Final Technical Report 2007

Water Quality Monitoring and Bioassessment in Four San Francisco Bay Region Watersheds in 2003-2004:

Kirker Creek
Mt. Diablo Creek
Petaluma River
San Mateo Creek

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(Revised 2008)

SAN FRANCISCO BAY REGIONAL WATER QUALITY CONTROL BOARD

www.waterboards.ca.gov/swamp

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List of Acronyms

BMI	Benthic Macroinvertebrates
CAMLnet	California Aquatic Macroinvertebrate Laboratory Network
CRM	Certified Reference Material
CSBP	California Stream Bioassessment Procedure
CTR	California Toxics Rule
DFG	Department of Fish and Game
DFG-ABL	Department of Fish and Game, Aquatic Biology Laboratory
DFG-WPCL	Department of Fish and Game - Water Pollution Control Laboratory
DO	Dissolved Oxygen
DQI	Data Quality Indicator
LCS	Laboratory Control Sample
MDL	Minimum detection limit
MLML	Moss Landing Marine Laboratory
MPN	Most Probable Number
MPSL	Marine Pollution Studies Laboratory
MQO	Measurement Quality Objective
MS/MSD	Matrix Spike / Matrix Spike Duplicate
MWAT	Maximum Weekly Average Temperature
MWMT	Maximum Weekly Maximum Temperature
NMS	Non-metric multidimensional scaling
OC	OrganoChlorine
OP	OrganoPhosphate (pesticide)
PAHs	Polynucleated Aromatic Hydrocarbons
PCBs	PolyChlorinated Biphenyls
PEC	Probable Effect Concentration
QAPP	Quality Assurance Project Plan
QC	Quality control
QMP, or QAMF	Quality Management Plan
RB2	Regional Board 2 (SF Bay Regional Board)
RL	Reporting limit
RPD	Relative Percent Difference
SC	Specific Conductance
SFBRWQCB	San Francisco Bay Regional Water Quality Control Board
STE	Standard Taxonomic Effort
SWAMP	Surface Water Ambient Monitoring Program
TEC	Threshold Effect Concentration
TRL	Target reporting limit
UCD-GC	UC Davis (Laboratory) at Granite Canyon

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1 Introduction

1.1 Overview of the Surface Water Ambient Monitoring Program in California

California Assembly Bill 982 (Water Code Section 13192; Statutes of 1999) required that the State Water Resources Control Board (SWRCB) assess and report on State water monitoring programs and prepare a proposal for a comprehensive surface water quality monitoring program. The SWRCB proposed to restructure the existing water quality monitoring programs into a new program, the Surface Water Ambient Monitoring Program (SWAMP). This program consists of statewide environmental monitoring focused on providing the information needed to effectively manage the State's water resources. SWAMP is designed to be consistent, cooperative, adaptable, scientifically sound, and to meet clear monitoring objectives. It will also facilitate reporting and categorizing of the State's water quality under Sections 305 (b) and 303 (d) of the federal Clean Water Act.

SWAMP has conducted statewide monitoring through the SWRCB and regional monitoring through the Regional Water Quality Control Boards. Currently, both the statewide component and the regional components are being redesigned.

1.2 Overview of the San Francisco Bay Region SWAMP Monitoring Program

SWAMP in the San Francisco Bay Region included:

- Monitoring watersheds to assess water quality impacts and establish regional reference sites; and
- Monitoring edible fish for contaminant levels in reservoirs and coastal areas where people catch and consume fish.

Five years of watershed monitoring have been completed. A previous document "Water Quality Monitoring and Bioassessment in Nine San Francisco Bay Region Watersheds" (SFBRWQCB 2007) reported on watersheds monitored in 2001-2002 and 2002-2003. These watersheds included Walker Creek, Lagunitas Creek, San Leandro Creek, Wildcat/San Pablo Creeks, Suisun Creek, Arroyo Las Positas in 2001-2002; and Pescadero/Butano Creeks, San Gregorio Creek, and Stevens/Permanente Creeks in 2002-2003. This document reports on four watersheds monitored in 2003-2004; the third year of the program (hereafter "year 3"). These watersheds are Kirker Creek, Mt. Diablo Creek, the Petaluma River and San Mateo Creek

From 1998 to 2001 SWAMP and previous monitoring programs (Toxic Substances Monitoring Program and Coastal Fish Contamination Program), conducted contaminant monitoring in edible fish in coastal areas and reservoirs popular for fishing. The results of these fish tissue studies can be found in the report "Chemical Concentrations in Fish Tissues from Selected Reservoirs and

Coastal Areas in the San Francisco Bay Region" (SFBRWQCB 2005). Both the watershed and the fish tissue reports are available at http://www.waterboards.ca.gov/sanfranciscobay/monitoring.html.

1.3 Goals and Objectives of the Watershed Component of SWAMP in the San Francisco Bay Region

The goal of the Surface Water Ambient Monitoring Program (SWAMP) in the San Francisco Bay Region has been to monitor and assess watersheds in the Region using a weight-of-evidence approach based on measurement of physical, chemical, and biological water quality parameters. Data developed in this program are intended to be used for evaluating watersheds for 305b reporting and 303d listing.

Specific objectives of the monitoring program are to develop new data to evaluate beneficial use protection; measure water quality indicators and stressors to characterize spatial and temporal trends; determine relationships between water quality indicators, specific stressors and land use, including water management; identify reference sites; and evaluate monitoring tools. Due to a reduction in regional SWAMP funding, in the future we plan to meet these objectives in collaboration with other watershed monitoring programs.

1.4 Scope of the Report

This report provides a data summary for watershed monitoring completed during year three of the regional program. Watershed data were compared with published water quality goals and reviewed to identify spatial and/or temporal trends. Data analysis was also geared to augment regional findings from previous years' monitoring, including linkage of results to land use and evaluation of the SWAMP monitoring tools. This report does not provide an evaluation of beneficial use support, nor does it assess watershed impairment; however, data provided herein can be used in support of such determinations.

Section 2 of this report provides summary information on the four watersheds, and shows the sampling locations. It also describes the study design for year 3, the logistics of field operations, and the laboratory methodology. Section 3 shows highlights of the results, arranged for each watershed in a separate sub-section (3.1 to 3.4); these are followed by a regional summary chapter (Sub-section 3.5). Section 4 provides discussion of all results, Section 5 lays out the conclusions and the recommendations, and Section 6 provides the references for the articles cited in the entire report. The body of this report (Sections 1 through 6) is followed by a set of appendices that contain the individual monitoring results and are an integral part of the reporting effort.

The authors of this report hope that all the basic information a reader will find essential to understanding the report has been provided. However, this report leans heavily on rationale, discussions, and details contained in three previously-released documents, and the reader is advised to have these documents accessible:

- SF Bay Region SWAMP interpretive report for years 1 and 2 (SFBRWQCB. 2007);
- SF Bay Region SWAMP work plan for year 3 (SFBRWQCB. 2002);
- The SWAMP Quality Management Plan with its appended protocols (Puckett 2002).

2 Methods

2.1 Watershed and site descriptions

2.1.1 Watershed and site selection criteria

The four watersheds selected for year 3 monitoring represented different microclimates, terrains, urbanization history, water impoundment layouts, types of impacts, and distributions of land use activities. They also span different sides of the Bay and are located in different counties (SFBRWQCB 2002). **Figure 2.1-1** shows their locations around the Bay.

In determining sampling sites within a watershed, SWAMP first considers the potential water quality concerns in the watershed. By hypothesizing where the sources of potential problems may be, sites are considered in those areas, depending of course on factors such as site accessibility, access permission, and project funding. By placing monitoring sites in locations both upstream and downstream of high impact areas, it is possible to make inferences, directly related to specific land uses.

Establishing reference sites is of utmost importance. The criteria for establishing reference sites for a watershed have been a long-debated issue, but general requirements are that they are accessible, are found in geographic and geologic conditions similar to those of impacted sites, and are as close to pristine historical conditions as is available in the watershed. The need for urban land use reference sites has also been identified, but their selection will be based on a different set of criteria.

Integrator sites are established at the lowest point in the watershed that is not tidally influenced. Although these sites receive contaminants from all sources and land use impacts in the watershed, they are limited in providing a fully cumulative picture because of transience and dilution of contaminants. Integrator sites are used to evaluate the relative contribution of contaminants to the receiving waters (SFBRWQCB 2002).

2.1.2 Year 3 sampling stations

Table 2.1-1 shows the lat/long coordinates for the 39 sites monitored by SWAMP in the four watersheds selected for 2003-2004 monitoring. Station elevations were gleaned from the SWAMP database, and flow regime information was obtained from Reconnaissance summaries, where available. Reconnaissance data sheets and summaries are available with SWAMP personnel at the SF Bay Region office.

Figures 2.1-2, 2.1-3, 2.1-4, and 2.1-5 show the four maps of the watersheds selected for year 3. As mentioned above, locations were selected to characterize the stream network in relation to urban areas and to provide an integrated picture of potential contaminants.

Table 2.1-1: Stations monitored in 2003

Station	Station Name	Latitude	Longitude	Elev-ation	Flow regime
Kirker Creek Watershed (CalWater **207)**					
KIR020	Floodway	38.0165	-121.83881	25 ft	Intermittent
KIR053	Los Medanos Lake	38.00711	-121.86275		
KIR090	East Leland	38.00975	-121.87983		Intermittent
KIR110	Buchanan Park	38.00088	-121.88808		
KIR115	Kirker Creek Apartments	37.99101	-121.89457	222 ft	
Mt. Diablo Creek watershed (CalWater **207)**					
MTD010	Port Chicago Highway	38.01861	-122.02602		
MTD020	Diablo Creek Golf Course	38.01362	-122.01484		
MTD030	Bailey Rd @ Laura	37.97156	-121.96985		
MTD050	Lydia Lane Park	37.94937	-121.94407		
MTD055	N. Mitchell Canyon Rd	37.94866	-121.94111		
MTD060	Diablo below confluence	37.94405	-121.93749	400 ft	
MTD100	Mitchell on Oak St	37.9357	-121.93886	466 ft	
MTD115	Mitchell at State Park	37.91979	-121.94221		
MTD120	Mitchell on Fire Rd	37.9205	-121.942	616 ft	
MTD130	Peacock Creek in Irish Canyon	37.94433	-121.92226		
MTD140	Donnor Creek	37.92084	-121.92669		Intermittent
Petaluma River Watershed (CalWater **206)**					
PET010	San Antonio Road bridge	38.18173	-122.60322		Intermittent
PET060	D Street	38.18765	-122.66415		Intermittent
PET070	Chileno Valley Rd.	38.1984	-122.70437		Intermittent
PET090	Ellis Creek @ S. Ely Rd.	38.23337	-122.5777		
PET120	Adobe at Sartori Drive	38.23676	-122.59678		
PET130	Fairway Meadows	38.24295	-122.59433		
PET150	Above Petaluma Adobe SHP	38.25533	-122.5835	169 ft	
PET220	Hands of Jesus	38.24751	-122.62795		Perennial
PET265	Lynch pedestrian path	38.25164	-122.63268		
PET280	Lynch at Adobe Road	38.27476	-122.61928	164 ft	
PET310	Outlets	38.25578	-122.65117		Perennial
PET315	Corona Rd Bridge	38.26098	-122.65982		
PET350	Rainsville KOA	38.27173	-122.67676		Intermittent
PET360	Liberty/ Marin/ Wiggins	38.27715	-122.6805		
PET400	Penngrove Park	38.29444	-122.66629		
San Mateo Creek Watershed (CalWater **204)**					
SMA020	Gateway Park	37.57028	-122.31861		
SMA060	Arroyo Court Park	37.56213	-122.32884		
SMA080	Sierra Drive	37.55722	-122.34194		
SMA110	Polhemus	37.53233	-122.35088		
SMA120	Above Polhemus	37.53258	-122.35121		
SMA160	Above Mud Dam	37.57516	-122.42935		
SMA180	Buckeye @ Old Cañada Rd	37.4878	-122.34309		

Blank spaces indicate that station elevation and flow regime information was not available.

Figure 2.1-1: San Francisco Bay watersheds monitored in year 3

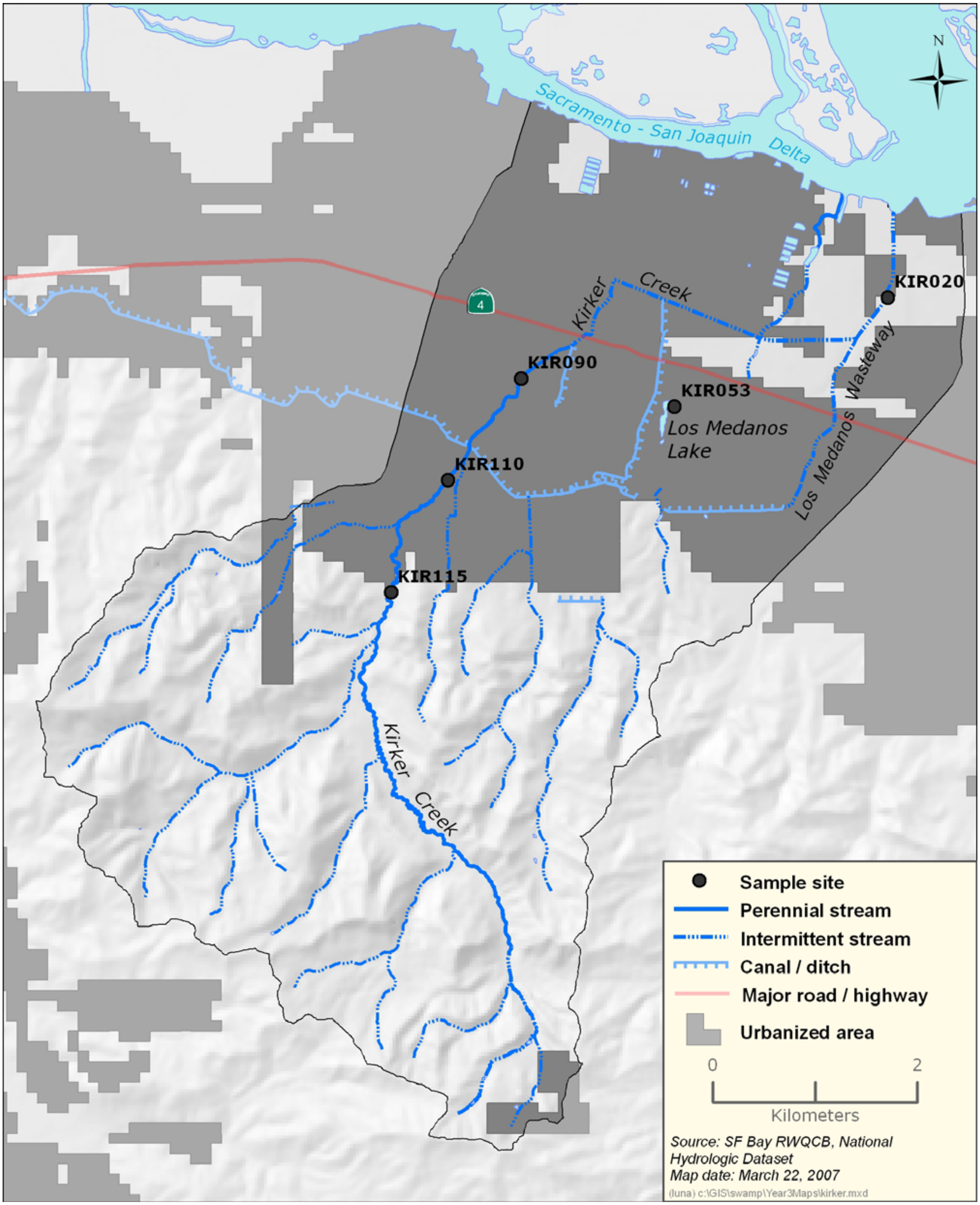


Figure 2.1-2: Location of year 3 monitoring stations in Kirker Creek watershed

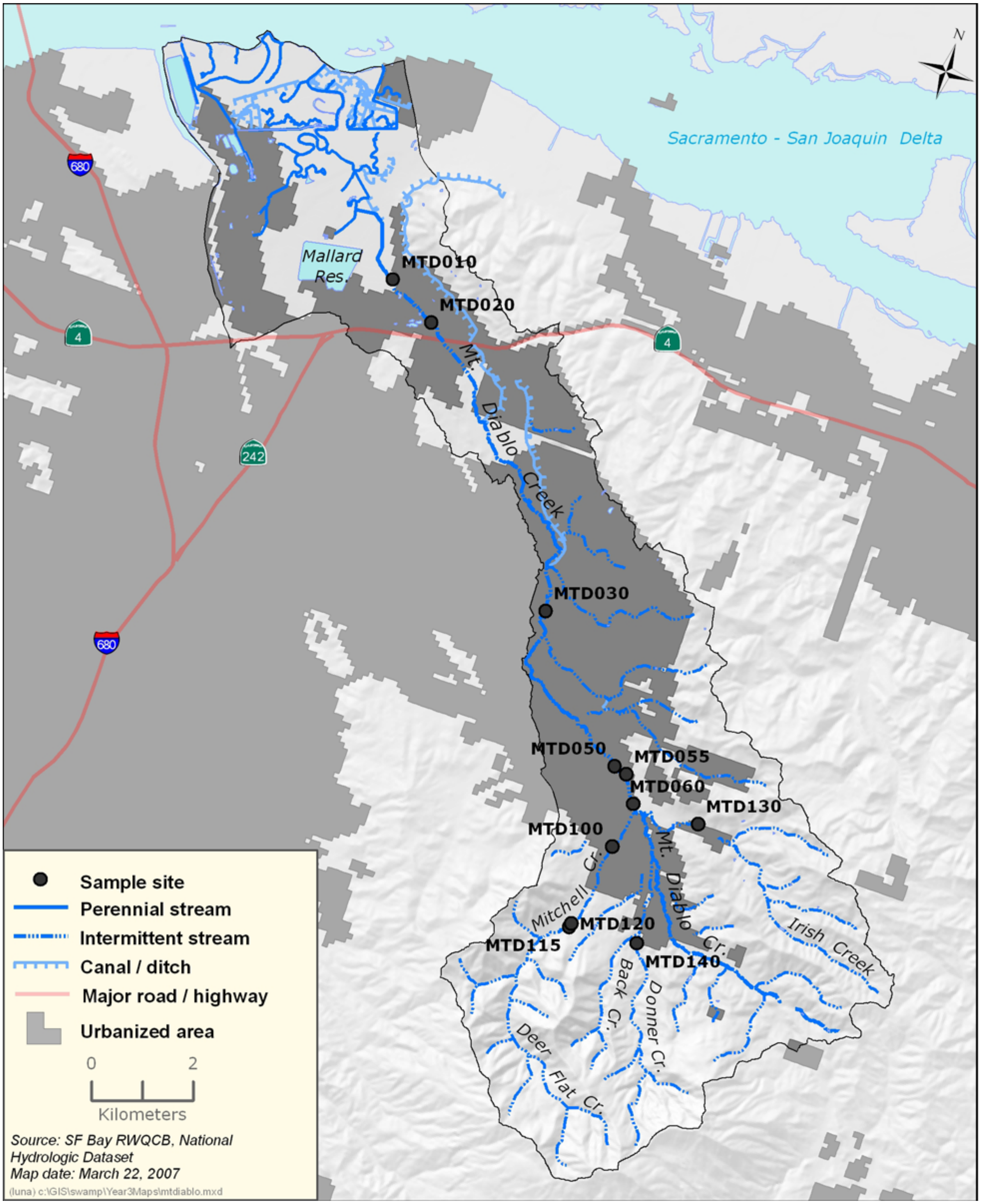


Figure 2.1-3: Location of year 3 monitoring stations in Mt. Diablo Creek watershed

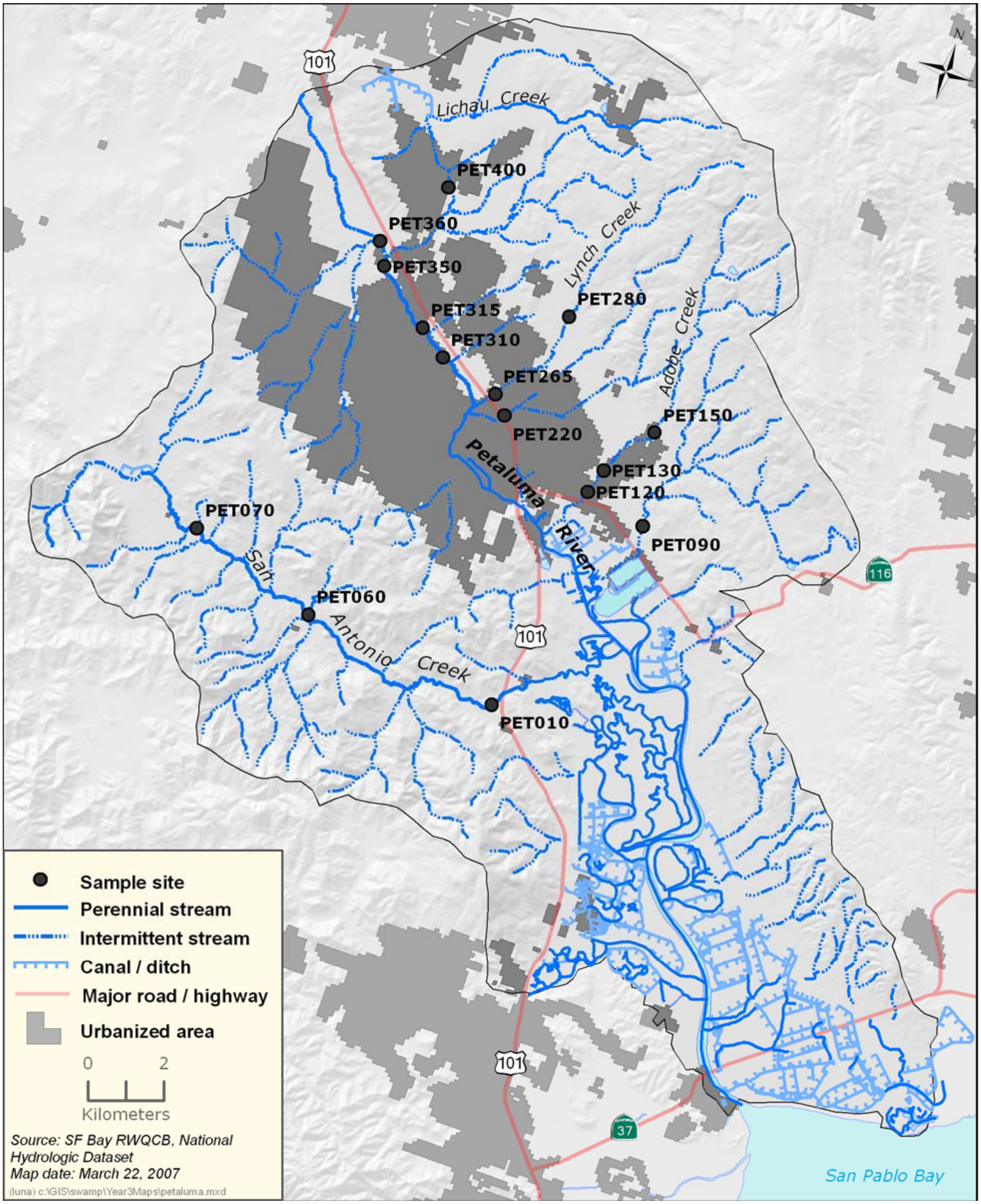
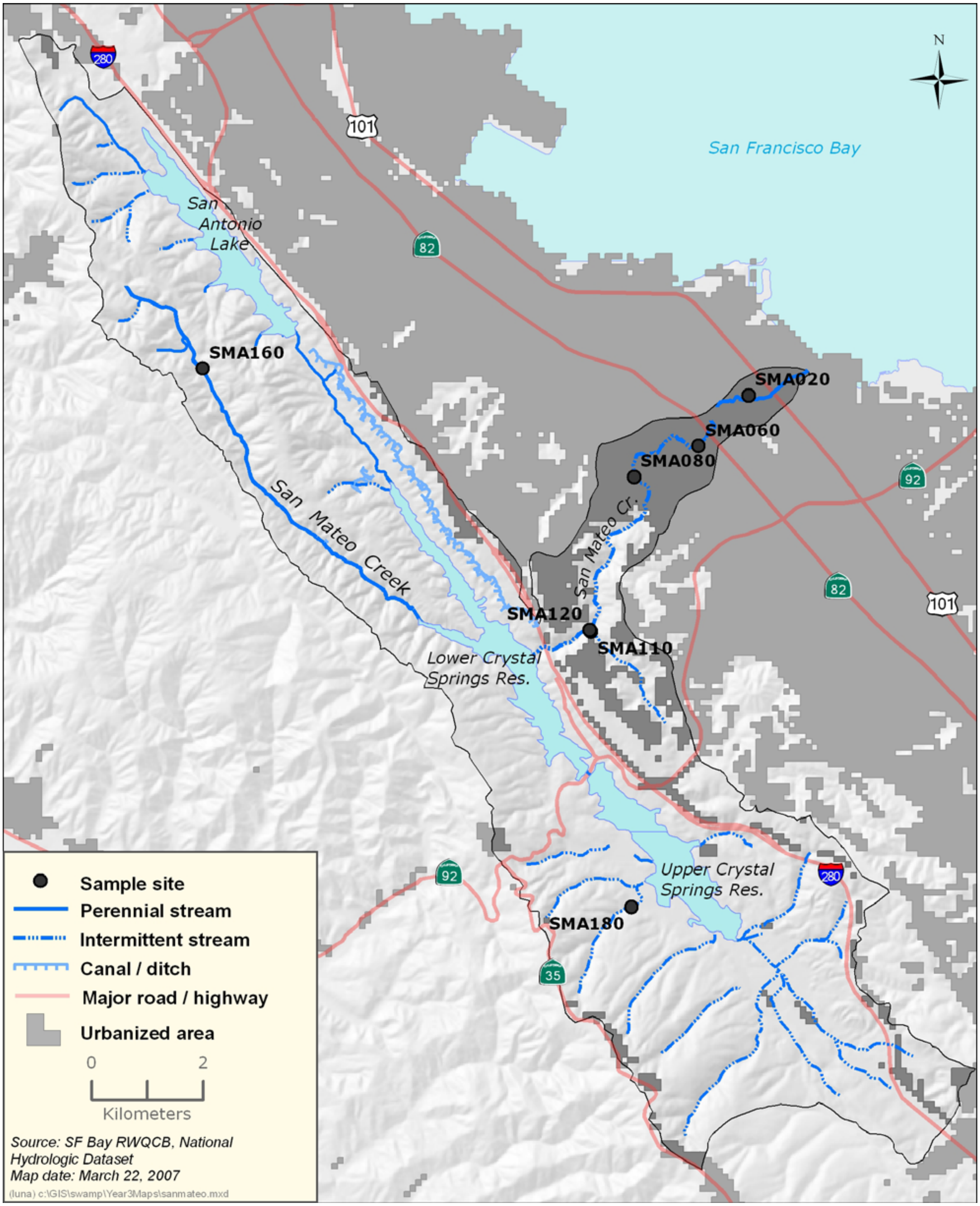


Figure 2.1-4: Location of year 3 monitoring stations in Petaluma River watershed



Source: SF Bay RWQCB, National Hydrologic Dataset
Map date: March 22, 2007

Figure 2.1-5: Location of year 3 monitoring stations in San Mateo Creek

2.2 Sampling design summary

One of the overall goals of SWAMP statewide is to develop a general picture of watershed health in the State. This calls for application of the probabilistic sampling design principle, in which each location has the same probability of being selected as all the other locations (so there is no ‘bias’ in the conditions monitored). However this approach required collection of a large number of samples to obtain good representation of the State’s highly-variable waterways. Monitoring goals at the regional level tend to focus on specific problem areas and potential reference sites. In this case the deterministic sampling design principle (in which locations are selected based on prior knowledge and the choices are directed to answer specific monitoring questions) was preferred. In the SF Bay Region, this directed sampling design was used to: 1) evaluate the influence of tributaries, 2) determine if beneficial uses are being protected at specific locations, 3) follow-up on previous data indicating potential impacts, 4) determine if specific land uses are having an impact on water quality and 5) identify reference sites.

To assure comprehensive coverage of the region under severe budget limitations, SWAMP implemented a rotating basin scheme: each year the Program monitored a few different watersheds, with the hope of returning to monitor each one every five years. The time unit allocated for each set was one year, which covered an entire cycle of seasons. Watershed and station selection for year 3 have been described above (Section 2.1). The timing selection rationale is described below, followed by description of the tiered monitoring approach that was developed to maximize the use of resources in obtaining relevant information.

2.2.1 Timing selection rationale

The strategy used for the Regional Water Board studies under SWAMP focused on three sampling events based on three hydrologic cycles. The three **hydrologic cycles** were the wet season (January-March), decreasing hydrograph/spring (April-May) and the dry season (June-October), although sampling time was decided primarily by water patterns (rather than by month).

2.2.2 Application of a tiered monitoring approach

“Tier 1” was the set of monitoring parameters that addresses the general health of the watershed. These included observations and field measurements during every Station visit, benthic macroinvertebrates (BMI) and physical habitat assessments in the spring, and periods of continuous field measurements throughout the watersheds at all seasons.

“Tier 2a” monitoring provided an opportunity to answer basic questions concerning protection of beneficial uses and potential impacts of land use and water management. Nutrients, various contaminants, pathogens, and toxicity were monitored at sites with potential impacts from land uses, or in reference sites to provide background levels. Tier 2a samples were collected during 3 hydrologic cycles.

“Tier 2b” monitoring looked at the cumulative effects of environmental contamination, both temporally (by selecting media that integrate contaminants over time, such as sediments and biota) and spatially (by sampling at an ‘integrator site’ at the bottom of each watershed, or the lowest point before tidal influence). Sediment sampling at the integrator stations was targeted to collection of fine-grain sediment samples (for chemical analyses and for toxicity testing using the amphipod *Hyalella azteca).* The clam *Corbicula* was deployed there as well, for bioaccumulation measurements.

Table 2.2-1 shows a summary of monitoring activities performed in 2003 by the different participants in relation to these three tiers.

Table 2.2-1: Summary of 2003 monitoring activities included in this report.

Characteristic group	Medium	Tier	Personnel	Activity type	Activity Frequency and Interval	Season & Timing *(Note 1)*	Total # of Stations	*Total # of Station Visits (Note 2)*
Local conditions *(Note a)*	all	Tier 1	MLML	Field Observations	3/yr, 3 months apart	all	18	50
"Vital signs" *(Note b)*	water	Tier 1	MLML	Discrete Field Measurements	3/yr, 3 months apart	all	18	50
Sonde probes suite *(Note c)*	water	Tier 1	RB2	Continuous Field Measurement deployments	up to 4/yr, 3 months apart	all	20	96 (48 deployments)
Physical habitat attributes	all	Tier 1	DFG-ABL	Field Observations	1/yr	spring	32	32
Benthic macroinvertebrate assemblages	biota	Tier 1	DFG-ABL	Sample; lab ID and count	1/yr	spring	32	32
Conventional WQ characteristics (including salts & nutrients)	water	Tier 2a	MLML	Sample, lab analysis	3/yr, 3 months apart	all	18	50
Water chemistry (Metals, organics) and toxicity	water	Tier 2a	MLML	Sample, lab analysis/tests	3/yr, 3 months apart	all	7	17
Coliform counts	water	Tier 2a	RB2	Sample, lab counts	5/yr, one week apart	summer	10	50
Sediment chemistry and toxicity	sediment	Tier 2b	MLML	Sample, lab analysis/tests	1/yr	spring	4	4
Tissue chemistry	tissue	Tier 2b	MLML	Sample, lab analysis	1/yr	spring	4	4

DFG-ABL -Department of Fish and Game, Aquatic Biology Laboratory; MLML - Moss Landing Marine Laboratory; RB2 - Regional Board 2 (SF Bay Region)

Note 1 Station visits occurred any time of day (not directed to a specific time). Trip scheduling was directed to non-rainy weather, i.e., base flow conditions.
Note 2 Activities done at specific stations are shown in Appendix Table A-1 and in the data appendix tables (B-1, C-1, D-1, and E-1)
Note a Local conditions include estimated flow, weather, Station appearance & odors, water color, and presence of special features;
Note b The “vital signs” are: temperature, pH, dissolved oxygen, and specific conductance; these were measured during sample collection to support lab data. Discrete measurements of turbidity and instantaneous current velocity were added in some cases.
Note c The YSI 6600 Sonde probe suite included temperature, pH, dissolved oxygen, and specific conductance, measured every 15 min. for 1-2 weeks.

2.3 Field operations

Field operations were conducted by several crews. Each crew had its own logistics, used the field data sheet tailored for its work, and followed the appropriate chain of custody procedures if shipping samples. Crews that performed multiple activities kept a consistent order to assure that one activity does not interfere with another. For example, Moss Landing Marine Laboratory (MLML) crews always began with observations and field measurements, followed by collection of water samples, and culminated by collection of sediment samples.

2.3.1 Department of Fish and Game, Aquatic Biology Laboratory (DFG-ABL)

DFG-ABL crews collected BMI samples at 32 stations on April 1,2,3, and 9, 2003 (see Appendix Table B-1), following the California Stream Bioassessment Procedure (CSBP) (Harrington 1999) with slight modifications. Three replicate samples were collected, each at a different segment, within a Station (defined as a line of 150m). Each sample represents a collection of organisms captured with a D-net (0.5 mm pore size) from 3 riffle sampling squares. Each square had an area of 1x1 ft and was sampled to the depth of 4-6". The three sub-samples were pooled together and preserved in 95 percent ethanol in the field. In summary, a total of nine squares were collected, batched into 3 replicate samples [Note: This sampling design using 3 replicate samples has been recently replaced with sampling 8 riffle squares randomly along the entire 150m reach and pooling the organisms into one sample. Other aspects of the protocol were also revised (Ode 2007). ABL crews also performed the physical habitat assessment at each site, following the CSBP protocol, which is based on U.S.EPA's Rapid Bioassessment Protocol (Barbour *et al.*, 1999a,b).

2.3.2 Waterboard (RB2) SWAMP operators

A. **Continuous field measurements** visits to deploy and retrieve data logging sondes were conducted at 20 sites by local SWAMP operators based at the SF Bay Region office (RB2). The sondes were programmed to measure pH, DO, temperature, specific conductivity (a.k.a 'specific conductance'), and depth every 15 minutes, and deployment episodes ranged between one and two weeks (with 3 exceptional deployments of 2, 3, and 18 days). These crews were also responsible for pre-deployment calibrations and post-deployment accuracy checks. During sonde deployment and retrieval, crews recorded location attributes (vegetation, depth of stream, flow, visual turbidity, occurrence of pools and riffles, and substrate quality) on data sheets and in photographs.

B. Water samples for **bacterial counts** were collected at 10 sites by local SWAMP operators based at the SF Bay Region office, following U.S.EPA methods for volunteer stream monitoring (U.S.EPA 1997). Samples were collected at weekly intervals (7/21/03, 7/28/03, 8/4/03, 8/11/03, and 8/18/03) to enable generation of a 30-day average of 5 samples.

2.3.3 Moss Landing Marine Laboratory (MLML)

A. **Water** sampling was conducted by crews from Marine Pollution Studies Laboratory (MPSL) at Moss Landing Marine Laboratory (MLML). Grab water samples for analysis of **conventional** characteristics were collected at 18 sites by MLML crew on January 20, 21, and 23, 2003 (winter round), April 21 and 22, 2003 (spring), and June 2 and 3, 2003 (dry season). The crew followed SWAMP protocols (Appendices to Puckett 2002), using a number of pre-cleaned plastic containers for each 'Sample". At the time of sampling, the crew also recorded field observations (e.g., weather, flow conditions, sample color or odor, presence of algae, etc.) and conducted field measurements (temp, pH, DO, and specific conductance) to support lab data. During these sampling trips, the same crew also collected grab water samples for analysis of **metals & organics**, and for water column **toxicity** testing, at 7 **selected sites**. The crew used pre-cleaned containers of glass or plastic, with the appropriate preservatives, as provided by each of the laboratories involved. At each sampling event, multiple containers were filled in sequence. All grab water samples were collected at stream locations that represent the bulk of the flow, about 10 cm below the surface. MLML crews were also responsible for collection of field blanks and field duplicates per SWAMP QAMP (Puckett 2002).

B. **Sediment** samples, for analysis of selected metals & organics and for bulk sediment toxicity testing, were collected at 4 sites by MLML crew on 4/21/03 and 4/22/03 following the SWAMP protocol (Appendices to Puckett 2002). The crew searched for areas where deposition of finer particles occur, and collected these sediments deliberately. Samples were composited from multiple scoops of the top 2 cm and homogenized thoroughly before sub-sampling for the different tests.

C. MLML crews were also responsible for deployment and retrieval of the clam *Corbicula fluminea* for **tissue** analyses. Clams were harvested from 'clean' areas in CA and were then deployed at each of the 4 watershed 'integrator sites', secured in polypropylene mesh bags anchored about 15 cm above the stream bed. The clams were retrieved on April 22, 2003, after deployment for one month. Other details are described in the SWAMP protocols (Appendices to Puckett 2002).

2.4 Laboratory analyses

Tables 2.4-1 and 2.4-2 show the groups of analytes and other characteristics that were analyzed, tested, or counted in various laboratories using a variety of methods. These tables also show the actual ranges of detection limits and reporting limits achieved for each analyte in water (Table 2.4-1) and sediments (Table 2.4-2). Complete analytical suites for OCs, OPs, PAHs, and PCBs, with achieved ranges of detection limits and reporting limits, are presented in appendix Table D-2. Extensive description of SWAMP laboratory work has been provided in the Years 1&2 report (SFBRWQCB 2007, Section 4). A brief extract from that section, plus additional information on selected laboratory activities, is provided below.

2.4.1 Benthic Macroinvertebrates

All samples were sorted and identified by the DFG ABL in accordance with the 2003 CSBP and the California Aquatic Macroinvertebrate Laboratory Network (CAMLnet) Standard Taxonomic Effort (STE). Three hundred individual organisms were selected randomly from each sample for identification (to the level of genus, where possible) and enumeration. For the analysis in this report, data from the three riffle samples per site were combined, and the raw data was standardized to the taxonomic levels specified in the CAMLnet STE (to accommodate analyses by different taxonomists) as described previously (SFBRWQCB 2007). The biological metrics shown in Appendix Table B-2 were then calculated.

2.4.2 Chemical analyses

Chemical analyses of water, sediment, and tissue samples were performed at a number of laboratories, predominantly: Department of Fish and Game Water Pollution Control Laboratory (DFG-WPCL) and Marine Pollution Studies Laboratory, Department of Fish and Game (MPSL-DFG), which were able to deliver the low detection levels required by SWAMP. Details are shown in Tables 2.4-1 and 2.4-2 , In Appendix Table B-2, and in Year 1& report (SFBRWQCB. 2007).

2.4.3 Toxicity testing

Water column and bulk sediment toxicity testing was performed at the UC Davis Marine Pollution Studies Laboratory at Granite Canyon (UCD-GC). The U.S.EPA whole effluent toxicity protocol (U.S.EPA 1994) was used to test the effect of water samples on three freshwater test organisms. Testing included the 7-day static renewal (chronic) tests for *Pimephales promelas* survival and growth and *Ceriodaphnia dubia* survival and reproduction, as well as the 96-hour static test for *Selenastrum capricornutum* growth. Sediment samples were used in the 10-day bulk toxicity test for *Hyalella azteca* survival and growth (U.S.EPA 2000a), but the test exposure was extended to 28 days**.**

2.4.4 Coliform counts

Coliform counts in water samples were performed by two methods. The first - the traditional multiple-tube fermentation method (Standard Method 9221E, APHA 1998), which counts total and fecal coliforms - was done by CalTest laboratory. Samples were not diluted to concentrations that allow for making the counts, and consequently many result points had non-definitive values (i.e., >1600 MPN/mL). Indicator bacteria were also enumerated by Standard Method 9223 (APHA 1998), a new enzyme-substrate method that uses the IDEXX Colilert ™ reagent to count total coliforms and *Escherichia coli*. This method was used in conjunction with SOP #1103 by U.S.EPA Region IX laboratory, in parallel to the fecal coliform counts.

Table 2.4-1: Laboratory analyses, tests, or counts performed with **water** samples in 2003

Group	Analyte	Laboratory	Method	Unit	MDLs Min	MDLs Max	RLs Min	RLs Max
Conventional								
	Alkalinity as CaCO3	DFG-WPCL	QC 10303311A	mg/L	3	3	10	10
	Ammonia as N	DFG-WPCL	EPA 350.3	mg/L	0.05	0.05	0.1	0.1
	Boron,Total	SFL	SM 4500-B B	mg/L	0.02	0.02	0.1	0.1
	Chloride	DFG-WPCL	EPA 300.0	mg/L	0.2	0.2	0.25	0.35
	Chlorophyll a	MPSL-DFG	EPA 445.0M	µg/L	0.045	0.045	0.045	0.05
	Dissolved Organic Carbon	AMS	EPA 415.1	mg/L	0.1	0.1	0.1	0.1
	Dissolved Solids,Total	DFG-WPCL	SM 2540 C	mg/L	10	10	12	12
	Hardness as CaCO3	DFG-WPCL	SM 2340 C	mg/L	1	1	1	1
	Nitrate as N	DFG-WPCL	QC 10107041B	mg/L	0.005	0.005	0.01	0.01
	Nitrite as N	DFG-WPCL	QC 10107041B	mg/L	0.005	0.005	0.01	0.01
	Nitrogen, Total Kjeldahl	DFG-WPCL	QC 10107062E	mg/L	0.12	0.12	0.5	0.5
	OrthoPhosphate as P	DFG-WPCL	QC 10115011M	mg/L	0.005	0.005	0.01	0.01
	Phosphorus as P,Total	DFG-WPCL	EPA 365.3	mg/L	0.03	0.03	0.05	0.05
	Sulfate	DFG-WPCL	EPA 300.0	mg/L	0.4	0.5	0.75	1
	Suspended Sediment Concentration (SSC)	MPSL-DFG	SM 2540 B	mg/L	0.6	0.6	0.6	0.6
	Total Organic Carbon	AMS	EPA 415.1	mg/L	0.1	0.1	0.1	0.1
Metals (Dissolved and Total)								
	Aluminum	MPSL-DFG	EPA 1638M	µg/L	0.1	0.1	0.3	0.3
	Arsenic	MPSL-DFG	EPA 1638M	µg/L	0.1	0.1	0.3	0.3
	Cadmium	MPSL-DFG	EPA 1638M	µg/L	0.002	0.002	0.05	0.05
	Chromium	MPSL-DFG	EPA 1638M	µg/L	0.03	0.03	0.09	0.09
	Copper	MPSL-DFG	EPA 1638M	µg/L	0.003	0.003	0.01	0.01
	Lead	MPSL-DFG	EPA 1638M	µg/L	0.002	0.002	0.05	0.05
	Manganese	MPSL-DFG	EPA 1638M	µg/L	0.003	0.003	0.01	0.01
	Mercury,Total	MPSL-DFG	EPA 1631EM	ng/L	0.09	0.16	0.2	0.48
	Nickel	MPSL-DFG	EPA 1638M	µg/L	0.006	0.006	0.018	0.018
	Selenium	MPSL-DFG	EPA 1638M	µg/L	0.1	0.1	0.3	0.3
	Silver	MPSL-DFG	EPA 1638M	µg/L	0.008	0.008	0.1	0.1
	Zinc	MPSL-DFG	EPA 1638M	µg/L	0.02	0.02	0.06	0.06
Organics								
	Chlorpyrifos	UCD-GC	ELISA SOP 3.3	µg/L	0.05	0.05	0.05	0.05
	Diazinon	UCD-GC	ELISA SOP 3.3	µg/L	0.03	0.03	0.03	0.03
	Herbicides	DFG-WPCL	EPA 619M	µg/L	0.02	0.02	0.05	0.05
	Organochlorine Pesticides (OC) Suite	DFG-WPCL	EPA 8081AM	µg/L	0.001	0.001	0.002	0.002
	Organophosphate Pesticides (OP) Suite	DFG-WPCL	EPA 8141AM	µg/L	0.03	0.03	0.05	0.05
	PAHs Suite	DFG-WPCL	EPA 8270M	µg/L	0.01	0.025	0.01	0.025
	PCBs Suite	DFG-WPCL	EPA 8082M	µg/L	0.001	0.001	0.002	0.002
Toxicity testing								
	Ceriodaphnia dubia	UCD-GC	(EPA WET 94)	NA	NA	NA	NA	NA
	Pimephales promelas	UCD-GC	(EPA WET 94)	NA	NA	NA	NA	NA
	Selenastrum capricornutum	UCD-GC	(EPA WET 94)	NA	NA	NA	NA	NA
Coliform counts								
	fecal coliform	SAL	SM 9221E					
	total coliform	EPA R-IX	SM 9223 IDEXX					
	E, coli	EPA R-IX	SM 9223 IDEXX					

MDL - minimum detection limit; RL - reporting limit; NA - not applicable
Complete analytical suites for OCs, OPs, PAHs, and PCBs are presented in appendix Table D-2

AMS: Applied Marine Sciences
DFG-WPCL: Department of Fish and Game Water Pollution Control Laboratory
EPA R-IX: EPA Region IX laroatroy, Richmond CA
MPSL-DFG: Marine Pollution Studies Laboratory, Department of Fish and Game
SAL: Sequoia Analytical Laboratories, Inc.
SFL: Sierra Foothill Laboratory
UCD-GC: University of California at Davis, Granite Canyon Laboratory

Table 2.4-2: Laboratory analyses performed with sediment samples in 2003

Group	Analyte	Laboratory	Method	Unit	MDLs Min	MDLs Max	RLs Min	RLs Max
Conventional analytes and sediment properties								
	Particle size distribution	AMS	ASTM D422	%	0.01	0.01	0.01	0.01
	Total Organic Carbon	AMS	EPA 9060	%	0.01	0.01	0.01	0.01
	Moisture	var	var	%				
Metals (Total)								
	Aluminum	MPSL-DFG	EPA 200.8	mg/Kg	0.1	0.1	0.3	0.3
	Arsenic	MPSL-DFG	EPA 200.8	mg/Kg	0.1	0.1	0.3	0.3
	Cadmium	MPSL-DFG	EPA 200.8	mg/Kg	0.002	0.002	0.05	0.05
	Chromium	MPSL-DFG	EPA 200.8	mg/Kg	0.03	0.03	0.09	0.09
	Copper	MPSL-DFG	EPA 200.8	mg/Kg	0.003	0.003	0.01	0.01
	Lead	MPSL-DFG	EPA 200.8	mg/Kg	0.002	0.002	0.05	0.05
	Manganese	MPSL-DFG	EPA 200.8	mg/Kg	0.003	0.003	0.01	0.01
	Mercury	MPSL-DFG	EPA 200.8	mg/Kg	0.004	0.004	0.012	0.012
	Nickel	MPSL-DFG	EPA 200.8	mg/Kg	0.006	0.006	0.018	0.018
	Silver	MPSL-DFG	EPA 200.8	mg/Kg	0.008	0.008	0.1	0.1
	Zinc	MPSL-DFG	EPA 200.8	mg/Kg	0.02	0.02	0.06	0.06
Organics								
	Pesticides (OC+OP) Suite	DFG-WPCL	EPA 8081AM	ng/g	var	var	var	var
	PAHs Suite	DFG-WPCL	EPA 8270M	ng/g	1.17	1.94	1.17	1.94
	PCBs Suite	DFG-WPCL	EPA 8082M	ng/g	0.046	0.079	0.232	0.396
Toxicity testing								
	Hyalella azteca 28d bulk	UCD-GC	EPA 600/R-99-064 mod		NA	NA	NA	NA

MDL - minimum detection limit; RL - reporting limit; NA - not applicable
Complete analytical suites for OCs, OPs, PAHs, and PCBs are presented in appendix Table D-2

AMS: Applied Marine Sciences
DFG-WPCL: Department of Fish and Game Water Pollution Control Laboratory
MPSL-DFG: Marine Pollution Studies Laboratory, Department of Fish and Game
UCD-GC: University of California at Davis, Granite Canyon Laboratory

2.5 Data analysis and interpretation

The term “data analysis” often refers to six types of formal activities: **(a) endpoint derivation** for individual samples (e.g., BMI metrics, percent survival,); this often involves the use of statistical tables (e.g., for MPN/100 mL) or programs (e.g. Probit for LC50) to derive the endpoint value and the confidence limits around it. The key word here is: single sample. **(b)** basic statistical treatment of raw data to test for **significance** and/or confidence (e.g., running the statistical package to detect significant toxicity); **(c)** computation of **summary statistics** (e.g., median, geometric mean, MWAT) for data sets made of multiple measurements, **(d)** comparisons of constituent concentrations to **quality benchmarks**, either individually or in compilations (e.g., mean toxicity quotient); **(e) hypothesis testing** to detect change (e.g, before vs after, or reference vs downstream sites); and **(f)** derivation of **correlation** coefficients and/or application **of multivariate analyses** to detect **associations or relationships** between different types of results or factors. Another common “data analysis” activity refers to **(g)** creation of result presentation items such as **tables and figures,** and conducting **observations** of these items.

Note that data verification and validation are an essential but a totally separate part of the data handling process.

Data analysis activities “a” and “b” were performed by the laboratories according to their Standard Operating Procedures; these activities are an integral part of the measurement systems themselves. RB2 SWAMP operators calculated summary statistics (activity type “c”) for continuous field measurements and for bacterial counts, following procedures established for year 1&2 (SFBRWQCB. 2007 Sections 4.6.2 and 4.6.5). The authors of this report conducted all comparisons to quality benchmarks (activity type “d”). Activities type “f” included adding year 3 data to existing (Years 1&2) multivariate analyses platforms. Tabulating and plotting the results (activity type “g”) is an integral part of report preparation and these presentation items were used to look at seasonality, upstream-downstream differences, spatial variability within the stream network, etc. The following sub-sections provide further description of selected year 3 data analysis activities.

2.5.1 Land use, BMI, and ordination plots

Years 1&2 report contained an elaborate review of land use in the watersheds monitored and presented a categorization system that enabled sorting of all year 1&2 sites into six land-use classes, ranging from open space to highly urbanized drainages (SFBRWQCB. 2007). Unfortunately, no resources were available to conduct a similar review for year 3 watersheds. However, benthic macroinvertebrate results from year 3 sites were used to augment the non-metric multidimensional scaling (NMS) ordination plot developed based on presence/absence of taxa for years 1&2 sites. That NMS plot showed clear relationship between BMI assemblages and three land use groups that represented (a) open space and rural residential, (b) grazing, agriculture and mixed, and (c) urban (SFBRWQCB. 2007, Section 6).

Ordination is a technique whereby multiple variables are reduced and expressed in a small number of dimensions. For this analysis, sites were graphed in two-dimensional ordination space based on the presence and absence of taxa. Presence/absence data was used because it is less variable than relative abundance data (which can be influenced by many additional factors such as food supply), and it is useful in large regional studies where sites contain heterogeneous assemblages**.** Sites that are close together in ordination space exhibit similar benthic assemblages; increasing distance between sites indicates that a greater number of different taxa were present at the sites. Non-metric multidimensional scaling (NMS) is the most generally effective ordination technique for ecological community data (McCune and Grace 2002).

2.5.2 Summary statistics and box plots for continuous monitoring episodes

Each sonde file generated from one deployment episode contained between 500 and 1800 individual measurements for each water quality characteristic (pH, temperature, dissolved oxygen, and specific conductivity). The Minimum and Maximum values within each data set were easily identified by an Excel function, and so were the median, the 25 percentile, and the 75 percentile values used to construct a box-plot presentation for each episode. This type of 'box and whisker' plots is widely used to explore the distribution of independent data points (e.g., Helsel and Hirsch 2005), but it has often been used for presentation of continuous monitoring data as well

The continuous temperature data were used to compute two endpoints: (a) the Maximum Weekly Average Temperature (MWAT) and (b) the Maximum Weekly Maximum Temperature (MWMT). These endpoints, calculated separately for each season, were used for comparison to water quality benchmarks as described below. In reality, the MWAT and MWMT benchmarks apply to data collected for a whole year, but it was necessary to do a theoretical extrapolation of 1-2 weeks to the entire year to generate an endpoint that enables checking for exceedances.

2.5.3 Comparisons of monitoring results to water quality benchmarks.

The phrase 'water (or sediment) quality benchmark' is a catch-all term to include objectives, guidelines, limits, targets, standards, and other types of values for concentrations of constituents that should not be exceeded in a given water body. There may be a profound difference between each sub-set of benchmarks, for example, objectives are used as regulatory tools, while guidelines are used for evaluation but are not legally binding. The term 'threshold' is often used in this report to convey the same meaning as 'benchmark'. For constituent concentrations, the word 'exceedance' means that the sample value was above the benchmark (and this was not 'good'). However, dissolved oxygen values are 'good' if they are above the benchmark, and 'good' pH values are within a defined range (usually 6.5 to 8.5), above and below which the conditions are considered 'not good', i.e., an 'exceedance'.

Tables 2.5-1 and 2.5 -2 show a compilation of quality benchmarks for water and sediments, respectively. These benchmarks were developed for the regional Basin Plan for protection of aquatic life, and were used by this report's authors to assess exceedances (activity type "d"). If there were no objectives for an analyte in the Basin Plan, the benchmarks from the California Toxics Rule were used (CTR; Federal Register, Part III; U.S.EPA; 40 CFR Part 131 Water

Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants for the State of California; Rule. May 18, 2000). If there were no benchmarks in either of these documents, other documents (California Department of Fish and Game benchmarks, TMDLs, U.S.EPA criteria) or peer reviewed literature articles were screened for the most appropriate benchmark. Some U.S.EPA benchmarks for nutrients may not be applicable to all types of streams monitored in year 3.

There are two levels of impact for some of the constituents, expressed either in relations to exposure duration (e.g., chronic or acute, for water), or in terms of probability of impact (i.e., PEC or TEC, for sediment). Essentially, measured sediment chemical concentrations below Threshold Effects Concentrations (TECs) are considered unlikely to contribute to adverse effects in sediment-dwelling organisms. In contrast, sediment chemical concentrations above Probable Effects Concentrations (PECs) are considered likely to be toxic to sediment-dwelling organisms. To estimate the effects of a mixture of contaminants, the Sediment Quality Guideline Quotient (SQGQ) values, a.k.a mean toxicity quotients, were calculated based on PEC values and the specifications recommended by MacDonald *et al* (2000). The breakdown of mean PEC quotients for metals, PAHs, and PCBs is shown in Appendix Table D-7c, with the toxicity test results. Further information about mean PEC quotients is contained in Years 1&2 report (SFBRWQCB. 2007). The reader is also referred to the SWAMP year 3 archive for the spreadsheet used to calculate PEC quotients for individual constituents and to compute the mean quotients for the different analyte groups.

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2.5.4 Toxicity results significance

The derivation of toxicity endpoints (data analysis activity type “a”) is usually straightforward, and most statistical packages include tests for statistical significance (activity type “b”). However, statistical significance may not necessarily indicate a **meaningful** toxic effect, and there are several variations on what construes a meaningful effect. Current SWAMP criteria require that organisms’ response in the sample be significantly different ($\alpha = 0.05$) from the negative control, and be less then 80% of the control; the combination of both criteria was used for year 3 results to denote toxicity (Appendix Table D-6). The reader is also referred to Section 4 of this report for discussion of ecological significance versus statistical significance of toxicity test results.

2.5.5 Coliform counts endpoints

The MPN/100 mL count results from the five consecutive sampling events conducted weekly in the summer of 2003 were used to generate the following summary statistics:

- The geometric mean, or ‘geomean’, was calculated for fecal coliform and *E. coli*
- The 90th percentile was calculated for fecal coliform.

These endpoints were compared to water quality benchmarks as described above.

Table 2.5-1: Water Quality Benchmarks for Protection of Aquatic Life

Characteristic	Description of Benchmark	Numeric Limit	Units	Reference
Temperature	Maximum, salmonid	22	° C	Zabinsky, 2005
	MWMT	17	° C	Zabinsky, 2005
	MWAT	15	° C	Zabinsky, 2005
Oxygen, dissolved	Minimum, warmwater	5	mg/L	Basin Plan, 2005
	Minimum, coldwater	7	mg/L	Basin Plan, 2005
	3-month median	80	%	Basin Plan, 2005
pH	Range	6.5 to 8.5	S.U.	Basin Plan, 2005
Ammonia, unionized	Annual median	0.025	mg/L	Basin Plan, 2005
Nitrate as N	Maximum	0.16	mg/L	USEPA, 2000b
Phosphorus, total as P	Maximum	30	µg/L	USEPA, 2000b
Arsenic, dissolved	1-hour average WQO	340	µg/L	Basin Plan, 2005
	4-day average WQO	150	µg/L	Basin Plan, 2005
Cadmium, total[a]	1-hour average WQO	3.9	µg/L	Basin Plan, 2005
	4-day average WQO	1.1	µg/L	Basin Plan, 2005
Chromium VI, dissolved	1-hour average WQO	16	µg/L	Basin Plan, 2005
	4-day average WQO	11	µg/L	Basin Plan, 2005
Copper, dissolved[a]	1-hour average WQO	13	µg/L	Basin Plan, 2005
	4-day average WQO	9	µg/L	Basin Plan, 2005
Lead, dissolved[a]	1-hour average WQO	65	µg/L	Basin Plan, 2005
	4-day average WQO	2.5	µg/L	Basin Plan, 2005
Mercury, total	1-hour average WQO	2.4	µg/L	Basin Plan, 2005
Nickel, dissolved[a]	1-hour average WQO	470	µg/L	Basin Plan, 2005
	4-day average WQO	52	µg/L	Basin Plan, 2005
Selenium, total	4-day average WQO	5	µg/L	Basin Plan, 2005
	1-hour average WQO	20	µg/L	Basin Plan, 2005
Silver, dissolved[a]	1-hour average WQO	3.4	µg/L	Basin Plan, 2005
Zinc, dissolved[a]	1-hour average WQO	120	µg/L	Basin Plan, 2005
	4-day average WQO	120	µg/L	Basin Plan, 2005
PCBs	Continuous 4-day average	0.014	µg/L	CTR
Chlorpyrifos	Continuous 4-day average	0.015	µg/L	CVRWQCB, 2006
Dacthal (DCPA)	Instantaneous max. AWQC	14,300	µg/L	USEPA, 1987
Diazinon	1-hour average	0.1	µg/L	SFBRWQCB, 2005
Disulfoton (Disyston)	Instantaneous max. AWQC	0.05	µg/L	USEPA, 1973
Endosulfan	Continuous 4-day average	0.056	µg/L	CTR
	Instantaneous maximum	0.22	µg/L	CTR
HCH, gamma- (gamma-BHC, Lindane)	Maximum 1-hour average	0.95	µg/L	CTR
Parathion, methyl	Instantaneous max. AWQC	0.08	µg/L	CDFG
Thiobencarb	Instantaneous max. AWQC	3.1	µg/L	CDFG
E. coli	log mean	126	MPN/100 mL	Basin Plan, 2005
Fecal coliform	log mean	<200	MPN/100 mL	Basin Plan, 2005
Fecal coliform	90th percentile	<400	MPN/100 mL	Basin Plan, 2005

***Note a:** Table values for total cadmium and for dissolved copper, lead, nickel, silver, and zinc assume a hardness of 100 mg/L CaCO3. Samples at other hardness levels must be calculated using formulas in the Basin Plan.*

Table 2.5-2: Sediment Quality Benchmarks

Characteristic	Description of Benchmark	Numeric Limit	Units
Arsenic	PEC	33	mg/kg
	TEC	9.79	mg/kg
Cadmium	PEC	4.98	mg/kg
	TEC	0.99	mg/kg
Chromium	PEC	111	mg/kg
	TEC	43.4	mg/kg
Copper	PEC	149	mg/kg
	TEC	31.6	mg/kg
Lead	PEC	128	mg/kg
	TEC	35.8	mg/kg
Mercury	PEC	1.06	mg/kg
	TEC	0.18	mg/kg
Nickel	PEC	48.6	mg/kg
	TEC	22.7	mg/kg
Zinc	PEC	459	mg/kg
	TEC	121	mg/kg
Anthracene	PEC	845	µg/kg
	TEC	57.2	µg/kg
Benz(a)anthracene	PEC	1050	µg/kg
	TEC	108	µg/kg
Benzo(a)pyrene	PEC	1450	µg/kg
	TEC	150	µg/kg
Chlordane	PEC	17.6	µg/kg
	TEC	3.24	µg/kg
Chrysene	PEC	1290	µg/kg
	TEC	166	µg/kg
DDD (sum op + pp)	PEC	28	µg/kg
	TEC	4.88	µg/kg
DDE (sum op + pp)	PEC	31.3	µg/kg
	TEC	3.16	µg/kg
DDT (sum op + pp)	PEC	62.9	µg/kg
	TEC	4.16	µg/kg
DDT (total)	PEC	572	µg/kg
	TEC	5.28	µg/kg
Dibenz(a,h)anthracene	**TEC**	33	µg/kg
Dieldrin	PEC	61.8	µg/kg
	TEC	1.9	µg/kg
Endrin	PEC	207	µg/kg
	TEC	2.22	µg/kg
Fluoranthene	PEC	2230	µg/kg
	TEC	423	µg/kg
Fluorene	PEC	536	µg/kg
	TEC	77.4	µg/kg
HCH, gamma	PEC	4.99	µg/kg
	TEC	2.37	µg/kg
Heptachlor epoxide	PEC	16	µg/kg
	TEC	2.47	µg/kg
Naphthalene	PEC	561	µg/kg
	TEC	176	µg/kg
PAH (total)	PEC	22800	µg/kg
	TEC	1610	µg/kg
PCB (total)	PEC	676	µg/kg
	TEC	59.8	µg/kg
Phenanthrene	PEC	1170	µg/kg
	TEC	204	µg/kg
Pyrene	PEC	1520	µg/kg
	TEC	195	µg/kg

Source: MacDonald et al 2000a

2.6 Data quality

Field and lab operators followed the SWAMP field procedures and the internal lab SOPs, as required to assure generation of data of known and documented quality. With some exceptions, the data reported in Section 3 and in Appendix Tables B, C, D, and E are SWAMP compliant. This means the following:

(a) Sample container, preservation, and holding time specifications of all measurement systems have been applied and were achieved as specified;
(b) All the quality checks required by SWAMP were performed at the required frequency;
(c) All measurement system runs included their internal quality checks and functioned within their performance/acceptance criteria; and
(d) All SWAMP measurement quality objectives (MQOs) were met.

Appendix F describes the actions done to **affect** (i.e., act to influence the outcome) and **check** (test to evaluate or verify) the different aspects of data quality in field measurements, sampling & shipping, and lab analyses. It also shows the outcomes of the quality checks conducted in year 3, and discusses their relevance to the six data quality indicators mentioned in the U.S.EPA Quality Assurance Project Plan guidance and the SWAMP Quality Management Plan. Some of the data did not meet all the conditions stated above. However, these data are still usable if the flaw or omission was not considered detrimental, and they were flagged as "estimated". The reader is referred to RB2 SWAMP Year 3 archive for spreadsheets that provide all the data as well as the data quality flags for each Result.

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3 Results

This section presents the results obtained in the four watersheds selected for monitoring in the third year of SWAMP activities in the San Francisco Bay Region. Information is presented in text, tables and figures pertaining to the individual watersheds in their watershed-specific subsections (3.1 through 3.4). Presentation items at the end of each subsection include one table (summary of exceedances), and two figures: a watershed map with results of selected BMI metrics, and summary box plots for continuous field measurements (these plots have been combined for the first two watersheds). Subsection 3.5 includes summary items that pertain to all four watersheds monitored in 2003-04. The tables and figures are shown at the end of the sub-section, in conventional order (tables first.)

This Result section shows only highlights of the results, whereas the entire data set is given in an array of appendices, which constitute an integral part of this report. The appendix tables are organized by subject matter, in the same internal order as the subjects in each of the watershed-specific subsection. This order, which reflects the data sources and the logistics, is as follows: Benthic Macroinvertebrates (BMI), continuous field measurements, water chemistry and toxicity, sediment chemistry and toxicity, tissue chemistry, and coliform counts. The appendices also contain a list of all samples, station visits, and continuous monitoring sonde files for each Station (appendix A), as well as sample inventories at the beginning of each subject appendix (Appendices B through E).

3.1 Kirker Creek Watershed

The Kirker Creek watershed (shown in Figure 2.1-2 above) is highly urbanized, and the original waterway has been altered via channelization of the coastal wetland area. Kirker Creek begins with its headwaters in the foothills of Mt. Diablo, in the Black Diamond Mines Regional Preserve, and continues through the cities of Pittsburg and Antioch before its discharge into New York Slough. Sites monitored in year 3 represent different land uses: KIR020 (Floodway) is in the wetlands below residential and industrial areas; KIR090 (East Leland) is influenced by inputs from highly urbanized areas, KIR110 (Buchanan Park) is in a residential area fed by suburban watering runoff in the summer; and KIR115 (Kirker Apartments) is just above the residential limits, so it drains grazed rangeland and the Black Diamond Mine (an historical coal mine) upstream in East Bay Regional Park District lands. Like many streams in eastern Contra Costa County, most of Kirker Creek is dry from spring through fall, precluding summertime sampling.

3.1.1 Benthic macroinvertebrates and physical habitat

Three sites were sampled for benthic macroinvertebrates and physical habitat in the Kirker Creek watershed. Several sites, including the integrator site KIR020, were not sampled by the field crews because of insufficient riffle habitat. Selected benthic macroinvertebrate results for Kirker Creek are shown in **Figure 3.1-1**. Metric values for each site are shown in Appendix Table B-2a and physical habitat data is shown in Appendix Table B-3.

Benthic macroinvertebrate assemblages from the three sample sites in the Kirker Creek watershed were all in poor condition. Taxonomic richness was low (10-17) and percent sensitive EPT taxa was less than 0.1% (Figure 3.1-1). Taxa intolerant of pollution were virtually absent; percent intolerant organisms ranged from 0.1% to 0.6% (Appendix B-2a). Assemblages were dominated by common, tolerant COBS (Chironomidae, Oligochaeta, *Baetis sp.*, and Simuliidae) taxa such as oligochaete worms (especially at KIR090) and chironomid midges (especially at KIR110 and KIR115). Compared to other sampling sites in the region, Kirker Creek sites were most closely related to degraded, urban sites from the lower watersheds of San Pablo Creek and Permanente Creek (Figure 3.5-1).

The most downstream site sampled for macroinvertebrates, KIR090, had a very low abundance of organisms (338/sample). In addition to worms and chironomids, other tolerant taxa such as fingernail clams (*Pisidium sp.*), leaches (Erpobdellidae), and moth flies (*Psychoda sp.*) were dominant. The streambed at this site was covered with fine sediment (sand), with no gravel present (Appendix Table B-3). Fine sediment is preferred by burrowing organisms, such as oligochaete worms, while gravel is required by many of the sensitive EPT taxa. Although these habitat conditions can partly explain the invertebrate assemblage at this site, the low diversity suggests that poor water quality conditions are significantly affecting benthic assemblages at this site.

The most upstream site, KIR115, was also dominated by tolerant taxa, including seed shrimp (Ostracoda), blackflies (*Simulium sp.*), and pouch snails (*Physa sp.*). Invertebrate abundance, however, was extremely high (45,538/sample), suggesting the site has high primary productivity and/or that the assemblage is dominated by small, short-lived taxa. The streambed at this site was also dominated (87%) by fine sediment (Appendix Table B-3).

3.1.2 Continuous field measurements

Figure 3.1-2 shows summary boxplots for temperature, dissolved oxygen (DO), pH, and specific conductance (SC) in Kirker Creek. The same figure also shows the boxplots for Mt. Diablo Creek watershed. Table C-2a in Appendix C details the summary statistics for continuous monitoring in the Kirker Creek watershed.

Each of the three sites monitored in Kirker Creek watershed (KIR020, KIR110, and KIR115) have significant exceedances of temperature guidelines in the spring, and of dissolved oxygen objectives during the winter and spring. These seasons are usually the least stressful period for these parameters. Only one site (KIR110, Buchanan Park) was monitored during summer and, because of a battery failure, only one day of data was collected. Therefore, summer MWMT, MWAT, and 7-day DO minimum metrics could not be calculated.

Temperature: Springtime temperatures exceeded the MWMT of 17°C at KIR020 and KIR115 and the MWAT of 15°C at KIR110 and KIR115. The maximum temperature of 22°C was exceeded for the one day of summer monitoring at KIR110.

Dissolved Oxygen (DO): The DO levels at each site were markedly low, even in the spring and winter. Except for KIR110 in the winter, each monitoring episode had concentrations below the

7 mg/L threshold, a median saturation below the 80 percent threshold, and a 7-day DO minimum below the 8 mg/L threshold. For the one day of summer monitoring at KIR110, even the maximum DO was below 7mg/L. The 211 percent saturation at KIR020 in the spring indicates excessive photosynthesis possibly from nutrient enrichment, given the high levels of total phosphorus.

pH: While the pH values met guidelines, KIR020 during the winter had a range greater than one pH unit. Such a range, together with a high DO saturation (119 percent), a nitrate exceedance factor over 10, and total phosphorus exceedance factor of 5, indicates eutrophication.

Specific Conductance: The high specific conductance values at KIR115 (above 4000 µS) are unusual, especially in the spring upstream of potential industrial and residential impacts. Downstream at KIR020, the specific conductance was more typical of freshwater. These high specific conductance values together with the high results for selenium, sulfate, and boron at KIR115 are consistent with salt-affected soils of a dry environment. Such conditions are detrimental to agriculture.

3.1.3 Water chemistry and toxicity

Five water samples were collected in Kirker Creek for analyses and testing in 2003; two of these samples were collected during the winter, two in the spring, and one in the dry season. The analytical results for conventional water quality characteristics, metals, and organics are shown in Appendix Tables D-3, D-4, and D-5. Toxicity test results are presented in Appendix Table D-6. Unlike continuous monitoring, water samples collected for chemical analyses and toxicity testing show a snapshot in time, and the results of 2003 can provide only an indication of the inherent variability and the potential for toxicity and elevated contaminant concentrations in the watershed.

Water samples collected at KIR020 and KIR115 frequently exceeded nutrient guidelines. The phosphorus guideline was always exceeded. Out of five water samples collected, there was one water quality objective exceedance for selenium (in the winter; see Table 3.1-1 below). Samples collected at Kirker Creek in the wet season (January) were toxic to *Ceriodaphnia dubia*. These samples contained diazinon and chlorpyrifos at concentrations that are known to be toxic to this species. Selenastrum growth was strongly affected in the two samples collected at KIR115, which had extremely high concentrations of salts, including sulfate and boron. At KIR020 more moderate levels of toxicity to Selenastrum were observed.

3.1.4 Sediment chemistry and toxicity, and tissue chemistry

One sediment sample was collected, at a ‘watershed integrator’ site located close to the mouth of Kirker Creek (KIR020). The results are shown in the tables of Appendix D-7, and exceedences of quality benchmarks are summarized in Table 3.1-1 below. Kirker Creek sediments from this site contained concentrations of arsenic, chromium, copper, nickel and zinc that exceeded Threshold Effect Concentrations (TEC). Exposure to this sediment caused 100% mortality of *Hyalella azteca* in a toxicity test (Table 3.1-1). Based on conclusions from previous studies conducted in the vicinity of this site (Amweg et al 2006), it is possible that this toxicity was caused by pyrethroids; however these compounds were not measured in year 3. The integrator site in Kirker Creek had finer grain sediment (65.2% clay and silt) and higher TOC (2.29%) than sediment from the other creeks sampled in 2003. Both fine grain sediment and TOC tend to bind contaminants, usually resulting in higher concentrations.

One clam sample was deployed and collected at the same site for tissue analyses; the draft results are presented in Appendix Table D-8. The concentrations of metals were slightly lower than those observed in other watersheds monitored in year 3. Eight organochlorine compounds (of the 30+ tested) were detected. PAH compounds were more prevalent in Kirker Creek than in the other creeks, with total PAH concentration peaking at 1299 ng/g dry weight. Of the trace amounts of PCBs detected, Kirker Creek clams had an array of congeners similar to other creeks, with total PCB concentration of 121 ng/g dry weight.

3.1.5 Coliform counts

Bacterial count results of individual samples are shown in Appendix Table E-1, and summary statistics are presented in Figure 3.5-4 below. Seven of ten bacterial samples collected at two stations in Kirker Creek during July and August contained fecal coliforms exceeding 1600 MPN/100 mL. Both stations exceeded fecal coliform and *E. coli* objectives.

Los Medanos Lake (KIR053) has a substantial population of resident waterfowl which may contribute to high coliform levels. The station at Buchanan Park (KIR110) is below an input from a park pond frequented by ducks. A high level of public use, however, including homeless resting spots near the site, was more evident from trash than at Los Medanos Lake. Such public use and sewer line leaks are a more likely source of coliform bacteria than waterfowl. Buchanan Park had the highest fecal coliform geomean, with individual counts above 1600 MPN/100 mL for four of the five water samples.

3.1.6 Summary of Kirker Creek watershed condition indicators

Benthic macroinvertebrate assemblages were seriously degraded throughout the watershed (Figure 3.1-1 and Appendix B). **Table 3.1-1** shows a summary of all the exceedances of water quality benchmarks in Kirker Creek in 2003. Temperature and dissolved oxygen benchmarks were exceeded in most deployments. There were frequent exceedances of nutrient criteria. Guidelines for organophosphate pesticides and water quality objectives for selenium were also exceeded. Some metals exceeded threshold-effect benchmarks in the sediment. Significant Ceriodaphnia mortality was observed in 2 of 5 water samples collected during the wet season. Sediment from the integrator station at KIR020 caused 100% mortality of Hyalella.

Table 3.1-1: Exceedances of water quality benchmarks in Kirker Creek in 2003

Group	Characteristic	Benchmark type	Limit	Units	KIR 020	KIR 053	KIR 110	KIR 115
Continuous Field Measurements					**2**		**3**	**1**
	Temperature	Maximum	22	° C			a	
		MWMT	17	° C	a			a
		MWAT	15	° C			a	a
	Oxygen, dissolved	Minimum, COLD	7	mg/L	a		a	a
		3-month median	80	%	a		a	a
	pH	Range	6.5 to 8.5	pH	a			
Conventional & Nutrient Water Samples					**3**			**2**
	Nitrate as N	Maximum	0.16	mg/L	1/3			2/2
	Phosphorus, total as P	Maximum	30	µg/L	3/3			2/2
Water Chemistry & toxicity Samples					**3**			**2**
	Selenium, total	Chronic	5	µg/L				1/2
	Chlorpyrifos	Chronic	0.015	µg/L	1/3			1/2
	Diazinon	Acute	0.1	µg/L	1/3			
	Ceriodaphnia toxicity	Acute - survival	SL*		1/3			1/2
		Chronic - reproduction	SL*		1/3			1/2
	Selenastrum toxicity	Growth	SL*		2/3			2/2
Coliform Water Samples						**5**	**5**	
	E. coli	log mean	>126	MPN/100 mL		b	b	
	Fecal coliform	log mean	>200	MPN/100 mL		b	b	
	Fecal coliform	90th percentile	>400	MPN/100 mL		b	b	
Sediment Chemistry and Toxicity Samples					**1**			
	Arsenic	TEC	9.79	mg/kg	1/1			
	Chromium	TEC	43.4	mg/kg	1/1			
	Copper	TEC	31.6	mg/kg	1/1			
	Nickel	TEC	22.7	mg/kg	1/1			
	Zinc	TEC	121	mg/kg	1/1			
	Hyalella toxicity	Acute - survival	SL*		1/1			
		Chronic - growth	SL*		1/1			

Notes
"a" - at least one exceedance at a station (each deployment file represents many monitoring days, with multiple minima).

"b" - an indication of exceedance in a summary statistic that looks at more than one data point.

* SL Significantly different from negative control (alpha=0.05), AND sample value is below 80% of control (Both 'toxicity criteria' met)
TEC Threshold effect concentration

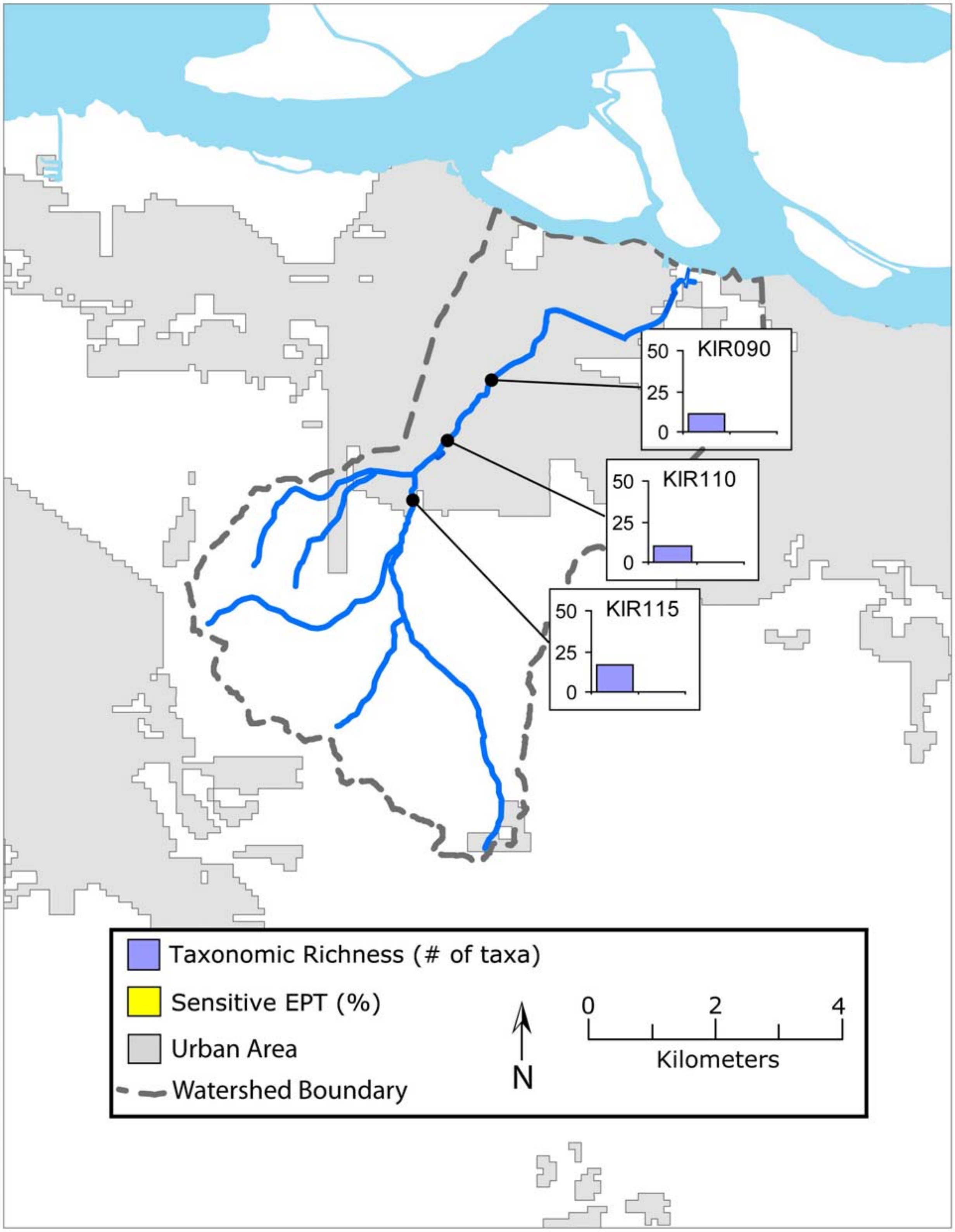

Figure 3.1-1: Results of selected BMI metrics in the Kirker Creek watershed

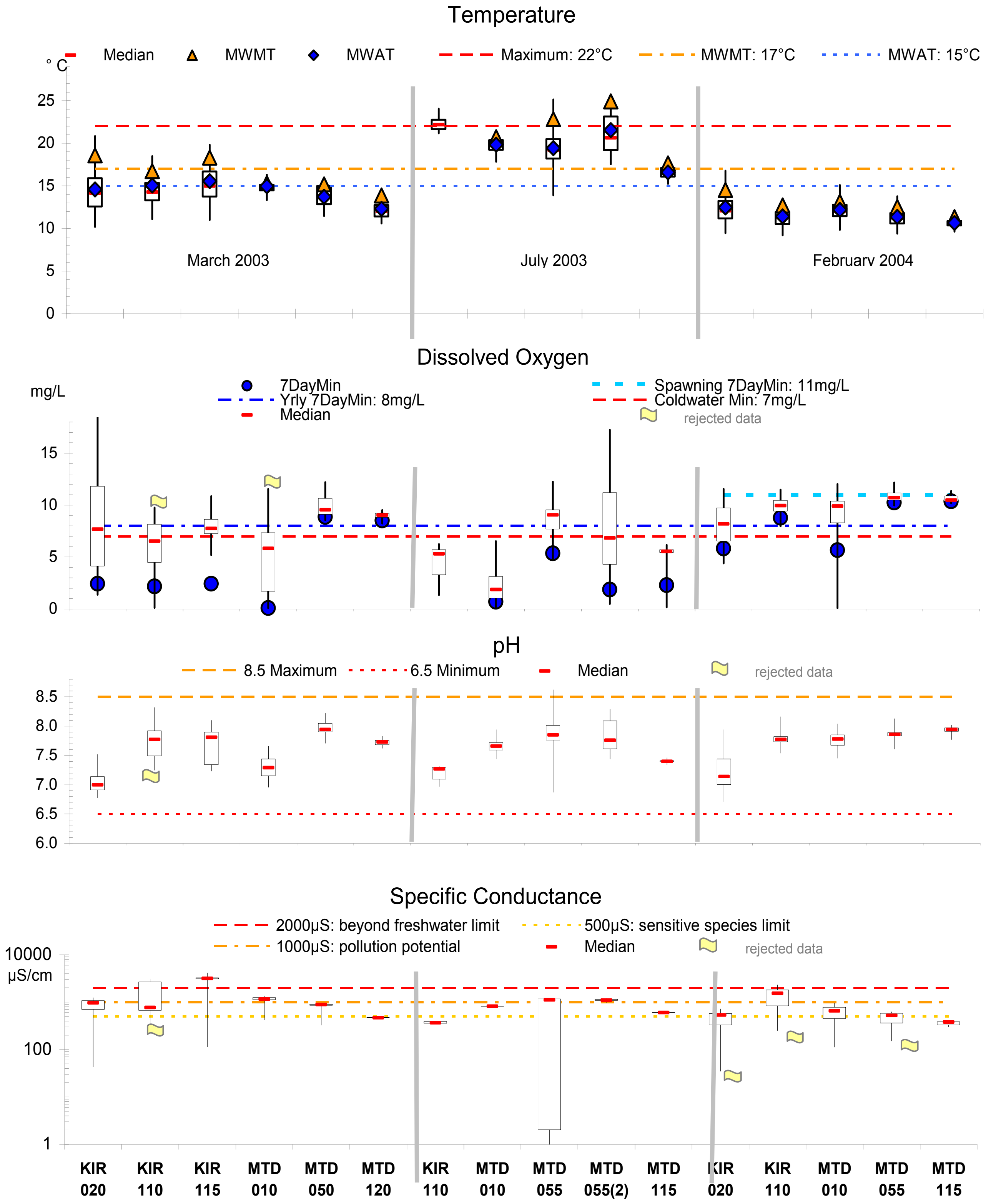

Figure 3.1-2: Continuous field monitoring summaries for Kirker and Mt. Diablo Creeks

3.2 Mt. Diablo Creek

The Mt. Diablo Creek watershed (Figure 2.1-3 above) is heavily urbanized throughout most of the lower and middle watershed: the city of Concord occupies the majority of the lower watershed, and the town of Clayton is situated in the middle watershed where the main tributaries meet the mainstem of the creek. The upper portions of the tributary streams Mitchell Canyon and Donner Canyon are within the Mt. Diablo State Park. Eleven monitoring sites in the Mt. Diablo Creek watershed were monitored in year 3. The MTD010 (Port Chicago Highway) site is close to a busy freeway and is below the Concord Naval Weapons Station, MTD020 (Diablo Creek Golf Course) and MTD030 (Bailey Rd at Laura) are on the mainstem within dense urban areas, while MTD050 (Lydia Lane Park), MTD055 (North Mitchell Canyon Drive) and MTD060 (Diablo Below Confluence) are on the mainstem in residential developments. The Mitchell Canyon tributary is represented by one urban site at MTD100 (Mitchell on Oak St) and two upstream sites, MTD115 (Mitchell at State Park) and MTD120 (Mitchell on Fire Road), located within Mount Diablo State Park. MTD130 (Peacock Creek in Irish Canyon) and MTD140 (Donnor Creek) are located at the edge of the rapidly-growing urbanized area in the Irish Canyon and the Donner Creek tributaries. Flow in the Mt. Diablo Creek watershed is mostly intermittent with dry creeks in the summer. Some creeks are fed by runoff from residential and golf course watering, and pools remain through the summer in upstream portions of Mitchell Creek.

3.2.1 Benthic macroinvertebrates and physical habitat

Nine sites were sampled for benthic macroinvertebrates and physical habitat in the Mt. Diablo Creek watershed. Metric values for each site are shown in Appendix Table B-2b and physical habitat data is shown in Appendix Table B-3.

Mainstem Mt. Diablo Creek sites (MTD010, MTD020, MTD030, MTD050, and MTD060) were dominated by the common, tolerant COBS (Chironomidae, Oligochaeta, *Baetis sp.*, and Simuliidae) taxa; percent COBS was greater than 90% at all five sites (Appendix B-2b). The *Baetis* mayfly was the only EPT taxa present at the upper three mainstem sites, while another baetid mayfly (*Fallceon quilleri*) was present at the two downstream sites. Sensitive EPT taxa were completely absent (**Figure 3.2-1**).

Upper watershed tributaries are generally in better condition than mainstem sites. Donner Creek (MTD140) and the upper Mitchell Canyon Creek site (MTD120) have diverse invertebrate assemblages, including many intolerant EPT taxa (Figure 3.2-1). These sites are similar to other intermittent streams draining open space in the Bay Area, such as Upper Marsh Creek (**Figure 3.5-1**).

The lower Mitchell Creek site (MTD100) in the town of Clayton exhibits some loss of taxa relative to the upstream site, including an absence of some EPT taxa such as heptageniid mayflies and certain caddisflies. Richness and tolerance metrics at MTD100 are significantly better than mainstem Mt. Diablo Creek sites, however (Figure 3.2-1).

Benthic assemblages at the Peacock Creek site (MTD130) are severely altered relative to the other tributaries, and more closely resemble the urban mainstem sites (Figure 3.5-1). Although several caddisflies were collected, tolerant non-insect taxa such as clams and snails were also commonly collected. The assemblage at this site is likely affected by poor habitat conditions, including a lack of riffle habitat and extensive fine sediment deposition (Appendix Table B-3). Water quality conditions are also suspect, as conductivity was very high (2850 uS) at the time of benthic sampling (Appendix Table B-3).

3.2.2 Continuous field measurements

The summary boxplots for temperature, DO, pH, and SC in Mt. Diablo Creeks are shown in **Figure 3.1-2**, in the previous section on Kirker Creek. Table C-2b in Appendix C details the summary statistics for continuous monitoring in the Mt. Diablo Creek watershed.

The six monitoring sites in the Mt. Diablo Creek watershed are affected by drainages of various land use activities. At the bottom of the watershed, MTD010 (Port Chicago Highway) is below the Concord Naval Weapons Station and a municipal golf course. Runoff from Port Chicago Highway flows directly into the creek. Lydia Lane Park (MTD050) and the two pools upstream at North Mitchell Canyon Drive (MTD055) receive runoff from the surrounding residential development and a private golf course. Two upstream sites on Mitchell Creek (MTD115, Mitchell at State Park, and MTD120, Mitchell on Fire Road) are within Mount Diablo State Park and represent the lowest land use impact in the watershed. Flow in the Mt. Diablo Creek watershed is mostly intermittent with dry creeks in the summer. Some creeks are fed by runoff from residential and golf course watering, and pools remain through the summer in upstream portions of Mitchell Creek.

Temperature: All the sites monitored in the summer exceeded MWMT and MWAT temperature thresholds. The North Mitchell Canyon Drive sites (MTD055 pools 1 and 2) exceeded the maximum temperature, indicating that they could not serve as refugia for fish during the summer. For a watershed with intermittent flow, these summertime exceedances are not surprising. Spring and winter temperatures met all guidelines.

Dissolved Oxygen (DO): The exceedances for DO are more unusual. At MTD010 (Port Chicago Highway), the spring and winter DO were exceptionally low, below even the warm water minimum of 5 mg/L, and way below the 7-day DO minimum. In the spring, the median percent saturation was also way below the threshold and there were high daily fluctuations of DO with substantial periods of anoxia at night. Such a condition suggests an excessive biological oxygen demand from eutrophication. In the winter, DO concentrations were reasonably high and stable until five days into the monitoring period. After five days, high daily fluctuations with low DO were measured. There appears to be a triggering event which set up this instability. The low DO recorded during the summer did not meet QA requirements.

The other sites monitored in the summer (both pools at MTD 055 and MTD115) were below the minimum DO even for warm water habitat, as well as the 7-day DO minimum in all instances. Large daily DO fluctuations and depth data indicate that pool 1 at MTD055 dried out and re-wetted every day in the summer, possibly from watering runoff (Figure 3.2-2). In the spring and summer, the Lydia Lane Park sites (MTD050 and both pools at MTD055) all have percent saturation above 120 percent, consistent with an observed high algal biomass. Although the 7-day minimum at the site farthest upstream in the state park, MTD120 (Mitchell on Fire Road), was below the spawning threshold of 11mg/L, the daily DO pattern was stable and healthy, indicative of good conditions.

pH: pH levels met guidelines except at MTD055 (pool 1) during the summer when excessive photosynthesis drove the pH above 8.5 with a range of 1.75 units. The pool was full of algae and had minimal flow.

Specific Conductance: Specific conductance was above 1000 µS at MTD010 in the spring and at the two pools at MTS055 in the summer. The relatively low (below 500 µS) specific conductance at the upstream sites (MTD115 and MTD120) was consistent with fresher water and fewer dissolved solids nearer the headwaters.

3.2.3 Water chemistry and toxicity

A total of 16 water samples were collected throughout the Mt. Diablo creek watershed for analysis of **conventional** water quality characteristics. Six of these samples were collected during the winter, 6 in the spring, and 4 in the dry season. The analytical results for **conventional** water quality characteristics are shown in Appendix Table D-3. Four of the 16 samples, collected at MTD010 and MTD100 during winter and spring, were also tested for metals, organics, and toxicity. The analytical results for metals and organics are shown in Appendix Tables D-4 and D-5, while the toxicity test results are presented in Appendix Table D-6.

Nutrient concentrations throughout Mt. Diablo creek frequently exceeded criteria, particularly at the lower reaches of the watershed (see Appendix Table D-3a). There were no cases of acute toxicity to *Ceriodaphnia dubia*, and the concentrations of diazinon, in the two samples where this pesticide were detected, were well below toxic levels; chlorpyrifos was not detected at all (Appendix Table D-5). Statistically-significant effects on *Ceriodaphnia* reproduction were observed in the two samples collected at MTD010 and MTD100 during the winter trip, but the effect may not be ecologically significant (see Discussion). Selenastrum growth was significantly reduced in the sample collected at MTD010 in winter, and fathead growth was reduced in the MTD100 spring sample; however the ecological significance is not clear in these cases as well (see Discussion).

3.2.4 Sediment chemistry and toxicity, and tissue chemistry

One sediment sample was collected, at a ‘watershed integrator’ site located close to the mouth of Mt. Diablo Creek. The results are shown in the tables of Appendix D-7. Mt. Diablo Creek sediments from MTD010 had relatively low concentrations of metals and organic substances. Only chromium and nickel exceeded the TEC; this is a common occurrence due to the geology of the area. There was a minor but significant effect on Hyalella survival (71% of control) and growth (57% of control) in a bulk sediment toxicity test. One clam sample was collected at the same site for tissue analyses; the **draft** results presented in Appendix Table D-8. The concentrations of metals were among the higher observed in the watersheds monitored in year 3.

Seven organochlorine compounds (of the 30+ tested) were detected. PAH compounds were as prevalent as in Kirker Creek, with total PAH concentration of 670 ng/g dry weight. Of the trace amounts of PCBs detected, Mt Diablo Creek clams had an array of congeners similar to other creeks, with total PCBs concentration of 90 ng/g dry weight.

3.2.5 Coliform counts

Bacterial count results of individual samples are shown in Appendix Tables E-1, and summary statistics are presented in Figure 3.5-4 below. Five bacterial samples were collected at MTD120 (Mitchell on Fire Rd) during July and August. Fecal coliforms and *E. coli* counts were relatively low. Of the stations sampled for coliform, only MTD120 was within standards for both fecal coliform and *E. coli*. This station serves as evidence of coliform levels expected at sites with minimal impacts.

3.2.6 Summary of Mt. Diablo Creek Watershed condition indicators

Benthic macroinvertebrate assemblages in the Mt. Diablo Creek watershed generally reflect poor conditions, except in the tributaries draining Mt. Diablo State Park. **Table 3.2-1** shows a summary of all the exceedances of water quality benchmarks in Mt. Diablo Creek in 2003. Temperature guidelines were exceeded during summer, and dissolved oxygen objectives were exceeded in all seasons. There were frequent exceedances of nutrients in the lower part of the watershed. One water sample exceeded mercury objectives. There were three cases of growth/reproduction effects in water toxicity tests. The sediment sample collected at the bottom of Mt. Diablo Creek had exceedances of TECs for mercury and nickel, and caused reduction of Hyalella survival and growth in the bulk sediment toxicity test.

Table 3.2-1: Exceedances of water quality benchmarks in Mt. Diablo Creek in 2003

Group	*Characteristic*	*Benchmark type*	*Limit*	*Units*	MTD **010**	MTD **050**	MTD **055**	MTD **056**	MTD **060**	MTD **100**	MTD **115**	MTD **120**	MTD **140**
Continuous Field Measurements					**3**	**1**	**2**	**1**			**2**	**1**	
	Temperature	Maximum	22	° C			a	a					
		MWMT	17	° C	a		a	a			a		
		MWAT	15	° C	a		a	a			a		
	Oxygen, dissolved	Minimum, COLD	7	mg/L	a		a	a			a		
		3-month median	80	%	a	a		a			a		
	pH	Range	6.5 to 8.5	pH			a						
Conventional WQ & Nutrient Water Samples					**2**	**3**			**3**	**2**		**3**	**3**
	Nitrate as N	Maximum	0.16	mg/L	2/2	3/3			3/3	2/2			
	Phosphorus, total as P	Maximum	30	µg/L	2/2	2/3			1/3				1/3
Water Chemistry & toxicity Samples					**2**					**2**			
	Ceriodaphnia toxicity	Chronic - reproduction	SL*		1/2					1/2			
	Pimephales toxicity	Acute - survival	SL*							1/2			
		Chronic - grough	SL*		1/2								
	Selenastrum toxicity	Growth	SL*		1/2								
Coliform Water Samples												**5**	
	(all coliform endpoints)											none	
Sediment Chemistry and Toxicity Samples					**1**								
	Mercury	TEC	0.18	mg/kg	1/1								
	Nickel	TEC	22.7	mg/kg	1/1								
	Hyalella toxicity	Acute - survival	SL*		1/1								
		Chronic - growth	SL*		1/1								

Notes

"a" - at least one exceedance at a station (each deployment file represents many monitoring days, with multiple minima).

"b" - an indication of exceedance in a summary statistic that looks at more than one data point.

* SL Significantly different from negative control (alpha=0.05), AND sample value is below 80% of control (Both 'toxicity criteria' met)

TEC Threshold effect concentration

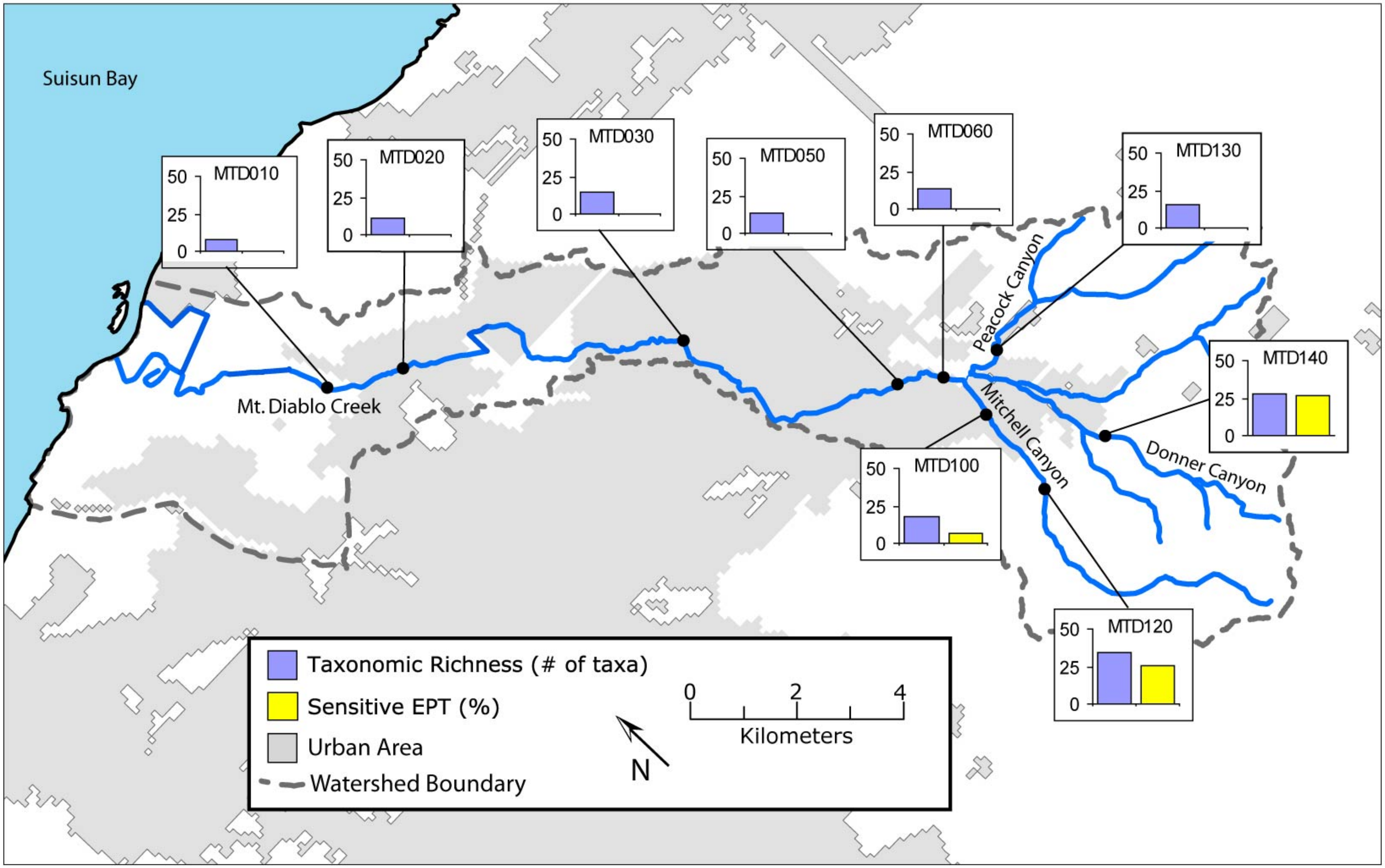

Figure 3.2-1: Results of selected BMI metrics in the Mt. Diablo Creek watershed

3.3 Petaluma River Watershed

The Petaluma River watershed (Figure 2.1-4 above) is heavily influenced by historic and current poultry and dairy farming, and has a substantial urban area within the city of Petaluma and adjacent communities. The tidal influences extend many miles up the slough, through highly channelized agricultural areas and tidal marshes. Of the 15 sites monitored in year 3, four sites are on the mainstem, with PET310, PET315 and PET350 in the urban area and PET360 above it. San Antonio Creek watershed is represented by three Stations (PET010, PET060, and PET070). PET090 on Ellis Creek represents a small un-urbanized drainage. The Adobe Creek tributary has two stations in the urban area (PET120 and PET130) and one station (PET150) just at the edge above the urban area. Other tributary stations include PET220 on Washington Creek, PET265 (urban) and PET280 (ag) on Lynch Creek, and PET400 (urban) on Lichau Creek. Water can be found year-round at most of the urban sites within the Petaluma River watershed.

3.3.1 Benthic macroinvertebrates and physical habitat

Thirteen sites were sampled for benthic macroinvertebrates and physical habitat in the Petaluma River watershed. Metric values for each site are shown in Appendix Table B-2c and physical habitat data is shown in Appendix Table B-3.

Mainstem Petaluma River sites (PET310, PET350, and PET360) had very low taxonomic richness and intolerant taxa values (**Figure 3.3-1**) and were dominated by COBS (Chironomidae, Oligochaeta, *Baetis sp.*, and Simuliidae) taxa, characteristic of polluted, urban areas. The streambed at PET350 and PET360 was covered in fine sediment, with no gravel present. Other sites in the Petaluma River watershed with similar poor benthic assemblages include Ellis Creek (PET090), lower Lynch Creek (PET265), and Lichau Creek (PET400). The Washington Creek site (PET220) deserves special mention due to its extremely low taxa richness (5) and dominance by oligochaetes (81%).

Adobe Creek sites (PET130, PET150) contained relatively diverse and intolerant assemblages, despite its location in an urban setting (Figure 3.3-1). Many sensitive EPT taxa, including heptageniid and ephemerellid mayflies, were collected at these sites. Physical habitat at these sites is generally good, with low levels of fine sediment and little channel alteration (Appendix Table B-3). Other sites in the watershed have equally good physical habitat, however, but poor benthic assemblages. Adobe Creek could serve as a useful model system to study how relatively healthy biological communities persist in urban areas.

San Antonio Creek (PET010, PET060, PET070) assemblages possess higher diversity and more sensitive taxa than at severely disturbed sites (Figure 3.3-1), but are still dominated by tolerant COBS taxa. These sites represent a moderate level of disturbance, falling between reference sites and urban sites (Figure 3.5-1). Similarly, the upper Lynch Creek site (PET280) is in better condition than the downstream site (PET265), based on the higher diversity and presence of several intolerant EPT taxa (Figure 3.3-1). The assemblage is dominated by oligochaetes, however, suggesting that poor habitat conditions could be a limiting factor at this site.

3.3.2 Continuous field measurements

Figure 3.3-2 shows the boxplot summaries for temperature, DO, pH, and SC in the Petaluma River watershed. Table C-2c in Appendix C details the summary statistics for continuous monitoring in the Petaluma River watershed.

The six monitoring sites in the Petaluma River watershed include sites on four tributaries and one on the mainstem. On the southeast tributary, PET010 is on San Antonio Creek at the Marin/Sonoma county line. The site drains ranches and grazing land, and it was dry in the summer. On the northeast tributary, PET120 (Adobe at Sartori Dr., below a small neighborhood park) and PET130 (Fairway Meadows) are on Adobe Creek, a known steelhead stream. Both sites drain a golf course and a residential neighborhood just within the urban boundary. PET120 replaced PET130 after the first monitoring period because of construction disrupting the original site, so they are grouped together.

On Lynch Creek, a tributary upstream, PET265 (Lynch pedestrian path) drains another golf course, a recreational park, a hospital, and a residential neighborhood in Petaluma. On the mainstem of Petaluma River, PET310 (Outlets) is in a linear park next to the parking lot for a large shopping center. Lastly, PET400 (Penngrove Park) is on Lichau Creek, an upstream tributary farther north. The site is outside Petaluma's urban boundary and drains a park and the small residential community of Penngrove as well as grazing land upstream.

Temperature: In the summer, all sites with flowing water (PET120, PET265, PET310, and PET400) exceeded the MWMT and the MWAT, but not the maximum temperature. In the fall (late dry season), both sites monitored (PET265 and PET310) exceeded the MWAT, and PET265 also exceeded the MWMT. In the spring, PET130 on Adobe Creek exceeded the MWMT.

Dissolved Oxygen (DO): The Petaluma River watershed had some exceptionally low DO values for aquatic life. All sites monitored in the summer (PET120, PET265, and PET310) were below the minimum concentration for cold-water habitat (7 mg/L), as well as the 7-day minimum (all below 1 mg/L) and median percent saturation (all below 20 percent). At two stations, PET265 and PET 310, even the maximum DO was below minimum thresholds. Although their DO data in the fall lack post-calibration QA, they would otherwise share the same exceedances and anoxic DO values. Only PET400 had DO levels that were not anoxic in the summer, although it lacks post-calibration QA.

Even in the spring, PET010, PET265, PET310, and PET400 were all below the 7 mg/L minimum and the 7-day DO minimum; PET101, PET310, and PET400 were also below the 80 percent median saturation limit. PET400 (Penngrove Park) had a maximum percent saturation above 120, consistent with excessive photosynthesis. In the spring, only PET130 on Adobe Creek had DO levels above minimum and median threshold values, and even then, it was below the recommended 7-day spawning minimum of 11 mg/L (however this benchmark may not be relevant in April). In the winter, PET010 on San Antonio had some unexpectedly low DO levels, which are referred to below with unusual pH values.

pH: All pH levels met guidelines, except PET010 on San Antonio, which had a winter range of values greater than 1 pH unit, suggesting excessive photosynthesis. Closer inspection reveals the sudden decrease in pH and DO was coincident with an increase in temperature and depth and a decrease in specific conductance. USGS flow data indicates a flow increase from 3 to 50 cfs at the same time: likely a rain event, especially since similar patterns of increase in depth and decrease in specific conductance are evident in data from the other sites at the same time.

Specific conductance: Specific conductance was above 1000 µS at PET310 during the summer and fall periods and at PET265 for the summer only. Both sites have low flow and some stagnant water in the dry season. They may be high in total dissolved solids because of evaporation.

3.3.3 Water chemistry and toxicity

A total of 20 water samples were collected in the Petaluma River watershed for analysis of **conventional** water quality characteristics in 2003. Seven of these samples were collected during the winter, 7 in the spring, and 6 in the dry season. The analytical results for conventional water quality characteristics are shown in Appendix Table D-3. Five of the 20 samples, collected at PET010 (winter & spring) and PET310 (winter, spring & summer), were also tested for metals, organics, and toxicity. The analytical results for metals and organics are shown in Appendix Tables D-4 and D-5, while the toxicity test results are presented in Appendix Table D-6.

Nutrient concentrations throughout the Petaluma River watershed frequently exceeded nitrogen criterion, regardless of season, and all samples exceeded total phosphorus criterion (see Appendix Table D-3a). There were no cases of acute toxicity to *Ceriodaphnia dubia*, and the concentrations of 0.012 ug/L diazinon, in the one sample where this pesticide were detected, was well below toxic levels; chlorpyrifos was not detected at all (Appendix Table D-5a). Statistically-significant effects on Ceriodaphnia reproduction were observed in the two samples collected at PET010 and PET310 during the winter trip, but the effect may not be ecologically significant (see Discussion). Selenastrum growth was significantly reduced in the samples collected at PET310 in spring and summer; however the ecological significance is not clear in this case as well (see Discussion).

3.3.4 Sediment chemistry and toxicity, and tissue chemistry

One sediment sample was collected in 2003 at PET310, a site located on the Petaluma River mainstem above confluence with the major tributaries. The results are shown in the tables of Appendix D-7. The sample had relatively low concentrations of metals and organic substances. Only nickel exceeded the TEC; this is a common occurrence due to the geology of the area. There was a minor effect on Hyalella growth (76% of control) in the bulk sediment toxicity test.

One clam sample was collected at the same site for tissue analyses; the **draft** results presented in Appendix Table D-8. The concentrations of metals were among the lower observed in year 3 (except for manganese). Seven organochlorine compounds (of the 30+ tested) were detected. PAH compounds were present at low concentrations, with a total PAH concentration of 230 ng/g dry weight (lowest among the watersheds tested). The Petaluma tissue sample also had the lowest concentrations of PCBs (84 ng/g dry weight).

3.3.5 Coliform counts

Bacterial count results of individual samples are shown in Appendix Tables E-1, and summary statistics are presented in Figure 3.5-4 below. Three of the four stations sampled for bacteria during July and August yielded summary statistics that exceeded fecal coliform benchmarks, and all four stations exceeded *E. coli* benchmarks.

Out of all ten sites sampled, the station on Lynch Creek, PET265 (Lynch at pedestrian path / CSAA lot), was one of two sites with results below both fecal coliform standards. However, it exceeded the *E. coli* standard. PET400 (Penngrove Park) was the only other station whose fecal coliform counts did not reach or exceed 1600 MPN/100mL (the maximum count achievable with the method used). However, its coliform counts still exceeded all standards.

Both PET310 (Outlets) and PET400 (Penngrove Park) have public traffic from adjacent trails and picnic tables, but vegetation presents a barrier to direct access along most of the creek. In the summer the low flow leaves stagnant water in pools. PET315 (Corona Road) was the site of an elaborate homeless encampment during the sampling period, with a makeshift outhouse near the creek and a kitchen setup just upstream of the sampling site. Its coliform levels were similar to PET310 (Outlets), exceeding all standards, but not the highest of the group.

3.3.6 Summary of Petaluma River Watershed condition indicators

Benthic macroinvertebrate assemblages in the mainstem Petaluma River and several tributaries (Washington Creek, Ellis Creek) were in poor condition (i.e., highly disturbed), while other tributaries showed evidence of low levels of disturbance (e.g., Adobe Creek) or moderate levels of disturbance (e.g., San Antonio Creek).

Table 3.3-1 shows a summary of all the exceedances of water quality benchmarks in the Petaluma River watershed in 2003. Temperature and dissolved oxygen benchmarks were exceeded in a little more than 50% of the deployments, there were frequent exceedances of criteria for nutrients and bacteria and minor chronic toxicity effects, but there were no exceedances of organics or trace metals benchmarks in water. The sediment had only one TEC exceedance, for nickel which is part of the natural geology, and one chronic effect in the Hyalella test.

Table 3.3-1: Exceedances of water quality benchmarks in the Petaluma River watershed in 2003

Group	*Characteristic*	*Benchmark type*	*Limit*	*Units*	PET 010	PET 120	PET 130	PET 150	PET 265	PET 280	PET 310	PET 315	PET 400
Continuous Field Measurements					**2**	**2**	**1**		**4**		**4**		**3**
	Temperature	MWMT	17	° C		a	a		a		a		a
		MWAT	15	° C		a			a		a		a
	Oxygen, dissolved	Minimum, COLD	7	mg/L	a	a			a		a		a
		3-month median	80	%	a	a			a		a		a
Conventional & Nutrient Water Samples					**2**		**3**	**3**	**3**	**3**	**3**		**3**
	Nitrate as N	Maximum	0.16	mg/L	2/2		1/3	1/3	3/3	1/3	3/3		2/3
	Phosphorus, total as P	Maximum	30	µg/L	2/2		3/3	3/3	3/3	3/3	3/3		3/3
Water Chemistry & toxicity Samples					**2**						**3**		
	Ceriodaphnia toxicity	Chronic - reproduction	SL*		1/2						1/3		
	Selenastrum toxicity	Growth	SL*								2/3		
Coliform Water Samples									**5**		**5**	**5**	**5**
	E. coli	log mean	>126	MPN/100 mL					b		b	b	b
	Fecal coliform	log mean	>200	MPN/100 mL							b	b	b
	Fecal coliform	90th percentile	>400	MPN/100 mL							b	b	b
Sediment Chemistry and Toxicity Samples											**1**		
	Nickel	TEC	22.7	mg/kg							1/1		
	Hyalella toxicity	Chronic - growth	SL*								1/1		

Notes

"a" - at least one exceedance at a station (each deployment file represents many monitoring days, with multiple minima).

"b" - an indication of exceedance in a summary statistic that looks at more than one data point.

* SL	Significantly different from negative control (alpha=0.05), AND sample value is below 80% of control (Both 'toxicity criteria' met)
TEC	Threshold effect concentration

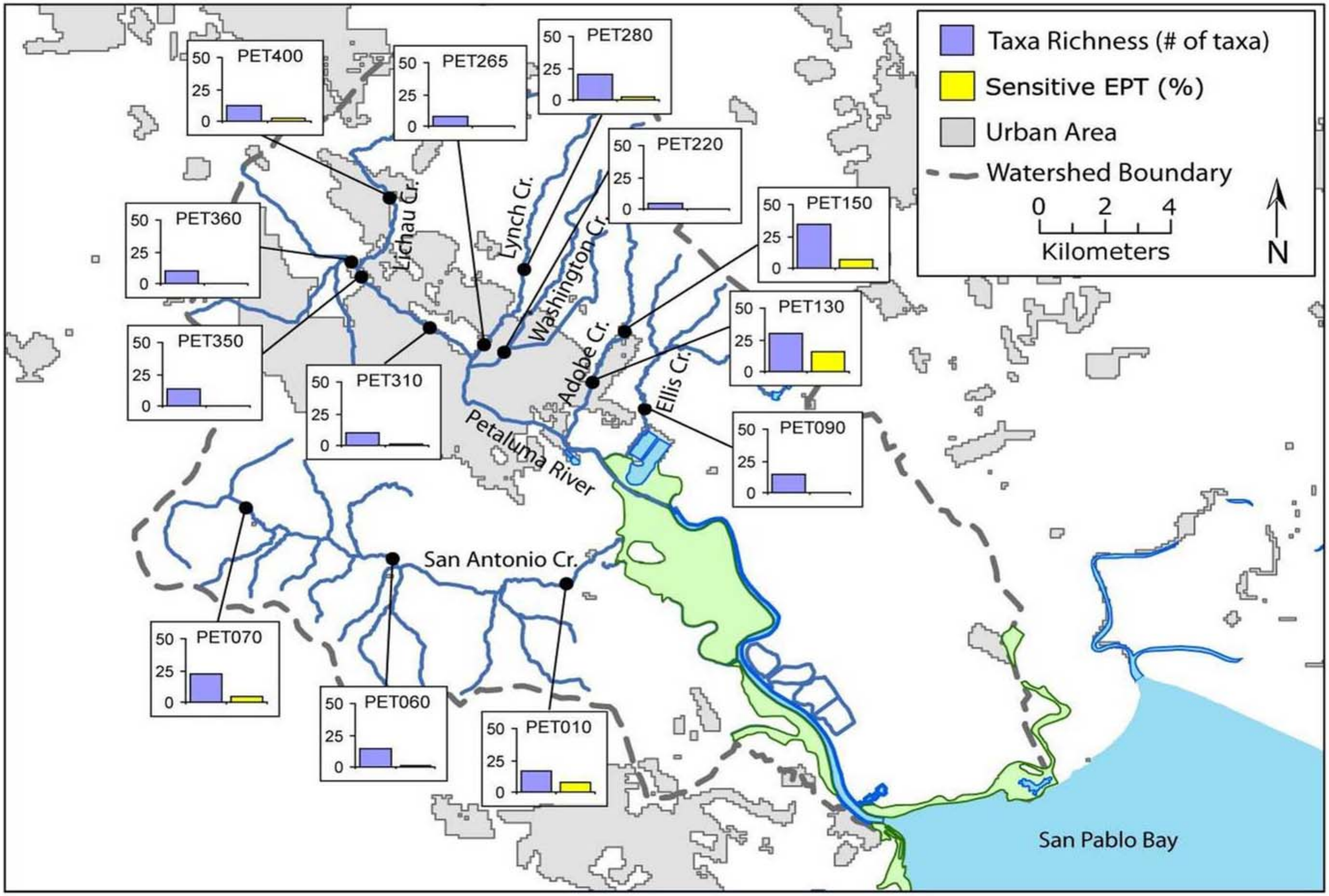

Figure 3.3-1: Results of selected BMI metrics in the Petaluma River watershed

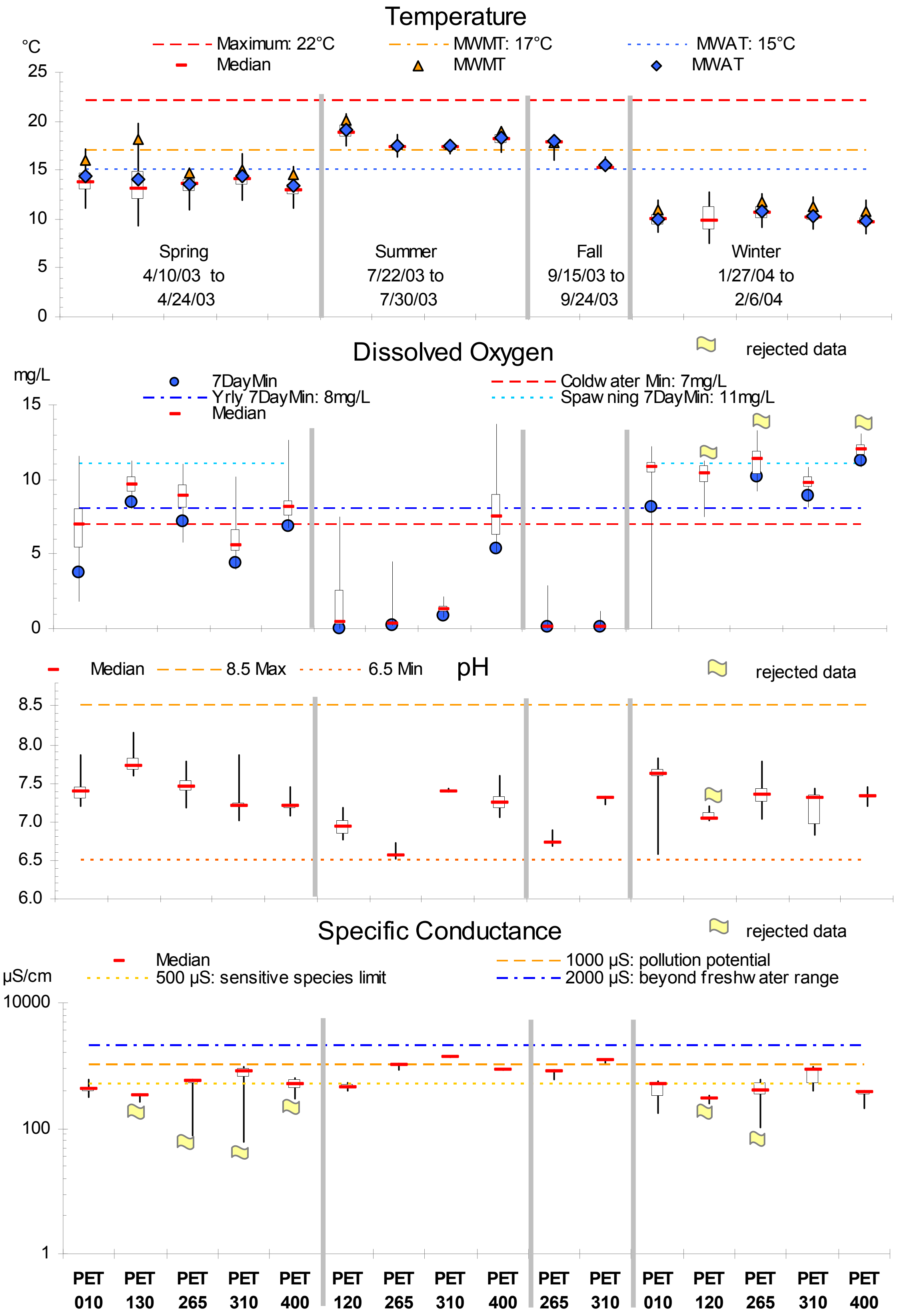

Figure 3.3-2: Continuous field monitoring summaries for Petaluma River

3.4 San Mateo Creek Watershed

San Mateo Creek watershed (Figure 2.1-5 above) is unique among the year 3 watersheds in that it has a large reservoir within its boundaries. The headwaters begin near Sweeney Ridge, and continue southeast until the Lower Crystal Springs Reservoir. Below the dam, the river continues through the cities of Hillsborough and San Mateo before draining into the San Francisco Bay at Ryder Park, just south of Coyote Point. The seven monitoring sites in the San Mateo Creek watershed represent both urban and open space drainages. SMA020 (Gateway Park) is in a tidally influenced urban segment. SMA060 (Arroyo Court Park) and SMA080 (Sierra Drive) are on the mainstem in dense urban areas, while SMA110 and SMA120 (at Polhemus and above it) drain a less dense residential area. Above the reservoir, SMA160 (Above Mud Dam) is located on the mainstem in an open-space area, and SMA180 (Buckeye at Old Cañada Rd) is on a tributary above the Upper Crystal Springs Reservoir (which drains into the Lower Crystal Springs Reservoir). Flow is intermittent at SMA180 and perennial at the other stations.

3.4.1 Benthic Macroinvertebrates (BMI) and physical habitat

Seven sites were sampled for benthic macroinvertebrates and physical habitat in the San Mateo Creek watershed. Metric values for each site are shown in Appendix Table B-2d and physical habitat data is shown in Appendix Table B-3.

Below the dam, mainstem San Mateo Creek (SMA020, SMA060, SMA080, and SMA120) sites and the Polhemus Creek site (SMA110) are in uniformly poor conditions, based on low benthic macroinvertebrate taxa richness and sensitive EPT abundance (**Figure 3.4-1**). Assemblages at the mainstem sites all have greater than 90% COBS (Chironomidae, Oligochaeta, *Baetis sp.*, and Simuliidae) taxa.

The upper watershed sites (SMA160 and SMA180), which drain the protected SFPUC watershed lands, are representative of perennial and intermittent reference conditions, respectively (Figure 3.5-1). Assemblages at these sites have high taxonomic richness, and sensitive EPT taxa are common and abundant (Figure 3.4-1). Percent COBS values are relatively low (32% and 53%, respectively) at these sites.

3.4.2 Continuous field measurements

Figure 3.4-2 shows the boxplot summaries for temperature, DO, pH, and SC monitored in the San Mateo Creek watershed. Table C-2d in Appendix C details the summary statistics for continuous monitoring in the San Mateo Creek watershed.

The five monitoring sites in the San Mateo Creek watershed fall into three land use categories: tidal / urban, residential, and minimally impacted. At the bottom of the watershed, SMA020 (Gateway Park) is in an engineered channel within an urban park in a dense residential and commercial area. Monitoring here revealed the site to be tidally influenced. Arroyo Court Park (SMA060) is in a small park surrounded by a dense residential neighborhood; Polhemus (SMA110, on Polhemus Creek) and Above Polhemus (SMA120, on San Mateo Creek) are adjacent sites which drain a less dense residential area about a mile below a dam. Buckeye @ Old Cañada Rd (SMA180) is a minimally impacted reference site on a tributary above Upper Crystal Springs Reservoir, within restricted-access SFPUC watershed lands. It was monitored only in the spring.

Temperature: All four sites monitored in the summer (SMA020, SMA060, SMA110, SMA120) had temperatures above the MWMT and MWAT thresholds; Gateway Park (SMA020) also exceeded the maximum temperature and exceeded the MWMT and MWAT in the fall. Polhemus (SMA110) also exceeded the MWAT in the fall. The reference site, SMA180, was not monitored in the summer because of low flow. Spring and winter temperatures met all guidelines.

Dissolved Oxygen (DO): In the summer, both Gateway Park and Arroyo Court Park (SMA020 and SMA060) had DO levels below the cold water minimum, below the median percent saturation, and below the 7-day DO minimum. SMA020 had anoxic periods and a maximum DO percent saturation above 120, consistent with excessive photosynthesis. In the fall, SMA020 had similar very low DO levels below the same thresholds. Polhemus (SMA110) also had DO levels below the 7 mg/L minimum and the 7-day DO minimum (8 mg/L).

In the spring, Arroyo Court Park (SMA060) and Above Polhemus (SMA120) had DO concentrations below the 7 mg/L standard, but SMA060 also had a low median percent saturation (only 52 percent) and a 7-day DO minimum of only 1 mg/L, way below the year round 8 mg/L threshold and the 11 mg/L spawning level. All the sites monitored in the spring were below the 11 mg/L spawning 7-day DO minimum. Although the DO at SMA180 did not pass QA standards, results indicate a steady DO level, and mostly at high levels.

In the winter, SMA020 and SMA110 were below the 7-day DO spawning minimum of 11 mg/L, while SMA060 and SMA120 were above. It is unclear if the 11 mg/L benchmark is relevant to this area. Overall, DO levels in the lower watershed were stressful to aquatic life throughout the year.

pH: All pH values were within standards except a high 8.51 pH at SMA120 (Above Polhemus) which seems to be consistently high, but not alarming.

Specific conductance: Monitoring at SMA020 in the summer and fall revealed specific conductance values so high (up to 42,437 µS) compared to the usual values around 600 µS that it is clear Gateway Park was tidally influenced. Subsequent investigation of the cycles confirmed a correlation with the tides. Specific conductance values above 1000 µS at SMA120 in the winter suggest high dissolved solids which could result from local geology or might indicate a human impact.

3.4.3 Water chemistry and toxicity

A total of 9 water samples were collected in the San Mateo Creek watershed, at SMA020, SMA160, and SMA180, for analysis of **conventional** water quality characteristics in 2003. Three of these samples were collected during the winter, 3 in the spring, and 3 in the dry season. The analytical results for conventional water quality characteristics are shown in Appendix Table

D-3. Three of these samples, collected at SMA020 (winter, spring & summer), were also tested for metals, organics, and toxicity. The analytical results for metals and organics are shown in Appendix Tables D-4 and D-5, while the toxicity test results are presented in Appendix Table D-6.

Generally, constituent concentrations in water samples collected in San Mateo Creek tributaries above the reservoir (SMA160 and SMA 180) were lower than in samples from SMA020, at the bottom of the watershed. Nutrient concentrations exceeded criteria in all SMA020 samples, regardless of season, but there were few exceedances of nutrient criteria in samples collected in SMA160 and SMA 180 (see Appendix Table D-3a). There were no cases of acute toxicity to *Ceriodaphnia dubia*, although the combined concentrations of diazinon and chlorpyrifos (0.092 and 0.075 ug/L, respectively) in the winter sample could cause toxicity (Appendix Table D-5a). Statistically-significant effects on fathead minnow survival (69% of Control) were observed only in spring sample collected at SMA020.

3.4.4 Sediment chemistry and toxicity, and tissue chemistry

One sediment sample was collected, at a ‘watershed integrator’ site located close to the mouth of San Mateo Creek, in 2003. The results are shown in the tables of Appendix D-7. San Mateo Creek sediments from SMA020 contained high concentrations, in exceedance of the Probable Effect Concentrations (PEC), of the naturally-occurring metals chromium and nickel. The SMA020 also contained more DDTs and other organic substances than other year 3 sediment samples, and had the highest mean PEC quotient (0.32). This sample caused acute toxicity to Hyalella (survival was only 18% of control) in the bulk sediment toxicity test. Station SMA020 (Gateway Park) sediment exhibited acute toxicity again in a pyrethroids study conducted in 2005 (see Section 4.1.3 below).

One clam sample was collected at the same site for tissue analyses; the **draft** results presented in Appendix Table D-8. The concentrations of metals were on the higher end observed in year 3, a total of 14 organochlorine compounds, including most chlordane species, were detected. The total PAH concentration was 623 ng/g dry weight, and the total PCB concentration was 144 ng/g dry weight (the highest observed in year 3).

3.4.5 Coliform counts

Bacterial count results of individual samples and summary statistics are presented as a scatterplot in Figure 3.5-4 below; data are reported in Appendix E. Six of fifteen bacterial samples collected at San Mateo Creek during July and August contained fecal coliforms at more than 1600 MPN/100 mL, and all summary statistics for all three stations exceeded benchmarks for fecal coliform and *E. coli*.

In the San Mateo Creek watershed, Gateway Park (SMA020) exceeded all coliform standards, but not as egregiously as Arroyo Court Park (SMA060) and Sierra Drive (SMA080), whose high levels of *E. coli* suggest possible sewer line leaks. Both sites are in high-income residential areas; a sewer line was adjacent to the creek and was being repaired during the sampling period. Lack of best management practices to prevent accidental spills was noted during the repair period that overlapped with sampling.

3.4.6 Summary of San Mateo Creek Watershed condition indicators

Benthic macroinvertebrate assemblages at sites on the mainstem San Mateo Creek and Polhemus Creek were in poor condition, while sites in protected open space in the upper watershed (SMA160 and SMA 180) were similar to reference conditions. **Table 3.4-1** shows a summary of all the exceedances of water quality benchmarks in San Mateo Creek in 2003. Temperature and dissolved oxygen benchmarks were exceeded often below the reservoir but not above; however, the stations above the reservoir were not monitored during summer. There were frequent exceedances of nutrients benchmarks in water, mostly below the reservoir, one exceedance of chlorpyrifos, and a mild acute toxicity effect to fish. Constituent concentrations in the sediment sample exceeded PECs for chromium and nickel, and exceeded TECs for mercury, chlordanes, and DDTs. That sediment sample was also acutely toxic to Hyalella (only 18% survived), and it impaired Hyalella growth.

Table 3.4-1: Exceedances of water quality benchmarks in San Mateo Creek in 2003

Group	*Characteristic*	*Benchmark type*	*Limit*	*Units*	SMA 020	SMA 060	SMA 080	SMA 110	SMA 120	SMA 160	SMA 180
Continuous Field Measurements					**4**	**4**		**4**	**3**		**1**
	Temperature	Maximum	22	° C	a						
		MWMT	17	° C	a	a		a	a		
		MWAT	15	° C	a	a		a	a		
	Oxygen, dissolved	Minimum, COLD	7	mg/L	a	a		a	a		
		3-month median	80	%	a	a					
	pH	Range	6.5 to 8.5	pH							
Conventional & Nutrient Water Samples					**3**					**3**	**3**
	Nitrate as N	Maximum	0.16	mg/L	3/3						1/3
	Phosphorus, total as P	Maximum	30	µg/L	3/3					1/3	1/3
Water Chemistry & toxicity Samples					**3**						
	Chlorpyrifos	Chronic	0.015	µg/L	1/3						
	Pimephales toxicity	Acute - survival	SL*		1/3						
Coliform Water Samples					**5**	**5**	**5**				
	E. coli	log mean	126	MPN/100 mL	b	b	b				
	Fecal coliform	log mean	>200	MPN/100 mL	b	b	b				
	Fecal coliform	90th percentile	>400	MPN/100 mL	b	b	b				
Sediment Chemistry and Toxicity Samples					**1**						
	Chromium	PEC	111	mg/kg	1/1						
	Mercury	TEC	0.18	mg/kg	1/1						
	Nickel	PEC	48.6	mg/kg	1/1						
	Chlordane	TEC	3.24	µg/kg	1/1						
	DDD (sum op + pp)	TEC	4.88	µg/kg	1/1						
	DDE (sum op + pp)	TEC	3.16	µg/kg	1/1						
	DDT (sum op + pp)	TEC	4.16	µg/kg	1/1						
	DDT (total)	TEC	5.28	µg/kg	1/1						
	Hyalella toxicity	Acute - survival	SL*		1/1						
		Chronic - growth	SL*		1/1						

Notes

"a" - at least one exceedance at a station (each deployment file represents many monitoring days, with multiple minima).

"b" - an indication of exceedance in a summary statistic that looks at more than one data point.

* SL	Significantly different from negative control (alpha=0.05), AND sample value is below 80% of control (Both 'toxicity criteria' met)
TEC	Threshold effect concentration
PEC	Probable effect concentration

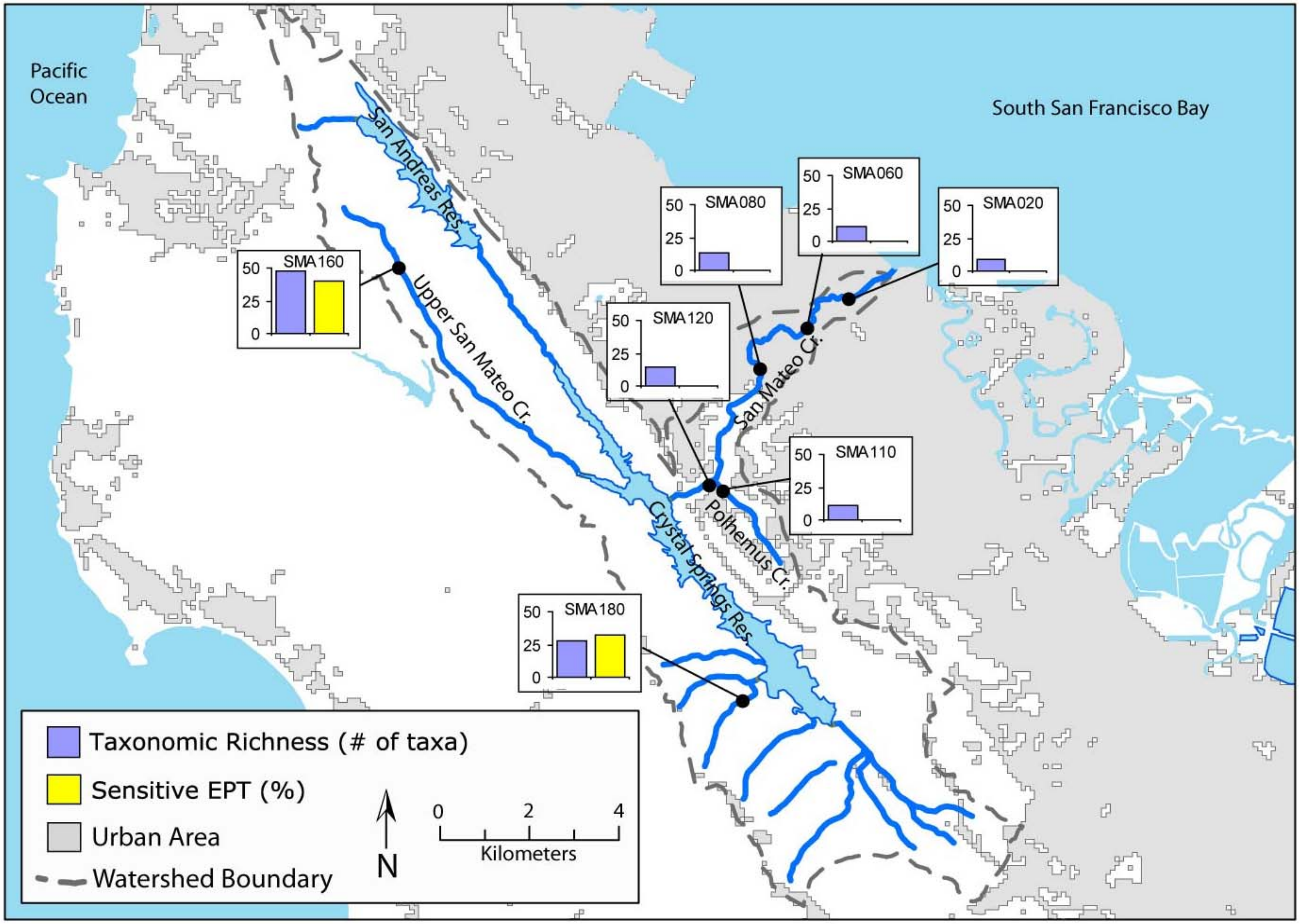

Figure 3.4-1: Results of selected BMI metrics in the San Mateo Creek watershed

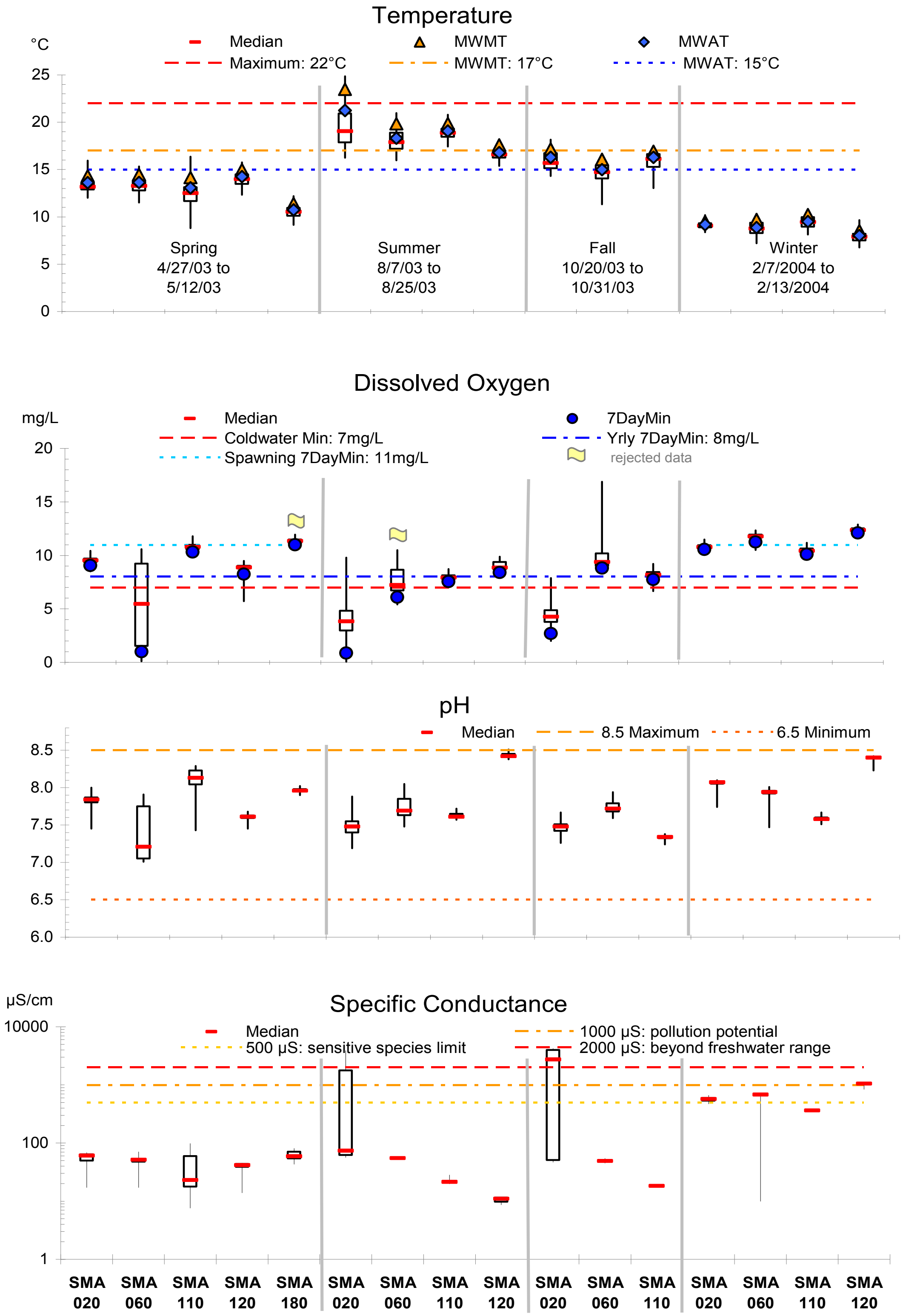

Figure 3.4-2: Continuous field monitoring summaries for San Mateo Creek

3.5 Regional summaries for all four watersheds

3.5.1 Regional Trends in Benthic Macroinvertebrates (BMI) assemblages

Figure 3.5-1 shows an NMS ordination plot of taxa presence at sites sampled in 2003 and other urban and reference sites (see Methods for information about NMS ordination plots). Ordination and cluster analysis of benthic macroinvertebrate data from SWAMP sampling in previous years indicates that sites in urban areas generally have very similar invertebrate assemblages that are indicative of poor water quality conditions. A subset of these urban sites are included in the ordination plot of 2003 sites. Analysis of data from previous years also shows that invertebrate assemblages in creeks draining protected open space are significantly different in streams with perennial flow and intermittent flow (summer dry streams). For comparison with sites sampled in 2003, a subset of these perennial and intermittent sites, considered to represent reference conditions, are also shown in the ordination (Figure 3.5-1).

3.5.2 Continuous field measurements summary (regional trends)

Table 3.5-1 shows a summary of continuous field measurement exceedances in all four watersheds monitored in 2003-04. All twelve stations monitored for at least seven days in the summer exceeded the following temperature and DO thresholds: above the MWMT of 17°C and the MWAT of 15°C, and below the DO minimum for coldwater habitat of 7 mg/L (a Basin Plan objective). All stations except one were below the 7-day DO minimum of 8 mg/L, and all but two were below the 80 percent saturation median.

In the spring, all stations met temperature thresholds except the three in Kirker Creek. Of the fourteen sites monitored in the spring that passed QA, ten had DO concentrations below 7 mg/L, and all were below one of the 7-day minimum guidelines. In winter, three bottom-of-the-watershed sites (KIR020, MTD020, and PET010) were below 7 mg/L.

The levels and ranges of pH in these watersheds are mostly an indication of eutrophication. The sites in wetlands (KIR020) or stagnant pools (MTD055) with ranges greater than 1 pH unit are not surprising. At PET010 in the winter, that range suggests that the nutrient level may be high in San Antonio Creek watershed.

Two stations had specific conductance levels above 2000 µS, outside the natural range of freshwater. At SMA020, it was due to tidal influence, which helps interpret other data from the site. Tidal fluctuations affect salinity, temperature, and DO, which in turn affect benthic macroinvertebrate assemblages. At KIR115, the high SC levels are consistent with saline soils in evaporative environments. Fifty percent of sites had SC above 1000 µS. Forty percent of the sites had SC levels between 500 and 1000 µS. Only two sites out of twenty were below the 500 µS threshold for sensitive species: PET130 on Adobe Creek and MTD120 on Mitchell Creek.

3.5.3 Water Chemistry and toxicity highlights

Figure 3.5-2 shows concentrations of selected metals in water samples collected in the four watersheds during 2003. Arsenic and selenium are present mostly in the dissolved fraction (less than 0.45 micron), and their concentrations may be correlated with salts (TDS) rather than suspended solids. At MTD010, the high concentrations of aluminum, cadmium, copper, lead (as well as mercury and zinc, not shown) appear to be related to high suspended solids. That sample was collected at MTD010 on a rainy day in the spring, probably after the runoff has reached the sampling station.

Figure 3.5-3 shows concentrations of selected organic compounds in water samples collected in the four watersheds during 2003. Here, too, the sample collected at MTD010 on that rainy spring day had exceptionally high concentrations; two PAH compounds were present at concentrations that are an order of magnitude higher then in the other samples – and are typical of urban runoff.

The organophosphate pesticides diazinon and chlorpyrifos were detected in a small number of samples. Only the samples collected at Kirker Creek (KIR020 and KIR115) in the wet season (January) were toxic to *Ceriodaphnia dubia*, and these samples contained diazinon plus chlorpyrifos concentrations that are known to be very toxic. Selenastrum growth was affected in the two samples collected at KIR115, which had extremely high concentrations of salts, including sulfate and boron. The samples from MTD100 and SMA020 in the spring caused partial mortality of fathead minnow (55% and 62 % survival, respectively), but constituent concentrations cannot provide any clue to the cause. It must be noted that many potential toxicants which may have been present in the samples have not been analyzed for.

Generally, water column toxicity to freshwater organisms (Appendix Table D-6) is not wide-spread in the samples collected during 2003, and most chronic effects are statistically significant but probably not ecologically significant (see Discussion).

3.5.4 Sediment quality

Appendix Table D-7 shows detected metals (D-7a) and organics (D-7b) concentrations in sediment samples, with highlights of quality benchmark exceedances. It also includes, in Table D-7c, the toxicity quotients calculated for each sediment sample, and the observed Hyalella toxicity in these samples. Within the small dataset of 2003, there is no visible relationship between the mean PEC quotient and the extent of toxicity; SMA020 sediment had the highest mean PEC quotient (0.32) but the most toxic sample was collected at KIR020, which had a mean PEC quotient of 0.17. However, four samples are not sufficient for any meaningful inference. And - as in the case of water samples - many potential toxicants (e.g., pyrethroids) may have been present in the sediments but have not been analyzed for (see Discussion).

There were probably other factors that affected the test organisms (e.g., high organic carbon). Samples differed in particle size and consistency. Concentration of contaminants appeared to be higher in the fine-grain sample collected at KIR020, and that sample caused complete mortality of the test organisms.

3.5.5 Coliform counts summary

Figure 3.5-4 shows Fecal Coliform and E. coli summary statistics and exceedances in 2003.

Water was sampled for coliform bacteria at ten stations on July 21 and 28, and August 4, 11, and 18, 2003, following the U.S.EPA protocol for five equally-spaced samplings within 30 days. This extended sampling regime accommodates the highly variable nature of bacterial reproduction by using results from five well-spaced events to calculate a logarithmic mean, also called a geometric mean or geomean. Results are reported for individual samples in Appendix E, as well as the following three summary statistics calculated from the five sampling events: geomeans for fecal coliform and *E. coli*, and 90th percentile for fecal coliform. Several levels of fecal coliform listed as 1600 MPN/100mL were actually at or above that level. Thus, the maximum, 90th percentile, and geomean calculated from those levels are the minimum possible representations of the actual populations. The scales in Figure 3.5-4 are logarithmic to accommodate the variation in values typical for bacterial growth. Individual results are represented by an “x” and connected with a line to emphasize the range.

Thresholds for fecal coliform and *E. coli* were used to evaluate impacts at each station. For recreational waters, U.S.EPA recommends *E. coli* as the best indicator of waterborne pathogens. While fecal coliform bacteria as a group have been shown not to correlate as reliably as *E. coli* with disease-causing agents, they are currently still a standard referenced in the Basin Plan. Although water samples were also analyzed for total coliform bacteria, they are no longer a recommended indicator and are not presented here. For *E. coli*, a geomean above U.S.EPA’s steady state limit of 126 MPN/100mL constitutes an exceedance. Most Probable Number/100mL is a statistic, essentially equivalent to Colony Forming Units/100mL. For fecal coliforms, a geomean above 200 MPN/100mL or a 90th percentile above 400 MPN/100mL each constitute an exceedance.

The station at Mitchell on Fire Rd. (MTD120) was the only one within both fecal coliform and *E. coli* standards. This station serves as evidence of coliform levels expected at sites with minimal impacts. The high levels found at sites in parks (Los Medanos Lake KIR053, Buchanan Park KIR110, Outlets PET310, Penngrove Park PET400, Gateway Park SMA020, and Arroyo Court Park SMA060) indicate that these areas should be re-tested.

Table 3.5-1: Summary of continuous field measurement exceedances of water quality benchmarks

		Monitoring Events					Temperature			Dissolved Oxygen				pH		SC		
Station	*Station Name*	*#*	*Sp*	*Sm*	*F*	*W*	*Max*	*MWMT*	*MWAT*	*7mg/L*	*7DMin*	*<80%*	*>120%*	*8.5*	*Δ 1*	*500*	*1K*	*2K*
KIR020	Floodway	2	√			√		●		●	●	●	●		●	●	●	
KIR110	Buchanan Park	3	√	√		√	●	NA	●	●	R	●			R	R	R	R
KIR115	Apartments	1	√					●	●	●	●	●				●	●	●
Kirker Total of 3 sites		**6**	**3**	**1**	**0**	**2**	**1**	**2**	**2**	**3**	**2**	**3**	**1**	**0**	**1**	**2**	**2**	**1**
MTD010	Port Chicago Hwy	3	√	√		√		●	●	●	●	●				●	●	
MTD050	Lydia Lane Park	1	√								S	●				●		
MTD055	N. Mitchell Canyon pool1	2		√		√	●	●	●	●	●		●	●	●	●	●	
MTD055	N. Mitchell Canyon pool2	1		√			●	●	●	●	●	●	●			●	●	
MTD115	Mitchell at State Park	2		√		√		●	●	●	●	●				●		
MTD120	Mitchell on Fire Road	1	√								S							
Mt Diablo Total of 6 sites		**10**	**3**	**4**	**0**	**3**	**2**	**4**	**4**	**4**	**4**	**4**	**2**	**1**	**1**	**5**	**3**	**0**
PET010	San Antonio Road	2	√			√				●	●	●			●	●		
PET120	Adobe at Sartori Drive	2		√		√		●	●	●	●	●				●		
PET130	Fairway Meadows	1	√					●			S							
PET265	Lynch pedestrian path	4	√	√	√	√		●	●	●	●	●	R			●	●	
PET310	Outlets	4	√	√	√	√		●	●	●	●	●				●	●	
PET400	Penngrove Park	3	√	√		√		●	●	●	●	●	●			●		
Petaluma Total of 6 sites		**16**	**5**	**4**	**2**	**5**	**0**	**5**	**4**	**5**	**5**	**5**	**1**	**0**	**1**	**5**	**2**	**0**
SMA020	Gateway Park	4	√	√	√	√	●	●	●	●	●	●	●			●	●	●
SMA060	Arroyo Court Park	4	√	√	√	√		●	●	●	●	●				●		
SMA110	Polhemus	4	√	√	√	√		●	●	●	●					●		
SMA120	Above Polhemus	3	√	√		√		●	●	●						●	●	
SMA180	Buckeye @ Old Cañada Rd	1	√													●		
San Mateo Total of 5 sites		**16**	**5**	**4**	**3**	**4**	**1**	**4**	**4**	**4**	**3**	**2**	**1**	**0**	**0**	**5**	**2**	**1**
Grand Total of 20 sites		**48**	**16**	**13**	**5**	**14**	**4**	**15**	**14**	**16**	**14**	**14**	**5**	**1**	**3**	**17**	**9**	**2**

Note: # = total number of monitoring events. Sp = spring, Sm = summer (dry), F = fall, W = winter (wet). √ = a monitoring event. ● = at least one exceedance at a station. NA = not enough data to generate the metric. R = exceedance is from data that did not pass post-calibration QA (rejected). S = spawning (Nov-May) level exceedance only. Max is 22°C, MWMT is 17°C, MWAT is 15°C, 7DMin is 8 mg/L year round and 11 mg/L November through May. Specific conductance (SC) is in µS/cm. See Table C-2A for details on evaluation thresholds.

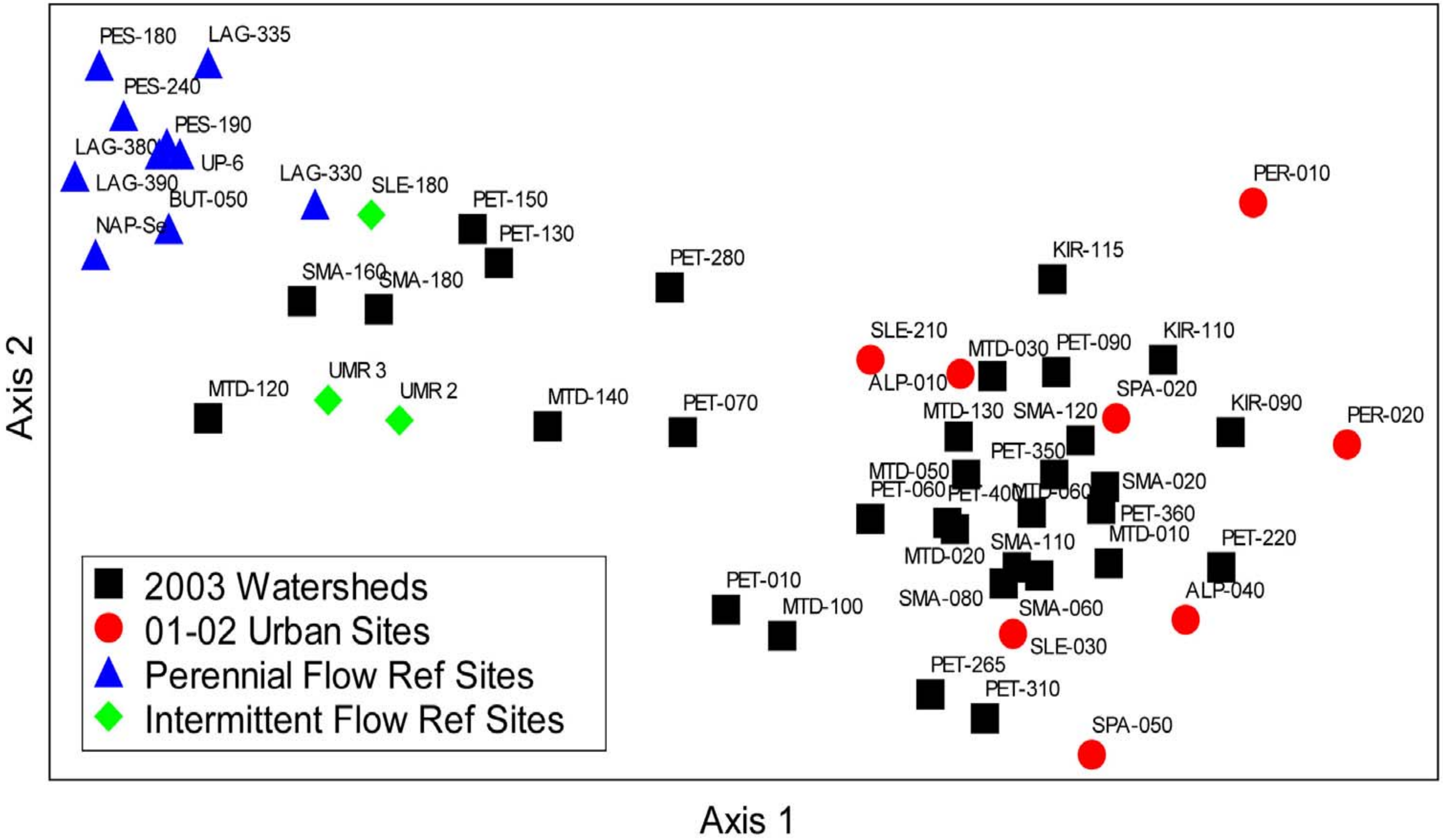

Figure 3.5-1: Ordination graph of taxa presence at 2003 sites and other urban and reference sites

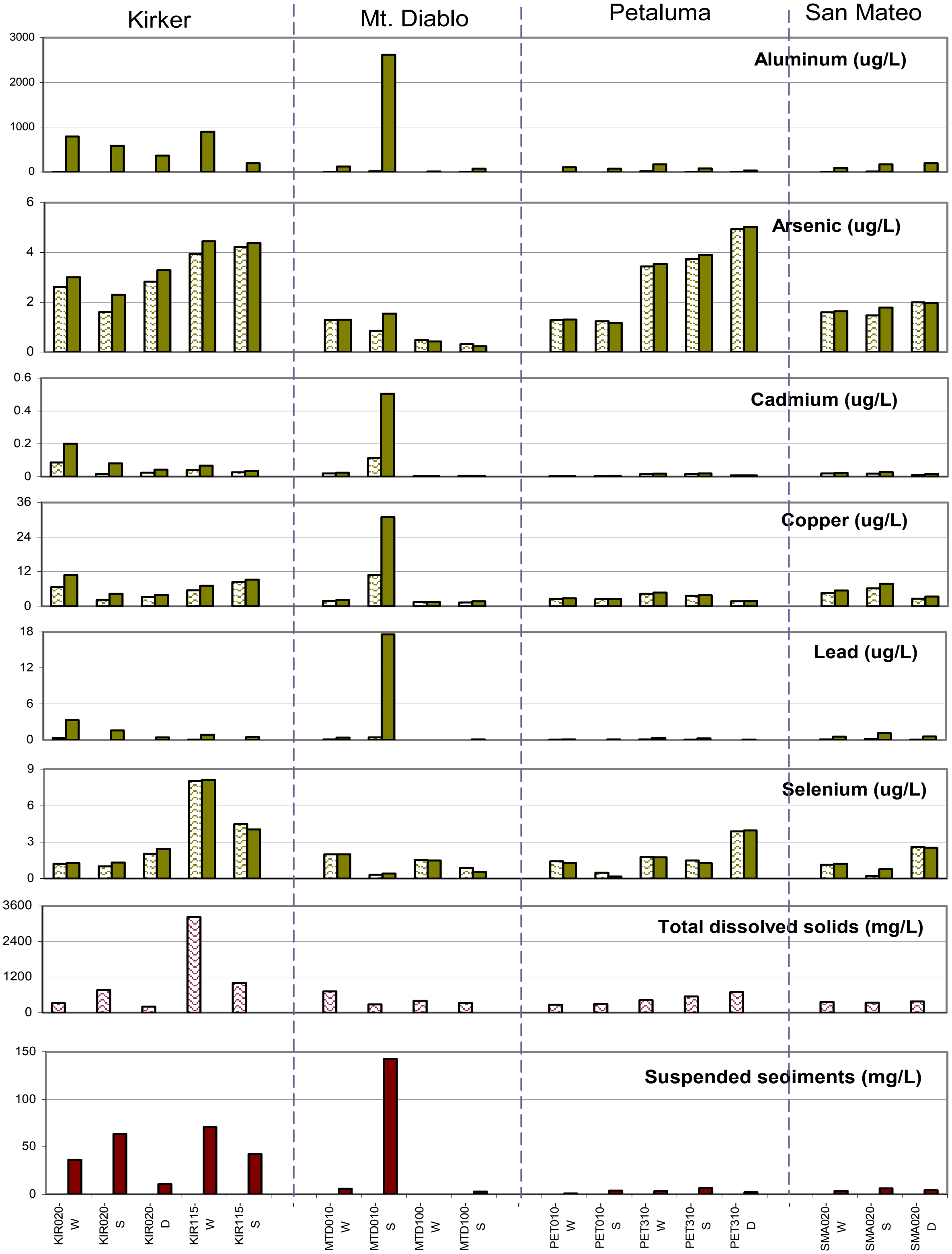

Figure 3.5-2: Concentrations of total and dissolved metals, and dissolved or suspended solids, in water samples in 2003

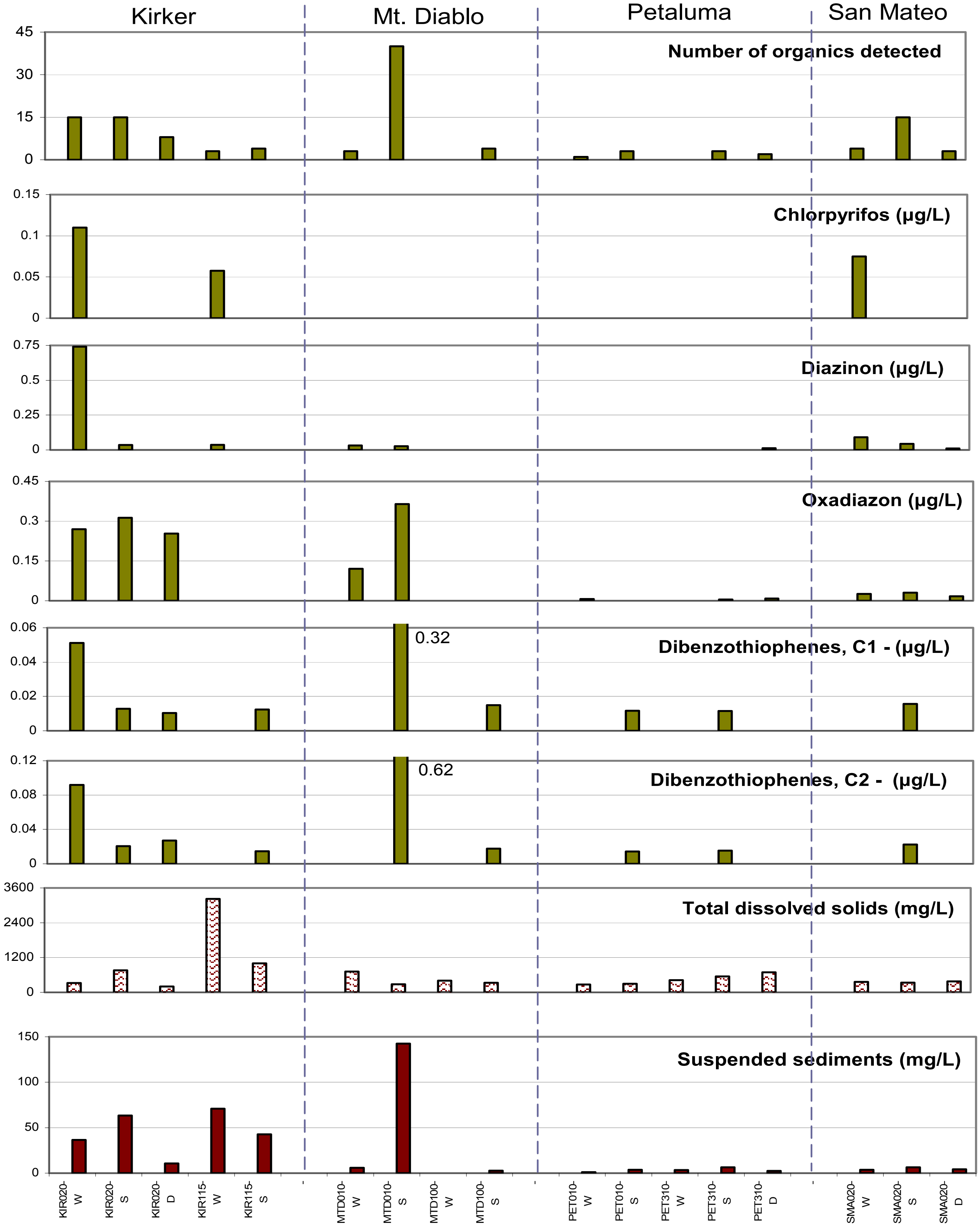

Figure 3.5-3: Concentrations of selected organic compounds in 2003 water samples

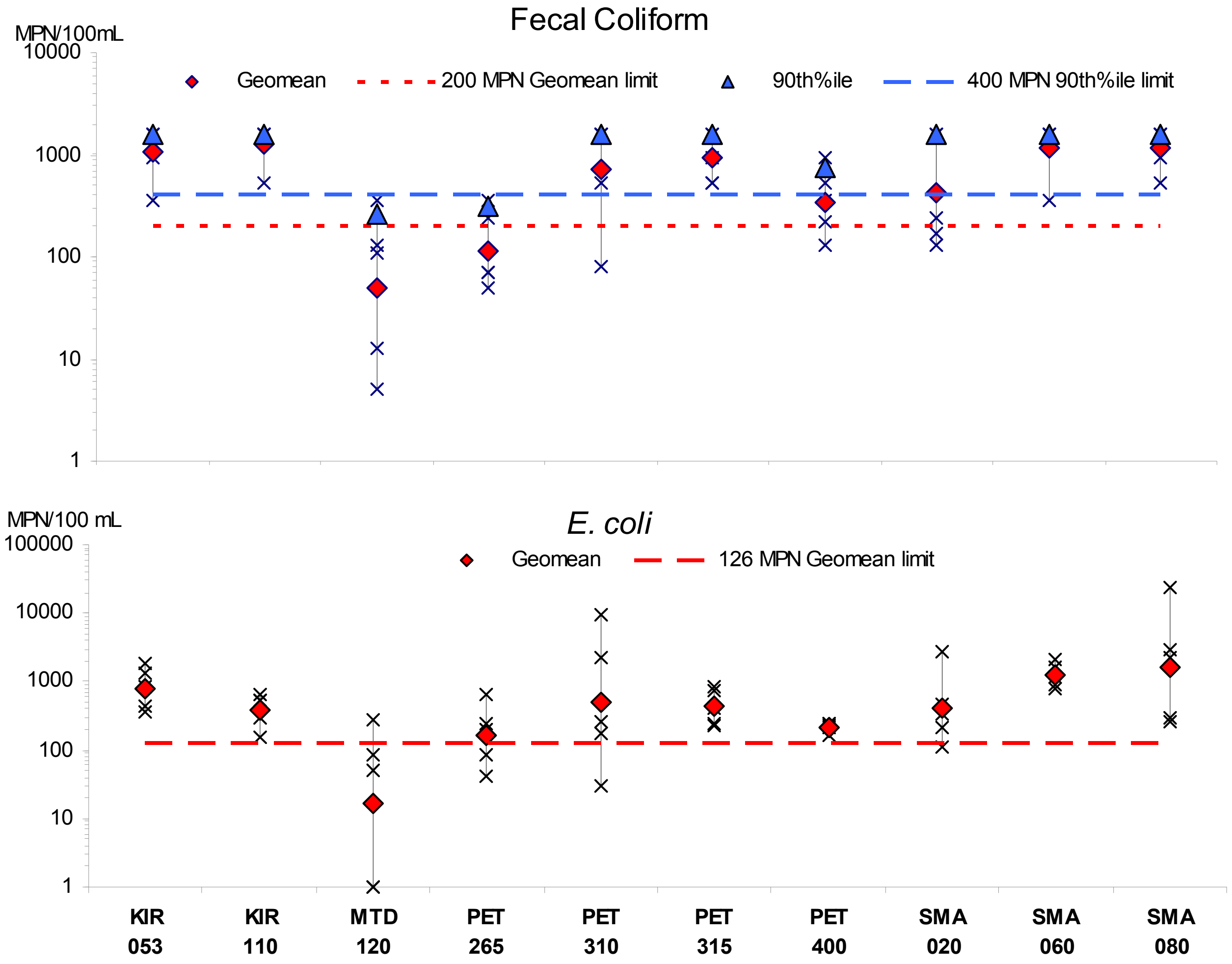

Figure 3.5-4: Fecal Coliform and E. coli summary statistics and exceedances in 2003

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4 Discussion

4.1 Methodology, comparisons to quality benchmarks, and data interpretation

4.1.1 Sampling design and protocol issues

Rain runoff versus base flows

The profound difference between base flows (dry weather) and storm runoff flows (wet weather) water quality has been established in numerous studies in the San Francisco Bay region and in many other semi-arid Ecoregions (e.g., WCC 1996). SWAMP activities are, by definition, directed to ambient conditions, i.e., base flows. One of the water samples collected in 2003 had exceptionally high concentrations of metals and organic compounds, which appeared to be related to high suspended solids (Figures 3.5-2 and 3.5-3). That sample was collected at MTD010 on a rainy day in the spring, at 16:00 (i.e., end of day), probably after the runoff had reached the sampling station. SWAMP ambient monitoring protocols call for sampling during dry weather only, but field crews are instructed to collect the water sample, even when they encounter rain runoff, if the rain has started after the sampling Trip has began. This was probably the case on April 21, 2003, and the crews noted that it had been raining (see Appendix Table D-3f for sequence of Stations visited and rain observations for that day). Thus**,** it was noted that the sample represents different conditions.

4.1.2 Comparisons to Quality Benchmarks

Although SWAMP is not a regulatory program per se, it strives to collect data that can be used to evaluate the conditions in the State's watersheds via comparisons to water quality benchmarks such as water quality objectives (that have regulatory significance) and water quality criteria (that are used as guidelines but do not necessary lead to regulatory action). In the year 3 dataset, U.S.EPA's water quality criteria for nitrate and total phosphorous were exceeded in a large number of samples (Appendix Table D-3a). These nutrient criteria were developed by U.S.EPA to protect waters, designated to support a number of beneficial uses, from eutrophication. The observed exceedances of these criteria indicate a potential for eutrophication.

Water quality benchmarks for temperature and dissolved oxygen were also exceeded, particularly during summer at low flow. The temperature thresholds may be too restrictive for the Ecoregions of these watersheds, and they are not regulatory. They do, however, indicate stressful conditions for aquatic life when coupled with the dissolved oxygen thresholds. Such stressful conditions are expected in watersheds with creeks that have intermittent flow and run dry in the summer, like in the Kirker and Mt. Diablo watersheds and in San Antonio Creek in the Petaluma River watershed. High temperatures and low DO in the spring, however, are unexpected.

As in the case of nutrients, water quality benchmarks for temperature and dissolved oxygen have been developed to specific beneficial uses, and thus may not be relevant to all waterways. In the case of protecting cold water fisheries (for which the beneficial use code is COLD), the question of relevance may be 'tested' in relation to historic distribution of anadromous salmonids such as steelhead. For example, Mt. Diablo Creek was a migration route for steelhead on their way to Mitchell Creek, even though it was dry during summer (Leidy *et al* 2003). On the other hand, many of the monitored watersheds or their tributaries never supported cold water fisheries, and for those the water quality benchmarks developed to protect warm water fisheries (or aquatic communities) may be more relevant.

4.1.3 Data interpretation

Explaining sediment toxicity

Table D-7c shows the toxicity quotients calculated for each sediment sample, and the observed Hyalella toxicity in these samples. There was no visible relationship between the mean PEC quotient and the extent of toxicity. As in the case of water samples - many potential toxicants (e.g., pyrethroids) may have been present in the sediments but were not analyzed for (see Kirker Creek and San Mateo Creek discussions below). In recognition that more of these suspected chemicals should be analyzed, SWAMP has added pyrethroids to the sediment analytical suite for the 4th year of monitoring and beyond. Sediment pyrethroids concentrations can be used to calculate toxicity units (TUs) based on dose-response curves generated from sediments representing a range of organic carbon contents; TUs might be useful in explaining the toxicity. Eventually, correlations with observed toxicity could be established and – if relevant – pyrethroids can also be considered for the PEC quotient calculations.

4.2 Local watershed issues

4.2.1 Kirker Creek: salts and toxic pesticides

Overall, Kirker Creek samples exhibited the highest incidence and severity of water column and sediment toxicity. The water sample collected at KIR020 in January had high concentrations of diazinon and chlorpyrifos (Figure 3.5-3), well above the Ceriodaphnia LC50, and caused total mortality of that test organism. Water samples collected at KIR115 had the most pronounced effect on Selenastrum growth (Appendix table D-6). Both water samples had very high concentrations of salts, as indicated by the high hardness value and the concentrations of chloride, sulfate, and boron (Appendix Table D-3c). These samples also had an appreciable amount of suspended solids (71 mg/ in January and 43 mg/L in April). The source of these salts, which may be disturbed geologic strata (e.g., in mine tailings), or may be related to human activities, needs to be characterized further. These results were not observed in the downstream station (KIR020); this means the high salts are a local effect.

The cause of Kirker Creek sediment toxicity can only be inferred at this time. Of the contaminants measured, the sediment contained concentrations of arsenic, chromium, copper, nickel and zinc that exceeded Threshold Effect Concentrations (TEC). However, it is also possible that this toxicity was caused by pyrethroids, which were not measured in this study. In a previous study, high percentages of Hyalella mortality were seen in bulk sediment toxicity tests with the three Kirker Creek samples collected at different seasons in the vicinity of KIR020 (Amweg et al 2006). Based on pyrethroids concentrations data and toxicity units analysis, the study concluded that there is good evidence for the role of pyrethroids in the observed toxicity.

4.2.2 San Mateo Creek Watershed

San Mateo Creek sediment sample from Gateways Park (SMA020) was also toxic to Hyalella, and - as in the case of Kirker Creek sediment toxicity - the cause can only be inferred for year 3. However, a recent study conducted in the San Mateo Creek watershed as part of a PRISM grant in 2004-2005, included toxicity testing and toxicity identification evaluation with SMA020 sediments. Three of 4 samples collected at the site were significantly toxic to Hyalella. This was coupled with chemical analysis of selected OC, OP, and pyrethroid pesticides. The study concluded that toxicity was caused by organic compounds and that pyrethroids could have contributed to the observed toxicity (Lowe *et al* 2007).

4.3 Regional perspective: Land use and flow regime

Results from year 3 monitoring reinforce the insights gained in previous years that the major factors affecting biological integrity in the San Francisco Bay Region are urbanization and flow regime. Whereas urbanization causes overwhelming changes in benthic assemblages, the effects of flow regime (perennial vs. intermittent) on invertebrates are obvious only in relatively undisturbed watersheds.

As in previous years, there were significant differences in invertebrate assemblages between streams that flow year-round and streams that go dry during the summer. Among minimally disturbed sites, intermittent streams had fewer taxa present, especially beetles and caddisflies, compared to perennial streams. However, the lack of information on streamflow conditions of Bay Area streams limits our ability to understand the temporal and spatial patterns of intermittency and the biological effects.

Benthic macroinvertebrates in urban streams experience a quadruple-threat of potential impacts:

(1) impervious surfaces can cause rapid streamflow response during winter storms that can mobilize the stream bed and dislodge invertebrates and other biota;
(2) toxic pollutants in stormwater or dry season discharges, such as pesticides and metals, can cause sudden mortality;

(3) modified physical habitat caused by culverts or channelization can introduce barriers to organism dispersal, and removal of riparian vegetation can result in high temperatures and low dissolved oxygen levels, and
(4) the long, dry summers characteristic of our Mediterranean climate, coupled with streamflow diversions and groundwater pumping, can reduce streamflow to a trickle or cause the stream to dry out completely.

Together, these impacts result in dramatically poor benthic invertebrate assemblages in urban streams. The majority (69%; 22/32) of all of the sites sampled in 2003 were similar in composition to previous sample sites located in densely urbanized areas (Figure 3.5-1). Benthic invertebrate assemblages in urban streams are dominated by tolerant COBS (Chironomidae, Oligochaeta, *Baetis sp.*, and Simuliidae) taxa, which usually make up >90% all organisms. These sites are also characterized by low taxonomic richness (<14 taxa) and the absence of sensitive EPT taxa. Of the 22 sites sampled in 2003 that fall into this group, most of the sites are located on mainstem streams in urban areas.

Several of the sites that exhibit poor biological integrity, however, are located upstream of urban land use in more rural settings. These sites, such as KIR115, MTD130, PET090, and SMA120, are unusual in that the benthic assemblages reflect heavily degraded conditions more typical of urban areas. Further investigation of these streams should focus on identifying the causes of this poor biological integrity.

Only four of the 32 sites (13%) where benthic macroinvertebrates were sampled represent an intermediate level of disturbance between urban sites and undisturbed conditions (Figure 3.5-1). Three of these sites (PET010, PET070, PET280) drain lands used primarily for cattle grazing. One site (MTD100) primarily drains the open space lands of Mt. Diablo State Park but is located within a suburban residential development in the town of Clayton. Benthic assemblages at these sites are dominated by COBS taxa, but also contain many pollution-sensitive taxa such as ephemerellid mayflies and perlodid stoneflies.

Six of the 32 sites (19%) monitored in 2003 were similar to conditions found in relatively undisturbed sites located in protected open space lands (Figure 3.5-1). Four of the six sites were located on small tributary streams within protected open space in the headwaters of Mt. Diablo Creek (MTD120 and MTD140) and San Mateo Creek (SMA140 and SMA160). Two sites on Adobe Creek (PET130 and PET150) in the Petaluma River watershed were not located in protected open space, yet possess benthic assemblages that are fairly similar to reference conditions for **temporary (intermittent**) streams. The downstream site on Adobe Creek (PET130) is located within a suburban residential development and downstream of a golf course, while the upstream site (PET150) drains some rural residential and grazing lands. The high quality benthic assemblages in Adobe Creek indicate that human land use in the watershed does not have significant effects on the stream ecosystem. Thus, the Adobe Creek watershed could serve as a ‘reference site’ and/or a model system to study how relatively healthy biological communities persist in urban areas.

An urban reference site should represent the best conditions attainable in the urban environment. Given the great extent of urban land use in the Bay Area, it is important to identify the least disturbed urban ‘reference’ sites in order to develop feasible restoration targets for streams in urban areas.

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5 Conclusions and Recommendations

Results of the year 3 SWAMP monitoring addressed in this report, agree with most of the general regional conclusions and recommendations of the Years 1&2 report (SFBRWQCB 2007). The conclusions and recommendations listed below have been compiled to expand on that report and to provide watershed-specific insight for watersheds sampled in year 3.

5.1 Region-wide conclusions and recommendations

At the regional scale, the following conclusions were identified:

- Benthic macroinvertebrate (BMI) assemblages at sites influenced by urban areas, even where the physical habitat conditions are adequate, are generally in very poor condition. This is consistent with the results from the nine watersheds monitored in years 1 and 2. Even benthic assemblages at sampling sites that only drain small amounts of urban land use are often significantly degraded and dominated by a few pollution tolerant taxa. Of the 20 urban sites sampled, only one site, on Adobe Creek in the Petaluma River watershed, contained numerous pollution-sensitive EPT taxa. This stream deserves further study as a potential ‘urban reference site’.

- There was clear evidence of eutrophication at a number of sites which had elevated concentrations of nutrients and chlorophyll a. Consistent with year 1 and 2 watersheds, nutrient concentrations at many stations exceeded U.S.EPA reference criteria (Appendix Table D-3a). Nutrient criteria for the state of California are being developed and may be more appropriate to this region.

- Low dissolved oxygen concentrations were measured during the spring, at a time of year when high stream flow and low temperatures were expected to keep the water well-oxygenated. However, flow at many sites was reduced to a trickle during spring (see Appendix Table D-3e). Dissolved oxygen was frequently lower than the water quality objective and temperatures often exceeded guidelines for salmonids.

Recommendations: Management recommendations and the evaluation of SWAMP monitoring tools described in the report for years 1 and 2 watersheds also apply to this report. The following recommendations expand on that report’s recommendations for future monitoring:

- The relationship and correlations between eutrophication indicators and streamflow should be further investigated in selected locations to identify management measures that will be effective even under conditions of water limitation (low streamflow).

- Although streamflow and velocity measurements were made during many of the water sampling events, additional data on streamflow are needed to better interpret water quality data. It is recommended to invest in operator training and in the field time needed to observe, estimate, and record streamflow at every site visit. Collaboration with other monitoring entities to exchange anecdotal and systematically collected flow information is highly recommended. Volunteers should be recruited and trained to collect qualitative flow information in the region's waterways.

5.2 Watershed-specific conclusions and recommendations

5.2.1 Kirker Creek watershed

Conclusions:

- **Poor conditions in upstream site:** Unlike many watersheds in the San Francisco Bay Area, which have relatively good water quality in upstream segments, Kirker Creek exhibited poor water quality throughout the watershed including the most upstream Station monitored (this was manifested by very high concentrations of salts, that may have inhibited growth of the algae Selanastrum, and by degraded benthic invertebrate assemblages).
- **Severity of Eutrophication**: Exceedences of DO objectives in the winter and spring, coupled with considerable amounts of nutrients and chlorophyll *a,* indicate that eutrophication is more severe in Kirker Creek than in the other year 3 watersheds.
- **High toxicity**: Kirker Creek samples collected during the wet season, which were acutely toxic to Ceriodaphnia, also contained diazinon and chlorpyrifos at concentrations that are known to be toxic to this organism. Selenastrum growth was significantly lower than the control in 4 out of 5 samples and in every season sampled. Two of these samples contained high concentrations of salts, including sulfate and boron that probably affected growth. There was 100% mortality to Hyalella exposed to sediment from the most downstream site (KIR020); this toxicity may have been due to pyrethroids. Another study (Amweg et al 2006) found toxicity to Hyalella in several samples from Kirker Creek that was attributed to pyrethroids. These findings indicate that toxic conditions are more prevalent in Kirker Creek than in the other year 3 watersheds.

Recommendations:

- Potential pollution sources in the Black Diamond Mines Regional Park, at the headwaters of Kirker Creek, should be investigated further.
- Future chemical analysis of sediments should include testing for pyrethroids.

5.2.2 Mt. Diablo Creek watershed

Conclusions:

- **Effect of poor habitat quality**: As expected, benthic invertebrate assemblages were in poor condition except in tributaries draining Mt. Diablo State Park (Mitchell Creek – MTD100 and MTD120 - and Donner Creek – MTD140), which drain open space areas. However, the poor condition of benthic assemblages in Peacock Creek (MTD130), observed despite the low intensity land use in this tributary, was unexpected. This site has poor habitat quality.
- **Extremely variable conditions**: Dissolved oxygen at the Port Chicago Highway site (MTD010) in spring and winter was exceptionally low at times, and there were high fluctuations of DO in winter, suggesting a highly eutrophied and unstable environment.

Recommendations:

- The relationship between benthic assemblages and physical habitat value should be further elucidated, separately from the effect of poor water and sediment quality.
- The temporal variability in water quality at the bottom of Mt. Diablo watershed should be further characterized.

5.2.3 Petaluma River

Conclusions:

- **Urban drainage with healthy BMI**: While benthic invertebrate assemblages in the main stem Petaluma and in the Washington Creek tributary (PET220) were in poor condition, Adobe Creek tributary (PET130 and PET150) had much healthier benthic communities. This tributary could serve as a model of how healthy benthic communities can exist in urban areas.

Recommendations:

- The possibility of using Adobe Creek as an ‘urban reference site’ should be further investigated.

5.2.4 San Mateo Creek

Conclusions:

- **Headwater reference sites**: Based on benthic macroinvertebrate results, upper watershed sites (SMA160 and SMA180) which drain SFPUC watershed lands are representative of perennial and intermittent reference conditions, respectively.
- **Reservoir release:** The degraded benthic invertebrate assemblage in San Mateo Creek downstream of Crystal Springs Dam, but upstream of urban land uses, suggests that poor water quality conditions may exist in water released from the dam.

- **Sediment toxicity:** Gateway Park (SMA020), close to the mouth of San Mateo Creek, had sediments that caused mortality (18% survival) in a toxicity test and had the highest probable effects concentration mean quotient of 0.32. Pyrethroids were not measured at this site, but may have contributed to toxicity.

Recommendations:

- The water quality conditions and BMI metric scores in headwater sites located on perennial flow segments should be further compared to conditions and scores at intermittent flow sites.
- Water quality conditions in perennial flow sites upstream of the reservoir should be monitored in summer as well, and compared to water released from the reservoir.
- Gateway Park can be a good site to use for further elucidation of the relationship between sediment contamination, PEC quotient, and toxic effects. Such studies will expand on the toxicity identification evaluations done recently via a PRISM grant (Lowe *et al* 2007) which concluded that sediment toxicity was caused by an organic compound.

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APPENDICES

TO

WATER QUALITY MONITORING AND BIOASSESSMENT IN FOUR SAN FRANCISCO BAY REGION WATERSHEDS IN 2003-2004

KIRKER CREEK
MT. DIABLO CREEK
PETALUMA RIVER
SAN MATEO CREEK

Final Report
June 15, 2007

Table of Contents

Table A-1: Summary of all monitoring activities performed in 2003-04 watersheds

Station	StationName	BMI analyses	Physical Habitat Assessment	Continuous monitoring deployment Events	Observations and Field Measurements	Conventional WQ characteristics (including Nutrients)	Water chemistry (Metals, organics) and toxicity	Sediment chemistry and toxicity	Tissue chemistry	Coliform counts
KIR020	Floodway			2	3	3	3	1	1	
KIR053	Los Medanos Lake									5
KIR090	East Leland	1	1							
KIR110	Buchanan Park	1	1	3						5
KIR115	Kirker Creek Apartments	1	1	1	2	2	2			
MTD010	Port Chicago Highway	1	1	3	2	2	2	1	1	
MTD020	Diablo Creek Golf Course	1	1							
MTD030	Bailey	1	1							
MTD050	Lydia Lane Park	1	1	1	3	3				
MTD055	N. Mitchell Canyon 1			2						
MTD056	N. Mitchell Canyon 2			1						
MTD060	Diablo below confluence	1	1		3	3				
MTD100	Mitchell on Oak St	1	1		2	2	2			
MTD115	Mitchell at State Park			2						
MTD120	Mitchell on Fire Rd	1	1	1	3	3				5
MTD130	Peacock Creek	1	1							
MTD140	Donnor Creek	1	1		3	3				
PET010	San Antonio Road bridge	1	1	2	2	2	2			
PET060	D St	1	1							
PET070	Chileno Valley Rd.	1	1							
PET090	Ellis Creek @ S. Ely Rd.	1	1							
PET120	Adobe at Sartori Drive			2						
PET130	Fairway Meadows	1	1	1	3	3				
PET150	Above Petaluma Adobe SHP	1	1		3	3				
PET220	Hands of Jesus	1	1							
PET265	Lynch pedestrian path	1	1	4	3	3				5
PET280	Lynch at Adobe Road	1	1		3	3				
PET310	Outlets	1	1	4	3	3	3	1	1	5
PET315	Corona Rd Bridge									5
PET350	Rainsville KOA	1	1							
PET360	Liberty/ Marin/ Wiggins	1	1							
PET400	Penngrove Park	1	1	3	3	3				5
SMA020	Gateway Park	1	1	4	3	3	3	1	1	5
SMA060	Arroyo Court Park	1	1	4						5
SMA080	Sierra Drive	1	1							5
SMA110	Polhemus	1	1	4						
SMA120	Above Polhemus	1	1	3						
SMA160	Above Mud Dam	1	1		3	3				
SMA180	Buckeye @ Old Cañada Rd	1	1	1	3	3				
	Number of sites monitored	32	32	20	18	18	7	4	4	10
	Total events for year 3	**32**	**32**	**48**	**50**	**50**	**17**	**4**	**4**	**50**
	Number planned (and % of Plan)	38 (84%)	38 (84%)		50 (100%)	50 (100%)	17 (100%)	4 (100%)	4 (100%)	50 (100%)

Numbers in the table indicate number of Samples, Sonde Event files, and/or Station Visits

Table B-1: Inventory of BMI Station Visits in 2003

Station	Station Name	Date Sampled	BMI	PHAB
KIR090	East Leland	4/9/2003	X	X
KIR110	Buchanan Park	4/9/2003	X	X
KIR115	Kirker Creek Apts	4/9/2003	X	X
MTD010	Port Chicago Hwy	4/2/2003	X	X
MTD020	Diablo Creek Golf Course	4/2/2003	X	X
MTD030	Bailey	4/2/2003	X	X
MTD050	Lydia Lane Park	4/3/2003	X	X
MTD060	Diablo below confluence	4/3/2003	X	X
MTD100	Mitchell on Oak St	4/3/2003	X	X
MTD120	Mitchell on Fire Road	4/3/2003	X	X
MTD130	Peacock Creek	4/3/2003	X	X
MTD140	Donnor Creek	4/3/2003	X	X
PET010	San Antonio Rd. Bridge	4/1/2003	X	X
PET060	D St	4/1/2003	X	X
PET070	Chileno Valley Rd.	4/2/2003	X	X
PET090	Ellis Creek @ S. Ely Rd.	4/3/2003	X	X
PET130	Fairway Meadows	4/3/2003	X	X
PET150	Above Petaluma Adobe SHP	4/3/2003	X	X
PET220	Hands of Jesus	4/2/2003	X	X
PET265	Lynch Ped Path	4/2/2003	X	X
PET280	Lynch@Adobe Rd.	4/2/2003	X	X
PET310	Outlets	4/3/2003	X	X
PET350	Rainsville KOA	4/3/2003	X	X
PET360	Liberty/ Marin/ Wiggins	4/2/2003	X	X
PET400	Penngrove Park	4/3/2003	X	X
SMA020	Gateway Park	4/1/2003	X	X
SMA060	Arroyo Court Park	4/1/2003	X	X
SMA080	Sierra Drive	4/1/2003	X	X
SMA110	Polhemus	4/1/2003	X	X
SMA120	Above Polhemus	4/1/2003	X	X
SMA160	Above Mud Dam	4/2/2003	X	X
SMA180	Buckeye @ Old Cañada Rd	4/2/2003	X	X

BMI = Benthic Macroinvertebrates
PHAB = Physical Habitat

Tables B-2: Summary of BMI metrics in the 2003 watersheds

Table B-2a: BMI metrics in Kirker Creek

	KIR090	KIR110	KIR115	Metric Definitions
Coleoptera Taxa	0	0	2	Number of Coleoptera (beetle) taxa
Diptera Taxa	3	5	8	Number of Diptera (true fly) taxa
Ephemeroptera Taxa	1	0	0	Number of Epehemeroptera (mayfly) taxa
Hemiptera Taxa	0	0	0	Number of Hemiptera (true bug) taxa
Lepidoptera Taxa	0	0	0	Number of Lepidoptera (moth) taxa
Megaloptera Taxa	0	0	0	Number of Megaloptera (hellgrammite) taxa
Odonata Taxa	0	0	1	Number of Odonata (dragonfly and damselfly) taxa
Plecoptera Taxa	0	1	0	Number of Plecoptera (stonefly) taxa
Trichoptera Taxa	0	0	1	Number of Trichoptera (caddisfly) taxa
Non-Insect Taxa	7	4	5	Number of non-insect taxa
Taxa Richness	11	10	17	Total number of invertebrate taxa
EPT Taxa	1	1	1	Number of Epehemeroptera, Plecoptera, and Trichoptera taxa
Abundance (#/sample)	338	2433	45538	Estimated number of organisms collected in entire sample
% EPT	0.3	0.1	0.1	Percent composition of Ephemeroptera, Plecoptera, and Trichoptera
% Sensitive EPT	0.0	0.1	0.1	Percent composition of EPT with tolerance values <3
% Chironomidae	13.3	52.1	50.8	Percent composition of Chironimidae (midges)
% Coleoptera	0.0	0.0	0.2	Percent composition of Coleoptera (beetles)
% Oligochaeta	62.1	35.2	18.1	Percent composition of Oligochaeta (worms)
% Non-insect	80.8	46.3	39.5	Percent composition of non-insect organisms
% Baetis	0.3	0.0	0.0	Percent composition of Baetis
% Simulium	0.0	1.0	6.9	Percent composition of Simulium (black flies)
% COBS	75.7	88.3	75.8	Percent composition of Chironimidae, Oligochaeta, Baetis, and Simulium
% Intolerant	0.3	0.6	0.1	Percent of organisms with tolerance values <3
% Tolerant	23.7	10.9	21.6	Percent of organisms with tolerance values >7
Tolerance Value	5.9	5.8	6.2	Average tolerance value of all organisms
% Predator	4.7	0.2	2.1	Percent of organisms that feed on other organisms
% Collector-filterer	11.6	1.0	8.4	Percent of organisms that filter fine particulate organic matter
%Collector-gatherer	81.6	98.4	85.5	Percent of organisms that gather fine particulate organic matter
% Scraper	2.1	0.2	3.8	Percent of organisms that graze on periphyton
% Shredder	0.0	0.1	0.0	Percent of organisms that shred coarse particulate organic matter
% Other	0.0	0.0	0.3	Percent of organisms with other types of feeding

Table B-2b: BMI metrics in Mt. Diablo Creek

	MTD010	MTD020	MTD030	MTD050	MTD060	MTD100	MTD120	MTD130	MTD140
Coleoptera Taxa	1	1	2	0	0	1	2	0	1
Diptera Taxa	2	3	6	3	3	2	9	6	9
Ephemeroptera Taxa	2	2	1	1	1	3	7	1	5
Hemiptera Taxa	0	0	0	1	0	0	0	0	0
Lepidoptera Taxa	0	0	0	0	0	0	0	0	0
Megaloptera Taxa	0	0	0	0	0	1	1	0	1
Odonata Taxa	0	0	0	0	0	0	0	1	0
Plecoptera Taxa	0	0	0	0	0	3	5	0	3
Trichoptera Taxa	0	0	0	0	0	2	5	2	4
Non-Insect Taxa	3	5	5	8	9	6	5	6	5
Taxa Richness	8	11	14	13	13	18	34	16	28
EPT Taxa	2	2	1	1	1	8	17	3	12
Abundance (#/sample)	10200	15637	311	15859	6208	7417	2336	12433	2740
% EPT	1.7	18.7	9.3	23.4	23.4	57.8	72.5	1.9	59.7
% Sensitive EPT	0.0	0.0	0.0	0.0	0.0	6.4	25.3	0.3	27.1
% Chironomidae	44.0	35.6	58.5	16.8	21.9	26.5	23.4	23.4	35.0
% Coleoptera	0.1	0.1	1.3	0.0	0.0	0.1	0.2	0.0	0.1
% Oligochaeta	52.0	12.9	20.3	31.1	37.9	5.3	0.5	9.3	0.3
% Non-insect	54.1	13.6	24.4	35.0	44.3	12.6	1.6	34.3	2.8
% Baetis	1.6	14.7	9.3	23.4	23.4	51.3	44.9	1.4	32.1
% Simulium	0.1	32.0	4.2	24.6	10.3	2.8	0.0	36.3	0.8
% COBS	97.7	95.1	92.3	96.0	93.5	86.0	68.8	70.4	68.2
% Intolerant	0.1	0.1	1.3	0.3	1.3	6.5	26.3	0.0	27.6
% Tolerant	2.1	0.4	4.5	3.2	4.1	7.1	0.6	24.9	1.2
Tolerance Value	5.5	5.6	5.7	5.5	5.4	5.3	4.1	6.4	4.5
% Predator	0.1	0.4	0.6	0.6	0.2	5.4	8.5	4.1	24.7
% Collector-filterer	0.1	32.0	4.2	24.7	10.5	2.9	0.0	37.5	0.8
%Collector-gatherer	97.7	67.1	89.7	71.5	84.3	83.5	82.1	53.1	72.8
% Scraper	2.1	0.4	2.9	3.2	4.9	6.4	2.4	4.8	1.0
% Shredder	0.0	0.0	1.3	0.0	0.1	1.7	5.3	0.3	0.6
% Other	0.0	0.0	1.3	0.0	0.0	0.1	1.6	0.2	0.1

Table B-2c: BMI metrics in the Petaluma River watershed

	PET010	PET060	PET070	PET090	PET130	PET150	PET220	PET265	PET280	PET310	PET350	PET360	PET400
Coleoptera Taxa	1	1	3	2	2	5	0	0	2	0	0	1	0
Diptera Taxa	4	3	4	5	4	5	2	5	6	2	3	2	3
Ephemeroptera Taxa	4	2	3	2	9	8	0	0	7	2	2	1	2
Hemiptera Taxa	1	0	0	0	0	0	0	0	0	0	0	1	0
Lepidoptera Taxa	0	0	0	0	0	0	0	0	0	0	0	0	0
Megaloptera Taxa	0	0	0	0	0	0	0	0	0	0	0	0	0
Odonata Taxa	0	0	0	0	1	1	0	0	0	0	0	0	0
Plecoptera Taxa	2	2	3	1	3	3	0	0	1	0	0	0	0
Trichoptera Taxa	0	1	2	0	4	5	0	1	1	0	0	0	0
Non-Insect Taxa	5	6	7	4	7	8	3	2	3	6	8	5	7
Taxa Richness	17	15	22	14	30	35	5	8	20	10	13	10	12
EPT Taxa	6	5	8	3	16	16	0	1	9	2	2	1	2
Abundance (#/sample)	12470	35745	18622	37093	8922	9925	54724	27024	32307	9233	15900	23508	31539
% EPT	52.3	12.7	23.5	12.9	30.4	28.9	0.0	0.1	14.4	1.1	0.3	0.2	8.9
% Sensitive EPT	8.3	1.1	4.6	0.3	15.1	6.7	0.0	0.1	2.5	0.9	0.1	0.0	2.2
% Chironomidae	9.7	25.7	41.4	16.7	64.0	46.4	10.6	9.5	15.5	28.6	18.1	30.7	41.8
% Coleoptera	0.2	0.1	0.7	0.2	0.9	1.7	0.0	0.0	0.5	0.0	0.0	0.1	0.0
% Oligochaeta	25.5	29.2	19.5	51.8	0.2	14.3	80.7	89.3	67.1	67.3	59.7	43.0	16.6
% Non-insect	26.9	32.0	21.8	52.7	1.5	17.2	88.3	89.5	67.5	70.0	73.1	54.9	17.3
% Baetis	44.0	11.4	18.4	12.5	14.4	21.1	0.0	0.0	11.2	0.2	0.2	0.2	6.7
% Simulium	8.2	29.5	10.2	17.1	0.5	4.5	1.1	0.1	1.2	0.2	8.1	13.9	31.5
% COBS	87.4	95.8	89.5	98.2	79.1	86.3	92.4	98.9	95.0	96.3	86.2	87.8	96.7
% Intolerant	8.3	1.1	4.7	0.3	14.3	5.8	0.0	0.1	2.5	3.1	0.5	0.0	2.2
% Tolerant	1.3	2.6	1.6	1.0	2.8	3.2	7.6	0.2	0.7	0.6	11.8	11.5	0.4
Tolerance Value	5.0	5.6	5.4	5.4	5.1	5.3	5.3	5.1	5.1	5.2	5.6	5.8	5.7
% Predator	4.9	1.3	6.6	0.3	4.1	3.5	0.0	0.6	1.2	0.1	0.0	0.3	0.4
% Collector-filterer	8.2	29.5	10.3	17.1	1.5	5.2	1.1	0.1	1.2	0.6	8.5	13.9	31.7
%Collector-gatherer	86.7	68.8	81.1	82.1	84.8	86.6	91.4	99.2	96.4	99.3	84.1	78.3	67.6
% Scraper	0.2	0.2	1.9	0.2	1.6	2.7	7.5	0.0	0.1	0.0	7.5	7.4	0.2
% Shredder	0.0	0.0	0.1	0.0	8.0	1.8	0.0	0.0	1.2	0.0	0.0	0.0	0.0
% Other	0.0	0.2	0.0	0.2	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table B-2d: BMI metrics in San Mateo Creek watershed

	SMA020	SMA060	SMA080	SMA110	SMA120	SMA160	SMA180
Coleoptera Taxa	0	0	0	0	0	8	3
Diptera Taxa	2	3	4	3	7	8	8
Ephemeroptera Taxa	1	1	1	1	1	8	5
Hemiptera Taxa	0	0	0	0	0	1	0
Lepidoptera Taxa	0	0	0	0	0	0	0
Megaloptera Taxa	0	0	0	0	0	0	1
Odonata Taxa	0	0	1	1	0	0	0
Plecoptera Taxa	0	0	0	0	0	7	5
Trichoptera Taxa	1	0	1	0	1	4	5
Non-Insect Taxa	5	7	6	10	2	12	1
Taxa Richness	9	11	13	15	11	48	28
EPT Taxa	2	1	2	1	2	19	15
Abundance (#/sample)	6197	4951	3717	2748	6489	5546	2825
% EPT	13.8	30.4	39.3	20.9	37.5	62.0	67.5
% Sensitive EPT	0.0	0.0	0.0	0.0	0.0	40.0	32.7
% Chironomidae	54.9	40.1	32.2	27.7	26.1	7.9	20.8
% Coleoptera	0.0	0.0	0.0	0.0	0.0	8.1	0.5
% Oligochaeta	26.7	9.0	10.9	6.4	16.2	3.2	5.5
% Non-insect	30.6	16.6	13.9	28.7	16.3	13.5	5.5
% Baetis	13.4	30.4	38.7	20.9	37.4	13.0	24.5
% Simulium	0.8	12.9	14.3	22.2	19.5	7.6	2.4
% COBS	95.8	92.4	96.1	77.2	99.3	31.6	53.2
% Intolerant	0.1	0.2	0.1	0.0	0.0	40.4	31.8
% Tolerant	0.7	1.1	1.3	11.9	0.2	9.3	0.0
Tolerance Value	5.6	5.6	5.5	6.0	5.5	3.8	3.8
% Predator	0.0	0.3	1.4	1.6	0.2	25.0	20.0
% Collector-filterer	0.8	13.4	14.3	22.2	19.6	13.8	4.2
%Collector-gatherer	95.2	79.5	81.9	55.0	79.9	41.3	69.5
% Scraper	3.7	6.6	1.7	21.1	0.1	14.4	1.4
% Shredder	0.0	0.0	0.0	0.0	0.1	5.1	3.5
% Other	0.3	0.1	0.7	0.0	0.1	0.4	1.4

Table B-3: Summary of physical habitat data in the 2003 watersheds

Station	Date	Physical Habitat Categories (from CSBP)													
		Epifaunal Substrate	Embedd-edness	Velocity/ Depth	Sed. Dep.	Channel Flow	Channel Alteration	Riffle Freq.	L-Bank Stability	R-Bank Stability	Bank Veg-L	Bank Veg-R	Riparian Zone-L	Riparian Zone-R	**Total Score**
KIR090	4/9/2003	5	0	10	0	16	10	2	6	6	7	8	7	7	**84**
KIR110	4/9/2003	10	12	13	10	14	15	15	6	6	5	5	7	5	**123**
KIR115	4/9/2003	8	2	10	0	16	14	10	7	4	4	4	5	5	**89**
MTD010	4/2/2003	8	2	14	2	20	18	10	4	5	6	6	5	4	**104**
MTD020	4/2/2003	10	12	12	10	19	17	12	2	2	5	5	2	2	**110**
MTD030	4/2/2003	14	15	10	16	16	10	1	8	4	7	7	2	2	**112**
MTD050	4/3/2003	16	15	16	12	20	17	16	7	6	7	8	4	7	**151**
MTD060	4/3/2003	16	15	16	14	20	20	17	8	7	7	7	4	8	**159**
MTD100	4/3/2003	16	15	15	16	20	20	18	4	6	5	7	6	6	**154**
MTD120	4/3/2003	17	17	16	15	20	20	18	8	8	8	8	9	10	**174**
MTD130	4/3/2003	4	2	10	2	20	16	4	4	4	5	5	8	10	**94**
MTD140	4/3/2003	15	14	14	16	20	20	17	8	7	8	8	9	10	**166**
PET010	4/1/2003	6	4	12	6	18	18	5	6	5	7	6	5	5	**103**
PET060	4/1/2003	4	4	12	3	12	15	8	2	3	3	4	2	2	**74**
PET070	4/2/2003	16	10	15	13	19	17	8	8	7	8	7	7	5	**140**
PET090	4/3/2003	5	4	12	6	17	12	12	2	2	3	1	1	1	**78**
PET130	4/3/2003	16	14	15	17	18	15	15	7	7	7	5	5	3	**144**
PET150	4/3/2003	12	6	12	10	16	16	17	2	2	2	1	4	4	**104**
PET220	4/2/2003	3	1	3	4	3	7	3	9	9	10	10	4	2	**68**
PET265	4/2/2003	15	6	11	16	17	18	15	4	8	4	6	6	3	**129**
PET280	4/2/2003	10	9	12	6	14	16	18	4	5	2	4	1	1	**102**
PET310	4/3/2003	3	1	11	2	15	8	1	3	6	4	5	1	1	**61**
PET350	4/3/2003	2	1	11	2	17	12	5	2	3	2	3	2	2	**64**
PET360	4/2/2003	2	1	7	3	8	16	12	8	5	2	2	1	1	**68**
PET400	4/3/2003	8	8	12	6	10	5	7	6	10	7	1	2	0	**82**
SMA020	4/1/2003	10	6	10	8	20	10	10	9	6	5	6	1	1	**102**
SMA060	4/1/2003	14	16	15	7	20	14	15	8	6	5	7	4	6	**137**
SMA080	4/1/2003	16	15	16	12	20	17	17	5	7	8	8	7	7	**155**
SMA110	4/1/2003	15	13	15	14	20	20	16	7	7	7	9	9	10	**162**
SMA120	4/1/2003	13	12	13	14	20	16	16	7	7	7	7	10	10	**152**
SMA160	4/2/2003	17	12	16	10	20	20	17	8	9	9	9	10	10	**167**
SMA180	4/2/2003	16	15	15	12	20	20	16	7	5	7	5	10	10	**158**

Table B-3 (cont.)

Station	Date	Canopy Cover (%)	Substrate Complex. (0-20)	Riffle Embedd. (0-20)	Substrate Size Distribution (%)					Riffle Gradient (%)	Specific Cond. (uS)	Disolved Oxygen (mg/L)	Average Velocity (ft./sec.)
					Fines	*Gravel*	*Cobble*	*Boulder*	*Bedrock*				
KIR090	4/9/2003	100	2	0	100	0	0	0	0	0	458	2.5	0.02
KIR110	4/9/2003	100	10	9	47	42	5	7	0	4	490	7.8	0.25
KIR115	4/9/2003	100	11	2	87	13	0	0	0	5	2850	8.3	0.21
MTD010	4/2/2003	80	5	4	77	23	0	0	0	2	1022	6.2	0.28
MTD020	4/2/2003	67	10	16	20	80	0	0	0	4	915	7.7	0.34
MTD030	4/2/2003	71	14	18	10	40	10	0	0	1	974	8.59	0.16
MTD050	4/3/2003	49	15	16	27	37	23	13	0	4	867	9.9	0.31
MTD060	4/3/2003	100	16	17	23	37	33	7	0	3	852	9.18	0.30
MTD100	4/3/2003	100	16	15	20	33	33	7	0	4	516	7.3	0.28
MTD120	4/3/2003	77	16	16	10	30	30	10	0	4	409	7.7	0.22
MTD130	4/3/2003	22	5	2	87	0	0	13	0	8	2266	8.8	0.22
MTD140	4/3/2003	67	15	14	30	30	30	10	0	5	398	9.2	0.22
PET010	4/1/2003	39	11	7	57	40	3	0	0	2	336	9.1	0.43
PET060	4/1/2003	36	5	7	67	30	3	0	0	3	502	11	0.54
PET070	4/2/2003	94	16	10	35	33	30	2	0	3	400	8.9	0.31
PET090	4/3/2003	37	6	7	62	37	2	0	0	1	850	8.4	0.28
PET130	4/3/2003	96	16	16	20	60	20	0	0	4	321	9.2	0.36
PET150	4/3/2003	11	13	8	20	63	17	0	0	2	296	11.8	0.33
PET220	4/2/2003	64	3	1	87	13	0	0	0	0	563	6.5	0.21
PET265	4/2/2003	97	7	5	18	77	5	0	0	2	360	10.2	0.21
PET280	4/2/2003	15	10	9	23	48	28	0	0	2	409	11.5	0.26
PET310	4/3/2003	82	2	2	67	30	3	0	0	0	956	6.61	0.27
PET350	4/3/2003	2	1	0	100	0	0	0	0	1	885	12.2	0.15
PET360	4/2/2003	0	1	1	100	0	0	0	0	0	938	13.3	0.38
PET400	4/3/2003	57	4	11	68	30	2	0	0	1	548	9.9	0.40
SMA020	4/1/2003	20	10	11	50	10	27	13	0	3	591	9.5	0.15
SMA060	4/1/2003	100	11	17	60	30	10	0	0	3	616	7.8	0.35
SMA080	4/1/2003	98	16	17	13	40	37	10	0	4	612	8.2	0.23
SMA110	4/1/2003	100	13	17	20	50	30	0	0	7	285	7.8	0.40
SMA120	4/1/2003	16	14	15	23	33	30	13	0	5	1003	8.98	0.17
SMA160	4/2/2003	100	10	17	20	80	0	0	0	3	236	10	0.38
SMA180	4/2/2003	94	17	17	13	40	40	7	0	5	788	10.5	0.28

Note: these data represent the average values of measurements made at each of three transects along the sampling reach

Table C-1: Inventory and deployment periods of continuous monitoring events conducted in 2003-04

Station	*Station Name*	*# of files*	*Spring*	*Summer*	*Fall*	*Winter*
KIR020	Floodway	2	3/19/03 - 3/27/03			2/20/04 - 2/27/04
KIR110	Buchanan Park	3	3/19/03 - 4/2/03	7/10/03 - 7/11/03		2/20/04 - 2/27/04
KIR115	Kirker Creek Apartments	1	3/18/03 - 4/1/03			
MTD010	Port Chicago Highway	3	3/19/03 - 4/2/03	7/10/03 - 7/17/03		2/20/04 - 2/27/04
MTD050	Lydia Lane Park	1	3/19/03 - 3/25/03			
MTD055	N. Mitchell Canyon Rd. 1	2		7/10/03 - 7/17/03		2/20/04 - 2/27/04
MTD055	N. Mitchell Canyon Rd. 2	1		7/10/03 - 7/17/03		
MTD115	Mitchell at State Park	2		7/10/03 - 7/17/03		2/20/04 - 2/27/04
MTD120	Mitchell on Fire Rd	1	3/19/03 - 4/2/03			
PET010	San Antonio Road bridge	2	4/10/03 - 4/24/03			1/27/04 - 2/6/04
PET120	Adobe at Sartori Drive	2		7/22/03 - 7/30/03		1/27/04 - 2/6/04
PET130	Fairway Meadows	1	4/10/03 - 4/24/03			
PET265	Lynch pedestrian path	4	4/10/03 - 4/24/03	7/22/03 - 7/30/03	9/15/03 - 9/24/03	1/27/04 - 2/6/04
PET310	Outlets	4	4/9/03 - 4/23/03	7/22/03 - 7/30/03	9/15/03 - 9/24/03	1/27/04 - 2/6/04
PET400	Penngrove Park	3	4/10/03 - 4/24/03	7/22/03 - 7/30/03		1/27/04 - 2/6/04
SMA020	Gateway Park	4	4/28/03 - 5/12/03	8/6/03 - 8/25/03	10/20/03 - 10/31/03	2/7/04 - 2/13/04
SMA060	Arroyo Court Park	4	4/27/03 - 5/11/03	8/7/03 - 8/25/03	10/20/03 - 10/31/03	2/7/04 - 2/13/04
SMA110	Polhemus	4	4/28/03 - 5/12/03	8/7/03 - 8/25/03	10/20/03 - 10/31/03	2/7/04 - 2/13/04
SMA120	Above Polhemus	3	4/28/03 - 5/12/03	8/7/03 - 8/20/03		2/7/04 - 2/13/04
SMA180	Buckeye @ Old Cañada Rd	1	4/28/03 - 5/12/03			

Table C-2: Summary statistics of continuous monitoring events conducted in 2003-04

Table C-2a: Summary of continuous field monitoring results and quality benchmark exceedances in Kirker Creek

		Spring			Summer	Winter		Evaluation thresholds: for details, see key on the right.
	Special Conditions		battery failure					
	Station	**KIR020**	**KIR110**	**KIR115**	**KIR110**	**KIR020**	**KIR110**	
	Start Date	3/19/03	3/19/03	3/18/03	7/10/03	2/20/04	2/20/04	
	End Date	3/27/03	4/2/03	4/1/03	7/11/03	2/27/04	2/27/04	
	# of Data Points	812	1333	1338	86	661	656	
Temp	Min.	10.20	11.11	10.98	21.18	9.44	9.18	
°C	0.25	12.57	13.27	13.72	21.64	11.16	10.51	
	Median	14.12	14.26	14.98	22.18	12.07	11.26	
	0.75	15.89	15.35	16.69	22.79	13.25	11.94	
	Max.	20.84	18.49	19.83	24.07	16.79	13.43	>22
	MWMT	18.57	16.73	18.32	NA	14.53	12.71	>17
	MWAT	14.60	15.05	15.55	NA	12.47	11.42	>15
	QA Qualifier	valid, 5	valid, 5	valid, 5	valid, 5	valid, 5	valid, 5	
DO	Min.	**1.39**	0.12	**5.19**	**1.35**	**4.41**	7.96	<7
mg/L	0.25	**4.11**	4.46	7.25	**3.28**	**6.53**	9.40	
	Median	7.68	6.53	7.74	**5.31**	8.20	9.96	
	0.75	11.82	8.18	8.64	**5.71**	9.73	10.46	
	Max.	20.44	9.76	10.85	**6.25**	11.56	11.50	
	7DMin	2.44	2.19	2.44	NA	5.82	8.78	<8
	MQO:± 0.5mg/L	n/a		n/a	n/a	0.13	0.19	<11
	QA Qualifier	valid, 1, 2	rejected, 5	valid, 1, 2	valid, 1	valid	valid	
DO	Min.	13.00	1.20	54.80	15.60	40.00	72.60	
%	0.25	38.65	43.00	71.90	37.70	60.80	85.60	
	Median	**74.95**	64.20	**76.20**	**62.35**	**77.10**	92.80	<80
	0.75	117.75	79.70	87.70	64.95	90.20	96.03	
	Max.	211.20	101.10	114.20	70.40	119.20	100.50	>120
	MQO: ± 5%	2.00		1.60	2.20	n/a	n/a	
	QA Qualifier	valid, 2	rejected, 5	valid, 2	valid	valid, 1	valid, 1	
	Min.	6.78	7.25	7.23	6.97	6.71	7.54	<6.5
pH	0.25	6.91	7.49	7.34	7.09	7.00	7.73	
	Median	7.00	7.77	7.81	7.27	7.14	7.77	
	0.75	7.14	7.92	7.90	7.30	7.44	7.82	
	Max.	7.52	8.32	8.10	7.32	7.94	8.16	>8.5
	Δ	0.74	1.07	0.87	0.35	1.23	0.62	>1.0
	MQO: ± 0.5	0.10		0.03	0.07	0.13	0.13	
	QA Qualifier	valid, 2	rejected, 5	valid, 2	valid	valid	valid	
	Min.	43	352	114	348	35	251	
SC	0.25	694	660	3055	354	325	826	
µS/cm	Median	965	775	3138	366	534	1531	>500
	0.75	1070	2678	3242	387	572	1795	>1000
	Max.	1238	3106	4143	390	718	2303	>2000
	MQO:± 5.0%	0.1		0.1	0.40	9.20	6.50	
	QA Qualifier	valid, 2	rejected, 5	valid, 2	valid	rejected	rejected	

QA Qualifiers code: 1 = Accuracy gleaned from percent saturation check; 2 = post-deployment accuracy check done at >24 h, but accuracy met MQO;
5 = Calibration and accuracy check records not available or not done (not required for Temp. probe)

Explanations

n/a means calibration done on other DO measure
NA means insufficient data to generate metric
rejected data lacked or failed post-calibration QA

Water Quality Benchmarks (a.k.a.Thresholds)

regulatory
guidance 1
guidance 2
guidance 3

>22°C maximum
>17 MWMT
> 15 MWAT

< 5 mg/L: warm water minimum
< 7 mg/L: cold water minimum

<8 mg/L year round
<11 mg/L spawning Nov-May

<80% 3 month median

>120% indicates overproduction

<6.5 minimum

> 8.5 maximum
>1.0 indicates overproduction

> 500 µS unsuitable for some species
>1000 µS potential pollution
> 2000 µS beyond freshwater range

Table C-2b: Summary of continuous field monitoring results and quality benchmark exceedances in Mt. Diablo Creek

		Spring			Summer				Winter			
	Flow				Isolated Pool	Intermittent Dry	Isolated Pool	Low Flow				
	Special Conditions						Algae					
	Station	**MTD010**	**MTD050**	**MTD120**	**MTD010**	**MTD055**	**MTD055 (2)**	**MTD115**	**MTD010**	**MTD055**	**MTD115**	
	Start Date	3/19/03	3/19/03	3/19/03	7/10/03	7/10/03	7/10/03	7/10/03	2/20/04	2/20/04	2/20/04	
	End Date	4/2/03	3/25/03	4/2/03	7/17/03	7/17/03	7/17/03	7/17/03	2/27/04	2/27/04	2/27/04	
	# of Data Points	1322	521	1330	648	663	656	680	637	657	657	
Temp	Min.	13.33	11.48	10.58	17.83	13.90	17.55	15.25	9.84	9.40	9.61	
°C	0.25	14.44	12.83	11.40	19.22	18.19	19.17	16.06	11.42	10.55	10.33	
	Median	14.80	13.84	12.00	19.79	19.19	20.65	16.45	11.99	11.19	10.56	
	0.75	15.12	14.98	12.75	20.37	20.48	23.16	17.11	12.78	11.82	10.87	
	Max.	16.34	15.92	14.33	21.30	25.15	25.40	18.24	15.10	13.78	11.98	>22
	MWMT	15.33	15.19	13.87	20.72	22.83	24.92	17.65	13.16	12.53	11.33	>17
	MWAT	14.96	13.72	12.30	19.85	19.43	21.54	16.57	12.20	11.37	10.65	>15
	QA Qualifier	valid, 5	valid, 5	valid, 5	valid, 5	valid, 5	valid, 5	valid, 5	valid, 5	valid, 5	valid, 5	
DO	Min.	0.09	8.56	8.25	0.09	4.85	0.49	0.16	0.10	9.97	10.18	<7
mg/L	0.25	1.68	9.09	8.81	1.02	7.68	4.29	5.42	8.28	10.47	10.38	
	Median	5.84	9.56	9.03	1.87	9.06	6.83	5.55	9.91	10.73	10.49	
	0.75	7.36	10.66	9.23	3.13	9.56	11.22	5.70	10.39	11.18	10.88	
	Max.	11.56	12.23	9.53	6.53	12.26	17.24	6.19	12.03	12.16	11.37	
	7DMin	0.10	8.87	8.52	0.71	5.37	1.87	2.30	5.67	10.26	10.37	<8
	MQO:±0.5mg/L	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.30	0.38	0.22	<11
	QA Qualifier	valid, 1, 2	valid, 1, 2	valid, 1, 2	rejected, 1	valid, 1	valid, 1	valid, 1	valid	valid	valid	
DO	Min.	0.90	82.40	79.30	0.90	52.70	5.40	1.70	0.90	92.80	92.20	
%	0.25	16.68	88.10	82.80	11.10	83.95	46.40	55.30	78.20	95.90	93.60	
	Median	57.15	90.20	84.20	20.40	98.90	76.10	56.70	91.50	97.70	94.30	<80
	0.75	73.15	104.60	85.30	34.88	100.00	131.95	58.20	97.40	100.50	98.30	
	Max.	115.80	122.50	87.50	73.60	136.20	196.10	64.30	115.10	115.50	100.60	>120
	MQO: ± 5%	3.00	3.00	1.20	5.90	0.70	2.10	3.40	n/a	n/a	n/a	
	QA Qualifier	valid, 2	valid, 2	valid, 2	rejected	valid	valid	valid	valid, 1	valid, 1	valid, 1	
	Min.	6.96	7.71	7.62	7.44	6.87	7.44	7.34	7.45	7.61	7.77	<6.5
pH	0.25	7.15	7.90	7.68	7.59	7.76	7.61	7.39	7.67	7.83	7.91	
	Median	7.29	7.94	7.73	7.66	7.85	7.76	7.40	7.78	7.86	7.94	
	0.75	7.44	8.05	7.76	7.72	8.01	8.09	7.41	7.85	7.89	7.97	
	Max.	7.66	8.22	7.83	7.94	8.62	8.29	7.46	8.04	8.13	8.02	>8.5
	Δ	0.70	0.51	0.21	0.50	1.75	0.85	0.12	0.59	0.52	0.25	>1.0
	MQO: ± 0.5	0.00	0.07	0.04	0.08	0.04	0.05	0.12	0.03	0.09	0.06	
	QA Qualifier	valid, 2	valid, 2	valid, 2	valid	valid	valid	valid	valid	valid	valid	
	Min.	423	326	455	786	0	991	584	113	151	299	
SC	0.25	1106	850	467	809	2	1072	592	450	358	325	
µS/cm	Median	1148	892	468	820	1110	1101	601	651	525	378	>500
	0.75	1246	903	472	831	1170	1143	606	779	579	384	>1000
	Max.	1366	926	476	841	1210	1194	621	954	624	389	>2000
	MQO:± 5.0%	1.4	0.7	0.3	0.60	1.00	2.20	1.00	1.80	5.70	3.60	
	QA Qualifier	valid, 2	valid, 2	valid, 2	valid	valid	valid	valid	valid	rejected	valid	

Evaluation thresholds: for details, see key on Table C-2-a.

QA Qualifiers code: 1 = Accuracy gleaned from percent saturation check; 2 = post-deployment accuracy check done at >24 h, but accuracy met MQO;
5 = Calibration and accuracy check records not available or not done (not required for Temp. probe)

Table C-2c: Summary of continuous field monitoring results and quality benchmark exceedances in the Petaluma River

		Spring					Summer				Fall		Winter					Evaluation thresholds: for details, see key on Table C-2-a.
	Station	PET010	PET130	PET265	PET310	PET400	PET120	PET265	PET310	PET400	PET265	PET310	PET010	PET120	PET265	PET310	PET400	
	Start Date	4/10/03	4/10/03	4/10/03	4/9/03	4/10/03	7/22/03	7/22/03	7/22/03	7/22/03	9/15/03	9/15/03	1/27/04	2/3/04	1/27/04	1/27/04	1/27/04	
	End Date	4/24/03	4/24/03	4/24/03	4/23/03	4/24/03	7/30/03	7/30/03	7/30/03	7/30/03	9/24/03	9/24/03	2/6/04	2/6/04	2/6/04	2/6/04	2/6/04	
	# of Data Points	1334	1335	1330	1347	1329	759	767	770	770	864	860	959	283	953	971	975	
Temp **°C**	Min.	11.09	9.28	11.01	11.92	11.03	17.49	16.42	16.70	16.88	16.05	14.89	8.61	7.51	9.07	9.02	8.54	
	0.25	12.92	11.97	12.81	13.47	12.40	18.26	17.16	17.03	17.69	17.60	15.09	9.33	8.75	9.98	9.73	9.30	
	Median	13.71	13.11	13.54	13.99	12.87	18.87	17.33	17.30	18.10	17.76	15.24	9.99	9.83	10.63	10.11	9.60	
	0.75	14.69	14.86	14.11	14.52	13.49	19.57	17.51	17.53	18.64	17.84	15.48	10.48	11.20	11.27	10.43	10.16	
	Max.	17.13	19.81	15.19	16.73	15.33	20.71	18.58	17.91	19.47	18.11	16.34	11.85	12.82	12.57	12.25	11.93	>22
	MWMT	16.05	18.08	14.63	15.01	14.62	20.07	17.73	17.57	18.96	17.80	15.64	10.98	NA	11.71	11.28	10.74	>17
	MWAT	14.43	14.06	13.60	14.38	13.36	19.09	17.43	17.41	18.36	17.98	15.46	10.04	NA	10.73	10.25	9.86	>15
	QA	valid, 5	valid, 5	valid, 5	valid, 5	valid, 5	valid, 5	valid, 5	valid, 5	valid, 5	valid, 5	valid, 5	valid, 5	valid, 5	valid, 5	valid, 5	valid, 5	
DO **mg/L**	Min.	**1.82**	8.05	**6.86**	**3.92**	**6.75**	**-0.30**	**0.20**	**0.71**	5.11	0.04	0.04	**-0.01**	7.54	9.22	8.17	10.79	< 7
	0.25	**5.34**	9.06	8.05	**5.11**	7.47	**0.20**	**0.26**	**1.12**	6.19	0.07	0.06	10.38	9.72	10.31	9.42	11.58	
	Median	**7.00**	9.60	8.92	**5.62**	8.11	**0.43**	**0.29**	**1.31**	7.49	0.08	0.08	10.77	10.39	11.34	9.80	11.95	
	0.75	8.04	10.19	9.67	**6.66**	8.59	**2.55**	**0.42**	**1.49**	8.98	0.10	0.20	11.09	10.93	11.93	10.21	12.35	
	Max.	11.59	11.20	11.02	10.15	12.67	7.45	**4.46**	**2.14**	13.67	2.87	1.13	12.20	11.28	13.33	10.87	13.06	
	7DayMin	3.77	8.50	7.22	4.43	6.86	-0.01	0.24	0.84	5.32	0.06	0.06	8.11	NA	10.15	8.85	11.25	<8
	MQO ± 0.5mg/L	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a				0.24	0.61	1.71	0.21	1.66	<11
	QA	valid, 1	valid, 1	valid, 1	valid, 1	valid, 1	valid, 1	valid, 1	valid, 1	rejected, 5	rejected, 5	rejected, 5	valid	rejected	rejected	valid	rejected	
DO **%**	Min.	18.5	80.50	71.20	38.10	62.90	-3.30	2.00	7.50	52.80	0.50	0.40	-0.10	68.40	82.30	72.80	95.00	
	0.25	50.55	87.10	77.30	50.30	70.60	2.15	2.70	11.70	65.03	0.70	0.60	90.65	86.50	93.20	83.80	101.50	
	Median	**68.45**	91.60	85.00	**54.70**	**76.70**	**4.70**	**3.10**	**13.60**	79.25	0.90	0.80	95.70	89.80	103.10	87.40	106.30	<80
	0.75	77.2	97.15	93.1	63.6	81.6	27.15	4.4	15.6	96.825	1.1	2	98.4	97.05	107	90.9	109	
	Max.	116.50	109.20	105.40	98.70	125.40	81.10	47.00	22.10	148.60	29.10	11.50	110.00	101.70	123.60	96.30	116.10	>120
	MQO ± 5.0%	0.40	2.70	4.30	4.80	1.30	0.70	0.80	0.60				n/a	n/a	n/a	n/a	n/a	
	QA	valid	valid	valid	valid	valid	valid	valid	valid	rejected, 5	rejected, 5	rejected, 5	valid	rejected	rejected	valid	rejected	
pH	Min.	7.20	7.60	7.19	7.01	7.07	6.76	6.52	7.38	7.06	6.69	7.22	6.58	7.02	7.04	6.82	7.21	<6.5
	0.25	7.28	7.66	7.38	7.19	7.16	6.83	6.54	7.39	7.17	6.71	7.29	7.57	7.02	7.24	6.96	7.31	
	Median	7.40	7.72	7.45	7.21	7.20	6.93	6.55	7.39	7.25	6.72	7.30	7.62	7.04	7.34	7.30	7.33	
	0.75	7.45	7.82	7.54	7.25	7.23	7.01	6.56	7.40	7.32	6.74	7.32	7.68	7.12	7.43	7.35	7.35	
	Max.	7.87	8.15	7.78	7.86	7.45	7.19	6.73	7.43	7.60	6.90	7.33	7.82	7.20	7.78	7.44	7.45	>8.5
	Δ	0.67	0.55	0.59	0.85	0.38	0.43	0.21	0.05	0.54	0.21	0.11	1.24	0.18	0.74	0.62	0.24	>1.0
	MQO ± 0.50	0.03	0.00	0.01	0.04	0.03	0.05	0.02	0.09	0.20	0.07	0.04	0.15	none	0.14	0.08	0.38	
	QA	valid	valid	valid	valid	valid	valid	valid	valid	valid	valid, 2	valid, 2	valid	rejected	valid	valid	valid	
SC **µS/cm**	Min.	313	257	77	62	298	408	837	1328	844	605	1081	175	249	104	389	203	
	0.25	372	322	497	630	428	427	1025	1336	849	792.75	1176	311.5	274	335	514	339	
	Median	418	336	552	804	511	437	1042	1344	850	825	1204	515	295	398	862	374	>500
	0.75	445	345	572	893	584	490	1058	1354	852	842	1212	532	316	520	898	392	>1000
	Max.	590	354	616	979	633	525	1084	1360	861	860	1224	554	327	596	972	404	>2000
	MQO ± 5.0%	0.40	none	none	none	none	0.40	0.30	0.10	0.70	3.30	3.80	1.20	none	6.1	4.80	0.08	
	QA	valid	rejected, 5	rejected, 5	rejected, 5	rejected, 5	valid	valid	valid	valid	valid, 2	valid, 2	valid	rejected	rejected	valid	valid	

QA Qualifiers code: 1 = Accuracy gleaned from percent saturation check; 2 = post-deployment accuracy check done at >24 h, but accuracy met MQO;
5 = Calibration and accuracy check records not available or not done (not required for Temp. probe)

Table C-2d: Summary of continuous field monitoring results and quality benchmark exceedances in San Mateo Creek

		Spring					Summer				Fall			Winter				Evaluation thresholds: for details, see key on Table C-2-a.
	Flow						Trickle	Moderate	Moderate	Moderate								
	Station	**SMA020**	**SMA060**	**SMA110**	**SMA120**	**SMA180**	**SMA020**	**SMA060**	**SMA110**	**SMA120**	**SMA020**	**SMA060**	**SMA110**	**SMA020**	**SMA060**	**SMA110**	**SMA120**	
	Start Date	4/28/03	4/27/03	4/28/03	4/28/03	4/28/03	8/6/03	8/7/03	8/7/03	8/7/03	10/20/03	10/20/03	10/20/03	2/7/04	2/7/04	2/7/04	2/7/04	
	End Date	5/12/03	5/11/03	5/12/03	5/12/03	5/12/03	8/25/03	8/25/03	8/25/03	8/20/03	10/31/03	10/31/03	10/31/03	2/13/04	2/13/04	2/13/04	2/13/04	
	# of Data Points	1348	1349	1348	1348	1348	1837	1735	1732	1253	1051	1047	1045	578	583	583	584	
Temp	Min.	12.01	11.51	8.81	12.33	9.16	16.23	15.96	17.41	15.39	14.33	11.32	13.03	8.37	7.20	8.12	6.76	
°C	0.25	12.87	12.77	11.63	13.47	10.08	17.84	17.17	18.42	16.25	15.10	14.02	15.25	8.89	8.27	8.93	7.49	
	Median	13.16	13.27	12.49	13.97	10.53	19.05	17.88	18.87	16.59	15.67	14.72	16.12	9.05	8.77	9.44	7.90	
	0.75	13.61	13.85	13.15	14.50	10.95	20.92	18.90	19.32	17.01	16.74	15.47	16.63	9.32	9.37	9.97	8.23	
	Max.	15.94	15.33	16.36	15.76	12.17	24.86	20.97	20.80	17.81	18.16	16.29	17.20	10.19	10.33	10.71	9.64	>22
	MWMT	14.31	14.48	14.14	14.99	11.40	23.47	19.84	19.85	17.60	17.17	16.08	16.94	9.49	9.72	10.23	8.53	>17
	MWAT	13.61	13.64	13.06	14.25	10.74	21.23	18.31	19.06	16.78	16.30	14.99	16.23	9.18	8.86	9.50	8.03	>15
	QA Qualifier	valid, 5	valid, 5	valid, 5	valid, 5	valid, 5	valid, 5	valid, 5	valid, 5	valid, 5	valid, 5	valid, 5	valid, 5	valid, 5	valid, 5	valid, 5	valid, 5	
DO	Min.	8.50	**0.10**	9.87	**5.73**	10.86	**0.06**	**5.41**	7.36	8.26	**2.01**	8.71	**6.66**	10.35	10.52	9.82	11.69	< 7
mg/L	0.25	9.35	**1.52**	10.58	8.74	11.14	**2.97**	**6.70**	7.79	8.68	**3.76**	9.00	8.01	10.69	11.65	10.24	12.22	
	Median	9.54	**5.47**	10.80	8.88	11.34	**3.82**	7.22	7.92	8.86	**4.27**	9.39	8.18	10.78	11.78	10.43	12.36	
	0.75	9.70	9.22	11.00	9.03	11.50	**4.84**	8.67	8.13	9.37	**4.88**	10.19	8.45	10.95	11.95	10.65	12.53	
	Max.	10.42	10.57	11.79	9.49	11.94	9.80	10.49	8.72	9.87	7.87	16.88	9.21	11.50	12.33	11.18	12.88	
	7DayMin	9.06	1.00	10.31	8.24	10.98	0.86	6.10	7.56	8.41	2.69	8.81	7.74	10.56	11.26	10.10	12.09	<8
	MQO ± 0.5mg/L	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.36	1.27	0.18	0.07	0.13	0.09	0.32	<11
	QA Qualifier	valid, 1	valid, 1	valid, 1	valid, 1	rejected, 1	valid, 1	valid, 1	valid, 1	valid, 1	valid	rejected	valid	valid	valid	valid	valid	
DO	Min.	83.70	1.00	98.50	55.60	98.90	0.70	55.30	78.40	85.40	23.80	83.50	67.80	91.50	91.50	87.80	102.90	
%	0.25	89.30	14.50	100.70	84.80	100.00	32.70	69.85	83.70	88.80	40.00	88.50	81.90	92.60	101.10	89.90	103.90	
	Median	90.80	**51.90**	101.30	85.80	101.90	**42.60**	**76.30**	84.50	90.60	**45.70**	91.60	82.70	93.40	101.50	90.80	104.40	<80
	0.75	92.80	88.20	101.83	87.70	103.00	55.10	93.10	87.40	96.10	52.75	100.75	84.50	95.30	102.60	92.60	104.90	
	Max.	98.60	103.20	104.70	92.80	106.50	131.20	114.40	93.30	102.10	96.50	162.10	91.20	100.10	104.00	99.90	106.70	>120
	MQO ± 5.0%	1.70	0.00	2.70	1.10	5.80	0.60	0.00	0.60	0.20	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
	QA Qualifier	valid	valid	valid	valid	rejected	valid	valid	valid	valid	valid, 1	rejected, 1	valid, 1	valid, 1	valid, 1	valid, 1	valid, 1	
pH	Min.	7.45	7.01	7.43	7.45	7.90	7.19	7.48	7.57	8.38	7.26	7.59	7.24	7.74	7.47	7.51	8.23	<6.5
	0.25	7.80	7.05	8.04	7.59	7.95	7.40	7.63	7.60	8.41	7.42	7.68	7.32	8.05	7.92	7.57	8.39	
	Median	7.84	7.21	8.13	7.61	7.96	7.48	7.69	7.61	8.42	7.48	7.72	7.34	8.07	7.94	7.58	8.40	
	0.75	7.87	7.75	8.23	7.63	7.98	7.55	7.85	7.65	8.45	7.51	7.79	7.35	8.08	7.96	7.60	8.41	
	Max.	8.00	7.91	8.29	7.68	8.02	7.88	8.05	7.72	**8.51**	7.67	7.94	7.38	8.10	8.01	7.67	8.42	>8.5
	Δ	0.55	0.90	0.86	0.23	0.12	0.69	0.57	0.15	0.13	0.41	0.35	0.14	0.36	0.54	0.16	0.19	>1.0
	MQO ± 0.50	0.03	0.04	0.03	0.01	0.00	0.05	0.05	0.25	0.08	0.01	0.04	0.13	0.05	0.03	0.02	0.08	
	QA Qualifier	valid	valid	valid	valid	valid	valid	valid	valid	valid	valid	valid	valid	valid	valid	valid	valid	
SC	Min.	171	171	76	139	430	564	527	199	87	471	454	177	472	10	351	845	
µS/cm	0.25	496	474	176	386	538	617	545	212	97	504	485	181	533	664	357	1013	
	Median	607	514	230	415	591	737	551	214	110	27582	493	183	572	681	364	1054	>500
	0.75	643	529	595	435	708	17817	557	217	115	39939	500	184	592	693	375	1076	>1000
	Max.	688	704	984	452	810	38874	585	283	117	42437	545	191	663	699	381	1099	>2000
	MQO ± 5.0%	1.20	0.10	0.20	0.50	0.20	1.20	0.70	0.50	0.00	2.30	1.20	0.04	0.20	0.80	0.70	0.70	
	QA Qualifier	valid	valid	valid	valid	valid	valid	valid	valid	valid	valid	valid	valid	valid	valid	valid	valid	

QA Qualifiers code: 1 = Accuracy gleaned from percent saturation check; 2 = post-deployment accuracy check done at >24 h, but accuracy met MQO;
5 = Calibration and accuracy check records not available or not done (not required for Temp. probe)

Table D-1: Inventory of Station Visits and associated chemistry & toxicity monitoring activities performed in 2003

Station	Station Name	Date	Time	Season	Observations	Field Measurements	Salts & other conventional char.	Nutrients	Metals	Organics	Water toxicity	Sediment chemistry and toxicity	Tissue
KIR020	Floodway	21/Jan/2003	8:45	Wet	x	x	x	x	x	x	x		
		21/Apr/2003	14:20	Spring	x	x	x	x	x	x	x	x	
		22/May/2003	8:00	Spring									x
		02/Jun/2003	11:50	Dry	x	x	x	x	x	x	x		
KIR115	Kirker Creek Apartments	21/Jan/2003	11:10	Wet	x	x	x	x	x	x	x		
		21/Apr/2003	12:45	Spring	x	x	x	x	x	x	x		
MTD010	Port Chicago Highway	21/Jan/2003	7:35	Wet	x	x	x	x	x	x	x		
		21/Apr/2003	16:00	Spring	x	x	x	x	x	x	x	x	
		22/May/2003	8:20	Spring									x
MTD050	Lydia Lane Park	21/Jan/2003	12:00	Wet	x	x	x	x					
		21/Apr/2003	12:10	Spring	x	x	x	x					
		02/Jun/2003	11:00	Dry	x	x	x	x					
MTD060	Diablo below confluence	21/Jan/2003	12:30	Wet	x	x	x	x					
		21/Apr/2003	11:50	Spring	x	x	x	x					
		02/Jun/2003	10:25	Dry	x	x	x	x					
MTD100	Mitchell on Oak St	21/Jan/2003	13:30	Wet	x	x	x	x	x	x	x		
		21/Apr/2003	11:15	Spring	x	x	x	x	x	x	x		
MTD120	Mitchell on Fire Rd	21/Jan/2003	14:20	Wet	x	x	x	x					
		21/Apr/2003	10:55	Spring	x	x	x	x					
		02/Jun/2003	10:45	Dry	x	x	x	x					
MTD140	Donnor Creek	21/Jan/2003	12:45	Wet	x	x	x	x					
		21/Apr/2003	10:15	Spring	x	x	x	x					
		02/Jun/2003	10:00	Dry	x	x	x	x					
PET010	San Antonio Road bridge	20/Jan/2003	7:45	Wet	x	x	x	x	x	x	x		
		22/Apr/2003	8:20	Spring	x	x	x	x	x	x	x		

Table D-1 (cont.)

Station	StationName	SampleDate	SampleTime	Season	Observations	Field Measurements	Salts & other conventional char.	Nutrients	Metals	Organics	Water toxicity	Sediment chemistry and toxicity	Tissue
PET130	Fairway Meadows	20/Jan/2003	9:15	Wet	x	x	x	x					
		22/Apr/2003	7:45	Spring	x	x	x	x					
		02/Jun/2003	16:05	Dry	x	x	x	x					
PET150	Above Petaluma Adobe SHP	20/Jan/2003	10:15	Wet	x	x	x	x					
		22/Apr/2003	7:15	Spring	x	x	x	x					
		02/Jun/2003	15:45	Dry	x	x	x	x					
PET265	Lynch pedestrian path	20/Jan/2003	11:05	Wet	x	x	x	x					
		22/Apr/2003	6:55	Spring	x	x	x	x					
		02/Jun/2003	16:25	Dry	x	x	x	x					
PET280	Lynch at Adobe Road	20/Jan/2003	13:55	Wet	x	x	x	x					
		21/Apr/2003	18:50	Spring	x	x	x	x					
		02/Jun/2003	15:25	Dry	x	x	x	x					
PET310	Outlets	20/Jan/2003	11:46	Wet	x	x	x	x	x	x	x		
		21/Apr/2003	17:45	Spring	x	x	x	x	x	x	x	x	
		22/May/2003	9:35	Spring									x
		02/Jun/2003	14:05	Dry	x	x	x	x	x	x	x		
PET400	Penngrove Park	20/Jan/2003	13:15	Wet	x	x	x	x					
		21/Apr/2003	18:30	Spring	x	x	x	x					
		02/Jun/2003	14:55	Dry	x	x	x	x					
SMA020	Gateway Park	23/Jan/2003	7:10	Wet	x	x	x	x	x	x	x		
		22/Apr/2003	15:00	Spring	x	x	x	x	x	x	x	x	
		22/May/2003	12:05	Spring									x
		03/Jun/2003	8:25	Dry	x	x	x	x	x	x	x		
SMA160	Above Mud Dam	23/Jan/2003	9:50	Wet	x	x	x	x					
		22/Apr/2003	12:25	Spring	x	x	x	x					
		03/Jun/2003	10:45	Dry	x	x	x	x					
SMA180	Buckeye @ Old Cañada Rd	23/Jan/2003	8:55	Wet	x	x	x	x					
		22/Apr/2003	13:05	Spring	x	x	x	x					
		03/Jun/2003	10:00	Dry	x	x	x	x					

Table D-2: Analytical suites for selected organic compounds methods

Table D-2a: PAHs analyzed in water, sediment and tissue in 2003

PAH name	Water (EPA 8270M)		Sediment (EPA 8270M)		Tissue (EPA 3545)	
	Detection Limit (µg/L)	Reporting Limit (µg/L)	Detection Limit (ng/g dry)	Reporting Limit (ng/g dry)	Detection Limit (ng/g dry)	Reporting Limit (ng/g dry)
Acenaphthene	0.01 to 0.025	0.01 to 0.025	1.17 to 1.94	1.17 to 1.94	12.3 to 18.9	12.3 to 18.9
Acenaphthylene	"	"	"	"	"	"
Anthracene	"	"	"	"	"	"
Benz(a)anthracene	"	"	"	"	"	"
Benzo(a)pyrene	"	"	"	"	"	"
Benzo(b)fluoranthene	"	"	"	"	"	"
Benzo(e)pyrene	"	"	"	"	"	"
Benzo(g,h,i)perylene	"	"	"	"	"	"
Benzo(k)fluoranthene	"	"	"	"	"	"
Biphenyl	"	"	"	"	"	"
Chrysene	"	"	"	"	"	"
Chrysenes, C1 -	"	"	"	"	"	"
Chrysenes, C2 -	"	"	"	"	"	"
Chrysenes, C3 -	"	"	"	"	"	"
Dibenz(a,h)anthracene	"	"	"	"	"	"
Dibenzothiophene	"	"	"	"	"	"
Dibenzothiophenes, C1 -	"	"	"	"	"	"
Dibenzothiophenes, C2 -	"	"	"	"	"	"
Dibenzothiophenes, C3 -	"	"	"	"	"	"
Dimethylnaphthalene, 2,6-	"	"	"	"	"	"
Fluoranthene	"	"	"	"	"	"
Fluoranthene/Pyrenes, C1 -	"	"	"	"	"	"
Fluorene	"	"	"	"	"	"
Fluorenes, C1 -	"	"	"	"	"	"
Fluorenes, C2 -	"	"	"	"	"	"
Fluorenes, C3 -	"	"	"	"	"	"
Indeno(1,2,3-c,d)pyrene	"	"	"	"	"	"
Methylnaphthalene, 1-	"	"	"	"	"	"
Methylnaphthalene, 2-	"	"	"	"	"	"
Methylphenanthrene, 1-	"	"	"	"	"	"
Naphthalene	"	"	"	"	"	"
Naphthalenes, C1 -	"	"	"	"	"	"
Naphthalenes, C2 -	"	"	"	"	"	"
Naphthalenes, C3 -	"	"	"	"	"	"
Naphthalenes, C4 -	"	"	"	"	"	"
Perylene	"	"	"	"	"	"
Phenanthrene	"	"	"	"	"	"
Phenanthrene/Anthracene, C1 -	"	"	"	"	"	"
Phenanthrene/Anthracene, C2 -	"	"	"	"	"	"
Phenanthrene/Anthracene, C3 -	"	"	"	"	"	"
Phenanthrene/Anthracene, C4 -	"	"	"	"	"	"
Pyrene	"	"	"	"	"	"
Trimethylnaphthalene, 2,3,5-	"	"	"	"	"	"

Table D-2b: PCBs analyzed in water, sediment and tissue in 2003

PCB name	Water (EPA 8082M)		Sediment (EPA 8082M)		Tissue (EPA 8082)	
	Detection Limit (µg/L)	Reporting Limit (µg/L)	Detection Limit (ng/g dry)	Reporting Limit (ng/g dry)	Detection Limit (ng/g dry)	Reporting Limit (ng/g dry)
PCB 005	0.001	0.002				
PCB 008	"	"	0.046 to 0.079	0.232 to 0.396	0.49 to 0 0.75	2.5 to 3.8
PCB 015	"	"				
PCB 018	"	"	"	"	"	"
PCB 027	"	"	"	"	"	"
PCB 028	"	"	"	"	"	"
PCB 029	"	"	"	"	"	"
PCB 031	"	"	"	"	"	"
PCB 033	"	"	"	"	"	"
PCB 044	"	"	"	"	"	"
PCB 049	"	"	"	"	"	"
PCB 052	"	"	"	"	"	"
PCB 056	"	"	"	"	"	"
PCB 060	"	"	"	"	"	"
PCB 066	"	"	"	"	"	"
PCB 070	"	"	"	"	"	"
PCB 074	"	"	"	"	"	"
PCB 087	"	"	"	"	"	"
PCB 095	"	"	"	"	"	"
PCB 097	"	"	"	"	"	"
PCB 099	"	"	"	"	"	"
PCB 101	"	"	"	"	"	"
PCB 105	"	"	"	"	"	"
PCB 110	"	"	"	"	"	"
PCB 114	"	"	"	"	"	"
PCB 118	"	"	"	"	"	"
PCB 128	"	"	"	"	"	"
PCB 137	"	"	"	"	"	"
PCB 138	"	"	"	"	"	"
PCB 141	"	"	"	"	"	"
PCB 149	"	"	"	"	"	"
PCB 151	"	"	"	"	"	"
PCB 153	"	"	"	"	"	"
PCB 156	"	"	"	"	"	"
PCB 157	"	"	"	"	"	"
PCB 158	"	"	"	"	"	"
PCB 170	"	"	"	"	"	"
PCB 174	"	"	"	"	"	"
PCB 177	"	"	"	"	"	"
PCB 180	"	"	"	"	"	"
PCB 183	"	"	"	"	"	"
PCB 187	"	"	"	"	"	"
PCB 189	"	"	"	"	"	"
PCB 194	"	"	"	"	"	"
PCB 195	"	"	"	"	"	"
PCB 200	"	"	"	"	"	"
PCB 201	"	"	"	"	"	"
PCB 203	"	"	"	"	"	"
PCB 206	"	"	"	"	"	"
PCB 209	"	"	"	"	"	"
			Aroclors in sediment (Newman, et al., 1988)		**Aroclors in tissue (EPA 8081A)**	
PCB AROCLOR 1248			11.6	29	123-191	308-476
PCB AROCLOR 1254			4.64	11.6	49-76	123-191
PCB AROCLOR 1260			4.64	11.6	49-76	123-191

Table D-2c: Organochlorine Pesticides analyzed in 2003

Pesticide Name	**MDLs**	**RLs**	**MDLs Min**	**MDLs Max**	**RLs Min**	**RLs Max**	**MDLs Min**	**MDLs Max**	**RLs Min**	**RLs Max**
	(µg/L)	**(µg/L)**	**ng/g (dry weight)**				**ng/g (dry weight)**			
Organochlorine Pesticides In Water (EPA 8081AM)			**OCs in Sediment (EPA 8081AM)**				**OCs in Tissue (EPA 8081AM)**			
Aldrin	0.001	0.002	0.302	0.515	1.2	2	3.20	4.95	12.30	19.10
Chlordane, cis-	0.001	0.002	0.831	1.42	2.3	4	8.82	13.60	24.70	38.10
Chlordane, trans-	0.001	0.002	0.469	0.8	2.3	4	4.98	7.70	24.70	38.10
Chlordene, alpha-	0.001	0.002	0.32	0.546	1.2	2	3.40	5.26	12.30	19.10
Chlordene, gamma-	0.001	0.002	0.297	0.507	1.2	2	3.16	4.88	12.30	19.10
Dacthal	0.001	0.002	0.733	1.25	2.3	4	7.79	12.00	24.70	38.10
DCBP(p,p')			0.928	1.58	11.6	19.8	9.86	15.20	123.00	191.00
DDD(o,p')	0.001	0.002	0.891	1.52	2.3	4	9.47	14.60	24.70	38.10
DDD(p,p')	0.001	0.002	1.04	1.78	2.3	4	11.10	17.10	24.70	38.10
DDE(o,p')	0.001	0.002	0.78	1.33	2.3	4	8.28	12.80	24.70	38.10
DDE(p,p')	0.001	0.002	0.668	1.14	2.3	4	7.10	11.00	24.70	38.10
DDMU(p,p')	0.001	0.002	1.4	2.38	3.5	5.9	14.80	22.90	37.00	57.20
DDT(o,p')	0.001	0.002	1.18	2.01	3.5	5.9	12.50	19.40	37.00	57.20
DDT(p,p')	0.002	0.005	2.87	4.89	5.8	9.9	30.50	47.10	61.60	95.30
Dieldrin	0.001	0.002	0.487	0.832	2.3	4	5.18	8.00	24.70	38.10
Endosulfan I	0.001	0.002	1.25	2.14	2.3	4	13.30	20.60	24.70	38.10
Endosulfan II	0.001	0.002	4.64	7.92	11.6	19.8	49.30	76.20	123.00	191.00
Endosulfan sulfate	0.001	0.002	4.64	7.92	11.6	19.8	49.30	76.20	123.00	191.00
Endrin	0.001	0.002	1.09	1.86	2.3	4	11.60	17.90	24.70	38.10
Endrin Aldehyde	0.002	0.005								
Endrin Ketone	0.002	0.005								
HCH, alpha	0.001	0.002	0.552	0.942	1.2	2	5.87	9.07	12.30	19.10
HCH, beta	0.001	0.002	0.715	1.22	2.3	4	7.59	11.70	24.70	38.10
HCH, delta	0.001	0.002	0.418	0.713	2.3	4	4.44	6.86	24.70	38.10
HCH, gamma	0.001	0.002	0.394	0.673	1.2	2	4.19	6.48	12.30	19.10
Heptachlor	0.001	0.002	0.599	1.02	2.3	4	6.36	9.83	24.70	38.10
Heptachlor epoxide	0.001	0.002	0.585	0.998	1.2	2	6.21	9.60	12.30	19.10
Hexachlorobenzene	0.0005	0.001	0.125	0.214	0.3	0.6	1.33	2.06	3.70	5.70
Methoxychlor	0.001	0.002	1.72	2.93	5.8	9.9	18.20	28.20	61.60	95.30
Mirex	0.001	0.002	1.1	1.87	3.5	5.9	11.60	18.00	37.00	57.20
Nonachlor, cis-	0.001	0.002	1.14	1.94	2.3	4	12.10	18.70	24.70	38.10
Nonachlor, trans-	0.001	0.002	0.45	0.768	1.2	2	4.78	7.39	12.30	19.10
Oxadiazon	0.001	0.002	1.09	1.85	3.5	5.9	11.50	17.80	37.00	57.20
Oxychlordane	0.001	0.002	0.427	0.729	1.2	2	4.54	7.01	12.30	19.10
Tedion	0.001	0.002	0.854	1.46	2.3	4	9.07	14.00	24.70	38.10
Toxaphene			9.28	15.8	23.2	39.6	98.60	152.00	247.00	381.00

Table D-2d: Organophosphate Pesticides analyzed in 2003

Pesticide Name	MDLs	RLs	MDLs Min	MDLs Max	RLs Min	RLs Max	MDLs Min	MDLs Max	RLs Min	RLs Max
	(µg/L)	(µg/L)	ng/g (dry weight)				ng/g (dry weight)			
Organophosphate Pesticides in water (EPA 8141AM)			**OPs in Sediment (EPA 8081AM)**				**OPs in Tissue (EPA 8081AM)**			
Aspon	0.03	0.05								
Azinphos ethyl	0.03	0.05								
Azinphos methyl	0.03	0.05								
Bolstar	0.03	0.05								
Carbophenothion	0.03	0.05								
Chlorfenvinphos	0.03	0.05								
Chlorpyrifos	0.02	0.05	0.97	1.66	2.3	4	10.30	15.90	24.70	38.10
Chlorpyrifos methyl	0.02	0.05								
Ciodrin	0.03	0.05								
Coumaphos	0.04	0.05								
Demeton-s	0.04	0.05								
Diazinon	0.005	0.02	7.84	13.4	23.2	39.6	83.30	129.00	247.00	381.00
Dichlofenthion	0.03	0.05								
Dichlorvos	0.03	0.05								
Dicrotophos	0.03	0.05								
Dimethoate	0.03	0.05								
Dioxathion	0.03	0.05								
Disulfoton	0.01	0.05								
Ethion	0.02	0.05								
Ethoprop	0.03	0.05								
Famphur	0.03	0.05								
Fenchlorphos	0.03	0.05								
Fenitrothion	0.03	0.05								
Fensulfothion	0.03	0.05								
Fenthion	0.03	0.05								
Fonofos	0.02	0.05								
Leptophos	0.03	0.05								
Malathion	0.03	0.05								
Merphos	0.03	0.05								
Methidathion	0.03	0.05								
Mevinphos	0.03	0.05								
Molinate	0.1	0.2								
Naled	0.03	0.05								
Parathion, Ethyl	0.03	0.05	0.974	1.66	2.3	4	10.40	16.00	24.70	38.10
Parathion, Methyl	0.01	0.05	1.76	3.01	4.6	7.9	18.70	29.00	49.30	76.20
Phorate	0.03	0.05								
Phosmet	0.03	0.05								
Phosphamidon	0.03	0.05								
Sulfotep	0.03	0.05								
Terbufos	0.03	0.05								
Tetrachlorvinphos	0.03	0.05								
Thiobencarb	0.1	0.2								
Thionazin	0.04	0.05								
Tokuthion	0.03	0.05								
Trichlorfon	0.03	0.05								
Trichloronate	0.03	0.05								

Table D-2e: Other Pesticides analyzed

Pesticide Name	MDLs (µg/L)	RLs (µg/L)
Organophosphate Pesticides (ELISA SOP 3.3)		
Chlorpyrifos	0.05	0.05
Diazinon	0.03	0.03
Herbicides in water (EPA 619M)		
Ametryn	0.02	0.05
Atraton	0.02	0.05
Atrazine	0.02	0.05
Prometon	0.02	0.05
Prometryn	0.02	0.05
Propazine	0.02	0.05
Secbumeton	0.02	0.05
Simazine	0.02	0.05
Simetryn	0.02	0.05
Terbuthylazine	0.02	0.05
Terbutryn	0.02	0.05

Table D-3: Concentrations of conventional WQ characteristics in 2003 samples

Table D-3a: Comparison of nutrient concentrations in 2003 samples to water quality benchmarks (WQBs)

Station	Season	Ammonia as N (mg/L)		Unionized Ammonia as N (mg/L) (WQB =0.025)	NH3 notes	Unionized Ammonia Exceed -ance Factor	Nitrate as N (mg/L) (WQB =0.16)	Nitrate Exceed -ance Factor	Phosphorus as P,Total (mg/L) (WQB =0.03)		Total P Exceed -ance Factor
KIR020	W	2.2			a, b		1.71	**10.7**	0.15		**5.0**
KIR020	S		ND				0.05	0.3	0.09		**3.0**
KIR020	D	0.05	J				0.07	0.4	0.13		**4.3**
KIR115	W	0.2			a		0.42	**2.6**	0.08		**2.6**
KIR115	S	0.06	J				0.36	**2.2**	0.08		**2.6**
MTD010	W	0.2			a		1.63	**10.2**	0.032	J	**1.1**
MTD010	S	0.5		0.004		0.16	0.92	**5.7**	0.28		**9.4**
MTD050	W	0.1			a		0.80	**5.0**	0.031	J	**1.0**
MTD050	S	0.08	J				0.76	**4.8**		ND	0.0
MTD050	D		ND				0.79	**4.9**	0.030	J	**1.0**
MTD060	W	0.1			a		0.87	**5.4**		ND	0.0
MTD060	S		ND				0.76	**4.7**		ND	0.0
MTD060	D		ND				0.66	**4.1**	0.031	J	**1.0**
MTD100	W	0.09	J				0.87	**5.4**		ND	0.0
MTD100	S		ND				0.48	**3.0**		ND	0.0
MTD120	W	0.07	J				0.04	0.3		ND	0.0
MTD120	S		ND				0.05	0.3		ND	0.0
MTD120	D		ND				0.04	0.2		ND	0.0
MTD140	W	0.07	J				0.07	0.4	0.030	J	**1.0**
MTD140	S		ND				0.06	0.4		ND	0.0
MTD140	D		ND				0.06	0.4		ND	0.0
PET010	W	0.3			a		1.71	**10.7**	0.61		**20.4**
PET010	S		ND				0.57	**3.5**	0.44		**14.6**
PET130	W	0.1			a		1.30	**8.1**	0.26		**8.5**
PET130	S		ND				0.07	0.4	0.17		**5.6**
PET130	D		ND				0.07	0.4	0.16		**5.5**
PET150	W	0.1			a		1.51	**9.4**	0.19		**6.2**
PET150	S		ND				0.06	0.4	0.13		**4.4**
PET150	D		ND				0.05	0.3	0.17		**5.7**
PET265	W	0.09	J				1.58	**9.9**	0.35		**11.7**
PET265	S		ND				1.27	**7.9**	0.21		**6.8**
PET265	D		ND				0.93	**5.8**	0.25		**8.3**
PET280	W	0.1			a		1.74	**10.9**	0.38		**12.7**
PET280	S		ND				0.10	0.6	0.35		**11.7**
PET280	D		ND				0.06	0.4	0.37		**12.4**
PET310	W	0.1			a		2.40	**15.0**	1.39		**46.3**
PET310	S	0.09	J				1.13	**7.1**	0.99		**32.9**
PET310	D	0.1		0.001		0.04	0.26	**1.6**	2.04		**68.0**
PET400	W	0.10	J				0.89	**5.6**	0.48		**16.1**
PET400	S		ND				0.24	**1.5**	0.34		**11.3**
PET400	D	0.05	J				0.11	0.7	0.61		**20.3**
SMA020	W	0.07	J				0.60	**3.8**	0.24		**8.1**
SMA020	S		ND				0.33	**2.0**	0.34		**11.5**
SMA020	D		ND				0.20	**1.3**	0.09		**3.1**
SMA160	W		ND				0.11	0.7	0.037	J	**1.2**
SMA160	S		ND				0.08	0.5		ND	0.0
SMA160	D		ND				0.06	0.4		ND	0.0
SMA180	W		ND				0.13	0.8	0.037	J	**1.2**
SMA180	S		ND				0.13	0.8		ND	0.0
SMA180	D		ND				0.21	**1.3**		ND	0.0

Notes: (a) pH not recorded.

(b) Unionized NH3 conentration is 0.004mg/L at pH7; 0.013mg/L at 7.5; and 0.025 at pH 7.8: pH is not likely to be above 7.5

ND=not detected. "J" is defined as 'estimated'; the analyte was detected, but the value is below the Reporting Limit

Table D-3b: Concentrations of selected nutrients, chlorphyll a, TOC, and SSC in 2003 samples

Station	Season	Nitrite as N (mg/L)		Nitrogen, Total Kjeldahl (mg/L)		Ortho - Phosphate as P (mg/L)	Chloro - phyll a (µg/L)	Total Organic Carbon (mg/L)	Suspended Sediment Conc. (mg/L)	
KIR020	W	0.12		3.2		0.04	4.3	11.4	36.4	
KIR020	S	0.01		0.8		0.01	14.6	8.9	63.5	
KIR020	D		ND	1.2		0.06	15.7	5.1	10.9	
KIR115	W	0.02		1.1		0.05	3.1	6.9	70.8	
KIR115	S	0.02		0.7		0.06	29.5	4.4	42.6	
MTD010	W	0.03		0.27	J	0.03	0.98	3.4	6.0	
MTD010	S	0.05		2.9		0.10	17.7	16	142.4	
MTD050	W	0.01		0.31	J	0.02	6.1	2.6	2.2	
MTD050	S		ND	0.19	J	0.03	2.36	2	0.7	
MTD050	D	0.008	J	0.37	J	0.04	5.32	2.4	2.1	
MTD060	W	0.01		0.20	J	0.02	7.2	2	2.6	
MTD060	S		ND	0.16	J	0.03	3.19	2.1	0.9	
MTD060	D		ND	0.50	J	0.03	9.87	2.4	0.8	
MTD100	W		ND	0.13	J	0.02	0.74	1.4		ND
MTD100	S		ND	0.20	J	0.02	5.04	1.6	2.8	
MTD120	W		ND	0.12	J	0.01	0.09	1	1.7	
MTD120	S		ND		ND	0.01	1.03	1.2	3.2	
MTD120	D		ND	0.14	J	0.02	0.93	1.4		ND
MTD140	W		ND	0.16	J	0.01	0.31	1	0.9	
MTD140	S		ND		ND	0.01	2.73	1.3	1.6	
MTD140	D		ND	0.15	J	0.02	0.92	1.2		ND
PET010	W	0.05		1.3		0.51	0.3	8.2	1.1	
PET010	S	0.008	J	1.0		0.42	4.99	5.9	3.8	
PET130	W	0.007	J	0.43	J	0.20	0.19	3.7		ND
PET130	S		ND	0.23	J	0.18	9.2	2.4	1.0	
PET130	D		ND	0.43	J	0.20	1.02	2.4	5.5	
PET150	W	0.006	J	0.5		0.19	1.01	3.8		ND
PET150	S		ND	0.28	J	0.14	35.7	2.4	3.0	
PET150	D		ND	0.37	J	0.20	6.13	2.2	0.8	
PET265	W	0.007	J	0.6		0.38	0.19	4.4	0.8	
PET265	S	0.01		0.32	J	0.23	12.9	3.5	3.0	
PET265	D		ND	0.7		0.25	3.53	2.6	37.8	
PET280	W	0.01		0.7		0.38	0.57	5.1		ND
PET280	S		ND	0.6		0.34	14.9	3.5	32.7	
PET280	D		ND	0.6		0.43	7.1	3.4	20.9	
PET310	W	0.04		2.3		1.26	5.3	15.1	3.4	
PET310	S	0.02		1.5		0.90	1.37	9.8	6.6	
PET310	D	0.007	J	1.6		0.85	45.4	6.7	2.4	
PET400	W	0.01		1.0		0.50	0.5	9.5	10.4	
PET400	S	0.007	J	0.6		0.30	1.86	5.2	3.8	
PET400	D		ND	1.3		0.37	64.6	4.6	122.5	
SMA020	W	0.04		0.49	J	0.21	0.20	4.2	3.7	
SMA020	S	0.008	J	0.7		0.35	8.07	5.6	6.3	
SMA020	D		ND	0.5		0.09	4.93	3.6	4.2	
SMA160	W		ND	0.22	J	0.01	0.05	2.6	0.9	
SMA160	S		ND	0.19	J	0.01	9.47	2	1.6	
SMA160	D		ND	0.22	J	0.02	0.49	1.1	1.4	
SMA180	W		ND	0.19	J	0.01	0.18	2.5		ND
SMA180	S		ND	0.27	J	0.02	3.12	2.9	3.2	
SMA180	D		ND	0.35	J	0.02	2.37	2.3	3.9	

ND=not detected. "J" is defined as 'estimated'; the analyte was detected, but the value is below the Reporting Limit

Table D-3c: Concentrations of salts in, and related attributes of, 2003 samples

Station	Season	Alkalinity as CaCO3 (mg/L)	Chloride (mg/L)	Hardness as CaCO3 (mg/L)	Sulfate (mg/L)	Boron, Total (mg/L)	
KIR020	W	67	27.3	120	50.5	0.2	
KIR020	S	358	110.0	388	202.0	0.4	
KIR020	D	88	29.1	99	31.6	0.3	
KIR115	W	540	***265.0***	***1060***	***1410.0***	***2.1***	
KIR115	S	386	***209.0***	***776***	***1140.0***	***1.6***	
MTD010	W	327	100.0	436	86.6	0.4	
MTD010	S	97	27.2	136	42.5	0.2	
MTD050	W	218	25.0	248	60.8	0.5	
MTD050	S	273	85.7		203.0	0.5	
MTD050	D	305	63.8		124.0	0.7	
MTD060	W	231	23.8	380	60.8	0.5	
MTD060	S	274	73.2		186.0	0.4	
MTD060	D	296	51.1		113.0	0.6	
MTD100	W	215	11.7	284	58.2	0.5	
MTD100	S	218	14.2	252	55.6	0.5	
MTD120	W	199	6.8	216	30.0	0.5	
MTD120	S	201	7.6		32.9	0.4	
MTD120	D	213	8.0		35.1	0.5	
MTD140	W	216	6.1	220	15.6	0.3	
MTD140	S	206	5.3		14.2	0.3	
MTD140	D	245	7.1		21.0	0.5	
PET010	W	150	28.5	162	22.5	0.1	
PET010	S	185	42.3	194	27.8	0.2	
PET130	W	121	11.7	113	13.1	0.1	
PET130	S	151	13.7		11.1	0.1	
PET130	D	176	16.6		10.1	0.1	J
PET150	W	114	11.5	107	13.1	0.1	
PET150	S	146	12.3		11.1	0.1	J
PET150	D	152	12.4		9.2	0.06	J
PET265	W	185	25.5	176	13.2	0.2	
PET265	S	214	37.2		16.9	0.06	J
PET265	D	224	43.6		18.1	0.1	
PET280	W	164	22.4	155	13.3	0.2	
PET280	S	203	33.2		10.5	0.1	
PET280	D	222	39.2		12.5	0.2	
PET310	W	172	76.6	219	42.4	0.2	
PET310	S	231	113.0	291	96.1	0.2	
PET310	D	288	181.0	386	63.2	0.3	
PET400	W	123	31.3	152	27.9	0.2	
PET400	S	179	47.1		55.1	0.06	J
PET400	D	181	60.2		97.4	0.1	
SMA020	W	216	51.5	243	37.0	0.2	
SMA020	S	206	44.5	213	34.7	0.2	
SMA020	D	242	52.4	267	41.1	0.1	
SMA160	W	76	22.3	82.3	11.5	0.06	J
SMA160	S	93	21.9		8.0	0.06	J
SMA160	D	97	21.6		7.5	0.1	
SMA180	W	149	60.5	325	208.0	0.1	
SMA180	S	134	48.7		167.0	0.1	
SMA180	D	199	92.9		290.0	0.2	

ND=not detected. "J" is defined as 'estimated'; the analyte was detected below the Reporting Limit

Table D-3d: Field observations and measurement results in 2003 water sample collection Station Visits

Station	Season	Oxygen, % Saturation	pH	Salinity (ppt)	Specific Conductivity (µS/cm)	Temperature (°C)	Turbidity (NTU)	Water Clarity	Water Color	Sky Code	Precipitation	Velocity (ft/s)	Flow comments
KIR020	W	85.5	NR	0.21	432	9.86	32.0	Semi-clear,	Brown,	fog,	Drizzle,		Steady flow
KIR020	S	105.6	7.18	0.56	1124	13.44	11.3	Semi-clear,		partly cloudy,	Dry,		Slight flow
KIR020	D	84.4	7.41	0.17	348	23.91	0.1	Semi-clear,	Colorless,	clear,	Dry,		
KIR115	W	173.9	NR	2.33	4375	10.52	13.1	Semi-clear,	Brown,	overcast,	Drizzle,		Visible, low
KIR115	S	94.3	7.82	1.73	3284	13.68	13.8	Semi-clear,	Colorless,	partly cloudy,	Drizzle,		Visible, low
MTD010	W	93.9	NR	0.49	1025	11.6	29.0	Semi-clear,	Green,	fog,	Rain,		Visible, low
MTD010	S	90.8	7.48	0.56	1131	14.46	10.8	Turbid,	Colorless,	partly cloudy,	Rain,		Visible, low
MTD050	W	141	NR	0.33	676	11.55	3.6	Clear,	Colorless,	overcast,	Dry,		Measurable
MTD050	S	93.2	7.91	0.39	786	12.66	3.0	Clear,	Colorless,	partly cloudy,	Dry,	1.57	
MTD050	D	91.9	7.92	0.48	963	17.78	0.8	Clear,	Colorless,	clear,	Dry,		
MTD060	W	135.3	NR	0.34	684	11.92	1.7	Clear,	Colorless,	overcast,	Dry,		Measurable
MTD060	S	95.9	7.59	0.37	761	12.82	6.3	Clear,	Colorless,	partly cloudy,	Dry,	1.22	
MTD060	D	105.5	7.63	0.21	885	17.48	0.3	Clear,	Colorless,	clear,	Dry,	2.11	
MTD100	W	139.1	NR	0.28	579	14.55	0.0	Clear,	Colorless,	overcast,	Drizzle,		Measurable
MTD100	S	95.4	7.71	0.26	535	12.03	2.0	Clear,	Colorless,	partly cloudy,	Dry,	1.37	
MTD120	W	125.4	NR	0.22	448	11.31	0.0	Clear,	Colorless,	overcast,	Dry,		Steady flow
MTD120	S	98.7	7.68	0.21	438	11.65	0.5	Clear,	Colorless,	partly cloudy,	Dry,	1.73	
MTD120	D	97.9	7.89	0.23	472	16.27	0.3	Clear,		clear,	Dry,		
MTD140	W	131.4	NR	0.21	426	10.52	1.0	Clear,	Colorless,	overcast,	Dry,		Measurable
MTD140	S	93.3	8	0.19	399	10.9	1.1	Clear,	Colorless,	partly cloudy,	Dry / rain	0.956	
MTD140	D	93.6	7.98	0.24	494	16.92	0.4	Clear,	Colorless,	clear,	Dry,	2.36	
PET010	W	86.1	NR	0.21	429	9.67	8.7	Semi-clear,	Brown,	fog,	Dry,	1.91	
PET010	S	76.6	7.57	0.25	0.504	12.21	3.9	Clear,	Colorless,	clear,	Dry,		Visible, low
PET130	W	94.9	NR	0.14	297	8.59	2.7	Clear,	Colorless,	Overcast /Fog	Dry,	1.06	
PET130	S	86.2	7.53	0.16	336	10.57	1.3	Clear,	Colorless,	clear,	Dry,	0.679	
PET130	D	95.8	7.77	0.19	395	23.76	0.8	Clear,	Colorless,	clear,	Dry,		

Table D-3d (cont.)

Station	Season	Oxygen, % Saturation	pH	Salinity (ppt)	Specific Conductivity (µS/cm)	Temper - ature (°C)	Turbidity (NTU)	Water Clarity	Water Color	Sky Code	Preci - pitation	Velocity (ft/s)	Flow comments
PET150	W	102.5	NR	0.14	284	8.33	2.6	Semi-clear,	Brown,	fog,	Dry,	0.818	
PET150	S	95.9	7.93	0.15	320	8.83	3.8	Clear,	Colorless,	clear,	Dry,	1.15	
PET150	D	115.2	8.88	0.16	331	28.27	2.2	Clear,	Colorless,	clear,	Dry,		
PET265	W	91.6	NR	0.22	449	10.19	0.6	Semi-clear,	Brown,	fog,	Dry,	0.726	
PET265	S	69.5	7.5	0.25	509	11.59	1.1	Clear,	Colorless,	clear,	Dry,		Visible, low
PET265	D	110.6	8.24	0.28	573	20.57	0.2	Clear,	Colorless,	clear,	Dry,		
PET280	W	105.4	NR	0.2	407	10.31	1.8	Clear,	Colorless,	fog,	Dry,	1.04	
PET280	S	104.1	8.15	0.23	479	15.64	2.8	Clear,	Colorless,	partly cloudy,	Dry,		Visible, low
PET280	D	42.1	7.11	0.26	544	20	2.5	Clear,	Colorless,	clear,	Dry,		
PET310	W	84.8	NR	0.32	662	9.79	6.7	Turbid,	Brown,	fog,	Dry,		Visible, low
PET310	S	85	7.27	0.44	889	15.25	6.3	Semi-clear,	Brown,	partly cloudy,	Dry,		Visible, low
PET310	D	152.8	7.46	0.59	1189	21.44	2.6	Clear,	Colorless,	clear,	Dry,		
PET400	W	93.8	NR	0.19	396	9.41	4.2	Semi-clear,	Brown,	fog,	Dry,		Visible, low
PET400	S	102.1	7.39	0.27	560	14.25	4.1	Clear,	Colorless,	clear,	Dry,		Visible, low
PET400	D	112	7.3	0.35	709	19.65	2.3	Clear,	Colorless,	clear,	Dry,		
SMA020	W	88.2	8.05	0.31	625	12.57	4.7	Turbid,	Green,	fog,	Dry,		Visible, low
SMA020	S	89.9	7.84	0.26	537	12.95	10.0	Semi-clear,	Green,	clear,	Dry,		Visible, low
SMA020	D	99.6	8.18	0.32	660	16.27	1.5	Clear,	Colorless,	clear,	Dry,		
SMA160	W	92.4	6.58	0.11	235	11.38	4.6	Clear,	Colorless,	overcast,	Dry,	1.52	
SMA160	S	85.2	7.32	0.12	259	10.89	2.6	Clear,	Colorless,	clear,	Dry,		Visible, low
SMA160	D	87.9	7.31	0.13	267	11.51	1.3	Clear,	Colorless,	clear,	Dry,		
SMA180	W	92.1	6.91	0.42	855	10.96	0.4	Clear,	Colorless,	overcast,	Dry,		Visible, low
SMA180	S	86.2	7.8	0.36	724	10.69	2.2	Clear,	Colorless,	clear,	Dry,	0.765	
SMA180	D	99.6	7.65	0.58	1159	13.53	0.6	Clear,	Colorless,	clear,	Dry,		

ND = Not Detected. NR = Not Recorded

Table D-3e: Alignment of Flow observations with constituent concnetrations and DO exceedances

Station	Season	Specific Conductance (µS/cm)	Temper-ature (°C)	Turbidity (NTU)	Water Color	Velocity (ft/s)	Flow Conditons (Note 1)	Station Water Depth (m)	Stream Width (m)	Nitrate as N (mg/L)	Nitrogen, Total Kjeldahl (mg/L)	Ortho - Phosphate as P (mg/L)	Phosphorus as P,Total (mg/L)	Chloro - phyll *a* (µg/L)	Sonde DO exceed - ances (Note 2)
KIR020	W	432	9.86	32.0	Brown,		Steady flow	0.25	2.5	0.07	3.16	0.04	0.13	4.30	x
KIR020	S	1124	13.44	11.3			Slight flow			0.05	0.82	0.01	0.09	14.60	x
KIR020	D	348	23.91	0.1	Colorless,		Visible, flat (?)	0.3	2.5	1.71	1.17	0.06	0.15	15.70	
KIR115	W	4375	10.52	13.1	Brown,		Visible, low	0.2	2	0.36	1.06	0.05	0.08	3.10	
KIR115	S	3284	13.68	13.8	Colorless,		Visible, low	0.3	2	0.42	0.68	0.06	0.08	29.50	x
MTD010	W	1025	11.6	29.0	Green,		Visible, low	0.5	5	1.63	0.27	0.03	0.03	0.98	x
MTD010	S	1131	14.46	10.8	Colorless,		Visible, low	0.6	7	0.92	2.91	0.10	0.28	17.70	x
MTD050	W	676	11.55	3.6	Colorless,		Measurable	0.3	3	0.76	0.31	0.02		6.10	
MTD050	S	786	12.66	3.0	Colorless,	1.6	>0.6 ft/s	0.3	3	0.79	0.19	0.03	0.03	2.36	n
MTD050	D	963	17.78	0.8	Colorless,		Visible, flat (?)	0.1	2	0.80	0.37	0.04	0.03	5.32	
MTD060	W	684	11.92	1.7	Colorless,		Measurable	0.5	8	0.66	0.20	0.02	0.03	7.20	
MTD060	S	761	12.82	6.3	Colorless,	1.2	>0.6 ft/s	0.5	7	0.76	0.16	0.03		3.19	
MTD060	D	885	17.48	0.3	Colorless,	2.1	>0.6 ft/s	0.75	2	0.87	0.50	0.03		9.87	
MTD100	W	579	14.55	0.0	Colorless,		Measurable	0.1	1	0.87	0.13	0.02		0.74	
MTD100	S	535	12.03	2.0	Colorless,	1.4	>0.6 ft/s	0.3	2	0.48	0.20	0.02		5.04	
MTD120	W	448	11.31	0.0	Colorless,		Steady flow	0.1	1	0.04	0.12	0.01		0.09	
MTD120	S	438	11.65	0.5	Colorless,	1.7	>0.6 ft/s	0.15	1.5	0.05		0.01		1.03	n
MTD120	D	472	16.27	0.3			Visible, flat (?)	0.1	1	0.04	0.14	0.02		0.93	
MTD140	W	426	10.52	1.0	Colorless,		Measurable	0.2	1.5	0.07	0.16	0.01	0.03	0.31	
MTD140	S	399	10.9	1.1	Colorless,	1.0	>0.6 ft/s	0.3	2	0.06		0.01		2.73	
MTD140	D	494	16.92	0.4	Colorless,	2.4	>0.6 ft/s	0.5	2	0.06	0.15	0.02		0.92	
PET010	W	429	9.67	8.7	Brown,	1.9	>0.6 ft/s	0.5	4	0.57	1.32	0.51	0.44	0.30	x
PET010	S	0.504	12.21	3.9	Colorless,		Visible, low	0.6	8	1.71	0.98	0.42	0.61	4.99	x
PET130	W	297	8.59	2.7	Colorless,	1.1	>0.6 ft/s	0.25	4	0.07	0.43	0.20	0.17	0.19	
PET130	S	336	10.57	1.3	Colorless,	0.7	>0.6 ft/s	0.1	2	0.07	0.23	0.18	0.16	9.20	n
PET130	D	395	23.76	0.8	Colorless,		Visible, flat (?)	0.1	1	1.30	0.43	0.20	0.26	1.02	

Table D-3e (cont.)

Station	Season	Specific Conductance (µS/cm)	Temperature (°C)	Turbidity (NTU)	Water Color	Velocity (ft/s)	Flow Conditons (Note 1)	Station Water Depth (m)	Stream Width (m)	Nitrate as N (mg/L)	Nitrogen, Total Kjeldahl (mg/L)	Ortho-Phosphate as P (mg/L)	Phosphorus as P,Total (mg/L)	Chlorophyll *a* (µg/L)	Sonde DO exceedances (Note 2)
PET150	W	284	8.33	2.6	Brown,	0.8	>0.6 ft/s	0.5	3	0.06	0.53	0.19	0.13	1.01	
PET150	S	320	8.83	3.8	Colorless,	1.2	>0.6 ft/s	0.1	2	0.05	0.28	0.14	0.17	35.70	
PET150	D	331	28.27	2.2	Colorless,		Visible, flat (?)	0.3	1.5	1.51	0.37	0.20	0.19	6.13	
PET265	W	449	10.19	0.6	Brown,	0.7	>0.6 ft/s	0.5	2	1.58	0.56	0.38	0.35	0.19	n
PET265	S	509	11.59	1.1	Colorless,		Visible, low	0.3	2	1.27	0.32	0.23	0.21	12.90	x
PET265	D	573	20.57	0.2	Colorless,		Visible, flat (?)	0.2	1	0.93	0.73	0.25	0.25	3.53	x
PET280	W	407	10.31	1.8	Colorless,	1.0	>0.6 ft/s	0.25	1.75	0.10	0.68	0.38	0.35	0.57	
PET280	S	479	15.64	2.8	Colorless,		Visible, low	0.1	1.5	0.06	0.59	0.34	0.37	14.90	
PET280	D	544	20	2.5	Colorless,		Visible, flat (?)	0.1	1	1.74	0.55	0.43	0.38	7.11	
PET310	W	662	9.79	6.7	Brown,		Visible, low	1	4	1.13	2.27	1.26	0.99	5.30	n
PET310	S	889	15.25	6.3	Brown,		Visible, low	0.6	7	2.40	1.48	0.90	1.39	1.37	x
PET310	D	1189	21.44	2.6	Colorless,		Visible, flat (?)	0.3	3.5	0.26	1.58	0.85	2.04	45.40	x
PET400	W	396	9.41	4.2	Brown,		Visible, low	0.8	3	0.89	1.02	0.50	0.48	0.48	n,r
PET400	S	560	14.25	4.1	Colorless,		Visible, low	0.5	2	0.11	0.63	0.30	0.61	1.86	x
PET400	D	709	19.65	2.3	Colorless,		Visible, flat (?)	0.3	1.5	0.24	1.32	0.37	0.34	64.60	x,r
SMA020	W	625	12.57	4.7	Green,		Visible, low	0.3	2	0.60	0.49	0.21	0.24	0.20	n
SMA020	S	537	12.95	10.0	Green,		Visible, low	0.6	3	0.33	0.69	0.35	0.34	8.07	n
SMA020	D	660	16.27	1.5	Colorless,		Visible, flat (?)	0.5	3.5	0.20	0.50	0.09	0.09	4.93	x
SMA160	W	235	11.38	4.6	Colorless,	1.5	>0.6 ft/s	0.5	2	0.11	0.22	0.01	0.04	0.05	
SMA160	S	259	10.89	2.6	Colorless,		Visible, low	0.3	1	0.08	0.19	0.01		9.47	
SMA160	D	267	11.51	1.3	Colorless,		Visible, flat (?)	0.1	1.5	0.06	0.22	0.02		0.49	
SMA180	W	855	10.96	0.4	Colorless,		Visible, low	0.3	1.8	0.13	0.19	0.01	0.04	0.18	
SMA180	S	724	10.69	2.2	Colorless,	0.8	>0.6 ft/s	0.3	1.5	0.13	0.27	0.02		3.12	n,r
SMA180	D	1159	13.53	0.6	Colorless,		Visible, flat (?)	0.7	3.5	0.21	0.35	0.02		2.37	

Note 1: Flow conditions category 'Visible, low' is based on "visible - not rmeasurable flow" in cruise report or data sheet comment
Flow conditions category 'Visible, flat (?)' is the interpretation of "Flow was visible, but centroid velocity measurements were not able to be taken" in cruise report

Note 2: Sonde runs were alinged by season, some were deplyed at sample collection time, all were run within same season.
x' indicates DO fell below 7.0 at least once during that run; **'n'** indicates no exceedances; **'r'** indicates the dataset was rejected for quality deficiency or uncertainty

Table D-3f: Field observations and measurements on a rainy day (April 21, 2003) and the next

Station	Season	Sample Date	Sample Time	Specific Conductivity (µS/cm)	Turbidity (NTU)	Water Clarity	Velocity (ft/s)	Preci - pitation	Sky Code	Comment
MTD140	S	21/Apr/2003	10:15	399	1.1	Clear,	0.956	Dry / rain	partly cloudy,	It rained on an off during the day
MTD120	S	21/Apr/2003	10:55	438	0.5	Clear,	1.73	Dry,	partly cloudy,	
MTD100	S	21/Apr/2003	11:15	535	2.0	Clear,	1.37	Dry,	partly cloudy,	
MTD060	S	21/Apr/2003	11:50	761	6.3	Clear,	1.22	Dry,	partly cloudy,	
MTD050	S	21/Apr/2003	12:10	786	3.0	Clear,	1.57	Dry,	partly cloudy,	
KIR115	S	21/Apr/2003	12:45	3284	13.8	Semi-clear,	low	Drizzle,	partly cloudy,	The water in this site was not diluted
KIR020	S	21/Apr/2003	14:20	1124	11.3	Semi-clear,	low	Dry,	partly cloudy,	
MTD010	S	21/Apr/2003	16:00	1131	10.8	Turbid,	low ??	Rain,	partly cloudy,	By this time the runoff arrived
PET310	S	21/Apr/2003	17:45	889	6.3	Semi-clear,	low	Dry,	partly cloudy,	Petaluma River watershed was dry that evening
PET400	S	21/Apr/2003	18:30	560	4.1	Clear,	low	Dry,	clear,	
PET280	S	21/Apr/2003	18:50	479	2.8	Clear,	low	Dry,	partly cloudy,	
next day...										
PET265	S	22/Apr/2003	6:55	509	1.1	Clear,	low	Dry,	clear,	
PET150	S	22/Apr/2003	7:15	320	3.8	Clear,	1.15	Dry,	clear,	
PET130	S	22/Apr/2003	7:45	336	1.3	Clear,	0.679	Dry,	clear,	
PET010	S	22/Apr/2003	8:20	504	3.9	Clear,	low	Dry,	clear,	
SMA160	S	22/Apr/2003	12:25	259	2.6	Clear,	low	Dry,	clear,	
SMA180	S	22/Apr/2003	13:05	724	2.2	Clear,	0.765	Dry,	clear,	
SMA020	S	22/Apr/2003	15:00	537	10.0	Semi-clear,	low	Dry,	clear,	

Table D-4: Comparison of metal concentrations in 2003 samples to water quality objectives (WQOs)

D-4a: Trace metals with hardness-dependent WQOs

Station	Sea-son	Hard-ness (mg/L)	Metal Name	Metal, Total (ug/L)		Metal, Dissolved (ug/L)		Acute WQ Objective (ug/L)	Acute Exceed-ance Factor	Chronic WQ Objective (ug/L)	Chronic Exceed-ance Factor	WQ Objective Fraction
KIR020	W	120	Cadmium	**0.201**		0.087		4.8	0.04	1.3	0.15	Total
KIR020	S	388	Cadmium	**0.080**		0.017	J	18.1	0.00	3.3	0.02	Total
KIR020	D	99	Cadmium	**0.043**	J	0.025	J	3.9	0.01	1.1	0.04	Total
KIR115	W	1060	Cadmium	**0.067**		0.039	J	56.2	0.00	7.2	0.01	Total
KIR115	S	776	Cadmium	**0.034**	J	0.026	J	39.6	0.00	5.7	0.01	Total
MTD010	W	436	Cadmium	**0.025**	J	0.019	J	20.6	0.00	3.6	0.01	Total
MTD010	S	136	Cadmium	**0.504**		0.112		5.5	0.09	1.4	0.35	Total
MTD100	W	284	Cadmium	**0.003**	J	0.002	J	12.7	0.00	2.6	0.00	Total
MTD100	S	252	Cadmium	**0.004**	J	0.004	J	11.1	0.00	2.3	0.00	Total
PET010	W	162	Cadmium	**0.003**	J	0.003	J	6.8	0.00	1.7	0.00	Total
PET010	S	194	Cadmium	**0.005**	J	0.003	J	8.3	0.00	1.9	0.00	Total
PET310	W	219	Cadmium	**0.018**	J	0.015	J	9.5	0.00	2.1	0.01	Total
PET310	S	291	Cadmium	**0.020**	J	0.017	J	13.1	0.00	2.6	0.01	Total
PET310	D	386	Cadmium	**0.007**	J	0.007	J	18.0	0.00	3.3	0.00	Total
SMA020	W	243	Cadmium	**0.023**	J	0.020	J	10.7	0.00	2.3	0.01	Total
SMA020	S	213	Cadmium	**0.028**	J	0.018	J	9.2	0.00	2.1	0.01	Total
SMA020	D	267	Cadmium	**0.015**	J	0.009	J	11.9	0.00	2.5	0.01	Total

Total and dissolved Cadmium MDL = 0.002; RL=0.05 ug/L

Station	Sea-son	Hard-ness (mg/L)	Metal Name	Metal, Total (ug/L)		Metal, Dissolved (ug/L)		Acute WQ Objective (ug/L)	Acute Exceed-ance Factor	Chronic WQ Objective (ug/L)	Chronic Exceed-ance Factor	WQ Objective Fraction
KIR020	W	120	Copper	10.8		**6.64**		16.6	0.40	10.9	0.61	Dissolved
KIR020	S	388	Copper	4.32		**2.25**		50.2	0.04	29.7	0.08	Dissolved
KIR020	D	99	Copper	3.86		**3.17**		13.9	0.23	9.2	0.34	Dissolved
KIR115	W	1060	Copper	7.08		**5.58**		129.5	0.04	70.1	0.08	Dissolved
KIR115	S	776	Copper	9.25		**8.42**		96.5	0.09	53.7	0.16	Dissolved
MTD010	W	436	Copper	2.18		**1.82**		56.1	0.03	32.8	0.06	Dissolved
MTD010	S	136	Copper	30.9		**10.9**		18.7	0.58	12.1	0.90	Dissolved
MTD100	W	284	Copper	1.47		**1.46**		37.4	0.04	22.8	0.06	Dissolved
MTD100	S	252	Copper	1.72		**1.31**		33.4	0.04	20.6	0.06	Dissolved
PET010	W	162	Copper	2.74		**2.47**		22.1	0.11	14.1	0.18	Dissolved
PET010	S	194	Copper	2.54		**2.38**		26.1	0.09	16.4	0.14	Dissolved
PET310	W	219	Copper	4.8		**4.36**		29.3	0.15	18.2	0.24	Dissolved
PET310	S	291	Copper	3.82		**3.67**		38.3	0.10	23.2	0.16	Dissolved
PET310	D	386	Copper	1.8		**1.76**		50.0	0.04	29.6	0.06	Dissolved
SMA020	W	243	Copper	5.42		**4.66**		32.3	0.14	19.9	0.23	Dissolved
SMA020	S	213	Copper	7.76		**6.25**		28.5	0.22	17.8	0.35	Dissolved
SMA020	D	267	Copper	3.36		**2.6**		35.3	0.07	21.6	0.12	Dissolved

Total and dissolved Copper MDL = 0.003; RL=0.01 ug/L

Station	Sea-son	Hard-ness (mg/L)	Metal Name	Metal, Total (ug/L)		Metal, Dissolved (ug/L)		Acute WQ Objective (ug/L)	Acute Exceed-ance Factor	Chronic WQ Objective (ug/L)	Chronic Exceed-ance Factor	WQ Objective Fraction
KIR020	W	120	Lead	3.270		**0.307**		103.0	0.003	4.01	0.077	Dissolved
KIR020	S	388	Lead	1.600		**0.015**	J	458.7	0.000	17.87	0.001	Dissolved
KIR020	D	99	Lead	0.399			ND	80.6	0.000	3.14	0.000	Dissolved
KIR115	W	1060	Lead	0.854		**0.034**	J	1648.7	0.000	64.25	0.001	Dissolved
KIR115	S	776	Lead	0.444		**0.011**	J	1108.5	0.000	43.20	0.000	Dissolved
MTD010	W	436	Lead	0.385		**0.076**		532.1	0.000	20.74	0.004	Dissolved
MTD010	S	136	Lead	17.600		**0.427**		120.8	0.004	4.71	0.091	Dissolved
MTD100	W	284	Lead	0.008	J	**0.004**	J	308.3	0.000	12.01	0.000	Dissolved
MTD100	S	252	Lead	0.066		**0.002**	J	264.8	0.000	10.32	0.000	Dissolved
PET010	W	162	Lead	0.094		**0.027**	J	150.9	0.000	5.88	0.005	Dissolved
PET010	S	194	Lead	0.084		**0.017**	J	189.8	0.000	7.40	0.002	Dissolved
PET310	W	219	Lead	0.313		**0.087**		221.5	0.000	8.63	0.010	Dissolved
PET310	S	291	Lead	0.239		**0.044**	J	318.0	0.000	12.39	0.004	Dissolved
PET310	D	386	Lead	0.022	J		ND	455.7	0.000	17.76	0.000	Dissolved
SMA020	W	243	Lead	0.530		**0.102**		252.8	0.000	9.85	0.010	Dissolved
SMA020	S	213	Lead	1.120		**0.181**		213.8	0.001	8.33	0.022	Dissolved
SMA020	D	267	Lead	0.580		**0.034**	J	285.0	0.000	11.11	0.003	Dissolved

Total and dissolved Lead MDL = 0.002; RL=0.05 ug/L

Table D-4a (Cont.)

Station	Sea-son	Hard-ness (mg/L)	Metal Name	Metal, Total (ug/L)	Metal, Dissolved (ug/L)	Acute WQ Objective (ug/L)	Acute Exceed-ance Factor	Chronic WQ Objective (ug/L)	Chronic Exceed-ance Factor	WQ Objective Fraction
KIR020	W	120	Nickel	5.46	**3.63**	547	0.01	61	0.06	Dissolved
KIR020	S	388	Nickel	5.43	**4.36**	1477	0.00	164	0.03	Dissolved
KIR020	D	99	Nickel	2.25	**1.82**	465	0.00	52	0.04	Dissolved
KIR115	W	1060	Nickel	6.14	**4.76**	3457	0.00	384	0.01	Dissolved
KIR115	S	776	Nickel	0.17	ND	2656	0.00	295	0.00	Dissolved
MTD010	W	436	Nickel	3.01	**2.71**	1631	0.00	181	0.01	Dissolved
MTD010	S	136	Nickel	14.40	**4.91**	609	0.01	68	0.07	Dissolved
MTD100	W	284	Nickel	0.95	**0.85**	1135	0.00	126	0.01	Dissolved
MTD100	S	252	Nickel	0.53	**0.15**	1025	0.00	114	0.00	Dissolved
PET010	W	162	Nickel	7.84	**7.11**	706	0.01	78	0.09	Dissolved
PET010	S	194	Nickel	6.39	**5.64**	822	0.01	91	0.06	Dissolved
PET310	W	219	Nickel	12.40	**12.00**	911	0.01	101	0.12	Dissolved
PET310	S	291	Nickel	9.80	**9.39**	1158	0.01	129	0.07	Dissolved
PET310	D	386	Nickel	7.75	**7.30**	1471	0.00	164	0.04	Dissolved
SMA020	W	243	Nickel	3.87	**3.46**	994	0.00	111	0.03	Dissolved
SMA020	S	213	Nickel	3.62	**2.59**	889	0.00	99	0.03	Dissolved
SMA020	D	267	Nickel	3.35	**2.08**	1077	0.00	120	0.02	Dissolved
Total and dissolved Nickel MDL = 0.006; RL=0.018 ug/L										
KIR020	W	120	Silver	0.775	**0.416**	5.6	0.075			Dissolved
KIR020	S	388	Silver	ND	ND	41.8				
KIR020	D	99	Silver	ND	ND	4.0				
KIR115	W	1060	Silver	ND	ND	235.5				
KIR115	S	776	Silver	ND	ND	137.7				
MTD010	W	436	Silver	ND	ND	51.1				
MTD010	S	136	Silver	0.052 J	ND	6.9				
MTD100	W	284	Silver	ND	ND	24.4				
MTD100	S	252	Silver	ND	ND	19.9				
PET010	W	162	Silver	ND	ND	9.3				
PET010	S	194	Silver	ND	ND	12.7				
PET310	W	219	Silver	ND	ND	15.6				
PET310	S	291	Silver	ND	ND	25.5				
PET310	D	386	Silver	ND	**0.009** J	41.4	0.000			Dissolved
SMA020	W	243	Silver	ND	ND	18.7				
SMA020	S	213	Silver	ND	ND	14.9				
SMA020	D	267	Silver	ND	ND	22.0				
Total and dissolved Silver MDL = 0.008; RL=0.1 ug/L. Chronic objective is not available										
KIR020	W	120	Zinc	106.00	**69.00**	139.8	0.49	139.8	0.49	Dissolved
KIR020	S	388	Zinc	25.70	**7.29**	377.9	0.02	377.9	0.02	Dissolved
KIR020	D	99	Zinc	8.64	**4.16**	118.8	0.04	118.8	0.04	Dissolved
KIR115	W	1060	Zinc	10.60	**5.88**	885.6	0.01	885.6	0.01	Dissolved
KIR115	S	776	Zinc	7.08	**5.34**	680.0	0.01	680.0	0.01	Dissolved
MTD010	W	436	Zinc	9.63	**8.58**	417.2	0.02	417.2	0.02	Dissolved
MTD010	S	136	Zinc	271.00	**85.90**	155.5	0.55	155.5	0.55	Dissolved
MTD100	W	284	Zinc	0.84	**0.79**	290.1	0.00	290.1	0.00	Dissolved
MTD100	S	252	Zinc	1.06	**0.50**	262.2	0.00	262.2	0.00	Dissolved
PET010	W	162	Zinc	1.86	**1.17**	180.3	0.01	180.3	0.01	Dissolved
PET010	S	194	Zinc	0.97	**0.70**	210.1	0.00	210.1	0.00	Dissolved
PET310	W	219	Zinc	9.82	**7.64**	232.8	0.03	232.8	0.03	Dissolved
PET310	S	291	Zinc	6.78	**5.55**	296.2	0.02	296.2	0.02	Dissolved
PET310	D	386	Zinc	2.54	**1.99**	376.3	0.01	376.3	0.01	Dissolved
SMA020	W	243	Zinc	7.75	**6.05**	254.2	0.02	254.2	0.02	Dissolved
SMA020	S	213	Zinc	12.60	**7.91**	227.4	0.03	227.4	0.03	Dissolved
SMA020	D	267	Zinc	4.27	**2.39**	275.4	0.01	275.4	0.01	Dissolved
Total and dissolved Zinc MDL = 0.02; RL=0.06 ug/L										

Table D-4b: Trace metals with fixed WQOs

Station	Sea-son	Metal Name	Metal, Total (ug/L)	Metal, Dissolved (ug/L)	Acute WQ Objective (ug/L)	Acute Exceed-ance Factor	Chronic WQ Objective (ug/L)	Chronic Exceed-ance Factor	WQ Objective Fraction
KIR020	W	Arsenic	3.0	**2.6**	340.0	0.01	150.0	0.02	Dissolved
KIR020	S	Arsenic	2.3	**1.6**	340.0	0.00	150.0	0.01	Dissolved
KIR020	D	Arsenic	3.3	**2.8**	340.0	0.01	150.0	0.02	Dissolved
KIR115	W	Arsenic	4.5	**4.0**	340.0	0.01	150.0	0.03	Dissolved
KIR115	S	Arsenic	4.4	**4.2**	340.0	0.01	150.0	0.03	Dissolved
MTD010	W	Arsenic	1.3	**1.3**	340.0	0.00	150.0	0.01	Dissolved
MTD010	S	Arsenic	1.6	**0.9**	340.0	0.00	150.0	0.01	Dissolved
MTD100	W	Arsenic	0.4	**0.5**	340.0	0.00	150.0	0.00	Dissolved
MTD100	S	Arsenic	0.2 J	**0.3**	340.0	0.00	150.0	0.00	Dissolved
PET010	W	Arsenic	1.3	**1.3**	340.0	0.00	150.0	0.01	Dissolved
PET010	S	Arsenic	1.2	**1.2**	340.0	0.00	150.0	0.01	Dissolved
PET310	W	Arsenic	3.5	**3.4**	340.0	0.01	150.0	0.02	Dissolved
PET310	S	Arsenic	3.9	**3.7**	340.0	0.01	150.0	0.02	Dissolved
PET310	D	Arsenic	5.0	**4.9**	340.0	0.01	150.0	0.03	Dissolved
SMA020	W	Arsenic	1.6	**1.6**	340.0	0.00	150.0	0.01	Dissolved
SMA020	S	Arsenic	1.8	**1.5**	340.0	0.00	150.0	0.01	Dissolved
SMA020	D	Arsenic	2.0	**2.0**	340.0	0.01	150.0	0.01	Dissolved

Total and dissolved Arsenic MDL = 0.1; RL=0.3 ug/L

KIR020	W	Chromium*	2.34	**0.69**	16	0.04	11	0.06	Dissolved
KIR020	S	Chromium*	1.07	**0.16**	16	0.01	11	0.01	Dissolved
KIR020	D	Chromium*	0.61	**0.14**	16	0.01	11	0.01	Dissolved
KIR115	W	Chromium*	1.88	**0.39**	16	0.02	11	0.04	Dissolved
KIR115	S	Chromium*	0.51	**0.13**	16	0.01	11	0.01	Dissolved
MTD010	W	Chromium*	0.89	**0.49**	16	0.03	11	0.04	Dissolved
MTD010	S	Chromium*	8.34	**1.41**	16	0.09	11	0.13	Dissolved
MTD100	W	Chromium*	0.25	**0.22**	16	0.01	11	0.02	Dissolved
MTD100	S	Chromium*	0.41	**0.24**	16	0.02	11	0.02	Dissolved
PET010	W	Chromium*	1.11	**0.74**	16	0.05	11	0.07	Dissolved
PET010	S	Chromium*	0.77	**0.41**	16	0.03	11	0.04	Dissolved
PET310	W	Chromium*	0.93	**0.49**	16	0.03	11	0.04	Dissolved
PET310	S	Chromium*	0.55	**0.31**	16	0.02	11	0.03	Dissolved
PET310	D	Chromium*	0.30	**0.24**	16	0.01	11	0.02	Dissolved
SMA020	W	Chromium*	1.89	**1.55**	16	0.10	11	0.14	Dissolved
SMA020	S	Chromium*	1.76	**1.08**	16	0.07	11	0.10	Dissolved
SMA020	D	Chromium*	1.64	**0.78**	16	0.05	11	0.07	Dissolved

Total and dissolved Chromium MDL = 0.03; RL=0.09 ug/L

* Chromium data are for all chromium species (mostly III+VI); the Objectives are for chromium VI

* If all chromium species combined do not exceed WQOs, one component would not exceed it either

KIR020	W	Mercury	**0.01**		2.4	0.006			Total
KIR020	S	Mercury	**0.04**		2.4	0.015			Total
KIR020	D	Mercury	**0.00**		2.4	0.001			Total
KIR115	W	Mercury	**0.01**		2.4	0.004			Total
KIR115	S	Mercury	**0.01**		2.4	0.003			Total
MTD010	W	Mercury	**0.01**		2.4	0.005			Total
MTD010	S	Mercury	**0.08**		2.4	0.033			Total
MTD100	W	Mercury	**0.01**		2.4	0.004			Total
MTD100	S	Mercury	**0.00**		2.4	0.002			Total
PET010	W	Mercury	**0.00**		2.4	0.002			Total
PET010	S	Mercury	**0.01**		2.4	0.005			Total
PET310	W	Mercury	**0.01**		2.4	0.004			Total
PET310	S	Mercury	**0.02**		2.4	0.007			Total
PET310	D	Mercury	**0.00**		2.4	0.001			Total
SMA020	W	Mercury	**0.01**		2.4	0.004			Total
SMA020	S	Mercury	**0.01**		2.4	0.006			Total
SMA020	D	Mercury	**0.00**		2.4	0.001			Total

Mercury was measured only as total, with variable MDLs and RLs depending on the sample. All values were above RLs.

Mercury chronic objective is not applicable for this comparison.

Table D-4b: Trace metals with fixed WQOs (cont.)

Station	Season	Metal Name	Metal, Total (ug/L)		Metal, Dissolved (ug/L)		Acute WQ Objective (ug/L)	Acute Exceedance Factor	Chronic WQ Objective (ug/L)	Chronic Exceedance Factor	WQ Objective Fraction
KIR020	W	Selenium	**1.26**		1.21		20	0.063	5	0.252	Total
KIR020	S	Selenium	**1.3**		1.0		20	0.07	5	0.26	Total
KIR020	D	Selenium	**2.5**		2.0		20	0.12	5	0.49	Total
KIR115	W	Selenium	**8.1**		8.0		20	0.41	5	**1.63**	Total
KIR115	S	Selenium	**4.0**		4.5		20	0.20	5	0.81	Total
MTD010	W	Selenium	**2.0**		2.0		20	0.10	5	0.40	Total
MTD010	S	Selenium	**0.4**		0.3		20	0.02	5	0.08	Total
MTD100	W	Selenium	**1.5**		1.5		20	0.07	5	0.30	Total
MTD100	S	Selenium	**0.6**		0.9		20	0.03	5	0.11	Total
PET010	W	Selenium	**1.3**		1.4		20	0.06	5	0.25	Total
PET010	S	Selenium	**0.2**	J	0.5		20	0.01	5	0.03	Total
PET310	W	Selenium	**1.7**		1.8		20	0.09	5	0.35	Total
PET310	S	Selenium	**1.3**		1.5		20	0.06	5	0.25	Total
PET310	D	Selenium	**4.0**		3.9		20	0.20	5	0.79	Total
SMA020	W	Selenium	**1.2**		1.1		20	0.06	5	0.24	Total
SMA020	S	Selenium	**0.8**		0.2	J	20	0.04	5	0.15	Total
SMA020	D	Selenium	**2.5**		2.6		20	0.13	5	0.50	Total

Total and dissolved Selenium MDL = 0.1; RL=0.3 ug/L

Table D-4c: Earth mineral metals with no WQOs

Station	Sea-son	Metal Name	Metal, Total (ug/L)	Metal, Dissolved (ug/L)
KIR020	W	Aluminum	791.0	7.6
KIR020	S	Aluminum	584.0	1.5
KIR020	D	Aluminum	368.0	2.7
KIR115	W	Aluminum	894.0	1.0
KIR115	S	Aluminum	196.0	2.2
MTD010	W	Aluminum	125.0	5.7
MTD010	S	Aluminum	2618.0	14.6
MTD100	W	Aluminum	12.8	0.7
MTD100	S	Aluminum	73.3	6.0
PET010	W	Aluminum	106.0	2.5
PET010	S	Aluminum	71.4	1.2
PET310	W	Aluminum	174.0	18.7
PET310	S	Aluminum	75.6	6.0
PET310	D	Aluminum	35.6	5.0
SMA020	W	Aluminum	96.8	4.1
SMA020	S	Aluminum	175.0	9.7
SMA020	D	Aluminum	193.0	2.7
Total and dissolved Aluminum MDL = 0.1; RL=0.3 ug/L				
KIR020	W	Manganese	300	190
KIR020	S	Manganese	1439	1286
KIR020	D	Manganese	31.8	13.6
KIR115	W	Manganese	471	415
KIR115	S	Manganese	305	288
MTD010	W	Manganese	145	150
MTD010	S	Manganese	238	79.3
MTD100	W	Manganese	3.34	2.82
MTD100	S	Manganese	9.49	3.52
PET010	W	Manganese	34.7	28
PET010	S	Manganese	44	40.5
PET310	W	Manganese	175	155
PET310	S	Manganese	422	384
PET310	D	Manganese	425	336
SMA020	W	Manganese	11.2	7.31
SMA020	S	Manganese	19.6	12.1
SMA020	D	Manganese	14.8	9.71
Total and dissolved Manganese MDL = 0.003; RL=0.01 ug/L				

Acute WQ Objectives refer to 1-hour average; Chronic WQ Objectives refer to 4-day average.
Exceedance Factor is computed by dividing the actual concentration (dissolved or total, as indicated) by the Objectives, for each row
ND=not detected. "J" is defined as 'estimated'; the analyte was detected, but the value is below the Reporting Limit

Table D-5: Concentrations of organic compounds in 2003 water samples

Table D-5a: Comparison of concentrations to water quality benchmarks (WQBs)

Station	**Season**	**Chlorpyrifos (µg/L) (WQB=0.015)**	**Chlorpyrifos Exceedance Factor**	**Diazinon (µg/L) (WQB=0.1)**	**Diazinon Exceedance factor**
KIR020	W	**0.11**	11	**0.74**	7.41
KIR020	S			0.04	0.35
KIR020	D				
KIR115	W	**0.06**	5.75	0.04	0.37
KIR115	S				
MTD010	W			0.03	0.32
MTD010	S			0.03	0.26
MTD100	W				
MTD100	S				
PET010	W				
PET010	S				
PET310	W				
PET310	S				
PET310	D			0.01	0.12
SMA020	W	**0.08**	7.51	0.09	0.92
SMA020	S			0.04	0.43
SMA020	D			0.01	0.10

Notes:
The following analytes were also measured in water samples, without any detections:

PCBs
Dacthal (DCPA)
Disulfoton (Disyston)
Endosulfan
HCH, gamma- (gamma-BHC, Lindane)
Parathion, methyl
Thiobencarb

Chlorpyrifos benchmark is for Continuous 4-day average (CVRWQCB, 2006)
Diazinon benchmark is for 1-hour average (SFBRWQCB, 2005)

Table D-5b (Page 1): Concentrations of all organic compounds detected in 2003 water samples

Station	Season	Total number of analytes detected	Acenaphthene	Anthracene	Benz(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(e)pyrene	Benzo(g,h,i)perylene	Benzo(k)fluoranthene	Biphenyl	Chlordane, trans-	Chlorpyrifos	Chrysene	Chrysenes, C1 -	Chrysenes, C2 -	Chrysenes, C3 -	DDE(p,p')	DDT(p,p')
			µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
KIR020	W	**15**											0.11						
KIR020	S	**15**					0.015												
KIR020	D	**8**																	
KIR115	W	**3**											0.06						
KIR115	S	**4**																	
MTD010	W	**3**																	
MTD010	S	**40**	0.02		0.03	0.06	0.09	0.13	0.26	0.02	0.02			0.12	0.16	0.20	0.38		
MTD100	W	**0**																	
MTD100	S	**4**		0.01			0.01												
PET010	W	**1**																	
PET010	S	**3**																	
PET310	W	**0**																	
PET310	S	**3**																	
PET310	D	**2**																	
SMA020	W	**4**											0.08						
SMA020	S	**15**										0.001 J						0.002	0.002 J
SMA020	D	**3**																	

Table D-5b (Cont.)

Station	Season	Diazinon	Dibenz(a,h)anthracene	Dibenzothiophene	Dibenzothiophenes, C1 -	Dibenzothiophenes, C2 -	Dibenzothiophenes, C3 -	Dieldrin	Fluoranthene	Fluoranthene/Pyrenes, C1 -	Fluorenes, C1 -	Fluorenes, C3 -	Indeno(1,2,3-c,d)pyrene	Methylnaphthalene, 1-	Methylnaphthalene, 2-	Methylphenanthrene, 1-	Mevinphos	Naphthalene
		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
KIR020	W	0.74			0.05	0.09	0.06											
KIR020	S	0.04			0.01	0.02					0.01	0.02	0.02					
KIR020	D				0.01	0.03	0.01					0.02						
KIR115	W	0.04																
KIR115	S				0.01	0.01					0.01	0.01						
MTD010	W	0.03																
MTD010	S	0.03	0.04	0.09	0.32	0.62	0.41		0.08	0.11	0.05	0.10	0.13	0.01	0.02	0.02		0.02
MTD100	W																	
MTD100	S				0.02	0.02												
PET010	W																	
PET010	S				0.01	0.01					0.01							
PET310	W																	
PET310	S				0.01	0.02												
PET310	D	0.01 J																
SMA020	W	0.09																
SMA020	S	0.04			0.02	0.02	0.02	0.00				0.02						
SMA020	D	0.01 J																

Table D-5b (Cont.)

Station	Season	Naphthalenes, C1 - µg/L	Naphthalenes, C2 - µg/L	Naphthalenes, C3 - µg/L	Naphthalenes, C4 - µg/L	Oxadiazon µg/L	Oxychlordane µg/L	Perylene µg/L	Phenanthrene µg/L	Phenanthrene/Anthracene, C1 - µg/L	Phenanthrene/Anthracene, C2 - µg/L	Phenanthrene/Anthracene, C3 - µg/L	Phenanthrene/Anthracene, C4 - µg/L	Pyrene µg/L	Trimethylnaphthalene, 2,3,5- µg/L
KIR020	W	0.05	0.07	0.08	0.05	0.27				0.04	0.03	0.03		0.03	
KIR020	S			0.01	0.01	0.31				0.02	0.01	0.02		0.01	
KIR020	D			0.01		0.25				0.01	0.01				
KIR115	W														
KIR115	S														
MTD010	W			0.03		0.12									
MTD010	S	0.05	0.07	0.08	0.31	0.36		0.03	0.04	0.14	0.18	0.19	0.07	0.13	0.01
MTD100	W														
MTD100	S														
PET010	W					0.01									
PET010	S														
PET310	W														
PET310	S					0.01									
PET310	D					0.01									
SMA020	W					0.03									
SMA020	S			0.01	0.02	0.03				0.01	0.01				
SMA020	D					0.02									

Table D-6: Toxicity of 2003 water samples to three freshwater test organisms

		Ceriodaphnia dubia						Pimephales promelas						Selenastrum capricornutum		
Station	**Season**	**Mean Survival (%)**	**% of Control**	**Code**	**Avg.# of Young /female**	**% of Control**	**Code**	**Survival (%)**	**% of Control**	**Code**	**Growth (Avg. weight, mg/ind)**	**% of Control**	**Code**	**Cell Count (Million cells/ml)**	**% of Control**	**Code**
KIR020	W	**0**	**0**	SL				95	97	NSG	**0.89**	**83**	SG	5.13	107	NSG
KIR020	S	100	100	NSG	28.2	122	NSG	100	112	NSG	0.72	99	NSG	**3.99**	**64**	SL
KIR020	D	100	125	NSG	33	147	NSG	97.5	109	NSG	0.85	97	NSG	**3.18**	**52**	SL
KIR115	W	**60**	**60**	SL	**8**	**32.4**	SL	93	95	NSG	1.14	106	NSG	**1.13**	**23.4**	SL
KIR115	S	100	100	NSG	26.3	113	NSG	92.5	103	NSG	0.83	114	NSG	**1.68**	**27**	SL
MTD010	W	90	90	NSG	**14**	**54.7**	SL	95	97	NSG	1.09	101	NSG	**3.66**	**76.1**	SL
MTD010	S	100	100	NSG	34.4	148	NSG	75.8	85	NSG	**0.42**	**58**	SL	**5.46**	**88**	SG
MTD100	W	100	100	NSG	**15**	**61.3**	SL	100	103	NSG	1.02	95	NSG	5.29	110	NSG
MTD100	S	100	100	NSG	25.9	112	NSG	**55**	**61**	NSL	0.67	92	NSG	5.72	92	NSG
PET010	W	90	90	NSG	**14**	**58.5**	SL	100	103	NSG	1.01	93	NSG	6.31	131	NSG
PET010	S	100	100	NSG	28.5	123	NSG	75.8	85	NSG	0.79	108	NSG	5.75	93	NSG
PET310	W	80	80	NSG	**16**	**64.9**	SL	98	100	NSG	1.12	103	NSG	5.64	117	NSG
PET310	S	100	100	NSG	31.4	135	NSG	75	84	NSG	0.86	118	NSG	**2.05**	**33**	SL
PET310	D	90	112.5	NSG	33	145	NSG	90	100	NSG	0.84	95	NSG	**2.44**	**40**	SL
SMA020	W	100	100	NSG	35	176	NSG	88	92	NSG	1.04	105	NSG	7.25	118	NSG
SMA020	S	100	100	NSG	27.3	118	NSG	**62**	**69**	SL	0.76	103	NSG	5.55	90	NSG
SMA020	D	100	125	NSG	28	125	NSG	87.5	97	NSG	0.93	105	NSG	5.50	91	NSG

Codes:

NSG	Not significantly different from negative control (alpha=0.05), and sample value was above 80% of control (No 'toxicity criteria' met)
SG	Significantly different from negative control (alpha=0.05), BUT sample value is above 80% of control (Only first 'toxicity criteria' met)
NSL	Not significantly different from negative control (alpha=0.05), but sample value was below 80% of control (only second 'toxicity criteria' met)
SL	Significantly different from negative control (alpha=0.05), AND sample value is below 80% of control (Both 'toxicity criteria' met)

Table D-7: Chemical Concentrations and toxicity in 2003 sediment samples

Table D-7a: Sediment properties and metal concentrations in comparison to Quality Benchmarks

Metal concentrations

Station	QB	Aluminum (mg/Kg)	Arsenic (mg/Kg)	Cadmium (mg/Kg)	Chromium (mg/Kg)	Copper (mg/Kg)	Lead (mg/Kg)	Manganese (mg/Kg)	Mercury (mg/Kg)	Nickel (mg/Kg)	Silver (mg/Kg)	Zinc (mg/Kg)
KIR020		42480	**11.50**	0.88	**74.9**	**54.9**	27.7	595	0.14	**37**	0.50	**298**
MTD010		30105	4.58	0.21	**56.6**	29.6	17.2	692	0.11	**45**	0.26	84.5
PET310		21216	4.66	0.13	29.7	10.4	6.75	433	0.08	**28.3**	0.23	60.1
SMA020		21975	8.28	0.24	**183**	29.7	24.8	714	**0.19**	**188**	0.19	116
	PEC		**33**	**4.98**	**111**	**149**	**128**		**1.06**	**48.6**		**459**
	TEC		**9.79**	**0.99**	**43.4**	**31.6**	**35.8**		**0.18**	**22.7**		**121**

PEC = Probable effect concentration; TEC = Threshold effect concentration

Sediment properties

Station	Total Organic Carbon (%)	Percent Moisture	% clay & silt (<0.075 mm)	% fine & medium sand (0.075 - 2 mm)	% coarse (> 2mm)
KIR020	2.3	49.9	65.2	33.1	1.6
MTD010	1.4	22.1	5.5	71.6	22.9
PET310	0.1	19.6	2.0	69.9	28.1
SMA020	0.3	21.1	0.1	93.8	6.0

Table D-7b: Sediment concentrations of detected pesticides in comparison to quality objectives

Station	**Chlordane, cis- (µg/kg)**	**Chlordane, trans- (µg/kg)**	**Chlordene, gamma- (µg/kg)**	**Chlor - pyrifos (µg/kg)**	**DDD(o,p') (µg/kg)**	**DDD(p,p') (µg/kg)**	**DDE(p,p') (µg/kg)**	**DDT(o,p') (µg/kg)**	**DDT(p,p') (µg/kg)**	*DDT (total)*
KIR020	1.66	2.59		3.85			2.45			2.45
MTD010		1.30		1.94			1.19			1.19
PET310		0.65								
SMA020	**4.1**	5.59	1.02		**1.49**	**4.02**	**9.18**	**2.4**	**13.3**	**30.39**

	Chlordane					DDD (sum op + pp)	DDE (sum op + pp)		DDT (sum op + pp)	DDT (total)
PEC	**17.6**					**28**	**31.3**		**62.9**	**572**
TEC	**3.24**					**4.88**	**3.16**		**4.16**	**5.28**

Station	**Dieldrin (µg/kg)**	*Endrin*	*HCH, gamma*	**Heptachlor (µg/kg)**	**Heptachlor epoxide (µg/kg)**	**Hexachlorobenzene (µg/kg)**	**Nonachlor, cis- (µg/kg)**	**Nonachlor, trans- (µg/kg)**	**Oxadiazon (µg/kg)**
KIR020					1.25	3.51		2.48	112
MTD010					0.79	132		1.39	163
PET310									
SMA020	1.82			0.85	0.93		1.29	4.47	

	Dieldrin	Endrin (ND)	HCH, gamma (ND)		Heptachlor epoxide				
PEC	**61.8**	**207**	**4.99**		**16**				
TEC	**1.9**	**2.22**	**2.37**		**2.47**				

PEC = Probable effect concentration; TEC = Threshold effect concentration

Table D-7c: Sediment observed toxicity and probable (toxic) effect concenrtation quotients for selected substances

					Hyalella azteca Survival (%)			H. azteca Growth (weight, mg/ind)				
Station	Metals Mean PEC Quotient	PCB PEC Quotient	PAH PEC Quotient	Sample Mean PEC Quotient	Mean	% of Control		Mean	% of Control		% fines (<0.075 mm)	Total Organic Carbon (%)
KIR020	0.456	0.035	0.018	**0.17**	**0**	**0**	SL				65.2	2.3
MTD010	0.305	0.011	0.006	**0.11**	**66**	**70.7**	SL	**0.34**	**56.6**	SL	5.5	1.4
PET310	0.181	0.004	0.001	**0.06**	96	102.7	NSG	**0.45**	**75.7**	SL	2.0	0.1
SMA020	0.923	0.021	0.020	**0.32**	**18**	**18.7**	SL	**0.15**	**25.9**	SL	0.1	0.3

NSG = Not significantly different from negative control (alpha=0.05), and sample value was above 80% of control (No 'toxicity criteria' met)
SL = Significantly different from negative control (alpha=0.05), AND sample value is below 80% of control (Both 'toxicity criteria' met)

PEC - probable effect concentration
PEC quotients for selected metals were derived by dividing the sample concentration of an individial metal by the PEC value, then calculating the mean (presented).
PEC quotients for sums of the 18 NIST PCBs were derived by dividing the summed concentration in each sample by the PEC value for total PCBs
PEC quotients for selected PAHs were derived by dividing the summed concentrations in each sample by the PEC value for total PAHs
Sample Mean PEC quotient is the mean calculated for all three groups of chemicals; mean quotient of over 0.5 is considered predictive of toxicity.

Table D-8: Tissue concentrations of detected analytes in 2003 clam samples

Table D-8a: Metal concentrations in clam tissues

Station	Moisture	Aluminum	Arsenic	Cadmium	Chromium	Copper	Lead	Manganese	Mercury	Nickel	Selenium	Silver	Zinc
	% dw	µg/g dw	µg/g dw	µg/g dw	µg/g dw	µg/g dw	µg/g dw	µg/g dw	µg/g dw	µg/g dw	µg/g dw	µg/g dw	µg/g dw
KIR020	**94.9**	224	13.2	1.95	5.14	158	0.38	72.3	0.33	ND	7.12	0.10	131
MTD010	**93.3**	1627	14.5	1.75	8.72	155	1.24	146	0.52	ND	7.16	0.12	153
PET310	**93.0**	313	12.6	1.66	4.84	139	0.35	147	0.48	ND	5.87	0.12	146
SMA020	**94.9**	428	15.3	2.27	8.31	190	1.27	40.3	0.47	ND	7.2	0.09	188

Table D-8b: Organochlorine compounds concentrations in clam tissues

Station	Lipid	Moisture	Chlordane, cis	Chlordane, trans	Chlordene, alpha	Chlordene, gamma	DDD(o,p')	DDD(p,p')	DDE(p,p')
	% dw	**%**	ng/g dw	ng/g dw	ng/g dw	ng/g dw	ng/g dw	ng/g dw	ng/g dw
KIR020	**0.50**	**94.7**		9.1				36.5	407
MTD010	**0.77**	**91.9**		9.2				22.3	261
PET310	**0.73**	**93**		8.34				25.5	276
SMA020	**0.49**	**94.8**	68.8	54.2	6.83	11.7	16.2	54.6	418

	DDT(p,p')	Dieldrin	Heptachlor epoxide	Hexachlorobenzene	Nonachlor, trans	Oxadiazon	Oxychlordane	PCB AROCLOR 1254
	ng/g dw	ng/g dw	ng/g dw	ng/g dw	ng/g dw	ng/g dw	ng/g dw	ng/g dw
KIR020		11.6		11.1	12.9	670		77
MTD010		10.2			16.7	227		66
PET310		7.47			13.7	133		65
SMA020	55.8	81.9	13.9		68.1	64.5	7.58	98

Table D-8c: PAH concentrations in clam tissues

Station	**Moisture**	Benzo(e)pyrene	Chrysene	Chrysenes, C1 -	Chrysenes, C2 -	Dibenzothiophenes, C2 -	Dibenzothiophenes, C3 -	Fluoranthene	Fluoranthene/Pyrenes, C1 -	Fluorenes, C2 -	Fluorenes, C3 -
	%	ng/g dw	ng/g dw	ng/g dw	ng/g dw	ng/g dw	ng/g dw	ng/g dw	ng/g dw	ng/g dw	ng/g dw
KIR020	**94.7**	21			20	34.6	68.7	85.5	248	24.5	99.2
MTD010	**91.9**			36.5	13.5	16.7	27.1	22.5	41.8		45
PET310	**93**					18.3	34.3	21.4			
SMA020	**94.8**		21.3			23	58.8	75.3	58.5		

	Methylphenanthrene, 1-	Naphthalenes, C3 -	Naphthalenes, C4 -	Perylene	Phenanthrene	Phenanthrene/Anthracene, C1 -	Phenanthrene/Anthracene, C2 -	Phenanthrene/Anthracene, C3 -	Phenanthrene/Anthracene, C4 -	Pyrene	**total PAHs**
	ng/g dw	ng/g dw	ng/g dw	ng/g dw	ng/g dw	ng/g dw	ng/g dw	ng/g dw	ng/g dw	ng/g dw	**ng/g dw**
KIR020		22.5	20.4	26.3	37.6	28.3	197	114	55.4	217	**1299**
MTD010		22.8	30.6		19.5	51.4	209	104		30.4	**670.8**
PET310	13.8	20.2	15.8			20.4		58.3		28.1	**230.6**
SMA020		23			23.7	42	106	108		83.5	**623.1**

Table D-8d: PCB congener concentrations in clam tissues

Station	Lipid	Moisture	PCB 008	PCB 018	PCB 028	PCB 031	PCB 033	PCB 044	PCB 049	PCB 052	PCB 056
	% dw	**%**	ng/g dw	ng/g dw	ng/g dw	ng/g dw	ng/g dw	ng/g dw	ng/g dw	ng/g dw	ng/g dw
KIR020	**0.50**	**94.7**		1.33	1.74	2.07	1.95	6.55	1.1	3.15	
MTD010	**0.77**	**91.9**	3.09	1.09	1.21	1.31	0.79	5.26	0.54	1.75	
PET310	**0.73**	**93**		1.05	1.55	1.59	1.46	4.16		1.87	
SMA020	**0.49**	**94.8**	3.24	0.86	1.1	7.44	1.99	9.29	1.12	2.25	0.80

	PCB 060	PCB 066	PCB 070	PCB 074	PCB 087	PCB 095	PCB 097	PCB 099	PCB 101	PCB 105	PCB 110
	ng/g dw	ng/g dw	ng/g dw	ng/g dw	ng/g dw	ng/g dw	ng/g dw	ng/g dw	ng/g dw	ng/g dw	ng/g dw
KIR020		2.95	3.64	1.35	1.95	6.42	2.57	2.42	6.13	4.08	7.95
MTD010	0.502	2.56	3.17	1.17	1.48	4.58	1.71	1.7	3.98	2.89	5.8
PET310		2.53	2.65	1.26	1.29	4.13	1.65	1.74	3.95	2.65	5.14
SMA020	1.6	7.16	3.81	1.85	2.33	7.13	2.77	2.12	6.11	4.66	11.2

	PCB 118	PCB 128	PCB 138	PCB 149	PCB 151	PCB 153	PCB 174	PCB 177	PCB 180	PCB 183	PCB 187	total PCBs
	ng/g dw	ng/g dw	ng/g dw	ng/g dw	ng/g dw	ng/g dw	ng/g dw	ng/g dw	ng/g dw	ng/g dw	ng/g dw	**ng/g dw**
KIR020	8.11	1.03	12	10.2	2.29	23.7			2.84		3.85	**121.4**
MTD010	5.77	0.87	7.77	8.63	1.33	16.1		0.54	2.21		2.69	**90.5**
PET310	5.68	0.89	7.8	7.59	1.1	16.4	0.65		2.16		2.71	**83.6**
SMA020	9.67	1.5	12.4	10.4	2.79	19.4	1.42		2.97	0.81	4.11	**144.3**

Table E-1: Inventory and Results of bacterial counts in 2003 watersheds

Table E-1a: Fecal coliforms counts (MPN/100mL), as determined by the multiple tube fermetation method

Station	*7/21/03*	*7/28/03*	*8/4/03*	*8/11/03*	*8/18/03*	*Geo-mean*	*90th %ile*
KIR053	350	*1600*	*1600*	*1600*	920	**1057**	**1600**
KIR110	540	*1600*	*1600*	*1600*	*1600*	**1288**	**1600**
MTD120	350	110	13	5	130	50	262
PET265	350	240	70	49	70	115	306
PET310	*1600*	1600	79	540	1600	**705**	**1600**
PET315	540	*1600*	1600	540	920	**928**	**1600**
PET400	540	220	130	350	920	**346**	**768**
SMA020	240	170	*1600*	1600	130	**423**	**1600**
SMA060	350	*1600*	1600	*1600*	1600	**1181**	**1600**
SMA080	*1600*	920	540	*1600*	*1600*	**1153**	**1600**

Counts are Most Probable Number per 100 milliliters (MPN/100 mL). Values in underlined italic font are equal to or greater than 1600. Geomeans (the logarithmic mean) and percentiles were calculated using 1600 as the most conservative value; however in all cases, the stations still exceeded the limits. Values in red highlight exceed the EPA limit for freshwater recreation (200 MPN for the geomean and 400 MPN for the 90th percentile).

Table E-1b: E. coli counts (MPN/100mL), as determined by the Colilert method

Station	*7/21/03*	*7/28/03*	*8/4/03*	*8/11/03*	*8/18/03*	*Geo-mean*
KIR053	450	1300	860	1900	370	**812**
KIR110	150	530	550	300	640	**384**
MTD120	270	52	*1*	*1*	84	16
PET265	250	630	85	200	41	**161**
PET310	9200	260	31	180	2300	**498**
PET315	760	840	420	230	240	**431**
PET400	230	240	160	210	250	**215**
SMA020	340	110	460	2800	220	**403**
SMA060	910	1200	2100	1600	780	**1234**
SMA080	2300	260	300	3000	24000	**1668**

Counts are Most Probable Number per 100 milliliters (MPN/100 mL). Values in italic represent non-detects for MTD120; to calculate the geomean, 1 was used instead. Values in red highlight exceed the limit for freshwater recreation (126 MPN for the geomean).

Appendix F Data quality report

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Field and lab operators followed the SWAMP field procedures and the internal lab Standard Operating Procedures (SOPs), as required to assure generation of data of known and documented quality. With some exceptions, the data reported in Section 3 and in Appendix Tables B, C, D, and E are SWAMP compliant. This means the following:

(a) Sample container, preservation, and holding time specifications of all measurement systems have been applied and were achieved as specified;
(b) All the quality checks required by the SWAMP Quality Management Plan (QMP) were performed at the required frequency;
(c) All measurement system runs included their internal quality checks and functioned within their performance/acceptance criteria; and
(d) All SWAMP measurement quality objectives (MQOs) were met.

F.1 Actions to affect and check data quality

Table F-1 shows the types of actions done to **affect** and **check** the different aspects of data quality in field measurements, sampling & shipping, and lab analyses. The table includes actions related to water properties (physical water quality parameters & analyte concentrations), as well as actions related to benthic macroinvertebrate (BMI) assessments, toxicity testing, and bacterial counts. Actions are organized by 'operational' setting (field and lab) and grouped into the different aspects of data quality that need to be addressed.

Data quality checks sometimes focus on different aspects for different areas of inquiry. Measurement **precision** appears to be relevant to all groups of characteristics, but the concept of **accuracy** often does not apply if there is no real Standard for the 'true value'. This is often the case with BMI assessments, toxicity testing, and bacterial counts; however there are several checks that can provide confirmation and they are listed in Table F-1 as well.

Data batching in relation to quality checks is very variable, meaning that some quality checks apply to specific analytes, some to a specific instrument, some to a batch of samples collected in one trip (e.g. field blanks), some to a lab batch or a toxicity test, etc. SWAMP has a set of qualifiers for each 'level' and the specific information is easily gleaned from the basic database query created by the SWAMP data management team.

The following sections are focused on two functional batching principles: (s) sampling activities validation (via field duplicates and field blanks) is related to sample batch (i.e., all samples collected in one Trip by the same crew and with the same gear); and (b) laboratory activities validation (via an array of Standards and spiked samples) is related to the 'lab batch' (i.e., all results generated in one analytical run or test).

F.2 Year 3 Quality Checks inventory and outcomes

SWAMP field crews followed existing protocols to affect and check the accuracy of field measurements; however, precision was not addressed in year 3. Sample collection and handling activities followed method specifications and included most of the required quality checks, as shown in **Table F-2**. The table shows the 'inventories' of blanks and duplicates collected for each trip (with the requirements shown in parentheses in some cases), and the outcomes of these checks in terms of uncontaminated blanks and reproducible quantitation of analytes. Due to severe budget constraints, field blanks for analytes in water were not collected (to free more resources for environmental samples). However, because all samples were collected by direct filling (i.e, no grab & transfer or trap & transfer methods were used), and sample water entered into pre-cleaned containers from batches or lots that have been checked and found clean, this was justified given the low risk of contamination.

Assuring and checking **sample integrity** involves actions that span the entire process of cleaning, collection, shipping, receiving, and holding. Actions to assure **lack of contamination** included pre-cleaning and packaging of containers, use of clean gloves, collection facing upstream, double-packing wet ice in the cooler, etc. **Lack of deterioration** was assured by rapid sample cooling and/or addition of preservatives, cold shipping and storage, and analysis within holding time. Sample integrity was **checked** by collecting and analyzing blanks, as well as by noting sample temperatures during staging/shipping/receiving and by measuring the pH of acidified samples. The detailed outcomes of these checks are available upon request.

Table F-3 shows all the quality checks performed in the laboratories that analyzed year 3 samples. These quality checks cover the aspects of laboratory accuracy and precision, in terms of analyte recoveries and repeatability of the measurement (via replicates of the same sample). There were also checks for laboratory blanks, to establish lack of lab ware contamination.

F.3 Year 3 measurements quality summary

Per U.S.EPA guidance, the SWAMP QMP discusses three Data Quality Indicators (DQIs) that relate to measurement quality: accuracy (or bias), precision, and sensitivity (in terms of resolution and detection limit). Each indicator has an array of measurement quality objectives (MQOs) that have been developed for specific characteristics or analyte groups to allow maximum use of the data. **Table F-4** shows a condensed version of SWAMP MQOs for lab analyses. The majority of data reported herewith have met these MQOs, meaning that they are of known quality and that their accuracy and precision are within these ranges.

Accuracy is the degree of closeness of a measurement result to the ‘true’ value, which is often represented by a Standard solution or a natural condition (e.g., oxygen saturation). The accuracy of continuous field measurements was checked after every deployment by conducting post-deployment accuracy checks within 24 hours. Appendix Table C-2 specifies the deployment episodes that were rejected due to inadequate accuracy or lack of information (in addition to instrument malfunction). In analytical procedures, measurement accuracy is gleaned from the recovery of analytes that have been spiked at known concentrations - from laboratory Standards or certified reference material (CRM) solutions – into pure water and/or an environmental sample (to check the effect of sample matrix on recovery). Another way to check recovery of certain organic compounds is to spike a sample with known concentrations of their surrogates - synthetic molecules that have similar chemical properties but are not found naturally in the sample**.** Year 3 data have adequate accuracy for most purposes.

Accuracy of BMI identification was checked by having two taxonomists analyze 10% of the samples and resolving discrepancies by comparison to organisms in other voucher collections or by consulting with other taxonomists. Toxicity tests were validated by conducting reference toxicant tests to show that the batches of test organisms used in year 3 tests actually responded as expected, i.e., within the lab control chart established by the lab. The ‘accuracy’ of bacterial counts was confirmed by running positive and negative controls for each **lot** of media and reagents (the IDEXX lab usually buys about 200 tests of the same lot). The control cultures included *Pseudomonas sp.* (negative for total coliform, negative for E. coli); *Klebsiela sp.* (positive for total coliform, negative for *E. coli*); and *E. coli* (positive on both).

Precision is the degree of agreement between two independent measurements of the same thing. In other words, it is a measure of the reproducibility of the entire sampling and analysis process (via field duplicates), and it is also a measure of the repeatability of the measurement or analysis (via repeated field measurements, and lab replicates). A high percentage of year 3 analytical chemistry data are of known precision, with Relative Percent Difference (RPD) of less than 25%. Precision of bacterial counts is considered acceptable by most practitioners if the repeated measurement result is within an order of magnitude of the original. U.S.EPA used RPD of <75% or <60% for lab replicates. There are no MQOs for bacterial counts precision in the SWAMP QMP. Year 3 field duplicates were collected in triplicates, and RPDs were computed from the two extreme values to provide the worst-case-scenario’. All RPDs thus obtained were <200%, indicating reasonably good reproducibility.

Detection sensitivity is addressed in the SWAMP QMP as recommended target reporting limits (TRLs), most of which were achieved in the analyses of year 3 samples (Tables 2.4-1, 2.4-2 in the main report and Appendix Table D-2). Another aspect of sensitivity is the **resolution** of the measurements. SWAMP field crews used high resolution probes for all discrete and continuous filed measurements (0.01 mg/L for DO, 0.01 C for Temperature, 0.01 pH unit, and 0.1 uS/cm for specific conductance).

F.4 Data completeness, representativeness, and comparability

The other three DQIs included in the U.S.EPA guidance, relate to three additional aspects of data quality: completeness, representativeness, and comparability.

Completeness is "a measure of the amount of valid data obtained from a measurement system" (U.S.EPA 2002). In the context of a Project, it can also be a property of the entire complement of samples planned for the project, and it is a measure of how many were actually collected (and yielded acceptable data) as compared to the sampling plan (i.e., to the number authorized in the work order, given budget constraints). The inventory of samples collected can be gleaned from Appendix Tables B-1, C-1, D-1, and E-1; and the % completeness is shown in Appendix Table A-1. In summary, 84% of planned bioassessment visits were performed, and 100% of the water, sediment, and tissue samples that were authorized were actually collected. All of these samples yielded **usable** data that were categorized either as SWAMP compliant or as "Estimated", i.e., with non-detrimental quality flags.

Representativeness is about how well a sample represents the monitored environment. Year 3 water samples are **representative** of the bulk of the flow at the spot where they were collected. However, because of the huge spatial variability during low flow conditions, it is uncertain how each water sample represents adjacent habitats and stream segments. The representativeness of sediment samples was enhanced by collection of sub-samples and pooling them into a composite sample. Similarly, the representativeness of every BMI sample was enhanced by pooling organisms obtained from nine 1x1 ft squares.

Comparability is a measure of the confidence with which one data set or method can be compared to another (U.S.EPA 2002).Year 3 data, by definition, are **SWAMP comparable.** Other data collection efforts in the region are striving to increase their comparability to SWAMP data.

Table F-1: Summary of Actions to Affect and Check the Quality of Year 3 Data

Activity	**data quality aspect**	**Affect** *(act to influence outcome)*	**Check** *(test to evaluate or verify)*
All	operator's competence	train, refresh, supervise	run proficiency tests, review work products
Field Measurements & assessments	Accuracy	calibrate (adjustable-reading instruments)	conduct accuracy check (all instruments)
	Precision	use consistent procedures under same conditions	repeat measurements
	Reproducibility	calibrate scoring & categorical observations made by different physical habitat assessors	repeat habitat value scoring by different operators
Sample collection & handling	Reproducibility	use consistent procedures under same conditions	collect and analyze field duplicates (exact same time & place)
	Lack of contamination	decontaminate sampling equipment and containers, seal & wrap samples; apply 'clean-hands-dirty-hands' technique; use sterile vessels for bacteria	collect and analyze blanks (Trip, Field, Equipment)
	Lack of deterioration	ship cold; preserve if appropriate	measure shipping temperature, pH upon arrival
	Lack of organism loss	collect BMI at appropriate depth and velocity, gather meticulously from D-net	deploy 2nd D-net behind 1st, examine content (Note 1)
Laboratory analyses & tests	Accuracy (or validity)	calibrate, use certified calibrator Standards; use appropriate BMI key; maintain acceptable water quality conditions in toxicity test chambers	run LCS, CRM, Matrix spikes, surrogates; compare IDs to other BMI voucher collections; run reference toxicant tests; run known positive and negative bacteria
	Precision	use consistent procedures under same conditions	run lab replicates, matrix spike duplicates; split BMI samples for separate examination (Note 1)
	Lack of contamination	decontaminate lab ware	analyze lab Blanks (method, reagent, etc.)
	Lack of deterioration	analyze within holding time	calculate holding time

Note 1: Quality checks for BMI were done during method development and are not done for every project

Table F-2: Inventory and outcomes of quality checks conducted by field crews for water and sediment samples in 2003

Trip(s) dates in 2003	Characteristic group	Medium	Container type/volume	Number of env. samples/trip *(Note 1)*	Field blanks (and required frequency) *(Note 2)*	Field blank outcome	field duplicate (and required frequency)	Field dup Reproducibilty Outcome
January 20,21,23	Conventionals	water	polyethylene 0.5L	18	n/c	--	1 (1/trip)	15 of 15 analyte pairs RPD<25%
	SSC	water	plastic 0.5L	18	n/c	--	1 (1/trip)	1 of 1 pairs RPD<25%
	Organics	water	amber glass 1L	7	n/c	--	1 (1/trip)	184 of 184 pairs RPD<25% (many pairs ND)
	Metals	water	polyethylene 60mL	7	n/c	--	1 (1/trip)	21 of 22 pairs RPD<25%
	Mercury ***(Note 3)***	water	glass 0.25L	7	n/c	--	1 (1/trip)	1 of 1 pairs RPD<25%
	Toxicity	water	amber glass 2.25L		n/c	--	1 (1/trip)	4 of 5 endpoints agree
April 21,22	Conventionals	water	polyethylene 0.5L	18	n/c	--	1 (1/trip)	13 of 14 pairs RPD<25%
	SSC	water	plastic 0.5L	18	n/c	--	1 (1/trip)	0 of 1 pairs RPD<25%
	Organics	water	amber glass 1L	7	n/c	--	1 (1/trip)	173 of 184 pairs RPD<25% (many pairs ND)
	Metals	water	polyethylene 60mL	7	n/c	--	1 (1/trip)	21 of 22 pairs RPD<25%
	Mercury ***(Note 3)***	water	glass 0.25L	7	n/c	--	1 (1/trip)	1 of 1 pairs RPD<25%
	Toxicity	water	amber glass 2.25L		NA	NA	1 (1/trip)	all endpoints agree
	All groups	**sediment**	***(Note 4)***	4	NA	NA	1 (1/trip)	119 of 145 pairs RPD<25% (many pairs ND)
June 2,3	Conventionals	water	polyethylene 0.5L	14	n/c	--	1 (1/trip)	12 of 13 RPD<25%
	SSC	water	plastic 0.5L	14	n/c	--	1 (1/trip)	1 of 1 RPD<25%
	Organics	water	amber glass 1L	3	n/c	--	0 (1/trip)	--
	Metals	water	polyethylene 60mL	3	n/c	--	0 (1/trip)	--
	Mercury ***(Note 3)***	water	glass 0.25L	3	n/c	--	0 (1/trip)	--
	Toxicity	water	amber glass 2.25L		n/c	--	0 (1/trip)	--
7/21/03,	Bacterial counts	water	plastic sterile 0.125L	10	1 (1/trip)	3 of 3 bact.groups <DL	1 (1/trip)	3 of 3 extremes RPD<200% (Note 5); 1 of 3 extremes RPD<75%
7/28/03,	Bacterial counts	water	plastic sterile 0.125L	10	1 (1/trip)	3 of 3 bact.groups <DL	1 (1/trip)	3 of 3 extremes RPD<200% (Note 5); 2 of 3 extremes RPD<75%
8/4/03,	Bacterial counts	water	plastic sterile 0.125L	10	1 (1/trip)	3 of 3 bact.groups <DL	1 (1/trip)	1 of 1 extremes RPD<75% (Note 6);
8/11/03,	Bacterial counts	water	plastic sterile 0.125L	10	1 (1/trip)	3 of 3 bact.groups <DL	1 (1/trip)	3 of 3 extremes RPD<200% (Note 5); 1 of 3 extremes RPD<75%
8/18/03,	Bacterial counts	water	plastic sterile 0.125L	10	1 (1/trip)	3 of 3 bact.groups <DL	1 (1/trip)	-- (Note 6)

NA = not applicable; n/c = not collected; ND = not detected; RPD = relative percent difference

Note 1	The number of samples is one Sample Batch, i.e. it includes all R2 Yr 3 environmental samples (without field dups and blanks) collected by one Field Crew during one Trip.
Note 2	Field blanks for analytes in water were not collected due to budget constraints and given the low risk of contamination. All samples were collected by direct filling into pre-cleaned containers from certified lots. Trip blanks, equipment blank, or rinsate blanks were not required (no grab & transfer or trap & transfer)
Note 3	Crews used the "clean-hands dirty-hands" technique to collect samples for total mercury
Note 4	Crews used a pre-cleaned 2-L sampling jug for collection and homogenization of each sample, and pre-cleaed containers for sub-samples
Note 5	bacterial counts reproducibilityy was checked with field triplicates; RPD was calculated from the two extreme results
Note 6	RPD was meaningless and not calculated if one of the triplicates had 'more than' result (not a real number)

Author's Note: Because generation of the data for the "outcome" columns is labor intensive, and the information gleaned may be of interest to a very small audience, the effort is not justified in most cases

Table F-3 (page 1): Inventory and outcomes of quality checks conducted by SWAMP laboratories for water and sediment samples in 2003

characteristic group	Medium	Number of lab batches *(Note 1)*		Number of Method Blanks	Method blank outcome	Number of surrogate analytes per complement	Number of samples spiked with a surrogate complement	surrogate recovery outcome (per # of individual surrogates}
Conventionals ***(Note 2)***	Water	4 to 6		4-8 per indiv. analyte	78 of 78 indiv. analytes ND	NA	NA	NA
OC Pesticides (EPA 8081AM) 34 analytes	Water	3		1,1,2 analyte suite per batch	132 of 132 analytes ND	2	3-8 samples/batch	38 of 38 surrogates within 50-150% recovery
OP Pesticides (EPA 8141AM) 46 analytes	Water	3		1,1,2 analyte suite per batch	138 of 138 analytes ND	1	3-8/batch	18 of 18 surrogates within 50-150% recovery
Diazinon&chlorpyrifos ELISA	Water	2 runs each		1,1 analyte per batch	4 of 4 analytes ND	NA	NA	NA
Triazine Herbicides (EPA 619M) 11 analytes	Water	3		1,1,1 analyte suite per batch	66 0f 66 analytes ND	n/sp	n/sp	n/sp
PCB Congenres (EPA 8082M) 50 analytes	Water	3		1,2,1 analyte suite per batch	200 of 200 analytes ND	1	3-8/batch	19 of 19 surrogates within 50-150% recovery
PAH (EPA 8270M) 43 analytes	Water	2		1,1 analyte suite per batch	86 of 86 analytes ND	9	8-10/batch	139 of 162 surrogates within 50-150% recovery
Metals (total&dissolved) (EPA1638M) 11 analytes	Water	3		1,1,1 analyte suite per batch	31 of 33 analytes <RL, 25 of 33 <MDL	NA	NA	NA
Mercury EPA (1631EM)	Water	3		2,2,2 (1/batch)	6 of 6 analytes ND	NA	NA	NA
All groups	**Sediment**	1 per group		1 per group	130 of 154 analytes ND	1 to 9	4	33 of 56 surrogates within 50-150% recovery
Fecal Coliforms (SM 9221	Water	5		0 (1/batch)	--	NA	NA	NA
Total Coliform (SM 9223 B-SOP1103)	Water	5		5 (1/batch)	5 of 5 'analytes' ND	NA	NA	NA
E. coli SM (9223 B-SOP1103)	Water	5		5 (1/batch)	5 of 5 'analytes' ND	NA	NA	NA

NA = not applicable; n/sp = not spiked; ND = not detected (Result below MDL); RPD = relative percent difference
These quality checks do not apply to **toxicty tests,** where acceptability was confirmed by reference toxicant tests done with each batch of test organisms.

Note 1: A Lab Batch is made of all the samples analyzed in one day by one lab instrument between calibrations
Note 2: Conventional water quality characteristics were analyzed in multiple batches with a variable number of quality checks. Details are available with SWAMP RB2 and DMT
Author's Note: Because generation of the data for the "outcome" columns is labor intensive, and the information gleaned may be of interest to a very small audience, the effort is not justified in most cases.

Table F-3 (cont.)

characteristic group	**Medium**	**Number of lab batches *(Note 1)***	**Number of of samples spiked with MS/MSD complement (and required frequency)**	**Number of CRM, LCS, or LCM complements, or Bacteria Pos/Neg controls**	**spike recovery outcome (all spiked analytes)**	**Number of lab replicates (same env. Sample)**	**Lab Repeatability Outcome (MS/MSD, CRM, and LabRep pairs)**	**Comments**
Conventionals (Note 2)	W	4 to 6	53 MS/D spikes (various indiv. analytes)	70 CRM and 8 LCS spikes (various indiv. analytes)	52 of 53 MS/D, 70 of 70 CRM, and 8 of 8 LCS spikes within 80-120% recovery	22 pairs (var analytes)	77 of 77 MS/D, 5 of 5 CRM, and 21 of 22 LabRep pairs RPD<25%	
OC Pesticides (EPA 8081AM) 34 analytes	W	3	1,1,1 (1/batch)	1,1,1 LCS (1/batch)	214 of 216 MS/D and 107 of 108 LCS spikes within 50-150% recovery	0	107 of 108 MS/D pairs RPD<25%	
OP Pesticides (EPA 8141AM) 46 analytes	W	3	2,1,1 (1/batch)	1,1,1 LCS (1/batch)	376 of 376 MS/D and 141 of 141 LCS spikes within 50-150% recovery	0	173 of 188 MS/D pairs RPD<25%	
Diazinon&chlorpyrifos ELISA	W	2	1,0 [MS only] (1/analyte/batch)	1,1 LCM/analyte /batch	5 of 6 spikes within 50-150% recovery	0 or 1 (1/batch)	not calc. (both ND)	
Triazine Herbicides (EPA 619M) 11 analytes	W	3	1,1,1 (1/batch)	1,1,1 LCS mix/batch	66 of 66 MS/D and 33 of 33 LCS spikes within 50-150% recovery	0	31 of 33 MS/D pairs RPD<25%	all Yr 3 Results are ND
PCB Congenres (EPA 8082M) 50 analytes	W	3	1,1,1 (1/batch)	1,2,1 LCS (1/batch)	306 of 306 MS/D and 204 of 204 LCS spikes within 50-150% recovery	0	153 of 153 MS/D pairs RPD<25%	all Yr 3 Results are ND
PAH (EPA 8270M) 43 analytes	W	2	1,1 (1/batch)	1,1 (1/batch)	205 of 208 MS/D and 92 of 104 LCS spikes within 50-150% recovery	0	100 of 104 MS/D pairs RPD<25%	many samples did not meet holding time
Metals (total&dissolved) (EPA1638M) 11 analytes	W	3	3,1,3 (1/batch)	2,1,2 CRM mix/batch	150 of 154 MS/D and 55 of 55 CRM spikes within 75-125% recovery	0,0,1 (1/analyte /batch)	77 of 77 MS/D, 22 of 22 CRM, and 11 of 11 LabRep pairs RPD<25%	
Mercury EPA (1631EM)	W	3	1,1,2 (1/batch)	1,1,1 CRM (1/batch)	8 of 8 MS/D and 3 of 3 CRM spikes within 75-125% recovery	1,1,0 (1/analyte /batch)	4 of 4 MS/D4 and 2 of 2 LabRep pairs RPD<25%	
All groups	**S**	1 per group	1 per group	1 LCM and 1 CRM per group	497 of 519 MS/D, LCS, and CRM spikes within 50-150% recovery	0	149 of 155 MS/D pairs RPD<25%	
Fecal Coliforms (SM 9221	W	5	NA			0 (1/batch)	--	
Total Coliform (SM 9223 B-SOP1103)	W	5	NA	1 set (1 set of 3 species per lot)	all OK	4 (1/batch)	3 of 3 pairs RPD<75%	
E. coli SM (9223 B-SOP1103)	W	5	NA	1 set (1 set of 3 species per lot)	all OK	4 (1/batch)	4 of 4 pairs RPD<75%	

MS = matrix spike; MSD = matrix spike duplicate; MS/D = both; CRM = certified reference material; LCS = lab control sample; LCM = lab certified material
NA = not applicable; n/sp = not spiked; ND = not detected; RPD = relative percent difference
These quality checks do not apply to **toxicty tests,** where acceptability was confirmed by reference toxicant tests done with each batch of test organisms.
Note 1: A Lab Batch is made of all the samples analyzed in one day by one lab instrument between calibrations
Note 2: Conventional water quality characteristics were analyzed in multiple batches with a variable number of quality checks. Details are available with SWAMP RB2 and DMT
Author's Note: Because generation of the data for the "outcome" columns is labor intensive, and the information gleaned may be of interest to a very small audience, the effort is not justified in most cases.

Table F-4: Measurement quality objectives for various groups of analytes in water.

Analyte Group	Surrogate Recovery (%)	Matrix Spike Recovery (%)	CRM, LCM, & LCS Recovery (%)	RPD (MS/MSD, Lab Rep, Field Dup) (%)
Conventional Constituents	NA	80-120	80-120	25
Trace Metals (Including Mercury)	NA	75-125	75-125	25
Synthetic Organics (PCBs, OCs, OPs, Triazines)	50-150	50-150	50-150	25

NA = not applicable
LCS = Laboratory Control Sample
CRM = Certified Reference Material
RPD = Relative Percent Difference – difference between two duplicates/replicates, expressed as a percentage of their average.