Water Quality Screening in the Cordilleras Creek Watershed in San Mateo County, California

SAN MATEO COUNTYWIDE
Water Pollution
Prevention Program
Clean Water. Healthy Community.

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May 2007

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Prepared for the

San Mateo Countywide Water Pollution Prevention Program

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SUMMARY

The San Mateo Countywide Water Pollution Prevention Program (Program) conducts Watershed Assessment and Monitoring (WAM) component activities in compliance with its municipal stormwater NPDES permit. A current emphasis is collecting screening-level biological, physical and chemical water quality data from creeks in representative urban watersheds in San Mateo County. Environmental indicator data are collected to help evaluate current creek health and water quality conditions. The Program recently performed this type of monitoring in the Cordilleras Creek watershed; this report documents the results. These data will help establish a baseline for future evaluations of long-term trends and thereby inform the Program's efforts to improve the effectiveness of its Best Management Practices (BMPs) to prevent or reduce stormwater runoff impacts.

The Cordilleras Creek watershed drains about 3.3 square miles. Jurisdictions within the watershed are unincorporated San Mateo County, the City of Redwood City and the Town of San Carlos. Land use patterns are typical for the bay-side of San Mateo County, with a relatively undeveloped upper watershed, primarily residential land use in the middle portion of the watershed and some commercial and industrial land use at the bottom of the watershed. The Program's field activities in the watershed included analysis of benthic macroinvertebrate (BMI) assemblages, physical habitat assessment, field instrument measurements (pH, temperature, conductivity, dissolved oxygen and water velocity), and chemical analysis and bioassay of creek grab water samples.

The Program performed BMI bioassessments in the Cordilleras Creek watershed during two consecutive spring seasons (April 2005 and May 2006). The limited BMI bioassessment data gathered during this study and the current lack of a regional Index of Biological Integrity (IBI)[1] preclude performing a rigorous analysis of the data at this time. However, the available data from both bioassessment years suggest that BMI assemblages throughout the watershed are moderately pollutant-tolerant and have low richness and diversity. Although there were some differences in taxonomic composition between sampling years, metrics associated with richness, diversity and pollutant-tolerance were similar across stations and years, indicating that the assemblages consisted of taxa with similar characteristics. An abundance of short-lived (requiring less than one year to complete their life cycles) BMI taxa suggests that Cordilleras Creek was intermittent (i.e., dried out during the dry season) during the water years in which sampling was conducted. A combination of intermittent stream flow and the similar and relatively low substrate quality found at all of the sampling stations

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[1] A Bay Area IBI is currently under development through the Bay Area Macroinvertebrate Bioassessment Information Network (BAMBI). The Program is continuing to provide in-kind staff assistance to BAMBI for IBI development and other activities.

may explain the relatively low biotic integrity found throughout the watershed.

General water quality parameters measured in the field included dissolved oxygen and pH. Dissolved oxygen measurements generally equaled or exceeded 8.0 milligrams per liter (mg/L), meeting the Basin Plan non-tidal water objectives for both cold water habitat (7.0 mg/L minimum) and warm water habitat (5.0 mg/L minimum). With the exception of five of the six measurements taken in April 2005, measurements of pH were within the acceptable range of 6.5 to 8.5 specified for San Francisco Bay Basin waters by the Basin Plan.

The Program collected grab water samples from three stations in the Cordilleras Creek watershed during three sampling episodes (December 7, 2004, April 27, 2005 and June 1, 2005). The sampling dates corresponded to three hydrologic seasons - the wet weather season, decreasing hydrograph (spring), and the dry weather season. Metals analysis results (e.g., copper and mercury) were compared to selected freshwater water quality criteria for aquatic life protection found in the Basin Plan and California Toxics Rule. None of the criteria was exceeded in any of the creek samples. In addition, organophosphorus pesticides, including diazinon, were not detected in the samples. The detection limit for diazinon was lower than a 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 three-species bioassays. The bioassays revealed sublethal effects only - inhibition of *Ceriodaphnia* reproduction in most tests and relatively minor inhibition of *Pimephales* growth in one test. The cause(s) of the sublethal effects is unknown, but there was no indication that diazinon or other organophosphorus pesticides were involved, since these pesticides were not detected in the water samples.

The Program recently performed creek walks (Unified Stream Assessment protocol) and trash assessments (Rapid Trash Assessment protocol) in the Cordilleras Creek watershed and five other watersheds in San Mateo County and is currently preparing an interpretive report on these activities. Future long-term monitoring activities in San Mateo County watersheds, which may include additional monitoring in the Cordilleras Creek watershed, will be planned after adoption of the new Bay Area regional municipal stormwater NPDES permit (referred to as the "Municipal Regional Permit").

Water Quality Screening
in the Cordilleras Creek Watershed in
San Mateo County, California

1.0 INTRODUCTION

The San Mateo Countywide Water Pollution Prevention Program (Program) conducts Watershed Assessment and Monitoring (WAM) component activities in compliance with its municipal stormwater NPDES permit. A current emphasis is collecting screening-level biological, physical and chemical water quality data from creeks in representative urban watersheds in San Mateo County.[2] These creeks are typically receiving waters for urban runoff discharges from municipal storm drain systems. The Program collects environmental indicator data (e.g., bioassessment and water column toxicity testing) to help evaluate current creek health and water quality conditions.

The Program recently performed this type of monitoring in the Cordilleras Creek watershed; this report documents the results. Specific objectives included:

- compiling and summarizing readily available existing data on the Cordilleras Creek watershed, including regulatory and water quality information;

- gathering initial data on creek aquatic ecosystem health via benthic macroinvertebrate (BMI) bioassessment; and

- evaluating water quality conditions in the creek by comparing field measurements of water quality parameters to selected water quality targets and criteria.

These data will help establish a baseline for future evaluations of long-term trends and thereby inform the Program's efforts to improve the effectiveness of its Best Management Practices (BMPs) to prevent or reduce stormwater runoff impacts.

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[2] To date, the Program has conducted screening-level monitoring programs in the San Pedro, San Mateo, Cordilleras and Belmont Creek watersheds.

2.0 BACKGROUND

2.1 Description of Study Area

The Cordilleras Creek watershed drains about 3.3 square miles (Figure 1). Jurisdictions within the watershed are unincorporated San Mateo County, the City of Redwood City and the Town of San Carlos (part of the lower reach of the creek defines the boundary between Redwood City and San Carlos). The creek originates in the Pulgas Ridge Open Space district and discharges into Smith and/or Steinberger Sloughs, depending on tidal and creek flow conditions. These tidewater sloughs are tributary to San Francisco Bay.

Land use patterns in the watershed are typical for the bay-side of San Mateo County. The upper watershed is relatively undeveloped and includes the Pulgas Ridge Open Space district and Edgewood County Park. The middle portion of the watershed has primarily residential land uses. A small portion of the watershed that is in the vicinity of El Camino Real and near the bottom of the watershed contains primarily commercial and industrial land uses. The overall watershed imperviousness is approximately 35 percent with 60 percent of the creek channel unmodified (STOPPP 2002).

2.2 Regulatory Information

The San Francisco Bay Regional Water Quality Control Board (Water Board) has developed a Water Quality Control Plan for the San Francisco Bay Basin (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 many Bay Area surface waters, but Cordilleras Creek is not included.[3]

The 2006 Clean Water Act Section 303(d) list designates all Bay Area urban creeks with beneficial uses in the Basin Plan as impaired by diazinon. Cordilleras Creek is not included in the 303(d) diazinon listing since it is not included in the Basin Plan. In addition, all "Urban Creeks of the San Francisco Bay Region" were placed on the State Water Resources Control Board 2002 "Monitoring List" due to the potential of trash to impair water quality. The 2002 Monitoring List has not been updated.

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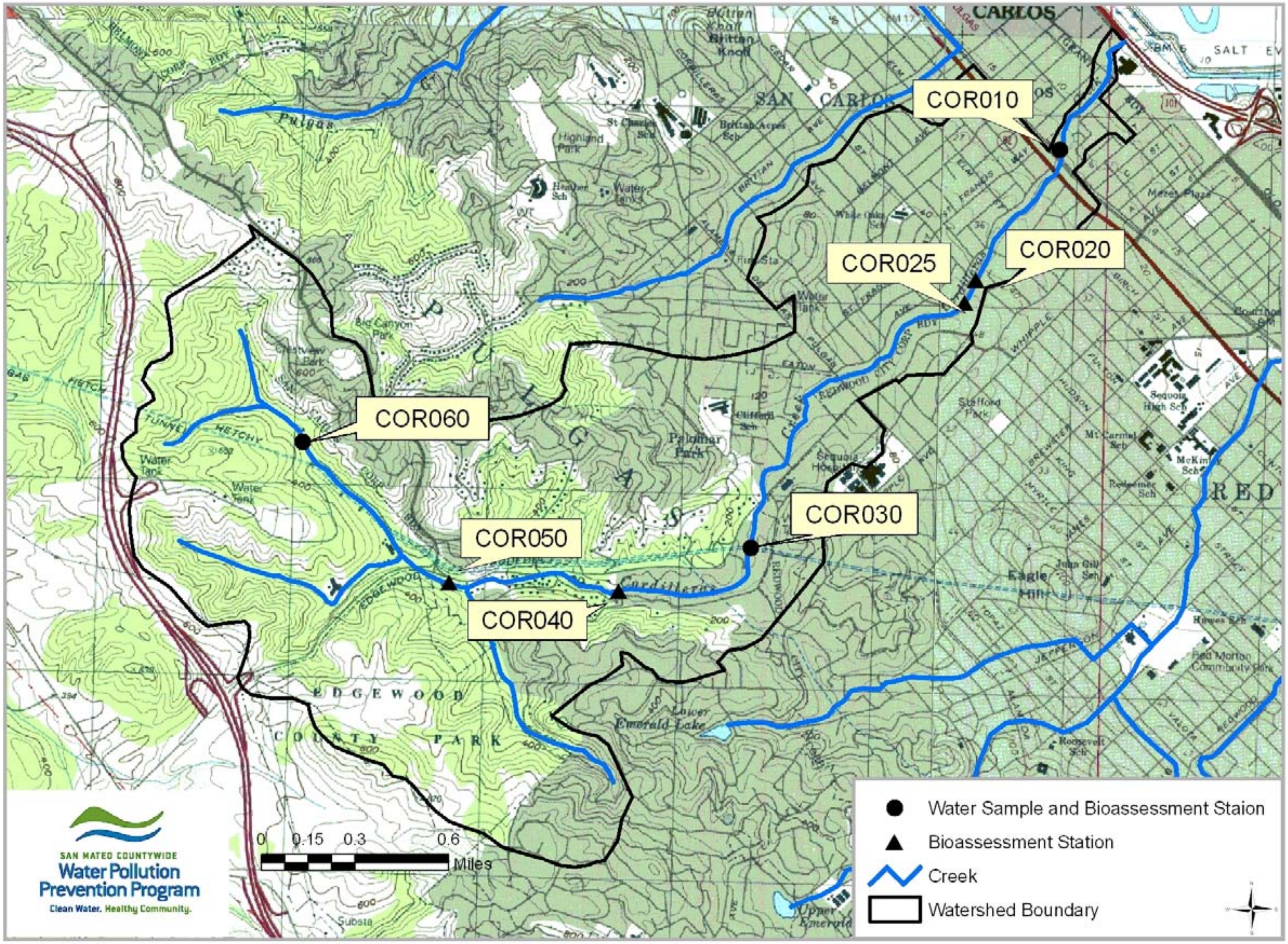
[3] The only creeks on the Bay side of San Mateo County with designated beneficial uses in the Basin Plan are San Mateo and San Francisquito Creeks.



Basemap Source: USGS

Figure 1. Bioassessment and Water Sampling Stations in the Cordilleras Creek Watershed

2.3 Previous Water Quality-Related Investigations

Limited existing water quality-related data on the Cordilleras Creek watershed were found:

- On October 24, 2000, the Joint Stormwater Agency Project collected a sediment sample from the bed of Cordilleras Creek at an upper watershed open space location (Edmunds Road crossing). The sample was analyzed for PCBs and mercury. This sample was intended to be representative of undeveloped open space areas and, as expected, these pollutants were found at relatively low levels: 5.8 ug/Kg total PCBs and 0.04 mg/Kg total mercury (KLI 2002).

- A California Department of Fish and Game representative, Redwood City Public Works staff and a consultant performed creek walks in the Cordilleras Creek watershed on April 29 and July 12, 2002. The creek walks identified potential fish barriers, fishery habitat, water diversions, non-native vegetation, bank stabilization structures, the general morphological condition of the creek, areas with channel or bank erosion, and sediment sources (Kamman 2002a and b).

- A community group has established a water quality testing station at Redwood High School, near the bottom of the Cordilleras Creek watershed. Volunteers have collected data on water temperature, turbidity, pH and dissolved oxygen at this station.

3.0 METHODS

Table 1 summarizes the Program's field activities in the Cordilleras Creek watershed, which included analysis of BMI assemblages, physical habitat assessment, field instrument measurements (pH, temperature, conductivity, dissolved oxygen and water velocity), and chemical analysis and bioassay of grab water samples.

Table 1. Summary of Field Monitoring Activities in the Cordilleras Creek Watershed

Type of Monitoring	Activity	Number of Sampling Stations	Parameters	Frequency/Interval
Screening-level biological, physical and chemical water quality monitoring of receiving waters.	Benthic macro-invertebrate bioassessment in creek.	7	Macroinvertebrate assemblages, visual physical habitat characteristics, temperature, pH, conductivity, dissolved oxygen and water velocity.	Two episodes: 1. April 2005 2. May 2006.
	Creek water testing.	3	Temperature, pH, conductivity, dissolved oxygen, water velocity, organophosphorus pesticides, metals,[1] hardness, suspended sediment concentration (SSC), and water column toxicity (three-species bioassay).[2]	Three episodes: 1. December 2004 2. April 2005 3. June 2005

[1] Al, Cr, Mn, Ni, Cu, Zn, Ag, Cd, Pb, As, and Se (total and dissolved) and Hg (total only).

[2] *Ceriodaphnia dubia* (water flea), *Pimephales promelas* (fathead minnow) and *Selenastrum capricornutum* (green alga).

3.1 Bioassessment

The Program collected BMI assemblage and physical habitat data during two consecutive spring seasons - April 2005 and May 2006. Program staff collected BMIs and performed visual assessments of physical habitat at seven stations in the watershed (Table 2 and Figure 1). The stations represent a range of subwatersheds, ecoregion subsections, elevations, creek characteristics and land use. The stations span 300 feet in elevation and two ecological subregions with varying levels of urbanized land uses. The farthest downstream station is channelized with earthen levees and drains commercial and residential land uses while the two stations farthest upstream have natural channels and primarily drain open space areas. The remaining stations have channels with varying levels of modification and predominately drain residential land uses.

Table 2. Descriptions of Sampling Stations[1]

Sampling Station[2]	Elevation (ft)	Reach Location	Predominant Land Use	Ecoregion Subsection	Channel Slope (%)	Channel Condition
COR010[3]	15	Downstream of Stafford St. at high school	Commercial and residential	Santa Clara Valley	0.4	Channelized by earthen levee
COR020[4,5]	30	Eaton Ave. and Cedar St. at private residence	Residential	Santa Clara Valley	0.7	Natural with many modifications, deeply incised
COR025[4,6]	32	Eaton Ave. and Park Ave. at private residence	Residential	Santa Clara Valley	0.7	Natural with modifications, deeply incised
COR030[3]	110	Cordilleras Rd. and Bennett Rd., 100 ft downstream from SFPUC Pipeline	Residential	Leeward Hills	1.6	Natural with many modifications, deeply incised
COR040[4]	150	Cordilleras Rd. and Springdale Way	Residential and urban vacant land	Leeward Hills	2.1	Natural, moderately incised
COR050[4]	230	Upstream of Old Stage Coach Rd. at Edgewood County Park	Open space	Leeward Hills	2.7	Natural
COR060[3]	320	About 500 ft upstream of culverted section in Pulgas Ridge Open Space area	Open space	Leeward Hills	2.3	Natural

[1] Adapted from BioAssessment Services report in Appendix A.

[2] See Figure 1 for sampling station locations.

[3] Water sampling and bioassessment station.

[4] Bioassessment only station.

[5] Sampled April 2005 only.

[6] Sampled May 2006 only.

BMI 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.

Conventional water quality parameters (temperature, pH, conductivity, and dissolved oxygen) and water velocity were measured using field instruments at each BMI sampling station during both BMI sampling episodes. In addition, physical habitat was qualitatively assessed at each BMI sampling station using USEPA's Rapid Bioassessment Protocols (Barbour et al. 1999). It should be noted that the estimate of substrate size percent composition addressed only the riffle habitat sampled and not other instream habitat types (e.g., pools). Thus the substrate composition measurements taken during this study only characterize the riffle habitat of the sampling stations and should not be extrapolated to the entire stream system. Percent fines are expected to be less than other instream habitats since riffles have a higher gradient and water velocity.

The BMI samples were submitted to BioAssessment Services of Folsom, California for analysis. Appendix A contains a report prepared by BioAssessment Services that documents the bioassessment methodology in detail. Appendix B of the BioAssessment Services report includes photographs of the sampling stations.

3.2 Water Testing

The Program collected grab water samples from Cordilleras Creek and its tributaries on December 7, 2004, April 27, 2005 and June 1, 2005. These three dates fall within three separate hydrologic seasons: the wet weather season, decreasing hydrograph (spring), and the dry weather season, respectively. Samples were collected at three sites during each episode (Figure 1 and Table 2): a commercial/residential station near the bottom of the watershed (COR010), a mid-watershed station in a residential area (COR030), and a station in the upper watershed in an open space area (COR060). The water sampling stations were in the same general location as three of the seven bioassessment stations and represent a range of creek conditions. Each grab water sample was tested for:

- organophosphorus pesticides, including diazinon;
- metals: Al, Cr, Mn, Ni, Cu, Zn, Ag, Cd, Pb, As, and Se (total and dissolved) and Hg (total only);
- hardness and suspended sediment concentration (SSC); 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[4] and their responses were compared to those of control organisms exposed to control water.

Conventional water quality parameters (temperature, pH, conductivity, and dissolved oxygen) and water velocity were measured using field instruments at each sampling station during each water sampling episode. Appendix B contains a report prepared by Kinnetic Laboratories of Santa Cruz, California with a detailed description of the water sampling methods.

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

4.0 RESULTS

4.1 Bioassessment

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

4.1.1 Benthic Macroinvertebrate Assemblages

Composite metric scores[5] did not show clear trends in BMI assemblage quality across stations or sampling episodes (Figure 2). In April 2005 the two downstream stations (COR010 and COR020) had lower composite metric scores compared to the other stations but this trend was not evident in May 2006.

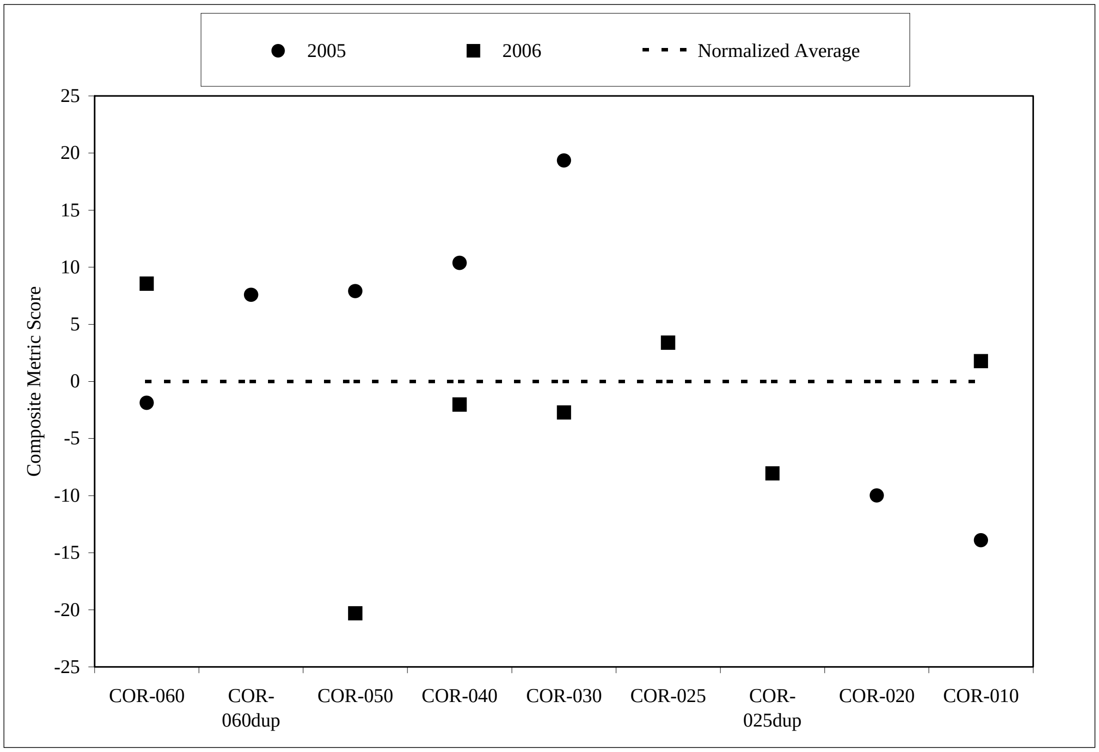

Figure 2. Composite Metric Scores (from BioAssessment Services report in Appendix A)

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[5] 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 BMI assemblage, which results in amplified responses.

BMI assemblages had low richness and diversity throughout the watershed for both sampling episodes. Short-lived BMI taxa (requiring less than one year to complete their life cycles) were abundant but pollutant-intolerant BMI taxa were absent (see Appendix A).

4.1.2 Physical Habitat Assessment

Habitat quality scores ranged from 91 to 161, and generally increased moving from downstream to upstream sampling stations (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 imply marginal or suboptimal habitat at most of the sampling stations. The April 2005 score for furthest upstream station COR060 implies optimal habitat.

Table 3. Physical Habitat Scores

Sampling Station[1]	April 2005		May 2006	
	Habitat Quality Score	Implied Habitat Quality (Barbour et al., 1999)	Habitat Quality Score	Implied Habitat Quality (Barbour et al., 1999)
COR010	91	Marginal	98	Marginal
COR020	92	Marginal	NA	NA
COR025	NA	NA	91	Marginal
COR030	127	Suboptimal	110	Suboptimal
COR040	127	Suboptimal	118	Suboptimal
COR050	144	Suboptimal	137	Suboptimal
COR060	161	Optimal	149	Suboptimal

[1]See Figure 1 for sampling station locations.
NA - Not Applicable.

4.2 Water Testing

Table 4 summarizes the results of the field probe conventional water quality parameter and water velocity measurements. Table 5 compares metals results to selected freshwater water quality criteria for aquatic life protection. The report in Appendix B contains additional information on the water sampling results and quality control measures, including organophosphorus pesticide analytes and method detection limits. Organophosphorus pesticides, including diazinon, were not detected in any of the samples. The original reports from the analytical laboratories are not included in this report due to their large size, but are available upon request.

Table 4. Field Instrument Measurement Results

Date Collected	Sampling Station[1]	pH	Temp-erature (°C)	Con-ductivity (µS/cm)	Dissolved Oxygen (mg/L)	Flow Velocity (ft/sec)
12/7/04	COR010	8.09	11.5	406	9.89	1.5
	COR030	8.12	11.3	493	10.14	0.77
	COR060	7.37	10.8	490	10.01	0.84
4/25/05 - 4/26/05	COR010	8.9	12	945	8.7	NR[2]
	COR020	9.0	12	1000	9.2	NR
	COR030	8.7	13	787	8.7	NR
	COR040	8.8	13	916	9.4	NR
	COR050	8.9	12	800	8.8	NR
	COR060	8.4	12	990	8.2	NR
4/27/05	COR010	8.16	13.4	750	9.76	0.7
	COR030	7.73	12.2	750	9.33	0.65
	COR060	8.12	12.8	796	9.44	0.54
6/1/05	COR010	8.18	15.9	716	7.97	0.72
	COR030	7.74	14.6	788	8.46	0.37
	COR060	7.92	16.9	850	5.88	NF[3]
5/2/06 or 5/5/06	COR010	8.1	14	962	10.7	2.7
	COR025	8.2	15	994	10.9	2.4
	COR030	8.0	14	967	13.5	2.6
	COR040	8.2	13	922	11.1	2.9
	COR050	8.0	14	978	11.1	2.8
	COR060	7.8	14	1024	11.1	0.9

[1] See Figure 1 for sampling station locations.

[2] NR - Not Reported.

[3] NF - No Flow. Creek was a standing pool at the sampling station at the time of sampling.

Table 6 presents a simplified summary of the results of the three species bioassays. The bioassays revealed sublethal effects only - inhibition of *Ceriodaphnia* reproduction in seven tests and *Pimephales* growth in one test. Toxicity was found in at least one sample from each sampling episode and at each sampling station. 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%).

Table 5. Comparison of Metals Results to Selected Freshwater Water Quality Criteria.[1,2]

Analyte		December 7, 2004			April 27, 2005			June 1, 2005		
		COR010	COR030	COR060	COR010	COR030	COR060	COR010	COR030	COR060
Hardness (mg/L)		220	280	250	420	440	440	390	440	440
Dissolved	Sample	1.0U	1.0	1.0U	1.2	1.1	1.0U	1.1	1.0U	1.1
Arsenic	CMC	340	340	340	340	340	340	340	340	340
(ug/L)	CCC	150	150	150	150	150	150	150	150	150
Dissolved	Sample	1.0U	1.0U	1.0U	0.20U	0.20U	0.20U	0.20U	0.20U	0.20U
Cadmium	CMC	10	13	12	19	19	19	19	19	19
(ug/L)	CCC	4.0	4.8	4.4	6.2	6.2	6.2	6.1	6.2	6.2
Dissolved	Sample	3.1	4.0	2.4	8.9J	9.6J	7.8J	4.3J	3.7J	4.3J
Chromium	CMC[3]	1000	1300	1200	1700	1700	1700	1700	1700	1700
(ug/L)	CCC[3]	340	410	380	550	550	550	540	550	550
Dissolved	Sample	5.4	4.0	2.7	2.2	1.8	1.0U	2.4	1.5	1.0U
Copper	CMC	29	36	32	50	50	50	49	50	50
(ug/L)	CCC	18	22	20	29	29	29	29	29	29
Dissolved	Sample	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Lead	CMC	150	190	170	280	280	280	270	280	280
(ug/L)	CCC	5.9	7.6	6.7	11	11	11	11	11	11
Dissolved	Sample	5.6	6.4	1.3	3.6	3.0	2.2	3.5	3.9	3.7
Nickel	CMC	910	1100	1000	1500	1500	1500	1500	1500	1500
(ug/L)	CCC	100	120	110	170	170	170	160	170	170
Dissolved	Sample	0.20U	0.20U	0.20U	0.20U	0.20U	0.20U	0.20U	0.20U	0.20U
Silver	CMC	13	20	17	37	37	37	36	37	37
(ug/L)	CCC	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dissolved	Sample	5.0U	5.0U	5.0U	5.0U	5.0U	5.0U	2.6	1.7	1.2
Zinc	CMC	230	280	250	380	380	380	370	380	380
(ug/L)	CCC	230	280	260	380	380	380	370	380	380
Total	Sample	0.015	0.0073	0.0081	0.0050U	0.0050U	0.0050U	0.0026	0.0022	0.0025
Mercury	4-Day Avg.[4]	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
(ug/L)	1-Hr Avg.[4]	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4

CMC - Criteria Maximum Concentration. The highest concentration of a pollutant to which aquatic life can be exposed for a short period of time without deleterious effects (40 CFR Part 131, May 18, 2000).

CCC - Criteria Continuous Concentration. The highest concentration of a pollutant to which aquatic life can be exposed for an extended period of time (4 days) without deleterious effects (40 CFR Part 131, May 18, 2000).

NA - Not Applicable.

J - Estimated quantity.

U - Not measured above reported sample method detection limit.

[1] All CMC and CCC values were calculated as a function of hardness, with the exception of the values for arsenic (40 CFR Part 131, May 18, 2000).

[2] Comparisons to water quality criteria were made for screening purposes only and are not intended to demonstrate compliance with the criteria.

[3] CMC and CCC are for chromium III but are conservatively compared to total chromium monitoring data.

[4] SFBRWQCB 1995.

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Table 6. Three-species Bioassay Results

Date Collected	Sampling Station[1]	Organism	Summary of Bioassay Results[2,3,4]	
			Survival Endpoint	Sub-lethal Endpoint (Reproduction/Growth)
12/7/04	COR010	*Ceriodaphnia*	Survival not reduced.	***Reduced reproduction.***
		Pimephales	Survival not reduced.	NM[5]
		Selenastrum	NA[6]	Growth not inhibited.
	COR030	*Ceriodaphnia*	Survival not reduced.	Reproduction not reduced.
		Pimephales	Survival not reduced.	NM
		Selenastrum	NA	Growth not inhibited.
	COR060	*Ceriodaphnia*	Survival not reduced.	Reproduction not reduced.
		Pimephales	Survival not reduced.	NM
		Selenastrum	NA	Growth not inhibited.
4/27/05	COR010	*Ceriodaphnia*	Survival not reduced.	***Reduced reproduction.***
		Pimephales	Survival not reduced.	Growth not reduced.
		Selenastrum	NA	Growth not inhibited.
	COR030	*Ceriodaphnia*	Survival not reduced.	***Reduced reproduction.***
		Pimephales	Survival not reduced.	Growth not reduced.
		Selenastrum	NA	Growth not inhibited.
	COR060	*Ceriodaphnia*	Survival not reduced.	***Reduced reproduction.***
		Pimephales	Survival not reduced.	Growth not reduced.
		Selenastrum	NA	Growth not inhibited.
6/1/05	COR010	*Ceriodaphnia*	Survival not reduced.	***Reduced reproduction.***
		Pimephales	Survival not reduced.	Growth not reduced.
		Selenastrum	NA	Growth not inhibited.
	COR030	*Ceriodaphnia*	Survival not reduced.	***Reduced reproduction.***
		Pimephales	Survival not reduced.	Growth not reduced.
		Selenastrum	NA	Growth not inhibited.
	COR060	*Ceriodaphnia*	Survival not reduced.	***Reduced reproduction.***
		Pimephales	Survival not reduced.	***Reduced growth.***
		Selenastrum	NA	Growth not inhibited.

Notes:

[1] See Figure 1 for sampling 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] As a quality control measure, concurrent or monthly reference toxicant bioassays were run with each test species. The *Pimephales* reference toxicant test failed test acceptability criteria for percent survival and growth, which introduces some uncertainty into the *Pimephales* test results (4/27/05 and 6/1/05 sample episodes).

[5] NM – Not Measured (due to laboratory error).

[6] NA – Not Applicable.

5.0 DISCUSSION

5.1 Bioassessment

BMI abundance, taxonomic diversity and community structure are highly responsive to changes in their aquatic environment. These characteristics make BMIs an excellent indicator biota of creek health. Rigorous interpretation of BMI bioassessment data is best accomplished within the context of an Index of Biological Integrity (IBI). An IBI synthesizes the diverse BMI assemblage information collected during a BMI bioassessment and facilitates using a numeric scale to show human impacts to the aquatic ecosystem in comparison to undisturbed reference sites. IBIs are specific to a geographic region and have been developed for both south and north coastal regions of California, but the reference conditions used to develop those IBIs may not be applicable to Bay Area watersheds. A Bay Area IBI is currently under development through the Bay Area Macroinvertebrate Bioassessment Information Network (BAMBI).[6] The Program is continuing to provide in-kind staff assistance to BAMBI for IBI development and other activities.

The limited BMI bioassessment data gathered during this study and the current lack of a regional IBI preclude performing a rigorous analysis of the Cordilleras Creek watershed data at this time. However, the available data from both bioassessment years suggest that BMI assemblages throughout the watershed are moderately pollutant-tolerant and have low richness and diversity. Although there were some differences in taxonomic composition between sampling years, metrics associated with richness, diversity and pollutant-tolerance were similar across stations and years, indicating that the assemblages consisted of taxa with similar characteristics. An abundance of short-lived (requiring less than one year to complete their life cycles) BMI taxa suggests that Cordilleras Creek was intermittent (i.e., dried out during the dry season) during the water years in which sampling was conducted.[7] Based upon the physical habitat scores, instream habitat and riparian buffer quality increased with elevation. BMI assemblage quality, however, did not follow this pattern. This finding may partly reflect the relatively similar substrate quality observed across all stations. A combination of intermittent stream flow and the similar and relatively low substrate quality found at all of the sampling stations may explain the relatively low biotic integrity found throughout the watershed.

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[6] BAMBI is assisting Bay Area municipal stormwater programs to refine and standardize BMI bioassessment protocols, coordinate bioassessment work in the region, and manage and interpret bioassessment data.

[7] During October 2006, the Program walked Cordilleras Creek using the Unified Stream Assessment (USA) protocol developed by the Center for Watershed Protection (SMCWPPP, in preparation). At that time, flow was low in the upper watershed and the lower watershed reaches were dry. Although flow will vary each water year with rainfall, this suggests the potential for intermittent flow in part or all of Cordilleras Creek during some or all water years.

5.2 Water Testing

General water quality parameters measured in the field included dissolved oxygen and pH.[8] With one exception, dissolved oxygen measurements equaled or exceeded 8.0 milligrams per liter (mg/L), meeting the Basin Plan non-tidal water objectives for both cold water habitat (7.0 mg/L minimum) and warm water habitat (5.0 mg/L minimum). The exception was a measurement of 5.88 mg/L at a sampling station near the top of the watershed (COR060) during the dry season sampling episode. The field notes (Appendix B) indicate that the creek was not flowing at the time and location of sampling and the sample was collected from a mostly stagnant pool. Measurements of pH varied from 7.37 to 9.0 and, with the exception of five of the six measurements taken in April 2005, were within the acceptable range of 6.5 to 8.5 specified for San Francisco Bay Basin waters by the Basin Plan.

The grab creek water samples collected during this study were analyzed for a suite of metals. Table 6 compares the results to selected freshwater water quality criteria for aquatic life protection found in the Basin Plan (SFBRWQCB 1995) and promulgated by the USEPA in what is referred to as the "California Toxics Rule (CTR)" (40 CFR Part 131, May 18, 2000). The CTR specifies water quality criteria as Criteria Maximum Concentration (CMC) and Criteria Continuous Concentration (CCC) values. CMCs are the highest concentration of a pollutant to which aquatic life can be exposed for a short period of time without deleterious effects. CCCs are the highest concentration of a pollutant to which aquatic life can be exposed for an extended period of time (4 days) without deleterious effects. Per the CTR, all CMC and CCC values were calculated as a function of hardness, with the exception of the values for arsenic, which are not hardness-dependent. None of the criteria was exceeded in any of the creek samples.[9]

Organophosphorus pesticide analytes, including diazinon, were not detected in the grab creek water samples. A Water Board staff report attached to a recent Basin Plan amendment[10] proposes 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 0.02 µg/L, which is lower than the proposed target, indicating that the target was not exceeded in the samples tested.

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[8] General water quality measurements from this study are a snapshot and do not capture natural variability due to factors such as daily photosynthesis cycles.

[9] The comparisons to water quality criteria were made for screening purposes only and are not intended to demonstrate compliance with the criteria.

[10] The Basin Plan amendment, which incorporates a Total Maximum Daily Load (TMDL) and water quality attainment strategy for diazinon and pesticide-related toxicity in the Bay Area's urban creeks, has been approved by the California State Water Resources Control Board and the Office of Administrative Law, and awaits final approval by U.S. EPA.

The bioassays revealed sublethal effects only - inhibition of *Ceriodaphnia* reproduction in most tests and relatively minor inhibition of *Pimephales* growth in one test. The cause(s) of the sublethal effects is unknown, but there was no indication that diazinon or other organophosphorus pesticides were involved, since these pesticides were not detected in the water samples. Temporal or spatial patterns were not apparent in the bioassay data. Toxicity was found in at least one sample from each sampling episode and at each sampling station, including a site that primarily drains open space.

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). However, 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. The Program 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.

5.3 Next Steps

The Program recently performed creek walks and trash assessments in the Cordilleras Creek watershed and five other watersheds in San Mateo County. The creek walks were conducted using the Unified Stream Assessment (USA) protocol developed by the Center for Watershed Protection. The protocol uses visual observations to provide an overall picture of creek conditions and features. Overall reach condition (e.g., bank stability, instream and riparian habitat, floodplain connectivity) was qualitatively assessed. In addition, a quantitative assessment was made of the extent of current erosion, channel modifications, number of stream crossings, utilities, and outfalls. Two trash problem areas were identified in each watershed during the creek walks. Each problem area was assessed in the fall and spring using the Water Board's Rapid Trash Assessment protocol, as modified by the Santa Clara Valley stormwater program for urban areas. The Program is currently evaluating the results of the creek walks and trash assessments and preparing an interpretive report. Future long-term monitoring activities in San Mateo County watersheds, which may include additional monitoring in the Cordilleras Creek watershed, will be planned after adoption of the new Bay Area regional municipal stormwater NPDES permit (referred to as the "Municipal Regional Permit").

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APPENDIX A

Bioassessment Report Prepared by BioAssessment Services

SAN MATEO COUNTYWIDE
Water Pollution
Prevention Program
Clean Water. Healthy Community.

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Biological Assessment of Cordilleras Creek, San Mateo County

- Spring 2005 and 2006 -

Prepared by:
BioAssessment Services
Folsom, California

in association with:
EOA, Inc.
Oakland, California

June 2006

SUMMARY

The San Mateo Countywide Stormwater Pollution Prevention Program (STOPPP) conducted biological assessments in the spring season of 2005 and 2006 to help evaluate general stream health and physical habitat quality in the Cordilleras Creek 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. Benthic macroinvertebrates are often used to monitor water quality and overall stream health because their abundance, taxonomic diversity and community structure are highly responsive to changes in their aquatic environment.

The six stream locations selected for the assessment spanned 300 feet in elevation and two ecological subregions with varying levels of urbanized land uses. The furthest downstream site was channelized with earthen levees with a drainage area consisting of commercial and residential land uses while the two sites furthest upstream had natural channels with drainage areas consisting of primarily open space. The remaining sites had channels with various levels of modification and were located within a drainage area of predominately residential land use.

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 benthic macroinvertebrates from each composite and identifying the subsampled organisms to a standard taxonomic level. Biological metrics, which are numeric measurements of biotic assemblage quality, were used to describe characteristics of the benthic macroinvertebrate assemblages.

Benthic macroinvertebrate assemblages were characterized as moderately tolerant with low richness and diversity throughout the drainage for both assessment years. Benthic macroinvertebrate taxa sampled from the sites were considered short-lived, requiring less than one year to complete their life cycles. Consequently, the abundance of short-lived benthic macroinvertebrates suggested that Cordilleras Creek is seasonal (i.e., flow is intermittent and related to seasonal rains), or was seasonal for the water year types in which sampling was conducted. While there was a slight trend of decreasing benthic macroinvertebrate assemblage quality with decreasing elevation and increasing urbanization, the lack of sensitive taxa in the upper, less urbanized watershed suggested that the apparent seasonality of the stream's surface water was an important factor influencing assemblage quality. The lack of BMI response to the physical habitat score may to some extent have resulted from the relative similar substrate quality across all the sites. It is likely that a combination of intermittent stream flow and the lack of substrate complexity found at the six Cordilleras Creek sites reduced biotic integrity. Although there were some differences in taxonomic composition by year of sampling, metrics associated with richness, diversity and tolerance were similar across sites and years, which indicated that the assemblages consisted of taxa with similar characteristics.

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1.0 INTRODUCTION

The San Mateo Countywide Stormwater Pollution Prevention Program conducted biological assessments in the spring season of 2005 and 2006 to help evaluate general stream health and physical habitat quality in the Cordilleras Creek watershed. Monitoring activities included conducting rapid benthic macroinvertebrate (BMI) assemblage bioassessments and physical habitat assessments at six stream locations in Cordilleras Creek. This report documents the results of the two-year bioassessment.

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. Voucher collections, which are the archived BMIs, provide verification of the work product.

1.1 Study Objectives

The objectives of the bioassessment were to:

- Assess biological integrity and overall “health” of Cordilleras Creek watershed using BMI assemblages at selected stream locations 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

The Cordilleras Creek watershed drains approximately three square miles. The creek originates in the foothills of the Santa Cruz Mountains at an elevation of about 600 feet along Pulgas Ridge. The creek flows in an eastern direction for approximately four miles and empties into Smith Slough and eventually into San Francisco Bay. There are two unnamed tributaries in the upper watershed that that drain primarily undeveloped land within the Pulgas Ridge Open Space District and Edgewood County Park. The lower 2.5 miles flow through the alluvial plain in highly urbanized areas of the Cities of San Carlos and Redwood City. The creek is tidally influenced just upstream of Industrial Road. The watershed area is comprised of primarily residential land uses (45%), a small amount of commercial and industrial land uses (1.1%), and other developed land uses (15.4%). The remaining undeveloped land uses consist of forested land and rangeland (34.6%).

2.0 METHODS

2.1 Site Selection

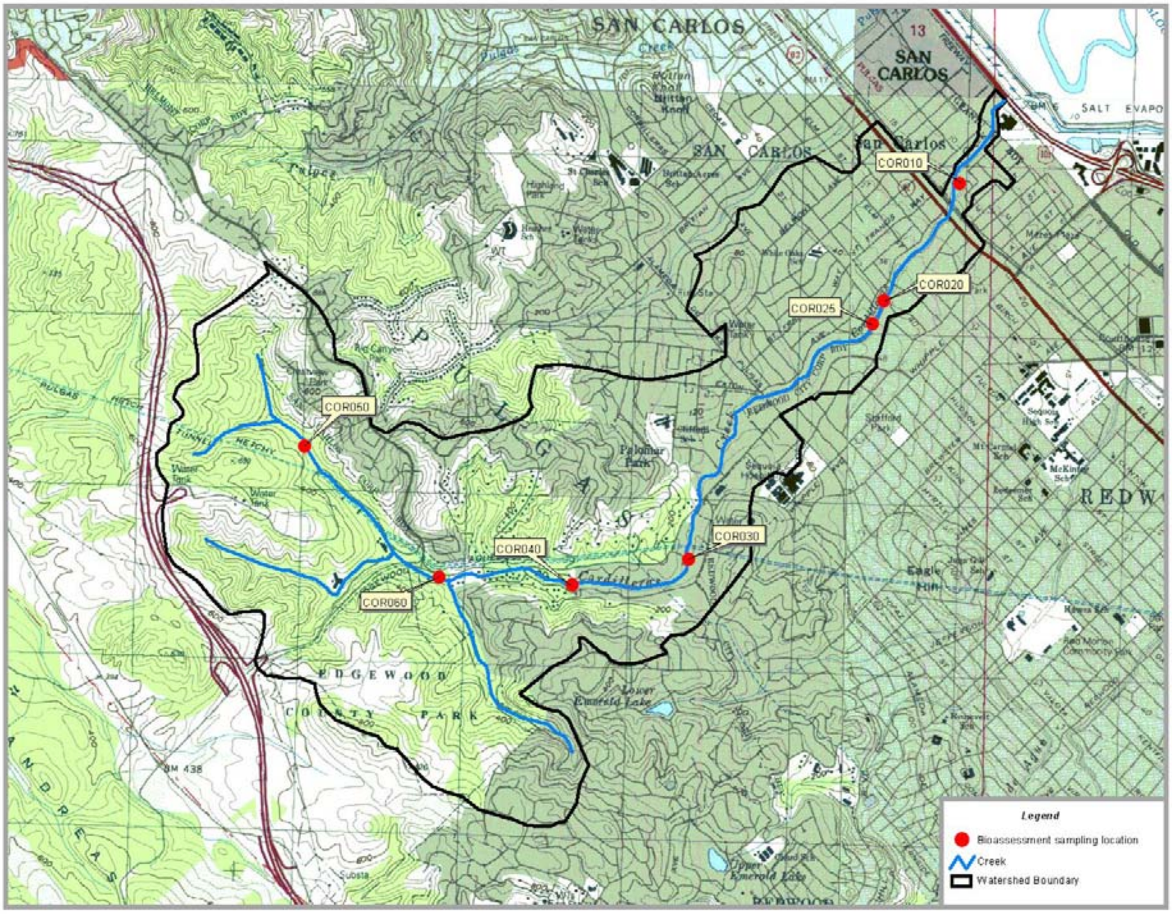
Bioassessments were conducted at the same six stream locations in the Cordilleras Creek watershed during both years of the monitoring program, with one exception. Sampling station COR025 replaced site COR020 in FY 05-06 because permission to gain access at the latter site could not be obtained. The monitoring sites 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) and field reconnaissance conducted in April 2005.

Table 1. Site location descriptions for the Cordilleras Creek biological assessment.

Sampling Station ID	Regional Database ID	Site Elevation (ft)	Stream Reach Location Description	Predominant Land Use	Ecoregion Subsection	Channel Slope (%)	Stream Channel Condition
C-1	COR-010	15	Downstream Stafford at High School	Commercial and residential	Santa Clara Valley	0.4	Channelized by earthen levee
C-2*	COR-020	30	Eaton and Cedar at private residence	Residential	Santa Clara Valley	0.7	Natural with many modifications, deeply incised
C-2.5**	COR-025	32	Eaton and Park at private residence	Residential	Santa Clara Valley	0.7	Natural with modifications, deeply incised
C-3	COR-030	110	Cordilleras Rd and Bennett; 100 ft downstream SFPUC Pipeline	Residential	Leeward Hills	1.6	Natural with many modifications, deeply incised
C-4	COR-040	150	Cordilleras Rd and Springdale	Residential; urban vacant land	Leeward Hills	2.1	Natural, moderately incised
C-5	COR-050	230	Upstream Old Stage Coach at Edgewood County Park	Open space	Leeward Hills	2.7	Natural
C-6	COR-060	320	About 500 ft upstream culverted section in Pulgas Ridge Open Space	Open space	Leeward Hills	2.3	Natural

* Sampled in FY 04-05 only
** Sampled in FY 05-06 only

Figure 1. Cordilleras Creek biological assessment site locations.



2.2 Field and Laboratory Methods

The following sections summarize the field and laboratory methods used for the bioassessment study.

2.2.1 Benthic Macroinvertebrate Field Sampling

STOPPP General Program staff collected BMI samples, measured water quality constituents, and conducted physical habitat assessments on the 25th and 26th of April 2005 and on the 2nd and 5th of May 2006. Benthic sampling and habitat assessment were conducted using methods outlined in the California Stream Bioassessment Procedure (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.

Macroinvertebrate sampling was conducted following the CSBP protocols for high gradient streams. Each study site 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).

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 Cordilleras Creek watershed during both the April 2005 and May 2006 sampling efforts.

2.2.2 Benthic Macroinvertebrate Laboratory 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 abundance was >150 per grid) to Petri dishes where the BMIs were removed systematically with the aid of a stereomicroscope and placed in vials containing 70% ethanol, 28% water 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 ("extras") 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, 28% water and 2% glycerol. A standard taxonomic effort 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 immature 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). Prior to metric calculations oligochaete individuals distributed among the families were converted to class Oligochaeta.

2.2.3 Chemical and Physical Habitat Parameters

Ambient water quality parameters (dissolved oxygen, temperature, pH and conductivity) were 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 Data Quality Assessment Methods

Quality Assurance/Quality Control (QA/QC) activities associated with the field data collection and laboratory analyses are described below. The major goal for these QA/QC procedures is to facilitate collecting representative, comparable, accurate and precise data, to the extent possible under the given limitations.

Duplicate samples were collected at 10% of the total number of sites (n=1) during this monitoring effort to evaluate precision of field sampling methods. In addition 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.

2.4 Bioassessment Data Analysis Methods

2.4.1 Macroinvertebrate Metrics

BMI taxa and the numbers of individuals 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 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 of the total number of organisms in sample)

2.4.2 Composite Metric Score

Finding a consistent pattern in all metrics is overwhelming due to the plethora of data, and individual metrics can yield conflicting results. Consequently, to better assess the biological integrity of a given site, several metrics are typically integrated into a single ranking score for identifying relative spatial and temporal trends for large regional data sets. 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, BMI composite metric scores were calculated for each site within a watershed 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 selected metrics, and then compare the resulting score between the various sampling sites. Typically, metrics should be responsive, have detectable values (>0) and should measure distinct attributes of the BMI assemblage while minimizing redundancy. Several widely used and responsive metrics such as EPT Richness, Coleoptera Richness and Intolerant Organisms were excluded from the composite metric scores because they were either not detected (Intolerant Organisms) or several sites contained no EPT or Coleoptera taxa. Consequently, the metrics used for the scores were taxonomic richness, percent collector taxa, percent non-insect taxa, predator richness, weighted mean tolerance value and Shannon Diversity. The composite metric score was an integrative index of these six metrics.

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).

2.4.3 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.

The output of the cluster analysis is a tree-like dendrogram, which shows relative site similarity based on BMI composition. A grouping variable (year) was used with cluster analysis to evaluate annual differences in BMI composition and was also applied to the Multi-Response Permutation Procedure (MRPP).

MRPP is a non-parametric procedure for detecting differences in composition of two or more groups of items, such as taxonomic composition (McCune and Mefford 1999). MRPP was used to test for significant differences in BMI composition between assessment years (2005 and 2006) and results were used in conjunction with interpretation of tables of numerically dominant taxa and cluster dendrograms.

3.0 RESULTS

3.1 Macroinvertebrate Metrics

Complete metric results for the Cordilleras Creek BMI data set are provided in Table 2. Note that the metrics listed in Table 2 were based on a level I standard taxonomic effort with the exception of chironomid taxa, which were identified to subfamily/tribe instead of family.

Richness and Composition Measures

Several metrics associated with richness are shown in Figure 2. Total Taxonomic Richness values ranged from 8 at site COR-050 (year 2006) to 18 at site COR-030 (year 2005). EPT and Coleoptera taxa were sparse throughout the creek system, as indicated by richness values ranging from 0 to 2. EPT Index metric values ranged from 0 at sites COR-010 and COR-020 (year 2005) to 48 at site COR-060 (year 2006) while there were no sensitive EPT taxa sampled from the sites. Shannon Diversity values were generally low throughout the drainage where they ranged from 0.94 at site COR-010 (year 2005) to 1.5 at site COR-060 (year 2005). Percent Dominant Taxon values ranged from 37 at site COR-060dup to 69 at site COR-010 (year 2005).

Tolerance Measures

Weighted mean tolerance values were consistently moderate across sites and for both years, ranging from 5.2 to 5.6 (on a scale from 0 to 10). There were no intolerant organisms sampled from the sites and the percentage of tolerant organisms was less than two percent.

Functional Feeding Groups

Plots of functional feeding groups (FFGs) are presented in Figure 3. The distribution of BMIs among the FFGs was similar at sites COR-010 through COR-050 where collector-gatherers comprised over 80 percent of the BMIs. The collector-gatherers consisted primarily of orthoclad midges, baetid mayflies and segmented worms. The collector-filterer FFG consisted entirely of black flies (*Simulium*), which were abundant at site COR-060 in year 2005. Several taxa contributed to the predator FFG including biting midges (*Bezzia/Palpomyia*), midges (Tanypodinae), flatworms (Planariidae) and damselflies (*Argia*). Scrapers and "other" FFGs were poorly represented at the sites, comprising less than one percent of the FFGs and shredders were not represented at the sites.

Abundance

Median BMI density (individuals per m^2) for the Cordilleras Creek samples was 2,400 and ranged from 1,146 at site COR-010 (year 2006) to 10,263 at site COR-060 (year 2005).

Table 2. Biological metric values for benthic macroinvertebrate assemblages sampled from Cordilleras Creek, San Mateo County.

Metrics	2005							2006						
	COR-060	COR-060 duplicate	COR-050	COR-040	COR-030	COR-020	COR-010	COR-060	COR-050	COR-040	COR-030	COR-025	COR-025 Duplicate	COR-010
Richness:														
Taxonomic*	10	11	12	14	18	10	9	11	8	10	11	11	9	14
EPT	1	1	1	1	1	0	0	1	1	1	1	1	2	1
Ephemeroptera	1	1	1	1	1	0	0	1	1	1	1	1	1	1
Plecoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Coleoptera	1	1	0	1	2	0	0	1	0	0	0	0	0	0
Predator*	3	4	5	5	7	4	3	5	2	4	4	4	2	6
Composition:														
EPT Index (%)	14	13	27	13	3.1	0.0	0.0	48	18	57	34	32	42	2.6
Sensitive EPT Index (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shannon Diversity*	1.5	1.5	1.4	1.3	1.4	1.0	0.94	1.4	1.2	1.2	1.3	1.3	1.2	1.1
Dominant Taxon (%)	45	37	48	61	58	64	69	48	58	57	47	48	42	65
CG Taxa + CF Taxa (%)*	60	45	42	50	44	60	56	55	75	60	64	55	56	43
Non-Insect Taxa (%)*	10	18	33	21	28	20	22	9	25	20	27	18	22	36
Tolerance:														
Tolerance Value*	5.6	5.5	5.3	5.3	5.4	5.4	5.3	5.4	5.3	5.2	5.2	5.2	5.2	5.4
Intolerant Organisms (%)	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0
Tolerant Organisms (%)	0.6	0.6	0.6	0.8	1.4	0.2	0.0	0.8	0.4	0.2	0.4	0.6	0.2	1.0
Functional Feeding Groups:														
Collector-Gatherers (%)	52	57	90	92	82	93	95	89	95	92	90	97	98	95
Collector-Filterers (%)	45	37	4.4	2.2	4.5	4.7	3.4	8.7	4.0	6.8	7.5	1.4	1.4	1.8
Scrapers (%)	0.0	0.2	0.6	0.2	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.2	0.8
Predators (%)	2.6	5.1	5.0	5.3	13	2.0	1.2	2.4	1.4	1.2	2.4	1.0	0.4	2.2
Shredders (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other (%)	0.2	0.2	0.0	0.4	0.2	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.2	0.0
Estimated Abundance:														
Composite Sample (9 ft^2)	8600	5600	980	1400	1000	1400	1800	3700	2000	2900	2000	2200	2500	960
#/ft^2	956	622	109	156	111	156	200	411	222	322	222	244	278	107
#/m^2	10263	6683	1169	1671	1193	1671	2148	4415	2387	3461	2387	2625	2983	1146

* metrics used for composite metric score

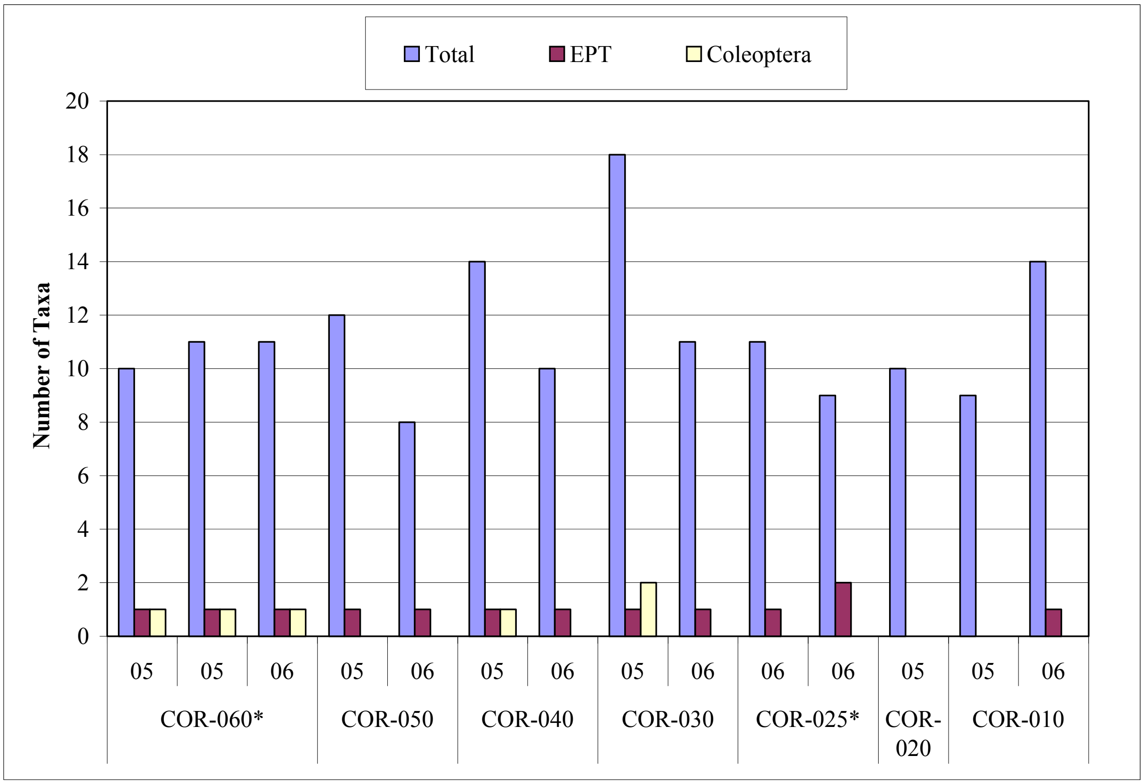


Figure 2. Richness metrics for Cordilleras Creek sites sampled in the spring season of 2005 and 2006, San Mateo County. Duplicate samples were collected at sites identified with an asterisk.

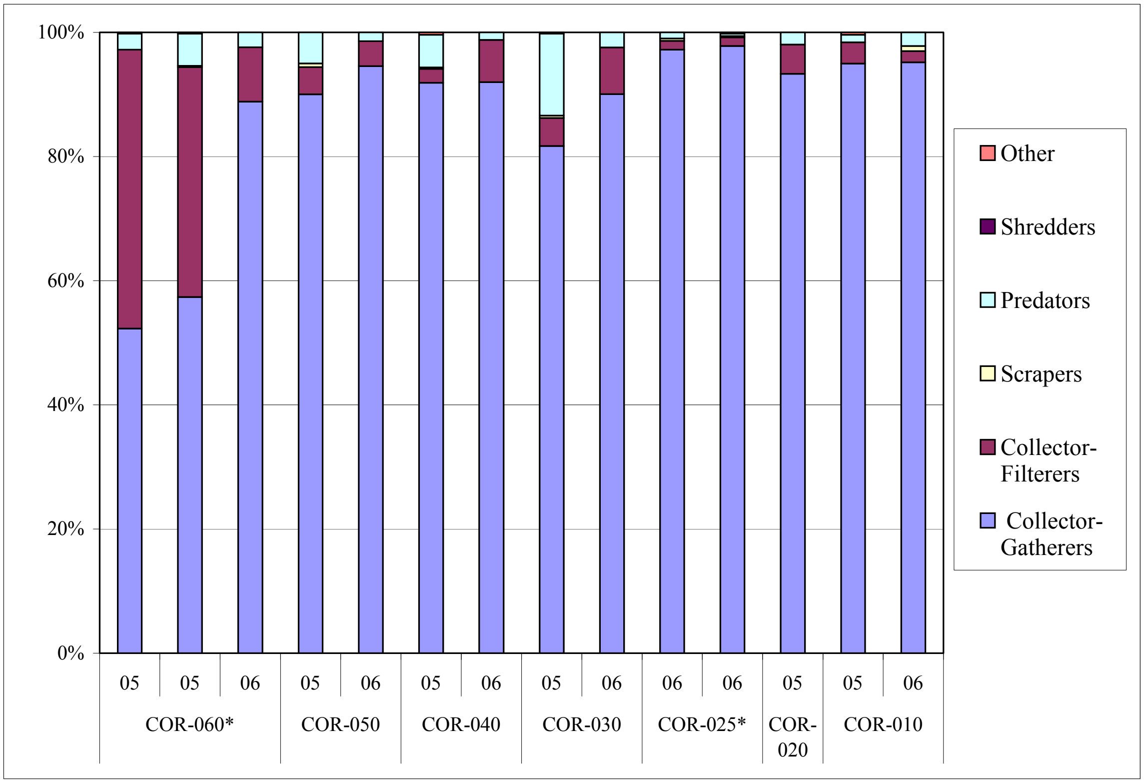


Figure 3. Macroinvertebrate functional feeding groups for Cordilleras Creek sites sampled in the spring season of 2005 and 2006, San Mateo County. Duplicate samples were collected at sites identified with an asterisk.

3.2 Composite Metric Scores

Composite metric scores show indistinct trends of BMI assemblage quality across sites and years of sampling (Figure 4). In year 2005 the two downstream sites had lower composite metric scores when compared to the other sites but this trend was not evident in year 2006. There is a subtle trend of differences between the two-year's of composite metric scores. This trend is supported in the distribution of numerically dominant taxa, which show generally higher *Baetis* abundance in year 2006.

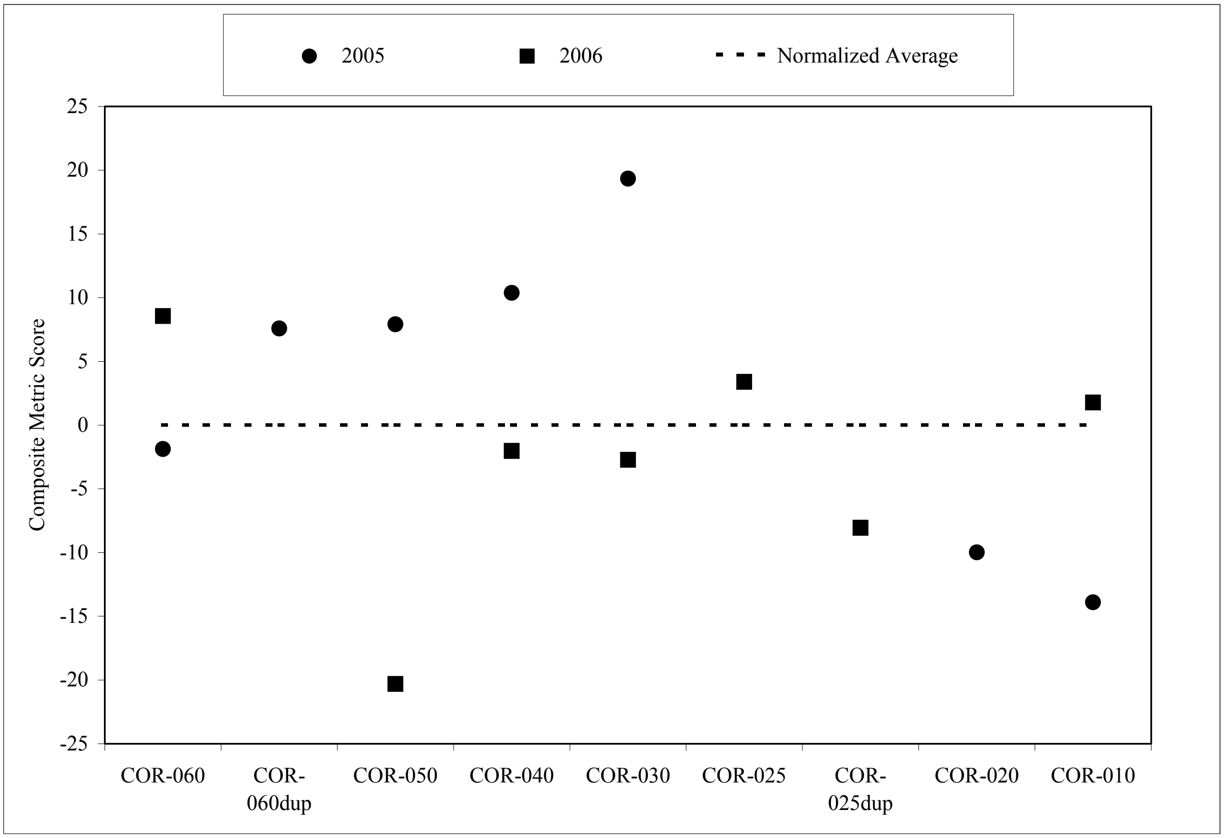


Figure 4. Composite metric scores for Cordilleras Creek sites sampled in the spring season of 2005 and 2006, San Mateo County.

3.3 Taxonomic Composition

Of the 14 samples collected in 2005 and 2006, including the duplicates, 7,019 BMIs were processed comprising 31 distinct taxa. Table 3 shows the five most numerically abundant (dominant) taxa at each site based on the modified level 1 standard taxonomic effort. A complete taxonomic list including California Tolerance Value (CTV) and functional feeding group (FFG) designations is presented in Appendix D.

Several numerically dominant taxa including orthoclad midges (Orthocladiinae), black flies (*Simulium*) and segmented worms (Oligochaeta) were common to all sites for both years (Table 3). The mayfly, *Baetis*, was the only dominant EPT taxon sampled from the stream system but its relative abundance was considerably higher in 2006 (33 percent) compared to 2005 (10 percent). The relative abundance of *Simulium* was lower in 2006 (14 percent in 2005 and 5 percent in 2006). There was a trend of increasing segmented worm (Oligochaeta) abundance with decreasing site elevation in year 2005 but in year 2006 oligochaete relative abundance was 25 percent at the highest elevation site (COR-060).

Table 3. Numerically dominant benthic macroinvertebrate taxa and their percent contribution by site for Cordilleras Creek, San Mateo County.

		Numerically Dominant Taxa				
Year	Site	1	2	3	4	5
2005	COR-010	Orthocladiinae	Oligochaeta	Tanytarsini	*Simulium*	Tanypodinae
		69%	21%	4%	3%	1%
	COR-020	Orthocladiinae	Oligochaeta	Tanytarsini	*Simulium*	Tanypodinae
		66%	24%	5%	5%	1%
	COR-030	Orthocladiinae	Oligochaeta	*Bezzia/ Palpomyia*	*Simulium*	*Baetis*
		59%	19%	10%	5%	3%
	COR-040	Orthocladiinae	Oligochaeta	*Baetis*	*Bezzia/ Palpomyia*	*Simulium*
		61%	15%	13%	3%	2%
	COR-050	Orthocladiinae	*Baetis*	Oligochaeta	*Simulium*	*Bezzia/ Palpomyia*
		49%	26%	12%	4%	3%
	COR-060	*Simulium*	Orthocladiinae	Oligochaeta	*Baetis*	*Bezzia/ Palpomyia*
		46%	21%	15%	15%	2%
	COR-060 dup	*Simulium*	Orthocladiinae	*Baetis*	Oligochaeta	*Bezzia/ Palpomyia*
		38%	34%	13%	8%	4%
2006	COR-010	Orthocladiinae	Oligochaeta	Tanytarsini	*Baetis*	*Simulium*
		66%	23%	4%	3%	2%
	COR-025	Orthocladiinae	*Baetis*	Oligochaeta	Tanytarsini	*Simulium*
		49%	32%	14%	3%	1%
	COR-025 dup	*Baetis*	Orthocladiinae	Oligochaeta	*Simulium*	Tanytarsini
		42%	41%	13%	1%	1%
	COR-030	Orthocladiinae	*Baetis*	Oligochaeta	*Simulium*	*Bezzia/ Palpomyia*
		47%	33%	8%	7%	1%
	COR-040	*Baetis*	Orthocladiinae	Oligochaeta	*Simulium*	Tanytarsini
		57%	22%	12%	7%	1%
	COR-050	Orthocladiinae	*Baetis*	Oligochaeta	*Simulium*	Tanytarsini
		58%	18%	17%	4%	1%
	COR-060	*Baetis*	Oligochaeta	Orthocladiinae	*Simulium*	Tanytarsini
		49%	25%	14%	9%	2%

Relative similarity of sites and assessment years based on taxonomic composition is shown as a dendrogram in Figure 5. At grouping level (1), site C060 (COR-060) and its duplicate in year 2005 are distinct from the other sites due mostly to the high relative abundance of black flies at the site. At grouping level (2), two groups of sites are separated partially by year of sampling: group (3) contains five of six sites sampled in year 2006 while group (4) contains four of six sites sampled in year 2005. While the MRPP indicated an insignificant annual difference (p=0.06), small sample size and within- year variation contributed to an elevated minimum effect size. Considering the partial grouping of sites by year of sampling and the distribution of numerically dominant taxa, notably *Baetis* and *Simulium*, it is not unreasonable to conclude that there were slight annual differences in BMI composition.

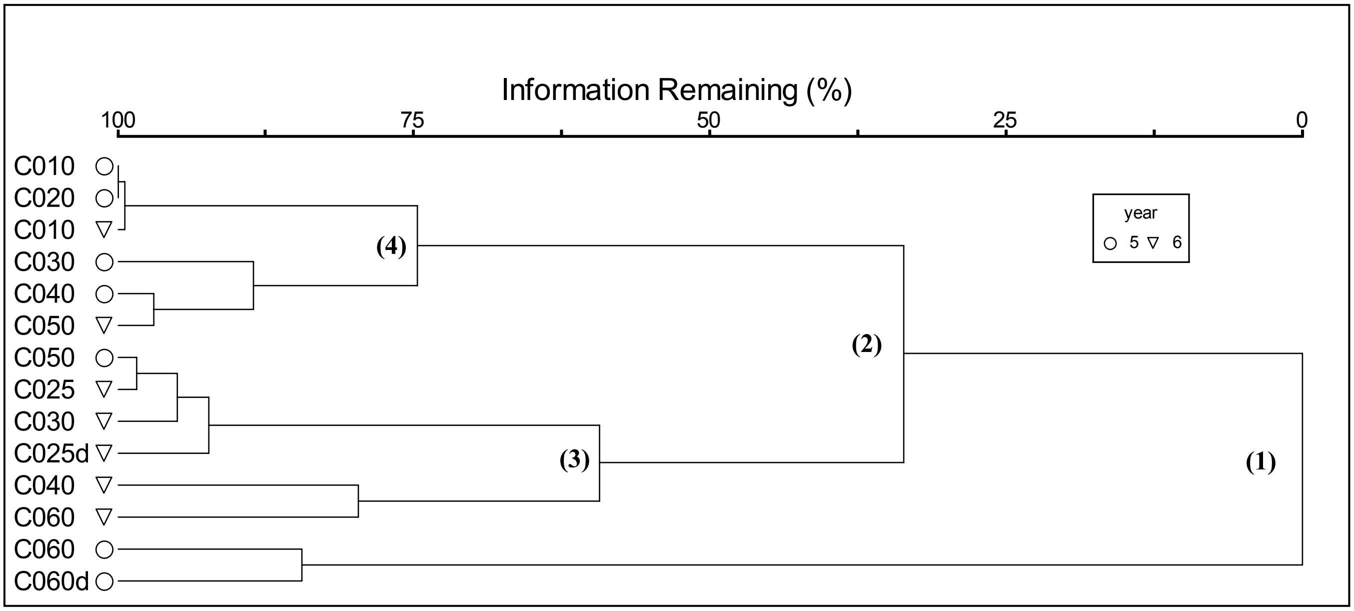


Figure 5. Dendrogram showing relative similarity of sites and sampling year (2005: 5 and 2006: 6) based on taxonomic composition of benthic macroinvertebrates sampled from Cordilleras Creek, San Mateo County. Site dissimilarity increases as links are made with decreasing information remaining. Site duplicates are indicated by "d".

3.4 Quality Control

Results of CDFG's independent review of one sample from the voucher collection are shown in Appendix E (Lab no. 2185). According to CDFG, the taxonomy was very good and performed in accordance with the CSBP level 1 STE. All sampled dipterans originally identified as Ephydridae were re-examined by the original taxonomist and changed to Sciomyzidae prior to data analysis.

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 moderately (38%) to densely (88%) canopied with intact to highly impaired riparian zones with the quality of riparian zones increasing with increasing site elevation (Table 4; Appendix F). Riffle substrate composition consisted of gravel (dominant) and cobble (subdominant) with moderate embeddedness. Riffle gradients generally decreased with decreasing site elevation.

Site scale habitat scores ranged from 91 at sites COR-010 (year 2005) and COR-025 (year 2006) to 161 at site COR-060 (year 2005). According to Barbour et al. (1999) the total habitat scores for sites COR-010 and COR-020 would imply marginal habitat; scores for sites COR-030, COR-040 and COR-050 would imply suboptimal habitat and scores for site COR-060 ranged in the suboptimal (year 2006) to optimal (year 2005) range. For reference, scores of 50 or less 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 temperature measured at the time of benthic sample collections ranged from 12º C to 16º C, specific conductance ranged from 787 µS/cm to 1024 µS/cm, pH ranged from 7.8 to 9.0 and dissolved oxygen ranged from 8.2 mg/l to 13.5 mg/l.

Table 4. **Physical habitat and water quality constituents documented for Cordilleras Creek, San Mateo County. Riffle characteristics and subjective assessment data are site mean values.**

	2005							**2006**						
Habitat Parameter	COR-060	COR-060 dup	COR-050	COR-040	COR-030	COR-020	COR-010	COR-060	COR-050	COR-040	COR-030	COR-025	COR-025 dup	COR-010
Riffle Characteristics														
Mean Length (ft)	6.3	7.3	9.0	10.0	11.0	16.0	11.0	4.0	10.7	12.3	10.7	15.7	11.3	12.7
Mean Width (ft)	5.0	4.0	4.0	6.5	6.8	7.3	8.5	4.2	5.3	6.5	7.2	8.5	9.3	7.7
Mean Depth (ft)	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3
Mean Velocity (ft/sec)	not reported							0.9	2.8	2.9	2.6	2.4	2.3	2.7
Subjective Assessment														
% Canopy	47	50	88	65	68	85	63	43	67	62	70	83	38	72
Substrate Complexity (1-10)	2.7	2.3	1.7	4.0	4.0	3.0	3.0	1.7	1.7	3.7	2.3	3.3	2.7	2.7
Embeddedness (1-10)	4.0	4.7	3.7	4.0	4.3	3.7	3.3	4.0	4.3	5.0	4.7	3.7	2.7	4.3
% Fines (<2 mm)	20	15	15	12	7	15	13	15	12	12	10	13	12	12
% Gravel (2-50 mm)	52	55	67	57	27	35	35	60	63	45	47	47	52	53
% Cobble (50-256 mm)	28	30	18	30	53	45	50	25	25	42	33	33	33	35
% Boulder (>256 mm)	0	0	0	2	7	5	2	0	0	1.7	5.0	6.7	3.3	0
% Bedrock (soild)	0	0	0	0	6.7	0	0	0	0	0	5.0	0	0	0
Substrate Consolidation	med	med	low	low	med	med	low	low	low	med	low	low	low	low
Reach Characteristics														
Total Length (ft)	156	156	192	166	108	226	224	115	108	147	220	287	287	190
% Gradient	2.3	2.3	2.7	2.1	1.6	0.7	0.4	2.3	2.7	2.1	1.6	0.7	0.7	0.4
Habitat Quality Score	161	161	144	127	127	92	91	149	137	118	110	91	91	98
Water Quality Conditions														
Time of Sampling	10:30	10:30	8:45	13:20	13:00	11:00	8:30	11:40	10:00	11:00	13:00	13:20	13:20	9:00
Water Temperature	12	12	12	13	13	12	12	14	14	13	14	15	15	14
Specific Conductance (uS/cm)	990	990	800	916	787	1000	945	1024	978	922	967	994	994	962
pH	8.4	8.4	8.9	8.8	8.7	9.0	8.9	7.8	8.0	8.2	8.0	8.2	8.2	8.1
Dissolved Oxygen (mg/l)	8.2	8.2	8.8	9.4	8.7	9.2	8.7	11.1	11.1	11.1	13.5	10.9	10.9	10.7

4.0 DISCUSSION

4.1 Evaluating Influences on Benthic Fauna

Since reference conditions have not been established in the Bay Area it is difficult to know what range of biotic metric values would be considered typical for a given region. IBIs have been developed for both south and north coastal regions of California, but reference conditions used to develop those IBIs may not be applicable to the SF Bay Area watersheds. 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 may contribute to 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 BMI assemblage quality. It should be noted that the metrics used for this assessment are widely used (Karr and Chu 1999, Ode and others 2005) but are not necessarily the most responsive to stressors affecting streams in the San Francisco Bay Area region. Additional BMI and associated habitat data representing a range of conditions including reference conditions for multiple years with a range of water year types would be required for conducting a comprehensive metric analysis. A regional database of BMI and various levels of habitat data are being developed through the Bay Area Macroinvertebrate Bioassessment Network (BAMBI), which will serve to consolidate information for development of a regional IBI. STOPPP is helping fund BAMBI's ongoing development of a regional IBI.

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 allochthonous 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).

The limited data set for the Cordilleras Creek system precludes definitive identification of trends among sites in terms of BMI assemblage quality. However, overall BMI richness and diversity appears low for the creek for two consecutive spring season assessments and intolerant taxa were absent. Furthermore, the BMIs sampled from the sites are generally considered short-lived, requiring less than one year to complete their life cycles. Consequently, the abundance of short-lived BMI taxa suggests that Cordilleras Creek is seasonal (i.e., flow is intermittent and related to seasonal rains); or was seasonal for the water year types in which sampling events were conducted. While there was a slight trend of decreasing BMI assemblage quality with decreasing elevation and increasing urbanization, the lack of sensitive taxa in the upper, less urbanized watershed suggests that seasonality of the stream's surface water is an important factor influencing assemblage quality. Furthermore, increases in quality of instream habitat and riparian buffer condition (i.e., physical habitat scores) with increasing elevation do not seem to affect the BMI assemblages. The lack of BMI response to the physical habitat score may to some extent result from the relative similar substrate quality across all sites. It is likely that a combination of intermittent stream flow and the lack of substrate complexity found at the six Cordilleras Creek sites result in lower biotic integrity. Although there were some differences in taxonomic composition by year of sampling, metrics associated with richness, diversity and tolerance were highly similar across sites and years, which indicated that the assemblages consisted of taxa with similar characteristics.

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APPENDIX A

Field data sheets used for documenting site characteristics during biological assessments

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 Cordilleras Creek sampling sites

Site COR010 – Cordilleras Creek downstream Stafford St at High School.

Site COR020 – Cordilleras Creek at Eaton Av. and Cedar St.

Site COR025 – Cordilleras Creek at Eaton Av. and Park Av.

Site COR030 – Cordilleras Creek at Cordilleras Rd and Bennett Rd.

Site COR040 – Cordilleras Creek at Cordilleras Rd and Springdale Way

Site COR050 – Cordilleras Creek upstream Old Stage Coach at Edgewood Co. Park

Site COR060 – Cordilleras Creek about 500 ft upstream culvert in Pulgas Ridge Open Space.

APPENDIX C

Metrics used to describe characteristics of benthic macroinvertebrate assemblages

BMI Metric	**Description**	**Response to Impairment**
Richness Measures		
1. Taxonomic	Total number of distinct taxa.	Decrease
2. EPT	Number of taxa in the orders Ephemeroptera (mayfly), Plecoptera (stonefly) and Trichoptera (caddisfly).	Decrease
3. Ephemeroptera	Number of mayfly taxa.	Decrease
4. Plecoptera	Number of stonefly taxa.	Decrease
5. Trichoptera	Number of caddisfly taxa.	Decrease
6. Coleoptera	Number of beetle taxa.	Decrease
7. Predator	Number of taxa they prey on living organisms.	Decrease
Composition Measures		
8. EPT Index (%)	Percent composition of mayfly, stonefly and caddisfly individuals.	Decrease
9. Sensitive EPT Index (%)	Percent composition of mayfly, stonefly and caddisfly individuals with tolerance values less than 4.	Decrease
10. Shannon Diversity Index	General measure of sample diversity that incorporates richness and evenness.	Decrease
11. Percent Dominant Taxon	The highest percentage of organisms represented by one taxon.	Increase
12. CG Taxa + CF Taxa (%)	Percentage of collector-gatherer taxa plus collector-filterer taxa	Increase
13. Non-Insect Taxa (%)	Percentage of non-insect taxa	Increase
Tolerance/Intolerance Measures		
14. California Tolerance Value (CTV)	CTVs between 0 and 10 weighted for abundance of individuals designated as pollution tolerant (higher values) and intolerant (lower values).	Increase
15. Percent Intolerant Organisms	Percentage of organisms that are highly intolerant to water and/ or habitat quality impairment as indicated by CTVs of 0, 1 or 2.	Decrease
16. Percent Tolerant Organisms	Percentage of organisms that are highly tolerant to water and/ or habitat quality impairment as indicated by CTVs of 8, 9 or 10.	Increase
Functional Feeding Groups (FFG)		
17. % Collector-gatherers (cg)	Percent of macroinvertebrates that collect or gather material.	Increase
18. % Collector-filterers (cf)	Percent of macroinvertebrates that filter suspended material from the water column.	Increase
19. % Scrapers (sc)	Percent of macroinvertebrates that graze upon periphyton.	Variable
20. % Predators (p)	Percent of macroinvertebrates that prey on living organisms.	Decrease
21. % Shredders (sh)	Percent of macroinvertebrates that shred leaf litter.	Decrease
22. % Others (ot)	Percent of macroinvertebrates that occupy an FFG not described above.	Variable
Other		
23. 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 Cordilleras Creek, April 2005 and May 2006

Taxonomic list and number of individuals subsampled from Cordilleras Creek sites, spring season 2005 and 2006.

Phylum Class Order Family Final ID	CTV[1]	FFG[2]	2005							2006						
			COR-010	COR-020	COR-030	COR-040	COR-050	COR-060	COR-060 dup	COR-010	COR-025	COR-025 dup	COR-030	COR-040	COR-050	COR-060
Arthropoda																
Insecta																
Coleoptera																
Dytiscidae																
Agabus	8	p						1	2							3
Elmidae																
Narpus	4	cg			1	2										
Narpus (adult)	4	sc			1											
Diptera																
Cyclorrhaphous/Brachycera	6							3	3							
Ceratopogonidae																
Bezzia/ Palpomyia	6	p	1	2	50	16	16	11	22	1	2	1	7	1	3	5
Ceratopogonidae	6	p						1	1							
Dasyhelea	6	cg	1													
Chironomidae																
Chironomini	6	cg		1												1
Orthocladiinae	5	cg	341	325	294	301	242	109	175	325	241	209	231	111	290	70
Tanypodinae	7	p	3	6	1	2	2		1	1	1			1	4	2
Tanytarsini	6	cg	21	26	3	10	11	4	7	20	15	6	2	3	4	9
Empididae																
Empididae	6	p								1						
Neoplasta	6	p			3		1				1	1				
Sciomyzidae																
Sciomyzidae	6	p		1		1	5			1	1					
Simuliidae																
Simulium	6	cf	17	24	23	11	22	226	186	9	7	7	37	34	20	44
Stratiomyidae																
Caloparyphus/Euparyphus	8	cg		1	3	3		2			1		2	1		
Tipulidae																
Tipula	4	om	2		1	2		1	1							

Phylum Class Order Family Final ID	CTV[1]	FFG[2]	2005							2006						
			COR-010	COR-020	COR-030	COR-040	COR-050	COR-060	COR-060 dup	COR-010	COR-025	COR-025 dup	COR-030	COR-040	COR-050	COR-060
Ephemeroptera																
Baetidae																
Baetis	5	cg			16	64	135	73	65	13	163	210	169	283	90	242
Odonata																
Aeshnidae																
Anax	8	p														1
Coenagrionidae																
Argia	7	p			7	6				6			1	2		1
Cordulegastridae																
Cordulegaster dorsalis	3	p			1								1			
Trichoptera																
Hydroptilidae																
Hydroptila	6	ph										1				
Malacostraca																
Amphipoda																
Crangonyctidae																
Stygobromus	4	cg											1			
Ostracoda																
Ostracoda	8	cg			2					1					2	
Annelida																
Oligochaeta																
Lumbriculida																
Lumbriculidae																
Lumbriculidae	8	cg												1		
Tubificida																
Enchytraeidae																
Enchytraeidae	8	cg	1	42	5	3	10	2	2	8	10			1	2	
Naididae																
Naididae	8	cg	107	81	91	71	53	73	39	106	61	64	39	59	84	125
Tubificidae																
Tubificidae	10	cg								3						

			2005							2006						
Phylum Class Order Family Final ID	CTV[1]	FFG[2]	COR-010	COR-020	COR-030	COR-040	COR-050	COR-060	COR-060 dup	COR-010	COR-025	COR-025 dup	COR-030	COR-040	COR-050	COR-060
Mollusca																
Gastropoda																
Prosobranchia																
Prosobranchia		sc				1										
Hydrobiidae																
Hydrobiidae	8	sc			1											
Pulmonata																
Lymnaeidae																
Fossaria	8	sc					2			3	2	1				
Physidae																
Physa/ Physella	8	sc					1		1	1						
Nemertea																
Enopa																
Tertastemmatidae																
Prostoma	8	p			1	1										
Platyhelminthes																
Turbellaria																
Tricladida																
Planariidae																
Planariidae	4	p	2	1	4		1			1			3	2		
Macroinvertebrates subsampled:			4506	510	508	494	501	506	505	4512	505	500	493	499	499	503

[1] California 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

APPENDIX E

Quality control results for the Cordilleras Creek biological assessment project

Comparative Taxonomic Listing of all Submitted Samples

Samples submitted by Bioassessment Services for Project: San Mateo Spring 2005

Report prepared by Brady Richards, CDFG ABL-Chico, 7/19/2005

Taxonomist	Sample no.	Vial #	Original ID	Original Count	Stage	ABL Count	ABL ID
	BAS-2185						
				0	x	0	
		1	Orthocladiinae	325		325	Orthocladiinae
		2	Naididae	81		79	Naididae
		3	Planariidae	1		1	Planariidae
		4	Tanytarsini	26		26	Tanytarsini
		5	Enchytraeidae	42		43	Enchytraeidae
		6	Simulium	24		24	Simulium
		7	Caloparyphus/Euparyphus	1		1	Caloparyphus/Euparyphus
		8	Bezzia/Palpomyia	2		2	Bezzia/Palpomyia
		9	Chironomini	1		1	Chironomini
		10	Tanypodinae	6		6	Tanypodinae
		11	Ephydridae	1		1	Sciomyzidae

APPENDIX F

Habitat data collected for the Cordilleras Creek biological assessment project

Riffle scale habitat data collected for Cordilleras Creek sites, spring season 2005.

	COR-010			COR-020			COR-030			COR-040		
Riffle Characteristics	R1	R2	R3	R1	R2	R3	R1	R2	R3	R1	R2	R3
Length (ft)	5	18	10	25	11	12	8	10	15	10	11	9
Width (ft)	8	9	8.5	7	8	7	5.5	7	8	8	6.5	5
Depth (ft)	0.2	0.19	0.22	0.25	0.22	0.25	0.25	0.22	0.26	0.19	0.23	0.3
Velocity (ft/sec)	nr	nr	nr	nr	nr	nr	nr	nr	nr	nr	nr	nr
Subjective Assessment												
% Canopy	60	65	65	95	90	70	40	80	85	80	85	30
Substrate Complexity (1-10)	3	3	3	3	3	3	4	4	4	4	4	4
Embeddedness (1-10)	4	3	3	3	4	4	5	4	4	3	5	4
% Fines (<2 mm)	10	15	15	15	20	10	5	10	5	20	5	10
% Gravel (2-50 mm)	35	35	35	30	35	40	20	30	30	60	55	55
% Cobble (50-256 mm)	55	50	45	50	40	45	50	50	60	20	40	30
% Boulder (>256 mm)	0	0	5	5	5	5	10	5	5	0	0	5
% Bedrock (solid)	0	0	0	0	0	0	15	5	0	0	0	0
Substrate Consolidation	low	low	low	med	med	med	med	med	med	low	low	med

	COR-050			COR-060			COR-060 dup		
Riffle Characteristics	R1	R2	R3	R1	R2	R3	R1	R2	R3
Length (ft)	8	5	14	6	6	7	7	5	10
Width (ft)	2.4	3	6.5	5	4	6	1.5	7	3.5
Depth (ft)	0.14	0.17	0.14	0.05	0.1	0.1	0.13	0.05	0.1
Velocity (ft/sec)	nr	nr	nr	nr	nr	nr	nr	nr	nr
Subjective Assessment									
% Canopy	85	90	90	40	40	60	40	50	60
Substrate Complexity (1-10)	2	1	2	2	3	3	2	2	3
Embeddedness (1-10)	4	4	3	4	4	4	6	4	4
% Fines (<2 mm)	10	20	15	20	20	20	20	15	10
% Gravel (2-50 mm)	60	75	65	55	50	50	50	60	55
% Cobble (50-256 mm)	30	5	20	25	30	30	30	25	35
% Boulder (>256 mm)	0	0	0	0	0	0	0	0	0
% Bedrock (solid)	0	0	0	0	0	0	0	0	0
Substrate Consolidation	low	low	low	med	med	med	med	low	med

Riffle scale habitat data collected for Cordilleras Creek sites, spring season 2006.

	COR-010			**COR-025**			**COR-025 dup**			**COR-030**		
Riffle Characteristics	R1	R2	R3	R1	R2	R3	R1	R2	R3	R1	R2	R3
Length (ft)	10	14	14	12	21	14	10	12	12	6	10	16
Width (ft)	7	9.5	6.5	8.5	10	7	9.5	10	8.5	5.5	10	6
Depth (ft)	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.3	0.4	0.2	0.2
Velocity (ft/sec)	2.9	2.1	3.1	2.4	2.5	2.3	2.4	2.6	2	3.7	1.9	2.2
Subjective Assessment												
% Canopy	50	75	90	75	80	95	5	30	80	60	90	60
Substrate Complexity (1-10)	2	3	3	3	4	3	3	2	3	3	2	2
Embeddedness (1-10)	4	4	5	4	4	3	2	3	3	5	4	5
% Fines (<2 mm)	10	15	10	15	10	15	10	15	10	5	10	15
% Gravel (2-50 mm)	60	50	50	50	40	50	55	65	35	40	50	50
% Cobble (50-256 mm)	30	35	40	30	40	30	35	20	45	35	35	30
% Boulder (>256 mm)	0	0	0	5	10	5	0	0	10	5	5	5
% Bedrock (solid)	0	0	0	0	0	0	0	0	0	15	0	0
Substrate Consolidation	low	low	low	low	low	low	low	low	low	low	low	low

	COR-040			**COR-050**			**COR-060**		
Riffle Characteristics	R1	R2	R3	R1	R2	R3	R1	R2	R3
Length (ft)	5	16	16	12	10	10	6	3	3
Width (ft)	5.5	8	6	3.5	6	6.5	5	3.5	4
Depth (ft)	0.2	0.2	0.3	0.2	0.2	0.2	0.2	0.2	0.1
Velocity (ft/sec)	3.2	3	2.4	2.9	2.4	3	0.9	NR	NR
Subjective Assessment									
% Canopy	85	75	25	60	90	50	40	60	30
Substrate Complexity (1-10)	4	4	3	2	1	2	1	2	2
Embeddedness (1-10)	5	5	5	5	4	4	4	4	4
% Fines (<2 mm)	10	15	10	10	15	10	20	10	15
% Gravel (2-50 mm)	40	40	55	60	65	65	60	60	60
% Cobble (50-256 mm)	50	40	35	30	20	25	20	30	25
% Boulder (>256 mm)	0	5	0	0	0	0	0	0	0
% Bedrock (solid)	0	0	0	0	0	0	0	0	0
Substrate Consolidation	med	med	low	low	low	low	low	low	low

Site scale habitat data collected for Cordilleras Creek, spring season 2005.

Habitat Parameter	COR-010	COR-020	COR-030	COR-040	COR-050	COR-060
Epifaunal Substrate/ Available Cover	7	8	10	12	14	15
Embeddedness	6	7	9	8	8	8
Velocity/Depth Regime	12	13	16	18	18	17
Sediment Deposition	3	8	10	8	8	8
Channel Flow Status	15	15	15	14	13	17
Channel Alteration	9	2	13	17	17	20
Frequency of Riffles	13	12	18	17	16	19
Bank Stability	14	16	14	11	18	19
Vegetative Protection	10	7	12	10	17	18
Riparian Vegetative Zone Width	2	4	10	12	15	20
Total Score	**91**	**92**	**127**	**127**	**144**	**161**

Site scale habitat data collected for Cordilleras Creek sites, spring season 2006.

Habitat Parameter	COR-010	COR-025	COR-030	COR-040	COR-050	COR-060
Epifaunal Substrate/ Available Cover	7	4	9	7	12	13
Embeddedness	7	6	8	9	8	8
Velocity/Depth Regime	16	11	13	16	12	16
Sediment Deposition	6	5	5	5	5	6
Channel Flow Status	15	15	17	16	15	14
Channel Alteration	9	7	14	16	17	20
Frequency of Riffles	16	18	11	17	17	18
Bank Stability	14	13	14	4	17	18
Vegetative Protection	6	10	11	14	17	18
Riparian Vegetative Zone Width	2	5	8	14	17	18
Total Score	**98**	**94**	**110**	**118**	**137**	**149**

APPENDIX B

Water Testing Report Prepared by Kinnetic Laboratories, Incorporated

SAN MATEO COUNTYWIDE
Water Pollution
Prevention Program
Clean Water. Healthy Community.

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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

August 24, 2005

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

Re: Cordilleras Creek Watershed Monitoring Report

Water samples were collected from three stream sites in the Cordilleras Creek watershed (Figure 1). Station IDs (identifications), descriptions, and locations are listed in Table 1. Three sampling events were performed with each representing one of three hydrological cycles. The three hydrological cycles were defined as: 2004/05 rainy season (wet season), March/April (decreasing hydrograph/spring), and June (the dry season). The wet season sampling event was performed on 7 December 2004. The decreasing hydrograph/spring sampling event was performed on 27 April 2005. The dry season sampling event was performed on 1 June 2005.

Conventional water quality parameters of temperature, pH, conductivity, and dissolved oxygen (D.O.) were measured with portable field instruments. Temperature, pH, and, conductivity were measured with a YSI Model 63 handheld instrument. D.O. was measured with a YSI Model 58 portable D.O. meter. In addition, water velocity was measured in feet/second with a Global Flow Probe, flow (velocity) meter, model number FP101. Grab water quality samples for analysis were collected directly into sample bottles as close to midstream as possible. General water quality field measurements are presented in Table 2. Water quality field measurements were successfully performed at all sites during all sampling events.

Water quality analytical laboratory results are presented for the wet season event (17 December 2004) in Table 3, for the decreasing hydrograph/spring event (27 April 2005) in Table 4, and for the dry season event (1 June 2005) in Table 5. No organophosphorus pesticide analytes were detected in any of the samples during all sampling events.

Water samples were tested for toxicity during all three sampling events. Three species bioassays were performed using the water flea (*Ceriodaphnia dubia*), the fathead minnow (*Pimephales promelas*), and the green algae (*Selenastrum capricornutum*). Results for the wet season sampling event are shown in Table 6[1]. Results for the decreasing hydrograph/spring sampling event are shown in Table 7. The dry season sampling event results are shown in Table 8.

Generally, the Quality Assurance/Quality Control (QA/QC) activities associated with the laboratory analyses were within QA/QC limits. There were some minor blanking hits for metals analyses but all were values reported below the reporting limit. In addition, there were some QC limits not met for the organophosphorus pesticide analyses (mainly high surrogate recoveries) but no qualification of data was necessary as all analytes were not measured above their associated reporting limits.

Dissolved chromium values were greater than the corresponding total recoverable value for most samples (Tables 3, 4, and 5). These discrepancies could possibly be explained by iron interference. Trapping of chromium by iron under neutral/acidic conditions makes it difficult to recover in the analysis. This was reported by MWH (Montgomery Watson Harza) Laboratories at the EVWD (East Valley Water District)/AWWA (American Water Works Association) Research Foundation 2004 Water Quality Conference in Ontario, California. Concentrations of iron in unfiltered samples are generally found to be much higher than in the filtered samples used for analysis of dissolved metals. As a result, it is expected that there would be greater levels of interference in the samples analyzed for total recoverable chromium if particulates in the sample contained high concentrations of iron. Samples filtered for the analysis of dissolved chromium would likely have low levels of iron and therefore less iron interference. Since iron was not a target analyte, we do not have total recoverable and dissolved iron information to support our belief that higher levels of iron in the unfiltered samples may be responsible for cases where the dissolved fraction of chromium exceeds the total recoverable concentration of chromium. The 7 December 2004 sample from Cord3 had a difference less than the reporting limit (1.0 ug/L) apart, well within acceptable method variability, and likely an indication that dissolved chromium forms the bulk of the measured total recoverable chromium. The total and dissolved chromium values for 27 April 2005 (with the exception of Cord3 total chromium) and 1 June 2005 sampling events should be qualified (J) an estimated quantity. In addition, total chromium for Cord3 on 27 April 2005 should be qualified (UJ) where the analyte was not detected and the reported quantitation limit is approximate and may be inaccurate or imprecise.

---

[1] The initial fathead minnow bioassays were terminated prematurely (on Day 6) due to laboratory error. The bioassays were subsequently re-initiated on 18 December 2004, and were therefore conducted outside the extended EPA 72-hour sample hold times. The growth endpoint for this test was not evaluated in the retest due to a laboratory error.

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

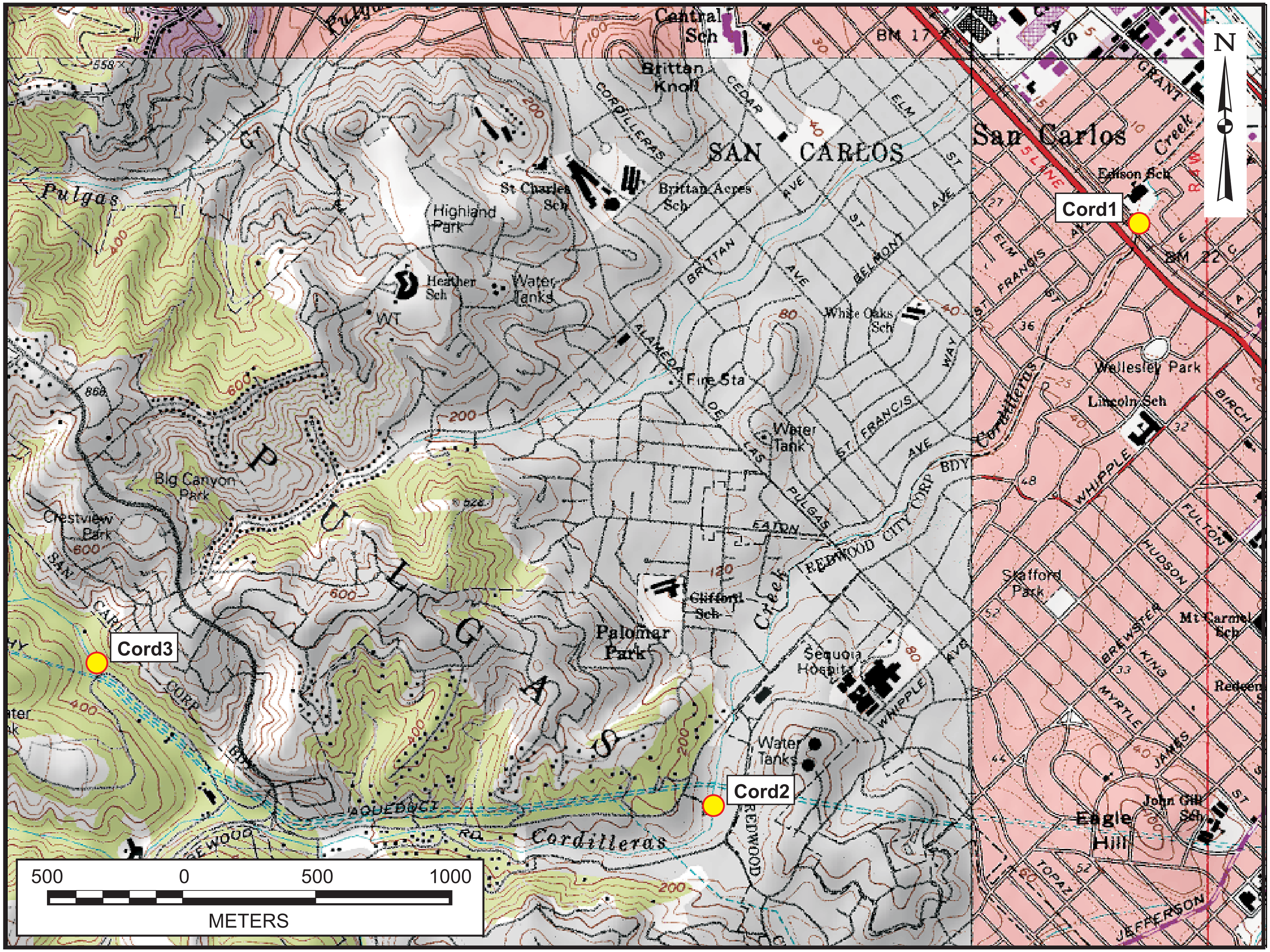


Figure 1. Cordilleras Creek Sampling Sites: Cord1 (at Stafford Street), Cord2 (at 1650 Cordilleras Rd.), and Cord3 (at Pulgas Ridge Open Space).

Table 1. Sampling Locations (December 2004, April and June 2005).

Station ID and Description		Latitude	Longitude
Cord1	Cordilleras Creek 1 at Stafford Street	37.49441	122.24415
Cord2	Cordilleras Creek 2 at 1650 Cordilleras Rd.	37.47518	122.26173
Cord3	Cordilleras Creek 3 at Pulgas Ridge Open Space	37.47989	122.28745

Table 2. General Water Quality Measurements for Each Sampling Event (December 2004, April and June 2005).

Station ID and Station Description		DATE	pH	Temp. (°C)	Cond. (µS/cm)	D.O. (mg/L)	Velocity (ft/sec)
		Wet Season Event (7 December 2004)					
Cord1	Cordilleras Creek 1	12/7/04	8.09	11.5	406	9.89	1.5
Cord2	Cordilleras Creek 2	12/7/04	8.12	11.3	493	10.14	0.77
Cord3	Cordilleras Creek 3	12/7/04	7.37	10.8	490	10.01	0.84
		Decreasing Hydrograph/Spring Event (27 April 2005)					
Cord1	Cordilleras Creek 1	4/27/05	8.16	13.4	750	9.76	0.7
Cord2	Cordilleras Creek 2	4/27/05	7.73	12.2	750	9.33	0.65
Cord3	Cordilleras Creek 3	4/27/05	8.12	12.8	796	9.44	0.54
		Dry Season Event (1 June 2005)					
Cord1	Cordilleras Creek 1	6/1/05	8.18	15.9	716	7.97	0.72
Cord2	Cordilleras Creek 2	6/1/05	7.74	14.6	788	8.46	0.37
Cord3	Cordilleras Creek 3	6/1/05	7.92	16.9	850	5.88	NM

NM=Not Measurable as creek was not flowing. Sample collected from standing pool

Table 3. Water Quality Results for Wet Sampling Event (7 December 2004).

		Stations	
	Cord1	**Cord2**	**Cord3**
NUTRIENTS AND ANIONS			
Total Hardness (mg/L)	**220**	**280**	**250**
SUSPENDED SEDIMENT CONCENTRATION			
Total Particulate Solids (mg/L)	**8.6**	**3.5**	**5.1**
Total Coarse Solids (mg/L)	<1.0	<1.0	<1.0
Total Fine (mg/L)	**8.4**	**3.3**	**5.0**
***TOTAL RECOVERABLE METALS* (µg/L)**			
Aluminum	**640**	**230**	**340**
Arsenic	1.0U	1.0U	1.0U
Cadmium	1.0U	1.0U	1.0U
Chromium	**6.1**	**4.2**	**1.5**
Copper	**7.4**	**5.0**	**3.7**
Lead	**1.1**	1.0U	1.0U
Manganese	**25**	**14**	**37**
Mercury	**0.015**	**0.0073**	**0.0081**
Nickel	**14**	**12**	**3.1**
Selenium	2.0U	2.0U	2.0U
Silver	0.20U	0.20U	0.20U
Zinc	**14**	**7.5**	**8.5**
***DISSOLVED METALS* (µg/L)**			
Aluminum	25U	25U	25U
Arsenic	1.0U	**1.0**	1.0U
Cadmium	1.0U	1.0U	1.0U
Chromium	**3.1**	**4.0**	**2.4**
Copper	**5.4**	**4.0**	**2.7**
Lead	1.0U	1.0U	1.0U
Manganese	**6.3**	**5.6**	**23**
Nickel	**5.6**	**6.4**	**1.3**
Selenium	2.0U	2.0U	2.0U
Silver	0.20U	0.20U	0.20U
Zinc	5.0U	5.0U	5.0U
ORGANOPHOSPHORUS PESTICIDES (ug/L)			
Azinphos methyl	0.20U	0.20U	0.20U
Bolstar	0.05U	0.05U	0.05U
Chlorpyrifos	0.05U	0.05U	0.05U
Coumaphos	0.10U	0.10U	0.10U
Demeton, o and s	0.05U	0.05U	0.05U
Diazinon	0.02U	0.02U	0.02U
Dichlorvos	0.05U	0.05U	0.05U
Disulfoton	0.05U	0.05U	0.05U
Ethion	0.05U	0.05U	0.05U
Ethoprop	0.05U	0.05U	0.05U
Fensulfothion	0.25U	0.25U	0.25U
Fenthion	0.05U	0.05U	0.05U
Malathion	0.05U	0.05U	0.05U
Merphos	0.05U	0.05U	0.05U
Mevinphos	0.05U	0.05U	0.05U
Parathion-ethyl	0.05U	0.05U	0.05U
Parathion-methyl	0.05U	0.05U	0.05U
Phorate	0.05U	0.05U	0.05U
Ronnel	0.05U	0.05U	0.05U
Stirophos	0.05U	0.05U	0.05U
Tokuthion (Prothiofos)	0.05U	0.05U	0.05U
Trichloronate	0.05U	0.05U	0.05U

Cord1 = Cordilleras Creek 1
Cord2 = Cordilleras Creek 2
Cord3 = Cordilleras Creek 3
Bolded sample values are for representational purposes only.
J = The result is an estimated quantity.
U = Not measured above reported sample method detection limit
UJ = Analyte was analyzed for, but was not detected. The reported quantitation limit is approximate and may be inaccurate or imprecise.

Table 4. Water Quality Results for Decreasing Hydrograph/Spring Sampling Event (27 April 2005).

		Stations	
	Cord1	**Cord2**	**Cord3**
NUTRIENTS AND ANIONS			
Total Hardness (mg/L)	**420**	**440**	**440**
SUSPENDED SEDIMENT CONCENTRATION			
Total Particulate Solids (mg/L)	<2.0	<2.0	<2.0
Total Coarse Solids (mg/L)	<1.0	<1.0	<1.0
Total Fine (mg/L)	<1.0	<1.0	<1.0
TOTAL RECOVERABLE METALS **(µg/L)**			
Aluminum	25U	**83**	**68**
Arsenic	1.0U	1.0U	1.0U
Cadmium	0.20U	0.20U	0.20U
Chromium	**1.0J**	**1.3J**	1.0UJ
Copper	**2.5**	**2.2**	**1.3**
Lead	1.0U	1.0U	1.0U
Manganese	**9.4**	**9.1**	**110**
Mercury	0.0050U	0.0050U	0.0050U
Nickel	**3.8**	**3.8**	**3.0**
Selenium	1.0U	1.0U	1.0U
Silver	0.20U	0.20U	0.20U
Zinc	**8.7**	**8.3**	**10**
DISSOLVED METALS **(µg/L)**			
Aluminum	25U	25U	25U
Arsenic	**1.2**	**1.1**	1.0U
Cadmium	0.20U	0.20U	0.20U
Chromium	**8.9J**	**9.6J**	**7.8J**
Copper	**2.2**	**1.8**	1.0U
Lead	1.0U	1.0U	1.0U
Manganese	**8.2**	**6.6**	**67**
Nickel	**3.6**	**3.0**	**2.2**
Selenium	1.0U	1.0U	1.0U
Silver	0.20U	0.20U	0.20U
Zinc	5.0U	5.0U	5.0U
ORGANOPHOSPHORUS PESTICIDES (ug/L)			
Azinphos methyl	0.20U	0.20U	0.20U
Bolstar	0.05U	0.05U	0.05U
Chlorpyrifos	0.05U	0.05U	0.05U
Coumaphos	0.10U	0.10U	0.10U
Demeton, o and s	0.05U	0.05U	0.05U
Diazinon	0.02U	0.02U	0.02U
Dichlorvos	0.05U	0.05U	0.05U
Disulfoton	0.05U	0.05U	0.05U
Ethion	0.05U	0.05U	0.05U
Ethoprop	0.05U	0.05U	0.05U
Fensulfothion	0.25U	0.25U	0.25U
Fenthion	0.05U	0.05U	0.05U
Malathion	0.05U	0.05U	0.05U
Merphos	0.05U	0.05U	0.05U
Mevinphos	0.05U	0.05U	0.05U
Parathion-ethyl	0.05U	0.05U	0.05U
Parathion-methyl	0.05U	0.05U	0.05U
Phorate	0.05U	0.05U	0.05U
Ronnel	0.05U	0.05U	0.05U
Stirophos	0.05U	0.05U	0.05U
Tokuthion (Prothiofos)	0.05U	0.05U	0.05U
Trichloronate	0.05U	0.05U	0.05U

Cord1 = Cordilleras Creek 1
Cord2 = Cordilleras Creek 2
Cord3 = Cordilleras Creek 3
Bolded sample values are for representational purposes only.
J = The result is an estimated quantity.
U = Not measured above reported sample method detection limit
UJ = Analyte was analyzed for, but was not detected. The reported quantitation limit is approximate and may be inaccurate or imprecise.

Table 5. Water Quality Results for Dry Season Sampling Event (1 June 2005).

		Stations	
	Cord1	**Cord2**	**Cord3**
NUTRIENTS AND ANIONS			
Total Hardness (mg/L)	**390**	**440**	**440**
SUSPENDED SEDIMENT CONCENTRATION			
Total Particulate Solids (mg/L)	<1.0	<1.0	**3.1**
Total Coarse Solids (mg/L)	<1.0	<1.0	**1.5**
Total Fine (mg/L)	<1.0	<1.0	**1.6**
***TOTAL RECOVERABLE METALS* (µg/L)**			
Aluminum	25U	25U	**44**
Arsenic	**1.1**	1.0U	1.0U
Cadmium	0.20U	0.20U	0.20U
Chromium	**1.0J**	**1.1J**	**1.0J**
Copper	**2.9**	**1.7**	1.0U
Lead	1.0U	1.0U	1.0U
Manganese	**13**	**5.0**	**190**
Mercury	**0.0026**	**0.0022**	**0.0025**
Nickel	**3.8**	**4.1**	**4.1**
Selenium	1.0U	1.0U	1.0U
Silver	0.20U	0.20U	0.20U
Zinc	**7.9**	**6.7**	**8.3**
***DISSOLVED METALS* (µg/L)**			
Aluminum	25U	25U	25U
Arsenic	**1.1**	1.0U	**1.1**
Cadmium	0.20U	0.20U	0.20U
Chromium	**4.3J**	**3.7J**	**4.3J**
Copper	**2.4**	**1.5**	1.0U
Lead	1.0U	1.0U	1.0U
Manganese	**11**	**3.5**	**190**
Nickel	**3.5**	**3.9**	**3.7**
Selenium	1.0U	1.0U	1.0U
Silver	0.20U	0.20U	0.20U
Zinc	**2.6**	**1.7**	**1.2**
ORGANOPHOSPHORUS PESTICIDES (ug/L)			
Azinphos methyl	0.20U	0.20U	0.20U
Bolstar	0.05U	0.05U	0.05U
Chlorpyrifos	0.05U	0.05U	0.05U
Coumaphos	0.10U	0.10U	0.10U
Demeton, o and s	0.05U	0.05U	0.05U
Diazinon	0.02U	0.02U	0.02U
Dichlorvos	0.05U	0.05U	0.05U
Disulfoton	0.05U	0.05U	0.05U
Ethion	0.05U	0.05U	0.05U
Ethoprop	0.05U	0.05U	0.05U
Fensulfothion	0.25U	0.25U	0.25U
Fenthion	0.05U	0.05U	0.05U
Malathion	0.05U	0.05U	0.05U
Merphos	0.05U	0.05U	0.05U
Mevinphos	0.05U	0.05U	0.05U
Parathion-ethyl	0.05U	0.05U	0.05U
Parathion-methyl	0.05U	0.05U	0.05U
Phorate	0.05U	0.05U	0.05U
Ronnel	0.05U	0.05U	0.05U
Stirophos	0.05U	0.05U	0.05U
Tokuthion (Prothiofos)	0.05U	0.05U	0.05U
Trichloronate	0.05U	0.05U	0.05U

Cord1 = Cordilleras Creek 1
Cord2 = Cordilleras Creek 2
Cord3 = Cordilleras Creek 3

Bolded sample values are for representational purposes only.

J = The result is an estimated quantity.
U = Not measured above reported sample method detection limit
UJ = Analyte was analyzed for, but was not detected. The reported quantitation limit is approximate and may be inaccurate or imprecise.

Table 6. Cordilleras Creek Summary of Bioassay Results (7 December 2004).

Sample	***Survival***			***Reproduction***				
	NOEC	***LOEC***	***LC_{50}***	***NOEC***	***LOEC***	***IC_{50}***	***IC_{25}***	***IC_{10}***
Ceriodaphnia dubia								
Cord1	100	>100	>100	100	>100	>100	>100	89.4
Cord2	100	>100	>100	100	>100	>100	>100	>100
Cord3	100	>100	>100	100	>100	>100	>100	>100
Pimephales promelas*								
Cord1	100	>100	>100	NM	NM	NM	NM	NM
Cord2	100	>100	>100	NM	NM	NM	NM	NM
Cord3	100	>100	>100	NM	NM	NM	NM	NM
Selenastrum capricornutum								
Cord1	NA	NA	NA	100	>100	>100	>100	>100
Cord2	NA	NA	NA	100	>100	>100	>100	>100
Cord3	NA	NA	NA	100	>100	>100	>100	>100

* Pimephales promelas test re-initiated outside of hold time as initial test was terminated prematurely on Day 6 in a laboratory error.
Values are percent sample
Cord1 = Cordilleras Creek 1
Cord2 = Cordilleras Creek 2
Cord3 = Cordilleras Creek 3
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
NM= Not Measurable due to a laboratory error.

Table 7. Cordilleras Creek Summary of Bioassay Results (27 April 2005).

Sample	***Survival***			***Reproduction***				
	NOEC	***LOEC***	***LC_{50}***	***NOEC***	***LOEC***	***IC_{50}***	***IC_{25}***	***IC_{10}***
Ceriodaphnia dubia								
Cord1	100	>100	>100	100	>100	>100	>100	71.5
Cord2	100	>100	>100	100	>100	>100	93.2	40.1
Cord3	100	>100	>100	100	>100	>100	>100	74.2
Pimephales promelas								
Cord1	100	>100	>100	100	>100	>100	>100	>100
Cord2	100	>100	>100	100	>100	>100	>100	>100
Cord3	100	>100	>100	100	>100	>100	>100	>100
Selenastrum capricornutum								
Cord1	NA	NA	NA	100	>100	>100	>100	>100
Cord2	NA	NA	NA	100	>100	>100	>100	>100
Cord3	NA	NA	NA	100	>100	>100	>100	>100

Values are percent sample
Cord1 = Cordilleras Creek 1
Cord2 = Cordilleras Creek 2
Cord3 = Cordilleras Creek 3
NOEC= Highest Test Concentration Not Producing a Statistically Significant Reduction in Survival or Fertilization
LOEC= Lowest Test Concentration Producing a Statistically Significant Reduction in Survival or Fertilization
LC_{50}= Median (50%) Lethal Concentration
IC_{50}= Concentration Inhibitory to Reproduction by 50% (Median)
IC_{25}= Concentration Inhibitory to Reproduction by 25%
IC_{10}= Concentration Inhibitory to Reproduction by 10%
NA= Not Applicable

Table 8. Cordilleras Creek Summary of Bioassay Results (1 June 2005).

	Survival			*Reproduction*				
Sample	***NOEC***	***LOEC***	***LC_{50}***	***NOEC***	***LOEC***	***IC_{50}***	***IC_{25}***	***IC_{10}***
Ceriodaphnia dubia								
Cord1	100	>100	>100	100	>100	>100	82.2	5.05
Cord2	100	>100	>100	50	100	>100	23.2	13.0
Cord3	100	>100	>100	12.5	25	75.8	5.96	2.38
Pimephales promelas								
Cord1	100	>100	>100	100	>100	>100	>100	>100
Cord2	100	>100	>100	100	>100	>100	>100	>100
Cord3	100	>100	>100	100	>100	>100	>100	82.6
Selenastrum capricornutum								
Cord1	NA	NA	NA	100	>100	>100	>100	>100
Cord2	NA	NA	NA	100	>100	>100	>100	>100
Cord3	NA	NA	NA	100	>100	>100	>100	>100

Values are percent sample

Cord1 = Cordilleras Creek 1
Cord2 = Cordilleras Creek 2
Cord3 = Cordilleras Creek 3
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

FIELD NOTES

CORDILLERAS CREEK MONITORING

KLI SAMPLING FIELD NOTES & WATER QUALITY OBSERVATIONS

Station/Location Name: Cordilleras Creek 1

Date & Time: 12/7/04 1245

KLI Field Crew: JT AH

Geographic Coordinates: Latitude = 37.49441 Longitude = 122.24415

Stream Characteristics:

Water Velocity (ft/sec) at 0.6 x Depth: 1.5 x 5"

Color: light brown

Depth/Width of Stream: 5" x 6'

Odors: None

Oil & Grease Sheen: [✓ none] / low / moderate / high

Trash: sm. amount - plastic, tiles

Turbidity: none / low / [✓ moderate] / high

Other:

Water Quality Parameters

pH: 8.09

Dissolved Oxygen (mg/L): 9.89

Temperature: 11.5°C

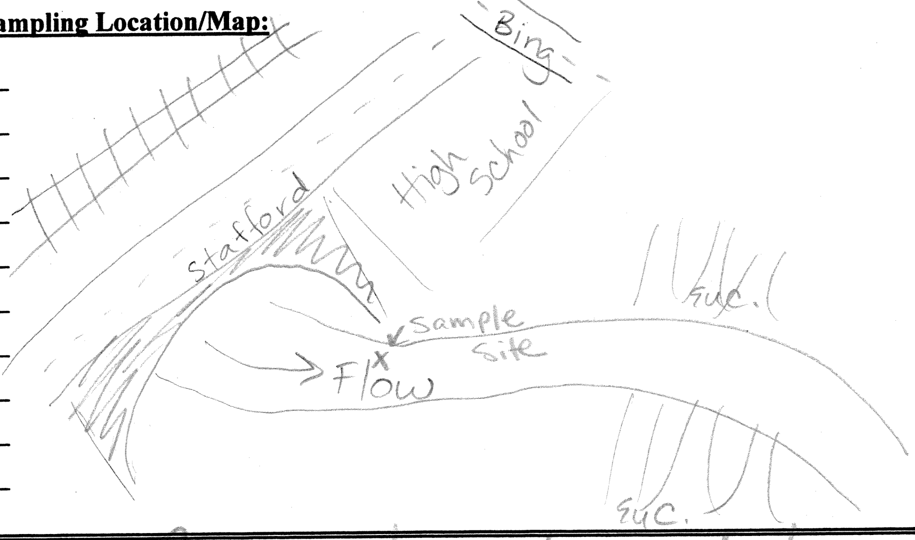
Conductivity (µS/cm): 405.9

Sampling Equipment & Procedures:

Other Notes/Observations:

Sampled downstream of bridge next to high school

Description & Sketch of Sampling Location/Map:



Crew Leader Signature & Date: Amy Hawk 12/7/04

CORDILLERAS CREEK MONITORING

KLI SAMPLING FIELD NOTES & WATER QUALITY OBSERVATIONS

Station/Location Name: Cordilleras Creek 2

Date & Time: 12/7/04 1530

KLI Field Crew: JT AH

Geographic Coordinates: Latitude = N 37°.47518 Longitude = W 122°.26173

Stream Characteristics:

Water Velocity (ft/sec) at 0.6 x Depth: 0.77 x 5"

Color: Light brown

Depth/Width of Stream: 5" x 5'

Odors: None

Oil & Grease Sheen: [✓ none] / low / moderate / high

Trash: Sm. Amount - plastic, paper

Turbidity: none / [✓ low] / moderate / high

Other: private property

Water Quality Parameters

pH: 8.12

Dissolved Oxygen (mg/L): 10.14

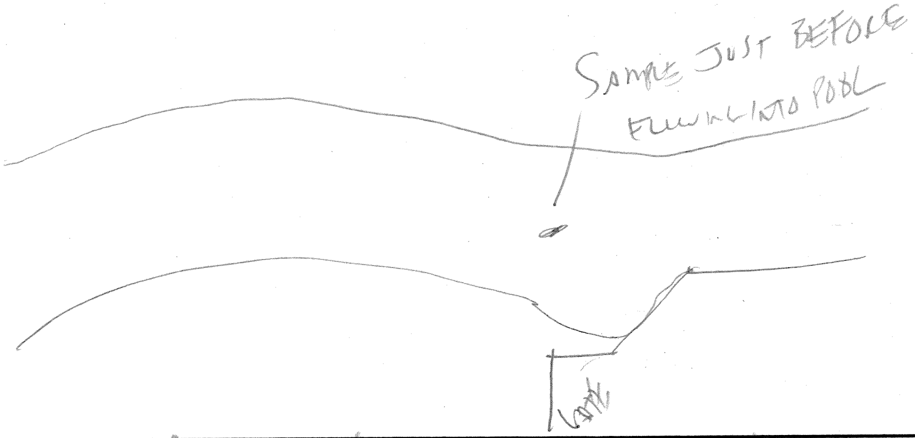
Temperature: 11.3° C

Conductivity (µS/cm): 493

Sampling Equipment & Procedures:

Other Notes/Observations:

Description & Sketch of Sampling Location/Map:



SAMPLE JUST BEFORE FLOWING INTO POOL

Crew Leader Signature & Date: Amy Howk 12/7/04

CORDILLERAS CREEK MONITORING

KLI SAMPLING FIELD NOTES & WATER QUALITY OBSERVATIONS

Station/Location Name: Cordilleras Creek 3

Date & Time: 12/07/04 11:30

KLI Field Crew: A.H. + J.T.

Geographic Coordinates: Latitude = 37.47989 Longitude = 122.28745

Stream Characteristics:

Water Velocity (ft/sec) at 0.6 x Depth: 0.84ft/sec

Depth/Width of Stream: 2" / 2'

Oil & Grease Sheen: [✓ none] / low / moderate / high

Turbidity: none / [✓ low] / moderate / high

Color: LIGHT BROWN

Odors: NO

Trash: NO

Other:

Water Quality Parameters

pH: 7.37

Temperature: 10.8°C

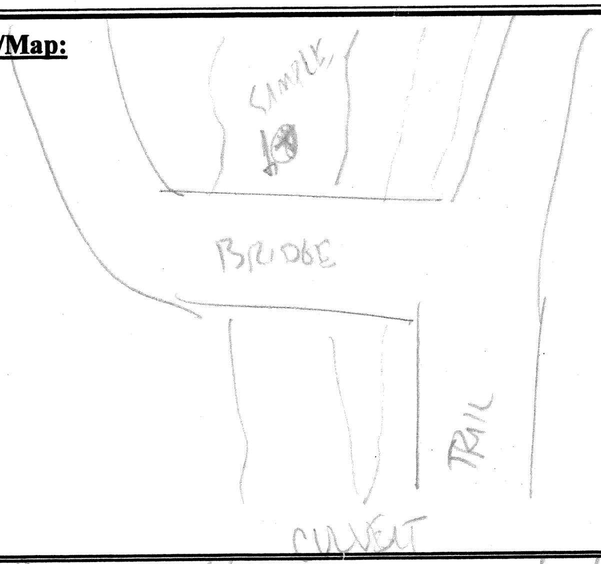
Dissolved Oxygen (mg/L): 10.01

Conductivity (µS/cm): 490

Sampling Equipment & Procedures:

Other Notes/Observations:

Description & Sketch of Sampling Location/Map:



Crew Leader Signature & Date: Amy Howk 12/7/04

CORDILLERAS CREEK MONITORING

KLI SAMPLING FIELD NOTES & WATER QUALITY OBSERVATIONS

Station/Location Name: Cordilleras Creek 1

Date & Time: 4/27/05 0930

KLI Field Crew: AH BC

Geographic Coordinates: Latitude = N 37.49443° Longitude = W122.24425°

Stream Characteristics:

Water Velocity (ft/sec) at 0.6 x Depth: 0.7 ft/sec

Color: Clear

Depth/Width of Stream: 0.35 ft. / 7.0 ft.

Odors: None

Oil & Grease Sheen: [✓ none] / low / moderate / high

Trash: yes - styrofoam, plastic, aluminum

Turbidity: [✓ none] / low / moderate / high

Other:

Water Quality Parameters

pH: 8.16

Dissolved Oxygen (mg/L): 9.76

Temperature: 13.4°C

Conductivity (µS/cm): 750

Sampling Equipment & Procedures:

Other Notes/Observations:

Description & Sketch of Sampling Location/Map:

Crew Leader Signature & Date: Amy Howk 4/27/05 0930

CORDILLERAS CREEK MONITORING

KLI SAMPLING FIELD NOTES & WATER QUALITY OBSERVATIONS

Station/Location Name: Cordilleras Creek 2

Date & Time: 4/27/05 0830

KLI Field Crew: Amy Howk & Brandy Curtis

Geographic Coordinates: Latitude = N 37.47518° Longitude = W 122.26176°

Stream Characteristics:

Water Velocity (ft/sec) at 0.6 x Depth: 0.65 ft/sec

Depth/Width of Stream: 0.45 ft / 5.0 ft

Oil & Grease Sheen: [✓ none] / low / moderate / high

Turbidity: [✓ none] / low / moderate / high

Color: Clear

Odors: None

Trash: None

Other: Aqua Air tank dripping into stream

Water Quality Parameters

pH: 7.73

Temperature: 12.2°C

Dissolved Oxygen (mg/L): 9.33

Conductivity (μS/cm): 750

Sampling Equipment & Procedures:

Other Notes/Observations:

5 Banana Slugs

Description & Sketch of Sampling Location/Map:

Crew Leader Signature & Date: Amy Howk 4/27/05 0830

CORDILLERAS CREEK MONITORING

KLI SAMPLING FIELD NOTES & WATER QUALITY OBSERVATIONS

Station/Location Name: Cordilleras Creek 3

Date & Time: 4/27/05 1100

KLI Field Crew: AH BC

Geographic Coordinates: Latitude = N 37.47998° Longitude = W 122.28753°

Stream Characteristics:

Water Velocity (ft/sec) at 0.6 x Depth: 0.54

Color: Clear

Depth/Width of Stream: 0.1' x 10'

Odors: Slight organic debris decomposition

Oil & Grease Sheen: [✓ none] / low / moderate / high

Trash: plastic, Al, p'nuts

Turbidity: none / [✓ low] / moderate / high

Other:

Water Quality Parameters

pH: 8.12

Dissolved Oxygen (mg/L): 9.44

Temperature: 12.8°C

Conductivity (µS/cm): 796

Sampling Equipment & Procedures:

Other Notes/Observations:

Description & Sketch of Sampling Location/Map:

Crew Leader Signature & Date: Amy Hawk 4/27/05 1100

CORDILLERAS CREEK MONITORING

KLI SAMPLING FIELD NOTES & WATER QUALITY OBSERVATIONS

Station/Location Name: Cordilleras Creek 1

Date & Time: 6/1/05 1000

KLI Field Crew: BC AH

Geographic Coordinates: Latitude = N 37.49451° Longitude = W 122.24426°

Stream Characteristics:

Water Velocity (ft/sec) at 0.6 x Depth: 0.72 x 0.2'

Color: Clear

Depth/Width of Stream: 0.2' x 4.7'

Odors: None

Oil & Grease Sheen: [✓ none] / low / moderate / high

Trash: Plastic, Bottles

Turbidity: [✓ none] / low / moderate / high

Other:

Water Quality Parameters

pH: 8.18

Dissolved Oxygen (mg/L): 7.97

Temperature: 15.9

Conductivity (µS/cm): 716

Sampling Equipment & Procedures:

Other Notes/Observations:

Mint growing on river bank.

Description & Sketch of Sampling Location/Map:

Crew Leader Signature & Date: Amy Hawk 6/1/05

CORDILLERAS CREEK MONITORING

KLI SAMPLING FIELD NOTES & WATER QUALITY OBSERVATIONS

Station/Location Name: Cordilleras Creek 2

Date & Time: 6/1/05 0830

KLI Field Crew: AH, BQC

Geographic Coordinates: Latitude = N37.47498° Longitude = W122.260666°

Stream Characteristics:

Water Velocity (ft/sec) at 0.6 x Depth: .37 mph average .4 mph max.

Color: Clear

Depth/Width of Stream: 1/2 ft deep x 6 ft wide

Odors: None* See below*

Oil & Grease Sheen: [✓ none] / low / moderate / high

Trash: Metal, Plastic, brick

Turbidity: [✓ none] / low / moderate / high

Other: Banana slugs

Water Quality Parameters

pH: 7.74

Dissolved Oxygen (mg/L): 8.46

Temperature: 14.6

Conductivity (µS/cm): 788

Sampling Equipment & Procedures:

Other Notes/Observations:

Sm. discharge from Linda's yard into stream (downstream of sampling). Strong smell immediately following - Sewer. Water Velocity recorded in mph

Description & Sketch of Sampling Location/Map:

Crew Leader Signature & Date: Amy Howk 6/1/05

CORDILLERAS CREEK MONITORING

KLI SAMPLING FIELD NOTES & WATER QUALITY OBSERVATIONS

Station/Location Name: Cordilleras Creek 3

Date & Time: 6/1/05 1115

KLI Field Crew: AH, OQC

Geographic Coordinates: Latitude = N 37.48021 Longitude = W122.28761

Stream Characteristics:

Water Velocity (ft/sec) at 0.6 x Depth: NM

Depth/Width of Stream: 0.5" X 1'

Oil & Grease Sheen: [✓ none] / low / moderate / high

Turbidity: [✓ none] / low / moderate / high

Color: Clear

Odors: None

Trash: None

Other: Flocculent layer in stream

Water Quality Parameters

pH: 7.92

Temperature: 16.9

Dissolved Oxygen (mg/L): 5.88

Conductivity (μS/cm): 850

Sampling Equipment & Procedures:

Creek level very low.

Other Notes/Observations:

Sampled in a pool 2.5' X 3.5' and 1' deep. Water mostly Stagnate. Smelled Sulfur when water got mixed up.

Description & Sketch of Sampling Location/Map:

Crew Leader Signature & Date: Amy Hawk 6/1/05

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