrate Complexity:	______	______	______
Embeddedness:	______	______	______
Substrate Composition:			
Fines (<0.1”):	______	______	______
Gravel (0.1-2”):	______	______	______
Cobble (2-10”):	______	______	______
Boulder (>10”):	______	______	______
Bedrock (solid):	______	______	______
Substrate Consolidation:	______	______	______
Percent Gradient:	______	______	______

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

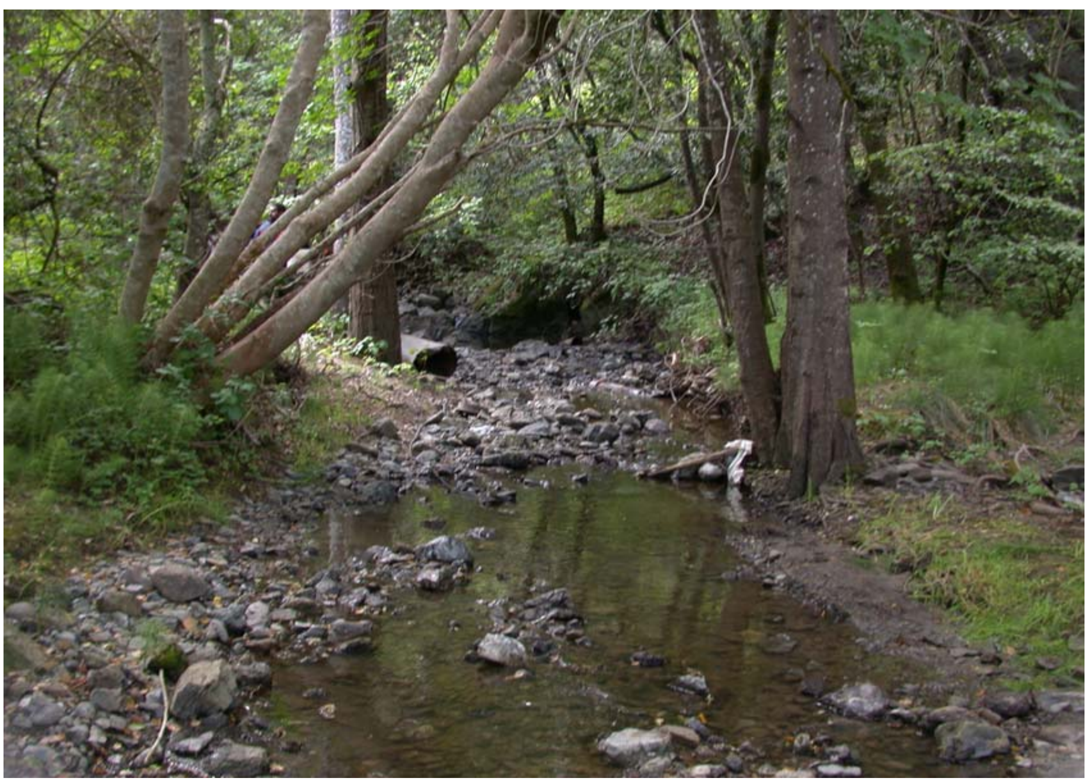
APPENDIX B

Photographs of San Mateo Creek
BMI Sampling Sites

Site SMA020 – San Mateo Creek at Gateway Park.

Site SMA060 – San Mateo Creek at Arroyo Court Park at Dartmouth.

Site SMA080 – San Mateo Creek at Sierra Drive.



Site SMA110 – Polehemus Creek at San Mateo Creek confluence.

Site SMA160 – San Mateo Creek above Mud Dam along Pilarcitos Ridge Road.

Site SMA180 – Un-named tributary above Old Canada Road past Adobe Gulch.

APPENDIX C

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 D

Taxonomic list of benthic macroinvertebrates sampled from San Mateo Creek and tributaries, April 2004

Final ID	CTV[1]	FFG[2]	San Mateo Creek SMA 20	SMA 60	SMA 80	SMA 160-R	PC[3] SMA 110	UNT[4] SMA 180-R
Arthropoda								
Insecta								
Coleoptera								
Elmidae								
Optioservus	4	sc				31		5
Optioservus (adult)	4	cg				10		
Hydraenidae								
Hydraena (adult)	5	sc				1		
Hydrophilidae	5	p						4
Diptera								
Ceratopogonidae								
Atrichopogon	6	cg						1
Bezzia/ Palpomyia	6	p			1			8
Chironomidae								
Chironomini	6	cg	8	2	1	1		
Orthocladiinae	5	cg	202	119	175	43	195	85
Tanypodinae	7	p				11		1
Tanytarsini	6	cg	5	19	20	1	27	6
Dixidae								
Dixa	2	cg				1		12
Dixidae	2	cg						2
Dolichopodidae								
Dolichopodidae	4	p						3
Pelecorhynchidae								
Glutops	3	p				1		
Psychodidae								
Psychoda	10	cg	1				1	1
Simuliidae								
Prosimulium	3	cf				1		
Simulium	6	cf	1	50	49	8	117	4
Stratiomyidae								
Caloparyphus	7	cg		1			4	2
Tipulidae								
Dicranota	3	p				2		
Hexatoma	2	p				1		
Limonia	6	sh			1		1	1
Tipula	4	om				1		
Ephemeroptera								
Ameletidae								
Ameletus	0	cg				1		84
Baetidae								
Baetis	5	cg	27	201	125	15	121	74
Diphetor hageni	5	cg				6		
Ephemerellidae								
Ephemerellidae	1	cg				5		
Serratella	2	cg				120		
Heptageniidae								
Cinygmula	4	sc				31		
Leucrocuta/Nixe	1	sc				15		6

Final ID	CTV[1]	FFG[2]	San Mateo Creek SMA 20	SMA 60	SMA 80	SMA 160-R	PC[3] SMA 110	UNT[4] SMA 180-R
Leptophlebiidae								
Paraleptophlebia	4	cg						48
Siphlonuridae								
Siphlonurus	7	cg					1	
Megaloptera								
Corydalidae								
Neohermes	0	p						1
Sialidae								
Sialis	4	p				1		
Plecoptera								
Chloroperlidae								
Chloroperlidae	1	p				67		12
Sweltsa	1	p				11		40
Leuctridae								
Paraleuctra	0	sh				3		
Nemouridae								
Malenka	2	sh						8
Peltoperlidae								
Soliperla	1	sh						1
Perlidae								
Calineuria californica	1	p				17		2
Perlodidae								
Isoperla	2	p				6		
Kogotus nomus	2	p						1
Perlodidae	2	p				8		9
Trichoptera								
Hydroptilidae								
Hydroptila	6	ph					7	
Hydroptilidae	4	ph		1				
Ochrotrichia	4	ph				1		
Lepidostomatidae								
Lepidostoma	1	sh				1		28
Odontoceridae								
Parthina	0	sh				31		
Philopotamidae								
Dolophilodes	2	cf						22
Polycentropodidae								
Polycentropus	6	p						5
Rhyacophilidae								
Rhyacophila	0	p				27		4
Uenoidae								
Neophylax	3	sc				4		
Arachnoidea								
Acari								
Acari	5	p	1					1
Hygrobatidae								
Atractides	8	p				2		
Sperchontidae								
Sperchon	8	p		2	1			

Final ID	CTV[1]	FFG[2]	San Mateo Creek SMA 20	SMA 60	SMA 80	SMA 160-R	PC[3] SMA 110	UNT[4] SMA 180-R
Torrenticolidae								
Torrenticola	5	p				1		
Malacostraca								
Amphipoda								
Hyalellidae								
Hyalella	8	cg	2	2		3		
Ostracoda								
Ostracoda	8	cg	5			1	1	
Annelida								
Oligochaeta								
Oligochaeta	6	cg						12
Lumbriculida								
Lumbriculidae								
Lumbriculidae	6	cg		19	4	1		
Tubificida								
Enchytraeidae								
Enchytraeidae	6	cg	6		3		4	
Naididae								
Naididae	6	cg	215	68	140		32	
Tubificidae								
Tubificidae	6	cg	6					
Molluska								
Bivalvia								
Pelecypoda								
Sphaeriidae								
Sphaeriidae	8	cf	1	7		9		
Gastropoda								
Pulmonata								
Lymnaeidae								
Fossaria	8	sc	3					
Physidae								
Physa/ Physella	8	sc		1			1	
Planorbidae								
Planorbidae	6	sc	4	13	1			
Platyhelminthes								
Turbellaria								
Tricladida								
Planariidae								
Planariidae	4	p					1	

1 Califrornia Tolerance Value

2 Functional Feeding Group:
collector-gatherer (cg); collector-filterer (cf); scraper (sc); predator (p); shredder (sh)
Note: omnivore (om) and piercer herbivore (ph) placed into other (ot) category for metric calculations

3 Polhemus Creek

4 Un-named Tributary

APPENDIX E

Quality control results for the San Mateo Creek biological assessment project, April 2004

DEPARTMENT OF FISH AND GAME

AQUATIC BIOASSESSMENT LABORATORY-CHICO
CALIFORNIA STATE UNIVERSITY, CHICO
CHICO, CA 95929-0555
530-898-4792

July 27, 2004

Tom King
BioAssessment Services Inc.
PMB 164
24988 Blue Ravine Road, Suite 108
Folsom, CA 95630

Dear Tom,

Attached are the results of our QC analysis of 3 BMI samples from the San Mateo and Santa Clara project from spring 2004. The results are presented in four summary tables.

Overall taxonomy was very good and performed in accordance with the CSBP 1 standards. The summary tables are self explanatory and describe our QC findings. One thing we would like to point out is early instar Caloparyphus and Euparyphus cannot be differentiated based on the thoracic spiracle character because the character doesn't develop until the 4th larval instar (Sinclair, B.J. 1989. The biology of Euparyphus Gerstaecker and Caloparyphus James occurring in madicolous habitats of eastern North America, with descriptions of adult and immature stages (Diptera: Stratiomyidae). Canadian Journal of Zoology 67:33-41).

We welcome any questions or comments you may have concerning this report.

Sincerely,

Joe Slusark and Brady Richards

Comparative Taxonomic Listing of all Submitted Samples

Samples submitted by BioAssessment Services for Project: San Mateo and Santa Clara, spring 2004.

Report prepared by J. Slusark CDFG ABL-Chico, 7/22/2004

Taxonomis	Sample no.	Vial	Original	Original Count	Stag	ABL Coun	ABL ID
	BAS-1830						
		1	Atractides	2		2	Atractides
		2	Torrenticola	1		1	Torrenticola
		3	Lumbriculidae	1		1	Lumbricina
		4	Pisidium	9		9	Pisidium
		5	Hyallela	3		3	Hyalella
		6	Ostracoda	1		1	Ostracoda
		7	Leucrocuta/ Nixe	15		15	Heptageniidae
		8	Serratella	120		120	Serratella
		9	Cinygmula	31		31	Cinygmula
		10	Ameletus	1		1	Ameletus
		11	Baetis	15		15	Baetis
		12	Diphetor hageni	6		6	Diphetor hageni
		13	Ephemerellidae	5		4	Serratella
		14	Calineuria californica	17		17	Calineuria californica
		15	Chloroperlidae	67		62	Chloroperlidae
		16	Paraleuctra	3		3	Paraleuctra
		17	Isoperla	6		7	Isoperla
		18	Perlodidae	8		2	Perlodidae
		18	Perlodidae	8		6	Calineuria californica
		19	Sweltsa	11		11	Sweltsa
		20	Neophylax	4		4	Neophylax
		21	Parthina	31		31	Parthina
		22	Ochrotrichia	1		1	Ochrotrichia
		23	Rhyacophila	27		27	Rhyacophila
		24	Lepidostoma	1		1	Lepidostoma
		25	Hydraena	1	A	1	Hydraena
		26	Optioservus	31		31	Optioservus

Taxonomis	Sample no.	Vial	Original	Original Count	Stag	ABL Coun	ABL ID
	BAS-1830						
		27	Optioservus	10	A	10	Optioservus
		28	Sialis	1		1	Sialis
		29	Simulium	8		8	Simulium
		30	Glutops	1		1	Glutops
		31	Hexatoma	1		1	Hexatoma
		32	Dicranota	2		2	Dicranota
		33	Tipula	1		1	Holorusia hespera
		34	Prosimulium	1		1	Prosimulium
		35	Dixa	1		1	Dixa
		36	Chironomini	1		1	Chironomini
		37	Tanytarsini	1		1	Tanytarsini
		38	Orthocladiinae	43		43	Orthocladiinae
		39	Tanypodinae	11		11	Tanypodinae

APPENDIX F

Habitat data collected during benthic sampling for the San Mateo Creek biological assessment project, April 2004

	SMA 020			SMA 060			SMA 080		
Riffle Characteristics	R1	R2	R3	R1	R2	R3	R1	R2	R3
Length (ft)	90	4	10	2	3	9	3	3	10
Width (ft)	13	19.5	18	11	8	14	10.67	8.5	17
Depth (ft)	0.58	0.22	0.38	0.18	0.18	0.17	0.2	0.25	0.19
Velocity (ft/sec)				4.74	3.72	4.1	3.15	3.31	
Subjective Assessment									
% Canopy	10	0	15	90	95	40	65	35	40
Substrate Complexity (1-10)	1	1	2	2	2	2	2	3	3
Embeddedness (1-10)	2	2	2	4	5	5	5	4	5
Substrate Quality Score	3	3	4	6	7	7	7	7	8
% Fines (<2 mm)	50	45	45	20	15	20	10	10	15
% Gravel (2-50 mm)	50	50	45	45	45	50	35	30	30
% Cobble (50-256 mm)	0	5	5	35	35	30	55	60	55
% Boulder (>256 mm)	0	0	5	0	5	0	0	0	0
% Bedrock (solid)	0	0	0	0	0	0	0	0	0
Substrate Consolidation	low	low	low	low	low	low	low	low	low

Riffle Characteristics	SMA 110			SMA 160			SMA 180		
Length (ft)	R1	R2	R3	R1	R2	R3	R1	R2	R3
Width (ft)	9	6	12	4	12	10	20	26	12
Depth (ft)	6	8.5	7	2.3	1.7	2.5	4.2	3	3.5
Velocity (ft/sec)	0.16	0.12	0.17	0.13	0.17	0.13	0.2	0.13	0.12
Subjective Assessment									
% Canopy									
Substrate Complexity (1-10)	60	70	90	60	80	80	50	95	95
Embeddedness (1-10)	4	4	5	3	3	4	8	8	8
Substrate Quality Score	5	5	4	5	5	5	7	7	7
% Fines (<2 mm)	9	9	9	8	8	9	15	15	15
% Gravel (2-50 mm)	5	10	10	40	35	35	5	5	5
% Cobble (50-256 mm)	50	40	35	60	60	60	30	30	25
% Boulder (>256 mm)	40	45	40	0	5	5	50	50	50
% Bedrock (solid)	5	5	10	0	0	0	15	15	20
Substrate Consolidation	0	0	5	0	0	0	0	0	0
	low	low	low	low	low	low	high	high	high

Habitat Parameter	San Mateo Creek SMA 020	SMA 060	SMA 080	SMA 160	Polhemus SMA 110	Un-named trib SMA 180
Epifaunal Substrate/ Available Cover	3	5	5	16	12	18
Embeddedness	4	9	10	10	11	18
Velocity/Depth Regime	5	12	10	17	16	15
Sediment Deposition	4	5	7	13	13	19
Channel Flow Status	18	18	18	18	18	18
Channel Alteration	3	8	11	17	18	20
Frequency of Riffles	2	16	13	13	18	16
Bank Stability	18	11	14	20	16	19
Vegetative Protection	12	10	12	19	16	20
Riparian Vegetative Zone Width	2	7	12	19	17	18
Total Score	71	101	112	162	155	181

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APPENDIX B

Water Quality Testing Report Prepared by Kinnetic Laboratories, Incorporated

San Mateo Countywide
Stormwater Pollution
Prevention Program

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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 Mateo Creek Watershed Monitoring Report

Water was collected from four stream sites in the San Mateo Creek watershed (Figure 1). Station IDs (identifications), descriptions, and locations are listed in Table 1. Sampling was performed during the wet season (January-March).

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 an 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 for organophosphorus pesticide concentrations are shown in Tables 3. No organophosphorus pesticide analytes were detected in any of the samples.

Water samples were tested for toxicity during the dry season sampling event and the wet season sampling event at sampling station stations B-1, LP-1, UP-1, and LS-1. To test the water samples for toxicity, three species bioassays were performed using the water flea (*Ceriodaphnia dubia*), the fathead minnow (*Pimephales promelas*), and the green algae (*Selenastrum capricornutum*). No sampling station showed a decrease in survival for the water flea or fathead minnow. There was no inhibition of growth observed for either the fathead minnow or green algae tests performed for all sampling stations. With the exception of sampling site SMA080 (San Mateo Creek at Sierra Drive), there was no inhibition of reproduction for the water flea. Only a very slight inhibition of reproduction for the water flea was observed in the sample from SMA080.

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

Jonathan Toal

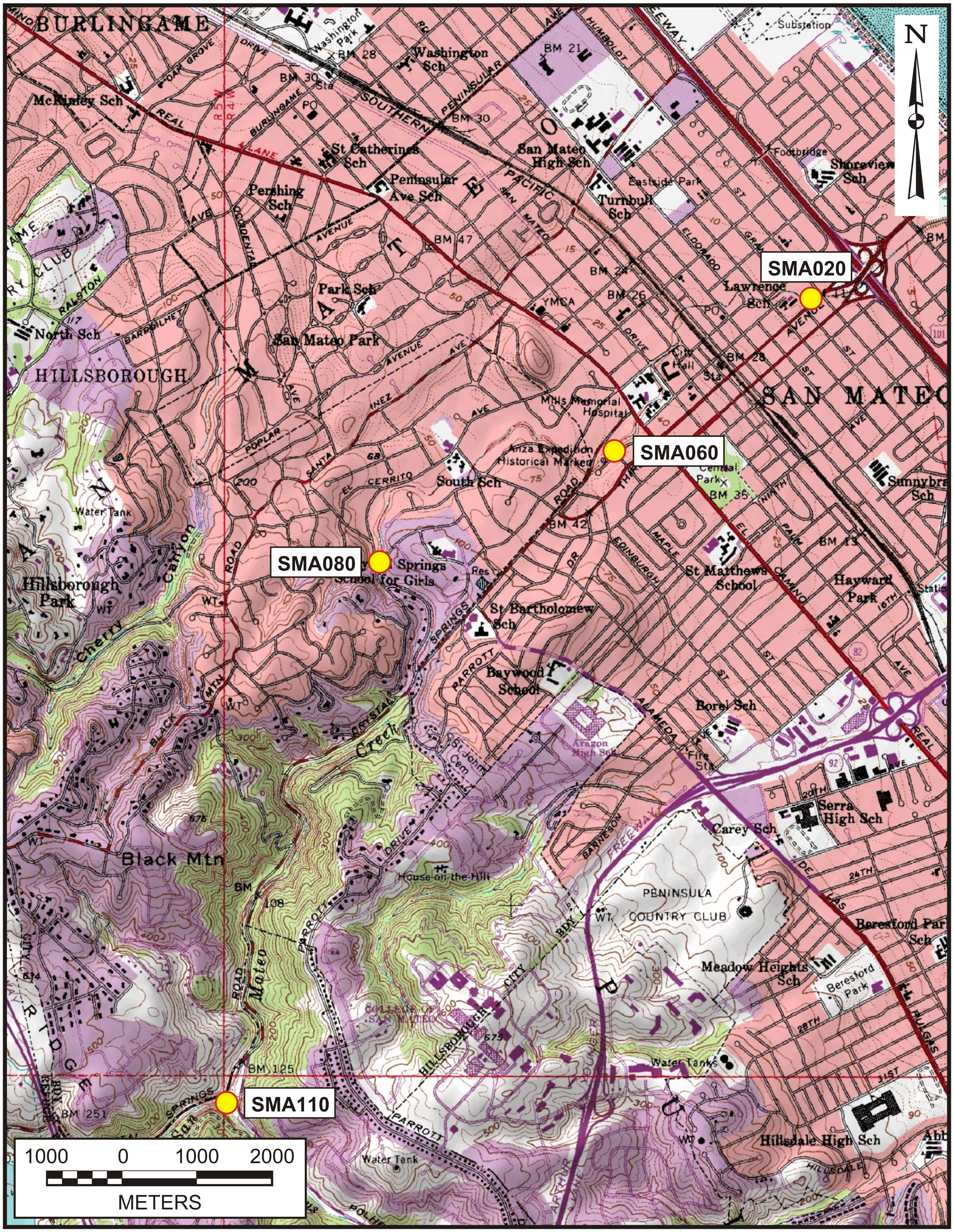

Figure 1. San Mateo Creek Watershed Monitoring Sampling Sites SMA020 (Gateway Park), SMA060 (Arroyo Court Park), SMA080 (Sierra Drive), and SMA110 (Polhemus Creek).

Table 1. Sampling Locations (24 February 2004).

Station ID and Description		Latitude	Longitude
San Mateo Creek Watershed			
SMA020	San Mateo Creek at Gateway Park.	37° 34.171’	122° 19.017’
SMA060	San Mateo Creek at Arroyo Court Park	37° 33.751’	122° 19.704’
SMA080	San Mateo Creek at Sierra Drive	37° 33.449’	122° 20.517’
SMA110	Polhemus Creek upstream of San Mateo Creek confluence	37° 31.957’	122° 21.053’

Table 2. General Water Quality Measurements (24 February 2004).

Station ID and Description		pH	Temp. (°C)	Cond. (µS/cm)	D.O. (mg/L)	Velocity (ft/sec)
SMA020	San Mateo Creek at Gateway Park.	7.89	11.8	447.8	9.22	0.84
SMA060	San Mateo Creek at Arroyo Court Park	8.09	12.0	461.0	10.59	0.35
SMA080	San Mateo Creek at Sierra Drive	8.03	12.0	438.5	11.01	0.24
SMA110	Polhemus Creek upstream of San Mateo Creek confluence	8.31	12.0	400.6	11.32	0.28

Table 3. Water Quality Results (24 February 2004).

	Stations			
	SMA020	**SMA060**	**SMA080**	**SMA110**
***ORGANOPHOSPHORUS PESTICIDES* (ug/L)**				
Azinphos menthyl	0.100U	0.100U	0.100U	0.100U
Bolstar	0.0500U	0.0500U	0.0500U	0.0500U
Coumaphos	0.0500U	0.0500U	0.0500U	0.0500U
Demeton, o and s	0.0500U	0.0500U	0.0500U	0.0500U
Diazinon	0.0100U	0.0100U	0.0100U	0.0100U
Dichlorvos	0.0500U	0.0500U	0.0500U	0.0500U
Disulfoton	0.0500U	0.0500U	0.0500U	0.0500U
Chlorpyrifos	0.0500U	0.0500U	0.0500U	0.0500U
Ethoprop	0.0500U	0.0500U	0.0500U	0.0500U
Fensulfothion	0.0500U	0.0500U	0.0500U	0.0500U
Fenthion	0.0500U	0.0500U	0.0500U	0.0500U
Merphos	0.0500U	0.0500U	0.0500U	0.0500U
Mevinphos	0.0500U	0.0500U	0.0500U	0.0500U
Parathion-methyl	0.0500U	0.0500U	0.0500U	0.0500U
Phorate	0.0500U	0.0500U	0.0500U	0.0500U
Ronnel	0.0500U	0.0500U	0.0500U	0.0500U
Stirophos	0.0500U	0.0500U	0.0500U	0.0500U
Tokuthion (Prothiofos)	0.0500U	0.0500U	0.0500U	0.0500U
Trichloronate	0.0500U	0.0500U	0.0500U	0.0500U
Ethion	0.0500U	0.0500U	0.0500U	0.0500U
Malathion	0.0500U	0.0500U	0.0500U	0.0500U
Parathion-ethyl	0.0500U	0.0500U	0.0500U	0.0500U

SMA020 = San Mateo Creek at Gateway Park
SMA060 = San Mateo Creek at Arroyo Court Park
SMA080 = San Mateo Creek at Sierra Drive
U = Not measured above reported sample method detection limit

Table 4. San Mateo Creek Watershed Monitoring Summary of Bioassay Results (24 February 2004).

Sample	Survival NOEC	Survival LOEC	Survival LC_{50}	Reproduction NOEC	Reproduction LOEC	Reproduction IC_{50}	Reproduction IC_{25}	Reproduction IC_{10}
Ceriodaphnia dubia								
SMA020	100	>100	>100	100[1]	>100[1]	>100[1]	>100[1]	>100[1]
SMA060	100	>100	>100	100	>100	>100	>100	>100
SMA080	100	>100	>100	100	>100	>100	>100	55.8
SMA110	100	>100	>100	100	>100	>100	>100	>100
Pimephales promelas								
SMA020	100	>100	>100	100	>100	>100	>100	>100
SMA060	100	>100	>100	100	>100	>100	>100	>100
SMA080	100	>100	>100	100	>100	>100	>100	>100
SMA110	100	>100	>100	100	>100	>100	>100	>100
Selenastrum capricornutum								
SMA020	NA	NA	NA	100	>100	>100	>100	>100
SMA060	NA	NA	NA	100	>100	>100	>100	>100
SMA080	NA	NA	NA	100	>100	>100	>100	>100
SMA110	NA	NA	NA	100[2]	>100[2]	>100	>100	>100

Values are Percent Sample
SMA020 = San Mateo Creek at Gateway Park
SMA060 = San Mateo Creek at Arroyo Court Park
SMA080 = San Mateo Creek at Sierra Drive
SMA110 = Polhemus Creek upstream of San Mateo Creek confluence
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
[1] = This sample did not meet the Test Acceptability Criteria (TAC) for the reproduction endpoint. Only one replicate produced ≥15 offspring, and mean productivity was 6.3 young per female. Relative to the laboratory control exposure, Fisher's Exact test showed no significant decrease in survival; and Steel's Test showed no significant decrease in reproduction in any sample concentration. Therefore, for survival and reproduction the NOEC was 100% and the LOEC was >100%.
[2] = Relative to the laboratory control exposure, Dunnet's Test showed a significant decrease in growth in the 6.25% sample concentration. However, note that this sample demonstrated an interrupted/inverse dose response, with all concentrations >6.25% not significantly diminished from the control exposure. After checking for test condition or procedural errors, and evaluating within treatment variability and test sensitivity (%MSD), it is likely that the significant difference is due to a Type 1 error. Therefore, the NOEC was 100% and the LOEC was >100%