Urban Creeks Monitoring Report

Water Quality Monitoring

Water Year 2015 (October 2014 – September 2015)

Submitted in Compliance with
NPDES Permit No. CAS612008 (Order No. R2-2015-0049),
Provision C.8.h.iii

SAN MATEO COUNTYWIDE
Water Pollution
Prevention Program

A Program of the City/County Association of Governments

March 31, 2016

CREDITS

This report is submitted by the participating agencies in the

SAN MATEO COUNTYWIDE
Water Pollution
Prevention Program
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City of San Bruno
City of San Carlos
City of San Mateo
City of South San Francisco
Town of Woodside
County of San Mateo
SMC Flood Control District

Prepared for:
San Mateo Countywide Water Pollution Prevention Program (SMCWPPP)
555 County Center, Redwood City, CA 94063
A Program of the City/County Association of Governments (C/CAG)

Prepared by:
EOA, Inc.
1410 Jackson St., Oakland, CA 94610

Preface

In early 2010, several members of the Bay Area Stormwater Agencies Association (BASMAA) joined together to form the Regional Monitoring Coalition (RMC), to coordinate and oversee water quality monitoring required by the 2009 Municipal Regional Stormwater National Pollutant Discharge Elimination System (NPDES) Permit in this document the 2009 permit is referred to as "MRP 1.0")[1]. The RMC includes the following participants:

- Clean Water Program of Alameda County (ACCWP)
- Contra Costa Clean Water Program (CCCWP)
- San Mateo Countywide Water Pollution Prevention Program (SMCWPPP)
- Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP)
- Fairfield-Suisun Urban Runoff Management Program (FSURMP)
- City of Vallejo and Vallejo Sanitation and Flood Control District (Vallejo)

In 2015, the San Francisco Bay Regional Water Quality Control Board (SFRWQCB or Regional Water Board) revised and reissued the MRP (the 2015 permit is referred to as "MRP 2.0"). This Urban Creeks Monitoring Report complies with MRP 2.0 Provision C.8.h.iii for reporting of all data in Water Year 2015 (October 1, 2014 through September 30, 2015). Data were collected pursuant to Provision C.8 of MRP 1.0. Data presented in this report were produced under the direction of the RMC and the San Mateo Countywide Water Pollution Prevention Program (SMCWPPP) using probabilistic and targeted monitoring designs as described herein.

Consistent with the BASMAA RMC Multi-Year Work Plan (Work Plan; BASMAA 2012) and the Creek Status and Long-Term Trends Monitoring Plan (BASMAA 2011), monitoring data were collected in accordance with the BASMAA RMC Quality Assurance Program Plan (QAPP; BASMAA, 2014a) and the BASMAA RMC Standard Operating Procedures (SOPs; BASMAA, 2014b). Where applicable, monitoring data were derived using methods comparable with methods specified by the California Surface Water Ambient Monitoring Program (SWAMP) QAPP[2]. Data presented in this report were also submitted in electronic SWAMP-comparable formats by SMCWPPP to the Regional Water Board on behalf of SMCWPPP Permittees and pursuant to Provision C.8.h.ii of MRP 2.0.

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[1] The San Francisco Bay Regional Water Quality Control Board (SFRWQCB) adopted MRP 1.0 on October 14, 2009 (SFRWQCB 2009). 76 cities, counties and flood control districts (i.e., Permittees) in the Bay Area are permitted under the MRP. The BASMAA programs supporting MRP Regional Projects include all MRP Permittees as well as the cities of Antioch, Brentwood, and Oakley, which are not named as Permittees under the MRP but have voluntarily elected to participate in MRP-related regional activities.

[2] The current SWAMP QAPP is available at: http://www.waterboards.ca.gov/water_issues/programs/swamp/docs/qapp/swamp_qapp_master090108a.pdf

List of Acronyms

ACCWP	Alameda County Clean Water Program
ASBS	Area of Special Biological Significance
BASMAA	Bay Area Stormwater Management Agency Association
BMP	Best Management Practice
C/CAG	San Mateo City/County Association of Governments
CCCWP	Contra Costa Clean Water Program
CDO	Cease and Desist Order
CEDEN	California Environmental Data Exchange Network
CRAM	California Rapid Assessment Method
CSCI	California Stream Condition Index
CW4CB	Clean Watersheds for a Clean Bay
DO	Dissolved Oxygen
FIB	Fecal Indicator Bacteria
FSURMP	Fairfield Suisun Urban Runoff Management Program
GIS	Geographic Information system
IBI	Benthic Macroinvertebrate Index of Biological Integrity
IPM	Integrated Pest Management
LID	Low Impact Development
MBNMS	Monterey Bay National Marine Sanctuary
MPC	Monitoring and Pollutants of Concern Committee
MRP	Municipal Regional Permit
MS4	Municipal Separate Storm Water Sewer System
MST	Microbial Source Tracking
MWAT	Maximum Weekly Average Temperature
MYP	Multi-Year Plan
NPDES	National Pollution Discharge Elimination System
PAHs	Polycyclic Aromatic Hydrocarbons
PBDEs	Polybrominated Diphenyl Ethers
PCBs	Polychlorinated Biphenyls
PEC	Probably Effect Concentration
PHAB	Physical Habitat
POC	Pollutant of Concern

QAPP	Quality Assurance Project Plan
RMC	Regional Monitoring Coalition
RMP	Regional Monitoring Program
RWSM	Regional Watershed Spreadsheet Model
S&T	Status and Trends
SCVURPPP	Santa Clara Valley Urban Runoff Pollution Prevention Program
SFEI	San Francisco Estuary Institute
SFRWQCB	San Francisco Regional Water Quality Control Board
SMCRCD	San Mateo County Resource Conservation District
SMCWPPP	San Mateo Countywide Water Pollution Prevention Program
SOP	Standard Operating Procedures
SPLWG	Sources, Pathways, and Loadings Work Group
SPoT	Statewide Stream Pollutant Trend Monitoring
SSID	Stressor/Source Identification
STLS	Small Tributaries Loading Strategy
SWAMP	Surface Water Ambient Monitoring Program
TEC	Threshold Effect Concentration
TMDL	Total Maximum Daily Load
TOC	Total Organic Carbon
TRC	Technical Review Committee
TU	Toxic Unit (equivalent)
UCMR	Urban Creeks Monitoring Report
USEPA	US Environmental Protection Agency
WLA	Waste Load Allocation
WQO	Water Quality Objective

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Table E.1. Water Year 2016 Creek Status Monitoring Stations

In compliance with Provision C.8.h.iii.(1), this table of all Creek Status Monitoring stations sampled in Water Year 2015 is provided immediately following the Table of Contents. See Section 3.0 for additional information on Creek Status Monitoring.

Map ID	Station Number	Bayside or Coastside	Watershed	Creek Name	Land Use	Latitude	Longitude	Probabilistic		Targeted			
								Bioassessment, Nutrients, General WQ	Toxicity, Sediment Chemistry	CRAM	Temp	Cont. WQ	Pathogen Indicators
378	202R00378	Bayside	Pescadero Creek	Pescadero Creek	NU	37.21994	-122.16385	X		X			
440	202R00440	Coastside	Purisima Creek	Purisima Creek	NU	37.43417	-122.34959	X		X			
1356	202R01356	Coastside	San Pedro Creek	Middle Fork San Pedro Creek	U	37.57524	-122.46105	X		X			
1612	202R01612	Coastside	San Pedro Creek	Middle Fork San Pedro Creek	U	37.57810	-122.47139	X		X			
1448	204R01448	Bayside	San Francisquito Creek	Atherton Creek	U	37.43459	-122.21776	X	X	X			
1972	204R01972	Bayside	Cordilleras Creek	Cordilleras Creek	U	37.48375	-122.25730	X		X			
2056	204R02056	Bayside	Laurel Creek	Laurel Creek	U	37.53342	-122.30243	X	X	X			
2248	204R02248	Bayside	Laurel Creek	Laurel Creek	U	37.52659	-122.32843	X		X			
1704	205R01704	Bayside	Atherton Creek	Dry Creek	U	37.43389	-122.26094	X		X			
1816	205R01816	Bayside	San Francisquito Creek	Corte Madera Creek	U	37.36615	-122.21570	X		X			
58	204SMA058	Bayside	San Mateo Creek	San Mateo Creek	U	37.56249	-122.32843					X	
59	204SMA059	Bayside	San Mateo Creek	San Mateo Creek	U	37.56331	-122.32707					X	
60	204SMA060	Bayside	San Mateo Creek	San Mateo Creek	U	37.56244	-122.32828						X
80	204SMA080	Bayside	San Mateo Creek	San Mateo Creek	U	37.55731	-122.34204						X
100	204SMA100	Bayside	San Mateo Creek	San Mateo Creek	U	37.53719	-122.35001						X
110	204SMA110	Bayside	San Mateo Creek	Polhemus Creek	U	37.53235	-122.3508						X
120	204SMA119	Bayside	San Mateo Creek	San Mateo Creek	U	37.53312	-122.35073						X
68	205ALA015	Bayside	San Francisquito Creek	Alambique Creek	U	37.40443	-122.25430				X		
71	205BCR010	Bayside	San Francisquito Creek	Bear Creek	U	37.41179	-122.24106				X		
69	205BCR050	Bayside	San Francisquito Creek	Bear Creek	U	37.427017	-122.25378				X		
72	205BCR060	Bayside	San Francisquito Creek	Bear Creek	U	37.42550	-122.26243				X		
70	205WUN150	Bayside	San Francisquito Creek	West Union Creek	U	37.431117	-122.27622				X		

U = Urban, NU = Non-urban

1.0 Introduction

This Urban Creeks Monitoring Report (UCMR), was prepared by the San Mateo Countywide Water Pollution Prevention Program (SMCWPPP), on behalf of its 22 member agencies (20 cities/towns, the County of San Mateo, and the San Mateo County Flood Control District) subject to the National Pollutant Discharge Elimination System (NPDES) stormwater permit for Bay Area municipalities referred to as the Municipal Regional Permit (MRP).

The MRP was first adopted by the San Francisco Regional Water Quality Control Board (SFRWQCB or Regional Water Board) on October 14, 2009 as Order R2-2009-0074 (referred to as MRP 1.0). On November 19, 2015, the SFRWQCB updated and reissued the MRP as Order R2-2015-0049 (referred to as MRP 2.0). This report fulfills the requirements of Provision C.8.g.iii of MRP 2.0 for comprehensively interpreting and reporting all monitoring data collected during the foregoing October 1 – September 30 (i.e., Water Year 2015). Data were collected pursuant to water quality monitoring requirements in Provision C.8 of MRP 1.0[3]. Monitoring data presented in this report were submitted electronically to the SFRWQCB by SMCWPPP and may be obtained via the San Francisco Bay Area Regional Data Center of the California Environmental Data Exchange Network (CEDEN) (http://water100.waterboards.ca.gov/ceden/sfei.shtml).

Chapters in this report are organized according to the following topics and MRP 1.0 provisions. Some topics are summarized briefly in this report but described more fully in appendices.

- **San Francisco Estuary Receiving Water Monitoring** (MRP 1.0 Provision C.8.b)
- **Creek Status Monitoring** (MRP 1.0 Provision C.8.c), including local targeted monitoring and SMCWPPP's contribution to the regional probabilistic monitoring program (Appendix A)
- **Monitoring Projects** (MRP 1.0 Provision C.8.d), specifically two completed SSID projects (Appendices B and C) and the BMP Effectiveness Investigation (Appendix E):
- **Pollutants of Concern (POC) Monitoring** (MRP 1.0 Provision C.8.e.i) (Appendices F and G)
- **Long-Term Trends Monitoring** (MRP 1.0 Provision C.8.e.ii)
- **Citizen Monitoring and Participation** (MRP 1.0 Provision C.8.f)
- **Recommendations and Next Steps**

Figure 1.1 maps locations of monitoring stations associated with Provision C.8 compliance in Water Year 2015 (WY2015), including Creek Status Monitoring, the Monitoring Projects (Stressor/Source Identification, BMP Effectiveness Investigation), SMCWPPP and Small Tributaries Loading Strategy (STLS) POC Monitoring, and Long-Term Trends Monitoring conducted at Stream Pollution Trend (SPoT) stations. This figure illustrates the geographic extent of monitoring conducted in San Mateo County in WY2015.

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[3] Water quality monitoring requirements in MRP 2.0 are generally similar to requirements in MRP 1.0. Differences in water quality monitoring requirements between MRP 1.0 and MRP 2.0 are briefly outlined in this report where applicable.

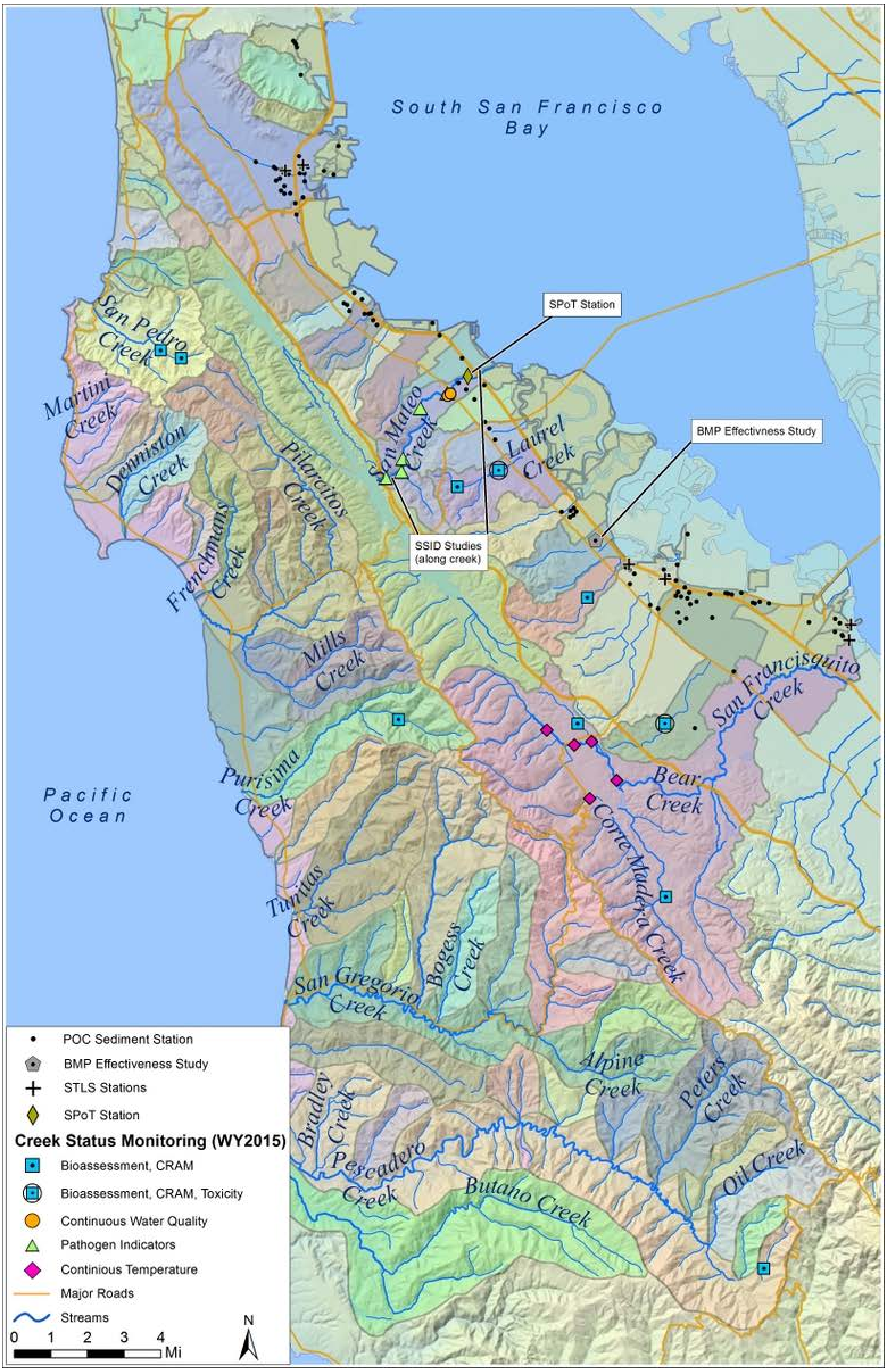

Figure. 1.1. San Mateo County MRP Provision C.8 monitoring locations: Creek Status Monitoring, Stressor/Source Identification (SSID) Studies, BMP Effectiveness Investigation, POC Monitoring, and Long-Term Trends (SPoT), WY2015.

1.1 RMC Overview

Provision C.8.a (Compliance Options) of the MRP allows Permittees to address monitoring requirements through a “regional collaborative effort,” their countywide stormwater program, and/or individually. In June 2010, Permittees notified the Regional Water Board in writing of their agreement to participate in a regional monitoring collaborative to address requirements in Provision C.8. The regional monitoring collaborative is referred to as the Bay Area Stormwater Management Agency Association (BASMAA) Regional Monitoring Coalition (RMC). With notification of participation in the RMC, Permittees were required to commence water quality data collection by October 2011. In a November 2, 2010 letter to the Permittees, the Regional Water Board’s Assistant Executive Officer (Dr. Thomas Mumley) acknowledged that all Permittees have opted to conduct monitoring required by the MRP through a regional monitoring collaborative, the BASMAA RMC. Participants in the RMC are listed in Table 1.1. SMCWPPP will continue its participation in the RMC during the permit term of MRP 2.0.

In February 2011, the RMC developed a Multi-Year Work Plan (RMC Work Plan; BASMAA 2011) to provide a framework for implementing regional monitoring and assessment activities required under MRP Provision C.8. The RMC Work Plan summarizes RMC projects planned for implementation between Fiscal Years 2009-10 and 2014-15 (BASMAA 2011). Projects were collectively developed by RMC representatives to the BASMAA Monitoring and Pollutants of Concern Committee (MPC), and were conceptually agreed to by the BASMAA Board of Directors (BASMAA BOD). A total of 27 regional projects are identified in the RMC Work Plan, based on the requirements described in Provision C.8 of the MRP 1.0[4].

Regionally implemented activities in the RMC Work Plan are conducted under the auspices of BASMAA, a 501(c)(3) non-profit organization comprised of the municipal stormwater programs in the San Francisco Bay Area. Scopes, budgets, and contracting or in-kind project implementation mechanisms for BASMAA regional projects follow BASMAA’s Operational Policies and Procedures and are approved by the BASMAA BOD. MRP Permittees, through their stormwater program representatives on the BOD and its subcommittees, collaboratively authorize and participate in BASMAA regional projects or tasks[5]. Regional project costs are shared by either all BASMAA members or among those Phase I municipal stormwater programs that are subject to the MRP.

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[4] Several regional projects have already been identified and will be conducted in compliance with MRP 2.0; however, the RMC will likely not compile the project descriptions in an updated Multi-Year Work Plan.

[5] Regional projects conducted in compliance with MRP 2.0 will continue to follow BASMAA Operational Policies and Procedures.

Table 1.1 Regional Monitoring Coalition participants.

Stormwater Programs	RMC Participants
Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP)	Cities of Campbell, Cupertino, Los Altos, Milpitas, Monte Sereno, Mountain View, Palo Alto, San Jose, Santa Clara, Saratoga, Sunnyvale, Los Altos Hills, and Los Gatos; Santa Clara Valley Water District; and, Santa Clara County
Clean Water Program of Alameda County (ACCWP)	Cities of Alameda, Albany, Berkeley, Dublin, Emeryville, Fremont, Hayward, Livermore, Newark, Oakland, Piedmont, Pleasanton, San Leandro, and Union City; Alameda County; Alameda County Flood Control and Water Conservation District; and, Zone 7
Contra Costa Clean Water Program (CCCWP)	Cities of Antioch, Brentwood, Clayton, Concord, El Cerrito, Hercules, Lafayette, Martinez, Oakley, Orinda, Pinole, Pittsburg, Pleasant Hill, Richmond, San Pablo, San Ramon, Walnut Creek, Danville, and Moraga; Contra Costa County; and, Contra Costa County Flood Control and Water Conservation District
San Mateo Countywide Water Pollution Prevention Program (SMCWPPP)	Cities of Belmont, Brisbane, Burlingame, Daly City, East Palo Alto, Foster City, Half Moon Bay, Menlo Park, Millbrae, Pacifica, Redwood City, San Bruno, San Carlos, San Mateo, South San Francisco, Atherton, Colma, Hillsborough, Portola Valley, and Woodside; San Mateo County Flood Control District; and, San Mateo County
Fairfield-Suisun Urban Runoff Management Program (FSURMP)	Cities of Fairfield and Suisun City
Vallejo Permittees	City of Vallejo and Vallejo Sanitation and Flood Control District

1.2 Coordination with Third-party Monitoring Programs

In WY2015, SMCWPPP continued to coordinate with water quality monitoring programs conducted by third parties, but that supplement Bay Area stormwater monitoring conducted via MRP 1.0. These programs include the San Francisco Bay Regional Monitoring Program (RMP) for Water Quality's Small Tributaries Load Strategy (STLS) and the Stream Pollutant Trends (SPoT) monitoring conducted by the State of California's Surface Water Ambient Monitoring Program (SWAMP). Water quality data from each of these programs are reported in this document and were utilized to comply with Provision C.8 of MRP 1.0, consistent with Provision C.8.a.[6] Data are specifically referenced in Sections 5.0 (POC Monitoring) and 6.0 (Trends Monitoring) of this report.

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[6] Data reported by these programs are summarized in this report, however were not included in the SMCWPPP electronic data submittal.

2.0 San Francisco Estuary Receiving Water Monitoring

As described in MRP Provision C.8.b, Permittees are required to provide financial contributions towards implementing an Estuary receiving water monitoring program on an annual basis that at a minimum is equivalent to the Regional Monitoring Program for Water Quality in the San Francisco Estuary (RMP). Since the adoption of the MRP 1.0, SMCWPPP has complied with this provision by making financial contributions to the RMP directly or through stormwater programs. Additionally, BASMAA and SMCWPPP staff actively participates in RMP committees, workgroups, and strategy teams as described in the following sections, which also provide a brief description of the RMP and associated monitoring activities conducted during WY2015. These contributions and participation will continue through MRP 2.0.

The RMP is a long-term monitoring program that is discharger funded and shares direction and participation by regulatory agencies and the regulated community with the goal of assessing water quality in the San Francisco Bay. The regulated community includes Permittees, publicly owned treatment works (POTWs), dredgers, and industrial dischargers. The San Francisco Estuary Institute (SFEI) is the implementing entity for the RMP and the fiduciary agent for RMP stakeholder funds. SFEI does not provide direct oversight of the RMP but does help identify stakeholder information needs, develop workplans that address these needs, and implement the workplans.

The RMP is intended to help answer the following core management questions:

1. *Are chemical concentrations in the Estuary potentially at levels of concern and are associated impacts likely?*
2. *What are the concentrations and masses of contaminants in the Estuary and its segments?*
3. *What are the sources, pathways, loadings, and processes leading to contaminant related impacts in the Estuary?*
4. *Have the concentrations, masses, and associated impacts of contaminants in the Estuary increased or decreased?*
5. *What are the projected concentrations, masses, and associated impacts of contaminants in the Estuary?*

The RMP budget is generally broken into two major program elements: Status and Trends, and Pilot/Special Studies. The following sections provide a brief overview of these programs. The RMP 2015 Detailed Workplan provides more details and establishes deliverables for each component of the RMP budget (http://www.sfei.org/sites/default/files/biblio_files/2015%20RMP%20Detailed%20Workplan.pdf). More information, including monitoring results, is available in the 2015 *State of the Estuary Report*[7] (http://www.sfestuary.org/about-the-estuary/soter/) and its companion, the 2015 *Pulse of the Bay* (http://www.sfei.org/programs/pulse-bay).

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[7] In 2015, the *State of the Estuary Report* was published as an online *Flipbook* with interactive charts and data stories, as well as in portable document format (pdf).

2.1 RMP Status and Trends Monitoring Program

The Status and Trends Monitoring Program (S&T Program) is the long-term contaminant-monitoring component of the RMP. The S&T Program was initiated as a pilot study in 1989, implemented thereafter, and then redesigned in 2007 based on a more rigorous statistical design that enables the detection of trends. The Technical Review Committee (TRC) continues to assess the efficacy and value of the various elements of the S&T Program and to recommend modifications to S&T Program activities based on ongoing findings. In 2015, the S&T Program was comprised of the following program elements that collect data to address the RMP management questions described above:

- Long-term water, sediment, and bivalve monitoring
- Episodic toxicity monitoring
- Sport fish monitoring on a five-year cycle
- USGS hydrographic and sediment transport studies
    - Factors controlling suspended sediment in San Francisco Bay
    - Hydrography and phytoplankton
- Triennial bird egg monitoring (cormorant and tern)
- Sediment sampling in Bay Margins

Additional information on the S&T Program and associated monitoring data are available for downloading via the RMP website at http://www.sfei.org/content/status-trends-monitoring.

2.2 RMP Pilot and Special Studies

The RMP also conducts Pilot and Special Studies on an annual basis. Studies are typically designed to investigate and develop new monitoring measures related to anthropogenic contamination or contaminant effects on biota in the Estuary. Special Studies address specific scientific issues that RMP committees, workgroups, and strategy teams identify as priority for further study. These studies are developed through an open selection process at the workgroup level and selected for funding through the TRC and the Steering Committee.

In 2015, Pilot and Special Studies focused on the following topics:

- Continuous monitoring of nutrients and dissolved oxygen at moored sensors
- Nutrients loads modeling
- Small tributary load monitoring (see Section 5.0 for more details)
- Chemicals of emerging concern (CEC) monitoring (perfluorochemicals, fipronil, and microplastics)
- Selection of priority margin areas for evaluation and development of conceptual PCB models
- Selenium in fish tissue monitoring

Results and summaries of the most pertinent Pilot and Special Studies can be found on the RMP website (http://www.sfei.org/rmp/rmp_pilot_specstudies).

In WY2015, a considerable amount of RMP and Stormwater Program staff time was spent overseeing and implementing Special Studies associated with the RMP's Small Tributary Loading Strategy (STLS) and the STLS Multi-Year Monitoring Plan (MYP). Pilot and Special Studies associated with the STLS are intended to fill data gaps associated with loadings of Pollutants of Concern (POC) from relatively small tributaries to the San Francisco Bay. Additional information on STLS-related studies is included in Section 5.0 (POC Loads Monitoring) of this report.

2.3 Participation in Committees, Workgroups and Strategy Teams

In WY2015, BASMAA and/or SMCWPPP staff actively participated in the following RMP Committees and workgroups:

- Steering Committee (SC)
- Technical Review Committee (TRC)
- Sources, Pathways and Loadings Workgroup (SPLWG)
- Contaminant Fate Workgroup (CFWG)
- Exposure and Effects Workgroup (EEWG)
- Emerging Contaminant Workgroup (ECWG)
- Sport Fish Monitoring Workgroup
- Nutrient Technical Workgroup
- Strategy Teams (e.g., PCBs, Mercury, Dioxins, Small Tributaries, Nutrients)

Committee and workgroup representation was provided by Permittee, stormwater program (including SMCWPPP) staff and/or individuals designated by RMC participants and the BASMAA BOD. Representation typically includes participating in meetings, reviewing technical reports and work products, co-authoring or reviewing articles included in the RMP's *Pulse of the Estuary*, and providing general program direction to RMP staff. Representatives of the RMC also provided timely summaries and updates to, and received input from Stormwater Program representatives (on behalf of Permittees) during BASMAA Monitoring and Pollutants of Concern Committee (MPC) and/or BASMAA BOD meetings to ensure Permittees' interests were represented.

3.0 Creek Status Monitoring

Provision C.8.c of MRP 1.0 and Provision C.8.d of MRP 2.0 requires Permittees to conduct creek status monitoring that is intended to answer the following management questions:

1. *Are water quality objectives, both numeric and narrative, being met in local receiving waters, including creeks, rivers and tributaries?*
2. *Are conditions in local receiving waters supportive of or likely supportive of beneficial uses?*

Creek status monitoring parameters, methods, occurrences, durations and minimum number of sampling sites for each stormwater program are described in Table 8.1 of the MRP. Based on the implementation schedule described in MRP Provision C.8.a.ii, creek status monitoring coordinated through the RMC began in October 2011.

The RMC's regional monitoring strategy for complying with MRP Provision C.8.c - Creek Status Monitoring - is described in the RMC Creek Status and Long-Term Trends Monitoring Plan (BASMAA 2011). The strategy includes a regional ambient/probabilistic monitoring component and a component based on local "targeted" monitoring. The combination of these monitoring designs allows each individual RMC participating program to assess the status of beneficial uses in local creeks within its Program (jurisdictional) area, while also contributing data to answer management questions at the regional scale (e.g., differences between aquatic life condition in urban and non-urban creeks).

Creek status monitoring data from WY2015 were submitted to the Regional Water Board by SMCWPPP. The analyses of results from creek status monitoring conducted by SMCWPPP in WY2014 are summarized below and presented in detail in Appendix A (SMCWPPP Creek Status Monitoring Report, WY2014).

The probabilistic monitoring design was developed to remove bias from site selection such that ecosystem conditions can be objectively assessed on local (i.e., SMCWPPP) and regional (i.e., RMC) scales. Probabilistic parameters consist of benthic macroinvertebrate and algae bioassessment, nutrients and conventional analytes. Riparian assessments, chlorine measurements, and collection of water and sediment toxicity and sediment chemistry are also conducted at probabilistic sites. Ten probabilistic sites were sampled by SMCWPPP in WY2015. A small number of additional non-urban sites were sampled by the SFRWQCB as part of the Surface Water Ambient Monitoring Program (SWAMP), in collaboration with SMCWPPP; however, the SWAMP data were not available at the time this report was completed.

The targeted monitoring design focuses on sites selected based on the presence of significant fish and wildlife resources as well as historical and/or recent indications of water quality concerns. Targeted monitoring parameters consist of water temperature, general water quality, pathogen indicators and riparian assessments. In WY2015, hourly water temperature measurements were recorded during the dry season using HOBO® temperature data loggers installed at five sites in the San Francisquito Creek watershed. General water quality monitoring (temperature, dissolved oxygen, pH and specific conductivity) was conducted using YSI continuous water quality equipment (sondes) for two 2-week periods (spring and late summer) at two sites in San Mateo Creek. Water samples were collected at five sites in San Mateo Creek for analysis of pathogen indicators (*E. coli* and fecal coliform).

Probabilistic and targeted Creek Status monitoring stations are listed in Table 3.1 and mapped in Figure 3.1 (and Figure 1.1, with other types of monitoring stations).

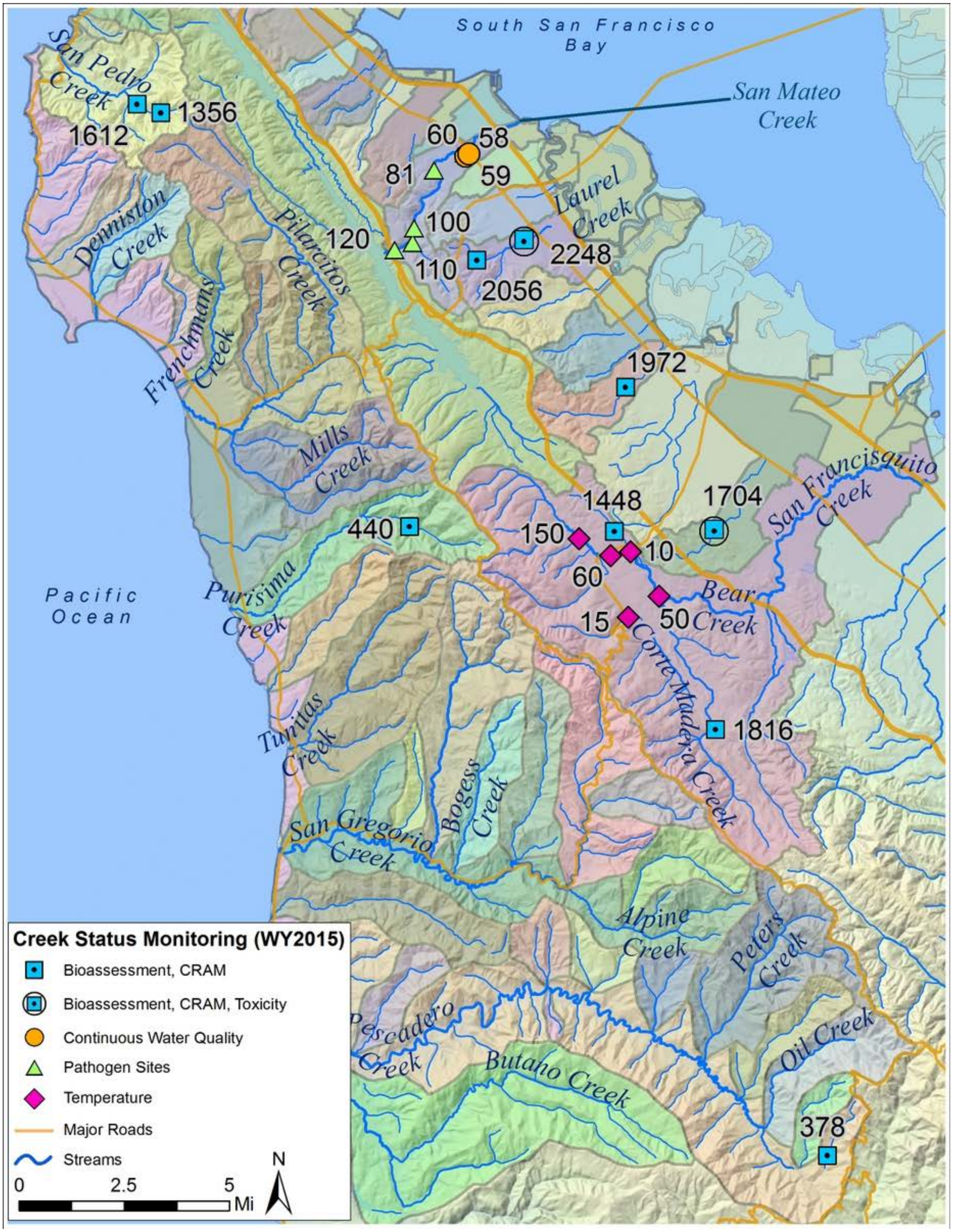

Figure 3.1. Map of major creeks and SMCWPPP stations monitored in WY2015 in compliance with MRP 1.0 Provision C.8.c.

Table 3.1. MRP 1.0 Provision C.8.c Creek Status monitoring stations in San Mateo County, WY2015.

Map ID	Station Number	Bayside or Coastside	Watershed	Creek Name	Land Use	Latitude	Longitude	Probabilistic		Targeted			
								Bioassessment, Nutrients, General WQ	Toxicity, Sediment Chemistry	CRAM	Temp	Cont. WQ	Pathogen Indicators
378	202R00378	Bayside	Pescadero Creek	Pescadero Creek	NU	37.21994	-122.16385	X		X			
440	202R00440	Coastside	Purisima Creek	Purisima Creek	NU	37.43417	-122.34959	X		X			
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1972	204R01972	Bayside	Cordilleras Creek	Cordilleras Creek	U	37.48375	-122.25730	X		X			
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1816	205R01816	Bayside	San Francisquito Creek	Corte Madera Creek	U	37.36615	-122.21570	X		X			
58	204SMA058	Bayside	San Mateo Creek	San Mateo Creek	U	37.56249	-122.32843					X	
59	204SMA059	Bayside	San Mateo Creek	San Mateo Creek	U	37.56331	-122.32707					X	
60	204SMA060	Bayside	San Mateo Creek	San Mateo Creek	U	37.56244	-122.32828						X
80	204SMA080	Bayside	San Mateo Creek	San Mateo Creek	U	37.55731	-122.34204						X
100	204SMA100	Bayside	San Mateo Creek	San Mateo Creek	U	37.53719	-122.35001						X
110	204SMA110	Bayside	San Mateo Creek	Polhemus Creek	U	37.53235	-122.3508						X
120	204SMA119	Bayside	San Mateo Creek	San Mateo Creek	U	37.53312	-122.35073						X
68	205ALA015	Bayside	San Francisquito Creek	Alambique Creek	U	37.40443	-122.25430				X		
71	205BCR010	Bayside	San Francisquito Creek	Bear Creek	U	37.41179	-122.24106				X		
69	205BCR050	Bayside	San Francisquito Creek	Bear Creek	U	37.427017	-122.25378				X		
72	205BCR060	Bayside	San Francisquito Creek	Bear Creek	U	37.42550	-122.26243				X		
70	205WUN150	Bayside	San Francisquito Creek	West Union Creek	U	37.431117	-122.27622				X		

3.1 Management Questions

The first management question (***Are water quality objectives, both numeric and narrative, being met in local receiving waters, including creeks, rivers and tributaries?***) is addressed primarily through the evaluation of probabilistic and targeted monitoring data with respect to the triggers defined in MRP 2.0. A summary of trigger exceedances observed for each site is presented below in Table 3.2. Sites where triggers are exceeded may indicate potential impacts to aquatic life or other beneficial uses and are considered for future evaluation of stressor source identification (SSID) projects (see Section 4.0 for a discussion of ongoing and completed SSID projects).

The second management question (***Are conditions in local receiving waters supportive of or likely supportive of beneficial uses?***) is addressed primarily by assessing indicators of aquatic biological health using benthic macroinvertebrate and algae data collected at probabilistic sites. Biological condition scores were compared to physical habitat and water quality data collected synoptically with bioassessments to evaluate whether any correlations exist that may explain the variation in biological condition scores.

3.2 Creek Status Results/Conclusions

Probabilistic Survey Design

- Between WY2012 and WY2015, a total of 50 probabilistic sites were sampled by SMCWPPP (n=40) and SWAMP (n=10) in San Mateo County, including 33 urban and 17 non-urban sites. There are now a sufficient number of samples from probabilistic sites to develop estimates of ambient biological condition and stressor assessment for urban streams in San Mateo County. A larger dataset is needed to estimate biological condition at more local scales (e.g., watershed and jurisdictional areas) and more than four years of data are required to assess trends.

Biological Condition Assessment

- The California Stream Condition Index (CSCI) tool was used to assess the biological condition for benthic macroinvertebrate data collected at probabilistic sites. Of the ten sites monitored in WY2015, five sites were rated in good condition (CSCI scores ≥ 0.795) and five sites rated as very likely altered condition (≤ 0.635) (Figure 3.2).
- CSCI scores were relatively consistent across four years of sampling. The median CSCI score for all four years ranged from 0.45 to 0.58 for urban sites and 0.9 to 1.1 for non-urban sites.
- Benthic algae data was collected synoptically with BMIs at all probabilistic sites. Algae index scores for diatom taxa (D18) were calculated for all sites. Four of the ten sites were rated in good condition (D18 scores ≥ 63), five sites rated as likely altered, and one site rated as very likely altered (<49).
- There was insufficient number of soft algae taxa to calculate algae indices S2 or H20 at any of the sites. Only three soft algal taxa were identified for all ten samples. Site characteristics and flow conditions prior to sampling do not appear to explain the absence of soft algae consistently at all the sites.
- There was very little difference in CSCI or algae IBI (D18) scores between perennial (n=8) and non-perennial (n=2) sites. CSCI scores had good response to different levels

of urbanization (calculated as percent impervious area). CSCI was highly correlated with physical habitat (PHAB) and CRAM scores. D18 was poorly correlated with both PHAB and CRAM scores.

Stressor Assessment

- Nutrients, algal biomass indicators, and other conventional analytes were measured in samples collected concurrently with bioassessments which are conducted in the spring season.
- CSCI scores has significant negative correlation with both land use variables (percent impervious and urban), specific conductivity, unionized ammonia, and SSC and positive correlation with two PHAB parameters (epifaunal substrate score and channel alteration score).
- Thresholds for water quality objectives were not exceeded.

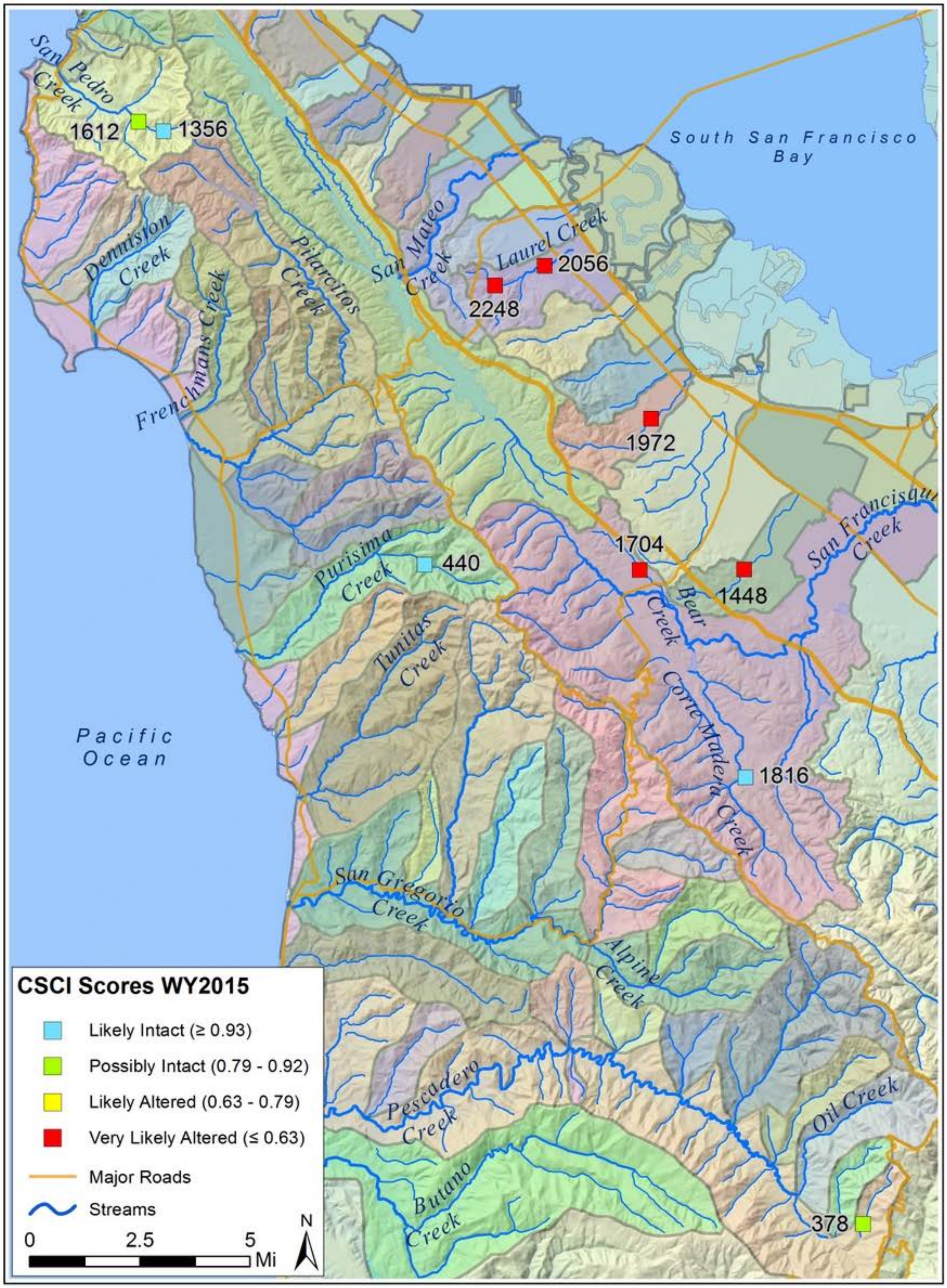

Figure 3.2. CSCI condition category for sites sampled in WY2015, San Mateo County.

Spatial and Temporal Variability of Water Quality Conditions

- There was minimal spatial variability in water temperature across the five sites in Bear Creek watershed.

- Dissolved oxygen concentrations were similar between the two San Mateo Creek sites, but were slightly lower during Event 2 compared to Event 1, possibly a result of warmer conditions late in the summer.

Potential Impacts to Aquatic Life

- Potential impacts to aquatic life were assessed through analysis of continuous temperature data collected at five targeted stations and continuous general water quality data (pH, dissolved oxygen, specific conductance, temperature) collected at two targeted stations. Stations were selected using the Directed Monitoring Design Principle.
- **Temperature**: The three temperature stations in Bear Creek exceeded the MRP 2.0 trigger threshold of having two or more weeks where the maximum weekly average temperature (MWAT) exceeded 17°C. Furthermore, both of the general water quality stations in San Mateo Creek exceeded the MWAT trigger during the second sampling event. None of the stations exceeded the maximum instantaneous trigger threshold of 24°C.
- All stations with MWAT trigger exceedances will be added to the list of candidate SSID projects; however, review of the monitoring data in the context of the ongoing drought and locally-derived temperature thresholds developed by NMFS suggests that temperature is not likely a limiting factor for salmonid habitat (i.e., summer rearing juveniles) in the study reaches.
- **Dissolved Oxygen**: The WQO for DO in waters designated as having cold freshwater habitat (COLD) beneficial uses (i.e., 7.0 mg/L) was met in all measurements recorded at the water quality stations in San Mateo Creek. As described in the Low DO SSID Project Report, previous low DO concerns in the study reach appear to have been mitigated by increased dry season releases from Crystal Springs Reservoir (see Appendix B).
- **pH**: Values for pH measured at the San Mateo Creek sites in WY2015 were within WQOs (6.5 to 8.5).
- **Specific Conductivity**: Specific conductivity concentrations recorded at the San Mateo Creek sites in WY2015 were below the trigger threshold of 2000 us/cm.
- **Chlorine**: Field testing for free chlorine and total chlorine residual was conducted at all ten probabilistic sites concurrent with spring bioassessment sampling (April-May), and at a subset (two) of the sites concurrent with dry season toxicity sampling (July). The MRP 1.0 trigger threshold of 0.08 mg/L was exceeded at one site on Atherton Creek. This site will be added to the list of candidate SSID projects.

Potential Impacts to Water Contact Recreation

- In WY2015, pathogen indicator sites were located in the San Mateo Creek watershed where a bacteria SSID study is in progress. Pathogen indicator triggers were exceeded at two of the five sites. Microbial source tracking (MST) techniques conducted as part of the SSID study suggest year-round human bacterial sources and wet-weather dog sources (Appendix C).

- It is important to recognize that pathogen indicator thresholds are based on human recreation at beaches receiving bacteriological contamination from human wastewater, and may not be applicable to conditions found in urban creeks. As a result, the comparison of pathogen indicator results to body contact recreation water quality objectives may not be appropriate and should be interpreted cautiously.

Water/Sediment Toxicity and Sediment Chemistry

- Water toxicity samples were collected from two sites during two sample events (winter storm event and summer). Although both wet weather samples were toxic relative to the Lab Control treatment, no water toxicity samples exceeded MRP 1.0 trigger thresholds.
- Sediment toxicity and chemistry samples were collected concurrently with the summer water toxicity samples. Chronic toxicity to *Hyalella azteca* in the Laurel Creek samples exceeded the MRP 1.0 trigger threshold. This site will be added to the list of candidate SSID projects.
- All sediment samples exceeded the trigger threshold from MRP 2.0 with at least one Threshold Effect Concentration (TEC) quotient or Probable Effect Concentration (PEC) quotient greater than or equal to 1.0. Therefore, both sites will be added to the list of candidate SSID projects. However, these findings were not unexpected in San Mateo County where naturally occurring chromium and nickel from serpentinite geology often results in high concentrations of these metals in receiving water sediments.

3.3 Trigger Assessment

The MRP requires analysis of the monitoring data to identify candidate sites for SSID projects. Creek Status Monitoring data were collected pursuant to MRP 1.0 but were evaluated and reported pursuant to MRP 2.0 which became effective January 1, 2016. Trigger thresholds against which to compare the data are provided for most monitoring parameters in MRP 2.0 and are described in the foregoing sections of this report. Stream condition was determined based on CSCI scores that were calculated using BMI data. Water and sediment chemistry and toxicity data were evaluated using numeric trigger thresholds specified in the MRP. In compliance with Provision C.8.e.i of MRP 2.0, all monitoring results exceeding trigger thresholds are added to a list of candidate SSID projects that will be maintained throughout the permit term. Follow-up SSID projects will be selected from this list. Table 3.2 lists of candidate SSID projects based on WY2015 Creek Status monitoring data.

Additional analysis of the data is provided in the foregoing sections of this report and should be considered prior to selecting and defining SSID projects. The analyses include review of physical habitat and water chemistry data to identify potential stressors that may be contributing to degraded or diminished biological conditions. Analyses in this report also include historical and spatial perspectives that help provide context and deeper understanding of the trigger exceedances.

Table 3.2. Summary of SMCWPPP trigger threshold exceedance analysis, WY2015. "No" indicates samples were collected but did not exceed the MRP trigger; "Yes" indicates an exceedance of an MRP trigger.

Station Number	Creek Name	Bioassessment	Nutrients	Chlorine	Water Toxicity	Sediment Toxicity	Sediment Chemistry	Continuous Temperature	Dissolved Oxygen	pH	Specific Conductance	Pathogen Indicators
202R00378	Pescadero Creek	No	No	No	--	--	--	--	--	--	--	--
202R00440	Purisima Creek	No	No	No	--	--	--	--	--	--	--	--
202R01356	Middle Fork San Pedro Creek	No	No	No	--	--	--	--	--	--	--	--
202R01612	Middle Fork San Pedro Creek	No	No	No	--	--	--	--	--	--	--	--
204R01448	Atherton Creek	Yes	No	Yes	No	No	Yes	--	--	--	--	--
204R01972	Cordilleras Creek	Yes	No	No	--	--	--	--	--	--	--	--
204R02056	Laurel Creek	Yes	No	No	No	Yes	Yes	--	--	--	--	--
204R02248	Laurel Creek	Yes	No	Yes	--	--	--	--	--	--	--	--
205R01704	Dry Creek	Yes	No	No	--	--	--	--	--	--	--	--
205R01816	Corte Madera Creek	No	No	No	--	--	--	--	--	--	--	--
204SMA058	San Mateo Creek	--	--	--	--	--	--	Yes	No	No	No	--
204SMA059	San Mateo Creek	--	--	--	--	--	--	Yes	No	No	No	--
204SMA060	San Mateo Creek	--	--	--	--	--	--	--	--	--	--	Yes
204SMA080	San Mateo Creek	--	--	--	--	--	--	--	--	--	--	Yes
204SMA100	San Mateo Creek	--	--	--	--	--	--	--	--	--	--	No
204SMA110	Polhemus Creek	--	--	--	--	--	--	--	--	--	--	No
204SMA119	San Mateo Creek	--	--	--	--	--	--	--	--	--	--	No
205ALA015	Alambique Creek	--	--	--	--	--	--	No	--	--	--	--
205BCR010	Bear Creek	--	--	--	--	--	--	Yes	--	--	--	--
205BCR050	Bear Creek	--	--	--	--	--	--	Yes	--	--	--	--
205BCR060	Bear Creek	--	--	--	--	--	--	Yes	--	--	--	--
205WUN150	West Union Creek	--	--	--	--	--	--	No	--	--	--	--

3.4 Management Implications

The Program's Creek Status Monitoring program (consistent with MRP 1.0 Provision C.8.c) focuses on assessing the water quality condition of urban creeks in San Mateo County and identifying stressors and sources of impacts observed. Although the sample size from WY2015 (overall n=10; urban n=9) is not sufficient to develop statistically representative conclusions regarding the overall condition of all creeks, it builds on data collected in WY2012 through WY2014 and could be used in a regional analysis of biological indicator and stressor data collected in San Mateo County. Even considering WY2015 data alone, it is clear that most urban streams have likely or very likely altered populations of aquatic life indicators (e.g., aquatic macroinvertebrates). These conditions are likely the result of long-term changes in stream hydrology, channel geomorphology, in-stream habitat complexity, and other modifications to the watershed and riparian areas associated with the urban development that has occurred over many decades. Furthermore, episodic or site specific increases temperature may not be optimal for aquatic life in local creeks.

SMCWPPP Permittees are actively implementing many stormwater management programs to address these and other stressors and associated sources of water quality conditions observed in local creeks, with the goal of protecting these natural resources. For example:

- In compliance with MRP 1.0 Provision C.3, new and redevelopment projects in the Bay Area are now designed to more effectively reduce water quality and hydromodification impacts associated with urban development. Low impact develop (LID) methods, such as rainwater harvesting and use, infiltration and biotreatment are required as part of development and redevelopment projects. These LID measures are expected to reduce the impacts of urban runoff and associated impervious surfaces on stream health. MRP 2.0 expands these requirements to include Green Infrastructure planning for all municipal projects.
- In compliance with MRP 1.0 Provision C.9, Permittees are implementing pesticide toxicity control programs that focus on source control and pollution prevention measures. The control measures include the implementation of integrated pest management (IPM) policies/ordinances, public education and outreach programs, pesticide disposal programs, the adoption of formal State pesticide registration procedures, and sustainable landscaping requirements for new and redevelopment projects. Through these efforts, the amount of pyrethroids observed in urban stormwater runoff should decrease significantly over time, and in turn significantly reduce the magnitude and extent of toxicity in local creeks. This work will continue under MRP 2.0.
- Trash loadings to local creeks have been reduced through implementation of new control measures in compliance with MRP 1.0 Provision C.10 and other efforts by Permittees to reduce the impacts of illegal dumping directly into waterways. These actions include the installation and maintenance of trash capture systems, the adoption of ordinances to reduce the impacts of litter prone items, enhanced institutional controls such as street sweeping, and the on-going removal and control of direct dumping. MRP 2.0 establishes a mandatory trash load reduction schedule, minimum areas to be treated by full trash capture systems, and requires development of receiving water monitoring programs for trash.
- In compliance with MRP 1.0 Provisions C.2 (Municipal Operations), C.4 (Industrial and Commercial Site Controls), C.5 (Illicit Discharge Detection and Elimination), and C.6 (Construction Site Controls) Permittees continue to implement programs that are designed to prevent non-stormwater discharges during dry weather and reduce the exposure of contaminants to stormwater and sediment in runoff during rainfall events. These programs will continue under MRP 2.0.
- In compliance with MRP 1.0 Provision C.13, copper in stormwater runoff is reduced through implementation of controls such as architectural and site design requirements, street sweeping, and participation in statewide efforts to significantly reduce the level of copper vehicle brake pads. These measures will be continued during the MRP 2.0 permit term.
- Mercury and polychlorinated biphenyls (PCBs) in stormwater runoff are being reduced through implementation of the respective TMDL water quality restoration plans. Under

MPR 2.0, the Program will continue to identify sources of these pollutants and will implement control actions designed to achieve new minimum load reduction goals.

Through the continued implementation of the above and other MRP-associated efforts and other watershed stewardship programs, SMCWPPP anticipates that stream conditions and water quality in local creeks will continue to improve over time. In the near term, toxicity observed in creeks should decrease as pesticide regulations better incorporate water quality concerns during the pesticide registration process. In the longer term, control measures implemented to “green” the “grey” infrastructure and disconnect impervious areas constructed in the past will take time to implement. Consequently, it may take several decades to observe the outcomes of these important, large-scale improvements to our watersheds in our local creeks. Long-term creek status monitoring programs designed to detect these changes over time are therefore beneficial to our collective understanding of the condition and health of our local waterways.

4.0 Monitoring Projects (C.8.d)

Three types of monitoring projects are required by Provision C.8.d of MRP 1.0:

1. Stressor/Source Identification Projects (C.8.d.i);
2. BMP Effectiveness Investigations (C.8.d.ii); and,
3. Geomorphic Projects (C.8.d.iii).

The overall scopes of these projects are generally described in MRP 1.0 and the RMC Work Plan (BASMAA 2011). The status of projects that SMCWPPP is conducting are described in the sections below and Figure 1.1 maps where these studies were (or are being) conducted.

4.1 Stressor/Source Identification Projects

As a participant in the RMC, SMCWPPP agreed to initiate two Stressor/Source Identification (SSID) Projects toward the region wide minimum of ten SSID Projects required by MRP 1.0. The SSID Projects must identify and isolate potential sources and/or stressors associated with observed water quality impacts. Creeks considered for SSID Projects are those with creek status monitoring results that exceed the triggers identified in Table 8.1 of MRP 1.0.

Based on creek status monitoring data collected by SMCWPPP, two SSID projects were completed in WY2015. Both projects are in San Mateo Creek.

4.1.1 San Mateo Creek Low Dissolved Oxygen SSID Project

Historical and recent (WY2013) monitoring data collected in the vicinity of De Anza Park in the San Mateo Creek watershed showed dissolved oxygen (DO) concentrations below the water quality objective (WQO) of 7 mg/L for waters designated as cold water habitat. During WY2014 SMCWPPP conducted a SSID project to address this potential water quality concern. Results of the SSID investigation suggest that low DO conditions are no longer present or expected in this reach of San Mateo Creek due to a recently implemented ongoing schedule of increased dry season releases of water from the upstream Crystal Springs Reservoir. These findings were confirmed through Creek Status Monitoring conducted in WY2015 per MRP 1.0 Provision C.8.c. No additional management measures are recommended and the SSID project is considered complete.

The Final Project Report was submitted to the Regional Water Board on July 9, 2015 and is included with this UCMR as Appendix B.

4.1.2 San Mateo Creek Pathogen Indicator SSID Project

Monitoring data collected in 2003 and 2012 at stations in San Mateo Creek showed fecal indicator bacteria (FIB) at densities exceeding WQOs for waters designated as having water contact recreation (REC-1) Beneficial Uses. During water years 2014 and 2015 SMCWPPP conducted a SSID project to address this potential water quality concern. Results of the SSID investigation suggest that FIB are present at densities exceeding REC-1 WQOs in San Mateo Creek reaches downstream of Sierra Drive. However, noncontact recreation (REC-2) Beneficial Use WQOs are not exceeded. Microbial source tracking (MST) techniques suggest that human sources are present year-round and dog sources are present during and shortly after wet weather. Many other potential sources of FIB are present in the watershed and likely contribute to the FIB densities measured at sampling stations. These include uncontrollable sources such as wildlife and natural bacterial growth in the creek bed and conveyance system.

A number of management actions designed specifically or opportunistically to control bacterial sources are currently planned or are being implemented by municipalities in the San Mateo Creek watershed. These include control measures for pet waste (signage and public education), trash reduction efforts that may reduce nuisance wildlife, programs to address homeless encampments, and several improvements to the sanitary sewer conveyance system in response to a Cease and Desist Order (CDO).

The City of San Mateo, Town of Hillsborough, San Mateo County, and SMCWPPP may wish to consider working together to increase public education and outreach targeting pet waste in the San Mateo Creek watershed. Potential examples include installation of additional cleanup signs, dog bag dispensers, and trash receptacles at creekside parks. Local municipalities should also continue the homeless elimination efforts begun through the HOPE strategy and HOT program. In addition, to help evaluate the effectiveness of current and planned control actions, SMCWPPP may wish to consider continuing to monitor FIB in San Mateo Creek via its MRP Creek Status monitoring program. However, even if human and dog sources are better controlled, results could still exceed WQOs due to uncontrollable sources such as wildlife and natural bacterial growth

The Final Project Report is included with this UCMR as Appendix C.

4.1.1 SSID Project Requirements under MRP 2.0

Provision C.8.e of MRP 2.0 requires that Permittees initiate a minimum number of SSID projects during the permit term. SMCWPPP intends to continue its participation in the RMC for which there is a region-wide minimum of eight new SSID Projects during the permit term. SMCWPPP has not yet initiated any SSID projects during MRP 2.0. Provision C.8.e requires that creek status, toxicity, and pesticide monitoring results (Provisions C.8.d and C.8.g) are reviewed annually and that a list is developed of all results exceeding the C.8.d trigger thresholds. Pollutant of Concern Monitoring (C.8.f) results may be included on the list as appropriate. See Table 3.2 for the list of WY2015 trigger exceedances. These sites will be considered as candidates for future SSID projects.

SSID projects conducted by RMC partners under MRP 1.0 are summarized in the Regional SSID Project Summary Table (Appendix D).

4.2 BMP Effectiveness Investigation

Provision C.8.d.ii of the MRP (BMP Effectiveness Investigation) requires that Permittees investigate the effectiveness of one Best Management Practice (BMP) in San Mateo County for stormwater treatment or hydrograph modification control measure[8]. The MRP encourages fulfillment of the requirement via investigation of BMP(s) used to fulfill requirements of Provisions C.3.b.iii, C.11.e, and C.12.e, provided the BMP Effectiveness Investigation includes the range of pollutants generally found in urban runoff.

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[8] MRP 2.0 does not require a BMP Effectiveness Investigation under Provision C.8 but does require monitoring to provide information on the effectiveness of future or existing management actions under Provision C.8.f (Pollutants of Concern Monitoring). SMCWPPP is developing a monitoring approach to comply with this requirement.

The Clean Watersheds for a Clean Bay (CW4CB) project was initiated to evaluate pilot BMPs installed for the control of polychlorinated biphenyls (PCBs) and mercury in stormwater runoff from urban areas pursuant to MRP Provisions C.11 and C.12. In San Mateo County, CW4CB includes monitoring curb extension bioretention/biotreatment facilities located along Bransten Road in the City of San Carlos. The CW4CB monitoring design at Bransten Road includes paired influent and effluent sampling and volume/flow measurements to calculate PCB and mercury load reductions. CW4CB analytical constituents include suspended sediments, total organic carbon, lead, mercury, and PCBs. Additional constituents generally found in stormwater runoff (e.g., nutrients, cadmium, chromium, copper, nickel, zinc) were added by the Program to supplement the CW4CB investigation. Samples were collected and flow volumes were measured during three storm events in WY2014 and one event in WY2015.

Mean concentrations of all total metals were generally lower in the effluent compared to the influent; whereas, mean concentrations of dissolved metals and nutrients were sometimes higher and sometime lower in the effluent. One factor that may contribute to this result is that bioretention facilities are typically less efficient at removing dissolved constituents compared to those in the particulate phase. However, recent reports regarding installation that was inconsistent with the design, resulting in localized flooding and potential system performance issues at the Bransten Road facility, may have affected its pollutant removal performance. These concerns are currently under investigation. If appropriate, SMCWPPP will calculate loadings and removal efficiencies for the constituents after the concerns at the site are better understood and resolved and any CW4CB hydrologic data are published.

Results of the C.8 BMP effectiveness monitoring are described in Appendix E. Monitoring results from the CW4CB project are scheduled to be reported separately by April 2017.

4.3 Geomorphic Project

MRP Provision C.8.d.iii requires Permittees to conduct a geomorphic monitoring project intended to help answer the management question:

- *How and where can our creeks be restored or protected to cost-effectively reduce the impacts of pollutants, increased flow rates, and increased flow durations of urban runoff?*

The provision requires that Permittees select a waterbody/reach, preferably one that contains significant fish and wildlife resources, and conduct one of three types of projects. SMCWPPP elected to conduct a geomorphic study to help in the development of regional curves which help estimate equilibrium channel conditions for different sized drainages. As part of this Geomorphic Study, SMCWPPP surveyed bankfull geometries at two consecutive riffles in the Middle Fork of San Pedro Creek. Results of the Geomorphic Study were described in Part A of the Integrated Monitoring Report (SMCWPPP 2014).

5.0 POC Loads Monitoring (C.8.e)

Pollutants of Concern (POC) loads monitoring is required by Provision C.8.e.i of MRP 1.0[9]. Loads monitoring is intended to assess inputs of POCs to the Bay from local tributaries and urban runoff, assess progress toward achieving wasteload allocations (WLAs) for TMDLs, and help resolve uncertainties associated with loading estimates for these pollutants. In particular, there are four priority management questions that need to be addressed though POC loads monitoring:

1. Which Bay tributaries (including stormwater conveyances) contribute most to Bay impairment from POCs?
2. What are the annual loads or concentrations of POCs from tributaries to the Bay?
3. What are the decadal-scale loading or concentration trends of POCs from small tributaries to the Bay?
4. What are the projected impacts of management actions (including control measures) on tributaries and where should these management actions be implemented to have the greatest beneficial impact?

In WY2015, SMCWPPP complied with Provision C.8.e.i of MRP 1.0 through:

- Continued participation in the RMP Small Tributaries Loading Strategy (STLS) Team, and
- Implementation of a targeted reconnaissance sediment sampling program (i.e., the PCBs and Mercury Opportunity Area Analysis).

POC monitoring in WY2015 focused primarily on identification of source areas of PCBs and mercury to the municipal separate stormwater sewer system (MS4) and San Francisco Bay. This approach differed from prior years and addressed the reprioritization of near-term information needs that occurred during development of MRP 2.0. Both components of WY2015 POC monitoring are described below.

5.1 Small Tributaries Loading Strategy

The RMP STLS was developed in 2009 by the STLS Team, which included representatives from BASMAA, Regional Water Board staff, RMP staff, and technical advisors and is overseen by the Sources, Pathways, and Loadings Workgroup (SPLWG). The objective of the STLS is to develop a comprehensive planning framework to coordinate POC loads monitoring/modeling between the RMP and RMC participants. In 2011, with concurrence of participating Regional Water Board staff, a framework (i.e., the STLS Multi-Year Plan) was developed presenting an alternative approach to the POC loads monitoring requirements described in Provision C.8.e.i of MRP 1.0, as allowed by Provision C.8.e. The most recent published version (Version 2013a) of the STLS Multi-Year Plan (MYP) was submitted with the Regional Urban Creeks Monitoring Report in March 2013 (BASMAA 2013). The STLS MYP is integrated with other RMP-funded

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[9] Provision C.8.f of MRP 2.0 requires POC Monitoring of PCBs, mercury, copper, emerging contaminants, and nutrients. MRP 2.0 defines yearly and total minimum number of samples for each POC. Five priority POC management information needs are identified including Source Identification, Contributions to Bay Impairment, Management Action Effectiveness, Loads and Status, and Trends. MRP 2.0 specifies minimum number of samples for each POC that must address each information need. SMCWPPP is in the process of developing a POC monitoring framework to comply with Provision C.8.f of MRP 2.0 over the next five years.

activities (see Section 2.0) and is a major component of the RMP MYP. Version 2013a of the STLS MYP includes two main elements that collectively address the four priority management questions for POC monitoring:

- Development and improvement of the Regional Watershed Spreadsheet Model (RWSM) as a tool for estimating regional loads of POCs to the Bay, and
- Watershed monitoring at six fixed stations.

Based on the lessons learned through the implementation of the STLS MYP in WY2012, WY2013, and WY2014, and the reprioritization of near-term information needs, SMCWPPP and its RMC partners implemented a revised approach to POC Loads monitoring in WY2015[10]. The revised monitoring approach was discussed at numerous STLS workgroup meetings during WY2014[11] and was agreed upon by STLS members, including Water Board staff, as the best approach to addressing near-term high priority information needs regarding PCB and mercury sources and loadings. The revised alternative approach initiated in WY2015 discontinues most POC loads monitoring stations sampled in previous Water Years, adds wet weather characterization monitoring, and maintains support of the RWSM. The sections below describe the tasks implemented by the RMP STLS in WY2015.

5.1.1 Wet Weather Characterization

With a goal of identifying watershed sources of PCBs and mercury, STLS field monitoring in WY2015 focused on collection of storm composite samples in the downstream reaches of approximately 20 catchments located throughout the region. The catchments range in size from 0.11 to 11.5 sq km and represent both natural creek watersheds and engineered MS4 drainage areas. The storm composite water samples were analyzed for concentrations of PCBs, total mercury, other metals (arsenic, cadmium, lead, copper, zinc), total organic carbon, dissolved organic carbon, suspended sediment concentration, and grain size distribution. In addition, a pilot study was conducted at a subset of 12 locations to collect fine sediments using specialized settling chambers. A full description of the methods and results is included in Appendix F (POC Reconnaissance Monitoring Progress Report, Water Year 2015).

Six catchments were targeted in San Mateo County based on recommendations by Program staff evaluating land uses in the County. (See Appendix G for a detailed description of the land use analysis approach.) All of the San Mateo County sampling stations were located at manholes accessing the MS4 or MS4 outlets to receiving waters.

Wet weather characterization monitoring will continue in WY2016 with support and sample station identification by SMCWPPP.

Compliance with Applicable Water Quality Standards

MRP Provision C.8.g.iii requires RMC participants to assess all data collected pursuant to Provision C.8 for compliance with applicable water quality standards. In compliance with this

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[10] The BASMAA Phase I stormwater managers discussed the approach with the Assistant Executive Officer of the SF Bay Regional Water Quality Control Board at the August 28, 2014 monthly meeting and amended the RMC to reflect the modification.

[11] Discussions about revised POC loads monitoring approaches for FY 13-14 (Water Year 2015) were discussed and ultimately agreed upon by Water Board staff and other STLS and RMC partners at the following STLS meetings: October 13, 2013; March 19, 2014; April 1, 2014; April 16, 2014; May 15, 2014; and June 9, 2014.

requirement, comparisons of data collected at the wet weather characterization monitoring stations in WY2015 to applicable numeric WQO is provided below.

When conducting a comparison to applicable WQOs/criteria, certain considerations should be taken into account to avoid the mischaracterization of water quality data:

Discharge vs. Receiving Water – WQOs apply to receiving waters, not discharges. WQOs are designed to represent the maximum amount of pollutants that can remain in the water column without causing any adverse effect on organisms using the aquatic system as habitat, on people consuming those organisms or water, and on other current or potential beneficial uses. In WY2015, POC monitoring data were not collected in receiving waters; instead, they were collected within the engineered storm drain network. Dilution is likely to occur when the MS4 discharges urban stormwater (and non-stormwater) runoff into the local receiving water. Therefore, it is unknown whether or not discharges that exceed WQOs result in exceedances in the receiving water itself, the location where there is the potential for exposure by aquatic life.

Freshwater vs. Saltwater - POC monitoring data were collected in freshwater, above tidal influence and therefore comparisons were made to freshwater WQOs/criteria.

Aquatic Life vs. Human Health - Comparisons were primarily made to objectives/criteria for the protection of aquatic life, not objectives/criteria for the protection of human health to support the consumption of water or organisms. This decision was based on the assumption that water and organisms are not likely being consumed from the stations monitored.

Acute vs. Chronic Objectives/Criteria - Monitoring was conducted during episodic storm events and results do not likely represent long-term (chronic) concentrations of monitored constituents. POC monitoring data were therefore compared to “acute” WQOs/criteria for aquatic life that represent the highest concentrations of an analyte to which an aquatic community can be exposed briefly (e.g., 1-hour) without resulting in an unacceptable effect.

Of the analytes monitoring at POC stations in WY2015, WQOs or criteria have only been promulgated for total mercury and total cadmium. WQOs for other metals analyzed are expressed in terms of the dissolved fraction of the metal in the water column for which data were not collected. Furthermore, the WQO for cadmium is are based on hardness which was not measured in the WY2015 samples. Therefore, the comparison of data collected in WY2015 to applicable numeric WQOs or criteria adopted by the Regional Water Board is limited to total mercury.

All of the samples collected in San Mateo County in WY2015 were well below the freshwater acute objective for mercury of 2.4 µg/L. Total mercury concentrations ranged from 0.014 µg/L to 0.055 µg/L. See Appendix F for tables listing the sampling results.

5.1.2 Regional Watershed Spreadsheet Model

The STLS Team and SPLWG continued to provide oversight in WY2015 to the development and refinement of the Regional Watershed Spreadsheet Model (RWSM), which is a land use based planning tool for estimation of overall POC loads from small tributaries to San Francisco Bay at a regional scale. The RWSM is being developed by SFEI on behalf of the RMP, with funding from both the RMP and BASMAA regional projects.

The RWSM is based on the idea that to accurately assess total contaminant loads entering San Francisco Bay, it is necessary to estimate loads from local watersheds. “Spreadsheet models” of stormwater quality provide a useful and relatively cheap tool for estimating regional scale watershed loads. Spreadsheet models have advantages over mechanistic models because the data for many of the input parameters required by mechanistic models may not currently exist, and also require large calibration datasets which take money and time to collect.

Development of a spreadsheet model to estimate POC loads from small tributaries to the Bay has been underway since 2010 when a water-based copper model was completed. Because PCBs and mercury are more closely related to sediments, a draft model for suspended sediments was developed. However, resulting loads estimates for PCBs and mercury appeared to be too high leading to the conclusion that accuracy and precision at small (e.g., watershed) scales is challenged by the regional nature of the calibration process and the simplicity of the model. In WY2015, a water-based model was adopted for PCBs and mercury along with new approaches to calibration which reflect the log-normal distribution of the dataset. The improved RWSM can be used for estimating regional scale annual average loads and could be useful for determining relative loading between sub-regions and more polluted versus less polluted watersheds.

During WY2015, SMCWPPP reviewed and provided input on draft reports referencing the RWSM or its loadings estimates (e.g., DRAFT Sources, Pathways and Loadings: Multi-Year Synthesis with a focus on PCBs and Hg). SMCWPPP also participated in the SPLWG which is the main venue for soliciting input from interested parties and technical advisors. SMCWPPP also worked with SFEI to identify potential GIS land use data layer improvements.

In WY2016, additional calibration data from the WY2015 wet weather characterization monitoring and BASMAA studies will be incorporated into the model. Improvements to the land use GIS layer will also help refine the model. As the modeling team at SFEI becomes more proficient with alternative water-based platforms (i.e., SWMM, HEC-RAS) through development of the Green Plan-IT tool, a more sophisticated basis may be adopted in future years. Decisions will be made in consultation with the STLS and the SPLWG.

5.1.3 STLS Trends Strategy

In WY2015, a new STLS Trends Strategy team was developed based on recommendations from the SPLWG to define where and how trends may be most effectively measured in relation to management effort so that data collection methods deployed over the next several years support this future need. Initially comprised of SFEI staff, RMC participants, and Regional Water Board staff, the STLS Trends Strategy team met monthly between July and September 2015. Additional interested parties and advisors such as EPA and USGS will be invited to participate in subsequent meetings. In WY2015, the STLS Trends Strategy team developed a mission statement, a list of questions to be addressed by trends monitoring, and a draft document outline. Decisions were also made regarding which indicators (e.g., water concentration, water column particle ratio, load, bed sediment concentration) should be considered under various application scenarios (e.g., Bay Area, single watersheds, individual management measures). The Draft Trends Strategy document in anticipated for review in early 2016. It will summarize the background, management questions, and guiding principles, and will describe coordination between the RMP and BASMAA within the context of the MRP, proposed tasks to answer the management questions, deliverables, and the overall timeline. SMCWPPP will continue to participate in the STLS Trends Strategy team in WY2016.

5.2 PCBs and Mercury Opportunity Area Analysis

As part of the development of PCB and mercury loading estimates presented in Part C of the Program's Integrated Monitoring Report (SMCWPPP 2014), SMCWPPP (in collaboration with SFEI) developed preliminary GIS data layers illustrating potential PCB and mercury source areas. These data layers along with existing data on PCBs/mercury concentrations in sediment and stormwater represent the current state-of-knowledge of source areas for these pollutants in San Mateo County. These preliminary data layers, however, are based on limited and potentially outdated information on land uses and current activities at properties that may contribute or limit the level of pollutants transported to the Bay via stormwater. In an effort to collect additional information on current land uses, facility practices and contributions of PCBs and mercury from these properties, SMCWPPP conducted a *PCB and Mercury Opportunity Area Analysis* as part of the Program's revised POC loads monitoring approach in WY2015. The outcome of this activity will assist Permittees in identifying source areas in San Mateo County, which if managed may provide further load reduction opportunities during future NPDES permit terms.

Appendix G contains the PCBs and Mercury Source Area Identification, Water Year 2015 POC Monitoring Report (SMCWPPP 2015a) which describes results of the *PCB and Mercury Opportunity Area Analysis.*

In WY2015 SMCWPPP conducted a targeted reconnaissance sediment sampling program on behalf of its Permittees in compliance with Provision C.8.e.i of MRP 1.0. Over one hundred bedded sediment samples were collected for PCBs and mercury analysis (these pollutants are often found bound to sediments in the environment) to screen for areas in the urban environment with elevated POC concentrations. The general goal was to continue identifying potential source areas for further study. These areas are potential opportunity areas for implementing controls to reduce stormwater discharges of PCBs and mercury.

Samples were distributed among the nine municipalities that collectively encompass over 93% of the old industrial land use in San Mateo County. Sample stations, mapped in Figure 1.1, were sited in locations considered most likely to contain PCBs based on nearby current and historical land use (e.g., PCB-related activities, presence of heavy or electrical equipment, recycling operations) and housekeeping (e.g., pavement in poor condition, evidence of sediment track out) conditions. Areas with already confirmed PCBs contamination were specifically excluded from the program. Bedded sediment samples from the urban storm drainage system (e.g., beneath manholes, storm drain inlets) and public right-of-way surfaces (e.g., street gutters) were collected using methods detailed in the Sampling and Analysis Plan (SAP) for PCBs and Mercury Opportunity Area Analysis and Implementation Planning (SMCWPPP 2015b).

Total PCBs (i.e., sum of 40 PCB congeners) concentrations ranged from less than 0.01 mg/kg to 1.46 mg/kg with an average of 0.11 mg/kg and a median of 0.04 mg/kg. A total of five samples exceeded the 0.5 mg/kg threshold that was selected by the Bay Area Stormwater Management Agencies Association (BASMAA) Monitoring and Pollutants of Concern Committee as an approximate benchmark for identifying areas that should be considered for future investigation (e.g., additional sampling, records review). Total mercury concentrations ranged from 0.03 mg/kg to 3.59 mg/kg with an average of 0.22 mg/kg and a median of 0.10 mg/kg. There is currently no comparable BASMAA benchmark for mercury; however, two samples exceeded 1.0 mg/kg. The primary objective of this project was not to identify specific source properties, but to identify areas where further investigation is warranted. SMCWPPP anticipates further investigation of the five areas with elevated PCB concentrations during the next term of the MRP.

The sampling design specifically targeted sample stations within the old industrial landscape that are influenced by parcels that were classified and prioritized as having relatively higher potential to be sources of PCBs. However, a strong correlation between the land use analysis and sampling results was lacking, and only five percent of the samples had total PCBs concentrations exceeding the 0.5 mg/kg threshold. This suggests that continuing to identify additional source areas and properties in San Mateo County may be challenging. The remainder of the PCB load appears to be coming from sources that are less elevated and more diffuse and will likely be more challenging to control. Thus data collected to date suggests that the diffuse nature of PCB contamination within the urban landscape may require a rethinking of the approach and timeline needed to meet TMDL load reduction goals.

Identifying pollutant source areas is a challenging and often a multi-year process. The sediment samples collected during this project in combination with historical sediment and stormwater runoff samples are part of an ongoing effort to identify areas in San Mateo County of high interest for further study and the potential opportunity to implement pollutant controls. SMCWPPP staff has identified priority outfall catchments and associated potential wet weather sampling locations that contain High interest source areas where elevated levels of PCBs have not already been found. SMCWPPP began the process of sampling wet weather composite samples for POC analysis at priority outfall catchments in WY2015 through the RMP (described in Section 5.1.1). In WY2016, the RMP will collect additional wet weather samples at high priority catchments, and SMCWPPP will conduct similar sampling at up to eight locations. These wet weather samples will help identify catchments that contain source areas where further investigation will be required.

SMCWPPP plans to continue working with other Bay Area countywide stormwater programs (through the BASMAA MPC Committee) to evaluate the results of the ongoing efforts in the Bay Area to identify PCBs and mercury source areas and plan next steps in San Mateo County. Follow-up monitoring will be conducted in coordination with compliance with Provision C.8.f (Pollutants of Concern Monitoring) of MRP 2.0. Monitoring under Provision C.8.f is intended to address a number of management questions related to priority pollutants such as mercury and PCBs, including helping to identify pollutant source areas. The overall objectives of follow-up efforts to address PCBs and mercury under Provisions C.11, C.12 and C.8.f of the reissued MRP will include continuing to identify which pollutant source areas in San Mateo County provide the greatest opportunities for implementing controls to reduce discharges of these pollutants.

6.0 Long-Term Trends Monitoring (C.8.e)

In addition to POC loads monitoring, Provision C.8.e requires Permittees to conduct long-term trends monitoring to evaluate if stormwater discharges are causing or contributing to toxic impacts on aquatic life. Required long-term monitoring parameters, methods, intervals and occurrences are included as Category 3 parameters in Table 8.4 of MRP 1.0, and prescribed long-term monitoring locations are included in MRP Table 8.3. Similar to creek status and POC loads monitoring, long-term trends monitoring began in October 2011 for RMC participants.

As described in the RMC Creek Status and Trends Monitoring Plan (BASMAA 2011), the State of California's Surface Water Ambient Monitoring Program (SWAMP) through its Statewide Stream Pollutant Trend Monitoring (SPoT) Program currently monitors the seven long-term monitoring sites required by Provision C.8.e.ii. Sampling via the SPoT program is currently conducted at the sampling interval described in Provision C.8.e.iii in the MRP. The SPoT program is generally conducted to answer the following management question:

- *What are the long-term trends in water quality in creeks?*

Based on discussions with Regional Water Board staff, RMC participants are complying with long-term trends monitoring requirements described in MRP 1.0 Provision C.8.e via monitoring conducted by the SPoT program[12]. This manner of compliance is consistent with the MRP language in Provisions C.8.e.ii and C.8.a.iv. RMC representatives coordinate with the SPoT program on long-term monitoring to ensure MRP monitoring and reporting requirements are addressed. The three specific goals of the SPoT program are:

1. Determine long-term trends in stream contaminant concentrations and effects statewide.
2. Relate water quality indicators to land-use characteristics and management effort.
3. Establish a network of sites throughout the state to serve as a backbone for collaboration with local, regional, and federal monitoring.

Additional information on the SPoT program can be found at http://www.waterboards.ca.gov/water_issues/programs/swamp/spot/. The most recent technical report prepared by SPoT program staff was published in 2014 and describes five-year trends from the initiation of the program in 2008 through 2012 (Phillips et al. 2014). An update to the report is anticipated in spring 2016.

The statewide network of SPoT sites represents approximately one half of California's watersheds and includes one station in San Mateo County at the base of San Mateo Creek (Figure 1.1). Sites are targeted in locations with slow water flow and appropriate micro-morphology to allow deposition and accumulation of sediments. Stream sediments are collected annually (funding permitting) during summer base flow conditions. Sediments are analyzed for a suite of water quality indicators including organic contaminants (organophosphate, organochlorine, and pyrethroid pesticides, and PCBs), trace metals, total

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[12] Trends monitoring is one of the five priority management information needs identified in Provision C.8.f of MRP 2.0 and is required for PCBs, mercury, and copper. SMCWPPP is in the process of developing a POC monitoring framework to comply with all aspects of Provision C.8.f of MRP 2.0 over the next five years. It is unlikely that data collected through the SPoT program will address requirements of MRP 2.0 Provision C.8.f. Although the SPoT program will continue for the foreseeable future, SMCWPPP may no longer summarize results in future UCMRs prepared in compliance with MRP 2.0.

organic carbon (TOC), polycyclic aromatic hydrocarbons (PAHs), and polybrominated diphenyl ethers (PBDEs). Samples are also assessed for toxicity using the amphipod *Hyalella azteca* at standard protocol temperature (23°C) and cooler temperatures (15°C) that more closely reflect the ambient temperature in California watersheds[13]. Although the data are not yet available, the SPoT analyte list was expanded in 2013 to include algal toxins (microcystin-LR) and the insecticide fipronil. The insecticide Imidacloprid and an additional test organism (*Chironomus dilutus*) more sensitive to fipronil and imidacloprid will likely be added in 2016.

The SPoT report (Phillips et al. 2014) summarizes the 2008 – 2012 data on statewide and regional scales. In addition, pollutant concentrations are correlated to SWAMP bioassessment data and land use characteristics (i.e., urban, agriculture, open space) on the 1 km, 5 km, and watershed scales. The SPoT report made the following *statewide* conclusions:

- There is a significant relationship between land use and stream pollution.
- Sediment toxicity remained relatively stable statewide between 2008 and 2012.
- Significantly more samples were toxic when tested at average ambient temperatures (15°C) compared to the standard protocol temperature (23°C). This is likely the result of the presence of pyrethroids which are slower to breakdown (metabolically) at lower temperatures (i.e., less pyrethroid is necessary to create the same toxic response).
- Percent *H. azteca* survival was significantly positively correlated with Index of Biological Integrity (IBI) scores[14]; whereas, pyrethroid pesticides and chlorinated compounds were significantly negatively correlated with IBI scores.
- IBI scores at toxic sites ranged from 0.1 to 13.6 and IBI scores at non-toxic sites ranged from 0 to 73.3, suggesting that factors other than contaminants (e.g., physical habitat) are influencing macroinvertebrate communities.
- There has been a steady decline statewide in organophosphate pesticide concentrations.

Regional conclusions include:

- Between 2008 and 2011, there was an overall regional trend of decreasing toxicity with a significant increase in *H. azteca* survival in San Mateo Creek.
- There was a statistically significant decrease in PCB and DDT concentrations at the San Mateo Creek station.

SPoT program staff provided SMCWPPP with monitoring data from the San Mateo County site (205SMA020 – San Mateo Creek). Data provided for 2013 and 2014 are preliminary and have not been through the full data validation process. SMCWPPP evaluated the data using the same methods used to evaluate MRP 1.0 Provision C.8.c sediment data. Threshold Effect Concentration (TEC) (Table 6.1) and Probable Effect Concentration (PEC) quotients (Table 6.2) as defined in MacDonald et al. (2000) were calculated for all non-pyrethroid constituents. In addition, pyrethroid Toxic Unit (TU) equivalents (Table 6.3) were calculated using TOC-normalized data and LC50 values from Maund et al. (2002) and Amweg et al. (2005).

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[13] *Hyalella azteca* toxicity increases with decreasing temperature due to slower metabolic breakdown of pyrethroids at lower temperatures and increased nerve sensitivity.

[14] IBI scores were calculated using methods that were appropriate to each region. The California Stream Condition Index (CSCI) will likely be used in the next reporting cycle.

TEC and PEC quotients for sediment concentrations of metals, PAHs, and organic contaminants at the San Mateo County SPoT station are generally higher than those calculated for Creek Status monitoring (Provision C.8.c. of MRP 1.0) which has been conducted in the same watershed in prior years. These results may illustrate the ongoing movement of fine sediment and variability in sources. They may also reflect the location of the SPoT stations which are typically lower in the watershed than Creek Status stations.

Table 6.1. Threshold Effect Concentration (TEC) quotients for sediment chemistry constituents measured by SPoT in San Mateo Creek. Bolded values exceed 1.0.

Site ID – Creek		205SMA020 – San Mateo Creek						
Sample Date	TEC	6/18/08	6/16/09	6/30/10	7/8/11	8/24/12	6/27/13	6/25/14
Metals (mg/kg DW)								
Arsenic	*9.79*	0.62	0.43	0.47	0.59	0.37	0.61	ns
Cadmium	*0.99*	0.43	0.18	0.20	0.32	0.22	0.35	ns
Chromium	*43.4*	**3.48**	**4.22**	**3.04**	**3.18**	**2.04**	**4.47**	ns
Copper	*31.6*	**2.27**	0.94	**1.02**	**1.56**	0.95	**2.27**	ns
Lead	*35.8*	**1.43**	0.75	0.81	0.82	0.60	**1.38**	ns
Mercury	*0.18*	0.96	0.82	**1.01**	0.77	0.34	**1.07**	ns
Nickel	*22.7*	**6.04**	**4.67**	**4.85**	**5.64**	**4.04**	**6.83**	ns
Zinc	*121*	**1.85**	0.81	0.89	**1.23**	0.88	**1.95**	ns
PAHs (µg/kg DW)								
Anthracene	*57.2*	0.35	0.17	ns	0.31	0.92	0.25	0.22
Fluorene	*77.4*	0.10	0.06	ns	0.00	0.17	0.10	0.08
Naphthalene	*176*	0.10	0.08	ns	0.09	0.06	0.06	0.08
Phenanthrene	*204*	0.69	0.42	ns	0.47	0.73	0.47	0.48
Benz(a)anthracene	*108*	0.94	0.48	ns	0.76	**1.48**	0.56	0.88
Benzo(a)pyrene	*150*	0.80	0.50	ns	0.45	**1.25**	0.47	0.70
Chrysene	*166*	0.84	0.44	ns	0.76	**1.21**	0.54	0.84
Dibenz[a,h]anthracene	*33.0*	0.94	0.55	ns	0.81	**1.35**	0.47	0.66
Fluoranthene	*423*	0.77	0.38	ns	0.49	0.86	0.38	0.45
Pyrene	*195*	**1.46**	0.76	ns	0.98	**1.61**	0.74	**1.04**
Total PAHs	*1,610*	**1.20**	0.71	ns	0.89	**1.40**	0.74	0.92
Pesticides (µg/kg DW)								
Chlordane	*3.24*	**9.29**	**7.87**	ns	**6.23**	**3.70**	**8.61**	ns
Dieldrin	*1.90*	**4.76**	**3.29**	ns	0.00	0.00	**2.52**	ns
Endrin	*2.22*	0.00	0.00	ns	0.00	0.00	0.00	ns
Heptachlor Epoxide	*2.47*	0.70	0.62	ns	0.00	0.00	0.44	ns
Lindane (gamma-BHC)	*2.37*	0.00	0.00	ns	0.00	0.00	0	ns
Sum DDD	*4.88*	**6.08**	**4.61**	ns	**1.45**	0.74	**3.86**	ns
Sum DDE	*3.16*	**13.68**	**11.84**	ns	**9.97**	**4.49**	**12.59**	ns
Sum DDT	*4.16*	**3.84**	**4.86**	ns	0.00	0.00	**4.78**	ns
Total DDTs	*5.28*	**16.83**	**15.18**	ns	**7.31**	**3.37**	**14.87**	ns
Total PCBs	*59.8*	0.52	0.27	ns	0.00	0.00	0.42	ns
Number of constituents with TEC >= 1.0		13	8	--	8	11	12	--

ns = not sampled in WY2015 due to budget constraints

Table 6.2. Probable Effect Concentration (PEC) quotients for sediment chemistry constituents measured by SPoT in San Mateo Creek. Bolded values exceed 1.0.

Site ID – Creek		205SMA020 – San Mateo Creek						
Sample Date	PEC	6/18/08	6/16/09	6/30/10	7/8/11	8/24/12	6/27/13	6/25/14
Metals (mg/kg DW)								
Arsenic	*33.0*	0.18	0.13	0.14	0.18	0.11	0.18	ns
Cadmium	*4.98*	0.09	0.04	0.04	0.06	0.04	0.07	ns
Chromium	*111*	**1.36**	**1.65**	**1.19**	**1.24**	**0.80**	**1.75**	ns
Copper	*149*	0.48	0.20	0.22	0.33	0.20	0.48	ns
Lead	*128*	0.40	0.21	0.23	0.23	0.17	0.39	ns
Mercury	*1.06*	0.16	0.14	0.17	0.13	0.06	0.18	ns
Nickel	*48.6*	**2.82**	**2.18**	**2.26**	**2.63**	**1.89**	**3.19**	ns
Zinc	*459*	0.49	0.21	0.24	0.32	0.23	**0.51**	ns
PAHs (µg/kg DW)								
Anthracene	*845*	0.02	0.01	ns	0.02	0.06	0.02	0.01
Fluorene	*536*	0.02	0.01	ns	0.00	0.02	0.01	0.01
Naphthalene	*561*	0.03	0.02	ns	0.03	0.02	0.02	0.03
Phenanthrene	*1170*	0.12	0.07	ns	0.08	0.13	0.08	0.08
Benz(a)anthracene	*1050*	0.10	0.05	ns	0.08	0.15	0.06	0.09
Benzo(a)pyrene	*1450*	0.08	0.05	ns	0.05	0.13	0.05	0.07
Chrysene	*1290*	0.11	0.06	ns	0.10	0.16	0.07	0.11
Fluoranthene	*2230*	0.15	0.07	ns	0.09	0.16	0.07	0.09
Pyrene	*1520*	0.19	0.10	ns	0.13	0.21	0.09	0.13
Total PAHs	*22,800*	0.09	0.05	ns	0.06	0.10	0.05	0.06
Pesticides (µg/kg DW)								
Chlordane	*17.6*	**1.71**	**1.45**	ns	**1.15**	**0.68**	**1.59**	ns
Dieldrin	*61.8*	0.15	0.10	ns	0.00	0.00	0.08	ns
Endrin	*207.0*	0.00	0.00	ns	0.00	0.00	0.00	ns
Heptachlor Epoxide	*16*	0.11	0.10	ns	0.00	0.00	0.07	ns
Lindane (gamma-BHC)	*4.99*	0.00	0.00	ns	0.00	0.00	0.00	ns
Sum DDD	*28*	**1.06**	0.80	ns	0.25	0.13	0.67	ns
Sum DDE	*31.3*	**1.38**	**1.19**	ns	**1.01**	0.45	**1.27**	ns
Sum DDT	*62.9*	0.25	0.32	ns	0.00	0.00	0.32	ns
Total DDTs	*572*	0.16	0.14	ns	0.07	0.03	0.14	ns
Total PCBs	*676*	0.05	0.02	ns	0.00	0.00	0.04	ns
Mean PEC Quotient		0.75	0.60	--	0.64	0.44	0.84	--

ns = not sampled in WY2015 due to budget constraints

Table 6.3. Pyrethroid Toxic Unit (TU) equivalents for sediment chemistry constituents measured in San Mateo Creek. Bolded sums exceed 1.0 TUs.

Site ID – Creek Sample Date	LC50 (µg/g dw)	205SMA020 – San Mateo Creek						
		6/18/08	6/16/09	6/30/10	7/8/11	8/24/12	6/27/13	6/25/14
Pyrethroid								
Bifenthrin	0.52	0.44	nd	0.22	0.80	0.45	0.13	0.57
Cyfluthrin	1.08	nd	nd	0.16	0.23	0.00	0.05	0.22
Cypermethrin	0.38	nd	nd	0.01	0.09	0.08	0.02	0.04
Deltamethrin	0.79	nd	nd	0.09	0.25	0.34	0.08	0.16
Esfenvalerate	1.54	nd	nd	0.02	0.10	0.23	0.03	0.28
Lambda-Cyhalothrin	0.45	nd	nd	0.00	0.01	0.02	0.00	0.01
Permethrin	10.83	0.01	nd	0.03	0.16	0.10	0.01	0.04
Sum of Toxic Unit Equivalents per Site	--	0.45	--	0.54	1.65	1.21	0.34	1.32
Survival as % of Control *Hyalella azteca*	--	59	79	88	91	101	96	81

nd = below detection limit

7.0 Citizen Monitoring and Participation (C.8.f)

Provision C.8.f of MRP 1.0[15] states that:

i. "*Permittees shall encourage Citizen Monitoring.*

ii. *In developing Monitoring Projects and evaluating Status and Trends data, Permittees shall make reasonable efforts to seek out citizen and stakeholder information and comment regarding waterbody function and quality.*

iii. *Permittees shall demonstrate annually that they have encouraged citizen and stakeholder observations and reporting of waterbody conditions. Permittees shall report on these outreach efforts in the annual Urban Creeks Monitoring Report*."

During the permit term of MRP 1.0, SMCWPPP staff has actively sought opportunities to encourage volunteer monitoring and/or incorporate information from such monitoring into SMCWPPP's water quality monitoring program. As part of this process, SMCWPPP staff has researched and documented related activities in San Mateo County. The County has a wealth of watershed stewardship organizations that primarily engage citizens and stakeholders in environmental education and restoration, and to a lesser extent, in classical water quality monitoring. Citizen monitoring of watershed resources in San Mateo County therefore occurs in several ways:

- In association with habitat restoration efforts, citizens monitor native plant survival and growth, and avian use of constructed bird boxes.
- The majority of citizen water quality monitoring focuses on identifying and cleaning up trash in water bodies, and sampling pathogen indicator organisms such as fecal coliform and *E. coli*. Many organizations conduct monthly trash cleanups in their local watersheds in addition to annual events coinciding with Earth Day, California Coastal cleanup day, and National River Cleanup Day. Groups that monitor pathogen indicators typically sample swimming beaches and associated creek confluences on a weekly basis. For example, the San Mateo County Department of Health coordinates with the San Mateo County Resource Conservation District (SMCRCD) and nine citizen volunteers, including those active with Surfrider Foundation and the Monterey Bay National Marine Sanctuary (MBNMS) to sample pathogen indicators weekly. During fall "first flush" events, the SMCRCD and the MBNMS coordinate to sample a broader suite of water quality parameters at several targeted storm drain outfalls in the San Mateo County designated Area of Biological Significance (ASBS). Such monitoring includes pathogen indicators, nutrients, and general water quality parameters.
- During the spring, the MBNMS coordinates with numerous volunteers as part of "snapshot day" to sample 27 sites on creeks and rivers in San Mateo County coastal watersheds for a broad suite of water quality analytes. Trained volunteers measure dissolved oxygen, pH, conductivity, air and water temperature, transparency/ turbidity, and collect water samples to be lab tested for nutrients (nitrates and orthophosphate) and bacteria. Every year Snapshot Day data are compiled to determine "Areas of Concern" - sites at where at least three of the nine analytes measured exceed associated water quality objectives. Snapshot Day data are used by the State of

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[15] Provision C.8 of MRP 2.0 no longer includes citizen monitoring; however Provision C.7 of MRP 2.0 requires public outreach and citizen involvement events.

California, in conjunction with other data, to list water bodies as impaired under the Clean Water Act. Other resource managers use Snapshot Day data to further engage citizenry and agencies to address problems of pollution in waterways.

- Citizens volunteer with the San Gregorio Environmental Resource Center to conduct general water quality monitoring and measure stream discharge and stage weekly. This group was recently awarded an EPA grant to demonstrate the feasibility of increasing water quality and restoring habitat while maintaining agricultural productivity.
- Acterra is an environmental non-profit serving the Silicon Valley area that provides a broad range of volunteer opportunities (e.g., habitat restoration) for adults and youth. Through their Streamkeeper Program, Acterra encourages citizens to note observations on San Francisquito Creek about four types of indicators: animals (presence/absence of uncommon or threatened and endangered species), plants (notably invasives), chemical (indicators of pollution), physical (including evidence of erosion, human disturbance), and social (including evidence of different types of human disturbance).

In WY2015, SMCWPPP staff reached out to several groups (e.g., Acterra, Surfrider, SMRCD) to encourage citizen and stakeholder observations and reporting of waterbody conditions. SMCWPPP staff participated in Acterra events and the Program helped fund maintenance of Acterra's water quality monitoring equipment.

8.0 Next Steps

Water quality monitoring required by Provision C.8 of MRP 1.0 and 2.0 is intended to assess the condition of water quality in the Bay area receiving waters (creeks and the Bay); identify and prioritize stormwater associated impacts, stressors, sources, and loads; identify appropriate management actions; and detect trends in water quality over time and the effects of stormwater control measure implementation. On behalf of San Mateo County Permittees, SMCWPPP conducts creek water quality monitoring and monitoring projects in San Mateo County in collaboration with the Regional Monitoring Coalition (RMC), and actively participates in the San Francisco Bay Regional Monitoring Program (RMP), which focuses on assessing Bay water quality and associated impacts.

In WY2016, SMCWPPP will continue to comply with water quality monitoring requirements of the MRP. As described throughout this UCMR, requirements in MRP 2.0 are generally similar but differ somewhat to requirements in MRP 1.0. The following list of next steps will be implemented in WY2016:

- SMCWPPP will continue to collaborate with the RMC (MRP 2.0 Provision C.8.a).
- Where applicable, monitoring data collected and reported by SMCWPPP will be SWAMP comparable (MRP 2.0 Provision C.8.b).
- SMCWPPP will continue to provide financial contributions towards the RMP and to assist BASMAA to actively participate in the RMP committees and work groups described in Sections 2.0 and 5.0 (MRP 2.0 Provision C.8.c).
- SMCWPPP will continue to conduct probabilistic and targeted Creek Status Monitoring consistent with the specific requirements in MRP 2.0 (MRP 2.0 Provision C.8.d).
- SMCWPPP will develop and begin implementation of a dry and wet weather Pesticides and Toxicity Monitoring program consistent with MRP 2.0 Provision C.8.g.
- SMCWPPP will continue to review monitoring results and maintain a list of all results exceeding trigger thresholds (MRP 2.0 Provision C.8.e.i). SMCWPPP will coordinate with the RMC to initiate a region wide goal of four new SSID projects by the third year of the permit (MRP 2.0 Provision C.8.e.iii).
- SMCWPPP will continue to participate in the STLS and SPLWG which address MRP 2.0 Provision C.8.f POC management information needs and monitoring requirements through wet weather characterization monitoring, refinement of the RWSM, and development of the STLS Trends Strategy.
- SMCWPPP will continue implementing a POC monitoring framework to comply with Provision C.8.f of MRP 2.0. The monitoring framework addresses the annual and total minimum number of samples required for each POC (i.e., PCBs, mercury, copper, emerging contaminants, nutrients) and each management information need (i.e., Source Identification, Contributions to Bay Impairment, Management Action Effectiveness, Loads and Status, Trends). WY2016 monitoring includes collection of wet weather composite water samples from catchments to identify watersheds where PCB and mercury control measures will be implemented as well as nutrient sampling.
- WY2016 POC monitoring accomplishments and allocation of sampling efforts for POC monitoring in WY2017 will be submitted in the Pollutants of Concern Monitoring Report that is due to the Water Board by October 15, 2016 (MRP 2.0 Provision C.8.h.iv).

- Results of WY2016 monitoring will be described in the Programs WY2016 Urban Creeks Monitoring Report that is due to the Water Board by March 31, 2017 (MRP 2.0 Provision C.8.h.iii).

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Appendix A

SMCWPPP Creek Status Monitoring Report, Water Year 2015

SAN MATEO COUNTYWIDE
Water Pollution
Prevention Program

Appendix A

SMCWPPP Creek Status Monitoring Report

Water Year 2015 (October 2014 – September 2015)

Submitted in compliance with Provision C.8.h.iii of
NPDES Permit No. CAS612008 (Order No. R2-2015-0049)

March 31, 2016

Preface

In early 2010, several members of the Bay Area Stormwater Agencies Association (BASMAA) joined together to form the Regional Monitoring Coalition (RMC), to coordinate and oversee water quality monitoring required by the 2009 Municipal Regional National Pollutant Discharge Elimination System (NPDES) Stormwater Permit (in this document the 2009 permit is referred to as "MRP 1.0")[1]. The RMC includes the following participants:

- Clean Water Program of Alameda County (ACCWP)
- Contra Costa Clean Water Program (CCCWP)
- San Mateo County Wide Water Pollution Prevention Program (SMCWPPP)
- Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP)
- Fairfield-Suisun Urban Runoff Management Program (FSURMP)
- City of Vallejo and Vallejo Sanitation and Flood Control District (Vallejo)

In 2015, the San Francisco Bay Regional Water Quality Control Board (SFRWQCB or Regional Water Board) revised and reissued the MRP (the 2015 permit is referred to as "MRP 2.0"). This Creek Status Monitoring Report complies with MRP 2.0 Provision C.8.h.iii for reporting of all data in Water Year 2015 (October 1, 2014 through September 30, 2015). Data were collected pursuant to Provision C.8.c of MRP 1.0. Data presented in this report were produced under the direction of the RMC and the San Mateo Countywide Water Pollution Prevention Program (SMCWPPP) using probabilistic and targeted monitoring designs as described herein

Consistent with the RMC Creek Status and Long-Term Trends Monitoring Plan (BASMAA 2012), monitoring data were collected in accordance with the BASMAA RMC Quality Assurance Program Plan (QAPP; BASMAA, 2014a) and BASMAA RMC Standard Operating Procedures (SOPs; BASMAA, 2014b). Where applicable, monitoring data were derived using methods comparable with methods specified by the California Surface Water Ambient Monitoring Program (SWAMP) QAPP[2]. Data presented in this report were also submitted in electronic SWAMP-comparable formats by SMCWPPP to the San Francisco Bay Regional Water Quality Control Board (SFRWQCB) on behalf of San Mateo County Permittees and pursuant to Provision C.8.h.ii of MRP 2.0.

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[1] The San Francisco Bay Regional Water Quality Control Board (SFRWQCB) issued MRP 1.0 to 76 cities, counties and flood control districts (i.e., Permittees) in the Bay Area on October 14, 2009 (SFRWQCB 2009). The BASMAA programs supporting MRP Regional Projects include all MRP Permittees as well as the cities of Antioch, Brentwood, and Oakley, which are not named as Permittees under the MRP but have voluntarily elected to participate in MRP-related regional activities.

[2] The current SWAMP QAPP is available at:
http://www.waterboards.ca.gov/water_issues/programs/swamp/docs/qapp/swamp_qapp_master090108a.pdf

List of Acronyms

ACCWP	Alameda County Clean Water Program
AFDM	Ash Free Dry Mass
AFS	American Fisheries Society
BASMAA	Bay Area Stormwater Management Agency Association
B-IBI	Benthic Macroinvertebrate Index of Biological Integrity
BMI	Benthic Macroinvertebrate
CAP	Conservation Action Plan
C/CAG	City/County Association of Governments
CCCWP	Contra Costa Clean Water Program
CRAM	California Rapid Assessment Method
CSCI	California Stream Condition Index
CTR	California Toxics Rule
DO	Dissolved Oxygen
EDD	Electronic Data Delivery
FSURMP	Fairfield Suisun Urban Runoff Management Program
GIS	Geographic Information System
GRTS	Generalized Random Tessellation Stratified
HDI	Human Disturbance Index
IBI	Index of Biological Integrity
IPM	Integrated Pest Management
LID	Low Impact Development
MF	Middle Fork
MPC	Monitoring and Pollutants of Concern Committee
MPN	Most Probable Number
MRP	Municipal Regional Permit
MS4	Municipal Separate Storm Sewer System
MST	Microbial Source Tracking
MUN	Municipal Beneficial Use
MWAT	Maximum Weekly Average Temperature
MWMT	Maximum Weekly Maximum Temperature
NMFS	National Marine Fisheries Service
NPDES	National Pollution Discharge Elimination System
NT	Non-Target

O/E	Observed to Expected
PAH	Polycyclic Aromatic Hydrocarbons
PCBs	Polychlorinated Biphenyls
PEC	Probable Effects Concentrations
PHAB	Physical Habitat Assessments
pMMI	Predictive Multi-Metric Index
PSA	Perennial Streams Assessment
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
RMC	Regional Monitoring Coalition
RWB	Reachwide Benthos
SCCWRP	Southern California Coastal Water Research Project
SCVURPPP	Santa Clara Valley Urban Runoff Pollution Prevention Program
SFPUC	San Francisco Public Utilities Commission
SFRWQCB	San Francisco Bay Regional Water Quality Control Board
SMC	Stormwater Monitoring Coalition
SMCWPPP	San Mateo County Water Pollution Prevention Program
SOP	Standard Operating Protocol
SSID	Stressor/Source Identification
SSO	Sanitary Sewer Overflow
SWAMP	Surface Water Ambient Monitoring Program
TEC	Threshold Effects Concentrations
TMDL	Total Maximum Daily Load
TNS	Target Non-Sampleable
TOC	Total Organic Carbon
TS	Target Sampleable
TU	Toxicity Unit
UCMR	Urban Creeks Monitoring Report
USEPA	Environmental Protection Agency
WQO	Water Quality Objective
WY	Water Year

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1.0 Introduction

This Creek Status Monitoring Report was prepared by the San Mateo Countywide Water Pollution Prevention Program (SMCWPPP or Program). SMCWPPP is a program of the City/County Association of Governments (C/CAG) of San Mateo County. Each incorporated city and town in the county and the County of San Mateo share a common National Pollutant Discharge Elimination System (NPDES) stormwater permit with other Bay Area municipalities referred to as the Municipal Regional Permit (MRP). The MRP was first adopted by the San Francisco Regional Water Quality Control Board (SFRWQCB or Regional Water Board) on October 14, 2009 as Order R2-2009-0074 (referred to as MRP 1.0). On November 19, 2015, the SFRWQCB updated and reissued the MRP as Order R2-2015-0049 (referred to as MRP 2.0). This report fulfills the requirements of Provision C.8.h.iii of MRP 2.0 for comprehensively interpreting and reporting all Creek Status[3] monitoring data collected during the foregoing October 1 – September 30 (i.e., Water Year 2015). Data were collected pursuant to water quality monitoring requirements in Provision C.8.c of MRP 1.0[4]. Monitoring data presented in this report were submitted electronically to the SFRWQCB by SMCWPPP and may be obtained via the San Francisco Bay Area Regional Data Center of the California Environmental Data Exchange Network (CEDEN) (http://water100.waterboards.ca.gov/ceden/sfei.shtml).

Sections of this report are organized according to the following topics:

- **Section 1.0** – Introduction including overview of the Program goals, background, monitoring approach, and statement of data quality
- **Section 2.0** – Probabilistic monitoring design, biological condition assessment, and stressor analysis
- **Section 3.0** – Targeted monitoring (continuous temperature, continuous general water quality, and pathogen indicators)
- **Section 4.0** – Pesticides and toxicity monitoring
- **Section 5.0** – Chlorine monitoring
- **Section 6.0** – Conclusions and recommendations

1.1 Creek Status Monitoring Goals

Provision C.8.c of MRP 1.0 requires Permittees to conduct creek status monitoring that is intended to answer the following management questions:

1. ***Are water quality objectives, both numeric and narrative, being met in local receiving waters, including creeks, rivers, and tributaries?***

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[3] Monitoring data collected pursuant to other C.8 provisions (e.g., Pollutants of Concern Monitoring, Stressor/Source Identification Monitoring Projects, BMP Effectiveness Investigation) are reported in the SMCWPPP Urban Creeks Monitoring Report (UCMR) to which this Creek Status Monitoring Report is appended.

[4] Water quality monitoring requirements in MRP 2.0 are generally similar to requirements in MRP 1.0. Differences in water quality monitoring requirements between MRP 1.0 and MRP 2.0 are briefly outlined in this report where applicable.

2. ***Are conditions in local receiving water supportive of or likely supportive of beneficial uses?***

Creek Status Monitoring required by Provision C.8.c of the MRP builds upon monitoring conducted by SMCWPPP (formerly STOPPP) between 1999 and 2009, is coordinated through the Regional Monitoring Coalition (RMC), and began on October 1, 2011. Creek status monitoring parameters, methods, occurrences, durations and minimum number of sampling sites are described in Table 8.1 of MRP 1.0 Provision C.8.c. Monitoring results are evaluated to determine whether triggers are met and further investigation is warranted as a potential Stressor Source Identification (SSID) Monitoring Project as described in MRP 1.0 Provision C.8.d.i. Results of Creek Status Monitoring conducted in Water Years 2012 through 2014 were submitted in prior reports (SMCWPPP 2015, SMCWPPP 2014).

1.2 Regional Monitoring Coalition

Provision C.8.a (Compliance Options) of MRP 1.0 allows Permitees to address monitoring requirements through a "regional collaborative effort," their Stormwater Program, and/or individually. The RMC was formed in early 2010 as a collaboration among a number of the Bay Area Stormwater Agencies Association (BASMAA) members and MRP Permittees (Table 1.1) to develop and implement a regionally coordinated water quality monitoring program to improve stormwater management in the region and address water quality monitoring required by the MRP[5]. With notification of participation in the RMC, Permittees were required to commence water quality data collection by October 2011. Implementation of the RMC's Creek Status and Long-Term Trends Monitoring Plan (BASMAA 2012) allows Permittees and the Regional Water Board to modify their existing creek monitoring programs, and improve their ability to collectively answer core management questions in a cost-effective and scientifically-rigorous way. Participation in the RMC is facilitated through the BASMAA Monitoring and Pollutants of Concern (MPC) Committee. SMCWPPP will continue its participation in the RMC during the permit term of MRP 2.0.

Table 1.1. Regional Monitoring Coalition participants.

Stormwater Programs	RMC Participants
Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP)	Cities of Campbell, Cupertino, Los Altos, Milpitas, Monte Sereno, Mountain View, Palo Alto, San Jose, Santa Clara, Saratoga, Sunnyvale, Los Altos Hills, and Los Gatos; Santa Clara Valley Water District; and, Santa Clara County
Clean Water Program of Alameda County (ACCWP)	Cities of Alameda, Albany, Berkeley, Dublin, Emeryville, Fremont, Hayward, Livermore, Newark, Oakland, Piedmont, Pleasanton, San Leandro, and Union City; Alameda County; Alameda County Flood Control and Water Conservation District; and, Zone 7
Contra Costa Clean Water Program (CCCWP)	Cities of Antioch, Brentwood, Clayton, Concord, El Cerrito, Hercules, Lafayette, Martinez, Oakley, Orinda, Pinole, Pittsburg, Pleasant Hill, Richmond, San Pablo, San Ramon, Walnut Creek, Danville, and Moraga; Contra Costa County; and, Contra Costa County Flood Control and Water Conservation District

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[5] The San Francisco Bay Regional Water Quality Control Board (SFRWQCB) issued the five-year MRP to 76 cities, counties and flood control districts (i.e., Permittees) in the Bay Area on October 14, 2009 (SFRWQCB 2009). The BASMAA programs supporting MRP Regional Projects include all MRP Permittees as well as the cities of Antioch, Brentwood, and Oakley which are not named as Permittees under the MRP but have voluntarily elected to participate in MRP-related regional activities.

Stormwater Programs	RMC Participants
San Mateo County Wide Water Pollution Prevention Program (SMCWPPP)	Cities of Belmont, Brisbane, Burlingame, Daly City, East Palo Alto, Foster City, Half Moon Bay, Menlo Park, Millbrae, Pacifica, Redwood City, San Bruno, San Carlos, San Mateo, South San Francisco, Atherton, Colma, Hillsborough, Portola Valley, and Woodside; San Mateo County Flood Control District; and, San Mateo County
Fairfield-Suisun Urban Runoff Management Program (FSURMP)	Cities of Fairfield and Suisun City
Vallejo Permittees	City of Vallejo and Vallejo Sanitation and Flood Control District

The goals of the RMC are to:

1. Assist Permittees in complying with requirements in MRP Provision C.8 (Water Quality Monitoring);

2. Develop and implement regionally consistent creek monitoring approaches and designs in the Bay Area, through the improved coordination among RMC participants and other agencies (e.g., Water Board) that share common goals; and

3. Stabilize the costs of creek monitoring by reducing duplication of effort and streamlining reporting.

The RMC's monitoring strategy for complying with MRP 1.0 Provision C.8.c is described in the RMC Creek Status and Long-Term Trends Monitoring Plan (BASMAA 2012). The strategy includes regional ambient/probabilistic monitoring and local "targeted" monitoring. The combination of these two components allows each individual RMC participating program to assess the status of beneficial uses in local creeks within its jurisdictional area, while also contributing data to answer management questions at the regional scale (e.g., differences between aquatic life condition in urban and non-urban creeks). Table 1.2 provides a list of which parameters are included in the probabilistic and targeted programs. This report includes data collected in San Mateo County under both monitoring components. Data are organized into report Sections that reflect the format of monitoring requirements in MRP 2.0.

Table 1.2. Creek Status Monitoring parameters in compliance with MRP 1.0 Provision C.8.c and associated monitoring component.

Monitoring Elements of MRP 1.0 Provision C.8.c	Monitoring Component		Report Section
	Regional Ambient (Probabilistic)	Local (Targeted)	
Bioassessment & Physical Habitat Assessment	X		2.0
Nutrients	X		2.0
Chlorine	X		5.0
Water Toxicity[1]	X		4.0
Sediment Toxicity[1]	X		4.0
Sediment Chemistry[1]	X		4.0
General Water Quality (Continuous)		X	3.0
Temperature (Continuous)		X	3.0
Pathogen Indicators		X	3.0
Stream Survey (CRAM)[2]		X	2.0

Notes:

1. Consistent with the RMC Creek Status and Long-term Trends Monitoring Plan (BASMAA 2012), toxicity and sediment chemistry monitoring was conducted at probabilistic sites during MRP 1.0. Similar monitoring is required in MRP 2.0 but has been moved out of the Creek Status Monitoring provision into a new provision (Pesticides and Toxicity Monitoring)..It is likely that SMCWPPP will no longer collect these samples at probabilistic sites during MRP 2.0.
2. Stream surveys under the SMCWPPP Monitoring Program were conducted at probabilistic sites. This type of monitoring is not required in MRP 2.0.

1.3 Monitoring and Data Assessment Methods

1.3.1 Monitoring Methods

Water quality data were collected in accordance with SWAMP-comparable methods and procedures described in the BASMAA RMC Standard Operating Procedures (SOPs; BASMAA 2014b) and associated Quality Assurance Project Plan (QAPP; BASMAA 2014a). These documents and the RMC Creek Status and Long-Term Trends Monitoring Plan (BASMAA 2012) are updated as needed to maintain their currency and optimal applicability. Where applicable, monitoring data were collected using methods comparable to those specified by the California Surface Water Ambient Monitoring Program (SWAMP) QAPP[6], and were submitted in SWAMP-compatible format to the SFRWQCB. The SOPs were developed using a standard format that describes health and safety cautions and considerations, relevant training, site selection, and sampling methods/procedures, including pre-fieldwork mobilization activities to prepare equipment, sample collection, and de-mobilization activities to preserve and transport samples.

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[6] The current SWAMP QAPP is available at: http://www.waterboards.ca.gov/water_issues/programs/swamp/docs/qapp/swamp_qapp_master090108a.pdf

1.3.2 Laboratory Analysis Methods

RMC participants, including SMCWPPP, agreed to use the same laboratories for individual parameters, developed standards for contracting with the labs, and coordinated quality assurance issues. All samples collected by RMC participants that were sent to laboratories for analysis were analyzed and reported per SWAMP-comparable methods as described in the RMC QAPP (BASMAA 2014a). Analytical laboratory methods, reporting limits and holding times for chemical water quality parameters are also reported in BASMAA (2014a). Analytical laboratory contractors included:

- BioAssessment Services, Inc. – BMI identification
- EcoAnalysts, Inc. – Algae identification
- CalTest, Inc. – Sediment Chemistry, Nutrients, Chlorophyll a, Ash Free Dry Mass
- Pacific EcoRisk, Inc. - Water and Sediment Toxicity
- BioVir Laboratories, Inc. – Pathogen indicators

1.3.3 Data Analysis Methods

Water and sediment chemistry and toxicity data generated during WY2015 were analyzed and evaluated to identify potential stressors that may be contributing to degraded or impacted biological conditions, including exceedances of water quality objectives (WQOs). Per Table 8.1 of MRP 1.0 (SFRWQCB 2009), Creek Status Monitoring data must be evaluated with respect to thresholds specified in the “Results that Trigger a Monitoring Project in Provision C.8.d.i” column. MRP 2.0 requires a similar analysis of the monitoring data to identify candidate sites for Stressor/Source Identification (SSID) projects; however, some of the trigger thresholds in MRP 2.0 have been revised or clarified. Unless otherwise noted, this report evaluates the data with respect to the trigger criteria listed in MRP 2.0.

In compliance with Provision C.8.e.i of MRP 2.0, all monitoring results exceeding trigger thresholds are added to a list of candidate SSID projects that will be maintained throughout the permit term. Followup SSID projects will be selected from this list.

1.4 Setting

There are 34 watersheds in San Mateo County draining an area of about 450 square miles. The San Mateo Range, which runs north/south, divides the county roughly in half. The eastern half (“Bayside”) drains to San Francisco Bay and is characterized by relatively flat, urbanized areas along the Bay. The western half (“coastside”) drains to the Pacific Ocean and consists of approximately 50 percent parkland and open space, with agriculture, and relatively small urban areas.

The complete list of probabilistic and targeted monitoring sites samples by SMCWPPP in WY2015 is presented in Table 1.3. Monitoring locations with monitoring parameter(s) are mapped in Figure 1.1.

Table 1.3. Sites and parameters monitored in WY2015 in San Mateo County.

Map ID	Station Number	Bayside or Coastside	Watershed	Creek Name	Land Use	Latitude	Longitude	Probabilistic		Targeted			
								Bioassessment, Nutrients, General WQ	Toxicity, Sediment Chemistry	CRAM	Temp	Cont. WQ	Pathogen Indicators
378	202R00378	Bayside	Pescadero Creek	Pescadero Creek	NU	37.21994	-122.16385	X		X			
440	202R00440	Coastside	Purisima Creek	Purisima Creek	NU	37.43417	-122.34959	X		X			
1356	202R01356	Coastside	San Pedro Creek	Middle Fork San Pedro Creek	U	37.57524	-122.46105	X		X			
1612	202R01612	Coastside	San Pedro Creek	Middle Fork San Pedro Creek	U	37.57810	-122.47139	X		X			
1448	204R01448	Bayside	San Francisquito Creek	Atherton Creek	U	37.43459	-122.21776	X	X	X			
1972	204R01972	Bayside	Cordilleras Creek	Cordilleras Creek	U	37.48375	-122.25730	X		X			
2056	204R02056	Bayside	Laurel Creek	Laurel Creek	U	37.53342	-122.30243	X	X	X			
2248	204R02248	Bayside	Laurel Creek	Laurel Creek	U	37.52659	-122.32843	X		X			
1704	205R01704	Bayside	Atherton Creek	Dry Creek	U	37.43389	-122.26094	X		X			
1816	205R01816	Bayside	San Francisquito Creek	Corte Madera Creek	U	37.36615	-122.21570	X		X			
58	204SMA058	Bayside	San Mateo Creek	San Mateo Creek	U	37.56249	-122.32843					X	
59	204SMA059	Bayside	San Mateo Creek	San Mateo Creek	U	37.56331	-122.32707					X	
60	204SMA060	Bayside	San Mateo Creek	San Mateo Creek	U	37.56244	-122.32828						X
80	204SMA080	Bayside	San Mateo Creek	San Mateo Creek	U	37.55731	-122.34204						X
100	204SMA100	Bayside	San Mateo Creek	San Mateo Creek	U	37.53719	-122.35001						X
110	204SMA110	Bayside	San Mateo Creek	Polhemus Creek	U	37.53235	-122.3508						X
120	204SMA119	Bayside	San Mateo Creek	San Mateo Creek	U	37.53312	-122.35073						X
68	205ALA015	Bayside	San Francisquito Creek	Alambique Creek	U	37.40443	-122.25430				X		
71	205BCR010	Bayside	San Francisquito Creek	Bear Creek	U	37.41179	-122.24106				X		
69	205BCR050	Bayside	San Francisquito Creek	Bear Creek	U	37.427017	-122.25378				X		
72	205BCR060	Bayside	San Francisquito Creek	Bear Creek	U	37.42550	-122.26243				X		
70	205WUN150	Bayside	San Francisquito Creek	West Union Creek	U	37.431117	-122.27622				X		

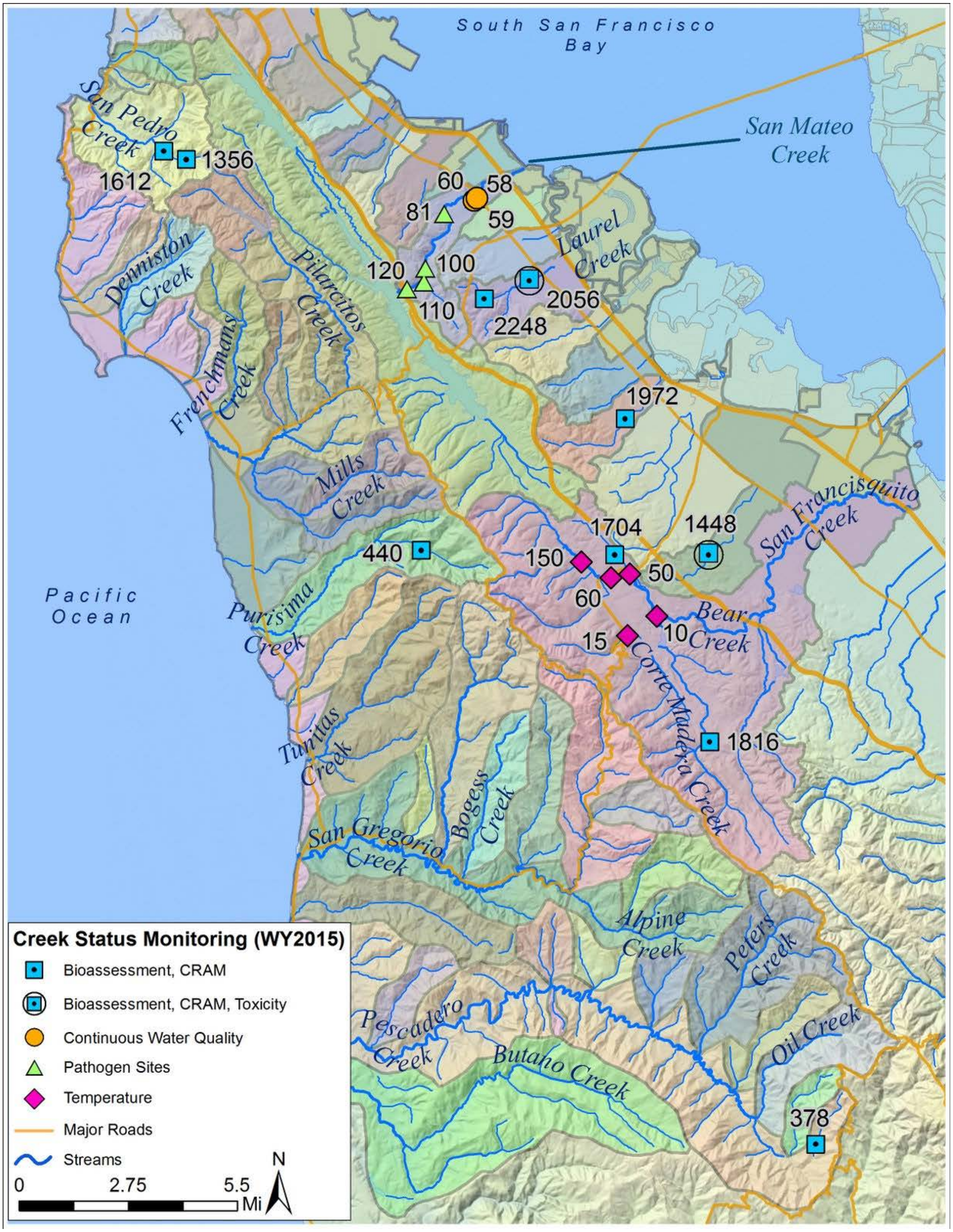

Figure 1.1. Map of SMCWPPP sites monitored in WY2015.

1.4.1 Designated Beneficial Uses

Beneficial Uses in San Mateo County creeks are designated by the SFRWQCB for specific water bodies and generally apply to all its tributaries. Uses include aquatic life habitat, recreation, and human consumption. Table 1.4 lists Beneficial Uses designated by the SFRWQCB (2013) for water bodies monitored by SMCWPPP in WY2015.

Table 1.4. Creeks Monitored by SMCWPPP in WY2015 and their Beneficial Uses (SFRWQCB 2013).

Waterbody	AGR	MUN	FRSH	GWR	IND	PROC	COM	SHELL	COLD	EST	MAR	MIGR	RARE	SPWN	WAR	WILD	REC-1	REC-2	NAV
Bayside Creeks																			
Alambique Creek									E						E	E	E	E	
Atherton Creek															E	E	E	E	
Bear Creek									E			E	E	E	E	E	E	E	
Cordilleras Creek															E	E	E	E	
Corte Madera Creek									E			E		E	E	E	E	E	
Dry Creek															E	E	E	E	
Laurel Creek															E	E	E	E	
Pescadero Creek	E	E							E			E	E	E	E	E	E	E	
Polhemus Creek									E						E	E	E	E	
San Mateo Creek			E						E			E	E	E	E	E	E	E	
West Union Creek									E			E	E	E	E	E	E	E	
Coastside Creeks																			
Purisima Creek	E								E			E	E	E		E	E	E	
Middle Fork San Pedro Creek		E							E				E		E	E	E	E	

Notes:

COLD = Cold Fresh Water Habitat
FRSH = Freshwater Replenishment
GWR - Groundwater Recharge
MIGR = Fish Migration
MUN = Municipal and Domestic Water
EST = Estuarine
NAV = Navigation
RARE= Preservation of Rare and Endangered Species
REC-1 = Water Contact Recreation
REC-2 = Non-contact Recreation
WARM = Warm Freshwater Habitat
WILD = Wildlife Habitat
E = Existing Use

1.4.2 Climate

San Mateo County experiences a Mediterranean-type climate with cool, wet winters and hot, dry summers. The wet season typically extends from November through March with local long-term, mean annual precipitation ranging from 20 inches near the Bay to over 40 inches along the highest ridges of the San Mateo Mountain Range (PRISM Climate Group 30-year normals, 1981-2010[7]). Figure 1.2 illustrates the geographic variability of mean annual precipitation in the area. It is important to understand that mean annual precipitation depths are statistically calculated or modeled; actual measured precipitation in a given year rarely equals the statistical average. Extended periods of drought and wet conditions are common. Figure 1.3 illustrates the temporal variability in annual precipitation measured at the San Francisco International Airport from WY1946 to WY2015. Creek Status Monitoring in compliance with the MRP began in WY2012 which was the first year of an ongoing severe drought on a statewide and local basis. Some climate scientists even suggest the current drought began as early as WY2006, punctuated by two slightly above average years in WY2009 and WY2010 (UCLA Water Resources Group[8]). As discussed in Section 2.0, this rainfall pattern drove decisions to discount a potentially significant April rainfall event and commence bioassessment monitoring early in the index period in order to ensure flowing conditions in several streams that were likely to desiccate.

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[7] http://www.prism.oregonstate.edu/normals/

[8] http://www.environment.ucla.edu/water/drought

Figure 1.2. Average annual precipitation in San Mateo County, modeled by the PRISM Climate Group for the period of 1981-2010.

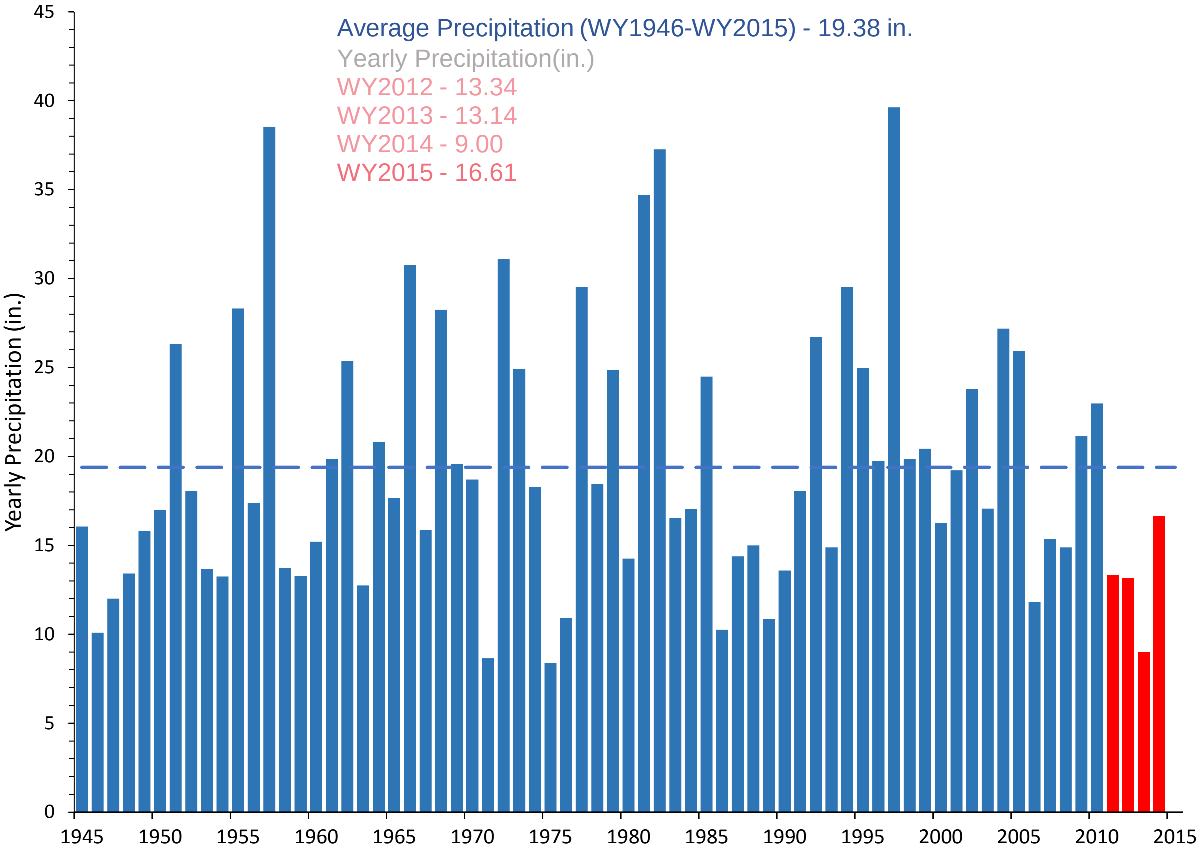

Figure 1.3. Annual rainfall recorded at the San Francisco International Airport, WY1946 – WY2015.

Individual dry years often result in decreased summer stream flows or earlier desiccation. The cumulative effect of sustained dry conditions can exasperate low flow conditions as ground water tables begin to fall. For these reasons, climate should be considered when evaluating water temperature and general water quality data as these parameters are influenced by water depth and stream flows. Periods of drought (rather than individual dry years) can also result in changes in riparian and upland vegetation communities and are associated with increased streambed sedimentation which can persist directly or indirectly for many years, depending on the occurrence and magnitude of flushing flow events. Therefore, periods of drought can influence the types of physical habitat measured by the Creek Status Monitoring program.

There is still some uncertainty regarding the impact of periods of drought on overall stream condition as assessed through the calculation of stream condition indices based on benthic macroinvertebrate data (USEPA 2012a). A study evaluating 20 years of bioassessment data collected in northern California showed that, although benthic macroinvertebrate taxa with certain traits may be affected by dry (and wet) years and/or warm (and cool) years, indices of biotic integrity (IBIs) based on these organisms appear to be resilient (Mazor et al. 2009, Lawrence et al. 2010). However, this study did not specifically examine the impact of *periods* of extended drought on IBIs which would require analysis of a dataset with a much longer period of record.

1.5 Statement of Data Quality

A comprehensive Quality Assurance/Quality Control (QA/QC) program was implemented by SMCWPPP covering all aspects of the probabilistic and targeted monitoring. In general QA/QC procedures were implemented as specified in the BASMAA RMC QAPP (BASMAA, 2014a), and monitoring was performed according to protocols specified in the BASMAA RMC SOPs) (BASMAA, 2014b), and in conformity with methods specified by the SWAMP QAPP[9]. A detailed QA/QC report is included as Attachment 1.

Overall, the results of the QA/QC review suggest that the Creek Status Monitoring data generated during WY2015 was of sufficient quality. However, some data were flagged in the project database, and some continuous monitoring data were rejected due to a probe malfunction.

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[9] The current SWAMP QAPP is available at: http://www.waterboards.ca.gov/water_issues/programs/swamp/docs/qapp/swamp_qapp_master090108a.pdf

2.0 Probabilistic Monitoring

2.1 Introduction

The probabilistic monitoring design allows each individual RMC participating program to objectively assess stream ecosystem conditions within its program area (County boundary) while contributing data to answer regional management questions about water quality and beneficial use condition in San Francisco Bay Area creeks. The survey design provides an unbiased framework for data evaluation that will allow a condition assessment of ambient aquatic life uses within known estimates of precision. The monitoring design was developed to address the management questions for both RMC participating county and overall RMC area described below:

1. What is the condition of aquatic life in creeks in the RMC area; are water quality objectives met and are beneficial uses supported?
    i. What is the condition of aquatic life in the urbanized portion of the RMC area; are water quality objectives met and are beneficial uses supported?
    ii. What is the condition of aquatic life in RMC participant counties; are water quality objectives met and are beneficial uses supported?
    iii. To what extent does the condition of aquatic life in urban and non-urban creeks differ in the RMC area?
    iv. To what extent does the condition of aquatic life in urban and non-urban creeks differ in each of the RMC participating counties?
2. What are major stressors to aquatic life in the RMC area?
    i. What are major stressors to aquatic life in the urbanized portion of the RMC area?
3. What are the long-term trends in water quality in creeks over time?

The first question is addressed by assessing indicators of aquatic biological health at probabilistic sampling locations. Once a sufficient number of samples have been collected, ambient biological condition can be estimated for streams at a regional scale. Over the past four years, SMCWPPP and the Regional Water Board have sampled 50 probabilistic sites in San Mateo County, providing a sufficient sample size to estimate ambient biological condition for urban streams countywide. There are still an insufficient number of samples to accurately assess the biological condition of non-urban streams in the county, as well as all streams within smaller areas of interest (e.g., watershed or jurisdictional areas)[10].

The second question is addressed by the collection and evaluation of physical habitat and water chemistry data collected at the probabilistic sites, as potential stressors to biological health. The extent and magnitude of these stressors above certain thresholds can also be assessed for streams in San Mateo County. In addition, the stressor levels can be compared to biological indicator data through correlation and relative risk analysis. Assessing the extent and relative

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[10] For each of the strata, it is necessary to obtain a sample size of at least 30 in order to evaluate the condition of aquatic life within known estimates of precision. This estimate is defined by a power curve from a binomial distribution (BASMAA 2012).

risk of stressors can help prioritize stressors at a regional scale and inform local management decisions.

The last question is addressed by assessing the change in biological condition over several years. Changes in biological condition over time can help evaluate the effectiveness of management actions. Trend analysis for the RMC probabilistic survey however, will require more than four years of data collection.

The following sections of this report present biological condition and stressor data collected at the ten probabilistic sites sampled by SMCWPPP in WY2015.

2.2 Methods

2.2.1 Survey Design

The RMC probabilistic design was developed using the Generalized Random Tessellation Stratified (GRTS) approach developed by the United States Environmental Protection Agency (USEPA) and Oregon State University (Stevens and Olson 2004). GRTS offers multiple benefits for coordinating amongst monitoring entities including the ability to develop a spatially balanced design that produces statistically representative data with known confidence intervals. The GRTS approach has been implemented recently in California by several agencies including the statewide Perennial Streams Assessment (PSA) conducted by Surface Water Ambient Monitoring Program (SWAMP) (Ode et al. 2011) and the Southern California Stormwater Monitoring Coalition's (SMC) regional monitoring program conducted by municipal stormwater programs in Southern California (SMC 2007).

Sample sites were selected and attributed using the GRTS approach from a sample frame consisting of a creek network geographic information system (GIS) data set within the 3,407-square mile RMC area (BASMAA 2012). The sample frame includes non-tidally influenced perennial and non-perennial creeks within five management units representing areas managed by the storm water programs associated with the RMC. The National Hydrography Plus Dataset (1:100,000) was selected as the creek network data layer to provide consistency with both the Statewide PSA and the SMC, and the opportunity for future data coordination with these programs.

The RMC sample frame was classified by county and land use (i.e., urban and non-urban) to allow for comparisons between these strata. Urban areas were delineated by combining urban area boundaries and city boundaries defined by the U.S. Census (2000). Non-urban areas were defined as the remainder of the areas within the RMC area. Some sites classified as urban fall near the non-urban edge of the city boundaries and have little upstream development. For the purposes of consistency, these urban sites were not re-classified. Therefore, data values within the urban classification represent a wide range of conditions.

The RMC participants weight their annual sampling efforts so that approximately 80% are in in urban areas and 20% in non-urban areas. During the permit term of MRP 1.0, RMC participants coordinated with the SFRWQCB by identifying additional non-urban sites from the probabilistic sample frame for SWAMP to conduct bioassessments[11]. Between WY2012 and WY2015, the

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[11] SFRWQCB SWAMP staff have indicated that they will not conduct RMC related bioassessment monitoring during MRP 2.0.

SFRWQCB conducted bioassessments at 10 sites in San Mateo County; only data collected prior to WY2015 are included in this report.

2.2.2 Site Evaluations

Sites identified in the regional sample draw were evaluated by each RMC participant in chronological order using a two-step process described in RMC Standard Operating Procedure FS-12 (BASMAA 2014b), consistent with the procedure described by Southern California Coastal Water Research Project (SCCWRP) (2012). Each site was evaluated to determine if it met the following RMC sampling location criteria:

1. The location (latitude/longitude) provided for a site is located on or is within 300 meters of a non-impounded receiving water body[12];
2. Site is not tidally influenced;
3. Site is wadeable during the sampling index period;
4. Site has sufficient flow during the sampling index period to support standard operation procedures for biological and nutrient sampling.
5. Site is physically accessible and can be entered safely at the time of sampling;
6. Site may be physically accessed and sampled within a single day;
7. Landowner(s) grant permission to access the site[13].

In the first step, these criteria were evaluated to the extent possible using a “desktop analysis.” Site evaluations were completed during the second step via field reconnaissance visits. Based on the outcome of site evaluations, sites were classified into one of three categories:

- **Target** – Target sites were grouped into two subcategories:
  - **Target Sampleable (TS)** - Sites that met all seven criteria and were successfully sampled.
  - **Target Non-Sampleable (TNS)** - Sites that met criteria 1 through 4, but did not meet at least one of criteria 5 through 7 were classified as TNS.
- **Non-Target (NT)** - Sites that did not meet at least one of criteria 1 through 4 were classified as non-target status.
- **Unknown (U)** - Sites were classified with unknown status when it could be reasonably inferred either via desktop analysis or a field visit that the site was a valid receiving water body and information for any of the seven criteria was unconfirmed.

All site evaluation information was documented on field forms and entered into a standardized database.

2.2.3 Field Sampling Methods

Biological sample collection and processing was consistent with the BASMAA RMC QAPP (BASMAA 2014a) and SOPs (BASMAA 2014b).

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[12] The evaluation procedure permits certain adjustments of actual site coordinates within a maximum of 300 meters.

[13] If landowners did not respond to at least two attempts to contact them either by written letter, email, or phone call, permission to access the respective site was effectively considered to be denied.

In accordance with the RMC QAPP (BASMAA 2014a) bioassessments were planned during the spring index period (approximately April 15 – July 15) with the goal to sample a minimum of 30 days after any significant storm (defined as at least 0.5-inch of rainfall within a 24-hour period). A 30 day grace period allows diatom and soft algae communities to recover from peak flows that may scour benthic algae from the bottom of the stream channel. During WY2015, significant storms occurred on April 7 and April 25. Due to antecedent dry conditions, bioassessments were initiated on April 16 at sites exhibiting low flow conditions. Visual observations at these sites indicated that the April 7 storm event did not appear to generate high flows. Presumably, antecedent dry ground conditions absorbed much of the runoff from the precipitation event. Bioassessments were not conducted between April 27 and May 7 to allow some of the more urban sites to recover from the April 7 rainfall event.

Each bioassessment sampling site consisted of an approximately 150-meter stream reach that was divided into 11 equidistant transects placed perpendicular to the direction of flow. Benthic macroinvertebrate (BMI) and algae samples were collected at each transect using the Reachwide Benthos (RWB) method (Ode 2007, Fetscher 2009). Physical habitat data were collected within the sample reach using methods described in Ode (2007) for the SWAMP "Basic" level of effort[14], with the following additional measurements/assessments as defined in the "Full" level of effort (as prescribed in MRP 1.0): water depth and pebble counts, cobble embeddedness, flow habitat delineation, and instream habitat complexity. The presence of micro- and macroalgae was assessed during the pebble counts following methods described in Fetscher (2009).

Immediately prior to biological and physical habitat data collection, water samples were collected at probabilistic sites for nutrients, conventional analytes, ash free dry mass, and chlorophyll a using the Standard Grab Sample Collection Method as described in SOP FS-2 (BASMAA 2014b). Water samples were also collected and analyzed for free and total chlorine using a Pocket Colorimeter^{TM} II and DPD Powder Pillows according to SOP FS-3 (BASMAAS 2014b) (see Section 5.0 for chlorine results). In addition, general water quality parameters (DO, pH, specific conductivity and temperature) were measured at or near the centroid of the stream flow using pre-calibrated multi-parameter probes.

Biological and water samples were sent to laboratory for analysis. The laboratory analytical methods used for BMIs followed Woodward et al. (2012), using Level 1 Standard Taxonomic Level of Effort, with the additional effort of identifying chironomids (midges) to subfamily/tribe instead of family (Chironomidae). Soft algae and diatom samples were analyzed following SWAMP protocols (Stancheva et al. 2015). The taxonomic resolution for all data was compared and revised when necessary to match the SWAMP master taxonomic list.

Approximately one month following bioassessments, riparian assessments using the California Rapid Assessment Method (CRAM) were conducted at the same locations (and reach lengths) monitored for the RMC probabilistic design (i.e., biological and physical habitat assessments, nutrients and physical chemical water quality). CRAM was conducted at bioassessment locations to assess the utility of using CRAM data to explain the aquatic biological condition. CRAM is performed within a defined riparian Assessment Area and is composed of the following subcategories: 1) buffer and landscape context; 2) hydrology; 3) physical structure; and 4) biotic

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[14] The SWAMP "Full" level of effort of physical habitat data collection is now required in MRP 2.0, starting in WY2016.

structure. Procedures describing methods for scoring riparian attributes are described in Collins et al. (2008).

2.2.4 Data Analysis

BMI and algae data were analyzed to assess the biological condition of the sampled reaches using condition index scores. The physical habitat and water chemistry data were evaluated as potential stressors to biological health using thresholds from published sources and regulatory criteria/guidance, as well as correlations with condition index scores. Data analysis methods are described below.

2.2.4.1 Biological Indicators

Benthic Macroinvertebrates

The California Stream Condition Index (CSCI) is an assessment tool that was developed by the State Water Resources Control Board (State Board) to support the development of California's statewide Biological Integrity Plan[15]. The CSCI translates benthic macroinvertebrate data into an overall measure of stream health. The CSCI was developed using a large reference data set that represents the full range of natural conditions in California and by the use of site-specific models for predicting biological communities. The CSCI combines two types of indices: 1) taxonomic completeness, as measured by the ratio of observed-to-expected taxa (O/E); and 2) ecological structure and function, measured as a predictive multi-metric index (pMMI) that is based on reference conditions. The CSCI score is computed as the average of the sum of O/E and pMMI.

The CSCI is calculated using a combination of biological and environmental data following methods described in Rehn et al. (2015). Biological data include benthic macroinvertebrate data collected and analyzed using protocols described in the previous section. The environmental predictor data are generated in GIS using drainage areas upstream of each BMI sampling location. The environmental predictors and BMI data were formatted into comma delimited files and used as input for the RStudio statistical package and the necessary CSCI program scripts, developed by Southern California Coastal Water Research Project (SCCWRP) staff.

The State Board is continuing to evaluate the performance of CSCI in a regulatory context. In the re-issued MRP 2.0 (adopted on November 19, 2015), the Regional Water Board defined a CSCI score of 0.795 as a threshold for identifying sites with degraded biological condition that may be considered as candidates for a Stressor Source Identification (SSID) project.

Benthic Algae

The State Water Board is currently developing and testing assessment tools for benthic algae data as a measure of biological condition and identification of potential stressors. A comprehensive set of 25 stream algal indices of biological integrity (IBIs) have been developed and tested using algae data collected in Southern California (Fetscher et al. 2014). The IBIs were developed from data comprised of either single-assemblage metrics (i.e., either diatoms or soft algae) or combinations of metrics presenting both assemblages (i.e, "hybrid" IBI). Three of

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[15] The State Water Board is currently working on a draft Biological Integrity Plan with public draft anticipated in spring 2016.

these algal IBIs were selected to evaluate algae data collected at bioassessments sites in San Mateo County, including a soft algae index (S2), a diatom index (D18) and a hybrid index (H20). Algae IBI scores were calculated using an online IBI calculator available on the SCCWRP website (http://www.sccwrp.org/Data/DataTools/algaeIBI.aspx). As previously mentioned, the algae IBIs were developed and tested on data collected in Southern California. Further study is needed to determine their applicability for assessing the biological condition of San Francisco Bay Area streams.

In WY2015, abundance and diversity of soft algae taxa in samples collected at all ten bioassessment sites in San Mateo County was exceptionally low. As a result, soft algae metric (S2) and hybrid metric (H20) could not be calculated due to an insufficient number of taxa. Thus, only the diatom metric (D18) was used to assess biological condition of algae in this report. Possible explanation for the low abundance of soft algae taxa will be discussed later in this report.

Riparian Habitat

The California Rapid Assessment Method (CRAM) evaluates four different components of riparian condition on a scale from 25 to 100. The four attributes include: 1) buffer and landscape context; 2) hydrology; 3) physical structure; and 4) biotic structure. These four attributes are summed together and divided by four to calculate an overall total CRAM score for each bioassessment site. For this study, total CRAM score was used as the biological indicator for riparian habitat condition. A statewide approach to define condition categories for CRAM scores has not been developed.

2.2.4.2 Biological Condition Thresholds

Existing thresholds for biological indicators defined in Mazor (2015) were used to evaluate the bioassessment data collected in San Mateo County and analyzed in this report (Table 2.1). The thresholds for each index were based on the distribution of scores for data collected at reference calibration sites in California (CSCI) or in Southern California (algae and CRAM). Four condition categories are defined by these thresholds: “likely intact” (greater than 30th percentile of reference site scores); “possibly intact” (between the 10th and the 30th percentiles); “likely altered” (between the 1st and 10th percentiles; and “very likely altered” (less than the 1st percentile). PHAB categories were created by applying three thresholds at each quartile.

Table 2.1. Condition categories used to evaluate CSCI, diatom (D18), CRAM, and PHAB scores.

Index	Likely Intact (>30th)	Possibly Intact (10th – 30th)	Likely Altered (1st – 10th)	Very Likely Altered (< 1st)
Benthic Macroinvertebrates (BMI)				
CSCI Score	$\geq$ 0.92	0.79 – 0.92	0.63 – 0.79	< 0.63
Benthic Algae				
D18 Score	$\geq$ 72	62 - 72	49 - 62	< 49
Riparian Habitat Condition				
Total CRAM Score	$\geq$ 79	72 - 79	63 - 72	< 63
Total PHAB Score	$\geq$ 45	30 - 45	16 - 30	< 16

A CSCI score below 0.795 is referenced in the recently re-issued MRP 2.0 as a threshold below which indicates a potentially degraded biological community, and thus should be considered for a SSID Project. The MRP threshold is the division between “possibly intact” and “likely altered” condition category described in Mazor (2015).

2.2.4.3 Stressor Variables

The physical habitat, general water quality and water chemistry data collected at the bioassessment sites were compiled and evaluated as potential stressor variables for biological condition. Some of the data required conversion to other analytes or units of measurement.

- Conversion of measured total ammonia to the more toxic form of unionized ammonia was calculated to compare with the 0.025 mg/L standard provided in the Basin Plan. The conversion was based on a formula provided by the American Fisheries Society (AFS, internet source). The calculation requires total ammonia and field-measured parameters of pH, temperature, and specific conductance.
- The total nitrogen concentration was calculated by summing nitrate, nitrite and Total Kjeldahl Nitrogen concentrations.
- The volumetric concentrations (mass/volume) for ash free dry mass and chlorophyll a (as measured by the laboratory) were converted to an area concentration (mass/area). Calculations required using both algae sampling grab size and composite volume.

Physical habitat variables consisted of reachwide endpoints of quantitative and qualitative habitat measurements. Quantitative measurements included percent canopy cover, percent sands & fines and percent micro- and macro-algae cover (both derived from pebble count data). Qualitative measurements included human disturbance index and three physical habitat (PHAB) scores (epifaunal substrate complexity, sediment deposition and channel alteration). Additional environmental variables were calculated in GIS by overlaying the drainage area for sample locations with land use and road data. The variables included percent urbanization, percent impervious and road density at three different spatial scales: watershed, 1000 km and 5000 km. The latter two variables represent the portion of the watershed area that is 1000 km and 5000 km upstream of the sampling location.

2.2.4.4 Stressor Thresholds

Stressor thresholds were used to evaluate the water chemistry data collected at the bioassessment sites (Table 2.2). Per provision C.8.d, thresholds for some of the nutrient and conventional analytes were derived from existing regulations and guidance. Relevant water quality standards for these analytes include the San Francisco Basin Water Quality Control Plan (Basin Plan) (SFRWQCB 2013), the California Toxics Rule (CTR) (USEPA 2000), and various USEPA sources. Of the eleven nutrients and conventional analytes sampled in association with bioassessment monitoring, water quality standards or established thresholds only exist for three: ammonia (unionized form) and chloride and nitrate (for waters with MUN beneficial use only). The Basin Plan also lists Water Quality Objectives for three of the general water quality parameters: dissolved oxygen, pH, and temperature (narrative). MRP 2.0 references an acute threshold for continuous measurements of temperature, defined by Sullivan et al. (2001), for streams supporting salmonid fish communities.

Table 2.2. Thresholds for nutrient and general water quality variables.

Environmental Variable	Units	Threshold	Direction	Source
Nutrients and Ions				
Nitrate as N	mg/L	10	Increase	Basin Plan
Un-ionized Ammonia	mg/L	0.025	Increase	Basin Plan
Chloride	mg/L	250	Increase	Basin Plan
General Water Quality				
Oxygen, Dissolved	mg/L	5.0 or 7.0	Decrease	Basin Plan
pH		6.5 and 8.5		Basin Plan
Temperature	°C	24	Increase	MRP

2.2.4.5 Stressor Association with Biological Conditions

Correlations between biological indicator data (i.e., CSCI scores, algae IBIs) and potential stressors (i.e., physical habitat measurements, water chemistry) were evaluated for all ten probabilistic sites using the Spearman rank method in Sigma Plot statistical software. The Spearman rank method was selected for its suitability of evaluating data that are not normally distributed. Coefficients values greater than ±0.5 indicate a strong relationship between variables. If the p-value is ≤0.05, the correlation is considered statistically significant.

Probabilistic data can be used to assess the extent and relative risk of stressors at the regional scale. Several approaches for evaluating stressor data have been used for other probability surveys (Ode et al. 2011, Mazor 2015), including: 1) relative risk and attributable risk estimates; 2) continuous risk relationships; and 3) biology-based stressor thresholds. These approaches are recommended for an analysis of stressors for the RMC area, including San Mateo County streams.

2.3 Results and Discussion

2.3.1 Site Evaluations

During WY2015, SMCWPPP and Regional Water Board conducted site evaluations at a total of 47 potential probabilistic sites in San Mateo County that were drawn from the master list. Of these sites, a total of eleven were sampled in WY2015 (rejection rate of 77%). Approximately 27% of the sampled sites were classified as non-urban land use (n=3). Land use classification, sampling location and date for each sampled site are shown in Table 2.3.

Table 2.3. Bioassessment sampling date and locations in San Mateo County in WY2015.

Station Code	Creek	Program	Land Use	Sample Date	Latitude	Longitude
202R00378	Pescadero Creek	SMCWPPP	NU	4/23/2015	37.21994	-122.16385
202R00408	Langley Cr	SWAMP	NU	NA	37.33100	-122.27439
202R00440	Purisima Creek	SMCWPPP	NU	5/13/2015	37.43417	-122.34959
202R01356	MF San Pedro Creek	SMCWPPP	U	5/11/2015	37.57524	-122.46105
202R01612	MF San Pedro Creek	SMCWPPP	U	5/11/2015	37.57810	-122.47139
204R01448	Atherton Creek	SMCWPPP	U	4/22/2015	37.43459	-122.21776
204R01972	Cordilleras Creek	SMCWPPP	U	5/13/2015	37.48375	-122.25730
204R02056	Laurel Creek	SMCWPPP	U	5/12/2015	37.53342	-122.30243
204R02248	Laurel Creek	SMCWPPP	U	5/12/2015	37.52659	-122.32286
205R01704	Dry Creek	SMCWPPP	U	4/22/2015	37.43389	-122.26094
205R01816	Corte Madera Creek	SMCWPPP	U	4/30/2015	37.36615	-122.21570

NA = information not available, NU = non-urban, U = urban

Since WY2012, a total of 50 probabilistic sites were sampled by SMCWPPP (n=40) and SWAMP (n=10)[16] in San Mateo County. During the four year sampling period, SMCWPPP sampled 33 urban and 7 non-urban sites; SWAMP sampled 10 non-urban sites. A total of 133 total sites were evaluated to obtain 50 samples, a rejection rate of 62%[17]. The rejection criteria included no access, low or no flow, and combination of other reasons (e.g., creek not present, tidal influence). The number of sites (and percentage of total evaluated sites) rejected for each criterion are presented in Table 2.4. The rejection rate in an important factor in defining the confidence level of statistical data interpretations. The location and site evaluation results for all 133 sites are shown in Figure 2.1.

Table 2.4. Probabilistic site evaluation results in San Mateo County between WY2012 – WY2015.

Subpopulation	Target Sampled Sites	Potential Target Not sampled due to access issues	Non-Target Rejected due to low or no flow	Non-Target Rejected for other reasons	Total Sites Evaluated
Urban	33 (38%)	30 (34%)	15 (17%)	10 (11%)	88
Non-Urban	17 (38%)	16 (36%)	10 (22%)	2 (4%)	45
Total	50 (38%)	46 (35%)	25 (18%)	12 (9%)	133

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[16] The data from one SWAMP sample collected in WY2015 were not available for analyses in this report. Data results from nine probabilistic sites sampled by SWAMP are included in this report.

[17] The rejection rate is an important factor in defining the confidence level of statistical data interpretations at countywide and regional scales.

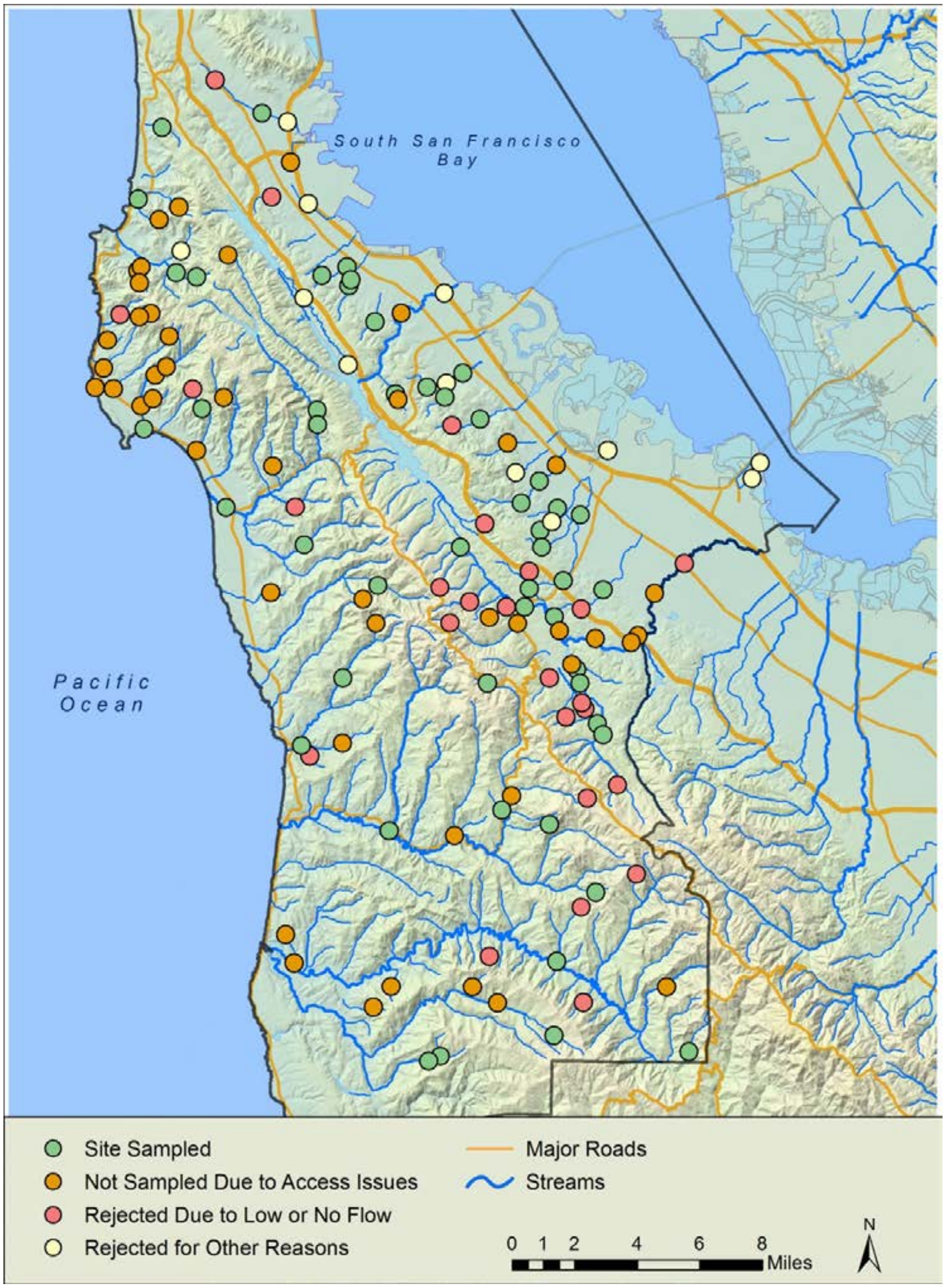

Figure 2.1. Site evaluation results for RMC probabilistic sites (n=133) conducted WY2012 – WY 2015 in San Mateo County.

Access issues (e.g., physical barriers, permission not granted) were the most common reason for not sampling a site (35% of total sites). Access issues at non-urban sites were primarily due to the lack of road access to remote sites and densely vegetated hill slopes adjacent to sites. Access issues at urban sites were primarily due to lack of owner permission to access private land; majority of creeks in San Mateo urban areas are privately owned. The remaining sites were rejected for a variety of reasons, including site location not on a creek or site was tidally influenced.

Low or no flow conditions were the second most common reason for site rejection (18% of all sites). Low flow conditions were documented at 15 urban sites and 10 non-urban sites evaluated. The inclusion of first order streams in the upper watershed areas in the Master List increases the potential for low flow conditions during the sample index period. In addition, the extended period of drought conditions during the four years of Creek Status Monitoring likely resulted in low flow conditions in reaches that would be perennial during normal years of rainfall.

2.3.2 Biological Condition Assessment

Biological condition, as represented by CSCI, D18 and total CRAM scores for the ten probabilistic sites sampled by SMCWPPP during WY2015 are listed in Table 2.5. Total PHAB scores for each bioassessment site are also presented for comparison. The condition categories for the three biological indicators and PHAB scores, as defined in Table 2.1, are illustrated for each of the ten sites in Figure 2.2.

Table 2.5. Biological condition scores, presented as CSCI, diatom IBI (D18), total CRAM and total PHAB, for ten probabilistic sites sampled in San Mateo County during WY2015. Site characteristics related to channel modification and flow condition are also presented. Bold values indicate "good" condition.

Station Code	Creek	Elevation (ft)	Land Use	Modified Channel[1]	Flow[2]	CSCI Score	Diatom "D18" IBI Score	Total CRAM Score	Total PHAB Score
202R00378	Pescadero Creek	868	NU	N	NP	**0.91**	**66**	**75**	**41**
202R00440	Purisima Creek	649	NU	N	P	**1.22**	**68**	**87**	**46**
202R01356	MF San Pedro Creek	280	U	N	P	**1.02**	**80**	**77**	**50**
202R01612	MF San Pedro Creek	180	U	N	P	**0.86**	58	**85**	**44**
204R01448	Atherton Creek	136	U	Y	P	0.42	62	45	12
204R01972	Cordilleras Creek	64	U	N	P	0.40	34	62	30
204R02056	Laurel Creek	49	U	Y	P	0.44	60	51	18
204R02248	Laurel Creek	172	U	N	P	0.37	56	57	32
205R01704	Dry Creek	383	U	N	NP	0.45	62	57	28
205R01816	Corte Madera Creek	612	U	N	P	**1.20**	**72**	**73**	**45**

[1] Highly modified channel is defined as having armored bed and banks (e.g., concrete, gabion, rip rap) for majority of the reach or characterized as highly channelized earthen levee.

[2] Flow status (P = perennial, NP = non-perennial) was based on visual observations at each site made during fall or spring seasons

Five of the ten bioassessment sites sampled in WY2015 had CSCI scores that were classified as "possibly intact" or "likely intact" condition. The combined classifications are above the MRP threshold value of 0.795 and are herein referred to as "good" biological condition in this report. Three of the sites ranked as "good" had scores over 1.0, which is typically a score for reference sites. Four of these sites were in coastal watersheds draining into the Pacific Ocean; two were classified as non-urban and two were in the San Pedro Valley County Park in the City of Pacifica. The fifth site (205R01816) was located just downstream of Windy Hill Open Space Preserve on Corte Madera Creek. The remaining five sites were all located in highly urban watersheds draining into the San Francisco Bay. The CSCI scores at these sites ranged from 0.37 to 0.45, all ranked as "very likely altered" (CSCI < 0.63), indicating highly degraded sites (Table 2.5).

Four of the five sites that were ranked in good condition based on CSCI scores were also ranked in good condition based on D18 scores (Table 2.5). The highest score (D18 = 80) occurred at the upstream site on the Middle Fork of the San Pedro Creek (202R01356). The lowest elevation site on the Middle Fork of San Pedro Creek (202R01612), approximately 1.0 mile further downstream, received a much lower D18 score (58). The lowest score (34) for all the sites was recorded at site 204R01972 in the highly urbanized reach of Cordilleras Creek.

All five sites that were ranked in good condition based on CSCI scores were also ranked in good condition based on total CRAM and total PHAB scores (Table 2.5). Although not considered a biological indicator, PHAB scores may be useful for evaluating factors related to physical habitat that may impact biological communities.

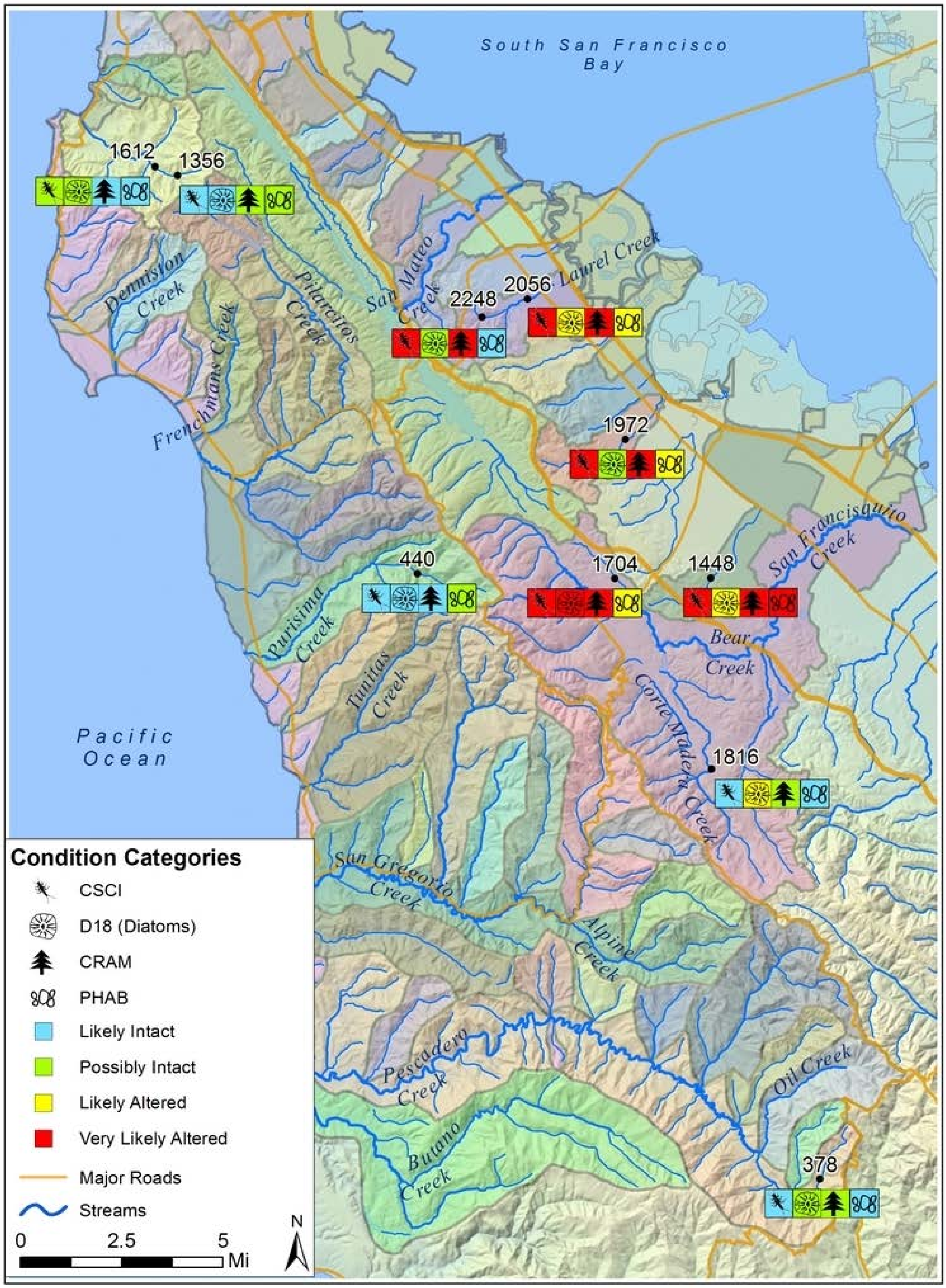

Figure 2.2. Condition category as represented by CSCI, D18, total CRAM, and total PHAB scores for ten probabilistic sites sampled in San Mateo County in WY2015.

There were an insufficient number of soft algae taxa collected in samples for all ten sites to calculate S2 or H20 scores. Only three soft algae taxa were identified in the ten samples that were collected in WY2015. There is no evidence to suggest that sampling errors (e.g., collection, preservation, storage and transport of samples) or laboratory errors (e.g., subsampling, taxa identification) caused these findings. Reasons for the lack of soft algae are unknown but may be related to recent rain events causing scour of channel substrate, sand-dominated substrate, low flow conditions related to prolonged drought, dense canopy cover limiting exposure to sunlight, and/or competition with diatoms. None of the factors listed above however, appear to explain the consistent lack of soft algae in samples at all ten sites.

The CSCI scores from WY2015 show similar patterns to previous years. The CSCI scoring distribution, shown as box plots, for both urban and non-urban sites sampled between WY2012 and WY2015 is shown in Figure 2.3. The median CSCI score for all four years ranged from 0.45 to 0.58 for urban sites and 0.9 to 1.1 for non-urban sites. Biological condition, based on CSCI score, for all 50 probabilistic sites sampled over the previous four years (WY2012-WY2015) are shown geographically in Figure 2.4.

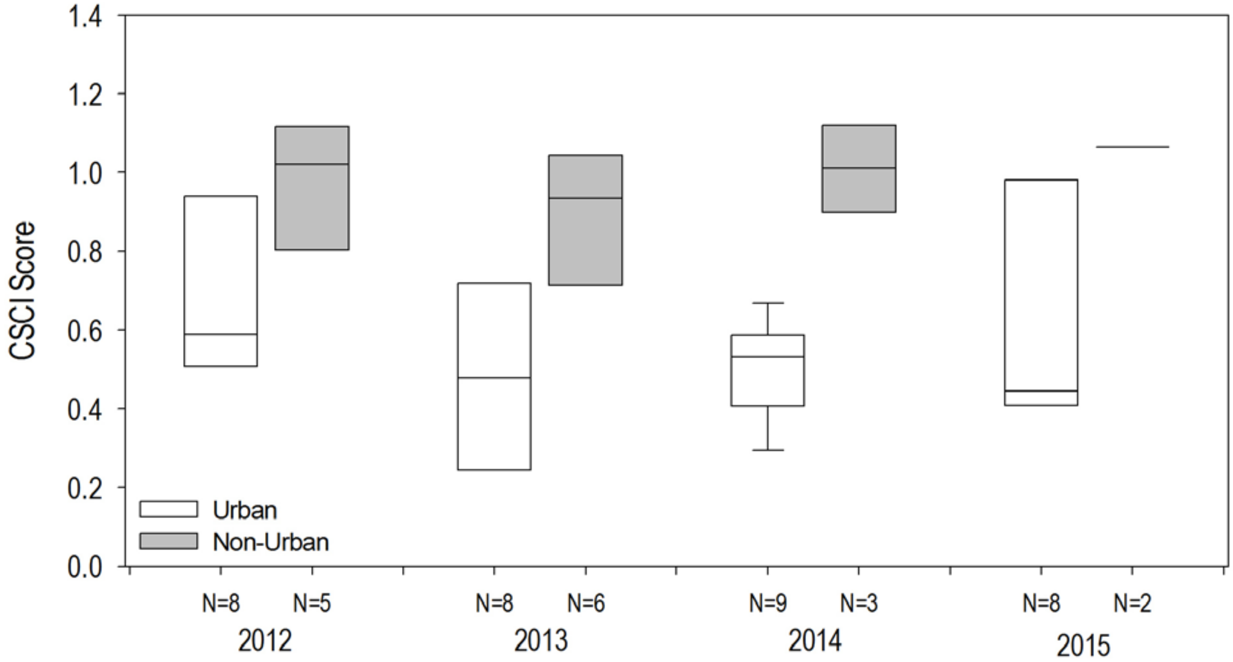

Figure 2.3. Box plots showing CSCI scores grouped by land use classification, for 50 bioassessment sites in San Mateo County, WY2012 - WY2015.

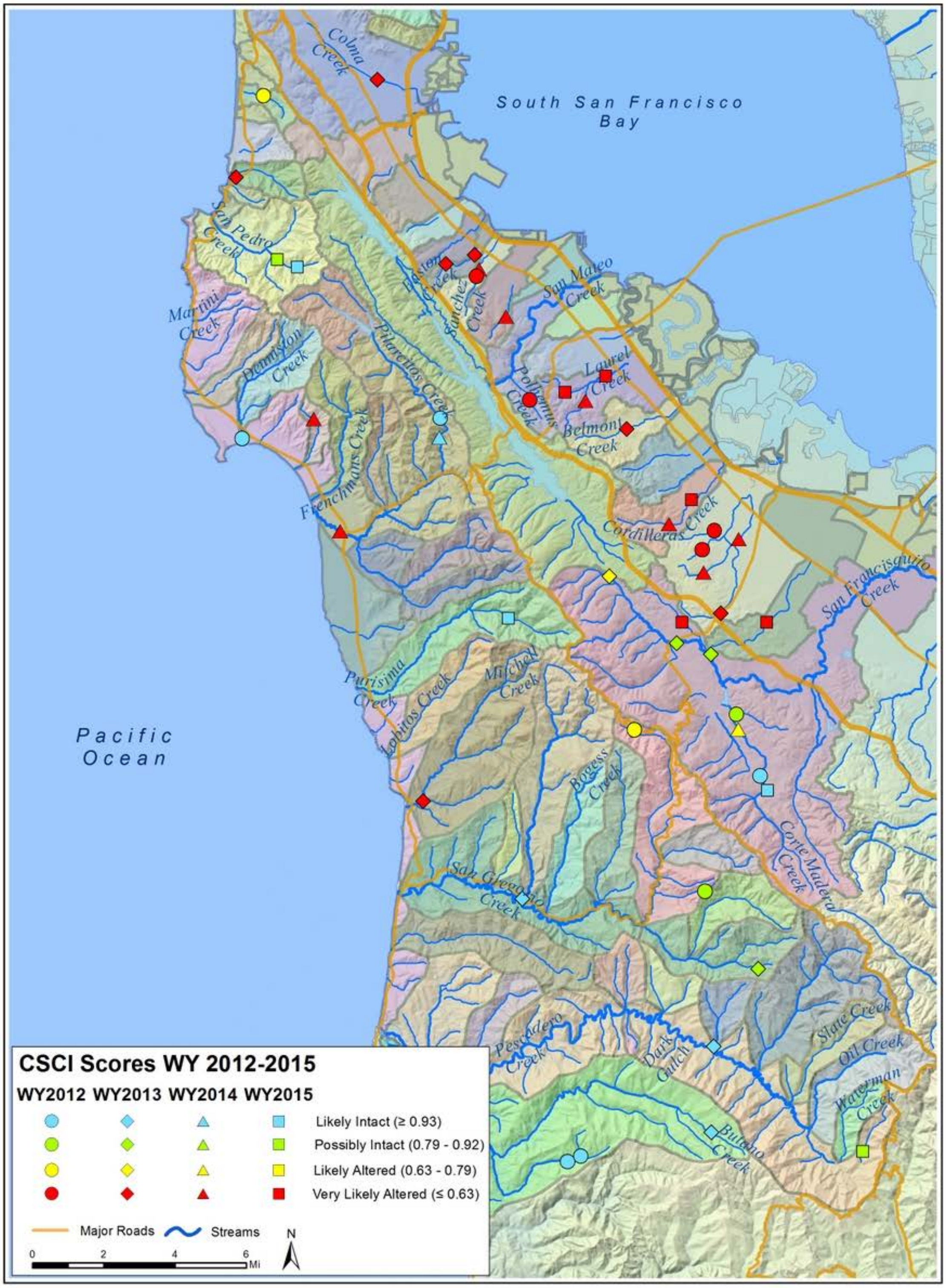

Figure 2.4. Biological condition based on CSCI scores for 50 sites sampled by SMCWPPP and SFRWQCB in San Mateo County between WY2012 and WY2015.

It is important to understand that the CSCI tool was developed by the State Board to assess wadeable, perennial streams in California. However, this report (and the MRP) use the CSCI to evaluate BMI data collected at both perennial and non-perennial sites. The CSCI scoring tool appears to have the same scoring distribution and central tendencies at non-perennial sites compared to perennial sites (Figure 2.5). Similarly, the D18 index has comparable scores at sites with either flow classification.

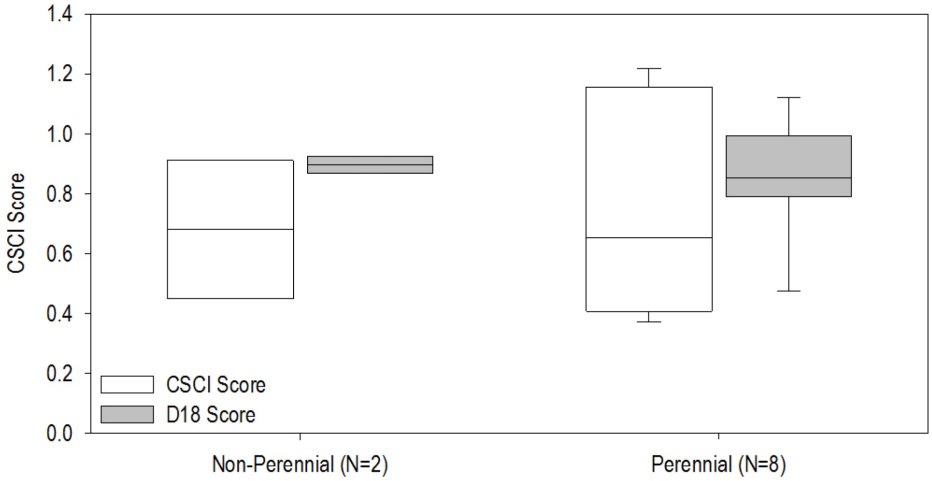

Figure 2.5. Box plots showing CSCI and algae IBI scores, grouped by flow classification, for 10 bioassessment sites sampled in San Mateo in WY2015.

The CSCI tool was relatively consistent in response across an urban gradient, with generally lower median scores associated with increasing urbanization (i.e., percent imperviousness) (Figure 2.6). The two sites with the highest CSCI scores were in the middle group (3-10%), with impervious area just above 3%. The D18 scores did not appear to respond to urban gradients in WY2015.

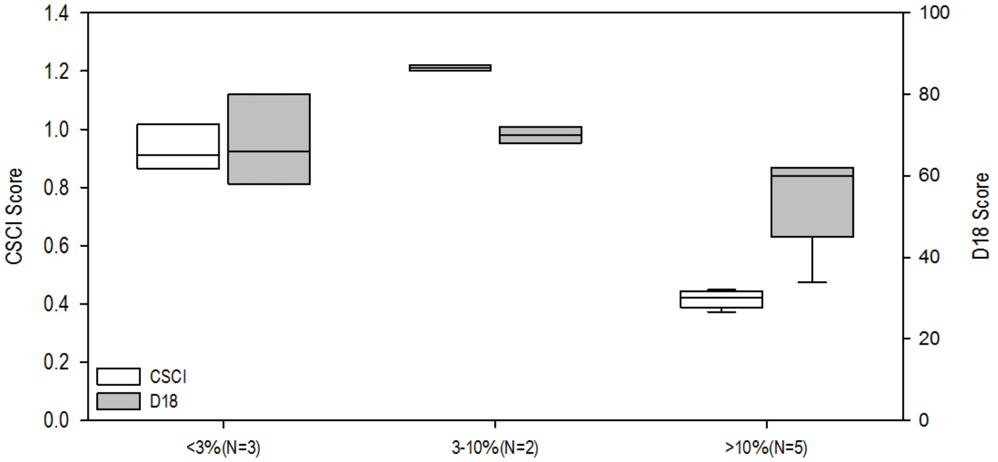

Figure 2.6. Box plots showing CSCI and algae IBI scores, grouped by percent impervious area, for 10 bioassessment sites sampled in San Mateo County in WY2015.

The individual attribute and CRAM scores for the ten probabilistic sites are presented in Table 2.6. Total CRAM score was highly correlated with CSCI score (R^2 = 0.733, p value = 0.002) (Figure 2.7). The CSCI score was more correlated with PHAB score (R^2 = 0.702, p value = 0.002) compared to D18 score (R^2 = 0.1967, p value = 0.2), suggesting that physical habitat (e.g., substrate quality, channel alteration) has a greater influence on the BMI community compared to diatoms assemblage (Figure 2.8). For this reason, algae may provide useful data to assess water quality issues at urban sites with poor habitat.

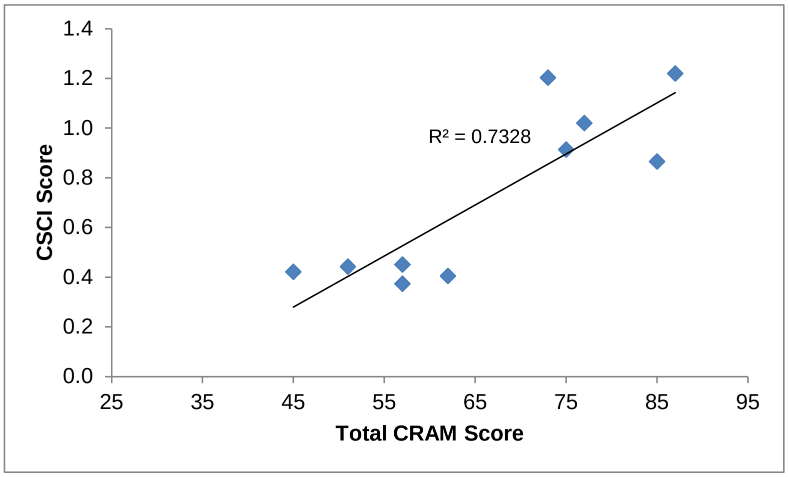

Figure 2.7. Total PHAB scores compared to CSCI scores at 10 bioassessment sites sampled in San Mateo County in WY2015.

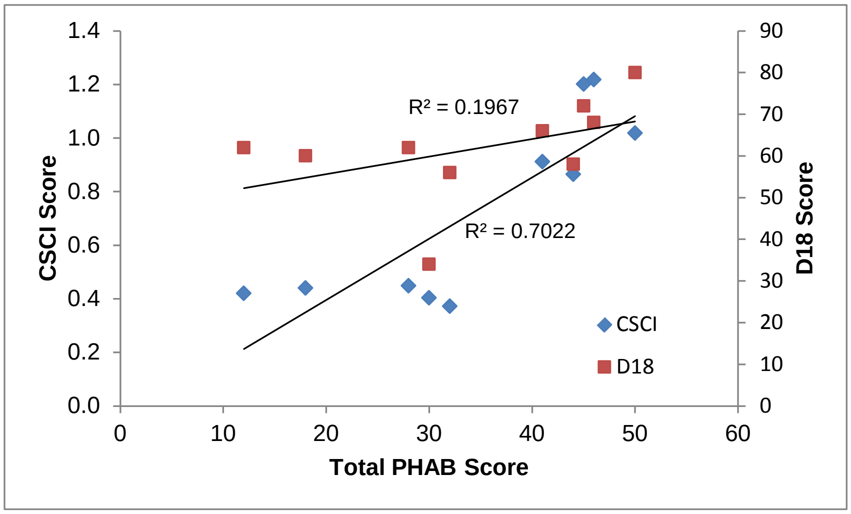

Figure 2.8. D18 and CSCI scores plotted with PHAB score for 10 bioassessment sites sampled in San Mateo County in WY2015.

Table 2.6. Physical habitat (PHAB) and riparian assessment scores (CRAM) for ten probabilistic sites in San Mateo County sampled in WY2015.

Station Code	Creek Name	PHAB				CRAM				
		Channel Alteration Score	Epifaunal Substrate Score	Sediment Deposition Score	Total Score	Land	Hydro	Physical	Biotic	Total Score
202R00378	Pescadero Creek	18	15	8	41	93	67	75	64	75
202R00440	Purisima Creek	18	18	10	46	93	83	88	83	87
202R01356	MF San Pedro Creek	20	17	13	50	93	67	75	72	77
202R01612	MF San Pedro Creek	18	18	8	44	93	75	88	83	85
204R01448	Atherton Creek	2	1	9	12	63	33	25	61	45
204R01972	Cordilleras Creek	9	11	10	30	68	50	63	69	62
204R02056	Laurel Creek	7	5	6	18	25	58	63	58	51
204R02248	Laurel Creek	14	10	8	32	36	58	63	69	57
205R01704	Dry Creek	12	9	7	28	78	42	38	69	57
205R01816	Corte Madera Creek	14	15	16	45	81	67	63	81	73

2.3.3 Stressor Assessment

2.3.3.1 Stressor Thresholds

Nutrient and conventional analyte concentrations measured in water samples collected at ten bioassessment sites in San Mateo County during WY2015 are listed in Table 2.7. There were no exceedances of water quality objectives. See Table 2.2 for a list of water quality objectives.

Physical habitat data and general water quality measurements sampled at the bioassessment sites in WY2015 are listed in Table 2.8. GIS calculations of percent urbanization of the drainage area upstream of each sampling location are also listed in Table 2.8.

2.3.3.2 Stressor Association with Biological Condition

Spearman Rank Correlations for environmental variables associated with CSCI scores are presented in Figure 2.9[18]. Statistically significant variables are indicated as shaded columns. Coefficients values greater than ±0.5 indicate a strong relationship between the variables. CSCI scores at the San Mateo sites had significant negative correlations with land use variables (percent impervious and urban), specific conductivity, chloride, temperature, and alkalinity and significant and positive correlations with two PHAB parameters (epifaunal substrate score and channel alteration score), total CRAM scores, and D18 scores.

Another potential stressor that should be considered but was not assessed relates to the lower than average precipitation and stream flow during the four years of probabilistic bioassessment sampling. Future sampling during wetter years may provide useful information to evaluate the impacts of drought on biological integrity of the streams.

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[18] A similar figure for D18 scores is not shown because there were no statistically significant variables for D18 scores.

Table 2.7. Nutrient and conventional constituent concentrations of water samples collected at ten sites in San Mateo County during WY2015. Analyte concentrations that exceed water quality objectives are indicated in bold. See Table 2.1 for WQO values.

Station Code	Creek	Ammonia as N	Unionized Ammonia (as N)	Chloride	AFDM	Chlorophyll a	DOC	Nitrate as N	Nitrite as N	Total Kjeldahl Nitrogen As N	Total Nitrogen	Ortho-Phosphate as P	Phosphorus as P	Silica as SiO2	SSC
		mg/L	mg/L	mg/L	g/m2	mg/m2	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Water Quality Objective		NA	0.025	250	NA	NA	NA	10	NA	NA	NA	NA	NA	NA	NA
202R00378	Pescadero Cr	0.14	.004	55	69	2	2.5	0.005	0.0025	0.53	0.54	0.13	0.14	29	5
202R00440	Purisima Cr	0.044	.002	26	11	45	1.5	0.110	0.0025	0.75	0.86	0.12	0.06	20	1
202R01356	MF San Pedro Cr	0.23	.003	27	50	11	1.2	0.005	0.0025	0.04	0.04	0.01	0.01	17	1
202R01612	MF San Pedro Cr	0.35	.009	23	96	30	1.2	0.017	0.0025	0.04	0.05	0.02	0.02	16	1
204R01448	Atherton Cr	0.15	.009	250	59	101	6.8	0.310	0.0025	1.10	1.41	0.10	0.12	23	1
204R01972	Cordilleras Cr	0.02	.0006	86	45	4	3.1	0.005	0.0025	0.48	0.49	0.06	0.16	13	1
204R02056	Laurel Cr	0.04	.002	120	22	11	3.9	0.670	0.01	0.83	1.51	0.09	0.10	16	1
204R02248	Laurel Cr	0.02	.0002	91	206	34	3.8	0.160	0.0025	0.40	0.56	0.06	0.07	19	1
205R01704	Dry Cr	0.12	.002	42	342	18	3.3	0.005	0.0025	0.75	0.76	0.12	0.10	24	8
205R01816	Corte Madera Cr	0.044	.001	40	49	8	2.8	0.005	0.0025	0.31	0.32	0.07	0.07	19	1
Number of exceedances		NA	0	0	NA	NA	NA	0	NA	NA	NA	NA	NA	NA	NA

NA = not applicable, NR = no threshold reference available

Table 2.8. Selected physical habitat variables and general water quality measurements collected at ten sites in San Mateo County during WY2015. Land use data calculated in GIS, is also provided. See Table 2.1 for threshold sources.

Station Code	Creek	% Micro Algae Cover	% Macro Algae Cover	% Canopy Cover	% Sands+ Fines	HDI Score	% Urban (watershed)	% Imperv (watershed)	Temp (C)	DO (mg/L)	pH	Specific Cond (uS/cm)
202R00378	Pescadero Cr	0	0	94	31	0.14	1%	1%	10.8	10.0	8.2	830
202R00440	Purisima Cr	0	0	89	17	0.83	11%	4%	10.7	10.7	8.5	665
202R01356	MF San Pedro Cr	0	0	100	9	0.15	0%	1%	11.1	10.5	7.8	458
202R01612	MF San Pedro Cr	0	0	98	17	0.38	0%	1%	11.7	10.6	8.1	398
204R01448	Atherton Cr	4	38	86	10	1.39	48%	17%	16.4	12.4	8.4	2801
204R01972	Cordilleras Cr	2	30	76	9	3.05	45%	19%	12.2	10.1	8.2	1115
204R02056	Laurel Cr	4	10	93	17	3.03	74%	39%	13.2	9.2	8.3	1129
204R02248	Laurel Cr	11	5	94	10	2.47	72%	41%	12.2	6.7	7.7	1179
205R01704	Dry Cr	1	3	90	22	1.12	61%	13%	11.8	9.5	8.0	875
205R01816	Corte Madera Cr	1	0	83	13	1.57	8%	3%	11.7	10.8	8.2	928
Water Quality Objective		NA	NA	NA	NA	NA	NA	NA	NA	5 or 7	6.5 and 8.5	NA
Number of exceedances		NA	NA	NA	NA	NA	NA	NA	NA	0	0	NA

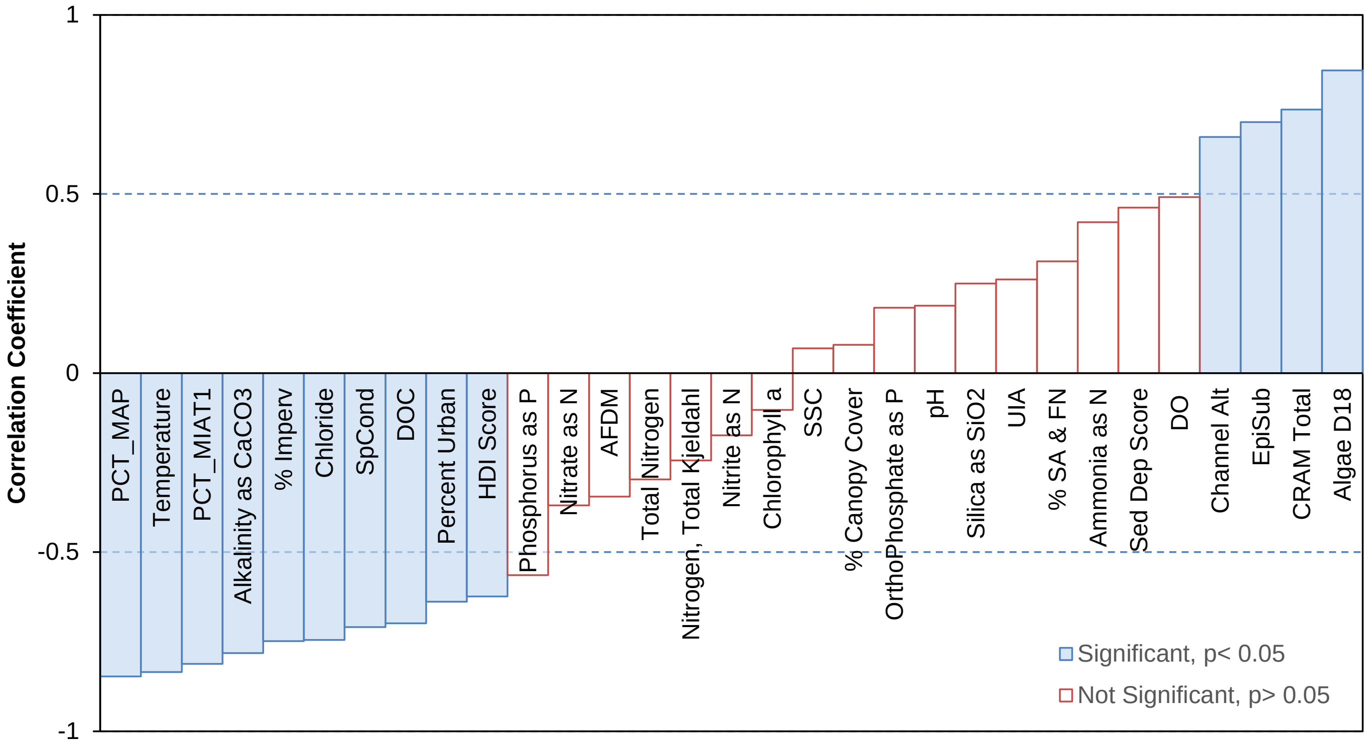

Figure 2.9. Spearman Rank Correlation for CSCI scores and stressor variable data collected at ten sites in San Mateo County in WY2015.

2.4 Conclusions and Recommendations

The following conclusions from the MRP Creek Status Monitoring conducted during WY2015 in San Mateo County are based on the following management questions:

1) *Are water quality objectives, both numeric and narrative, being met in local receiving waters, including creeks, rivers, and tributaries?*

2) *Are conditions in local receiving water supportive of or likely supportive of beneficial uses?*

The first management question is addressed primarily through the evaluation of probabilistic data with respect to water quality objectives and thresholds from published literature. Sites where exceedances occur may indicate potential impacts to aquatic life or other beneficial uses and are considered for future evaluation of stressor source identification projects.

The second management question is addressed primarily through calculation of indices of biological integrity using benthic macroinvertebrate and algae data collected at probabilistic sites. Biological condition scores were compared to physical habitat and water quality data collected synoptically with bioassessments to evaluate whether any correlations exist that may explain the variation in biological condition.

Probabilistic Survey Design

- Between WY2012 and WY2015, a total of 50 probabilistic sites were sampled by SMCWPPP (n=40) and SWAMP (n=10) in San Mateo County, including 33 urban and 17 non-urban sites. There are now a sufficient number of samples from probabilistic sites to develop estimates of ambient biological condition and stressor assessment for urban streams in San Mateo County.

- Additional samples are needed to estimate biological condition at more local scales (e.g., watershed and jurisdictional areas) and to increase the confidence of estimates at sites in non-urban areas.

Biological Condition Assessment

- The California Stream Condition Index (CSCI) tool was used to assess the biological condition for benthic macroinvertebrate data collected at probabilistic sites. Of the 10 sites monitored in WY2015, five sites were rated in good condition (CSCI scores $\geq$ 0.795) and five sites rated as very likely altered condition ($\leq$ 0.635).
- The five sites with CSCI scores less than the trigger threshold of 0.795 will be added to the list of candidate SSID projects.
- CSCI scores were relatively consistent across four years of sampling. The median CSCI score for all four years ranged from 0.45 to 0.58 for urban sites and 0.9 to 1.1 for non-urban sites.
- Benthic algae data was collected synoptically with BMIs at all probabilistic sites. Algae index scores for diatom taxa (D18) were calculated for all sites. Four sites were rated in good condition (D18 scores $\geq$ 63), five sites rated as likely altered, and one site rated as very likely altered (<49).

- There was insufficient number of soft algae taxa to calculate algae indices S2 or H20 at any of the sites. Only three soft algal taxa were identified for all ten samples. Site characteristics and flow conditions prior to sampling do not appear to explain the absence of soft algae consistently at all the sites.
- There was very little difference in CSCI or algae IBI (D18) scores between perennial (n=8) and non-perennial (n=2) sites. CSCI scores had good response to different levels of urbanization (calculated as percent impervious area). CSCI was highly correlated with PHAB and CRAM scores. D18 was poorly correlated with both PHAB and CRAM scores.

Stressor Assessment

- Nutrients, algal biomass indicators, and other conventional analytes were measured in samples collected concurrently with bioassessments which are conducted in the spring season.
- CSCI scores has significant negative correlation with both land use variables (percent impervious and urban), specific conductivity, unionized ammonia, and SSC and positive correlation with two PHAB parameters (epifaunal substrate score and channel alteration score).
- Thresholds for water quality objectives were not exceeded.

Trend Assessment

- Trend analysis for the RMC probabilistic survey will require more than four years of data collection. Preliminary long-term trend analysis of biological condition may be possible for some stream reaches using a combination of historical targeted data with the probabilistic data.
- Targeted re-sampling at probabilistic sites can provide additional data to evaluate longer term trends at selected locations.

3.0 Targeted Monitoring

3.1 Introduction

During WY2015 (October 1, 2014 – September 30, 2015) water temperature, general water quality, and pathogen indicators were monitored at selected sites using a targeted monitoring design based on the directed principle[19] to address the following management questions:

1. What is the spatial and temporal variability in water quality conditions during the spring and summer season?
2. Do general water quality measurements indicate potential impacts to aquatic life?
3. What are the pathogen indicator concentrations at creek sites where there is potential for water contact recreation to occur?

The first management question is addressed primarily through evaluation of water quality results in the context of existing aquatic life and recreational uses. Temperature and general water quality data were evaluated for potential impacts to potential lifestage and overall population of fish community present within monitored reach.

The second and third management questions are addressed primarily through the evaluation of targeted data with respect to water quality objectives and thresholds from published literature. Sites where exceedances occur may indicate potential impacts to aquatic life or other beneficial uses and are considered for future evaluation of stressor source identification projects.

3.2 Study Area

In compliance with MRP 1.0, temperature was monitored at a minimum of four sites, general water quality was monitored at two sites, and five sites were sampled for pathogen indicators[20]. The targeted monitoring design focuses on sites selected based on the presence of significant fish and wildlife resources as well as historical and/or recent indications of water quality concerns.

3.2.1 Temperature

Continuous (hourly) temperature measurements were recorded at five sites in San Mateo County from April through September 2015[21]. All sites were located in the San Francisquito Creek watershed which hosts one of the last remaining wild steelhead (*Oncorhynchus mykiss*) populations among Bay Area streams. All sites were previously monitored in WY2014 and were located in pools that have historically remained wet throughout the summer. One site was located in Alambique Creek, three sites in Bear Creek, and one site in West Union Creek (tributary to Bear Creek). Located in the northwestern headwaters, Bear Creek drains approximately 25 percent (12 square miles) of the San Francisquito Creek Watershed.

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[19] Directed Monitoring Design Principle: A deterministic approach in which points are selected deliberately based on knowledge of their attributes of interest as related to the environmental site being monitored. This principle is also known as "judgmental," "authoritative," "targeted," or "knowledge-based."

[20] MRP 2.0 requires a similar targeted sampling design.

[21] SMCWPPP typically monitors water temperature at more stations than the MRP requires to mitigate for potential equipment loss.

Alambique Creek is a tributary to Searsville Reservoir which is owned and operated by Stanford University. Summer water temperatures are an important factor in assessing the quality of habitat and have generally been good in the Bear Creek watershed (Smith and Harden 2001). However, due to persistent drought conditions, WY2015 may represent a worst case scenario for summer temperatures. Station locations are mapped in Figure 3.1.

3.2.2 General Water Quality

Continuous (15-minute) general water quality measurements (temperature, dissolved oxygen, pH, specific conductance) were recorded at two stations in San Mateo Creek during two two-week sampling events in WY2015 (Figure 3.2). Both stations were located within 0.15 miles upstream of the El Camino Real culvert which functions as a grade control structure within the creek, decreasing upstream channel slope and velocity, and causing fine sediments to accumulate. Although these characteristics have caused low concentrations of dissolved oxygen in prior years, increased dry season flows out of Crystal Springs Reservoir appear to have eliminated the potential water quality stressors (see Appendix B of the WY2015 UCMR). One of the stations (204SMA059) was similarly monitored in WY2014 along with another station approximately one mile upstream. The WY2015 sampling stations are located downstream of the juvenile steelhead rearing and spawning habitat that occurs within a two-mile reach of San Mateo Creek below the Crystal Springs Reservoir (Brinkerhoff, SFPUC, personal communication 2013). Sample Events 1 and 2 were conducted in May and August/September, 2015, respectively.

3.2.3 Pathogen Indicators

Pathogen indicator densities were measured during one sampling event in WY2015 at the same stations along San Mateo Creek and at the mouth of Polhemus Creek that were sampled in WY2014 (Figure 3.2). Both creeks are designated for contact (REC-1) and non-contact (REC-2) water recreation Beneficial Uses, although none of the stations could be considered “bathing beaches.” Only one station (204SMA060 – De Anza Park) is sited at a creekside park. Other stations were selected to characterize geographic patterns of pathogen indicator densities within the watershed. Data collected from these sites was used to inform the SSID study investigating the extent and source of pathogen indicators in San Mateo Creek (see Appendix C of the UCMR).

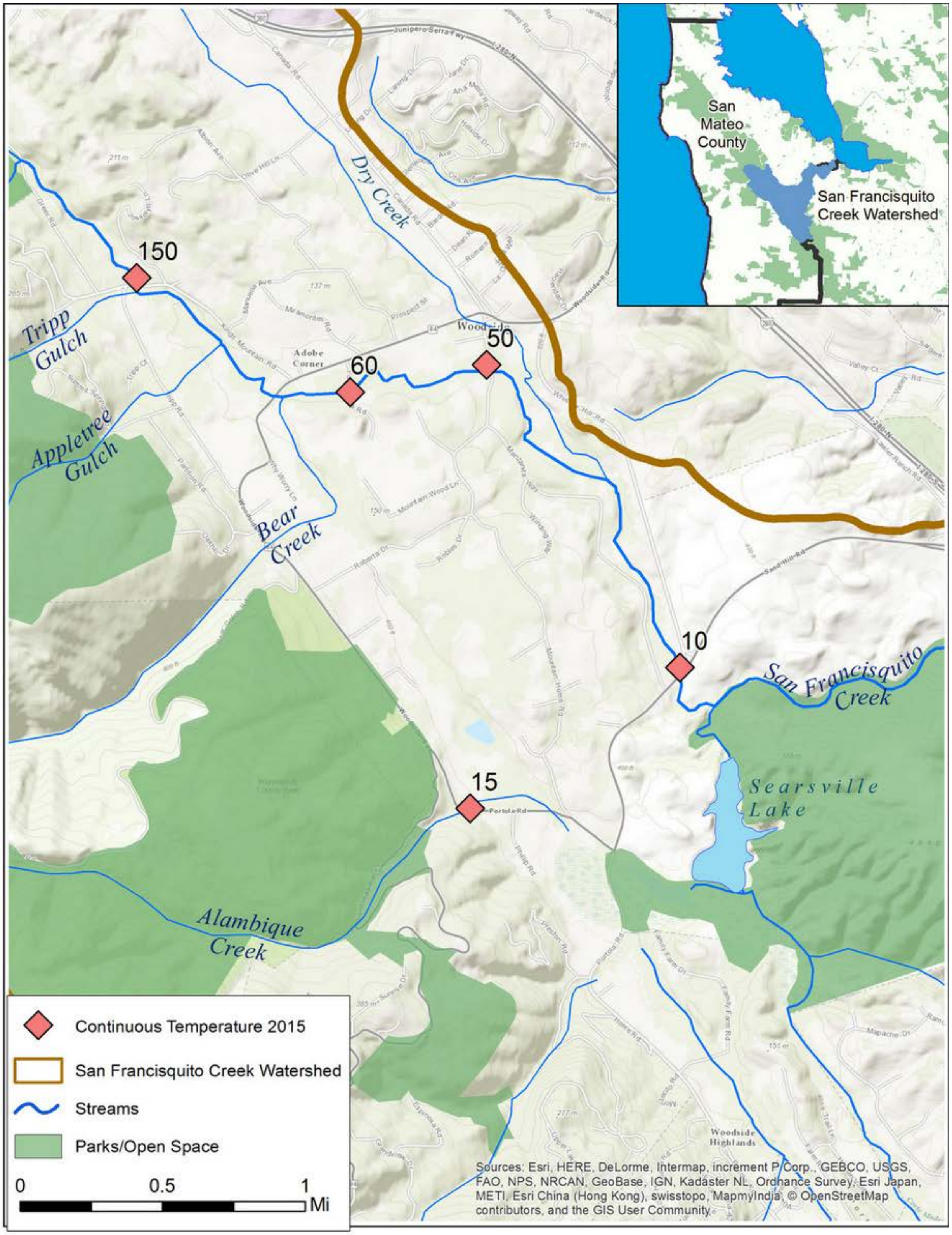

Figure 3.1. Continuous temperature stations in Alambique, Bear, and West Union Creeks, San Mateo County, WY2015.

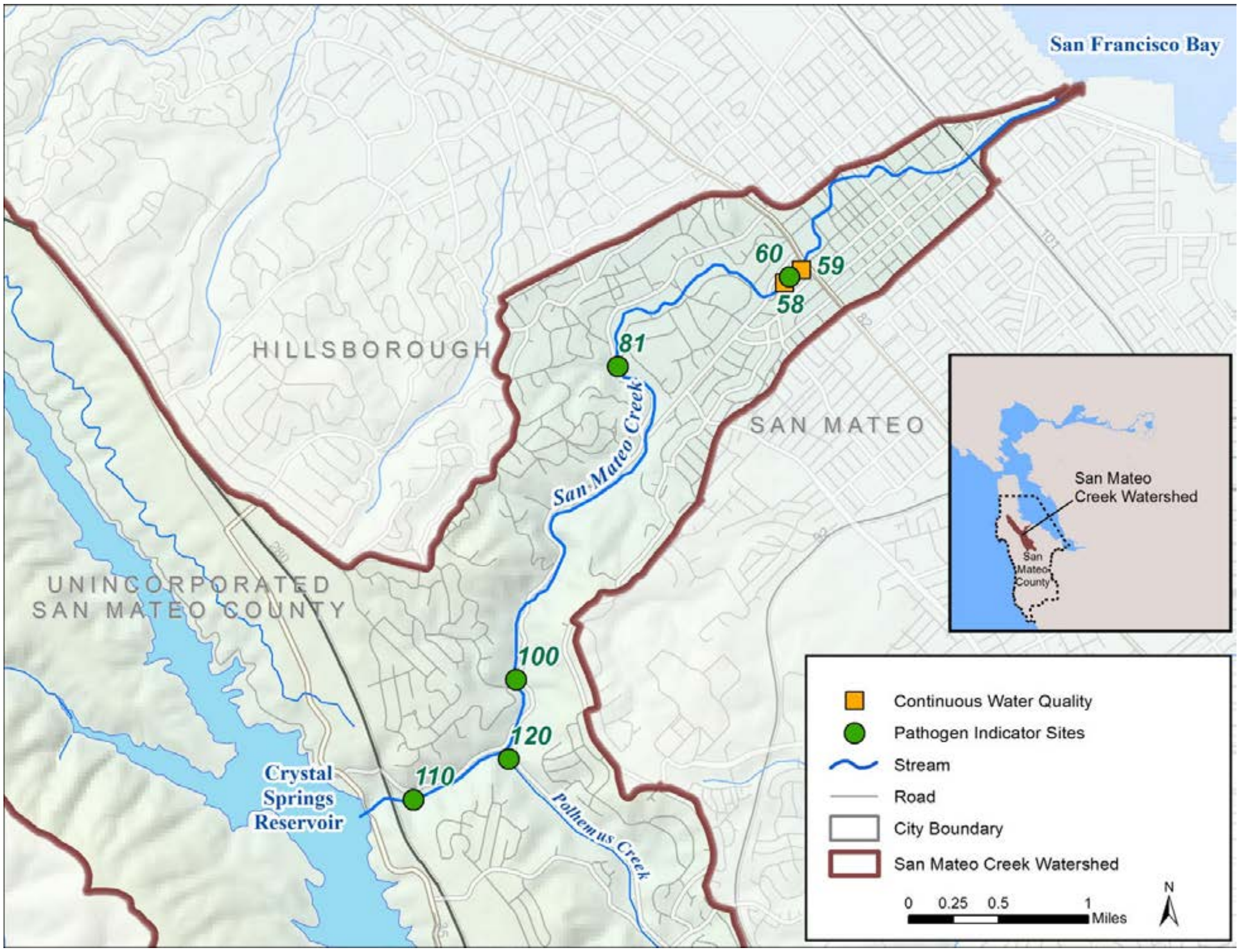

Figure 3.2. General water quality and pathogen indicator monitoring sites, San Mateo Creek, WY2015.

3.3 Methods

Water quality data were collected in accordance with SWAMP-comparable methods and procedures described in the BASMAA RMC SOPs (BASMAA 2014b) and associated QAPP (BASMAA 2014a). Data were evaluated with respect to the MRP 2.0 provision C.8.d “Followup” triggers for each parameter and/or triggers from MRP 1.0 were monitoring parameters differ from MRP 2.0.

3.3.1 Continuous Temperature

Digital temperature loggers (Onset HOBO Water Temp Pro V2) programmed to record data at 60-minute intervals were deployed at targeted sites from April through September 2015. Procedures used for calibrating, deploying, programming and downloading data are described in RMC SOP FS-5 (BASMAA 2014b).

3.3.2 Continuous General Water Quality

Water quality monitoring equipment recording dissolved oxygen, temperature, conductivity, and pH at 15-minute intervals (YSI 6600 data sondes) was deployed at targeted sites for two 2-week periods: once during spring season (Event 1) and once during summer season (Event 2) in 2015. Procedures used for calibrating, deploying, programming and downloading data are described in RMC SOP FS-4 (BASMAA 2014b).

3.3.3 Pathogen Indicators

Water samples were collected during the dry season. Sampling techniques for pathogen indicators (fecal coliform and *E. coli*) include direct filling of containers at targeted sites and immediate transfer of samples to analytical laboratories within specified holding time requirements. Procedures used for sampling and transporting samples are described in RMC SOP FS-2 (BASMAA 2014b). MRP 2.0 replaces fecal coliform with Enteroccoci.

3.3.4 Data Evaluation

Trigger Comparison

Continuous temperature, water quality, and pathogen indicator data generated during WY2015 were analyzed and evaluated to identify potential stressors that may be contributing to degraded or impacted biological conditions, including exceedances of water quality objectives (WQOs). Provision C.8.d of MRP 2.0, identifies trigger criteria as the principal means of evaluating the creek status monitoring data to identify sites where water quality impacts may have occurred. Sites with targeted monitoring results exceeding the trigger criteria are identified as candidate SSID projects. The relevant trigger criteria for continuous temperature, continuous water quality, and pathogen indicator data are listed in Table 3.1.

Table 3.1. Water Quality Objectives and thresholds used for trigger evaluation.

Monitoring Parameter	Objective/Trigger Threshold	Units	Source
Temperature	Two or more weekly average temperatures exceed the MWAT of 17.0°C for a Steelhead stream, or when 20% of the results at one sampling station exceed the instantaneous maximum of 24°C.	°C	MRP Provision C.8.d.iii.
General Water Quality Parameters	20% of results at each monitoring site exceed one or more established standard or threshold - applies individually to each parameter		
Conductivity	2000	uS	MRP Provision C.8.d.iii.
Dissolved Oxygen	WARM < 5.0, COLD < 7.0	mg/L	SF Bay Basin Plan Ch. 3, p. 3-4
pH	> 6.5, < 8.5 [1]	pH	SF Bay Basin Plan Ch. 3, p. 3-4
Temperature	Same as Temperature (See Above)		
Pathogen Indicators			
Fecal coliform	≥ 400	MPN/ 100ml	SF Bay Basin Plan Ch. 3
E. coli	≥ 410	MPN/ 100ml	EPA's statistical threshold value for estimated illness rate of 36 per 1000 primary contact recreators

[1] Special consideration will be used at sites where imported water is naturally causing higher pH in receiving waters.

Temperature Trigger Considerations

Sullivan et al. (2000) is referenced in MRP 2.0 provision C.8.iii.(4) as the published source for the given trigger threshold(s) to use for evaluating water temperature data, specifically for creeks that have salmonid fish communities. The report summarizes results from previous field and laboratory studies investigating the effects of water temperature on salmonids of the Pacific Northwest and lists acute and chronic thresholds that can potentially be used to define temperature criteria. The authors identified annual maximum temperature (acute) and maximum 7-day weekly average temperature (MWAT) chronic indices as biologically meaningful thresholds. They found the MWAT index to be most correlated with growth loss estimates for juvenile salmonids, which can be used as a threshold for evaluating the chronic effects of temperature on summer rearing life stage.

Previous studies conducted by EPA (1977) identified a MWAT of 19°C for steelhead and 18°C for coho salmon. Using risk assessment methods, Sullivan et al (2000) identified lower thresholds of 17°C and 14.8°C for steelhead and coho respectively. The risk assessment method applied growth curves for salmonids over a temperature gradient and calculated the percentage in growth reduction compared to the growth achieved at the optimum temperature. The risk assessment analysis estimated that temperatures exceeding a threshold of 17°C would potentially cause 10% reduction in average salmonid growth compared to optimal conditions. In contrast, exceedances of the 19°C threshold derived by EPA (1977) would result in a 20% reduction in average fish growth compared to optimal conditions.

The lower MWAT thresholds presented in Sullivan et al. (2000) are based on data collected from creeks in the Pacific Northwest region, which exhibits different patterns of temperature associated with climate, geography and watershed characteristics compared to creeks supporting steelhead and salmon in Central California. Furthermore, a single temperature threshold may not apply to all creeks in the San Francisco Bay Area due to high variability in climate and watershed characteristics within the region.

In October 2015, the National Marine Fisheries Service (NMFS) released a public draft of their Coastal Multispecies Recovery Plan for coastal chinook, Northern California steelhead and Central California Coast steelhead. The Recovery Plan addresses the Central California Coast Steelhead Distinct Population Unit, which includes steelhead populations in the Santa Clara Valley watersheds. The plan includes an assessment of physical habitat and water quality as well as natural and anthropogenic threats to their habitat and survival. The NMFS developed a Conservation Action Planning (CAP) Analysis for the major watersheds supporting salmonid populations (e.g., Coyote Creek). Water temperature was one of the factors used to evaluate existing conditions for steelhead. The CAP utilized a threshold of 20°C for maximum weekly maximum temperature (MWMT), or 7-day maximum, to protect summer juvenile steelhead populations.

Previous studies evaluating the differences between MWMT and MWAT, have shown that MWMT better reflects transient water temperature peaks (Welsh et al. 2001) and any acute effects of the single point maximum temperature. The MWMT is suggested to be a more biologically meaningful parameter that can better predict the ability of a given waterbody to support cold-water adapted species. It is important to note however, that stream temperature affects rearing salmonids in interaction with many other factors, all of which vary with species and location. In cases where low flow conditions in concert with high temperatures during summer season are impacting steelhead populations, management actions that improve food availability (e.g., increase summer flow) may better address factors that are more critically limiting steelhead production. For monitoring, fish size thresholds at critical life stages such as smolting may be a much better indicator for understanding viability of steelhead populations (Atkinson et al. 2011).

In compliance with MRP 2.0 provision C.8.d, sites with temperature data exceeding the 17°C MWAT trigger threshold are added to the list of candidate SSID project. However, temperature thresholds, such as the MWMT used by NMFS to assess condition of cold water fish community in San Francisco Bay watersheds, should be considered as an alternative threshold to evaluate continuous temperature data.

3.4 Results and Discussion

3.4.1 Continuous Temperature

Temperature loggers were deployed on March 31, 2015, checked on June 30, 2015, and removed on September 22, 2015. The Alambique Creek station was completely dry during the June field check, and the logger was removed. A review of data from this logger suggested that Alambique Creek dried up approximately one week before the field check (June 24, 2015). The other four sites remained wet during the entire sampling period and loggers were removed September 22, 2015; however, it is possible that the pools were no longer supported by surface flows by the end of the sampling period.

Summary statistics for the water temperature data collected at the five sites are shown in Table 3.2. Temperatures recorded at the four sites in Bear and West Union Creeks were relatively consistent between sites with medians ranging from 15.2 °C to 16.1 °C. Temperatures at the Alambique Creek site were slightly cooler (median temperature was 12.5 °C) during its shorter deployment/wet period. Box plots showing the distribution of water temperature data at the five sites in are shown in Figure 3.3. The instantaneous maximum temperature threshold (24.0 °C) and WY2014 results are shown for reference. WY2015 results were similar to WY2014 but had a wider range on both ends of temperature spectrum for all stations. Temperatures remained below the instantaneous maximum threshold at all but one site in WY2015 (Bear Creek at Sand Hill Rd; station 205BRC010).

Table 3.2 Descriptive statistics for continuous water temperature measured at five sites in San Mateo County from March 31 through September 22, 2015. Recording of data at Alambique Creek ended on June 24th, 2015 due to dry conditions.

Creek Name		Alambique Creek	Bear Creek			West Union Creek
Location		Portola Rd	Sand Hill Rd	Mountain Home Rd	Fox Hollow Rd	Kings Mountain Rd
Site ID		205ALA015	205BRC010	205BRC050	205BRC060	205WUN150
Start Date		3/31/2015	3/31/2015	3/31/2015	3/31/2015	3/31/2015
End Date		6/24/2015	9/22/2015	9/22/2015	9/22/2015	9/22/2015
Temperature (°C)	Minimum	8.6	8.9	9.0	9.4	9.7
	Median	12.1	16.1	15.8	16.1	15.2
	Mean	12.5	16.0	15.5	15.3	14.7
	Maximum	17.9	27.1	20.6	19.2	19.5
	7-day Mean	12.5	16.0	15.5	15.4	14.8
	N	2040	4196	4196	4196	4195

The instantaneous maximum temperature threshold exceedances at Bear Creek at Sand Hill Rd (station 205BRC010) are the result of approximately one month of data (August – September) during which daily spikes in temperature were recorded (Figure 3.4). The daily spikes began at 8:00 AM with a quick temperature increase of 5 to 10 ºC that disappeared from the records by 10:00 AM. The temperature then decreased steadily over the remainder of the day. In very dry years such as WY2015 when flows are extremely low it is difficult to determine the cause of the temperature spikes. Possible explanations include: sunshine hitting the instrument, warm overland flows from nearby properties, or temporary diversions from the creek causing water levels to drop below the instrument. As a result of these unexplained spikes, this station will be considered for an SSID study.

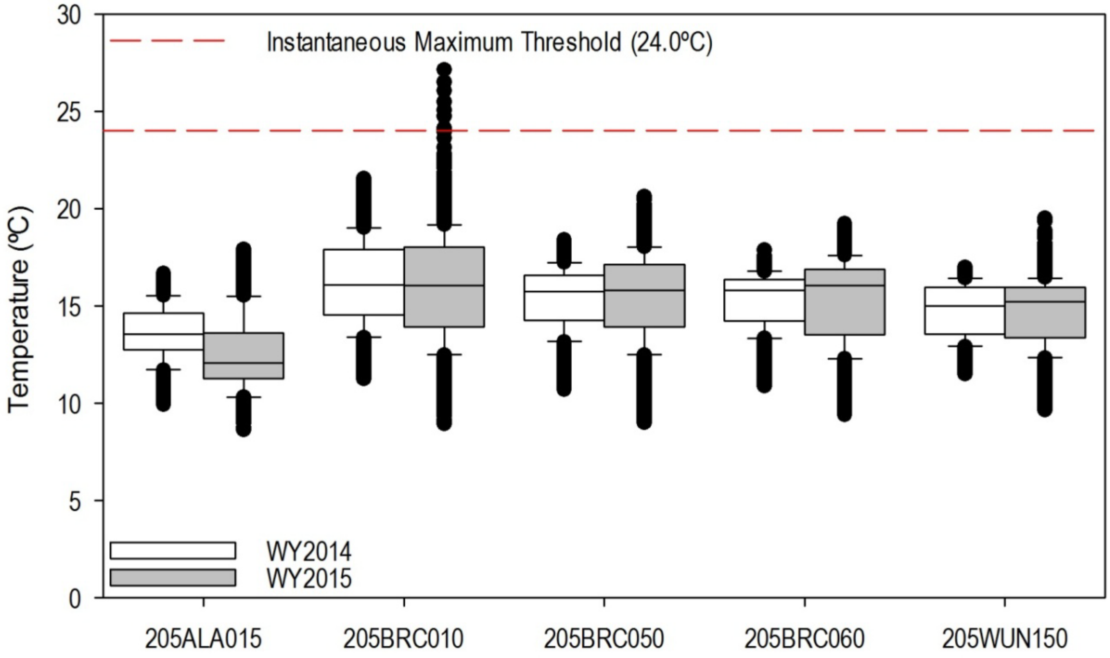

Figure 3.3. Box plots of water temperature data collected at five sites in the San Francisquito Creek watershed from April through September, WY2014 and WY2015.

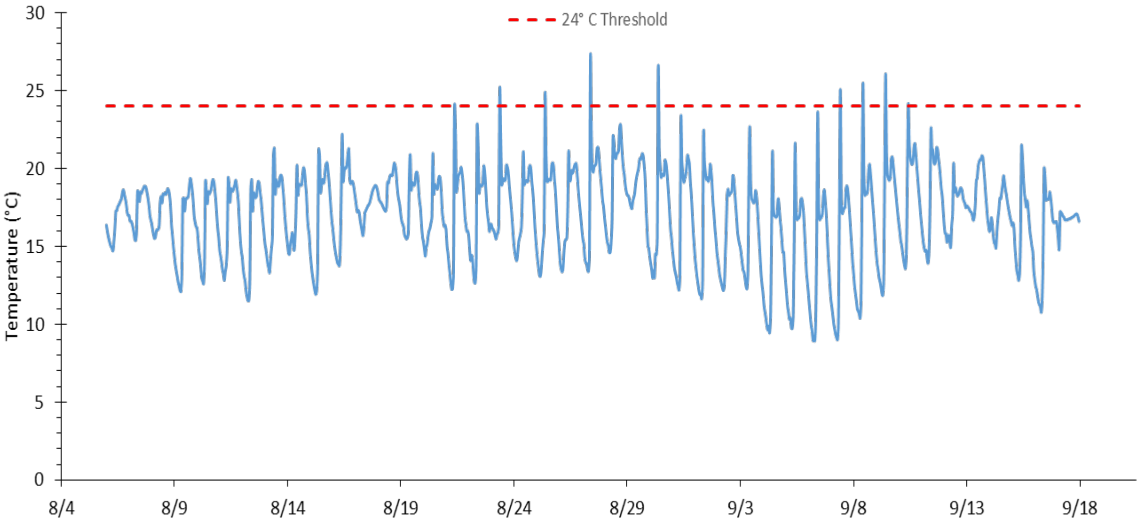

Figure 3.4 Hourly temperature recorded at site 205BRC010 (Bear Creek at Sand Hill Road) from August 7 to September 18, 2015. The cause of the daily temperature spikes is unknown.

Box plots showing the distribution of water temperature data, calculated as the weekly (7-day) mean, for the five sites are shown in Figure 3.5. The MWAT temperature threshold of 17.0 °C is shown for reference along with results from WY2014. Several weekly average temperatures calculated for the Bear Creek stations exceeded the MWAT temperature trigger in both WY2014 and WY2015.

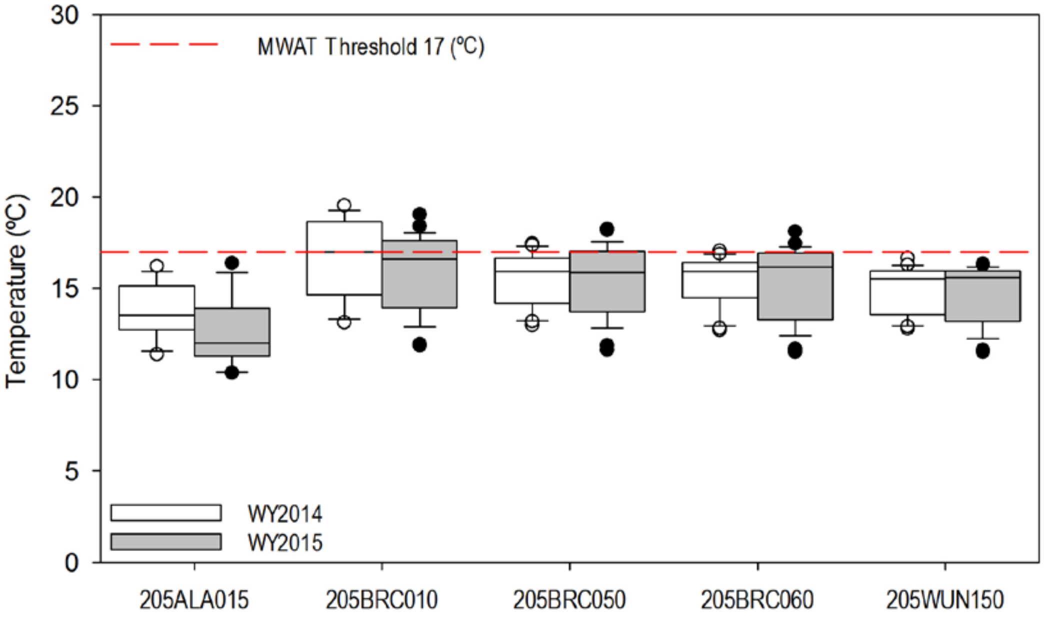

Figure 3.5. Box plots of water temperature data calculated as a weekly (7-day) average, recorded at five sites in the San Francisquito Creek watershed, from April through September WY2014 and WY2015.

Trigger analysis of temperature data using the MWAT threshold is presented in Table 3.3. The temperature trigger is defined as when two or more weekly average temperatures at a single site exceed the MWAT threshold of 17.0 ºC, or when 20% of the results at one sampling station exceed the instantaneous maximum of 24 ºC. Triggers were exceeded at all Bear Creek sites, with 6 to 10 weeks exceeding the MWAT of 17ºC. The MWAT trigger was not exceeded at the Alambique Creek or West Union Creek sites. None of the sites exceeded the trigger for instantaneous maximum of 24 ºC.

Table 3.3. Trigger analysis of WY2015 temperature data, San Francisquito Creek watershed. Trigger exceedances are shown in **bold.**

Site ID	Creek	Site Name	Number of Weeks MWAT > 17ºC	Trigger Exceeded	% of Results Inst. Max > 24ºC	Trigger Exceeded
205ALA015	Alambique Creek	Portola Rd	0	No	0	No
205BCR010	Bear Creek	Sand Hill	7	**Yes**	< 1	No
205BCR050		Mountain Home Rd	10	**Yes**	0	No
205BCR060		Fox Hollow Rd	6	**Yes**	0	No
205WUN150	West Union Creek	Kings Mountain Rd	0	No	0	No

The Basin Plan (SFRWQCB 2013) designates several Beneficial Uses for Bear Creek that are associated with aquatic life uses, including COLD, WARM, MIGR, SPWN and RARE (Table 1.4). Rearing and spawning habitat for steelhead trout is supported throughout the Bear Creek mainstem and its major tributary, West Union Creek (Leidy et al. 2005). Recent work to improve fish passage at water diversion facilities has also provided steelhead access to portions of Bear Gulch. Fish barriers effectively block passage for steelhead in Alambique Creek; however, resident rainbow trout are supported in the lower reaches of the creek (Leidy et al. 2005).

Although the MRP 2.0 MWAT trigger of 17.0 ºC was exceeded at the Bear Creek stations, it is unlikely that temperature is a limiting factor for steelhead or rainbow trout (*Oncorhynchus mykiss)* in the Bear Creek branch of the San Francisquito Creek watershed. The MWAT trigger was developed for salmonid streams in the Pacific Northwest where the climate is cooler than the Bay Area. Salmonid species in the Bay Area have adapted to warmer temperatures and as appropriate, regulatory/resource agencies (e.g., NMFS) have set temperature targets for certain cold water streams based on the life history needs of specific species. Furthermore, a majority of the monitoring sites were located in pools within channels that had intermittent flow late in the dry season. Trout populations in WY2015 stations would likely be limited by minimal food resources due to lack of flowing water and riffle habitat upstream of the pools rather than temperature.

3.4.2 General Water Quality

Summary statistics for general water quality measurements collected at two stations in San Mateo Creek during two sampling event periods in WY2015 are listed in Table 3.4, time series plots of the data are shown in Figures 3.6 and 3.7. Where appropriate, data from WY2014 are listed or shown for reference. Sampling Event 1 was conducted May 1 – 16, 2015 and Event 2 was conducted August 19 – September 3, 2015. Station locations are mapped in Figure 3.2.

Table 3.4. Descriptive statistics for continuous water temperature, dissolved oxygen, pH, and specific conductance measured at sites in San Mateo Creek during WY2014 and WY2015. Data were collected every 15 minutes over a two two-week time periods during May (Event 1) and August (Event 2).

		204SMA080		204SMA059				204SMA058	
		Sierra Dr		De Anza Park				El Camino	
Parameter	Data Type	May WY14	Aug WY14	May WY14	Aug WY14	May WY15	Aug WY15	May WY15	Aug WY15
Temp (° C)	Min	12.0	15.7	12.7	16.5	12.2	16.4	12.3	16.6
	Median	14.8	17.4	15.4	17.8	13.7	18.0	13.8	18.2
	Mean	14.9	17.4	15.5	17.9	13.8	18.0	13.9	18.1
	Max	17.6	17.4	18.7	19.8	16.4	19.8	16.5	19.9
	7-day Mean	15.2	17.7	15.8	18.0	13.7	17.9	13.9	18.9
Dissolved Oxygen (mg/l)	Min	8.5	8.0	8.3	5.7	9.4	8.5	9.4	8.0
	Median	9.3	8.6	9.2	7.9	10.2	9.1	10.1	8.6
	Mean	9.4	8.7	9.4	8.0	10.2	9.3	10.1	8.7
	Max	10.5	10.1	11.0	8.9	10.9	10.4	10.8	9.6
	Min 7-day Avg.	8.6	8.1	8.6	7.0	10.2	9.3	10.1	5.1
pH	Min	7.4	7.5	7.6	7.5	7.7	7.5	7.8	7.5
	Median	7.8	7.6	8.0	7.7	7.9	7.7	8.0	7.6
	Mean	7.8	7.6	8.0	7.7	7.9	7.7	8.0	7.6
	Max	8.1	8.0	8.4	7.9	8.4	8.0	8.2	7.9
Specific Conductance (µS/cm)	Min	177	232	199	261	216	186	217	186
	Median	299	242	330	270	246	190	244	190
	Mean	300	243	329	271	245	190	242	190
	Max	366	310	407	290	257	208	256	208
Total number data points (n)		1725	1738	1729	1735	1425	1443	1425	1443

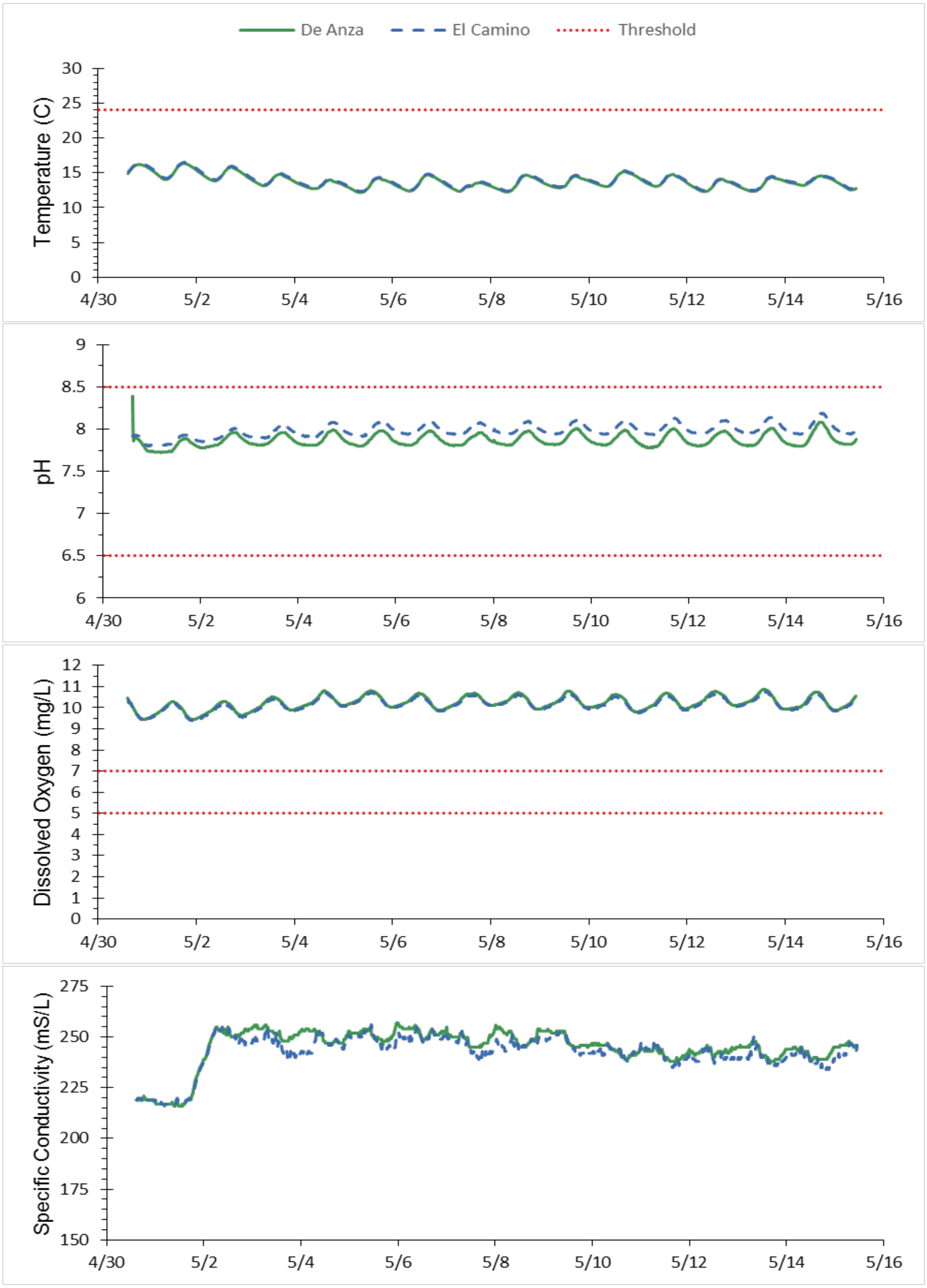

Figure 3.6 Continuous water quality data (temperature, pH, dissolved oxygen, and specific conductance) collected at two sites in San Mateo Creek during May 1 - 16, 2015 (Event 1).

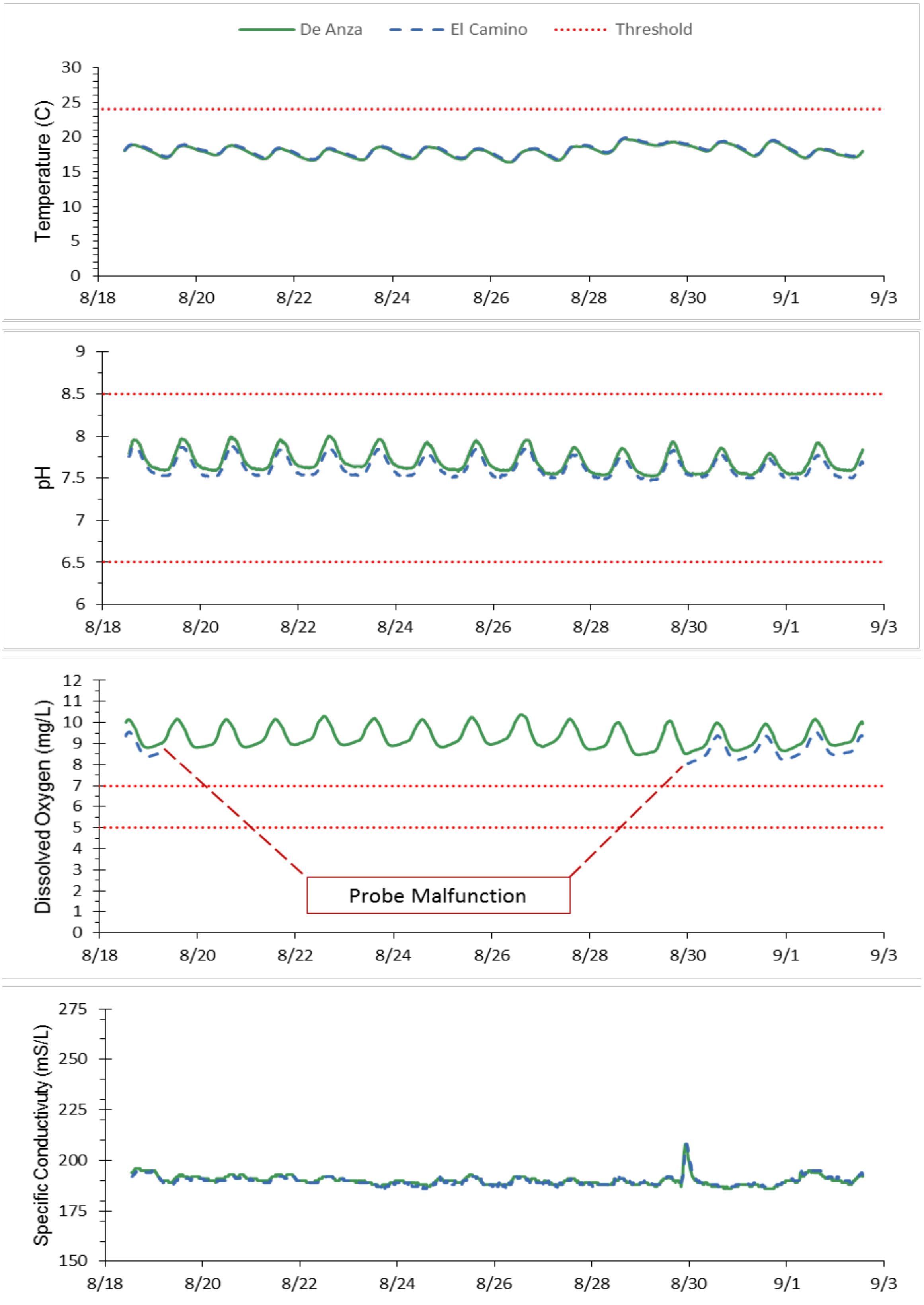

Figure 3.7 Continuous water quality data (temperature, pH, dissolved oxygen, and specific conductance) collected at two sites in San Mateo Creek during August 19 - September 3, 2015 (Event 2).

Temperature

Box plots showing the distribution of water temperature data collected at the two sites in San Mateo Creek in WY2015 are shown in Figure 3.8 with the instantaneous maximum temperature threshold of 24 °C for reference. The calculated weekly average temperature and MWAT threshold (17.0 °C) are shown in Figure 3.9. Trigger analysis of temperature data using the instantaneous maximum and MWAT thresholds is summarized in Table 3.5. The instantaneous maximum threshold of 24 °C was not exceeded at either station. The MWAT threshold was exceeded for two weeks of monitoring at both sites during the second sampling event.

The Basin Plan (SFRWQCB 2013) designates several Beneficial Uses for San Mateo Creek that are associated with aquatic life uses, including COLD, WARM, MIGR, SPWN and RARE (Table 1.4). If the MWAT threshold of 17.0 °C is appropriate for San Mateo Creek, the data collected by SMCWPPP in WY2015 indicate that water temperature could adversely affect aquatic life uses in the urban reach of San Mateo Creek between El Camino Real and De Anza Park. However, if Bay Area salmonids are adapted to warmer temperatures, temperature may not be a limiting factor.

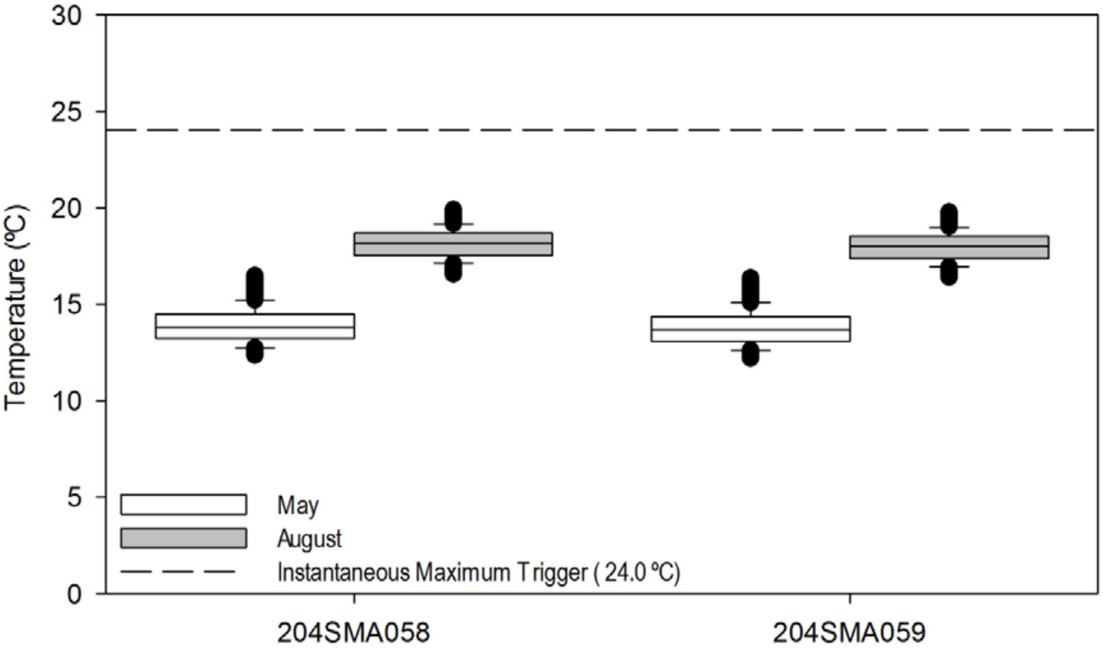

Figure 3.8. Box plots of water temperature data, measured during two sampling events in WY2015 at two sites in San Mateo Creek compared to the instantaneous maximum temperature trigger.

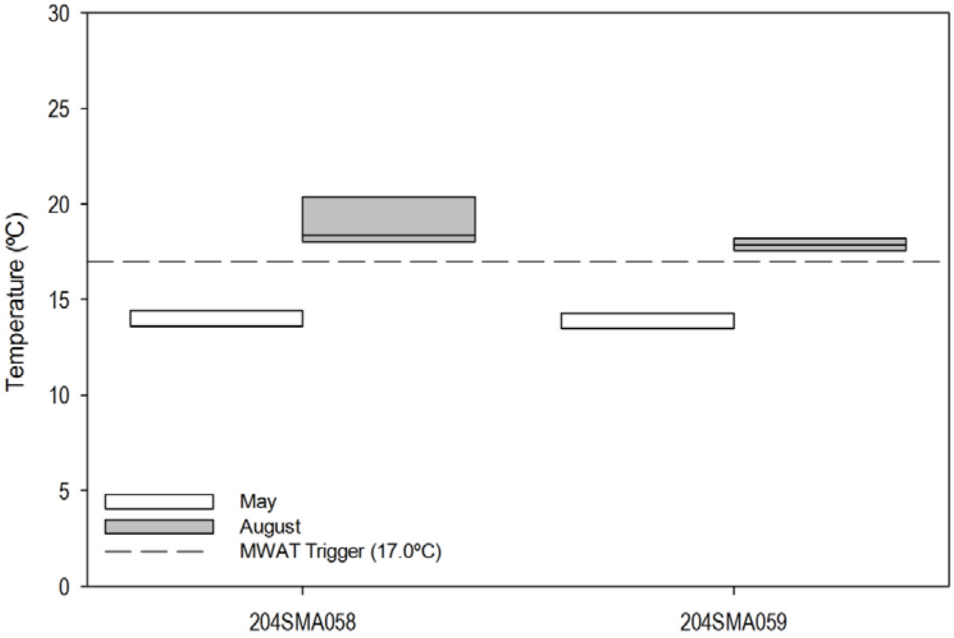

Figure 3.9. Box plots of water temperature data, calculated as a 7-day non-rolling average, collected during two sampling events in WY2015 at two sites in San Mateo Creek compared to the MWAT threshold.

Table 3.5. Trigger analysis of WY2015 temperature data, San Mateo Creek stations. Trigger exceedances are shown in **bold**.

Site ID	Creek Name	Site	Monitoring Event	Number of Weeks MWAT > 17ºC	Trigger Exceeded	% of Results Inst. Max > 24ºC	Trigger Exceeded
204SMA059	San Mateo	DeAnza Park	May	0	0	0	No
			August	2	Yes	0	No
204SMA058		El Camino	May	0	0	0	No
			August	2	Yes	0	No

Dissolved Oxygen

The distribution of dissolved oxygen (DO) levels measured in San Mateo Creek during the two sampling events is presented in Figure 3.10. The Basin Plan minimum WQOs for WARM (5.0 mg/L) and COLD (7.0 mg/L) Beneficial Uses are indicated in the figure. The dissolved oxygen probe at 204SMA058 (El Camino) malfunctioned for 11 days during Event 2, resulting in no usable data being collected at that site during the time frame (Figure 3.7). However, because of the proximity of the two sites and the pattern of data recorded before and after the malfunction, it is assumed that DO concentrations were similar during the probe malfunction. Trigger analysis of DO data is shown in Table 3.6. All DO measurements were above the WARM and COLD minimum DO WQOs. An SSID study investigating low DO in San Mateo Creek was conducted in WY2014 and WY2015. The SSID Project Report, included as Appendix B to the WY2015 UCMR concluded that previously recorded low DO levels are no longer likely as a result of increased dry season releases from Crystal Springs Reservoir which is owned and operated by the San Francisco Public Utilities Commission (SFPUC).

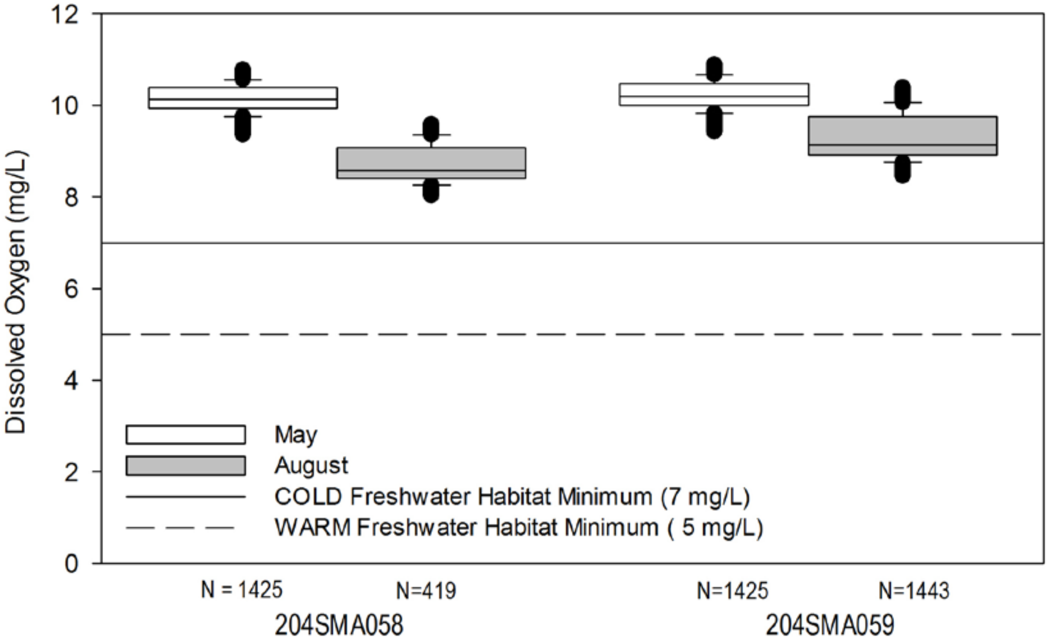

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Figure 3.10. Box plots of dissolved oxygen data collected using sondes during two sampling events at sites in San Mateo Creek compared to Basin Plan Water Quality Objectives.

Table 3.6. Percent of dissolved oxygen data measured during two events at two sites in San Mateo Creek that are below trigger values identified in Table xx.

Site ID	Creek Name	Site	Monitoring Event	*Percent Results DO < 5.0 mg/L*	*Percent Results DO < 7.0 mg/L*	*Trigger > 20% Results*
204SMA059	San Mateo	DeAnza Park	May	0%	0%	No
			August	0%	0%	No
204SMA058		El Camino	May	0%	0%	No
			August	0%	0%	No

pH

Figure 3.11 compares pH levels measured during the two sampling events in WY2015 at the San Mateo Creek sites to the Basin Plan WQOs for pH (< 6.5 and/or > 8.5). The pH measurements remained within the WQOs at both sampling locations, thus no triggers occurred.

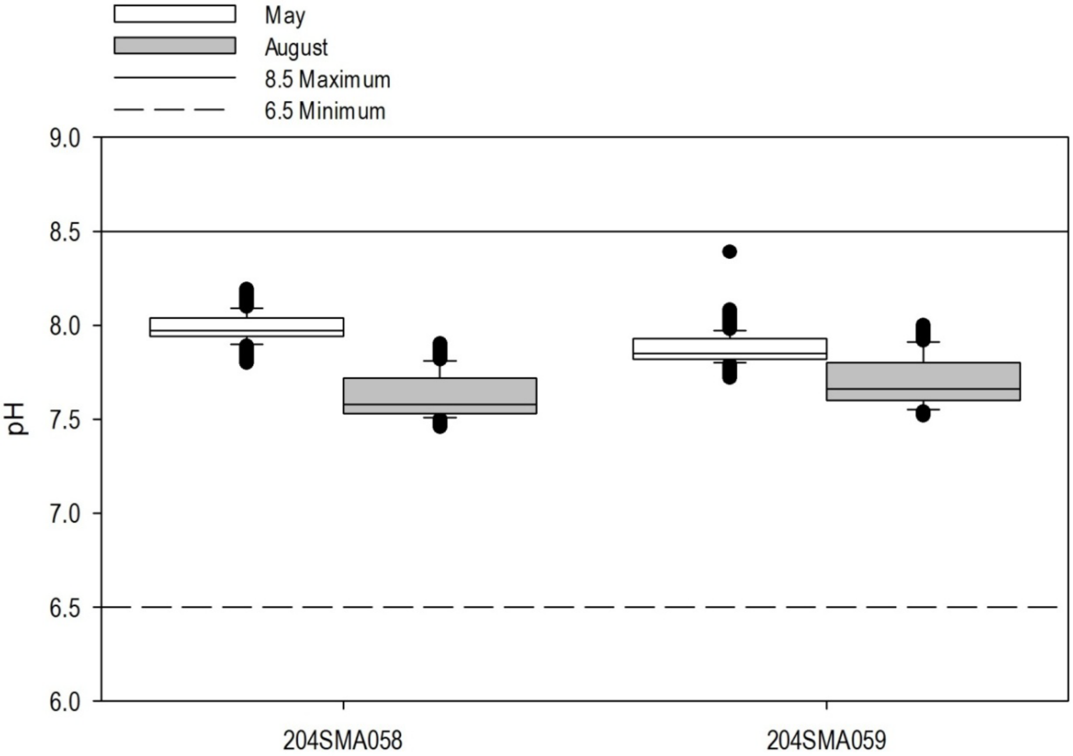

Figure 3.11. Box plots of pH data measured during two sampling events at sites in San Mateo Creek compared to Basin Plan WQOs.

Specific Conductivity

Box plots showing the distribution of specific conductance measurements recorded during WY2015 at the San Mateo Creek sites are shown in Figure 3.12. The average concentrations and the range of concentrations recorded were lower at both sites during the August deployment, perhaps as a result of Crystal Springs reservoir releases which may comprise a greater proportion of total flow compared to local runoff, seepage, and groundwater contributions which presumably decrease in late summer. The MRP 2.0 identifies trigger for specific conductance as 2000 us/cm. There were no measurements above 2000 at either site during either deployment.

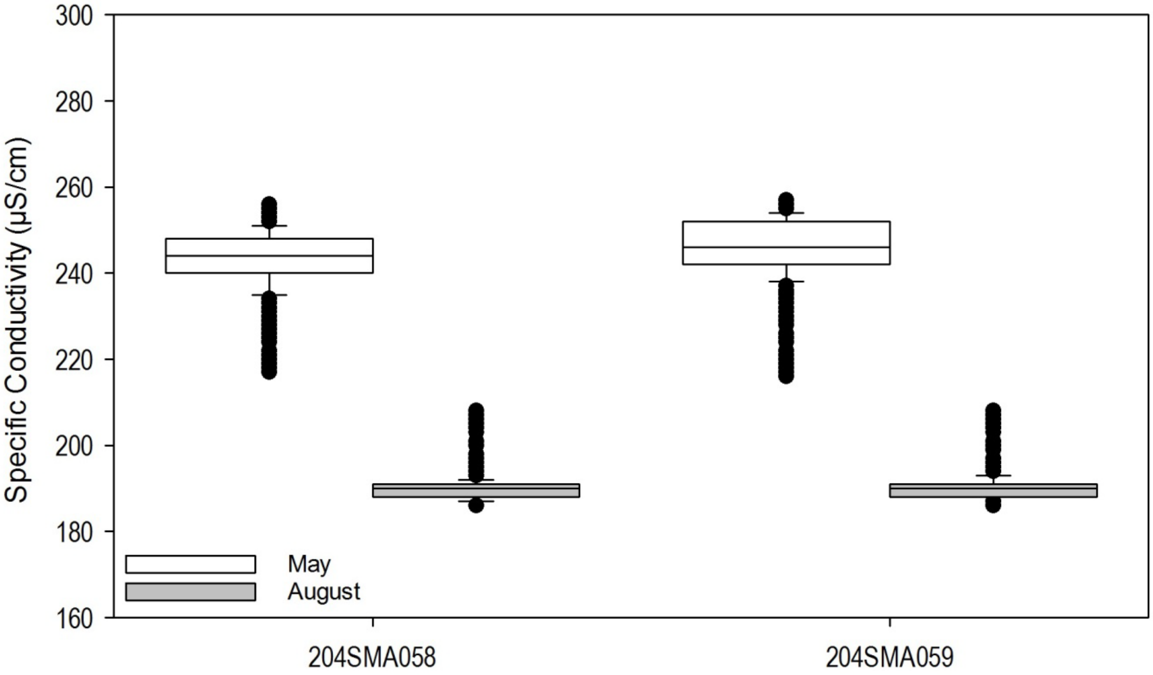

Figure 3.12. Box plots of specific conductance measurements recorded during two sampling events at sites in San Mateo Creek, WY2015.

3.4.3 Pathogen Indicators

Pathogen indicator densities measured in water samples in WY2015 are listed in Table 3.7. During this one grab sampling event, there was an increase in pathogen indicator densities in the downstream direction. The downstream-most station (204SMA060 – De Anza Park) exceeded the Basin Plan fecal coliform WQO and the 2012 EPA *E. coli* criterion for recreational waters. These data were used to support an SSID study investigating the extent and source(s) of pathogen indicators in San Mateo Creek. The SSID Project Report is included as Appendix C to the WY2015 UCMR.

The SSID study concluded that pathogen indicators (i.e., *E. coli*) were primarily present at densities exceeding REC-1 WQOs in lower reaches of San Mateo Creek along creekside parks. In these locations, *E. coli* densities exceeding REC-1 WQOs were observed during wet and dry weather sampling events. Application of microbial source tracking (MST) techniques (i.e., human and dog genetic markers in the Bacteroidales group) suggest year-round human sources impact lower San Mateo Creek while dog sources primarily impact the creek during wet-weather. However, uncontrollable sources including wildlife waste and bacterial growth in the environment also contribute to *E. coli* densities. All municipalities in the lower San Mateo Creek watershed are currently implementing or planning prescribed actions to eliminate conditions in the sanitary sewer collection system that cause or contribute to sanitary sewer overflows (SSOs). The SSID Project Report recommends that local municipalities continue implementing those measures and consider increasing public education and outreach targeting pet waste in the San Mateo Creek watershed.

It is important to acknowledge that a) the REC-1 WQOs for pathogen indicators in the San Francisco Basin Plan do not distinguish among sources of bacteria; and b) pathogen indicators do not directly represent actual pathogen concentrations. Animal fecal waste is much less likely to contain pathogens of concern to human health than human sources. In most cases, it is the human sources that are associated with REC-1 health risks rather than wildlife or domestic animal sources (USEPA 2012).

Table 3.7. Fecal coliform and *E. coli* levels measured in San Mateo County during WY2015.

Site ID	Creek Name	Site Name	*Fecal Coliform (MPN/100ml)*	*E. Coli (MPN/100ml)*	Sample Date
		Trigger Threshold	*400*	*410*	
204SMA060	San Mateo Creek	DeAnza Park	500	500	6/30/15
204SMA080		Sierra Drive	500	500	6/30/15
204SMA100		Tartan Trail	50	50	6/30/15
204SMA119		USGS Gage	4	4	6/30/15
204SMA110	Polhemus Creek	At Mouth	13	13	6/30/15

3.5 Conclusions and Recommendations

Conclusions and recommendations for targeted monitoring in WY2015 are listed below.

Spatial and Temporal Variability of Water Quality Conditions

- There was minimal spatial variability in water temperature across the five sites in Bear Creek watershed.
- Dissolved oxygen concentrations were similar between the two San Mateo Creek sites, but were slightly lower during Event 2 compared to Event 1.

Potential Impacts to Aquatic Life

- Potential impacts to aquatic life were assessed through analysis of continuous temperature data collected at five targeted stations and continuous general water quality data (pH, dissolved oxygen, specific conductance, temperature) collected at two targeted stations. Stations were deliberatively selected using the Directed Monitoring Design Principle.

- The three temperature stations in Bear Creek exceeded the MRP 2.0 trigger threshold of having two or more weeks where the maximum weekly average temperature (MWAT) exceeded 17°C. Furthermore, both of the general water quality stations in San Mateo Creek exceeded the MWAT trigger during the second sampling event. None of the stations exceeded the maximum instantaneous trigger threshold of 24°C.
- All stations with MWAT trigger exceedances will be added to the list of candidate SSID projects; however, review of the monitoring data in the context of the ongoing drought and locally-derived temperature thresholds developed by NMFS suggests that temperature is not likely a limiting factor for salmonid habitat (i.e., summer rearing juveniles) in the study reaches.
- The WQO for DO in waters designated as having cold freshwater habitat (COLD) beneficial uses (i.e., 7.0 mg/L) was met in all measurements recorded at the water quality stations in San Mateo Creek. As described in the Low DO SSID Project Report, previous low DO concerns in the study reach appear to have been mitigated by increased dry season releases from Crystal Springs Reservoir (see Appendix B to the WY2015 UCMR).
- Values for pH measured at the San Mateo Creek sites in WY2015 were within WQOs (6.5 to 8.5).
- Specific conductivity concentrations recorded at the San Mateo Creek sites in WY2015 were below the trigger threshold of 2000 us/cm.

Potential Impacts to Water Contact Recreation

- In WY2015, pathogen indicator sites were located in the San Mateo Creek watershed where a bacteria SSID study is in progress. Pathogen indicator triggers were exceeded at two of the five sites. Microbial source tracking (MST) techniques conducted as part of the SSID study suggest year-round human bacterial sources and wet-weather dog sources.

- It is important to recognize that pathogen indicator thresholds are based on human recreation at beaches receiving bacteriological contamination from human wastewater, and may not be applicable to conditions found in urban creeks. As a result, the comparison of pathogen indicator results to body contact recreation water quality objectives may not be appropriate and should be interpreted cautiously.

4.0 Toxicity and Sediment Chemistry Monitoring

4.1 Introduction

Toxicity testing provides a tool for assessing toxic effects (acute and chronic) of all the chemicals in samples of receiving waters or sediments and allows the cumulative effect of the pollutants present in the sample to be evaluated. Because different test organisms are sensitive to different classes of chemicals and pollutants, several different organisms are monitored. Sediment chemistry monitoring for a variety of potential pollutants conducted synoptically with toxicity monitoring provides preliminary insight into the possible causes of toxicity should they be found.

MRP 1.0 provision C.8.c (Table 8.1) requires that SMCWPPP collect and analyze water toxicity samples from two sites at a frequency of twice per year. Sediment samples must be collected from the same three sites during the dry season and analyzed for toxicity and a large suite of potential pollutants.

4.2 Methods

4.2.1 Water Toxicity

In WY2015, in compliance with Table 8.1 of MRP 1.0, water toxicity samples were collected from two sites at a frequency of twice per year, during storm events and summer dry conditions. Sites were selected from urban probabilistic sites that would be safe to access during storm events and with a high likelihood of containing fine depositional sediments during dry season sampling. See Figure 1.1 for a map of toxicity and sediment chemistry monitoring stations. Samples were tested for toxic effects using four species: an algae (*Selenastrum capricornutum*), two aquatic invertebrates (*Ceriodaphnia dubia* and *Hyalella azteca*), and one fish species (*Pimephales promelas* or fathead minnow)[22]. Both acute and chronic endpoints (survival and reproduction/growth) were analyzed for *Ceriodaphnia dubia* and fathead minnow. *Selenastrum capricornutum* are tested only for the chronic (growth) endpoint and *Hyalella azteca* are tested only for the acute (survival) endpoint.

In the field, the required number of 4-L labeled amber glass bottles were filled and placed on ice to cool to < 6C. Bottle labels include station ID, sample code, matrix type analysis type, project ID, and date and time of collection. The laboratory was notified of the impending sampling delivery to meet 24-hour sample hold time. Procedures used for sampling and transporting samples are described in SOP FS-2 (BASMAA 2014b).

4.2.2 Sediment Toxicity and Chemistry

Sediment samples were collected during the dry season at the same subset of probabilistic sites and tested for sediment toxicity and an extensive list of sediment chemistry constituents. Sediment toxicity testing was performed with just one species, *Hyalella azteca*. Both acute and chronic endpoints (survival and growth) were analyzed. In WY2015 sediment chemistry analytes

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[22] MRP 2.0 adds the midge *Chironomus dilutus* which is highly sensitive to fipronil and neonicotinoid pesticides.

included metals, polycyclic aromatic hydrocarbons (PAHs), and organochlorine and pyrethroid pesticides[23].

Before conducting sampling, field personnel surveyed the proposed sampling area for appropriate fine-sediment depositional areas. Personnel carefully entered the stream to avoid disturbing sediment at collection sub-sites. Sediment samples were collected from the top 2 cm at each sub-site beginning at the downstream-most location and continuing upstream. Samples were placed in a compositing container, thoroughly homogenized, and then aliquoted into separate jars for chemical or toxicological analysis using standard clean sampling techniques (see SOP FS-6, BASMAA 2014b). Sample jars were submitted to respective laboratories per SOP FS-13 (BASMAA 2014b).

4.2.3 Data Evaluation

Water and Sediment Toxicity

Data evaluation involves first determining whether the samples are toxic to the test organisms relative to the laboratory control treatment via statistical comparison at $p < 0.5$. For samples with toxicity, the sample endpoints (survival, reproduction, growth) are then compared to the laboratory control endpoints to determine whether the trigger criteria from MRP 1.0 Table 8.1 and Table H-1 have been exceeded[24].

The laboratory determines whether a sample is toxic by statistical comparison of the results from multiple test replicates of the selected aquatic species in the environmental sample to multiple test replicates of those species in laboratory control water. The threshold for determining statistical significance between environmental samples and control samples is fairly small, with statistically significant toxicity often occurring for environmental test results that are as high as 90% of the Control. Therefore, there is a wide range of possible toxic effects that can be observed – from 0% to approximately 90% of the Control values.

For water sample toxicity tests, MRP 1.0 Table 8.1 identifies toxicity results of less than 50% of the Control as requiring follow-up action. For sediment sample tests, MRP 1.0 Table H-1 identifies toxicity results more than 20% less than the control as requiring follow-up action.[25] Therefore, samples that are identified by the lab as toxic (based on statistical comparison of samples vs. Control at $p = 0.05$) are evaluated to determine whether the result was less than 50% of the associated Control (for water samples) or statistically different and more than 20% less the Control (for sediment samples).

Sediment Chemistry

In compliance with MRP 2.0, sites are identified as candidate SSID projects if sediment chemistry results exceed probable effects concentrations (PECs) or the more conservative threshold effects concentrations (TECs).

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[23] MRP 2.0 adds the pesticides carbaryl and fipronil to the list of required analytes.

[24] MRP 2.0 requires that toxicity is evaluated using the Test of Significant Toxicity (TST) statistical approach. The TST approach was not conducted in WY2015; therefore data is evaluated using MRP 1.0 trigger thresholds.

[25] Footnote #162 to Table H-1 of MRP 1.0 reads, “Toxicity is exhibited when Hyallela (sic) survival statistically different than and < 20 percent of control”; this is assumed to be intended to read “…statistically different than and more than 20 percent less than control”.

For sediment chemistry trigger criteria, TECs and PECs are as defined in MacDonald et al., 2000. For all contaminants specified in MacDonald et al. (2000), the ratio of the measured concentration to the respective TEC value was computed as the TEC quotient. PEC quotients were also computed for all non-pyrethroid sediment chemistry constituents, using PEC values from MacDonald et al. (2000). All results where a PEC or TEC quotient was equal to or greater than 1.0 were identified and added to the list of candidate SSID projects. Concentrations equal to one-half of the respective laboratory method detection limits were substituted for non-detect data so that these statistics could be computed. Therefore, some of the calculated numbers for TEC and PEC quotients may be artificially elevated (and contribute to trigger exceedances) due to the method used to account for filling in non-detect data.

The TECs for bedded sediments are very conservative values that do not consider site specific background conditions, and are therefore not very useful in identifying real water quality concerns in receiving waters in the San Mateo County. Most sites in San Mateo County are likely to have at least one TEC quotient equal to or greater than 1.0. This is due to high levels of naturally-occurring chromium and nickel in geologic formations (i.e., serpentinite) and soils that contribute to TEC and PEC quotients. This is particularly true for sites located higher in the watersheds where contributing watersheds are underlain by a higher percent of natural sources. For this reason, SMCWPPP also analyzed the sediment chemistry data using the trigger criteria from MRP 1.0. Sites with three or more TEC quotients exceeding 1.0 and/or mean PEC quotients exceeding 0.5 were identified.

MRP 2.0 does not require consideration of pyrethroid sediment chemistry data for followup SSID projects, perhaps because they are ubiquitous in the urban environment. However, SMCWPPP followed MRP 1.0 data analysis procedures to compare pyrethroid contamination at the monitored sites. Pyrethroid toxicity unit (TU) equivalents were computed for individual pyrethroid results, based on available literature values for pyrethroids in sediment LC50 values.[26] Because organic carbon mitigates the toxicity of pyrethroid pesticides in sediments, the LC50 values were derived on the basis of TOC-normalized pyrethroid concentrations. Therefore, the pyrethroid concentrations as reported by the lab were divided by the measured total organic carbon (TOC) concentration at each site, and the TOC-normalized concentrations were then used to compute TU equivalents for each pyrethroid. For each site, the TU equivalents for the various individual pyrethroids were summed, and sites where the summed TU was equal to or greater than 1.0 were identified. Concentrations equal to one-half of the respective laboratory method detection limits were substituted for non-detect data so that these statistics could be computed, potentially resulting in artificially elevated results.

4.3 Results and Discussion

4.3.1 Toxicity

Significant Toxicity Analysis

Table 4.1 provides a summary of toxicity testing results for wet weather and dry season **water** samples. Relative to laboratory controls, both of the wet weather samples were found to be

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[26] The LC50 is the concentration of a given chemical that is lethal on average to 50% of test organisms.

chronically toxic to *Ceriodaphnia dubia* and acutely toxic to *Hyalella azteca*. Toxicity was not observed in the dry season water samples.

Table 4.2 provides a summary of toxicity testing results for **sediment** samples. Compared to the laboratory control, the sediment sample collected at site 204R02056 (Laurel Creek) was determined to be chronically toxic to *Hyalella azteca*.

Trigger Comparison

Table 4.3 details results for the water and sediment tests that were found to be toxic to *Ceriodaphnia dubia* and *Hyalella azteca* relative to the laboratory controls, along with comparisons to the relevant trigger criteria from MRP 1.0. Neither of the **water** samples with significant reductions in survival or reproduction met the MRP 1.0 trigger criteria of more than 50% less than the laboratory control. However, the **sediment** sample with chronic toxicity to *Hyalella azteca* was more than 20% less than the laboratory control and therefore exceeded the trigger.

Table 4.1. Summary of SMCWPPP water toxicity results, WY2015, wet weather and dry season.

SMCWPPP Water Samples			*Toxicity relative to the Lab Control treatment?*					
Sample Station	*Creek*	*Sample Date*	*Selenastrum capricornutum*	*Ceriodaphnia dubia*		*Hyalella azteca*	*Pimephales promelas*	
			Growth	*Survival*	*Reproduction*	*Survival*	*Survival*	*Growth*
Wet Weather								
204R01448	Atherton Creek	2/6/15	No	No	Yes	Yes	No	No
204R02056	Laurel Creek	2/6/15	No	No	Yes	Yes	No	No
Dry Season								
204R01448	Atherton Creek	7/7/15	No	No	No	No	No	No
204R02056	Laurel Creek	7/7/15	No	No	No	No	No	No

Table 4.2. Summary of SMCWPPP sediment toxicity results, WY2015, dry season.

Dry Season Sediment Samples			Toxicity relative to the Lab Control treatment?	
Sample Station	Creek	Collection Date	*Hyalella azteca*	
			Survival	Growth
204R01448	Atherton Creek	7/7/15	No	No
204R02056	Laurel Creek	7/7/15	No	Yes

Table 4.3. For samples with significant toxicity (i.e., "Yes" in Tables 4.2 and 4.3), comparison between laboratory control and toxicity results (*Hyalella azteca and Ceriodaphnia dubia*) in the context of MRP 1.0 trigger criteria.

Treatment/ Sample ID	Creek	Test Initiation Date (Time)	Species Tested	10-Day Mean % Survival	Mean Reproduction/ Mean Dry Weight	Trigger Exceedance in Comparison to MRP 1.0 Trigger Criteria
Water						
Lab Control	*N/A*	2/7/15 (1530)	*Ceriodaphnia dubia*	*100*	*36.5*	*N/A*
204R01448	Atherton Cr			--	25.4	No (Not <50% of Lab Control)
204R02056	Laurel Cr			--	28.3	No (Not <50% of Lab Control)
Lab Control	*N/A*	2/7/15 (1740)	*Hyalella azteca*	*98*	--	*N/A*
204R01448	Atherton Cr			74	--	No (Not <50% of Lab Control)
204R02056	Laurel Cr			54	--	No (Not <50% of Lab Control)
Sediment						
Lab Control	*N/A*	7/12/15 (1610)	*Hyalella azteca*	*91.3*	*0.13*	*N/A*
204R02056	Laurel Creek			--	0.09	Yes (<20% of Lab Control)

N/A = Not Applicable

4.3.2 Sediment Chemistry

Sediment chemistry results are evaluated as potential stressors based on TEC quotients, PEC quotients, and TU equivalents, according to criteria in MRP 1.0 and MRP 2.0

Table 4.4 lists TEC quotients for all non-pyrethroid sediment chemistry constituents, calculated as the measured concentration divided by the highly conservative TEC value, per MacDonald et al. (2000). TECs are intended to identify concentrations below which harmful effects on sediment-dwelling organisms are unlikely to be observed. Table 4.4 provides a count of the number of constituents that exceed TEC values for each site, as evidenced by a TEC quotient greater than or equal to 1.0. All of the sites exceeded the relevant trigger criterion from MRP 1.0 which is interpreted to stipulate three or more constituents with TEC quotients greater than or equal to 1.0. At site 204R01448 (Atherton Creek) there were a total of four out of 27 constituents with TEC quotients greater than or equal to 1.0, three of which were organochlorine pesticides that have been banned since 1983 (chlordane) and 1972 (DDT and its breakdown products). At site 204R02056 (Laurel Creek) there were six constituents with TEC quotients greater than or equal to 1.0, two of which were metals associated with serpentinite geology (chromium and nickel); the remainder were banned organochlorine pesticides (chlordane and DDT). It is unclear why these legacy pollutants were observed at two unrelated sites in San Mateo County. Laboratory error is one possible explanation. Laboratory control samples intended to assess analytical accuracy exceeded the RMC data quality objectives for DDD and DDT (see Attachment A). As a result, these data were flagged but not rejected.

Table 4.5 provides PEC quotients for all non-pyrethroid sediment chemistry constituents, and calculated mean values of the PEC quotients for each site. PECs are intended to identify concentrations above which toxicity to benthic-dwelling organisms are predicted to be probable. Mean PEC quotients are calculated to evaluate the combined effects of multiple contaminants in sediment. Site 204R02056 (Laurel Creek) had one constituent (nickel) with a PEC quotient equal to or greater than 1.0 (the MRP 2.0 trigger threshold) which is likely related to serpentinite geology in the watershed. The PEC trigger from MRP 1.0 (mean PEC greater than 0.5) was not exceeded at either site.

Table 4.6 provides a summary of the calculated TU equivalents for the pyrethroids for which there are published LC50 values in the literature, as well as a sum of TU equivalents for each site. Because organic carbon mitigates the toxicity of pyrethroid pesticides in sediments, the LC50 values were derived on the basis of TOC-normalized pyrethroid concentrations. Similarly, the pyrethroid concentrations as reported by the lab were divided by the measured TOC concentration at each site, and the TOC-normalized concentrations were used to compute TU equivalents for each pyrethroid. The individual TU equivalents were summed to produce a total pyrethroid TU equivalent value for each site. None of the sites meet the MRP 1.0 action criterion of TU sums greater than or equal to 1.0. Bifenthrin was measured in TOC-normalized concentrations exceeding one half the LC50. Bifenthrin is considered to be the leading cause of pyrethroid-related toxicity in urban areas (Ruby 2013).

Table 4.4. Threshold Effect Concentration (TEC) quotients for WY2015 sediment chemistry constituents. Bolded and shaded values indicate TEC quotient ≥ 1.0.

Site ID Creek	TEC	204R01448 Atherton Cr	204R02056 Laurel Cr
Metals (mg/kg DW)			
Arsenic	9.79	0.29	0.51
Cadmium	0.99	0.11	0.11
Chromium	43.4	0.32	**1.0**
Copper	31.6	0.57	0.73
Lead	35.8	0.34	0.47
Mercury	0.18	0.46	0.21
Nickel	22.7	0.79	**2.6**
Zinc	121	0.40	0.77
PAHs (ug/kg DW)			
Anthracene	57.2	0.35	0.03 [a]
Fluorene	77.4	0.07	0.02 [a]
Naphthalene	176	0.01 [a]	0.01 [a]
Phenanthrene	204	0.49	0.10
Benz(a)anthracene	108	0.56	0.07
Benzo(a)pyrene	150	0.34	0.01 [a]
Chrysene	166	0.60	0.12
Dibenz[a,h]anthracene	33.0	0.05 [a]	0.05 [a]
Fluoranthene	423	0.47	0.05
Pyrene	195	**1.0**	0.10
Total PAHs	1,610	0.59 [c]	0.07 [c]
Pesticides (ug/kg DW)			
Chlordane	3.24	**4.0**	**1.6**
Dieldrin	1.9	0.32 [a]	0.32 [a]
Endrin	2.22	0.23 [a]	0.23 [a]
Heptachlor Epoxide	2.47	0.22 [a]	0.22 [a]
Lindane (gamma-BHC)	2.37	0.15 [a]	0.15 [a]
Sum DDD	4.88	0.92 [c]	**1.1** [c]
Sum DDE	3.16	**1.5** [c]	**3.4** [c]
Sum DDT	4.16	0.36 [c]	0.36 [c]
Total DDTs	5.28	**2.0** [c]	**3.3** [c]
Number of constituents with TEC quotient >= 1.0		**4**	**6**

a. Concentration was below the method detection limit (MDL). TEC quotient calculated using 1/2 MDL.

b. TEC quotient calculated from concentration below the reporting limit (DNQ-flagged).

c. Total calculated using 1/2 MDLs.

Table 4.5. Probable Effect Concentration (PEC) quotients for WY2015 sediment chemistry constituents. Bolded and shaded values indicate PEC quotient ≥ 1.0. Mean PEC quotients did not exceed 0.5.

Site ID		**204R01448**	**204R02056**
Creek	**PEC**	**Atherton Cr**	**Laurel Cr**
Metals (mg/kg DW)			
Arsenic	33.0	0.08	0.15
Cadmium	4.98	0.02	0.02
Chromium	111	0.13	0.41
Copper	149	0.12	0.15
Lead	128	0.09	0.13
Mercury	1.06	0.08	0.03
Nickel	48.6	0.37	**1.2**
Zinc	459	0.10	0.20
PAHs (ug/kg DW)			
Anthracene	845	0.02 [a]	0.00 [a]
Fluorene	536	0.01 [a]	0.00 [a]
Naphthalene	561	0.00 [a]	0.00 [a]
Phenanthrene	1170	0.09	0.02
Benz(a)anthracene	1050	0.06 [b]	0.01
Benzo(a)pyrene	1450	0.04 [a]	0.00
Chrysene	1290	0.08	0.02
Fluoranthene	2230	0.09 [b]	0.01
Pyrene	1520	0.13	0.01
Total PAHs	22,800	0.04 [c]	0.01 [c]
Pesticides (ug/kg DW)			
Chlordane	17.6	0.73 [a]	0.30 [a]
Dieldrin	61.8	0.01 [a]	0.01 [a]
Endrin	207.0	0.00 [a]	0.00 [a]
Heptachlor Epoxide	16	0.03 [a]	0.03 [a]
Lindane (gamma-BHC)	4.99	0.07 [a]	0.07 [a]
Sum DDD	28	0.16 [c]	0.19 [c]
Sum DDE	31.3	0.15 [c]	0.3 [c]
Sum DDT	62.9	0.02 [c]	0.02 [c]
Total DDTs	572	0.02 [c]	0.03 [c]
Mean PEC Quotient		**0.10**	**0.12**

a. Concentration was below the method detection limit (MDL). PEC quotient calculated using 1/2 MDL.

b. PEC quotient calculated from concentration below the reporting limit (DNQ-flagged).

c. Total calculated using 1/2 MDLs.

Table 4.6. Calculated pyrethroid toxic unit (TU) equivalents for WY2015 pyrethroid concentrations.

			204R01448	204R02056
Pyrethroid	**Units**	**LC50**	**Atherton Cr**	**Laurel Cr**
Bifenthrin	µg/g dw	0.52	**0.56**	0.51
Cyfluthrin	µg/g dw	1.08	0.06	0.07
Cypermethrin	µg/g dw	0.38	0.02 [a]	0.04 [a]
Deltamethrin	µg/g dw	0.79	0.01 [a]	0.02 [a]
Esfenvalerate	µg/g dw	1.54	0.01 [a]	0.01 [a]
Lambda-Cyhalothrin	µg/g dw	0.45	0.01 [a]	0.02 [a]
Permethrin	µg/g dw	10.83	0.03	0.03 [b]
Sum of Toxic Unit Equivalents per Site			**0.70**	**0.70**

a. Concentration was below the method detection limit (MDL). TU equivalents calculated using 1/2 MDL.

b. TU equivalents calculated from concentration below the reporting limit (DNQ-flagged).

4.4 Conclusions and Recommendations

Statistically significant toxicity to *Ceriodaphnia dubia* and/or *Hyalella azteca* was observed in both wet weather **water samples;** however, the magnitude of the toxic effects in the samples compared to laboratory controls were not great and did not exceed MRP 1.0 trigger criteria. No toxicity was observed in dry season water samples.

One of the dry weather **sediment samples** had statistically significant toxicity associated *Hyalella azteca* growth (Laurel Creek). *Hyalella azteca* is particularly sensitive to pyrethroid pesticides; however, this sample had relatively few detected pyrethroids and none at concentrations exceeding the LC50 when normalized to TOC. Laurel Creek will be added to the list of candidate SSID projects.

TEC and PEC quotients were calculated for all non-pyrethroid constituents measured in **sediment samples**. Both sites had at least one TEC or PEC quotient exceeding 1.0. In compliance with MRP 2.0, both stations will therefore be placed on the list of candidate SSID projects.

5.0 Chlorine Monitoring

5.1 Introduction

Chlorine is added to potable water supplies and wastewater to kill microorganisms that cause waterborne diseases. However, the same chlorine can be toxic to the aquatic species. Chlorinated water may be discharged to the municipal separate stormwater sewer systems (MS4s) and/or urban creeks from residential activities, such as pool dewatering or over-watering landscaping, or from municipal activities, such as hydrant flushing or water main breaks.

To assess whether the chlorine in receiving waters is potentially toxic to the aquatic life living there, SMCWPPP field staff measured total and free chlorine residual in urban creeks. Total chlorine residual is comprised of combined and free chlorine, and is always greater than or equal to the free chlorine residual. Combined chlorine is the chlorine that has reacted with ammonia or organic nitrogen to form chloramines, while free chlorine is the chlorine that is remains unbound.

5.2 Methods

In accordance with the BASMAA RMC Creek Status and Long-Term Trends Monitoring Plan (BASMAA 2012), WY2015 field testing for free chlorine and total chlorine residual was conducted at all 10 probabilistic sites concurrent with spring bioassessment sampling (April-May), and at a subset (two) of the sites concurrent with dry season toxicity sampling (July). Probabilistic site selection methods are described in Section 2.0.

Field testing for free and total chlorine residual conformed to methods and procedures described in the BASMAA RMC SOPs (BASMAA 2014b), which are comparable to those specified in the SWAMP QAPP. Per SOP FS-3 (BASMAAS 2014b), water samples were collected and analyzed for free and total chlorine using a Pocket Colorimeter^{TM} II and DPD Powder Pillows, which has a method detection limit of 0.02 mg/L. If concentrations exceed the trigger criteria of 0.08 mg/L, the site was immediately resampled. Per MRP 1.0, if the resample is still greater than 0.08 mg/L, the site is considered as a candidate for a followup SSID project. MRP 1.0 requirements were followed in WY2015.

MRP 2.0 increases the trigger criteria to 0.1 mg/L and requires different followup actions. Provision C.8.d.ii of MRP 2.0 requires that Permittees report free and total chlorine concentrations exceeding 0.1 mg/L "to the appropriate Permittee central contact point for illicit discharges to that the illicit discharge staff can investigate and abate the associated discharge in accordance with its Provision C.5.e – Spill and Dumping Complaint Response Program."

5.3 Results

Twelve chlorine measurements were collected in WY2015. These measurements were compared to the MRP 1.0 trigger threshold of 0.08 mg/L. If a repeat chlorine measurement was not conducted, the original measurement was evaluated.

None of the samples exceeded the threshold for free chlorine residual. One of the 12 samples (8 %), collected during the summer event in Atherton Creek, exceeded the threshold for total chlorine residual[27].

Table 5.1. Summary of SMCWPPP chlorine testing results compared to MRP 1.0 trigger of 0.08 mg/L, WY2015. Values above the trigger are indicated by shaded cells.

Station Code	Creek	Date	Free Chlorine (mg/L)[1]	Total Chlorine Residual (mg/L)[1]	Exceeds Trigger?[2] (0.8 mg/L)
202R00378	Pescadero Creek	4/23/2015	< 0.02	< 0.02	No
202R00440	Purisima Creek	5/13/2015	< 0.02	< 0.02	No
202R01356	Middle Fork San Pedro Creek	5/11/2015	0.03	0.02	No
202R01612	Middle Fork San Pedro Creek	5/11/2015	0.02	< 0.02	No
204R01448	Atherton Creek	4/22/2015	0.02	0.03	No
204R01448	Atherton Creek	7/7/2015	0.03	0.15	Yes
204R01972	Cordilleras Creek	5/13/2015	< 0.02	0.03	No
204R02056	Laurel Creek	5/12/2015	0.03	0.03	No
204R02056	Laurel Creek	7/7/2015	0.03	0.05	No
204R02248	Laurel Creek	5/12/2015	< 0.02	< 0.02	No
205R01704	Dry Creek	4/22/2015	< 0.02	< 0.02	No
205R01816	Corte Madera	4/30/2015	0.02	0.03	No
Number of samples exceeding 0.08 mg/L:			0	1	--
Percentage of samples exceeding 0.08 mg/L:			0%	8%	--

[1] The method detection limit is 0.02 mg/L.

[2] The MRP 1.0 threshold applies to both free and total chlorine measurements.

5.4 Conclusions and Recommendations

While the July 7, 2015 total chlorine residual concentration in Atherton Creek exceeded the trigger, the free chlorine concentration for this sample was only slightly higher than the detection limit, as were the free and total chlorine samples collected at the site during the first monitoring event. The elevated total chlorine concentration is likely a one-time potable water discharge from one of the properties built out to the edge of the creek. As illicit chlorine discharges are highly episodic, it would be difficult to determine the source of the elevated total (combined) chlorine residual concentration in Atherton Creek. A follow-up sample at the same site in Atherton Creek during the following spring is recommended and if that sample exceeds the trigger, Atherton Creek will be added to the list of candidate sites for possible followup SSID projects.

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[27] A followup sample was not collected immediately to confirm the concentration so the original measurement was evaluated.

6.0 Conclusions and Recommendations

In WY2015, in compliance with provision C.8.c of MRP 1.0 and the BASMAA RMC Creek Status and Long-Term Trends Monitoring Plan (BASMAA 2012), SMCWPPP continued to implement a two-component monitoring design that was initiated in WY2012. The strategy includes a regional ambient/probabilistic monitoring component and a component based on local "targeted" monitoring. The combination of these monitoring designs allows each individual RMC participating program to assess the status of beneficial uses in local creeks within its Program (jurisdictional) area, while also contributing data to eventually answer management questions at the regional scale (e.g., differences between aquatic life condition in urban and non-urban creeks).

The following conclusions from the MRP creek status monitoring conducted during WY2015 in San Mateo County are based on the management questions presented in Section 1.0:

1) ***Are water quality objectives, both numeric and narrative, being met in local receiving waters, including creeks, rivers, and tributaries?***

2) ***Are conditions in local receiving water supportive of or likely supportive of beneficial uses?***

The first management question is addressed primarily by comparison of probabilistic and targeted monitoring data to the triggers defined in MRP 2.0. A summary of trigger exceedances observed for each site is presented in Table 6.1. Sites where triggers are exceeded may indicate potential impacts to aquatic life or other Beneficial Uses and are considered for future evaluation of stressor source identification (SSID) projects.

The second management question is addressed primarily by assessing indicators of aquatic biological health using benthic macroinvertebrate and algae data collected at probabilistic sites. Biological condition scores were compared to physical habitat and water quality data collected synoptically with bioassessments to evaluate whether any correlations exist that may help explain the variation in biological condition scores.

6.1 Conclusions

Probabilistic Survey Design

- Between WY2012 and WY2015, a total of 50 probabilistic sites were sampled by SMCWPPP (n=40) and SWAMP (n=10) in San Mateo County, including 33 urban and 17 non-urban sites. There are now a sufficient number of samples from probabilistic sites to develop estimates of ambient biological condition and stressor assessment for urban streams in San Mateo County.

- Additional samples are needed to estimate biological condition at more local scales (e.g., watershed and jurisdictional areas) and to increase the confidence of estimates at sites in non-urban areas.

Biological Condition Assessment

- The California Stream Condition Index (CSCI) tool was used to assess the biological condition for benthic macroinvertebrate data collected at probabilistic sites. Of the 10 sites monitored in WY2015, five sites were rated in good condition (CSCI scores ≥ 0.795) and five sites rated as very likely altered condition (≤ 0.635).

- The five sites with CSCI scores less than the trigger threshold of 0.795 will be added to the list of candidate SSID projects.
- CSCI scores were relatively consistent across four years of sampling. The median CSCI score for all four years ranged from 0.45 to 0.58 for urban sites and 0.9 to 1.1 for non-urban sites.
- Benthic algae data was collected synoptically with BMIs at all probabilistic sites. Algae index scores for diatom taxa (D18) were calculated for all sites. Four sites were rated in good condition (D18 scores ≥ 63), five sites rated as likely altered, and one site rated as very likely altered (<49).
- There was insufficient number of soft algae taxa to calculate algae indices S2 or H20 at any of the sites. Only three soft algal taxa were identified for all ten samples. Site characteristics and flow conditions prior to sampling do not appear to explain the absence of soft algae consistently at all the sites.
- There was very little difference in CSCI or algae IBI (D18) scores between perennial (n=8) and non-perennial (n=2) sites. CSCI scores had good response to different levels of urbanization (calculated as percent impervious area). CSCI was highly correlated with PHAB and CRAM scores. D18 was poorly correlated with both PHAB and CRAM scores.

Stressor Assessment

- Nutrients, algal biomass indicators, and other conventional analytes were measured in samples collected concurrently with bioassessments which are conducted in the spring season.
- CSCI scores has significant negative correlation with both land use variables (percent impervious and urban), specific conductivity, unionized ammonia, and SSC and positive correlation with two PHAB parameters (epifaunal substrate score and channel alteration score).
- Thresholds for water quality objectives were not exceeded.

Trend Assessment

- Trend analysis for the RMC probabilistic survey will require more than four years of data collection. Preliminary long-term trend analysis of biological condition may be possible for some stream reaches using a combination of historical targeted data with the probabilistic data.
- Targeted re-sampling at probabilistic sites can provide additional data to evaluate longer term trends at selected locations.

Spatial and Temporal Variability of Water Quality Conditions

- There was minimal spatial variability in water temperature across the five sites in Bear Creek watershed.

- Dissolved oxygen concentrations were similar between the two San Mateo Creek sites, but were slightly lower during Event 2 compared to Event 1.

Potential Impacts to Aquatic Life

- Potential impacts to aquatic life were assessed through analysis of continuous temperature data collected at five targeted stations and continuous general water quality data (pH, dissolved oxygen, specific conductance, temperature) collected at two targeted stations. Stations were deliberatively selected using the Directed Monitoring Design Principle.
- The three temperature stations in Bear Creek exceeded the MRP 2.0 trigger threshold of having two or more weeks where the maximum weekly average temperature (MWAT) exceeded 17°C. Furthermore, both of the general water quality stations in San Mateo Creek exceeded the MWAT trigger during the second sampling event. None of the stations exceeded the maximum instantaneous trigger threshold of 24°C.
- All stations with MWAT trigger exceedances will be added to the list of candidate SSID projects; however, review of the monitoring data in the context of the ongoing drought and locally-derived temperature thresholds developed by NMFS suggests that temperature is not likely a limiting factor for salmonid habitat (i.e., summer rearing juveniles) in the study reaches.
- The WQO for DO in waters designated as having cold freshwater habitat (COLD) beneficial uses (i.e., 7.0 mg/L) was met in all measurements recorded at the water quality stations in San Mateo Creek. As described in the Low DO SSID Project Report, previous low DO concerns in the study reach appear to have been mitigated by increased dry season releases from Crystal Springs Reservoir (see Appendix B to the WY2015 UCMR).
- Values for pH measured at the San Mateo Creek sites in WY2015 were within WQOs (6.5 to 8.5).
- Specific conductivity concentrations recorded at the San Mateo Creek sites in WY2015 were below the trigger threshold of 2000 us/cm.
- Field testing for free chlorine and total chlorine residual was conducted at all ten probabilistic sites concurrent with spring bioassessment sampling (April-May), and at a subset (two) of the sites concurrent with dry season toxicity sampling (July). The MRP 1.0 trigger threshold of 0.08 mg/L was exceeded at one site on Atherton Creek. This site will be added to the list of candidate SSID projects.

Potential Impacts to Water Contact Recreation

- In WY2015, pathogen indicator sites were located in the San Mateo Creek watershed where a bacteria SSID study is in progress. Pathogen indicator triggers were exceeded at two of the five sites. Microbial source tracking (MST) techniques conducted as part of the SSID study suggest year-round human bacterial sources and wet-weather dog sources.

- It is important to recognize that pathogen indicator thresholds are based on human recreation at beaches receiving bacteriological contamination from human wastewater, and may not be applicable to conditions found in urban creeks. As a result, the comparison of pathogen indicator results to body contact recreation water quality objectives may not be appropriate and should be interpreted cautiously.

Water Toxicity

- Water toxicity samples were collected from two sites during two sample events (winter storm event and summer). Although bothwet weather samples were toxic relative to the Lab Control treatment, no water toxicity samples exceeded MRP 1.0 trigger thresholds.

Sediment Toxicity and Chemistry

- Sediment toxicity and chemistry samples were collected concurrently with the summer water toxicity samples. Chronic toxicity to *Hyalella azteca* in the Laurel Creek samples exceeded the MRP 1.0 trigger threshold. This site will be added to the list of candidate SSID projects.
- All sediment samples exceeded the trigger threshold from MRP 2.0 with at least one Threshold Effect Concentration (TEC) quotient or Probable Effect Concentration (PEC) quotient greater than or equal to 1.0. Therefore, both sites will be added to the list of candidate SSID projects. However, these findings were not unexpected in San Mateo County where naturally occurring chromium and nickel from serpentinite geology often results in high concentrations of these metals in receiving water sediments.

6.2 Trigger Assessment

The MRP requires analysis of the monitoring data to identify candidate sites for SSID projects. Creek Status Monitoring data were collected pursuant to MRP 1.0 but were evaluated and reported pursuant to MRP 2.0 which became effective January 1, 2016. Trigger thresholds against which to compare the data are provided for most monitoring parameters in MRP 2.0 and are described in the foregoing sections of this report. Stream condition was determined based on CSCI scores that were calculated using BMI data. Water and sediment chemistry and toxicity data were evaluated using numeric trigger thresholds specified in the MRP. In compliance with provision C.8.e.i of MRP 2.0, all monitoring results exceeding trigger thresholds are added to a list of candidate SSID projects that will be maintained throughout the permit term. Followup SSID projects will be selected from this list. Table 6.1 lists of candidate SSID projects based on WY2015 Creek Status monitoring data.

Additional analysis of the data is provided in the foregoing sections of this report and should be considered prior to selecting and defining SSID projects. The analyses include review of physical habitat and water chemistry data to identify potential stressors that may be contributing to degraded or diminished biological conditions. Analyses in this report also include historical and spatial perspectives that help provide context and deeper understanding of the trigger exceedances.

Table 6.1. Summary of SMCWPPP MRP trigger threshold exceedance analysis, WY2015. "No" indicates samples were collected but did not exceed the MRP trigger; "Yes" indicates an exceedance of the MRP trigger.

Station Number	Creek Name	Bioassessment	Nutrients	Chlorine	Water Toxicity	Sediment Toxicity	Sediment Chemistry	Continuous Temperature	Dissolved Oxygen	pH	Specific Conductance	Pathogen Indicators
202R00378	Pescadero Creek	No	No	No	--	--	--	--	--	--	--	--
202R00440	Purisima Creek	No	No	No	--	--	--	--	--	--	--	--
202R01356	Middle Fork San Pedro Creek	No	No	No	--	--	--	--	--	--	--	--
202R01612	Middle Fork San Pedro Creek	No	No	No	--	--	--	--	--	--	--	--
204R01448	Atherton Creek	Yes	No	Yes	No	No	Yes	--	--	--	--	--
204R01972	Cordilleras Creek	Yes	No	No	--	--	--	--	--	--	--	--
204R02056	Laurel Creek	Yes	No	No	No	Yes	Yes	--	--	--	--	--
204R02248	Laurel Creek	Yes	No	Yes	--	--	--	--	--	--	--	--
205R01704	Dry Creek	Yes	No	No	--	--	--	--	--	--	--	--
205R01816	Corte Madera Creek	No	No	No	--	--	--	--	--	--	--	--
204SMA058	San Mateo Creek	--	--	--	--	--	--	Yes	No	No	No	--
204SMA059	San Mateo Creek	--	--	--	--	--	--	Yes	No	No	No	--
204SMA060	San Mateo Creek	--	--	--	--	--	--	--	--	--	--	Yes
204SMA080	San Mateo Creek	--	--	--	--	--	--	--	--	--	--	Yes
204SMA100	San Mateo Creek	--	--	--	--	--	--	--	--	--	--	No
204SMA110	Polhemus Creek	--	--	--	--	--	--	--	--	--	--	No
204SMA119	San Mateo Creek	--	--	--	--	--	--	--	--	--	--	No
205ALA015	Alambique Creek	--	--	--	--	--	--	No	--	--	--	--
205BCR010	Bear Creek	--	--	--	--	--	--	Yes	--	--	--	--
205BCR050	Bear Creek	--	--	--	--	--	--	Yes	--	--	--	--
205BCR060	Bear Creek	--	--	--	--	--	--	Yes	--	--	--	--
205WUN150	West Union Creek	--	--	--	--	--	--	No	--	--	--	--

6.3 Management Implications

The Program's Creek Status Monitoring program (consistent with MRP 1.0 provision C.8.c) focuses on assessing the water quality condition of urban creeks in San Mateo County and identifying stressors and sources of impacts observed. Although the sample size from WY2015 (overall n=10; urban n=9) is not sufficient to develop statistically representative conclusions regarding the overall condition of all creeks, it builds on data collected in WY2012 through WY2014 and could be used in a regional analysis of biological indicator and stressor data collected in San Mateo County. Even considering WY2015 data alone, it is clear that most urban streams have likely or very likely altered populations of aquatic life indicators (e.g., aquatic macroinvertebrates). These conditions are likely the result of long-term changes in stream hydrology, channel geomorphology, in-stream habitat complexity, and other modifications to the watershed and riparian areas associated with the urban development that has occurred over the past 50 plus years. Furthermore, episodic or site specific increases temperature may not be optimal for aquatic life in local creeks.

SMCWPPP Permittees are actively implementing many stormwater management programs to address these and other stressors and associated sources of water quality conditions observed in local creeks, with the goal of protecting these natural resources. For example:

- In compliance with MRP 1.0 provision C.3, new and redevelopment projects in the Bay Area are now designed to more effectively reduce water quality and hydromodification impacts associated with urban development. Low impact develop (LID) methods, such as rainwater harvesting and use, infiltration and biotreatment are required as part of development and redevelopment projects. These LID measures are expected to reduce the impacts of urban runoff and associated impervious surfaces on stream health. MRP 2.0 expands these requirements to include Green Infrastructure planning for all municipal projects
- In compliance with MRP 1.0 provision C.9, Permittees are implementing pesticide toxicity control programs that focus on source control and pollution prevention measures. The control measures include the implementation of integrated pest management (IPM) policies/ordinances, public education and outreach programs, pesticide disposal programs, the adoption of formal State pesticide registration procedures, and sustainable landscaping requirements for new and redevelopment projects. Through these efforts, it is estimated that the amount of pyrethroids observed in urban stormwater runoff will decrease by 80-90% over time, and in turn significantly reduce the magnitude and extent of toxicity in local creeks. This work will continue under MRP 2.0.
- Trash loadings to local creeks have been reduced through implementation of new control measures in compliance with MRP 1.0 provision C.10 and other efforts by Permittees to reduce the impacts of illegal dumping directly into waterways. These actions include the installation and maintenance of trash capture systems, the adoption of ordinances to reduce the impacts of litter prone items, enhanced institutional controls such as street sweeping, and the on-going removal and control of direct dumping. MRP 2.0 establishes a mandatory trash load reduction schedule, minimum areas to be treated by full trash capture systems, and requires development of receiving water monitoring programs for trash.
- In compliance with MRP 1.0 provisions C.2 (Municipal Operations), C.4 (Industrial and Commercial Site Controls), C.5 (Illicit Discharge Detection and Elimination), and C.6 (Construction Site Controls) Permittees continue to implement programs that are designed to prevent non-stormwater discharges during dry weather and reduce the exposure of contaminants to stormwater and sediment in runoff during rainfall events. These programs will continue under MRP 2.0.
- In compliance with MRP 1.0 provision C.13, copper in stormwater runoff is reduced through implementation of controls such as architectural and site design requirements, street sweeping, and participation in statewide efforts to significantly reduce the level of copper vehicle brake pads. These measures will be continued during the MRP 2.0 permit term.
- Mercury and polychlorinated biphenyls (PCBs) in stormwater runoff are being reduced through implementation of the respective TMDL water quality restoration plans. Under

MPR 2.0, the Program will continue to identify sources of these pollutants and will implement control actions designed to achieve new minimum load reduction goals.

Through the continued implementation of MRP-associated and other watershed stewardship programs, SMCWPPP anticipates that stream conditions and water quality in local creeks will continue to improve overtime. In the near term, toxicity observed in creeks should decrease as pesticide regulations better incorporate water quality concerns during the pesticide registration process. In the longer term, control measures implemented to “green” the “grey” infrastructure and disconnect impervious areas constructed over the course of the past 50 plus years will take time to implement. Consequently, it may take several decades to observe the outcomes of these important, large-scale improvements to our watersheds in our local creeks. Long-term creek status monitoring programs designed to detect these changes over time are therefore beneficial to our collective understanding of the condition and health of our local waterways.

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ATTACHMENTS

Attachment A
QA/QC Report

Attachment 1

Quality Assurance/Quality Control Report

Prepared by:

EOA, Inc
1410 Jackson Street
Oakland, CA 94612

Prepared for:

San Mateo Countywide Pollution Prevention Program
(SMCWPPP)

February 26, 2016

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Acronyms

BASMAA	Bay Area Stormwater Management Agencies Association
BMI	Benthic Macroinvertebrates
DQO	Data Quality Objective
EDDs	Electronic data deliverables
LCS	Laboratory Control Sample
LCSD	Laboratory Control Sample Duplicate
MQO	Measurement Quality Objective
MS	Matrix Spike
MSD	Matrix Spike Duplicate
PAH	Polycyclic Aromatic Hydrocarbon
PR	Percent Recovery
QA	Quality Assurance
QC	Quality Control
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance and Quality Control
RMC	Regional Monitoring Coalition
RPD	Relative Percent Difference
SAFIT	Southwest Association of Freshwater Invertebrate Taxonomists
SFRWQCB	San Francisco Regional Water Quality Control Board
SMCWPPP	San Mateo Countywide Pollution Prevention Program
SOP	Standard Operating Procedures
STE	Standard Taxonomic Effort
SWAMP	Surface Water Ambient Monitoring Program

1. INTRODUCTION

In Water Year 2015 (WY2015; October 1, 2014 through September 30, 2015), the San Mateo Countywide Pollution Prevention Program (SMCWPPP) conducted Creek Status Monitoring in compliance with provision C.8.c of the National Pollutant Discharge Elimination System (NPDES) stormwater permit for Bay Area municipalities referred to as the Municipal Regional Permit (referred to as MRP 1.0). The monitoring strategy includes regional ambient/probabilistic monitoring and local "targeted" monitoring as described in the Bay Area Stormwater Management Agencies Association (BASMAA) Regional Monitoring Coalition (RMC) Creek Status and Long-Term Trends Monitoring Plan (BASMAA 2012). SMCWPPP implemented a comprehensive data quality assurance and quality control (QA/QC) program, covering all aspects of the probabilistic and targeted monitoring. Data QA/QC for data collected was performed according to procedures detailed in the Quality Assurance Project Plan (QAPP) developed by BASMAA RMC (BASMAA 2014a) and BASMAA RMC Standard Operating Procedures (SOP; BASMAA 2014b), SOP FS-13 (Standard Operating Procedures for QA/QC Data Review). The BASMAA RMC SOP and QAPP are based on the SOP and QAPP developed by the Surface Water Ambient Monitoring Program (SWAMP; SCCWRP 2009).

1.1. DATA TYPES EVALUATED

During creek status monitoring, several data types were collected and evaluated for quality assurance and quality control. These data types include the following:

1. Bioassessment data
    a. Benthic Macroinvertebrates
    b. Algae
2. Physical Habitat Assessment
3. Field Measurements
4. Water Chemistry
5. Sediment Chemistry
6. Water and Sediment Toxicity
7. Pathogen Indicators
8. Continuous Water Quality (2-week deployment; 15-minute interval)
    a. Temperature
    b. Dissolved Oxygen
    c. Conductivity
    d. pH
9. Continuous Temperature Measurements (5-month deployment; 1-hour interval)

1.2. LABORATORIES

Laboratories providing analytical and taxonomic identification support to SMCWPPP and the RMC were selected based on demonstrated capability to adhere to specified protocols. Laboratories are certified and are as follows:

- Caltest Analytical Laboratory – nutrients, chlorophyll a, ash free dry mass, sediment chemistry
- Pacific EcoRisk, Inc. - water and sediment toxicity
- BioVir Laboratories, Inc. – pathogen indicators
- BioAsessment Services – benthic macroinvertebrate (BMI) identification
- EcoAnalysts, Inc. – algae identification

1.3. QA/QC ATTRIBUTES

The RMC SOP and QAPP identify seven data quality attributes that are used to assess data QA/QC. They include (1) Representativeness, (2) Comparability, (3) Completeness, (4) Sensitivity, (5) Precision,

(6) Accuracy, and (7) Contamination. These seven attributes are compared to Data Quality Objectives (DQOs), which were established to ensure that data collected are of adequate quality and sufficient for the intended uses. DQOs address both quantitative and qualitative assessment of the acceptability of data – representativeness and comparability are qualitative while completeness, sensitivity, precision, accuracy, and contamination are quantitative assessments.

Specific DQOs are based on Measurement Quality Objectives (MQOs) for each analyte. Chemical analysis relies on repeatable physical and chemical properties of target constituents to assess accuracy and precision. Conversely, biological data are quantified by experienced taxonomists relying on organism morphological features.

1.3.1. Representativeness

Data representativeness assesses whether the data were collected so as to represent actual conditions at each monitoring location. For this project, all samples and field measurements are assumed to be representative if they are performed according to protocols specified in the RMC QAPP and SOPs.

1.3.2. Comparability

The QA/QC officer ensures that the data may be reasonably compared to data from other programs producing similar types of data. For RMC Creek Status monitoring, individual stormwater programs try to maintain comparability within in RMC. The key measure of comparability for all RMC data is the California Surface Water Ambient Monitoring Program (SWAMP).

1.3.3. Completeness

Completeness is the degree to which all data were produced as planned; this covers both sample collection and analysis. For chemical data and field measurements an overall completeness of greater than 90% is considered acceptable for RMC chemical data and field measurements. For bioassessment-related parameters – including BMI and algae taxonomy samples/analysis and associated field measurement – a completeness of 95% is considered acceptable.

1.3.4. Sensitivity

Sensitivity analysis determines whether the methods can identify and/or quantify results at low enough levels. For the chemical analyses in this project, sensitivity is considered to be adequate if the reporting limits (RLs) comply with the specifications in RMC QAPP Appendix E: RMC Target Method Reporting Limits. For benthic macroinvertebrate data, taxonomic identification sensitivity is acceptable provided taxonomists use standard taxonomic effort (STE) Level I as established by the Southwest Association of Freshwater Invertebrate Taxonomists (SAFIT). There is no established level of sensitivity for algae taxonomic identification.

1.3.5. Accuracy

Accuracy is assessed as the percent recovery of samples spiked with a known amount of a specific chemical constituent. Chemistry laboratories routinely analyze a series of spiked samples; the results of these analyses are reported by the laboratories and evaluated using the RMC Database QA/QC Testing Tool. Acceptable levels of accuracy are specified for chemical analytes and toxicity test parameters in RMC QAPP Appendix A: Measurement Quality Objectives for RMC Analytes, and for biological measurements in Appendix B: Benthic Macroinvertebrate MQOs and Data Production Process.

1.3.6. Precision

Precision is nominally assessed as the degree to which replicate measurements agree, nominally determined by calculation of the relative percent difference (RPD) between duplicate measurements. Chemistry laboratories routinely analyze a series of duplicate samples that are generated internally. The RMC QAPP also requires collection and analysis of field duplicate samples at a rate of 10% of all water quality samples for most chemical parameters, and 5% of all samples for bacteria samples and sediment chemistry samples. Field duplicates are not required for toxicity samples. The results of the duplicate analyses are reported by the laboratories and evaluated using RMC Database QA/QC Testing Tool. Acceptable levels of precision are specified for chemical analytes and toxicity test parameters in RMC

QAPP Appendix A: Measurement Quality Objectives for RMC Analytes, and for biological measurements in Appendix B: Benthic Macroinvertebrate MQOs and Data Production Process.

1.3.7. Contamination

For chemical data, contamination is assessed as the presence of analytical constituents in blank samples. Chemistry laboratories routinely analyze a series of duplicate samples that are generated internally. The RMC QAPP also requires collection and analysis of field blank samples at a rate of 5% for dissolved organic carbon.

2. METHODS

2.1. REPRESENTATIVENESS

To ensure representativeness, each member of the SMCWPPP field crew has received and reviewed the all applicable SOPs and QAPP. Field crew members also attended a two-day bioassessment and field sampling training session from the California Water Boards Training Academy. The course is taught by California Department of Fish and Wildlife, Aquatic Bioassessment Laboratory staff and covers procedures for sampling benthic macroinvertebrates, algae, and measuring physical habitat characteristics using the applicable SWAMP SOPs. As a result, each field crew member is knowledgeable of, and performs data collection according to the protocols in the RMC QAPP and SOP, ensuring that all samples and field measurements are representative of conditions in Santa Clara Valley urban creeks.

2.2. COMPARABILITY

In addition to the bioassessment and field sampling training, SMCWPPP field crew members participate in a biannual (even years) inter-calibration exercise with other stormwater programs prior to field assessments. During inter-calibration exercises, the field crews also review water chemistry (nutrient) sample collection and water quality field measurement methods. Close communication throughout the field season with other stormwater program field crews also ensures comparability.

Sub-contractors collecting samples and the laboratories performing analyses received copies of the RMC SOP and QAPP, and have acknowledged review of the documents. Data collection and analysis by these parties adhere to the RMC protocols and is included in their operating contracts.

Following completion of the field and laboratory work, the field data sheets and laboratory reports were reviewed by the SMCWPPP Program Quality Assurance staff, and were compared against the methods and protocols specified in the SOPs and QAPP. Specifically, staff checks for conformance with field and laboratory methods as specified in SOPs and QAPP, including sample collection and analytical methods, sample preservation, sample holding times, etc.

Electronic data deliverables (EDDs) are submitted to the San Francisco Regional Water Quality Control Board (SFRWQCB) in Microsoft Excel templates developed by SWAMP, to ensure data comparability with the SWAMP program. In addition, data entry follows SWAMP documentation specific to each data type, including the exclusion of qualitative values that do not appear on SWAMP's look up lists[1]. Completed templates are reviewed using SWAMP's online data checker[2], further ensuring SWAMP-comparability.

2.3. COMPLETENESS

2.3.1. Data Collection

All efforts are made to collect 100% of planned samples. Upon completion of all data collection, the number of samples collected for each data type was compared to the number of samples planned and the number required by Table 8.1 of MRP 1.0, and reasons for any missed samples were identified. When possible, SMCWPPP staff resampled sites if missing data were identified prior to the close of the monitoring period. Specifically, continuous water quality data is reviewed immediately following deployment, and if data are rejected, samplers are redeployed immediately.

For bioassessments, the SMCWPPP field crew makes all efforts to collect the required number of BMI and algae subsamples per site; in the event of a dry transect, the samples are slid to the closest sampleable location to ensure 11 total subsamples in each station's composite sample.

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[1] Look up lists available online at http://swamp.waterboards.ca.gov/swamp_checker/LookUpLists.php.

[2] Checker available online at http://swamp.waterboards.ca.gov/swamp_checker/SWAMPUpload.php

2.3.2. Field Sheets

Following the completion of each sampling event, the field crew leader/local monitoring coordinator reviewed any field generated documents for completion, and any missing values were entered. Once field sheets were returned to the office, a second SMCWPPP staff member reviewed the field sheets again, and noted any missing data.

2.3.3. Laboratory Results

SMCWPPP staff assessed laboratory reports and EDDs for the number and type of analysis performed to ensure all sites and samples were included in the laboratory results.

2.4. SENSITIVITY

2.4.1. Biological Data

The benthic macroinvertebrate taxonomist, BioAssessment Services, confirmed that organisms were identified to SAFIT STE Level I.

2.4.2. Chemical Analysis

The reporting limits for chemical analysis were compared to the target reporting limits in Appendix E (RMC Target Method Reporting Limits) of the RMC QAPP. Results with reporting limits exceeding the target reporting limit were flagged.

2.5. ACCURACY

2.5.1. Biological Data

Ten percent of the total number of BMI samples collected was submitted to the California Department of Fish and Wildlife (CDFW) Aquatic Bioassessment Laboratory for independent assessment of taxonomic accuracy, enumeration of organisms and conformance to standard taxonomic level. For SMCWPPP, two samples were evaluated for QC purposes.

2.5.2. Chemical Analysis

Caltest evaluated and reported the percent recovery (PR) of laboratory control samples (LCS; in lieu of reference materials) and matrix spikes (MS), which were recalculated and compared to the applicable measurement quality objectives (MQOs) set by Appendix A (Measurement Quality Objectives for RMC Analytes) of the RMC QAPP MQOs. If a QA sample did not meet MQOs, all samples in that batch for that particular analyte were flagged.

For reference materials, percent recovery is calculated as:

PR = MV / EV x 100%

Where: MV = the measured value
EV = the expected (reference) value

For matrix spikes, percent recovery is calculated as:

PR = [(MV – NV) / SV] x 100%

Where: MV = the measured value of the spiked sample
EV = the native, unspiked result
SV = the spike concentration added

2.5.3. Water Quality Data Collection

Accuracy for continuous water quality monitoring sondes was assured via continuing calibration verification for each instrument before and after each two-week deployment. Instrument drift was calculated by comparing the instrument's measurements in standard solutions taken before and after deployment. The drift was compared to measurement quality objectives for drift listed on the SWAMP calibration form, included as an attachment to the RMC SOP FS-3.

Temperature data were checked for accuracy by comparing measurements taken by HOBO temperature loggers with NIST thermometer readings in room temperature water and ice water prior to deployment. The mean difference and standard deviation for each HOBO is calculated, and if a logger has a mean difference exceeding 0.2 °C, it is replaced.

2.6. PRECISION

2.6.1. Field Duplicates

Duplicate biological and water chemistry samples were collected at 10% (two) of the 20 probabilistic sites sampled to evaluate precision of field sampling methods. The relative percent difference (RPD) for water chemistry field duplicates was calculated and compared to the MQO (RPD < 25%) set by Table 26-1in Appendix A of the RMC QAPP. If the RPD of the two field duplicates did not meet the MQO, the results were flagged.

The RMC QAPP requires collection and analysis of duplicate sediment samples at a rate of 5% of total samples collected for the project. For WY2015, one of SMCWPPP's RMC partners(Contra Costa Clean Water Program) collected one sediment sample field duplicate to account for the 10 sediment sites monitored by the RMC in WY2015. The sediment sample and field duplicate were collected together using the Sediment Scoop Method described in the RMC SOP, homogenized, and then distributed to two separate containers. The RPD for the two sediment sample field duplicates was calculated for each analyte and compared to the MQOs (RPD < 25%) set by Tables 26-6 and 26-7 in Appendix A of the RMC QAPP. If the RPD of the two field duplicates did not meet the MQO, the results were flagged.

The RPD is calculated as:

$$RPD = ABS ([X1-X2] / [(X1+X2) / 2])$$

Where: X1 = the first sample result

X2 = the duplicate sample result

2.6.2. Chemical Analysis

The analytical laboratory, Caltest, evaluated and reported the RPD for laboratory duplicates, laboratory control duplicates, and matrix spike duplicates. The RPDs for all duplicate samples were recalculated and compared to the applicable MQO set by Appendix A of the RMC QAPP. If a laboratory duplicate sample did not meet MQOs, all samples in that batch for that particular analyte were flagged.

2.7. CONTAMINATION

Blank samples were analyzed for contamination, and results were compared to MQOs set by Appendix A of the RMC QAPP. In addition to a laboratory blank that was run with each batch, the RMC QAPP requires the collection and analysis of field blank samples at a rate of 5% for dissolved organic carbon. This equates to a total of three such samples for the RMC total of 60 samples region-wide. One of the field blanks was taken in San Mateo County in WY2015.

For creek status monitoring, the RMC QAPP requires all blanks to be less than the analyte reporting limits. If a blank sample did not meet this MQO, all samples in that batch for that particular analyte were flagged.

3. RESULTS

3.1. OVERALL PROJECT REPRESENTATIVENESS

The SMCWPPP staff and field crew members are trained in SWAMP and RMC protocols, and receive significant supervision from the local monitoring coordinator and QA officer. As a result, creek status monitoring data is considered to be representative of conditions in Santa Clara Valley Creeks.

3.2. OVERALL PROJECT COMPARABILITY

SMCWPPP creek status monitoring data is considered to be comparable to both other agencies in the RMC and to SWAMP due to trainings, use of the same electronic data templates, and close communications.

3.3. BIOASSESSMENTS AND PHYSICAL HABITAT ASSESSMENTS

The BMI taxonomic laboratory, BioAssessment Services, has received the RMC QAPP, and confirms that the laboratory QA/QC procedures align with the procedures in Appendices B through D of the RMC QAPP and meet the BMI MQOs in Appendix B.

3.3.1. Completeness

The SMCWPPP program completed ten of ten planned/required bioassessments and physical habitat assessments for WY2015 for a 100% completion rate. Benthic macroinvertebrate, algae samples, and physical habitat assessments were collected at all 11 transects for all ten sites, for a 100% completion rate.

3.3.2. Sensitivity

The benthic macroinvertebrate taxonomic identification met sensitivity objectives; the taxonomy laboratory, BioAssessment Services, confirmed that organisms were identified to SAFIT STE Level I.

3.3.3. Accuracy

One BMI sample was submitted to the CDFW Aquatic Bioassessment Laboratory for QC and had no major taxonomic discrepancies. The QC report is available upon request.

3.3.4. Precision

Duplicate algae and BMI samples were collected at one site in WY 2015. Few major taxonomic discrepancies were found between the field duplicates.

3.3.5. Contamination

All field collection equipment was decontaminated between sites in accordance with the RMC SOP FS-8 and CDFW protocols. As a result, it is assumed that samples were free of biological contamination.

3.4. FIELD MEASUREMENTS

Field measurements of temperature, dissolved oxygen, pH, specific conductivity, and chlorine residual were collected concurrently with bioassessments and water chemistry samples. Chlorine residual was measured using a HACH Pocket Colorimeter^{TM} II, which uses the DPD method. All other parameters were measured with a YSI Professional Plus multi-parameter instrument. All data collection was performed according to RMC SOP FS-3 (Performing Manual Field Measurements).

3.4.1. Completeness

Temperature, dissolved oxygen, pH, specific conductivity, total chlorine residual, and free chlorine residual were collected at all 10 bioassessment sites for a 100% completeness rate.

3.4.2. Sensitivity

Free and total chlorine residual are measured using a HACH Pocket Colorimeter^{TM} II, which uses the DPD method. For this method, the estimated detection limit for the low range measurements (0.02-2.00 mg/L) is 0.02 mg/L. There is, however, no established reporting limit. Based on industry standards and best professional judgment, the method reporting limit is assumed to be 0.1 mg/L, which is much lower than the 0.5 mg/L target reporting limit listed in the RMC QAPP for free and total chlorine residual.

There are also no method reporting limits for temperature, dissolved oxygen, pH, and conductivity measurements, but the actual measurements are much higher than target reporting limits in the RMC QAPP, so it is assumed that target reporting limits are met for all field measurements.

3.4.3. Accuracy

Data collection occurred Monday through Thursday, and the multi-parameter instrument was calibrated at least 12 hours prior to the first sample on Monday, with the dissolved oxygen probe calibrated every morning to ensure accurate measurements. Calibration solutions are certified standards, whose expiration dates were noted prior to use. The chlorine kit is factory-calibrated and does not need to be calibrated.

3.4.4. Precision

Precision could not be measured as no duplicate field measurements were taken.

3.5. WATER CHEMISTRY

Water chemistry samples were collected by SMCWPPP staff concurrently with bioassessment samples, and analyzed were by Caltest Analytical Laboratory (Caltest) within their respective holding times. Caltest performed all internal QA/QC requirements as specified in the QAPP and reported their findings to the RMC. Key water chemistry Measurement Quality Objectives (MQOs) are listed in RMC QAPP Tables 26-1, 26-2, 26-5, and 26-7.

3.5.1. Completeness

All ten water chemistry samples and one duplicate samples were analyzed for all requested analytes, and 100% of results were reported. Water chemistry data were flagged when necessary, but none were rejected.

3.5.2. Sensitivity

Laboratory reporting limits met or were lower than target reporting limits for all nutrients except ammonia and chloride. The reporting limit for one of the ammonia samples and all of the chloride samples exceeded the target reporting limit due to sample dilutions. Chloride concentrations were much higher than reporting limits and the elevated reporting limits do not decrease confidence in the measurements. However, the one ammonia sample with an elevated reporting limit was non-detect, and confidence is diminished for that sample. Target and actual reporting limits are shown in Table 1.

Table 1. Target and actual reporting limits for nutrients analyzed in SMCWPPP creek status monitoring.

Analyte	Target RL mg/L	Actual RL mg/L
Ammonia	0.1	0.1-0.2
Chloride	1	1-20
Total Kjeldahl Nitrogen	0.5	0.1
Nitrate	0.05	0.05
Nitrite	0.03	0.03
Dissolved Organic Carbon	0.6	0.5
Orthophosphate	0.01	0.01
Silica	1	1
Phosphorus	0.01	0.01
Suspended Sediment Concentration	3	3

3.5.3. Accuracy

Recoveries on all laboratory control samples (LCS) were within the MQO target range of 80-120% recovery. Half of the MS/MSD percent recoveries exceeded the MQO range listed in the RMC QAPP for three conventional analytes, including ammonia, nitrate, and silica. The affected samples have been assigned the appropriate SWAMP flag.

The PR range on laboratory reports was as 70-130%, 85-115% or 90-110% for some conventional analytes (nutrients) while the RMC QAPP lists the PR as 80-120% for both LCS and MS for all conventional analytes in water. As a result, some QA samples that exceeded RMC MQOs were flagged by the local QA officer, but not by the laboratory and vice versa.

3.5.4. Precision

The relative percent differences (RPD) for all matrix spike duplicate pairs were within the MQO target of < 25%, but one laboratory duplicate RPD exceeded the RPD MQO for suspended sediment concentration. The field duplicate sample also had several RPD MQO exceedances; the MQO was exceeded for total Kjeldahl nitrogen, chlorophyll a, and ash free dry mass. Due to the nature of chlorophyll a and AFDM collection, discrepancies are to be expected due to the potential natural variability in algae production within the reach and the collection of field duplicates at different locations along each transect (as specified in the protocol). In past years of sampling, TKN was commonly among the analytes that exceed the field duplicate RPD MQOs.

The field duplicate samples and their RPDs are shown in Table 2. Because of the variability in reporting limits, values less than the Reporting Limit (RL) were not evaluated for RPD. For those analytes whose RPDs could be calculated and did not meet the RMC MQO, they were assigned the appropriate SWAMP flag. It should be noted that the laboratory report cited a maximum RPD of 20%, while the RPD limit in the RMC QAPP is 25% for all conventional analytes in water. This discrepancy does not impact any SMCWPPP water chemistry samples.

Table 2. Field duplicate water chemistry results for site 205R01816, collected on April 14, 2015. Data in highlighted rows exceed monitoring quality objectives in RMC QAPP.

Analyte Name	Fraction Name	Unit	Original Result	Duplicate Result	RPD	Exceeds MQO (>25%)
Alkalinity as $CaCO_3$	Total	mg/L	219	224	2%	No
Ammonia as N	Total	mg/L	0.044	< 0.04	N/A	No
Chloride	None	mg/L	40	41	2%	No
Dissolved Organic Carbon	None	mg/L	2.8	2.8	0%	No
Nitrate as N	None	mg/L	< 0.01	< 0.01	N/A	No
Nitrite as N	None	mg/L	< 0.005	< 0.005	N/A	No
Total Kjeldahl Nitrogen	None	mg/L	0.31	0.44	35%	Yes
Ortho Phosphate as P	Dissolved	mg/L	0.07	0.07	0%	No
Phosphorus as P	Total	mg/L	0.069	0.071	3%	No
Silica as SiO2	Total	mg/L	19	19	0%	No
Suspended Sediment Concentration	None	mg/L	< 2	< 2	N/A	No
Chlorophyll a	Particulate	mg/m^2	6.31	8.12	25%	Yes
Ash Free Dry Mass	Fixed	g/m^2	23.96	48.70	68%	Yes

[a] In accordance with the RMC QAPP, if the native concentration of either sample is less than the reporting limit, the RPD is not applicable

3.5.5. Contamination

None of the target analytes were detected in any of the laboratory blanks or in the one field blank collected in San Mateo County.

3.6. SEDIMENT CHEMISTRY

Sediment chemistry samples were collected by Kinnetic Laboratories, Inc (KLI) concurrently with dry season toxicity samples at two sites on July 7, 2015. Inorganic and synthetic organic compounds were analyzed by Caltest and grain size distribution was analyzed by Soil Control Laboratories, a subcontractor laboratory. All samples were analyzed within the one year holding time for analytes in sediment, set by the RMC SOP. Caltest conducted all QA/QC requirements as specified in the RMC QAPP and reported their findings to the RMC. Key sediment chemistry MQOs are listed in RMC QAPP Tables 26-4, 26-6, and 26-7.

3.6.1. Completeness

Both planned samples were analyzed for all requested analytes, and 100% of results were reported. Sediment chemistry data were flagged when necessary, but none were rejected.

3.6.2. Sensitivity

Laboratory reporting limits were generally much higher than target reporting limits for metals, while RLs for polycyclic aromatic hydrocarbons (PAHs) and grain size distribution categories were much lower than target RLs. Organochlorine and pyrethroid pesticide RLs generally met or were slightly lower than target RLs. Target and actual reporting limits for analytes with higher reporting limits than designated in the QAPP are shown in Table 3. For the analytes in Table 3, all sample concentrations were higher than laboratory reporting limits, except for gamma-HCH, heptachlor epoxide, which were below the detection limit for both sites, and trans-permethrin at one site, which was above the detection limit, but below the reporting limit. The trans-permethrin concentration was still below the target detection limit, and would not be qualified differently had the laboratory RL matched the target RL.

Table 3. Target and actual reporting limits for metals in sediment analyzed in SMCWPPP creek status monitoring.

Analyte	Target RL mg/kg	Actual RL mg/kg
Arsenic	0.3	0.5-0.51
Cadmium	0.01	0.04
Chromium	0.1	0.2
Copper	0.01	0.2
Lead	0.01	0.1
Nickel	0.02	0.1-0.2
Zinc	0.1	2-4
Heptachlor epoxide	1	2
Gamma-HCH	1	2
Permethrin (cis and trans)	0.33	0.41
Total organic carbon	0.01%	0.12%

3.6.3. Accuracy

Inorganic Analytes

The PR MQO for inorganic analytes in sediment (metals) listed in the RMC QAPP and in the laboratory reported is 75-125%. No QA samples exceeded the MQO for LCS or MS percent recovery for metals.

Synthetic Organic Compounds

The recovery MQO for synthetic organic compounds in sediment (PAHs, organochlorine and pyrethroid pesticides) is 70-130% for LCS and 50-150% for matrix spikes in the RMC QAPP. However, the PR MQOs listed in the laboratory reports for synthetic organic compounds varied by analyte and were much larger than PR ranges listed in the QAPP. The MQOs ranged from 1 to 275% in certain cases. Several analytes were flagged by the local QA officers, but not by the laboratory.

The recovery of LCS and LCS duplicates exceeded the RMC MQO lower limit for all four PAHs (anthracene, benz(a)anthracene, benzo(a)pyrene, perylene) and two organochlorine pesticides, including DDD(p,p'),DDT(p,p'). The MS/MSD percent recoveries exceeded the RMC MQO range for three PAHs (benzo(g,h,i)perylene, 2,6-dimethylnaphthalene, and indeno(1,2,3-c,d)pyrene), three organochlorine pesticides (DDT(o,p'), DDT(p,p'), and endrin), and one pyrethroid pesticide (cypermethrin). Analytes that exceeded RMC MQOs were flagged, but no data were rejected.

3.6.4. Precision

Inorganic Analytes

The RMC QAPP lists the maximum RPD for inorganic analytes (metals) as 25%, while the laboratory report lists the maximum as 30% for most metals and 35% for mercury. None of the duplicates for metals exceeded the RMC RPD MQO.

Synthetic Organic Compounds

The maximum RPD for synthetic organics listed in the sediment laboratory report lists ranges from 30 to 50% for most analytes, and are much higher for gamma-BHC (Lindane) and p,p'-DDT at 52% and

59%,respectively. However, the RMC QAPP lists the MQO as less than 25% RPD for all synthetic organics. The RPD for duplicates was evaluated using the RMC MQO of < 25%, and as a result, several analytes that were not flagged by the laboratory were flagged by the local QA officer. The RPD for MS/MSDs exceeded the RMC QAPP MQOs for one pyrethroid pesticide (cypermethrin) and several PAHs (benz(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, benzo(e)pyrene, chrysene, fluoranthene, phenanthrene, pyrene).

Field Duplicates

A sediment sample field duplicate was collected in Contra Costa County on July 7, 2015, and evaluated for precision. The field duplicate sample and corresponding RPDs are shown in Table 4. Because of the variability in reporting limits, values less than the Reporting Limit (RL) were not evaluated for RPD. Analytes that exceeded the MQO of RPD < 25% were coarse sand (0.5-1.0 mm), cyfluthrin, benz(a)anthracene, deltamethrin/tralomethrin, 1-methylnaphthalene, nitrobenzene-d5 (surrogate), and phenanthrene. Given the inherent variability associated with field duplicates, the low number of analytes whose RPDs fall outside of the MQO limits is remarkable. However, the method used to collect sediment field duplicates provides more insight to laboratory precision than precision of field methods, but the results do suggest that field methods are very precise.

Table 4. Sediment chemistry duplicate field results for site 206R01024, collected on July 7, 2015 in Contra Costa County. Data in highlighted rows exceed monitoring quality objectives in RMC QAPP.

Analyte		Unit	Original	Duplicate	RPD	Exceeds MQO? (<25%)
Grain Size Distribution	Clay: <0.0039 mm	%	29.96	29.46	2%	No
	Silt: 0.0039 to <0.0625 mm	%	49.68	48.4	3%	No
	Granule: 2.0 to <4.0 mm	%	0.46	< 0.01	N/A	N/A
	Sand: Coarse 0.5 to <1.0 mm	%	0.54	0.39	32%	Yes
	Sand: Fine 0.125 to <0.25 mm	%	4.9	5.29	8%	No
	Pebble: Large 16 to <32 mm	%	< 0.01	< 0.01	N/A	N/A
	Sand: Medium 0.25 to <0.5 mm	%	1.48	1.18	23%	No
	Pebble: Medium 8 to <16 mm	%	< 0.01	< 0.01	N/A	N/A
	Pebble: Small 4 to <8 mm	%	0.8	< 0.01	N/A	N/A
	Sand: V. Coarse 1.0 to <2.0 mm	%	0.47	0.52	10%	No
	Sand: V. Fine 0.0625 to <0.125 mm	%	12.97	14.76	13%	No
	Pebble: V. Large 32 to <64 mm	%	< 0.01	< 0.01	N/A	N/A
Metals	Arsenic	mg/Kg dw	5.8	5.7	2%	No
	Cadmium	mg/Kg dw	0.52	0.51	2%	No
	Chromium	mg/Kg dw	17	17	0%	No
	Copper	mg/Kg dw	16	16	0%	No
	Lead	mg/Kg dw	9.3	9.3	0%	No
	Mercury	mg/Kg dw	0.056	0.055	2%	No
	Nickel	mg/Kg dw	28	28	0%	No
	Zinc	mg/Kg dw	70	67	4%	No
Organochlorine Compounds	Chlordane, cis-	ng/g dw	< 1.1	< 1.1	N/A	N/A
	Chlordane, trans-	ng/g dw	< 1.1	< 1.1	N/A	N/A
	DDD(o,p')	ng/g dw	< 2.2	< 2.2	N/A	N/A
	DDD(p,p')	ng/g dw	< 0.86	< 0.87	N/A	N/A
	DDE(o,p')	ng/g dw	< 2.2	< 2.2	N/A	N/A
	DDE(p,p')	ng/g dw	< 1.3	< 1.3	N/A	N/A
	DDT(o,p')	ng/g dw	< 2.2	< 2.2	N/A	N/A
	DDT(p,p')	ng/g dw	< 1.1	< 1.1	N/A	N/A
	Dieldrin	ng/g dw	< 1.3	< 1.3	N/A	N/A
	Endrin	ng/g dw	< 1.1	< 1.1	N/A	N/A

Table 4. Sediment chemistry duplicate field results for site 206R01024, collected on July 7, 2015 in Contra Costa County. Data in highlighted rows exceed monitoring quality objectives in RMC QAPP.

Analyte		Unit	Original	Duplicate	RPD	Exceeds MQO? (<25%)
	HCH, gamma-	ng/g dw	< 0.76	< 0.76	N/A	N/A
	Heptachlor Epoxide	ng/g dw	< 1.2	< 1.2	N/A	N/A
Pyrethroids	Bifenthrin	ng/g dw	2.7	2.4	12%	No
	Cyfluthrin, total	ng/g dw	0.72	0.96	29%	Yes
	Cyhalothrin, Total lambda-	ng/g dw	0.16	< 0.065	N/A	N/A
	Cypermethrin, total	ng/g dw	0.21	0.22	5%	No
	Permethrin, cis-	ng/g dw	1	0.99	1%	No
	Permethrin, trans-	ng/g dw	0.45	0.41	9%	No
	Total Organic Carbon	%	2.4	2.4	0%	No
Polycyclic Aromatic Hydrocarbons	Acenaphthene	ng/g dw	< 3.2	< 3.3	N/A	N/A
	Acenaphthylene	ng/g dw	< 3.2	< 3.3	N/A	N/A
	Anthracene	ng/g dw	5.4	4.3	23%	No
	Benz(a)anthracene	ng/g dw	22	11	67%	Yes
	Benzo(a)pyrene	ng/g dw	65	54	18%	No
	Benzo(b)fluoranthene	ng/g dw	< 3.2	< 3.3	N/A	N/A
	Benzo(e)pyrene	ng/g dw	86	76	12%	No
	Benzo(g,h,i)perylene	ng/g dw	43	43	0%	No
	Benzo(k)fluoranthene	ng/g dw	< 3.2	< 3.3	N/A	N/A
	Biphenyl	ng/g dw	4.3	< 3.6	N/A	N/A
	Chrysene	ng/g dw	65	76	16%	No
	Decachlorobiphenyl(Surrogate)	% Recovery	107	95	12%	No
	Deltamethrin/Tralomethrin	ng/g dw	0.68	0.3	78%	Yes
	Dibenz(a,h)anthracene	ng/g dw	22	< 3.3	N/A	N/A
	Dibenzothiophene	ng/g dw	< 3.6	< 3.6	N/A	N/A
	Dimethylnaphthalene, 2,6-	ng/g dw	65	65	0%	No
	Esfenvalerate/Fenvalerate, total	ng/g dw	< 0.14	< 0.14	N/A	N/A
	Esfenvalerate-d6-1(Surrogate)	% Recovery	85	89	5%	No
	Esfenvalerate-d6-2(Surrogate)	% Recovery	85	88	3%	No
	Fluoranthene	ng/g dw	< 3.2	< 3.3	N/A	N/A
	Fluorene	ng/g dw	< 3.2	< 3.3	N/A	N/A
	Fluorobiphenyl, 2-(Surrogate)	% Recovery	66	58	13%	No
	Indeno(1,2,3-c,d)pyrene	ng/g dw	< 3.2	< 3.3	N/A	N/A
	Methylnaphthalene, 1-	ng/g dw	4.3	3.3	26%	Yes
	Methylnaphthalene, 2-	ng/g dw	7.6	6.5	16%	No
	Methylphenanthrene, 1-	ng/g dw	< 3.2	< 3.3	N/A	N/A
	Naphthalene	ng/g dw	5.4	4.3	23%	No
	Nitrobenzene-d5(Surrogate)	% Recovery	53	39	30%	Yes
	Perylene	ng/g dw	< 16	< 3.3	N/A	N/A
	Phenanthrene	ng/g dw	22	11	67%	Yes
	Pyrene	ng/g dw	< 3.2	< 3.3	N/A	N/A
	Terphenyl-d14(Surrogate)	% Recovery	48	52	8%	No
	Tetrachloro-m-xylene(Surrogate)	% Recovery	61	52	16%	No

3.6.5. Contamination

None of the target analytes were detected in any of the blanks.

3.7. TOXICITY TESTING

Water samples were collected at two San Mateo County sites twice during WY2015 – once during a rain event (February 6, 2015) and a once during the dry season (July 7, 2015). Sediment samples were also collected at the same two sites during the dry season event. The water samples were analyzed for toxicity to four organisms – *Selenastrum capricornutum, Ceriodaphnia dubia, Pimephales promelas, and Hyalella azteca* – and the sediment samples were analyzed for toxicity to *Hyalella azteca.* Internal laboratory procedures that align with the RMC QAPP, including water and sediment quality testing and reference toxicant testing, were performed and submitted to SMCWPPP. The laboratory data QC checks found that all conditions and responses were acceptable. No toxicity results were rejected.

3.8. PATHOGEN INDICATORS

Pathogen indicator samples collected by KLI were analyzed by BioVir. Samples were collected on the morning of June 30, 2015 and were analyzed on later that day. *E. coli*, fecal coliform, and total coliform were reported for five field samples, along with a laboratory duplicate and a method blank.

3.8.1. Completeness

The five planned pathogen samples were collected and analyzed for a100% completeness rate. No data were rejected.

3.8.2. Sensitivity

All reported coliform reporting limits were above the target RL 2 MPN/100mL listed in the project QAPP.

3.8.3. Accuracy

No certified reference material (CRM) was run for pathogen indicators. As a result, accuracy could not be calculated for pathogen indicators.

3.8.4. Precision

One laboratory duplicate was run for the three pathogen indicators. However, the QAPP requires a minimum of 15 duplicate samples before MQO measurements can be made. As a result, pathogen samples could not be evaluated for precision, and no samples were flagged.[3]

3.8.5. Contamination

One method blank was run in the batch for E. coli, fecal coliform, and total coliform. All three analytes were less than the MDL/RL (2 MPN/100mL).

3.9. CONTINUOUS WATER QUALITY

Continuous water quality measurements were recorded at two sites once during the beginning of the monitoring index period in May 2015 and again at the end of the index period in August 2015, for a total of four events. Temperature, pH, dissolved oxygen, and specific conductivity were recorded once every 15 minutes over two-week deployments using a multi-parameter water quality sonde (YSI 6600-V2)

3.9.1. Completeness

The minimum number of monitoring events and sites was met, but 70% of the dissolved oxygen data was flagged and rejected for second event at the site on San Mateo Creek at El Camino, 204SMA058. The beginning and the end of the deployment showed the diurnal pattern seen in the other parameters and

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[3] For the one set of duplicates run, the RPDs for the E. coli and fecal coliform were 67%, while the RPD for total coliform was 93%.

upstream site, but a large portion maintained a concentration of 0 mg/L. This was likely a result of a temporary sensor malfunction, as the sonde passed the drift check (see Table 5). Unfortunately, a replacement sonde could not be deployed and the dissolved oxygen data were flagged and rejected. Though 70% of the dissolved oxygen data rejected was rejected for that event, it only constituted 4.5% of all the continuous water quality monitoring data collected in San Mateo County. As a result, the overall completion rate for continuous water quality monitoring was 95.5%.

3.9.2. Sensitivity

There are no method reporting limits for temperature measurements, but the actual measurements are much higher than target reporting limits in the RMC QAPP, so it is assumed that target reporting limits are met for all field measurements.

3.9.3. Accuracy

A summary of the drift measurements is shown in Table 5. All drift calculations met their corresponding measurement quality objective, including Event 1 at 204SMA058, which had a sensor malfunction.

Table 5. Drift measurements for two continuous water quality monitoring events in San Mateo urban creeks during WY 2015. Bold and highlighted values exceeded measurement quality objectives.

Parameter	Measurement Quality Objectives	204SMA058		204SMA059	
		Event 1	Event 2	Event 1	Event 2
Dissolved Oxygen (mg/l)	± 0.5 mg/L or 10%	-0.39	-0.13	-0.42	0.39
pH 7.0	± 0.2	-0.07	-0.17	0.02	-0.07
pH 10.0	± 0.2	-0.01	0.16	0.03	0.01
Specific Conductance (uS/cm)	± 10%	-0.1%	-0.9%	0.2%	-0.6%

3.9.4. Precision

A quick test not required by the RMC QAPP was run to evaluate the precision of the sondes. Following the final monitoring event, the two sondes were placed in a water bath with an extra sonde and were allowed to run for an hour at a 30-second recording interval. The median of each parameter (temperature, pH, dissolved oxygen, and conductivity) for each sonde was compared to the overall median. The only parameter with a non-zero RPD was conductivity. However, all of the RPDs were less than 15% and attributed to the fact that potable water is below the conductivity probe's minimum detection limit.

3.10. CONTINUOUS TEMPERATURE MONITORING

Continuous temperature monitoring was conducted from April through September 2015 at five sites in San Mateo County. Onset HOBO Water Temperature Data loggers recorded one measurement per hour.

3.10.1. Completeness

Anticipating a lost HOBO temperature logger or premature stream desiccation, SMCWPPP deployed one extra temperature logger, for a total of five loggers. All five loggers were retrieved and no data were rejected for an over 100% completeness rate.

3.10.2. Sensitivity

There is no target reporting limit for temperature listed in the RMC QAPP, thus sensitivity could not be evaluated for continuous temperature measurements.

3.10.3. Accuracy

A pre-deployment accuracy check was run on the temperature loggers, and none of the loggers exceeded the 0.2 °C mean difference for the room temperature bath or ice bath.

3.10.4. Precision

There are no precision protocols for continuous temperature monitoring.

4. CONCLUSIONS

All data that were planned were collected, and data that exceeded measurement quality objectives were flagged. Continuous dissolved oxygen measurements were rejected at 205SMA058 due to a sensor malfunction, but the overall project was over 95% complete.

5. REFERENCES

Bay Area Stormwater Management Agency Association (BASMAA). 2012. Regional Monitoring Coalition Final Creek Status and Long-Term Trends Monitoring Plan. Prepared By EOA, Inc. Oakland, CA. 23 pp.

Bay Area Stormwater Management Agency Association (BASMAA) Regional Monitoring Coalition. 2014a. Creek Status Monitoring Program Quality Assurance Project Plan, Final Draft Version 2. Prepared for BASMAA by EOA, Inc. on behalf of the Santa Clara Urban Runoff Pollution Prevention Program and the San Mateo Countywide Water Pollution Prevention Program, Applied Marine Sciences on behalf of the Alameda Countywide Clean Water Program, and Armand Ruby Consulting on behalf of the Contra Costa Clean Water Program. 80 pp plus appendices.

Bay Area Stormwater Management Agency Association (BASMAA) Regional Monitoring Coalition. 2014b. Creek Status Monitoring Program Standard Operating Procedures Version 2. Prepared for BASMAA by EOA, Inc. on behalf of the Santa Clara Urban Runoff Pollution Prevention Program and the San Mateo Countywide Water Pollution Prevention Program, Applied Marine Sciences on behalf of the Alameda Countywide Clean Water Program, and Armand Ruby Consulting on behalf of the Contra Costa Clean Water Program. 203 pp.

Surface Water Ambient Monitoring Program (SWAMP) Quality Assurance Team. 2008. SWAMP Quality Assurance Program Plan, Version 1.0. Prepared for the California State Water Quality Control Board by Moss Landing Marine Laboratories and San Jose State University Research Foundation. 1 September. 108 pp.

Appendix B

San Mateo Creek Low Dissolved Oxygen SSID Final Project Report

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

County Government Center
555 County Center, 5th Floor
Redwood City, CA 94063

P 650.599.1514
F 650.363.7882
flowstobay.com

July 9, 2015

Mr. Bruce H. Wolfe
Executive Officer
San Francisco Bay Regional Water Quality Control Board
1515 Clay Street, Suite 1400
Oakland, CA 94612

Subject: Submittal of SMCWPPP Stressor/Source Identification Final Project Report (San Mateo Creek Low Dissolved Oxygen)

Dear Mr. Wolfe:

On behalf of all San Mateo Countywide Pollution Prevention Program (SMCWPPP) Permittees, I am pleased to submit the San Mateo Creek Low Dissolved Oxygen Stressor/Source Identification (SSID) Final Project Report. This SSID Final Project Report is submitted in compliance with Provision C.8.d of the Municipal Regional Stormwater NPDES Permit (Order # R2-2009-0074), also known as the MRP. The report contains descriptions of water quality monitoring conducted as part of a site specific study to investigate low dissolved oxygen conditions identified through Creek Status Monitoring (Provision C.8.c) in San Mateo Creek. The study results suggest that low dissolved oxygen no longer occurs on a large scale in San Mateo Creek due to a new Crystal Springs Reservoir release schedule implemented by the San Francisco Public Utilities Commision (SFPUC).

We look forward to discussing the findings and conclusions included in the San Mateo Creek Low Dissolved Oxygen SSID Final Project Report and to continuing to work with you and your staff to successfully address new challenges regarding water quality monitoring. Please contact me if you have any comments or questions.

Certification Regarding SMCWPPP Stressor/Source Identification Final Project Report

"I certify, under penalty of law, that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to ensure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted, is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

Sincerely,

Matthew Fabry

Matthew Fabry
Program Coordinator

cc: SMCWPPP Watershed Assessment and Monitoring Subcommittee
Tom Mumley, Water Board Assistant Executive Officer
Jan O'Hara, Water Board Staff

Attachments: San Mateo Creek Low Dissolved Oxygen Final Project Report

SAN MATEO CREEK LOW DISSOLVED OXYGEN STRESSOR/SOURCE IDENTIFICATION STUDY

Prepared in support of provision C.8.d.i of
NPDES Permit # CAS612008

Final Project Report

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

San Mateo Countywide Water Pollution Prevention Program

June 23, 2015

EXECUTIVE SUMMARY

This report presents the results of the San Mateo Creek Low Dissolved Oxygen Stressor/Source Identification (SSID) project which was conducted to address requirements in the San Francisco Bay Municipal Regional Permit (MRP) for discharges of stormwater runoff. Per MRP Provision C.8.d.i, the San Mateo Countywide Water Pollution Prevention Program (SMCWPPP) has conducted two SSID Projects focused on follow-up to creek status monitoring data that exceed trigger thresholds (the second SSID project addressed indicator bacteria and will be reported on separately). SSID projects are designed to identify and isolate potential sources and/or stressors associated with observed potential water quality impacts. Additional actions required by Provision C.8.d.i are to identify and evaluate the effectiveness of potential actions for controlling the cause(s) of the trigger stressor/source and to confirm the problem was addressed.

Historical and more recent (WY2013) monitoring data collected in the vicinity of De Anza Park in the San Mateo Creek watershed showed dissolved oxygen (DO) concentrations below the water quality objective (WQO) of 7 mg/L for waters designated as cold water habitat. During WY2014 SMCWPPP conducted a SSID project to address this potential water quality concern. Results of the SSID investigation suggest that low DO conditions are no longer expected in this reach of San Mateo Creek due to a recently implemented ongoing schedule of increased dry season releases of water from the upstream Crystal Springs Reservoir. These findings are currently being confirmed through one additional year of Creek Status Monitoring conducted per MRP Provision C.8.c. No additional management measures are recommended at this time (beyond the new ongoing dry season controlled releases) and the SSID project should be considered complete.

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1.0 INTRODUCTION

This report presents the results of the San Mateo Creek Low Dissolved Oxygen Stressor/Source Identification (SSID) Project which was conducted in WY2014 to address requirements listed under Provision C.8.d.i of the San Francisco Bay Region National Pollutant Discharge Elimination System (NPDES) Municipal Regional Permit (MRP) for discharges of stormwater runoff. Per MRP Provision C.8.d.i, the San Mateo Countywide Water Pollution Prevention Program (SMCWPPP) is conducting two SSID Projects focused on follow-up to creek status monitoring data that exceed trigger thresholds (per Table 8.1 of the MRP). SSID projects are designed to identify and isolate potential sources and/or stressors associated with observed potential water quality impacts. Additional actions required by Provision C.8.d.i are to identify and evaluate the effectiveness of potential actions for controlling the cause(s) of the trigger stressor/source, and to confirm the problem was addressed.

Based on historical and recent monitoring data with results below the dissolved oxygen (DO) water quality objective (WQO) of 7 mg/L for waters designated as cold water habitat, SMCWPPP conducted a low DO SSID Project in the San Mateo Creek watershed. The SSID field investigations in WY2014 did not identify low DO concentrations similar to those recorded in WY2003 (SFRWQCB 2007) and WY2013 (SMCWPPP 2014b). It is likely that reduced DO concentrations can develop in pockets at the bottom of deep pools during low flow conditions. However, these pockets are currently less likely to form due to a new dry season controlled release schedule from an upstream reservoir. Furthermore, the low DO pockets are limited in geographic extent and duration due to daily recirculation/turnover of the pools. Therefore, they probably do not impact cold fresh water habitat beneficial uses for the overall reach investigated. No management measures are recommended at this time (beyond the new ongoing dry season controlled releases) and the SSID project should be considered complete.

Chapter 2.0 of this report describes the watershed. Chapter 3.0 summarizes previous water quality monitoring background on WQOs. Chapter 4.0 presents the SSID field methods and findings. Chapter 5.0 includes a discussion of the results and recommendations for future monitoring. Chapter 6.0 is a list of referenced citations.

1.1 Dissolved Oxygen

Dissolved oxygen is a measure of how much oxygen is dissolved in water. Because it is crucial for aquatic organisms, DO is commonly measured to assess stream health. Different types of organisms require different amounts of DO, with salmonids and Plecoptera (stoneflies) typically requiring higher concentrations than warm water organisms. The Water Quality Control Plan for the San Francisco Bay Basin (Basin Plan; SFRWQCB 2013) lists WQOs for DO in non-tidal waters as follows: 5.0 mg/L minimum for waters designated as warm water habitat (WARM) and 7.0 mg/L minimum for waters designated as cold water habitat (COLD). Although these WQOs provide suitable thresholds to evaluate triggers, further evaluation may be needed to assess the overall extent and degree that COLD and/or WARM beneficial uses are supported at a specific location. For example, lower reaches of a stream may not support salmonid spawning or rearing habitat, but may be important for upstream or downstream fish migration. Salmonid use, life stage, and/or other fish communities should be considered when evaluating DO concentrations in a stream.

Oxygen enters streams through the atmosphere and, sometimes, through groundwater discharge. In fast-moving stream reaches, water is aerated by bubbles as it moves through riffles. In slow-moving stream reaches, oxygen may only enter via the top layer of water. Cold water can hold more oxygen than warm water; therefore, the concentration of DO in water is inversely related to water temperature and daily and seasonal fluctuations are typical. Natural processes also affect DO concentration in water including aquatic plant photosynthesis, which releases oxygen, and respiration by plants, bacteria, and other organisms, which consumes oxygen.

1.1.1 Dissolved Oxygen Reduction Factors

There are several factors that may have been driving the previously observed reduction in dissolved oxygen in San Mateo Creek. These include increased residence time, reduced potential for re-aeration, and increased loading of organic material and nutrients. These factors in combination may result in higher rates of biological oxygen demand (BOD) and sediment oxygen demand (SOD).

- **Residence time** is the amount of time that water remains in a water body (i.e., reduced flow increases the residence time).
- **Re-aeration** is the net rate of transfer of oxygen from the atmosphere to a body of water at the air/water interface. The transfer rate increases with greater surface area-to-volume ratio and water turbulence.
- **Biochemical oxygen demand (BOD)** is the consumption (or decrease) of dissolved oxygen in water caused by microorganisms during the break down of organic material, oxidation of reduced inorganic compounds, conversion of organic nitrogen into ammonia and nitrate by bacteria, or respiration by plants, bacteria, and invertebrates. **Sediment oxygen demand (SOD)** refers to consumption of oxygen by these same processes when they occur in the channel substrate.

Human activities, including residential/commercial development, agriculture, and industrial practices can contribute to DO depletion in the receiving waters. Land use changes may result in modifications to both stream flow and channel geometry. In addition, anthropogenic activities may directly introduce chemical contaminants, organic material, and nutrients to the creek, via non-point sources such as vehicle emissions, fertilizers, pesticides, yard and animal wastes, and septic systems. These substances can increase the chemical and biochemical oxygen demand, primarily through increased respiration of plants and microbes.

1.1.1.1 Residence Time and Re-aeration

Stream impoundments and/or diversions can reduce flow velocity and turbulence resulting in higher residence times. Straightening and/or deepening of the channel can reduce the surface-to-volume ratio leading to lower re-aeration rates. Anthropogenic activities that result in decreases in channel gradient (e.g., channel subsidence, increased sediment loading) can reduce the flushing and/or mixing of water. The removal of vegetation along the riparian corridor can lower potential inputs of large woody debris that provide habitat and channel complexity that may also increase the potential for water turbulence.

1.1.1.2 Organic and Nutrient Loading

Anthropogenic activities (e.g., vegetation management, landscaping) may result in a greater amount of organic material and nutrients being delivered to the stream. Organic material in the stream may come from two sources: 1) aquatic macrophytes and algae growing in the stream (autochthonous source); and 2) external sources such as leaf/grass litter, soil erosion and animal waste (allochthonous sources). Increase in nutrient concentrations can result in increased rates of primary productivity, which in turn, can increase DO concentrations at the water surface during the day, but reduce DO levels at night or at the stream bottom where light is unable to sufficiently penetrate. Following algal blooms, DO reductions can occur as algae community shifts to respiration (in the absence of light) and during the process of decomposition of dead algae by bacteria.

1.1.1.3 Biological and Sediment Oxygen Demand

Changes in channel geometry that result in reduced rates of mixing and/or flushing of water, coupled with increased loading of organic material, may result in higher levels of BOD and SOD (i.e., increasing the period that substances can exert an oxygen demand in the reach). These conditions may result in an increased potential for oxygen consumption associated with microbial decomposition of organic matter and respiration by plants, bacteria and invertebrates. During periods of low flow conditions, oxygen demand may be driven by external sources (i.e. water flowing from upstream and urban runoff inputs), or internal sources (i.e., fine sediment, chemical substances and organic material deposited on bottom of stream).

1.1.1.4 Secondary Drivers (Temperature and Sediment)

Temperature and sediment are considered secondary drivers that affect the primary drivers. Human activities (e.g., riparian vegetation removal) can result in higher solar radiation and increase water temperatures in the stream. Increasing temperature tends to reduce DO concentrations by reducing oxygen's solubility in water. Surface heating (i.e., stratification) can decrease re-aeration of water below the surface. Increase in water temperatures can also result in higher algal growth rates, as well as increasing the rates of DO-depleting reactions such as decomposition and respiration.

High suspended sediment concentrations can potentially impact DO concentrations by reducing the light penetration and visibility in the stream, which may in turn reduce photosynthesis and growth by submerged aquatic plants, phytoplankton, and periphyton. High suspended sediment can also result in an increase in heat absorption, leading to increased water temperatures (and lower DO levels). Deposited and bedded sediments may lead to reduced oxygen levels by either restricting flow through streambed substrates or by oxygen consumption by bacterial respiration, especially when sediments contain a high concentration of organic matter.

Another important effect on BOD concentrations is the BOD originating from upstream sources. Imported BOD concentrations are the concentration of BOD-generating substances (e.g., algal biomass) from upstream reaches, tributaries or storm water outfalls.

2.0 Study Area

San Mateo Creek drains a 33-square mile watershed including parts of unincorporated San Mateo County, the City of San Mateo, and the Town of Hillsborough. The upper 88 percent of the watershed is characterized by the northwest/southeast trending ridges and valleys of the San Andreas Rift Zone and the Santa Cruz Mountains. Runoff from this undeveloped 29-square mile area drains to a system of reservoirs which were constructed in the late 1800s and are now owned and operated by the San Francisco Public Utilities Commission (SFPUC). These include the San Andreas Reservoir, Upper Crystal Springs Reservoir, and Lower Crystal Springs Reservoir, all of which are oriented along the northwest trending San Andreas Rift Zone.

Below the Lower Crystal Springs reservoir dam, the watershed encompasses approximately five square miles and is mostly urbanized. The overall watershed imperviousness below the dam is approximately 38 percent (STOPPP 2002). Low and medium density residential uses characterize the area upstream of El Camino Real. High density residential and commercial uses characterize the watershed downstream of El Camino Real. Runoff from these areas is conveyed to the creek via a network of underground storm drain pipes (i.e., the MS4). Nearly 50 percent of the creek channel below the dam is modified (STOPPP 2002). Flows are conveyed within engineered channels and underground pipes, including a 2,000 foot culvert that begins downstream of El Camino Real. San Mateo Creek flows to San Francisco Bay at Ryder Park, just south of Coyote Point.

2.1 Lower Crystal Springs Dam Improvements

The Crystal Springs Reservoir System serves as the emergency water supply for San Mateo and San Francisco Counties. It is owned and operated by the SFPUC and consists of Upper and Lower Crystal Springs Reservoirs, San Andreas Reservoir, and various tunnels, pipes, pumps, and outlet structures. SFPUC’s Water System Improvement Program (WISP) includes two related projects that affect baseflows in San Mateo Creek. Together, the Crystal Springs/San Andreas Transmission System Upgrade and the Lower Crystal Springs Dam Improvements projects repair existing leaks in the system and set a schedule for controlled releases.

Construction on the Lower Crystal Springs Dam and Pump Station was conducted between January and October 2014. Prior to construction, dry weather flows below the dam were limited to approximately 0.6 cubic feet per second (cfs) as the result of water leaks from aging pipes at the Pump Station. During the construction period, leaks were sealed and water was pumped from the reservoir directly into the creek, resulting in dry season flows that averaged about 1.0 cfs. Occasional flow pulses were also generated to maintain water temperature targets below the dam (Aaron Brinkerhoff, SFPUC, personal communication, January 2015). The WISP projects were officially completed in January 2015, following a successful test of the emergency high flow release valve[1]. With completion of the project, the SFPUC began implementation of a defined water release schedule intended to enhance habitat for steelhead and other native fish in lower San Mateo Creek. Release schedule baseflows, measured at the U.S. Geological Survey (USGS) gage located approximately 0.2 mile downstream of the dam (USGS Gage #11162753),

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[1] Approximately 350 cfs was released during a 2-hour period on January 15, 2015.

must range from 3 to 17 cfs, depending on the water year type (e.g., dry, normal, wet) and the time of year (NMFS 2010). The release schedule was approved by the U.S. Army Corps of Engineers as part of the formal consultation process with the National Marine Fisheries Service (NMFS) and the California Department of Fish and Game (CDFG) for Endangered Species Act compliance for the WISP projects (San Francisco Planning Department 2010). In addition to minimum releases, the SFPUC will conduct aquatic resource monitoring for ten years following project completion. SFPUC monitoring in San Mateo Creek below the dam will consist of water quality measurements (continuous temperature and DO, pH and turbidity grab samples), steelhead spawning surveys, smolt migrant trapping, fish population surveys, and benthic macro-invertebrate community sampling (ENTRIX/MSE 2009).

2.2 Beneficial Uses

Beneficial uses in San Mateo Creek are designated by the San Francisco Bay Regional Water Quality Control Board (SFRWQCB) and generally apply to all tributaries. Designated beneficial uses include: freshwater replenishment (FRSH), cold freshwater habitat (COLD), fish migration (MIGR), preservation of rare and endangered species (RARE), fish spawning (SPWN), warm freshwater habitat (WARM), wildlife habitat (WILD), water contact recreation (REC-1), and non-contact recreation (REC-2).

Review of historical records suggests that San Mateo Creek once supported coho salmon, steelhead trout (anadromous), rainbow trout (nonanadromous), and California roach (Leidy et al. 2005). Steelhead trout may still use San Mateo Creek for both spawning and rearing; however, Crystal Springs Dam forms a barrier to fish migration, limiting access to higher quality habitat in the upper watershed. If steelhead do spawn in Lower San Mateo Creek, it would occur sometime between January and April. Young fry would stay in the creek for several years before heading out to sea.

3.0 Previous Water Quality Monitoring

3.1 Surface Water Ambient Monitoring Program (2003)

In 2003, the SFRWQCB monitored seven stations within the San Mateo Creek Watershed to assess water quality and establish regional reference sites as part of the Surface Water Ambient Monitoring Program (SWAMP) (Figure 1). The seven stations were selected to represent a range of subwatershed, ecoregion subsections, elevations, stream characteristics, and land use. Sondes programmed to continuously monitor pH, DO, temperature, and specific conductivity were deployed for one or two week "episodes" during three parts of the annual hydrograph: wet season, decreasing hydrograph/spring, and dry season (SFRWQCB 2007). DO concentrations measured at two of the stations below Crystal Springs reservoir were below the cold water minimum WQO of 7 mg/L during the spring (April 27 to May 12, 2003), summer (August 7 to 25, 2003), and fall (October 20 to 31, 2003) episodes. These stations were located at Gateway Park (station SMA020) near the upstream extent of the tidally-influenced reach of San Mateo Creek, and at Arroyo Court/De Anza Historical Park (SMA060) approximately 200 feet upstream of the El Camino Real crossing. Due to large fluctuations in DO (i.e., maximum DO percent saturation levels were measured above 120 percent), the SFRWQCB (2007) report concluded that the pattern of DO concentrations was consistent with excessive photosynthesis.

The SWAMP sampling program also included benthic macroinvertebrate sampling and physical habitat measurements conducted in spring 2003 to assess ecological condition (SFRWQCB 2007). All stations below Crystal Springs Dam were categorized as having poor conditions based on low benthic macroinvertebrate taxa richness and low abundance of sensitive species (Ephemeroptera, Plecoptera, Tricoptera [EPT]). These findings are typical of urban streams.

3.2 Watershed Assessment and Monitoring Program (2004)

SMCWPPP (formerly referred to as STOPPP) performed screening-level biological and chemical water quality monitoring in 2004 as part of its Watershed Assessment and Monitoring Program (SMCWPPP 2005). Benthic macroinvertebrates were collected, visual assessments of physical habitat were conducted, and conventional water quality parameters (temperature, pH, conductivity, and DO) were measured in April 2004 at six of the SWAMP stations, including SMA020 and SMA060. Grab water samples were collected in February 2004 at four of the stations, including SMA020 and SMA060, and were tested for organophosphorus pesticides and toxicity (ceriodaphnia, pimephales, selenastrum). Benthic macroinvertebrate assemblages measured in April 2004 by SMCWPPP were similar to those measured by SWAMP in 2003. Low concentrations of DO were not recorded in the spot measurements, organophosphorus pesticides were not detected, and toxicity was not observed at SMA020 and SMA060. SMCWPPP (2005) concluded that poor ecological conditions measured in San Mateo Creek below Crystal Springs Dam were likely the result of urbanization in the lower part of the watershed.

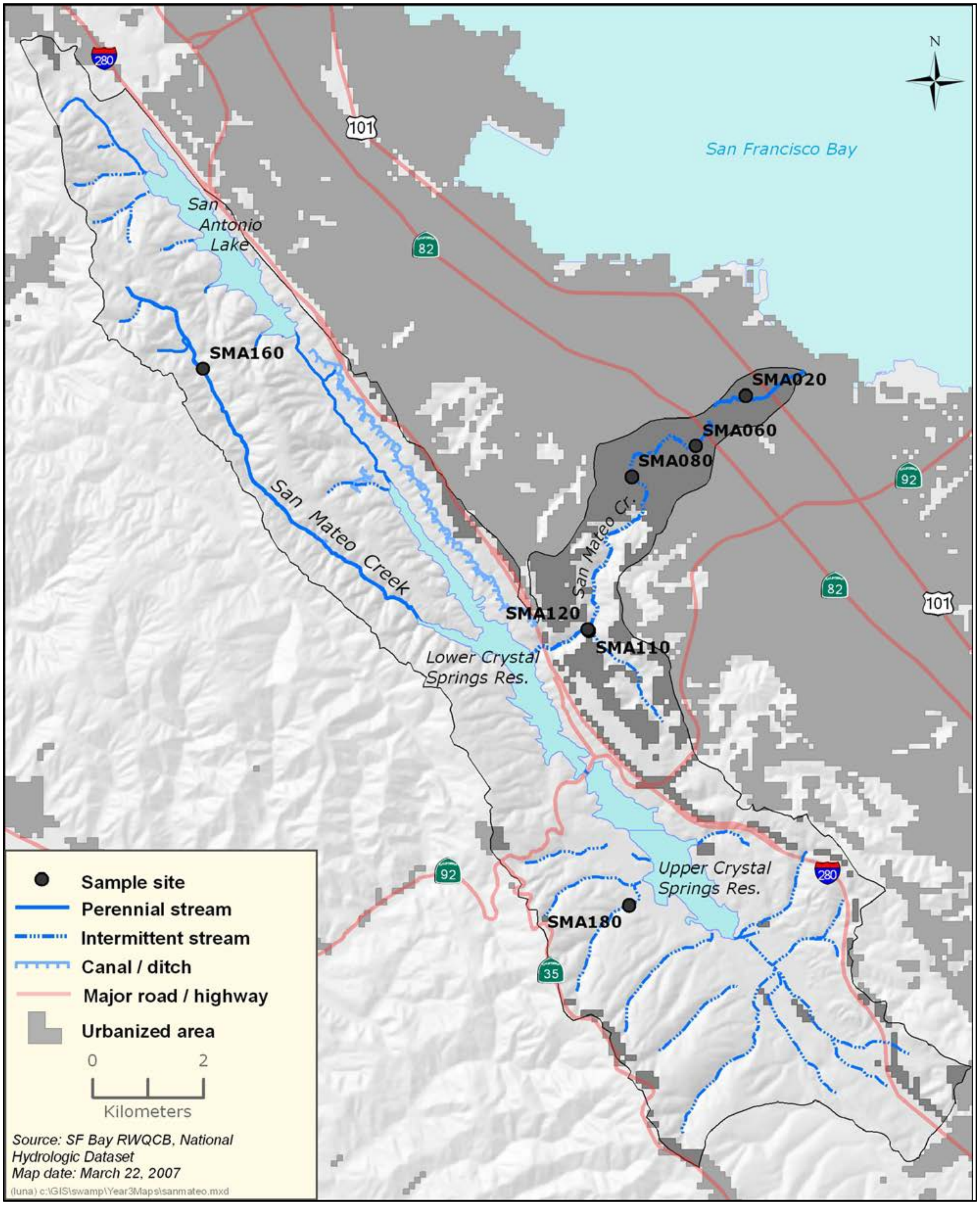

Figure 1. Location of stations monitored by SWAMP in San Mateo Creek in 2003 (source of figure: SFRWQCB 2007).

3.3 Creek Status Monitoring Program (2013)

In water year[2] 2013 (WY2013), SMCWPPP conducted continuous water quality monitoring at two sites in San Mateo Creek (Figure 2). Creek status monitoring of water quality was conducted to fulfill MRP Provision C.8.c. A monitoring site at Arroyo Court/De Anza Historical Park (SMA059 – labeled 59 in Figure 2), previously sampled by SFRWQCB (SMA060), was selected in an effort to confirm reduced DO levels observed in 2003 at that location in San Mateo Creek (SFRWQCB 2007). A second station on San Mateo Creek, just below Crystal Springs Dam (SMA122), was also sampled by SMCWPPP to assess the extent of the low DO conditions.

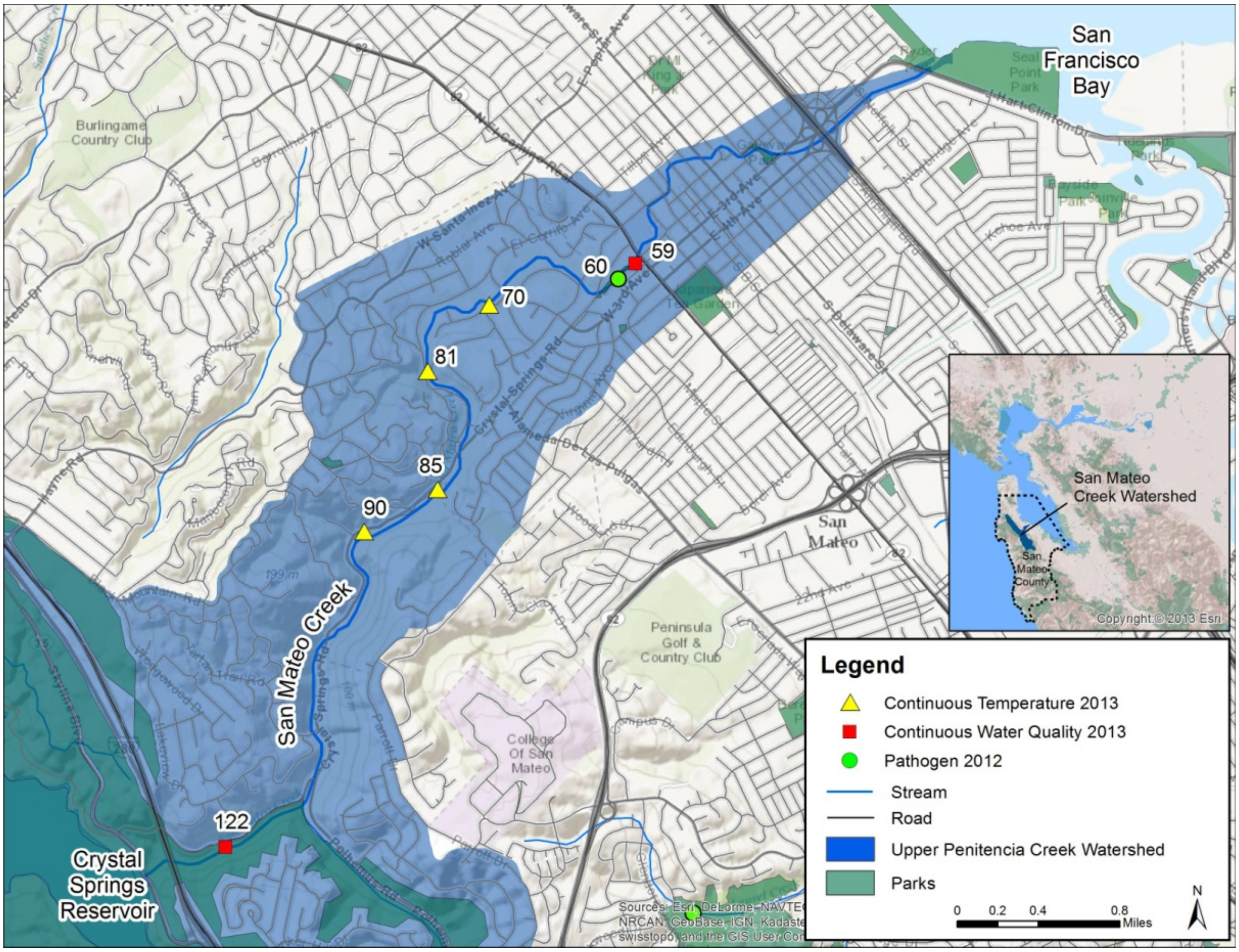

Figure 2. Continuous water quality and temperature sampling stations monitoring by SMCWPPP in WY2013.

Water quality sondes measuring pH, DO, temperature, and specific conductance were installed at both sites for two two-week periods in June and September 2013. The sonde at station SMA059

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[2] Most hydrologic monitoring occurs for a period defined as a water year, which begins on October 1 and ends on September 30 of the named year. For example, water year 2013 (WY2013) began on October 1, 2012 and concluded on September 30, 2013.

was suspended just above the bottom of a relatively deep pool at the downstream end of De Anza Park. The sonde was encased in a protective 4-inch diameter PVC tube to prevent damage and to keep the probes off the creek bottom. The right bank (looking downstream) consists of a wooden retaining wall (Figure 3).

Figure 3. Pool at downstream end of De Anza Park (SMA059).

Dry season conditions in the pool were characterized by slow flow velocity and fine, soft, organic bottom sediments that contain anaerobic bacteria as evidenced by sulfide odor when disturbed. It is possible that the soft, organic bottom sediments shifted after installation, partially burying the probes. It is unknown whether the 2003 sonde deployment was within the same pool or in an area with similar bottom sediments; the SFRWQCB (2007) report does not include specific site or installation details.

The June 2013 monitoring results from station SMA059 indicate a strong daily fluctuation in DO concentrations (Figure 4). However, the pattern was not consistent with excessive photosynthesis resulting from algal blooms as suggested in the SFRWQCB (2007) report. In algal bloom settings there is typically a gradual increase in DO beginning at sunrise (caused by algal photosynthesis converting carbon dioxide to oxygen and carbohydrates) with peak levels occurring in late afternoon or at dusk. After sunset, algal photosynthesis ceases but organisms in the water continue to consume oxygen causing DO levels gradually decrease through the night with the lowest levels recorded just before sunrise. In contrast, the San Mateo De Anza record has DO concentrations peaking just before midnight within an hour after the lowest levels are recorded (Figure 4). Following the peak, DO concentrations drop sharply but stay elevated for approximately 10 hours before another sharp drop to the lowest concentration of the day. This pattern is more consistent with daily stratification of the pool (possibly as a result of low streamflow, high air temperatures, cold groundwater seepage, or some combination of these factors) followed by mixing of the water column at night as air temperatures cool and the surface layer sinks. Data collected at the upstream sonde (SMA122) showed more typical patterns but lowest and highest DO concentrations were slightly shifted from expected. Similar patterns have been observed in Coyote Creek by the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP 2014).

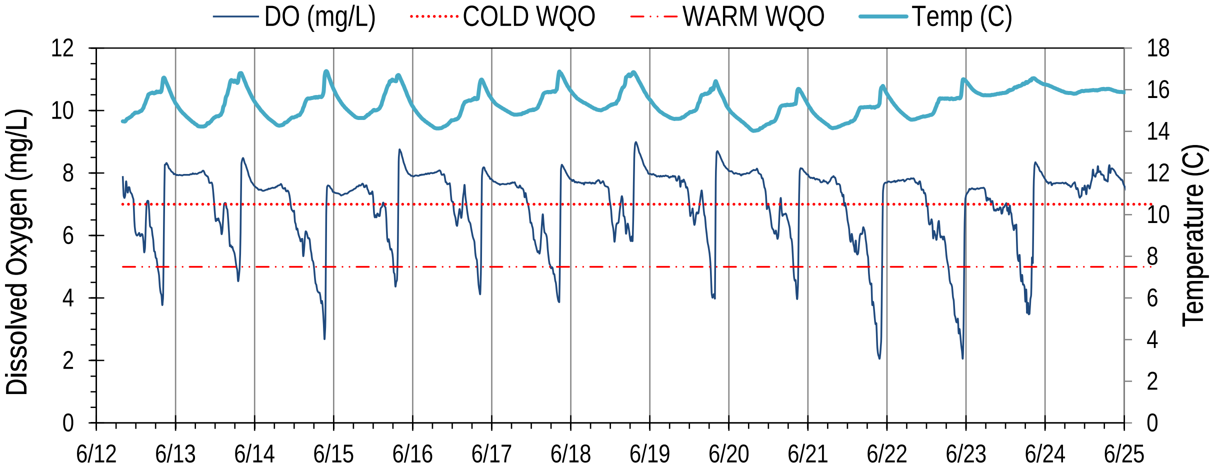

Figure 4. DO and temperature) measured at 15-minute intervals in June 2013, San Mateo Creek at De Anza Historical Park (SMA059). Both parameters exhibit daily fluctuations with lowest DO and highest temperatures recorded shortly before midnight.

The September 2013 deployment at De Anza Park showed a similar DO pattern observed during the June deployment for the first two days (Figure 5). After the first flush storm on September 21 (0.39 inches recorded at San Francisco International Airport), the pattern changed dramatically. The daily pattern became muted and there was a gradual increase in DO concentrations over the course of the next seven days.

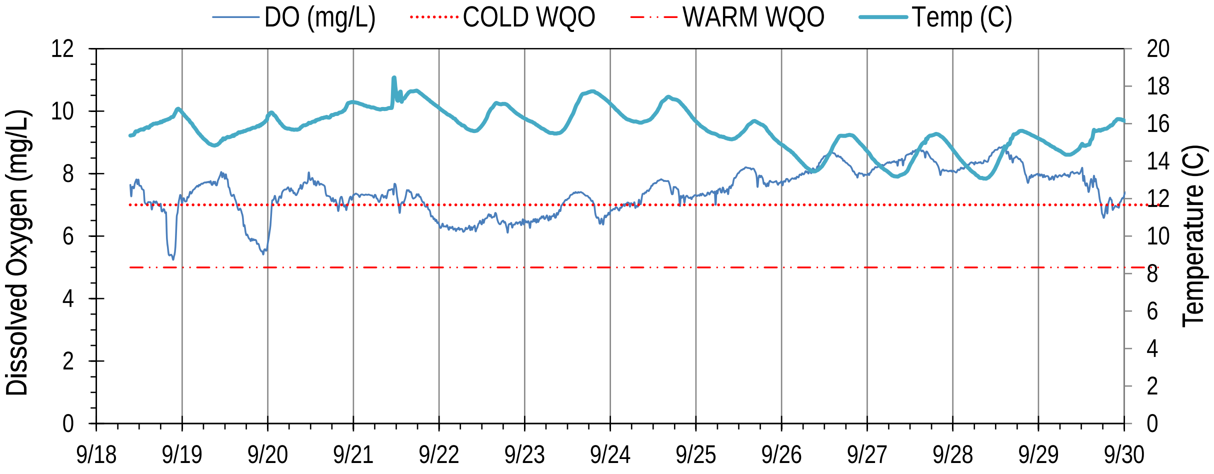

Figure 5. DO concentration (blue line) and temperature (red line) measured at 15-minute intervals in September 2013. A daily DO pattern, with lows recorded shortly before midnight, is recorded during the 2-day period before the September 21 storm event.

Results of the WY2013 sampling at De Anza Park exceeded the MRP trigger threshold for DO (i.e., 20% of results below the DO WQO of 7 mg/L).

Table 1. Percent of DO data recorded during two events in 2013 at two sites in San Mateo Creek that exceeded the MRP trigger for DO.

Site ID	**Creek Name**	**Site**	**Monit-oring Event**	***Percent Results DO < 5.0 mg/L***	***Percent Results DO < 7.0 mg/L***
204SMA059	San Mateo Creek	De Anza Park	June 2013	8%	36%
			Sept 2013	0%	24%
204SMA122		Below Reservoir	June 2013	0%	0%
			Sept 2013	0%	0%

The trigger in DO at this site was the impetus for conducting the San Mateo Creek Low DO SSID Project in WY2014, which is described in Section 4.0.

4.0 SSID Investigation

The San Mateo Creek Low Dissolved Oxygen SSID Project investigated the magnitude, duration, and geographic extent of low DO in San Mateo Creek. Methods included deployment of continuous water quality monitoring equipment (sondes) at two locations in the creek during the dry season of WY2014, and spot measurements of DO concentration at the bottom of pool habitats throughout a 0.75 mile reach of San Mateo Creek. Field methods and findings are described in the sections below.

4.1 Continuous Water Quality Monitoring

Sondes were deployed at two locations in San Mateo Creek during WY2014 (Figure 6). One sonde was deployed at De Anza Park (SMA059) for the entire dry season (May 9 through September 2, 2014). A second sonde (SMA080) was deployed approximately 1 mile upstream near the Sierra Drive crossing for two two-week periods: May 9 through May 27, 2014 and August 15 through September 2, 2014.

Figure 6. Continuous water quality stations in San Mateo Creek monitored in 2014. Stream reach with spot DO measurements is also shown.

The sondes were programmed to record general water quality parameters (DO, temperature, specific conductivity, and pH) at 15-minute intervals. The accuracy of sonde probe readings was checked against calibration standard solutions at three different stages during the project: 1) pre-deployment; 2) field checks; and 3) post-deployment. Field checks were conducted at site SMA059 every two to three weeks to assess whether the equipment was working properly. Field checks consisted of data retrieval, battery replacement (if needed) and cleaning and re-calibration of sensors. Procedures used for calibrating, deploying, programming and downloading data are described in the Regional Monitoring Coalition (RMC) Standard Operating Procedures (SOP) FS-4 (BASMAA 2014a). The calibration checks were compared to Measurement Quality Objectives (MQO) for data accuracy (Table 2) as defined in the RMC Quality Assurance Project Plan (QAPP) Version 2.0 (BASMAA 2014b). All data met the MQOs.

Table 2. Measurement Quality Objectives (MQOs) for continuous water quality parameters.

Parameter	Measurement Quality Objectives
Dissolved Oxygen (mg/l)	± 0.5 mg/L
pH 7.0 and pH 10.0	± 0.2
Specific Conductance (uS/cm)	± 0.5 %

The sonde at De Anza Park (SMA059) was re-positioned several times throughout the monitoring period to check for potential variability of low DO conditions and to reduce the chances of vandalism or theft. A summary of the deployment events at the De Anza site are as follows:

- Initial deployment of sonde on May 9 was in approximately the same position as the WY2013 deployment (i.e., within the pool along the right bank). However, in WY2014, the sonde was placed in a metal cage rather than the PVC casing. The metal cage was used to provide more space between sensors and the soft, organic bottom sediments (Figure 7).
- The sonde was re-positioned during a field check on June 9 to a location approximately five feet downstream of the initial location to decrease visibility of the equipment from the shore and reduce the potential for vandalism or theft.
- On July 29, the sonde was removed from the metal cage and placed in the PVC casing. The goal was to lower the probes in the water column to investigate DO conditions closer to the stream bed (i.e., similar deployment method that was used in WY2013).

Figure 7. Photograph of sonde within metal cage, showing how probes would be elevated approximately six inches off the stream bed.

Descriptive statistics for data collected at the two continuous water quality monitoring sites in San Mateo Creek during the dry season in 2014 are presented in Table 3. The distribution of DO measurements for both sites is shown as box plots in Figure 8 and as a continuous plot in Figure 9. Water quality data collected at the De Anza Park site (SMA059) are presented for the entire four month deployment period, as well as for the two two-week intervals in May and August to provide comparison with the water quality data recorded at the upstream site (SMA080) for the same time periods.

There were minimal differences in water quality conditions between the two sites during the two sampling events. Overall, the upstream site (Sierra Drive) had marginally better water quality than the De Anza Park site (i.e., lower temperature, higher DO, lower pH, and lower specific conductance). In addition, the differences in water quality between the two stations were greater during the Aug/Sep deployment compared to the May deployment.

- There was no difference in mean DO between the sites during the May deployment (9.4 mg/L).
- DO was slightly higher at the Sierra site (mean DO 8.7 mg/L) during the Aug/Sept deployment compared to the De Anza site (mean DO 8.0 mg/L).
- DO concentrations at the De Anza Park site ranged between 5.7 to 11.0 mg/L for the entire deployment, with a mean value of 8.6 mg/L.
- Over 99 percent of the entire 15-minute DO record at De Anza exceeded the COLD WQO of 7.0 mg/L minimum.

- Temperature, pH, and specific conductance readings were slightly higher at De Anza site compared to the Sierra site.
- All pH measurements met the WQO (i.e., > 6.5 and < 8.5).

Table 3. Descriptive statistics for continuous water temperature, dissolved oxygen, conductivity, and pH data measured at two sites in San Mateo Creek during WY2014.

Parameter	**Data Type**	**Site**	**De Anza Park (SMA059)**			**Sierra Dr (SMA080)**	
		Start	**May 9**	**Aug 15**	**May 9**	**May 9**	**Aug 15**
		End	**May 27**	**Sept 2**	**Sept 2**	**May 27**	**Sept 2**
Temperature (° C)	Min		12.7	16.5	12.7	12.0	15.7
	Median		15.4	17.8	17.2	14.8	17.4
	Mean		15.5	17.9	17.1	14.9	17.4
	Max		18.7	19.8	21.3	17.6	17.4
	Max 7-day Mean		15.8	18.0	19.1	15.2	17.7
Dissolved Oxygen (mg/l)	Min		8.3	5.7	5.7	8.5	8.0
	Median		9.2	7.9	8.5	9.3	8.6
	Mean		9.4	8.0	8.6	9.4	8.7
	Max		11.0	8.9	11.0	10.5	10.1
	7-day Avg. Min		8.6	7.0	7.0	8.6	8.1
pH	Min		7.6	7.5	7.5	7.4	7.5
	Median		8.0	7.7	7.8	7.8	7.6
	Mean		8.0	7.7	7.8	7.8	7.6
	Max		8.4	7.9	8.4	8.1	8.0
Specific Conductance (µS/cm)	Min		199	261	199	177	232
	Median		330	270	298	299	242
	Mean		329	271	294	300	243
	Max		407	290	456	366	310
Total number data points (n)			1729	1735	11134	1725	1738

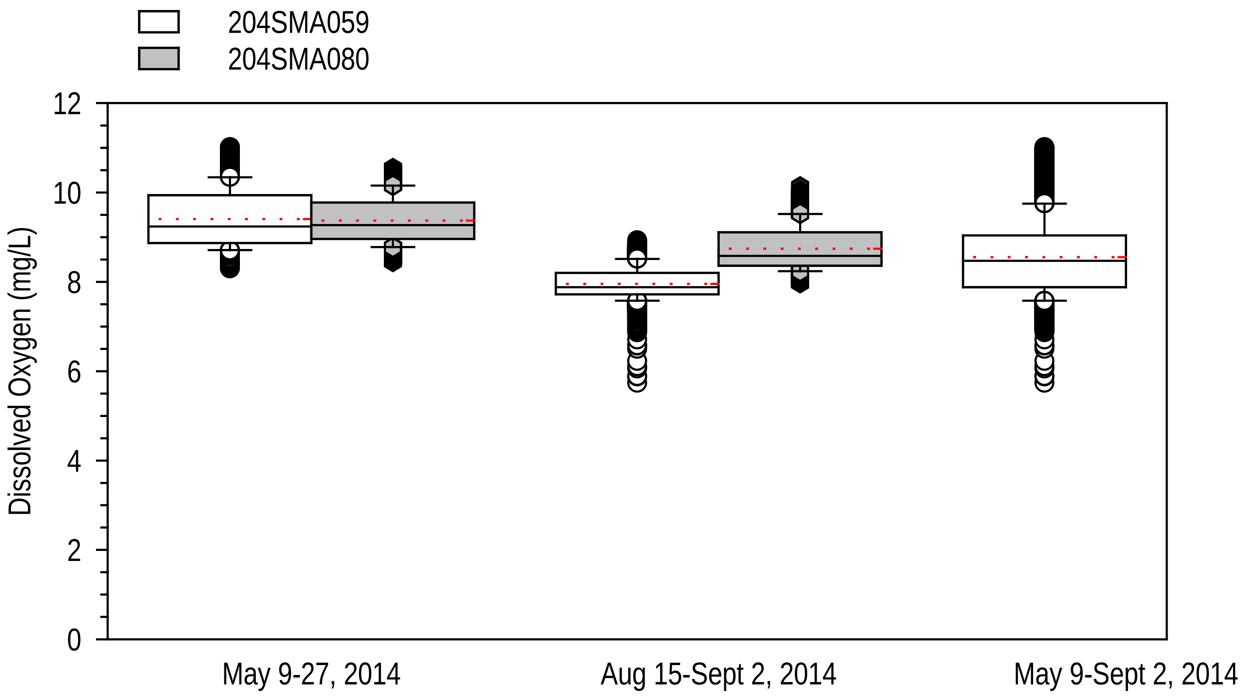

Figure 8. Box plots of DO concentrations recorded at two sites in San Mateo Creek during the dry season of 2014.

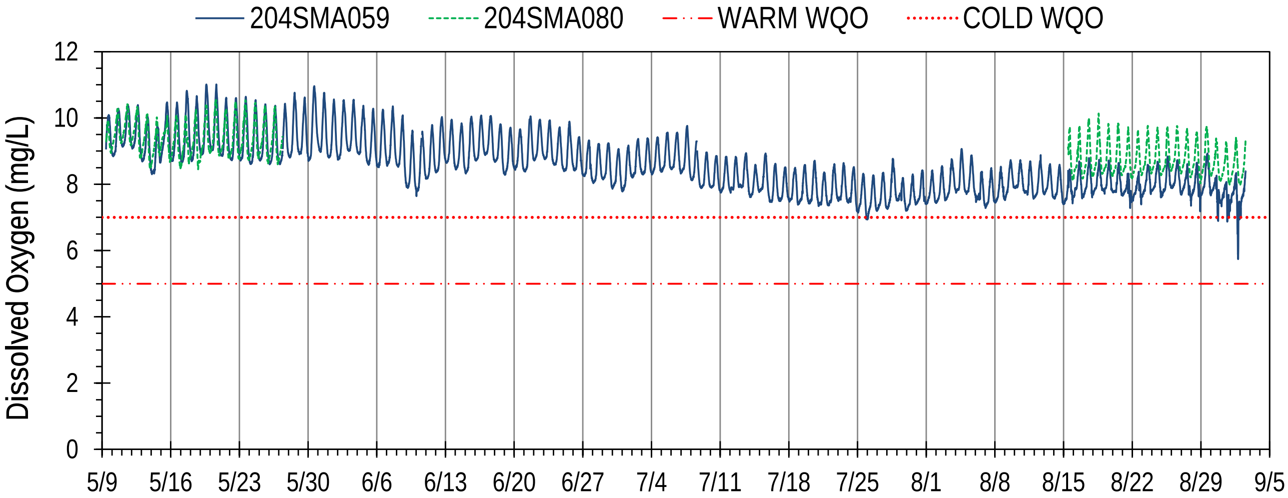

Figure 9. Plot of DO measurements recorded by sondes deployed at two sites in San Mateo Creek during the dry season of 2014.

4.2 Creek Walk

On July 29, 2014, a channel reach walk was conducted between the culvert at El Camino Real and Stonehedge Road (approximately 3,900 feet or 0.74 mile) (Figure 7). Spot measurements of

DO were conducted in 18 relatively deep pools along the reach using a multi-parameter YSI Pro-Plus handheld meter equipped with a Galvanic membrane DO sensor. General observations of pool depth and substrate were also made.

DO concentrations ranged from 6.6 mg/L to 9.2 mg/L with an average of 7.8 mg/L and a median of 7.6 mg/L. Depths of sampled pools ranged from 21 inches to 42 inches. There were no correlations between DO concentration and pool depth. Only two measurements were below the COLD WQO of 7 mg/L. Both of those pools were characterized by soft, organic bottom sediments and both were located within a subreach extending approximately 150 feet upstream of the culvert at El Camino Real. Station SMA059 is located within this subreach, approximately 100 feet upstream of the culvert. This 150-foot subreach was characterized as having soft, organic sediments within pools and relatively low flow velocities. Although channel gradients were not surveyed, it is likely that this subreach has a lower gradient than the upstream reach, a possible result of the El Camino Real culvert functioning as a grade control. Visual observations suggest that flow velocities are slower and more stagnant upstream of the culvert, causing fine sediment and organic matter to drop out of the water column and increased oxygen demand, and therefore potentially lowering DO concentrations in the subreach between De Anza Park and the El Camino Real crossing.

The 3,900-foot (0.74-mile) reach observed on July 29, 2014 was previously mapped and described by SMCWPPP (2007) using the Unified Stream Assessment (USA) protocol developed by the Center for Watershed Protection. SMCWPPP (2007) described a 260-foot subreach upstream of the El Camino Real culvert (i.e., the lower end of the WY2014 survey) as having turbid water, sedimentation zones, and hardened, steep banks. Upstream of this subreach, water clarity increases and substrates are dominated by coarser sediments (i.e., gravel and cobble). The WY2014 observations were consistent with SMCWPPP (2007) findings.

5.0 Discussion

SSID field investigations in WY2014 and WY2015 in and near San Mateo Creek at De Anza Park generally did not identify the low DO concentrations that were observed in previous monitoring studies conducted during the dry seasons of WY2003 (SFRWQCB 2007) and WY2013 (SMCWPPP 2014b). Between the May 9 and September 2, 2014 period of record, less than 0.1 percent of the DO readings collected at 15-minute intervals at the De Anza Park site (SMA059) fell below the COLD WQO of 7 mg/L. DO concentrations measured in pools upstream of the De Anza Park site during the dry season were consistently above the COLD WQO. However, the SSID study confirmed soft bottom sediments (likely the result of low gradients) and isolated low DO concentrations (less than 7 mg/L) in the subreach downstream of De Anza Park.

Higher stream baseflows during the dry season of WY2014, as compared to WY2013, were likely an important factor in improving water quality conditions (i.e., increasing DO concentrations). The higher baseflows in WY2014 are due to controlled discharges from Lower Crystal Springs Dam by the SFPUC during construction of the WISP projects. In WY2015, SFPUC began implementation of the San Mateo Creek minimum water release schedule that was required by NMFS during the WISP project approval process. The new minimum water release schedule requires baseflows at the USGS gage of 3 to 17 cfs, depending on the water year type (e.g., dry, normal, wet) and the time of year.

The higher flows result in higher flow velocities and re-aeration rates in the stream, as well as lower residence times for organic materials and other oxygen demanding substances. Figure 10 illustrates the differences in flow between the two years recorded by the USGS in San Mateo Creek below Crystal Springs Reservoir (USGS Station 11162753) which is located approximately 3.5 miles upstream of SMA059. The increase in baseflows in WY2014 may also have contributed to reduced water temperatures. Waters with lower temperature are able to dissolve more oxygen. Figure 10 illustrates differences in daily median water temperatures between the two years recorded by the USGS in San Mateo Creek below Crystal Springs Reservoir (USGS Station 11162753).

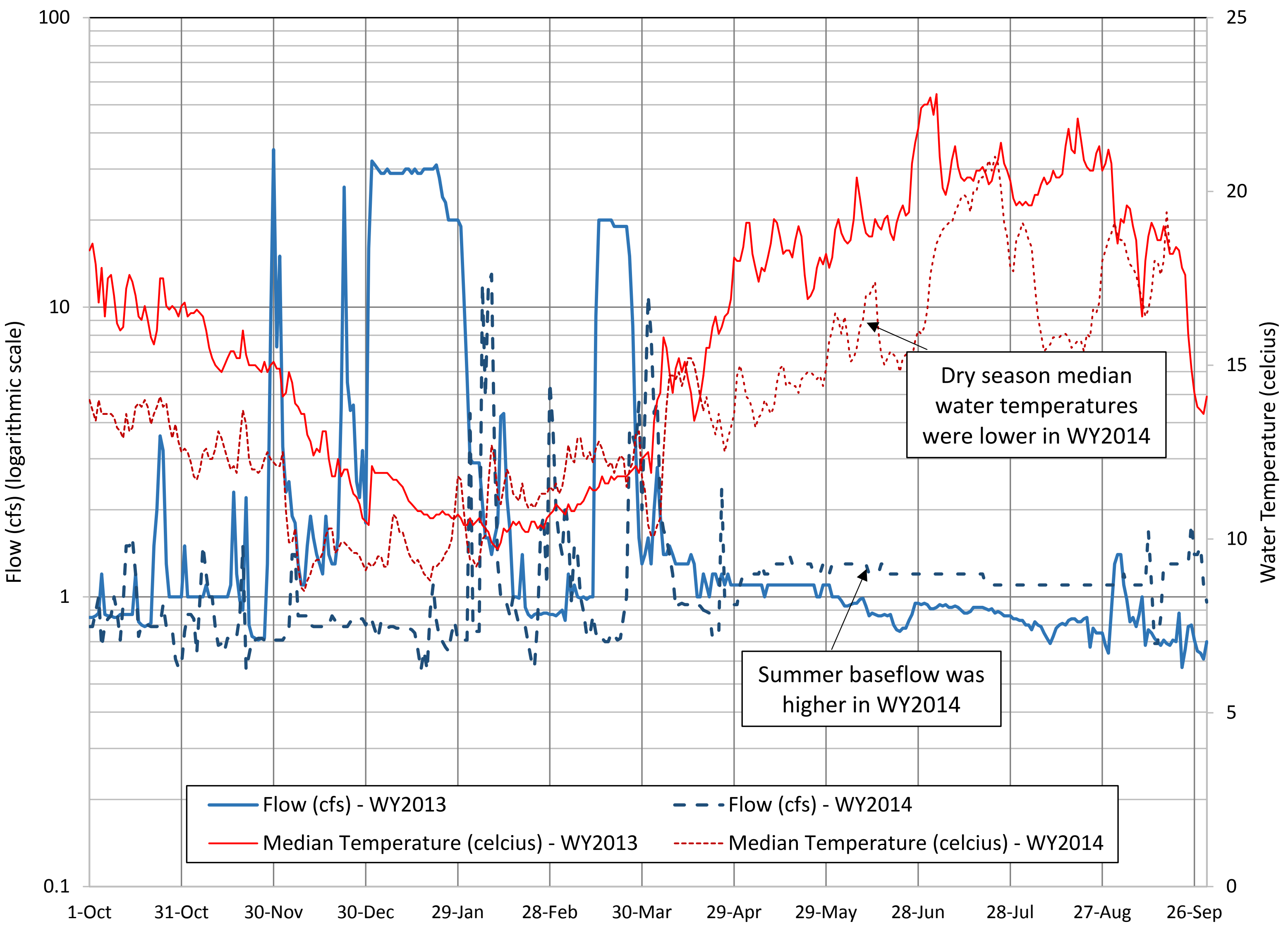

Figure 10. Mean daily flow and median daily temperature recorded at San Mateo Creek below Crystal Springs Reservoir, WY2013 and WY2014 (USGS Station 11162753).

Changes to physical habitat conditions may also have been an important factor influencing changes to the DO concentrations at the De Anza Park site. Large woody debris (LWD) plays a major role in stream morphology, pool formation, and sediment deposition (Lassettre and Harris 2001). LWD was noted upstream of SMA059 in WY2013 and WY2014, and was potentially responsible for the presence of the pool. However, field observations in WY2014 indicate less LWD in WY2014 compared to WY2013. Removal of the LWD (presumably naturally caused) could have altered sediment deposition processes in the downstream pool, resulting in less fine sediment and organic material accumulation at the sonde location.

It is likely that reduced DO concentrations may develop in pockets at the bottom of deep pools during periods of reduced flow and increased temperatures that typically occur during the late summer/fall season. These pockets are limited in geographic extent (i.e., bottom of deep pools with high accumulation of sediment and organic material) and duration due to daily recirculation/turnover of the pools. As a result, these isolated and temporary low DO conditions are not expected to impact COLD beneficial uses for the study reach (between El Camino Real and Sierra Drive).

The completion of the dam construction project at the Crystal Springs Reservoir and the establishment of a minimum baseflow of 3 cfs during the dry season are likely to result in significant improvements to the water quality conditions at De Anza Park. In addition, post construction monitoring for next ten years by the SFPUC for temperature, other water quality indicators, and condition of steelhead populations will provide valuable information to managers to ensure that dam operations are supporting aquatic life uses.

5.1 WY2015 Follow-up

On April 30, 2015[3], a site visit was conducted to observe whether streambed conditions had changed in response to the high flow test event (350 cfs) of January 15, 2015 and the new Crystal Springs Dam release schedule. The pool at the De Anza station (SMA059) was approximately one foot greater in depth with a firmer substrate than previously observed. Streambed substrate conditions farther downstream (near the El Camino Real culvert) were much coarser than previously observed. Furthermore, water clarity in the reach between De Anza Park and the El Camino Real culvert was also considerably improved compared to previous observations. It is hypothesized that the high flow event on January 15, 2015 functioned to scour fine sediments from the pool at De Anza Park and move gravels into the reach immediately upstream of the El Camino Real culvert. The reduction in fine sediments and organic material will likely decrease the occurrence of low DO in this reach.

5.2 Recommendations

Results of the SSID investigation suggest that low DO conditions are no longer expected in San Mateo Creek in the vicinity of De Anza Park (SMA059) as a result of a new release schedule

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[3] Flow at the USGS gage (Station 11162753) was reported as about 5.5 cfs on April 30, 2015.

from Crystal Springs Reservoir. However, these findings are currently being confirmed through Creek Status Monitoring (MRP Provision C.8.c) in WY2015. Beyond the new ongoing dry season controlled releases, no management measures are recommended at this time and the SSID project should be considered complete.

6.0 References

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Appendix C

San Mateo Creek Pathogen Indicator SSID Final Project Report

SAN MATEO CREEK PATHOGEN INDICATOR STRESSOR/SOURCE IDENTIFICATION

Prepared in support of Provision C.8.d.i of
the Municipal Regional Permit
(NPDES Permit # CAS612008)

Final Project Report

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

September 28, 2015

EXECUTIVE SUMMARY

This report presents the results and recommendations of the San Mateo Creek Pathogen Indicator Stressor/Source Identification (SSID) project. The project was conducted to address requirements in the San Francisco Bay Municipal Regional Permit (MRP) for discharges of stormwater runoff. Per MRP Provision C.8.d.i, the San Mateo Countywide Water Pollution Prevention Program (SMCWPPP) has conducted two SSID projects that follow-up on creek status monitoring data that exceed trigger thresholds (the other SSID project addressed low dissolved oxygen in San Mateo Creek and was reported on separately). SSID projects are designed to identify and isolate potential sources and/or stressors associated with observed potential water quality impacts. Additional actions required by Provision C.8.d.i are to identify and evaluate the effectiveness of potential actions for controlling the cause(s) of the trigger stressor/source and to confirm that the problem was addressed.

Monitoring data collected in 2003 and 2012 at stations in San Mateo Creek showed fecal indicator bacteria (FIB) at densities exceeding water quality objectives (WQOs) for waters designated as having water contact recreation (REC-1) Beneficial Uses. During water years 2014 and 2015 SMCWPPP conducted a SSID project to address this potential water quality concern. Results of the SSID investigation suggest that FIB are present at densities exceeding REC-1 WQOs in San Mateo Creek reaches downstream of Sierra Drive. However, noncontact recreation (REC-2) Beneficial Use WQOs are not exceeded. Microbial source tracking (MST) techniques suggested that human sources are present year-round and dog sources are present during and shortly after wet weather. Many other potential sources of FIB are present in the watershed and likely contribute to the FIB densities measured at sampling stations. These include uncontrollable sources such as wildlife and natural bacterial growth in the creek bed and conveyance system.

A number of management actions designed specifically or opportunistically to control bacterial sources are currently planned or are being implemented by municipalities in the San Mateo Creek watershed. These include control measures for pet waste (signage and public education), trash reduction efforts that may reduce nuisance wildlife, programs to address homeless encampments, and several improvements to the sanitary sewer conveyance system in response to a Cease and Desist Order (CDO).

The City of San Mateo, Town of Hillsborough, San Mateo County, and SMCWPPP may wish to consider working together to increase public education and outreach targeting pet waste in the San Mateo Creek watershed. Potential examples include installation of additional cleanup signs, dog bag dispensers, and trash receptacles at creekside parks. Local municipalities should also continue the homeless elimination efforts begun through the HOPE strategy and HOT program. In addition, to help evaluate the effectiveness of current and planned control actions, SMCWPPP may wish to consider continuing to monitor FIB in San Mateo Creek via its MRP Creek Status monitoring program. However, even if human and dog sources are better controlled, results could still exceed WQOs due to uncontrollable sources such as wildlife and natural bacterial growth.

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APPENDICES

1.0 INTRODUCTION

This report presents the results of the San Mateo Creek Pathogen Indicator Stressor/Source Identification (SSID) Project which was initiated in 2013 to address requirements listed under Provision C.8.d.i of the San Francisco Bay Region National Pollutant Discharge Elimination System (NPDES) stormwater Municipal Regional Permit (MRP) (Order R2-2009-0074). Per MRP Provision C.8.d.i, the San Mateo Countywide Water Pollution Prevention Program (SMCWPPP) has conducted two SSID Projects during the permit term. SMCWPPP conducted two projects in San Mateo Creek based on creek status monitoring results that exceed trigger thresholds (per Table 8.1 of the MRP). SSID projects are designed to identify and isolate potential sources and/or stressors associated with observed potential water quality impacts. Additional actions required by Provision C.8.d.i are to identify and evaluate the effectiveness of potential actions for controlling the cause(s) of the trigger stressor/source, and to confirm the problem was addressed.

SMCWPPP initiated the Pathogen Indicator SSID Project in San Mateo Creek in response to monitoring data collected by SMCWPPP during water year[1] 2012 (WY2012) that exceeded fecal coliform and *Escherichia coli* (*E. coli*) trigger thresholds. Historical pathogen indicator bacteria data from San Mateo Creek collected by others also indicated potential water quality issues. This introduction (Section 1.0) provides background on pathogen indicators and water quality objectives (WQOs) developed to protect recreational beneficial uses. Section 2.0 of this report describes the watershed and past pathogen indicator monitoring results. Section 3.0 presents results of the SSID project monitoring. Section 4.0 reviews potential sources of bacteria to San Mateo Creek and current management actions. Section 5.0 recommends consideration of additional management actions and monitoring. References are listed in Section 6.0.

1.1 Pathogen Indicators and Water Quality Objectives

The State Water Resources Control Board (State Water Board) is part of the California Environmental Protection Agency and administers water rights, water pollution control, and water quality functions for the state. The State Water Board and its nine Regional Water Quality Control Boards implement the federal Clean Water Act (CWA) and the state Porter-Cologne Act. Surface water and groundwater quality are regulated through development and enforcement of WQOs and implementation of plans that will protect the Beneficial Uses of the State's waters. Regional Water Quality Control Plans (referred to as Basin Plans) designate Beneficial Uses, WQOs that ensure the protection of those uses, and programs of implementation to achieve WQOs.

Several Beneficial Uses have been designated for San Mateo Creek, including water contact recreation (REC-1) and noncontact water recreation (REC-2), which are defined in the San Francisco Bay Basin Plan as:

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[1] Most hydrologic monitoring occurs for a period defined as a water year, which begins on October 1 and ends on September 30 of the named year. For example, water year 2012 (WY2012) began on October 1, 2011 and concluded on September 30, 2012.

- **REC-1:** *"Uses of water for recreational activities involving body contact with water where ingestion of water is reasonably possible. These uses include, but are not limited to, swimming, wading, water-skiing, skin and scuba diving, surfing, whitewater activities, fishing, and uses of natural hot springs."*

- **REC-2: "***Uses of water for recreational activities involving proximity to water, but not normally involving contact with water where water ingestion is reasonably possible. These uses include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tide pool and marine life study, hunting, sightseeing, or aesthetic enjoyment in conjunction with the above activities."*

REC-1 activities involve body contact with water where immersion and ingestion of water is reasonably possible. In San Mateo Creek, REC-1 uses are limited due to the lack of public access to the creek and typically shallow water habitat where access is available. The most likely places where humans could come in contact with San Mateo Creek waters are at creek-side parks such as De Anza Historical Park (also known as Arroyo Court Park) and Gateway Park. However, these parks do not include swimming or bathing beaches and the water is relatively shallow. Therefore, water contact is likely very limited. REC-2 is a more appropriate designation for San Mateo Creek. REC-2 uses that may occur at San Mateo Creek parks include hiking, picnicking, sightseeing, and nature studies.

REC-1 use of water bodies with fecal contamination can cause gastrointestinal (GI) and other types of illnesses if pathogens (i.e., certain viruses, bacteria, or protozoa) are present and if water is ingested. Testing water samples for specific pathogens is generally not practical for a number of reasons (e.g., concentrations of pathogens from fecal contamination may be small but still of concern, laboratory analysis is often difficult and expensive, and the number of possible pathogens is large). Therefore, the presence of pathogens is usually *inferred* by testing for "pathogen indicator" organisms, including fecal indicator bacteria (FIB). Since the 1950's, numerous epidemiological investigations have been conducted to evaluate the relationship between illness rates and suitable pathogen or fecal indicators. The United States Environmental Protection Agency (USEPA) recommends using *E. coli* and enterococci as indicators of fecal contamination based on historical and recent epidemiological studies (USEPA 2012).

The San Francisco Bay Basin Plan (2013) Table 3-1 establishes REC-1 WQOs for fecal coliform, total coliform, and enterococci, and REC-2 WQOs for fecal coliform. Table 3-2 of this Basin Plan refers to the now superseded 1986 USEPA criteria for *E. coli* and enterococci in ambient water. Criteria listed by both agencies are based on sampling protocols where five equally-spaced samples are collected over a 30-day period and the geometric mean (GM) is calculated. A statistical threshold value (STV) sometimes referred to as a "single sample maximum" (SSM) is also listed. The STV is intended to be a value that should not be exceeded by more than a designated percentage of the samples used to calculate the GM, but is typically used as a SSM by regulators. San Francisco Bay Basin Plan (2013) WQOs for pathogen indicators in freshwater/estuarine water are listed in Table 1. Comparisons are often made to the 90th percentile WQOs when evaluating the results of FIB analysis of single grab samples.

The USEPA (1986) ambient water quality criteria for *E. coli* and enterococci were derived from epidemiological studies of bathers recreating at surface water beaches that received bacteriological contamination via treated human wastewater[2]. The criteria distinguish between different levels of beach usage and establish STVs corresponding to the 75th, 82nd, 90th, and 95th percentiles of the expected water quality sampling distribution. In 2012, USEPA published new recreational water quality criteria that supersede the 1986 recommendations. The USEPA (2012) GM criteria remain similar to 1986 criteria; however, the SSM (or STV) no longer distinguishes between different levels of beach usage and is set at the updated 90th percentile. USEPA (2012) considers the 90th percentile protective of all primary contact recreation. Furthermore, USEPA no longer recommends use of fecal coliform as a FIB.

The San Francisco Bay Basin Plan (2013) has not been updated to reference or reflect the new USEPA (2012) criteria. However, the State Water Board is proposing amendments to the Basin Plans to include updated WQOs for bacteria to protect REC-1 beneficial uses. The proposed amendments may include a revised indicator organism (*E. coli* or enterococci) based on the ambient recreational criteria developed by USEPA (2012), designation of a new limited water contact recreation (LREC-1) use, and other elements necessary for bacteria control implementation (e.g., natural source exclusion approaches, high flow suspension, seasonal suspensions). A draft staff report for public comment is anticipated in fall of 2015 with adoption in spring 2016.

Table 8.1 of the MRP lists “trigger” thresholds that must be considered during evaluation of MPR Provision C.8.c Creek Status monitoring data. For pathogen indicators, the trigger thresholds are USEPA fecal coliform and *E. coli* criteria.

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[2] Similar health studies conducted at sites affected by non-human sources of fecal contamination have not provided a clear linkage between water quality measured by FIB and health effects (USEPA 2014).

Table 1. Bacteriological objectives and criteria for water recreation in freshwater.

	Total Coliform	**Fecal Coliform**	***E. coli***	**Enterococci**
	(MPN/100ml)	*(MPN/100ml)*	*(CFU/100ml)*	*(CFU/100ml)*
REC-1				
GM	--	200 [a]	125 [b], 126 [c]	33 [b] , 35 [c]
Median	240 [a]			
SSM	10,000 [a]	--	--	--
75th Percentile (designated beach)	--	--	235 [b]	61 [b]
82nd Percentile (moderate bathing use)	--	--	298 [b]	89 [b]
90th Percentile (light bathing use)	--	400 [a]	406 [b]	108 [b]
95th Percentile (infrequent bathing use)	--	--	576 [b]	151 [b]
STV	--	--	410 [c]	130 [c]
REC-2				
Mean	--	2,000 [a]	--	--
90th Percentile	--	4,000 [a]	--	--

GM = geometric mean, REC-1 = water contact recreation, REC-2 = noncontact water recreation, SSM = single sample maximum, STV = statistical threshold value

[a] San Francisco Bay Basin Plan (Regional Water Board 2013)

[b] USEPA (1986)

[c] USEPA (2012). Criteria correspond to an illness rate of 36 incidents of GI per 1,000 primary contact recreators.

2.0 Study Area

San Mateo Creek drains a 33-square mile watershed including parts of unincorporated San Mateo County, the City of San Mateo, and the Town of Hillsborough (Figure 1). The upper watershed is characterized by the northwest/southeast trending ridges and valleys of the San Andreas Rift Zone and the Santa Cruz Mountains. Runoff from this undeveloped 29-square mile area drains to a system of reservoirs which are owned and operated by the San Francisco Public Utilities Commission (SFPUC). These include the San Andreas Reservoir, Upper Crystal Springs Reservoir, and Lower Crystal Springs Reservoir.

Below the Lower Crystal Springs reservoir dam, the watershed encompasses approximately five square miles and is mostly urbanized, with imperviousness of approximately 38 percent (STOPPP 2002). Low and medium density residential uses characterize the area upstream of El Camino Real. High density residential and commercial uses characterize the watershed downstream of El Camino Real. Runoff from these areas is conveyed to the creek via a network of underground storm drain pipes (i.e., the municipal separate storm sewer system (MS4)). Nearly 50 percent of the creek channel below the dam has been modified (STOPPP 2002). In the modified reaches, flows are conveyed within engineered channels and underground pipes, including a 2,000 foot culvert that begins downstream of El Camino Real. San Mateo Creek flows to San Francisco Bay at Ryder Park, just south of Coyote Point.

Prior to WY2014, dry weather flows from the Crystal Springs Reservoir System to San Mateo Creek were limited to about 0.7 cubic feet per second (cfs) as the result of water leaks from aging pipes at the pump stations. This dry season flow condition changed with construction on the Lower Crystal Springs Dam and Pump Station which was conducted between January and October 2014 as part of SFPUC’s Water System Improvement Program (WISP). During the construction period, leaks were sealed and water was pumped from the reservoir directly into the creek, resulting in dry season flows that averaged about 1.0 cfs. With completion of the project in November 2014, SFPUC began implementation of a defined water release schedule intended to enhance habitat for steelhead and other native fish in lower San Mateo Creek (i.e., below the dam). Release schedule baseflows, measured at the U.S. Geological Survey (USGS) gage located approximately 0.2 mile downstream of the dam (USGS Gage #11162753), must range from 3 to 17 cfs, depending on the water year type (e.g., dry, normal, wet) and the time of year (NMFS 2010). The release schedule was approved by the U.S. Army Corps of Engineers as part of the formal consultation process with the National Marine Fisheries service (NMFS) and the California Department of Fish and Game (CDFG) for Endangered Species Act compliance for the WISP projects (San Francisco Planning Department 2010).

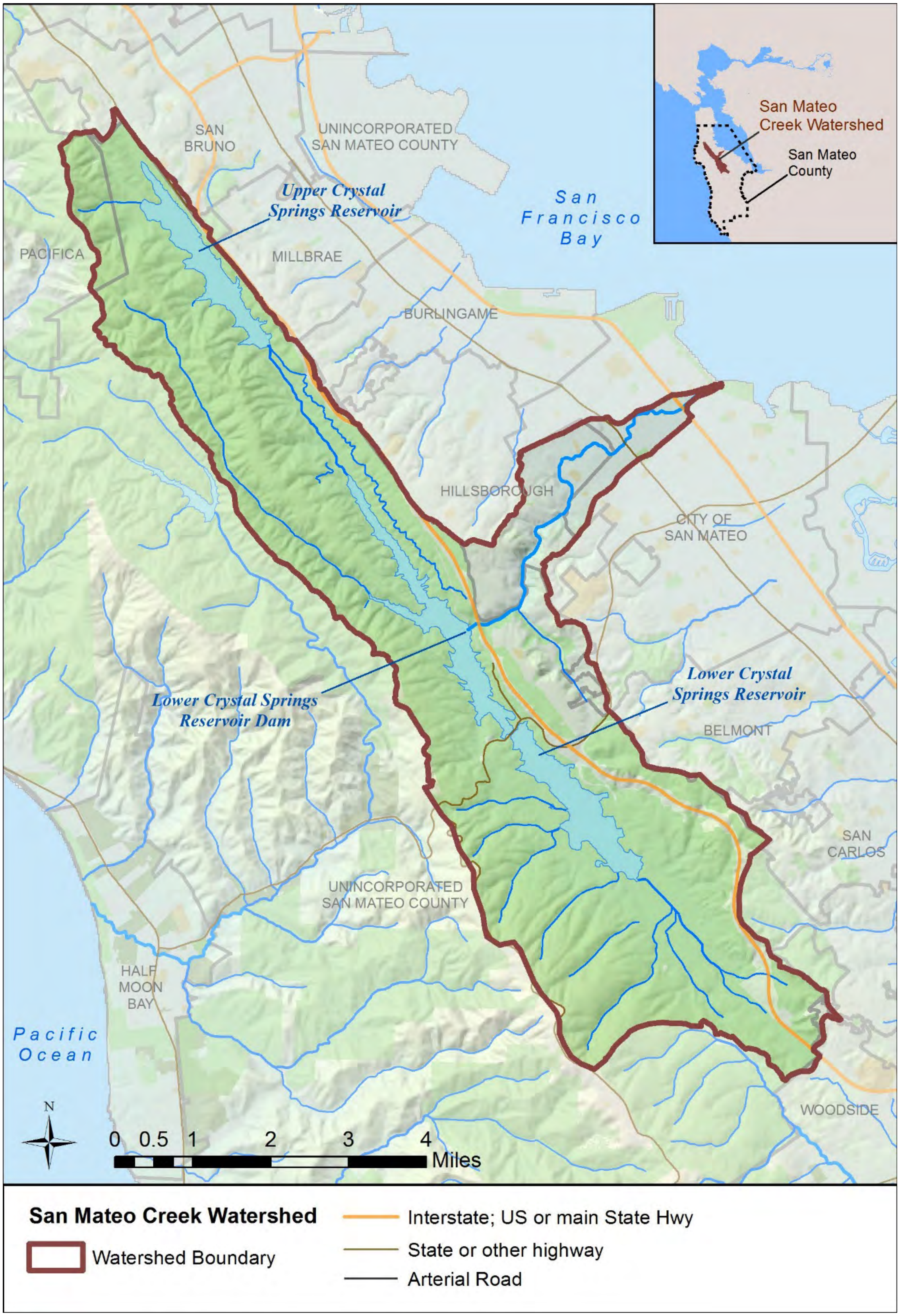

Figure 1. San Mateo Creek watershed, San Mateo County, CA.

2.1 Prior Pathogen Indicator Monitoring

2.1.1 2003 Monitoring

In 2003, the Regional Water Board monitored several stations within the San Mateo Creek watershed to assess water quality and establish regional reference sites as part of the Surface Water Ambient Monitoring Program (SWAMP). In addition to several other general water quality parameters[3], grab samples were collected and analyzed for total and fecal coliform and *E. coli* (Regional Water Board 2007). The pathogen indicator sampling was conducted at three stations on San Mateo Creek (Sierra Drive, De Anza Park, and Gateway Park) on five consecutive dry season weeks (July 21, July 28, August 4, August 11, and August 18, 2003). All of the geometric means exceeded corresponding WQOs and most of the individual samples exceeded the 90th percentile WQOs. Pathogen indicator bacteria results, downloaded from the California Environmental Data Exchange Network (CEDEN), are listed in Table 2. Sample locations are mapped in Figure 2.

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[3] Sondes programmed to continuously monitor pH, dissolved oxygen, temperature, and specific conductivity were deployed for one or two week “episodes” during three parts of the annual hydrograph: wet season, decreasing hydrograph/spring, and dry season.

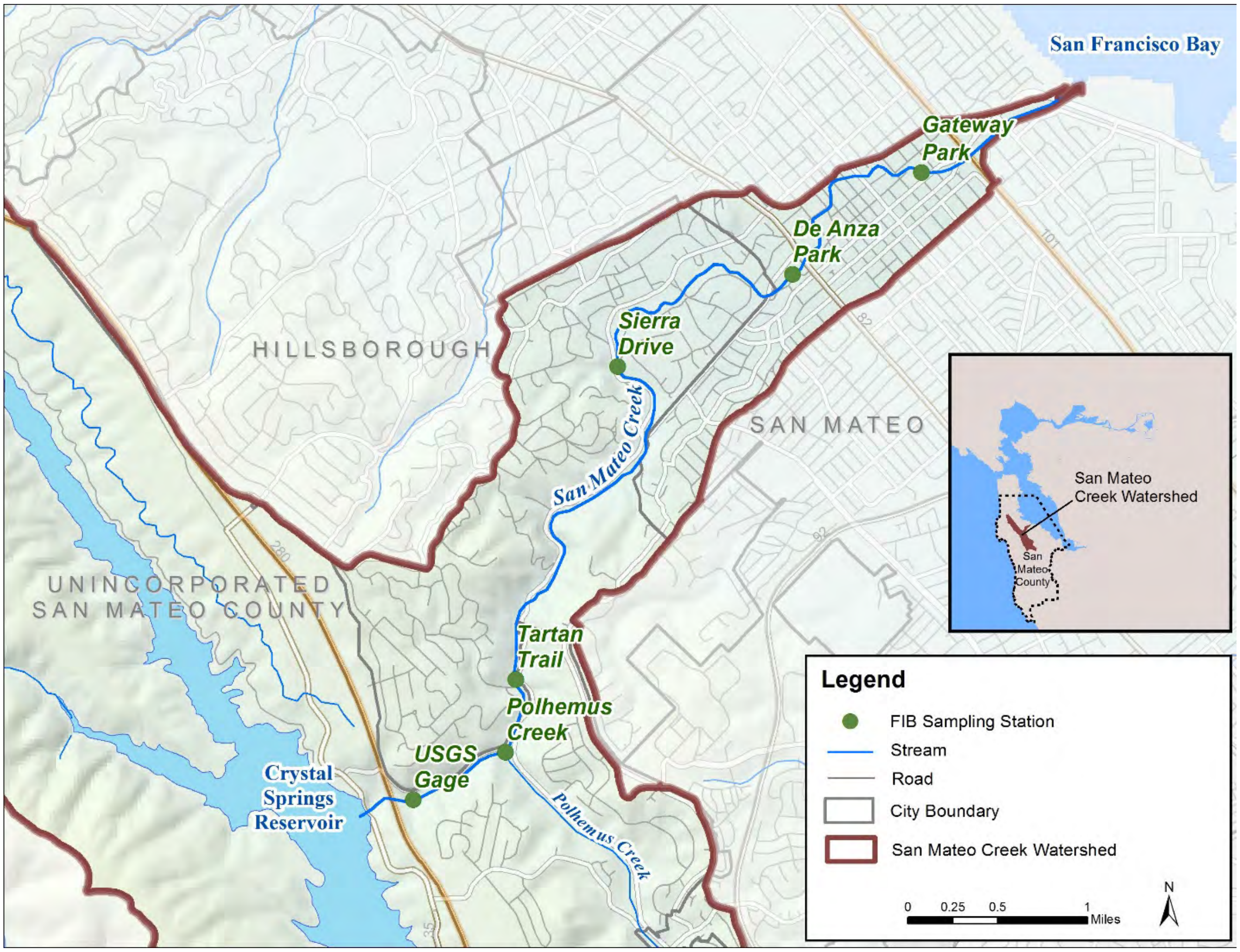

Figure 2. Bacteria sampling stations in San Mateo Creek watershed.

2.1.2 2012 Monitoring

In WY2012, SMCWPPP conducted MRP Provision C.8.c pathogen indicator sampling (fecal coliform and *E. coli*) at locations in five city parks or trails throughout San Mateo County where it appeared possible that the public could engage in water contact recreation, including one of the Regional Water Board (2007) stations – San Mateo Creek at De Anza Historical Park. The monitoring design was to collect single water grab samples (rather than five consecutive samples collected equally spaced over a 30-day period). Therefore, the 90th percentile WQOs are the more appropriate criteria to use when evaluating the data. Both the fecal coliform and *E. coli* WQOs for REC-1 were exceeded. REC-2 WQOs (for fecal coliform) were not exceeded. Results at the De Anza park station are within the same range measured by the Regional Water Board in 2003 (Table 2) (SMCWPPP 2014a).

Table 2. Pathogen indicator levels measured in San Mateo Creek.

Station	**Sample Date**	**Total Coliform**	**Fecal Coliform**	***E. Coli***
		(MPN/100ml)	*(MPN/100ml)*	*(MPN/100ml)*
REC-1 WQO (GM/90th PCTL)		*240/10,000[1]*	*200/400*	*126/410*
REC-2 WQO (mean/90th PCTL)		*NA*	*2,000/4,000*	*NA*
Gateway Park				
	7/21/2003	16,000	240	340
	7/28/2003	20,000	170	110
	8/4/2003	24,000	1,600	460
	8/11/2003	24,000	1,600	2,800
	8/18/2003	24,000	130	220
Gateway Park Geometric Mean		*21,338*	*423*	*403*
De Anza Park				
	7/21/2003	17,000	350	910
	7/28/2003	12,000	1,600	1,200
	8/4/2003	16,000	1,600	2,100
	8/11/2003	17,000	1,600	1,600
	8/18/2003	17,000	1,600	780
De Anza Park Geometric Mean		*15,665*	*1,181*	*1,234*
	7/17/2012	ns	1,300	1,300
Sierra Drive				
	7/21/2003	16,000	1,600	2,300
	7/28/2003	6,100	920	260
	8/4/2003	8,700	540	300
	8/11/2003	16,000	1,600	3,000
	8/18/2003	24,000	1,600	24,000
Sierra Drive Geometric Mean		*12,667*	*1,153*	*1,668*

GM = geometric mean, NA = not applicable, ns = not sampled, WQO = water quality objective.

[1] Total coliform WQOs are shown as median/single sample maximum (SSM).

3.0 SSID Investigation and Results

The San Mateo Creek Pathogen Indicator SSID Project investigated the magnitude, seasonal variability, and predominant sources of pathogen indicators in the watershed. The investigation used both field and desktop approaches based on guidance provided in The California Microbial Source Identification Manual: A Tiered Approach to Identifying Fecal Pollution Sources to Beaches (SCCWRP 2013). The field approach used for the study is discussed in this section. Desktop approaches to identifying potential bacterial sources are discussed in Section 4.0.

Field monitoring approaches to investigate potential sources of bacteria included:

1. <u>FIB Monitoring:</u> Grab samples were collected approximately monthly from February 26 through November 4, 2014 at Gateway Park and De Anza Park. Samples were analyzed for FIB (*E. coli* and enterococcus). As part of SMCWPPP's creek status monitoring program (MRP Provision C.8.c), additional FIB (fecal coliform and *E. coli*) grab samples were collected from five stations (including De Anza Park) within the watershed during a single dry season sampling event in WY2014 (July 8, 2014) and a separate event in WY2015 (June 30, 2015) to capture a snapshot of bacterial source areas.
2. <u>Bacteroidales Monitoring / Microbial Source Tracking:</u> The February 26 through November 4, 2014 monthly grab samples from Gateway Park and De Anza Park were analyzed for the bacterial group of the Bacteroidales for source species identification. During each site visit, observations of fecal material and potential fecal sources were noted.

Details and results are discussed in the sections below. See also Appendix A for additional details on the Gateway Park and De Anza Park FIB and Bacteroidales study.

3.1 FIB Monitoring

Two stations previously sampled for FIB by the Regional Water Board as part of the SWAMP and by SMCWPPP in compliance with MRP Provision C.8.c requirements were targeted by the San Mateo Creek Pathogen Indicator SSID Project: Gateway Park and De Anza Park (Figure 2). Both stations are located in creekside parks, locations that had the highest potential for water contact recreation (REC-1) in San Mateo Creek; however, low baseflows at both parks result in relatively shallow water depths, bathing beaches do not exist, and swimming holes are absent, suggesting that REC-2 uses are more likely. Samples were analyzed for FIB (*E. coli* and enterococcus) and the bacterial group of Bacteroidales.

3.1.1 Stations and Study Design

De Anza Park is a small creekside park located within a residential neighborhood just upstream of the El Camino Real crossing. A narrow, unpaved footpath runs through dense ivy under the riparian canopy along an approximately 800-foot reach. A few benches offer opportunities for relaxation. Runoff from nearby streets (e.g., Arroyo Court) is conveyed directly to the creek via storm drains. Samples were collected near the downstream end of the park. Photos in Figures 3 and 4 illustrate the park environment and channel.

Figure 3. Downstream end of De Anza Park showing a large debris trapping structure.

Figure 4. Footpath along right bank of San Mateo Creek at De Anza Park. The channel is within the riparian vegetation on the right side of the photo.

Gateway Park is located approximately one mile downstream of De Anza Park near downtown San Mateo. Nearly half of the creek channel between the two stations is contained within an underground culvert. Below Gateway Park, the creek enters another large culvert and is then conveyed within an engineered channel to San Francisco Bay. Gateway Park is considered the upstream extent of the tidally-influenced reach of San Mateo Creek. Gateway Park features manicured lawns, a playground, paved trails, and picnic tables. Samples were collected near the downstream end of the park. Figures 5 and 6 illustrate the Gateway Park environment and channel.

Figure 5. Upstream end of Gateway Park looking downstream.

Figure 6. Downstream end of Gateway Park looking upstream.

Grab samples were collected approximately monthly from February 26 to November 4, 2014 from the De Anza and Gateway Park stations. During the wet season, sampling was scheduled opportunistically to occur during or immediately after storm events. Dry weather sampling at the Gateway Park station, which is within the tidally-influenced reach of San Mateo Creek, was timed to occur as close as possible to low tide in order to avoid capturing Bay water that is pushed up the creek during high tide. Sampling methods were consistent with the Bay Area Stormwater Management Agencies Association (BASMAA) Regional Monitoring Coalition (RMC) Creek Status Monitoring Program Standard Operating Procedures (SOPs) (BASMAA 2014a). Quality control samples were collected consistent with the BASMAA RMC Quality Assurance Project Plan (QAPP) (BASMAA 2014b).

Additional pathogen indicator samples were collected on July 8, 2014 and June 30, 2015, to fulfill monitoring requirements listed in MRP Provision C.8.c (Creek Status Monitoring). Grab water samples for *E. coli* and fecal coliform were collected from the De Anza Park station and four additional stations farther up in the watershed, including the Sierra Drive station which was sampled by the Regional Water Board in 2003. Creek Status Monitoring stations were located immediately downstream of storm drain outfalls with relatively large catchments. All five stations are mapped in Figure 2.

3.1.2 FIB Results

FIB results from Gateway Park and De Anza Park are listed in Table 3 and described in Appendix A. Table 3 also lists precipitation conditions noted during sampling. Three samples were collected during or shortly after precipitation events: February 26, February, 28, and April 1, 2014. The September 23 and November 4, 2014 samples were collected during dry periods but after the first few storm events of WY2015 had occurred (Figure 7). Flow and tidal hydrographs for each sampling event are included as Appendix B.

Typical of FIB monitoring results (USEPA 2010), there was a high degree of variability in measured densities with standard deviations exceeding the median results. Dry season *E. coli* densities were generally within the same range as those reported for these stations in 2003 (Regional Water Board 2007) and 2012 (SMCWPPP 2014a) (see Table 2). With one exception (i.e., De Anza Park on May 20), *E. coli* densities were consistently above the USEPA 2010 criteria of 410 CFU/100ml (Table 1). There was a slight seasonal signal, with *E. coli* densities generally higher during the wet periods. The highest *E. coli* densities (24,000 MPN/100ml at Gateway Park and 8,000 MPN/100ml at De Anza Park) were measured during the February 26 storm event. The lowest *E. coli* densities were measured on May 20 (500 MPN/100ml at Gateway Park and 300 MPN/100ml at De Anza Park). Enterococci results followed the same general pattern.

Table 3 lists specific conductance (SC) and temperature measurements collected during sampling visits. Specific conductance is a measure of the ability of water to conduct an electrical current. It is highly dependent on the amount of dissolved solids (such as salt) in the water and often used as a proxy for salinity. Specific conductance in freshwater streams generally ranges from 100 µmhos/cm to 500 µmhos/cm; whereas, specific conductance in San Francisco Bay ranges from approximately 10,000 to 30,000 µmhos/cm depending on the amount of freshwater entering the system. Specific conductance measured at Gateway Park ranged from 136 to 404 µmhos/cm and was similar to measurements at De Anza Park suggesting that Gateway Park samples characterized watershed runoff and stream flow rather than tidal inflows. The series of charts in Appendix B depict sample times with tidal and flow data, confirming this finding.

Table 4 lists *E. coli* and fecal coliform densities from the creek status monitoring events on July 8, 2014 and June 30, 2015. FIB densities measured just below Lower Crystal Springs Reservoir at the USGS gage are very low (4 MPN/100ml *E. coli* in 2014 and 2015). Polhemus Creek, a small tributary that discharges to San Mateo Creek between the USGS gage and the Tartan Trail station, also had low FIB densities (30 MPN/100ml in 2014 and 13 MPN/100ml in 2015). FIB densities increase significantly in the downstream direction and do not exceed USEPA 2012 criteria until the Sierra Drive station (500 MPN/100ml in 2015). The highest densities (1,700 MPN/100ml in 2014) were measured at De Anza Park. REC-2 WQOs for fecal coliform (4,000 MPN/100ml) were not exceeded.

Table 3. *E. coli*, enterococci, and Bacteroidales monitoring results, Gateway Park and De Anza Park, WY2014.

Date	Time	*E. coli* *(MPN/100ml)*	Enterococci *(MPN/100ml)*	Bacteroidales *(P/A)*	HUM183 *(P/A)*	Dog *(P/A)*	Temp. *(°C)*	SC *(µmhos/cm)*	Precipitation Notes
Gateway Park									
2/26/2014	13:20	24,000	>2,419	P	P	P	ns	ns	recent rain
2/28/2014	12:30	4,700	4,900	P	P	P	13.4	190	raining
4/1/2014	10:47	2,200	1,300	P	P	A	11.2	296	intermittent showers
4/22/2014	12:30	5,000	980	P	P	P	14.3	404	none
5/20/2014	11:25	500	727	P	P	A	16.0	309	none
6/18/2014	11:00	1,100	1,414	P	P	A	16.5	221	none
7/16/2014	8:30	1,400	1,414	P	P	A	18.1	357	none
9/23/2014	8:30	5,000	816	P	P	A	17.4	259	none
11/4/2014	16:00	800	1,986	P	P	P	ns	136	none
	Mean	*4,967*	*1,773*						
	Median	*2,200*	*1,414*						
	SD	*7,374*	*1,292*						
De Anza Park									
2/26/2014	12:50	8,000	2,419	P	P	P	ns	ns	recent rain
2/26/2014	*12:50*	*8,000*	*1,733*	*P*	*P*	*P*	--	--	*field duplicate*
2/28/2014	12:10	5,300	1,700	P	P	P	13.5	220	raining
4/1/2014	10:10	800	1,300	P	P	A	10.4	334	intermittent showers
4/22/2014	12:00	1,700	816	P	P	A	12.5	388	none
5/20/2014	11:10	300	249	P	P	A	15.5	295	none
6/18/2014	10:30	1,100	1,120	P	P	A	15.5	227	none
7/8/2014	9:10	1,700	ns	ns	ns	ns	ns	ns	none
7/16/2014	8:45	1,400	1,120	P	P	A	17.4	291	none
9/23/2014	9:10	9,000	1,733	P	P	A	16.8	256	none
11/4/2014	15:30	1,100	1,120	P	P	P	ns	135	none
	Mean	*3,040*	*1,210*						
	Median	*1,550*	*1,120*						
	SD	*3,190*	*487*						

ns = not sampled, P/A = present/absent

Table 4. Fecal coliform and *E. coli* densities measured in San Mateo Creek watershed on July 8, 2014 and June 30, 2015. (Bold values exceed USEPA 2012 REC-1 criteria)

Site ID	**Creek Name**	**Site Name**	***Fecal Coliform*** *(MPN/100ml)*	***E. Coli*** *(MPN/100ml)*	***Fecal Coliform*** *(MPN/100ml)*	***E. Coli*** *(MPN/100ml)*
MRP Trigger Threshold (REC-1 WQO)			*400*	*410*	*400*	*410*
REC-2 WQO			*4,000*	*--*	*4,000*	*--*
Sample Date			*7/8/2014*		*6/30/2015*	
204SMA060	San Mateo Creek	DeAnza Park	**1700**	**1700**	**500**	**500**
204SMA080		Sierra Drive	300	300	**500**	**500**
204SMA100		Tartan Trail	50	50	50	50
204SMA119		USGS Gage	8	4	4	4
204SMA110	Polhemus Creek	At Mouth	30	30	13	13

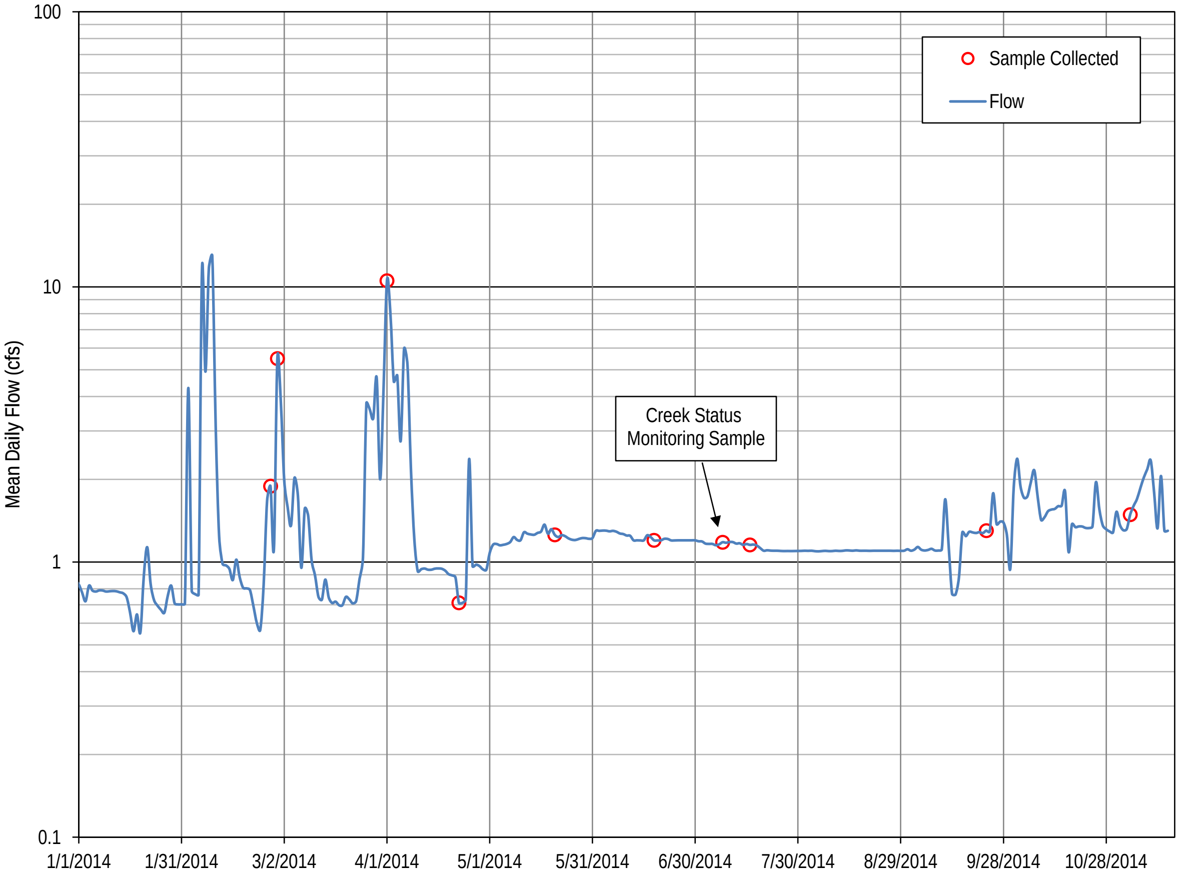

Figure 7. Bacteria sampling events and mean daily flow, San Mateo Creek, CA.

3.3 Bacteroidales Monitoring/Microbial Source Tracking

The presence of *E. coli* in San Mateo Creek may indicate fecal contamination; however, *E. coli* results alone do not indicate whether or not the fecal contamination is associated with a potentially controllable source such as human or pet waste. Therefore, microbial source tracking (MST) techniques were applied to begin characterizing which individual animal species are contributing to fecal contamination in the creek. The Gateway Park and De Anza Park investigation included sampling for the bacterial group of Bacteroidales as an MST approach. Bacteroidales are an abundant bacteria found in human and animal feces that have been found to survive for up to six days in the environment similar to other pathogens but have little potential for growth. They have a high degree of host specificity and therefore can be used to distinguish between human and other sources of fecal contamination by analyzing gene markers using real-time polymerase chain reaction (rt-PCR). An iterative process was followed in which each sample was first analyzed for the presence of the general genetic marker (GEN-BAC) for the Bacteroidales group. Samples with a positive GEN-BAC result were subsequently analyzed for the presence or absence of the human genetic marker (HUM183) and the dog marker. Results of the Bacteroidales analyses are listed in Table 3. See Appendix A for a more detailed discussion of the analytical techniques and quality assurance methods used in the Bacteroidales analyses.

Bacteroidales (GEN-BAC) and the human marker were present in all samples at both parks. Based on the relative abundance of the human marker to the GEN-BAC marker, it appears that the human marker made up less of the Bacteroidales group in the samples during or following rainfall events (February 26 and 28, 2014) (Table 3). This suggests that human sources of fecal contamination are less significant during periods when San Mateo Creek is receiving flow volumes from storm runoff and more significant during baseflow. In contrast, the dog marker was generally only present during the rain-affected samples (e.g., February 26 and 28, 2015) (Table 3). This suggests that canine feces deposited in the parks or in areas that wash into the MS4 are reaching the creek during storm events.

4.0 Potential Bacteria Sources and Ongoing Management Actions

Table 5 lists potential sources of pathogens that may be present in the San Mateo Creek watershed. Potential sources are grouped into two categories: controllable and uncontrollable. Controllable sources are those that could be reduced through management actions implemented by municipalities or others; however, the magnitude of reduction may be constrained. Uncontrollable sources occur naturally and would be difficult or impossible to reduce. The SSID study was designed to begin assessing which sources are present in the watershed and which are most important. Desktop approaches included map and aerial photo review and interviews with municipal staff regarding animal control, homeless encampments, and other potential bacterial sources. The sections below describe potential bacterial sources and current management actions that may reduce those sources.

Table 5. Potential sources of pathogen indicators in San Mateo Creek watershed.

Controllable Sources
Pet Waste (cats and dogs).
Wildlife (birds, rodents, deer) in some urban areas may be partially controllable. Human activities, such as littering, can attract wildlife by creating scavenging areas.
Trash Receptacle Leachate. Rodents and birds scavenge in trash bins. They may also contain discarded pet waste or diapers.
Human Waste Discharges (homeless encampments, leaking sewer lines and septic systems).
Uncontrollable Sources
Birds and other wildlife (deer, raccoons, ground squirrels, rabbit, skunk, opossum, wild turkey) in less urban areas (e.g., open space, riparian corridors, and forested areas).
Bacteria naturally present in the environment (e.g., soils and sediments in the watershed, creek, and conveyance system).

4.1 Land Use

Approximately 88 percent of the San Mateo Creek watershed lies within the undeveloped areas upstream of Lower Crystal Springs Reservoir. Section 3.2 (below) describes how FIB densities immediately below the reservoir are very low, suggesting that the upper watershed is not a major source of FIB to lower reaches. Figure 8 maps land uses in the lower watershed (i.e., drainage area below Lower Crystal Springs Reservoir) which is located in three municipalities: unincorporated San Mateo County, Hillsborough, and the City of San Mateo. Immediately below the reservoir, land uses consist primarily of low density residential. Development density transitions to industrial and commercial uses in the City of San Mateo near the mouth of the creek. Residential, commercial, and industrial land uses may be associated with all of the potential sources listed in Table 5 except wildlife in less urban areas.

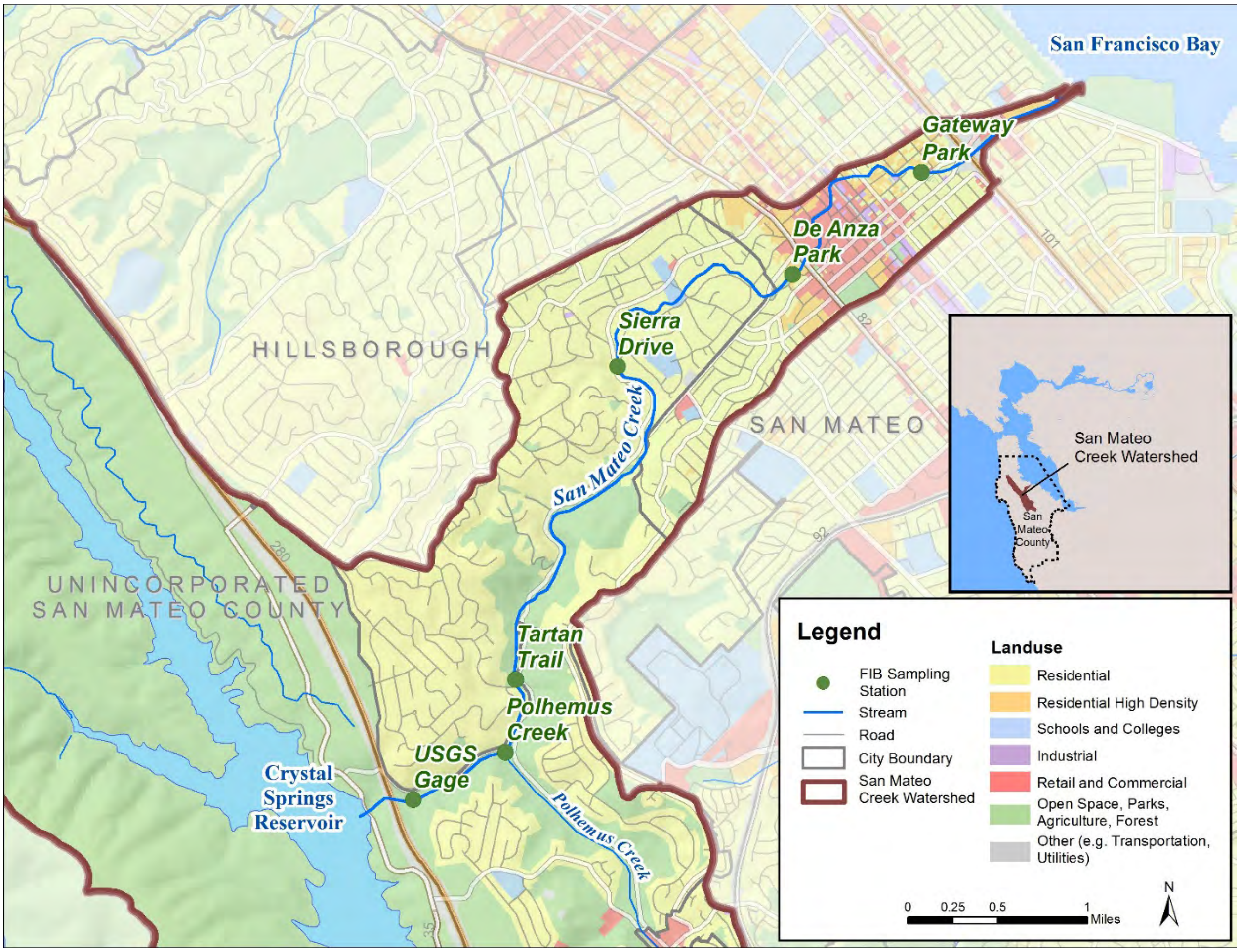

Figure 8. Land uses in lower San Mateo Creek watershed.

4.2 Pet Waste

Pet waste left on sidewalks, streets, yards, trails, and open space areas can enter the creek during runoff events (e.g., storms, sidewalk washing, irrigation). Even in the absence of other fecal sources, pet waste from dogs, cats, and other domestic animals contains fecal indicator bacteria (e.g., *E. coli*, fecal coliform) in quantities that can cause exceedances of WQOs in nearby creeks. Many pet owners may not be aware of the how pet waste contributes to water contamination. Municipal codes limit the number of pets (including chickens) that can be kept on residential properties. Dog and cat licensing is required throughout the lower San Mateo Creek watershed (i.e., City of San Mateo, Hillsborough, unincorporated County) through the County Health System. There are approximately 7,000 dogs and 2,000 cats licensed in the City of San Mateo and Hillsborough. Because not all pet owners obtain licenses, a more likely count of the number of pets residing in these cities is 15,000 dogs and 13,000 cats[4]. This represents a large potential source of bacteria to San Mateo Creek.

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[4] Estimates based on extrapolation guidelines from the American Veterinary Medical Association.

The De Anza and Gateway Park study included observations of fecal material and sources in the parks during site visits. Although confirmatory laboratory analysis of the fecal material was not conducted, feces ascribed to dogs were observed at Gateway Park during three of the nine site visits and at De Anza Park during six of nine visits (Table 6). Furthermore, City of San Mateo Park staff noted frequent dog play in the creek and problems with owners not picking up after their dogs.

The City enforces municipal code requirements primarily through the complaint system. Complaints about excessive animal feces on residential properties are received frequently (i.e., weekly) and cleanup requests are usually very successful. The City Parks Department controls pet waste at all parks by posting signs about picking up after dogs and providing tens of thousands of dog bags per year in dog bag dispensers. Through participation in SMCWPPP, all municipalities in the watershed are working to educate the public about the consequences of pet waste on receiving waters and the need to pick it up. The "Get the Scoop on Pet Poop" flyer is posted on the SMCWPPP Team Effort website (http://www.flowstobay.org/teameffort) and distributed at outreach events.

Table 6. Park use and fecal matter observations at Gateway and De Anza Parks.

		Park Use (Y/N) (count)				**Fecal Matter**	
Date	**Time**	*Ducks*	*Dogs*	*Humans*	*Deer*	*(Y/N)*	*Note*
Gateway Park							
2/26/2014	13:20	Y (23)	N	Y (4)	N	N	--
2/28/2014	12:30	Y (18)	Y (1)	Y (6)	N	Y	duck feces
4/1/2014	10:47	Y (9)	N	Y (1)	N	Y	duck and dog feces on walkway
4/22/2014	12:30	Y (10)	N	Y (8)	N	N	--
5/20/2014	11:25	Y (6)	N	Y (8)	N	Y	duck and dog feces creekside
6/18/2014	11:00	Y (6)	N	N	N	Y	dog feces on bank
7/16/2014	8:30	N	N	N	N	Y	on foot bridge
9/23/2014	8:30	Y (22)	Y (2)	Y (2)	N	Y	human feces under foot bridge
11/4/2014	16:00	Y (16)	N	Y (6)	N	N	--
De Anza Park							
2/26/2014	12:50	Y (1)	N	Y (1)	N	Y	dog feces on curb above storm drain
2/28/2014	12:10	Y (7)	N	N	N	N	--
4/1/2014	10:10	Y (8)	N	N	N	Y	deer feces on creek bank
4/22/2014	12:00	Y (6)	N	Y (6)	N	Y	dog feces in gutter, deer
5/20/2014	11:10	Y (7)	Y (1)	Y (1)	Y (3)	Y	deer and dog feces
6/18/2014	10:30	Y (2)	Y (2)	Y (2)	Y (3)	Y	dog feces
7/16/2014	8:45	Y (4)	Y (1)	Y (1)	Y ()	Y	dog feces on road, deer feces on bank
9/23/2014	9:10	N	N	Y (2)	Y (2)	Y	dog feces in plastic bag near outfall
11/4/2014	15:30	Y (3)	N	N	Y (4)	Y	deer feces

4.3 Trash

Unmanaged trash can be a source of bacteria to creeks, both directly and by attracting birds, rodents, and other wildlife. In compliance with Provision C.10.c of the MRP, municipalities in the lower San Mateo Creek watershed each developed a Long-Term Trash Load Reduction Plan and Assessment Strategy (Long-Term Plan) using a regionally consistent outline and guidance developed by BASMAA (City of San Mateo 2014, County of San Mateo 2014, Town of Hillsborough 2014). The Long-Term Plans identify and map trash generating areas and trash sources, delineate and prioritize Trash Management Areas (TMAs), and describe current and future control measures. Although the Long-Term Plans are focused on reducing the impacts of discharges from the MS4s, they also address direct dumping and wind dispersion of trash where possible.

Areas of high and very high trash generation were mapped in the lower San Mateo Creek watershed, including four creek hotspots (three in San Mateo and one in Hillsborough). Management actions being implemented in the watershed include installation and maintenance of full trash capture devices, enhanced street sweeping, creek cleanup events, outreach to businesses and residents, improved bins/container management, and bag and polystyrene bans. The goal is reduce trash in MS4 discharges by 70% in 2017 and 100% in 2022.

4.4 Wildlife

Wildlife sources of bacteria are generally considered uncontrollable. The riparian corridor along the perennial lower San Mateo Creek, and to a lesser extent parks and large residential lots in the watershed, provide desirable habitat for attracting and sustaining many wildlife and avian populations. These include raccoons, skunks, squirrels, deer, ducks, rodents, pigeons, snakes, woodrats, bobcats, mountain lions and coyotes. Multiple ducks and a family of deer were observed in the creek at De Anza Park during nearly every site visit (Table 6). In addition, raccoons and skunks are reported to enter the storm drain system throughout the lower San Mateo Creek watershed. Furthermore, rodents and pigeons are common nuisance wildlife in commercial and industrial areas of the City of San Mateo.

Former pigeon problems in downtown areas have been curtailed by hiring a bird control specialist who educates business owners on how to not attract birds and eliminate potential nesting sites. Other wildlife are controlled infrequently on an as-needed basis. In addition, the trash reduction efforts described in Section 4.3 are expected to reduce nuisance wildlife.

4.5 Wastewater

4.5.1 Municipal Wastewater Treatment

Most properties in the lower San Mateo Creek watershed are served by the San Mateo Wastewater Treatment Plant (WWTP) which discharges to San Francisco Bay under NPDES Order No. R2-2013-0006 and NPDES Order No. R2-2012-0096 (which establishes region-wide mercury and PCBs requirements) (Carollo 2014). Each municipality served by the WWTP individually owns and operates their own respective collection systems and must comply with the Statewide General Waste Discharge Requirements for Sanitary Sewer Systems, and the Revised Monitoring and Reporting Program Order No. 2013-0058-EXEC.

Cease and Desist Order

A sanitary sewer overflow (SSO) is defined as any overflow, release, discharge, or diversion of untreated or partially treated wastewater from a sanitary sewer system. SSOs can contain FIB, pathogenic organisms, and other pollutants. They have the potential to pollute surface and ground water.

In 2009, the Regional Water Board issued Cease and Desist Order (CDO) No. R2-2009-0020 to the City of San Mateo and the satellite collection systems owned by Hillsborough and the County due to SSO discharges. The CDO requires the implementation of several prescribed actions to eliminate the conditions in the collection system that cause or contribute to SSOs or unauthorized discharges from the WWTP. Many of these actions are still under development.

- **Crystal Springs/El Cerrito Trunk Sewer Project.** The City of San Mateo, Hillsborough, and County must upsize piping in Hillsborough's collection system and install a new wet weather relief line in the City's collection system. The Crystal Springs/El Cerrito Trunk line parallels San Mateo Creek for approximately 15,800 linear feet between El Camino Real (near De Anza Park) and Polhemus Road. It was targeted by the CDO due to significant undersizing and several SSOs in January 2008 totaling 643,900 gallons. The project is under construction as of September 2015.
- **Crystal Springs County Sanitary District's (CSCSD) Remaining Capital Improvement Plan (CIP) Projects.** The County must complete, by September 2014, the eight remaining CIP project identified in its 1999 Sewer Master Plan.
- **SSO Spill Response**. By June 2009, each agency submitted an SSO Response Plan, which describes emergency response and contingency procedures in the event of an SSO.
- **Collection System Maintenance and Management**. Four Regional Water Board submittals were completed by May 2010, including development and implementation of a plan to ensure that the entire collection system is cleaned within a three-year timeframe; a report describing the computerized sewer maintenance management system; certification that all pump stations are capable of pumping peak wet weather flow and can operate continuously; and a Fats, Oils and Grease Blockage Control report.
- **Collection System Condition and Capacity Assessments**. Two Regional Water Board submittals were completed by November 2009, including a plan for inspection of gravity sewers and manholes and installation of flow meters to assess peak dry weather and wet weather flow rates.
- **Capacity Assurance**. Implementation of short-term capacity improvements is required by November 2016.

4.5.2 Individual Sewage Disposal Systems

One property in unincorporated San Mateo County is on a private septic system (e.g., individual sewage disposal system) with one or two leach fields. It is located just downstream of the San Mateo Creek and Polhemus Creek confluence. Per San Mateo County Ordinance chapter 4.84, it is subject to a triennial inspection by the County Health Officer to ensure its continued proper functioning.

4.5.3 Direct Sources of Wastes

Homeless encampments sometimes occur along the creek at bridge crossings in the denser residential and commercial areas of the City of San Mateo (i.e., Highway 101, 3rd Avenue, Darcy's Tunnel) at Gateway Park, and occasionally as far upstream as De Anza Park. These uses can be a significant source of human fecal material and other pollutants (e.g., trash) directly to the creek. When encampments are reported to the City of San Mateo Police Department, the homeless are notified with postings that they need to permanently vacate the encampment along with their belongings within a certain period of time. If they remain beyond the specified time period, then the Police Department can forcibly remove them and have the Public Works Department remove their belongings and any debris left behind.

The City and County of San Mateo are also actively involved in efforts to prevent encampments by helping to move homeless people into housing. In 2005, the County initiated the Housing Our People Effectively (HOPE) 10-year strategic plan to end homelessness in the County. One outcome of HOPE was the pilot Housing Outreach Team (HOT) program, implemented in 2006 in downtown San Mateo. The HOT program provides permanent housing and outreach to homeless people. In addition, in 2013, the City of San Mateo installed fencing in two problem areas to prohibit access to the Creek.

4.6 Bacteria Fate and Transport

An understanding of the fate and transport of bacteria in the system is critical to developing effective and cost-efficient control measures. Numerous variables can affect the concentration of FIB measured at any one location.

Removal mechanisms include inactivation (i.e., loss in viability of the microorganism) and physical transport (either downstream or into bed sediments). Inactivation or die-off is dependent on several factors, including temperature, pH, salinity, nutrient concentrations, predation, and ultraviolet (UV) irradiance. Bacteria can attach to sediment particles even under flowing or turbulent conditions resulting in removal from the water column and the formation of biofilms. However, bacteria colonies can grow in the sediment and later become resuspended in the water column. Bed sediments thereby can transition from a sink to a source. Modeling of these mechanisms is difficult because the conditions (physical and chemical variables) under which bacteria attach or detach from particles are not fully understood (Walters et al. 2013).

5.0 Discussion and Recommendations

During WY2014 and WY2015, the San Mateo Creek Pathogen Indicator SSID Project investigated elevated FIB densities observed in San Mateo Creek during WY2012 Creek Status Monitoring and historically. The San Mateo Creek watershed is characterized by a large (i.e., 27-square mile) open space upper watershed with controlled releases to a smaller (5-square mile) lower watershed which drains to San Francisco Bay. The lower watershed encompasses a gradient of increasingly dense urban land uses in the downstream direction.

5.1 Bacterial Extent and Sources

Field and desktop approaches were implemented to assess the seasonal and geographic extent and potential sources of elevated FIB densities.

- **Geographic Extent**. *E. coli* was measured at densities consistently exceeding REC-1 WQOs in lower San Mateo Creek along creekside parks (Gateway and De Anza Parks) where water contact recreation, although unlikely, could occur. Elevated FIB densities were not observed during dry season sampling at stations higher up in the watershed (i.e., above Sierra Drive). REC-2 WQOs for fecal coliform were not exceeded.
- **Seasonal Extent.** With one exception, *E. coli* was measured at densities exceeding REC-1 WQOs at Gateway and De Anza Parks densities throughout the monitoring period (i.e., February through November 2014 and June 2015). Although there was a high degree of variability in FIB densities (typical of bacteriological studies), there was a slight (but inconsistent) wet weather signal, with the highest *E. coli* densities observed during or shortly after storm events. A more intensive sampling program would be required to provide more statistical certainty regarding seasonal differences.
- **Potential Sources**. The presence of residential, commercial, and industrial land uses in the watershed suggests a number of potential bacteriological sources. Controllable sources include pet waste, human waste discharges from homeless encampments and leaking sewer lines, wildlife waste exacerbated by litter, and trash receptacle leachate; however, the extent to which municipalities can control these sources may be constrained. Uncontrollable sources include wildlife waste in less urban areas and bacterial growth in the environment. Application of MST techniques (i.e., human and dog genetic markers in the Bacteroidales group) suggest year-round human sources impact lower San Mateo Creek while dog sources primarily impact the creek during wet-weather.

5.2 Current and Planned Management Actions

A number of management actions designed specifically or opportunistically to control bacterial sources are currently planned or are being implemented by municipalities in the lower San Mateo Creek watershed. These include:

- **Pet Waste.** Control measures for pet waste currently include municipal code enforcement and complaint response, pet waste cleanup signage and dog bag dispensers, and public outreach and education.
- **Wildlife Waste.** Control measures for wildlife waste include a successful public education program targeting pigeons in commercial areas of San Mateo. Trash reduction efforts may also reduce nuisance wildlife.
- **Trash.** All municipalities in the lower San Mateo Creek watershed have developed and are implementing Long-Term Trash Load Reduction Plans with the goal of reducing trash in MS4 discharges by 70% in 2017 and 100% in 2022.
- **Wastewater**. All municipalities in the lower San Mateo Creek watershed are currently implementing or planning prescribed actions to eliminate conditions in the sanitary sewer collection system that cause or contribute to SSOs. Actions include improved maintenance and management to system assessments and tracking systems. In addition, replacement of the significantly undersized Crystal Springs/El Cerrito Trunk line, which runs along San Mateo Creek between El Camino Real and Polhemus Creek, is under construction as of September 2015. Homeless encampments along the creek are being targeted by the HOT program which provides permanent housing and outreach to homeless peoples. The City of San Mateo has also installed fencing in two problem areas.

5.3 Recommendations

Although municipalities are implementing many recent management actions, FIB densities measured in WY2014 and WY2015 in San Mateo Creek at Gateway and De Anza Parks remain within the same range as FIB densities measured in 2003 and WY2012. Furthermore, in spite of signage and public outreach, dog waste was frequently observed at Gateway and De Anza Parks and dog genetic markers were measured in many wet-weather samples. It is possible that management actions already planned for the near future will result in future reductions in FIB densities. For example, CDO actions may address the year-round presence of human genetic markers in water samples at De Anza Park where homeless encampments and other human sources are unlikely.

The City of San Mateo, Town of Hillsborough, San Mateo County, and SMCWPPP may wish to consider working together to increase public education and outreach targeting pet waste in the San Mateo Creek watershed. Potential examples include installation of additional cleanup signs, dog bag dispensers, and trash receptacles at creekside parks. Local municipalities should also continue the homeless elimination efforts begun through the HOPE strategy and HOT program. In addition, to help evaluate the effectiveness of current and planned control actions, SMCWPPP may wish to consider continuing to monitor FIB in San Mateo Creek via its MRP Creek Status monitoring program. However, even if human and dog sources are better controlled, FIB monitoring results could still exceed WQOs due to uncontrollable sources such as wildlife and natural bacterial growth.

It is important to acknowledge that a) the REC-1 WQOs for FIB in the San Francisco Basin Plan do not distinguish among sources of FIB and that b) FIB do not directly represent actual pathogen concentrations. Animal fecal waste is much less likely to contain pathogens of concern to human health than human sources. In most cases, it is the human sources that are associated with REC-1 health risks rather than wildlife or domestic animal sources (USEPA 2012).

6.0 References

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IEH /BioVir Laboratories

ELAP# 1795
ACLASS 17025

685 Stone Road, Unit 6 ● Benicia, CA 94510 ● (707) 747-5906 ●1-800-GIARDIA ● FAX (707) 747-1751 ● WEB: www.biovir.com

DATE: April 9, 2015

TO: Bonnie DeBerry
EOA, Inc

FROM: Richard Danielson, Ph.D.
Laboratory Director

SUBJECT: Results of Indicator of Fecal Pollution Study: *E. coli*, *Enterococci* and Bacteroidales analysis of San Mateo Creek, San Mateo, CA. **Amended Report**

From February, 2014 to November, 2014, samples were collected in San Mateo Creek, San Mateo, CA for a variety of indicator organisms, including the fecal coliforms, Enterococci and the bacterial group of the Bacteroidales. The target areas were within two public parks, DeAnza and Gateway (please see Figure 7).

In summary, at no point during this study did the microbiological water quality in San Mateo Creek at DeAnza Park or Gateway Park meet recreational (body contact) standards. In all instances, indicators of microbiological water quality significantly exceeded the standards. Further, there was evidence that the sources of the fecal pollution included wild animals, domestic animals and humans.

There were nine sample events, three collections following rainfall, the other six during dry conditions. Sample collection was timed with low-tide events in order to reduce the influence that high-tide water from San Francisco Bay may have had on the site at Gateway Park. 500 mL samples were collected in sterile plastic bottles from the shore using an extension pole to out into the flow of the creek. Samples were transported same-day to the laboratory with ice packs to keep them cool. All samples were processed within 5 hours of final collection.

Environmental information was collected at each site including temperature; conductivity; type of wild and domestic animal activity observed; and, general observations of the condition of the creek (odors, debris, weather conditions, etc.).

A summary of all the microbiological data is presented in Attachment A. Chain of custody forms with the raw data collected on site is presented in Attachment B. A collage of photographs taken throughout the year are presented in Attachment C.

Physical State of the Parks

DeAnza. The sample site in DeAnza Park was located in the eastern part of an urban green-way with many trees forming a canopy and thick ivy undergrowth. There is public access down to the creek at several locations with both constructed and foot-worn paths throughout. For the majority of the sample visits there was only occasional debris of waste (plastic bags, paper, etc.). Storm drains from the street lead into the creek. In regards to animal activity, there was a family of at least four deer that resided in the immediate area and deer scat was prominent throughout along the banks of the creek. Ducks were numerous and almost always present. There was direct evidence of domestic canine activity on the street above and on several occasions people were walking their dogs in the park area during a sampling event.

Gateway. The sample site in Gateway Park was located at the eastern end of the park before an overpass. Gateway is a constructed urban park to the west of the creek with un-maintained banks on the east. Public access is an easy walk to the creek from the banks throughout the length of the creek through the park. Debris is common and spread along the length of the creek in the area comprised of plastic bags, paper, bottles, cans, etc. In regards to animal activity, ducks were numerous and always present. Turtles also inhabit the creek at this site. There was direct evidence of domestic canine activity on the walkways above and on several occasions people were walking their dogs in the park area during a sampling event.

Indicator Data – *E. coli* Bacteria

For the analysis of *E. coli* bacteria, Standard Methods for the Examination of Water and Wastewater, 9221F (2006) was used. This is a method where portions of the sample in increasing dilution are dispensed into a series of selective and differential media. In addition, to further select of *E. coli* bacteria, there is a high-temperature incubation step. The results of this test are expressed as a most probable number (MPN) per 100 mL volume. A summary of the data is presented in Figures 1 and 2 and Tables 1, below.

Figure 1.

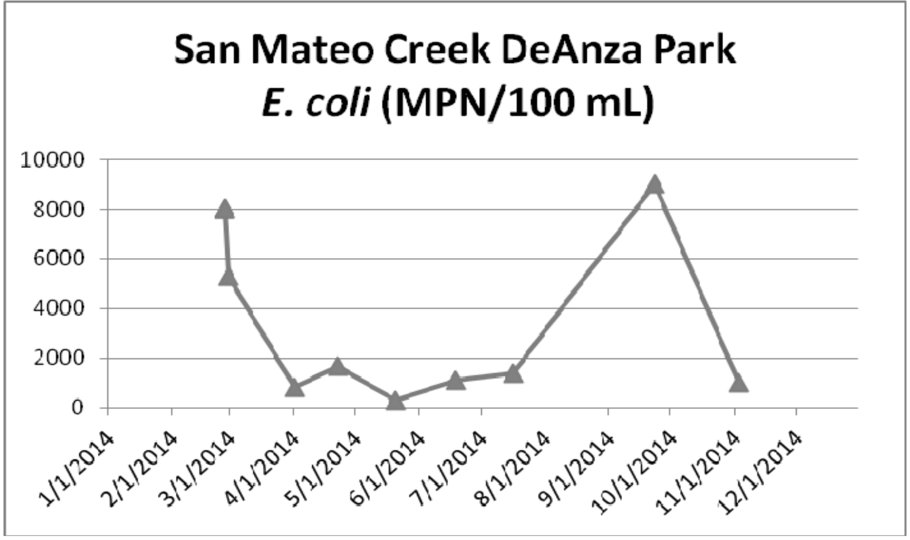


Figure 2

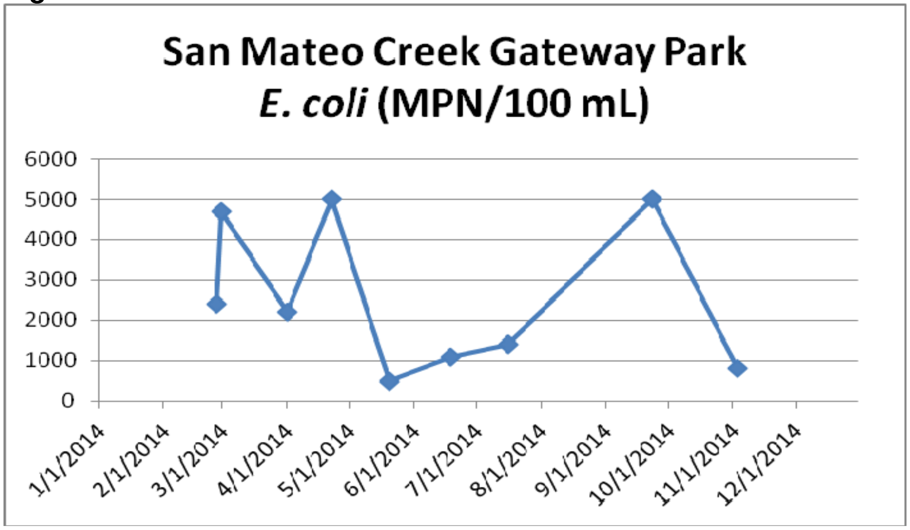


Table 1.

E. coli **DeAnza**			***E coli*** **Gateway**	
	MPN/100 mL			MPN/100 mL
Mean	3660		Mean	2400
Median	1550		Median	2200
Minimum	300		Minimum	500
Maximum	9000		Maximum	5000

Indicator Data – *Enterococcus* Bacteria

For the analysis of *Enterococcus* bacteria, the Enterolert (Idexx) Quantitray Method was used. This is a method where portions of the sample are dispensed into a series of smaller volumes into a segmented tray. The media is a minimal media supplemented with a compound that is broken down and fluoresces under a black light by the enterococci. In addition, to further select for *Enterococcus* bacteria, there is a high-temperature incubation step. The results of this test are expressed as a most probable number (MPN) per 100 mL volume. A summary of the data is presented in Figure 3 and 4, and in Table 2, below.

Figure 3

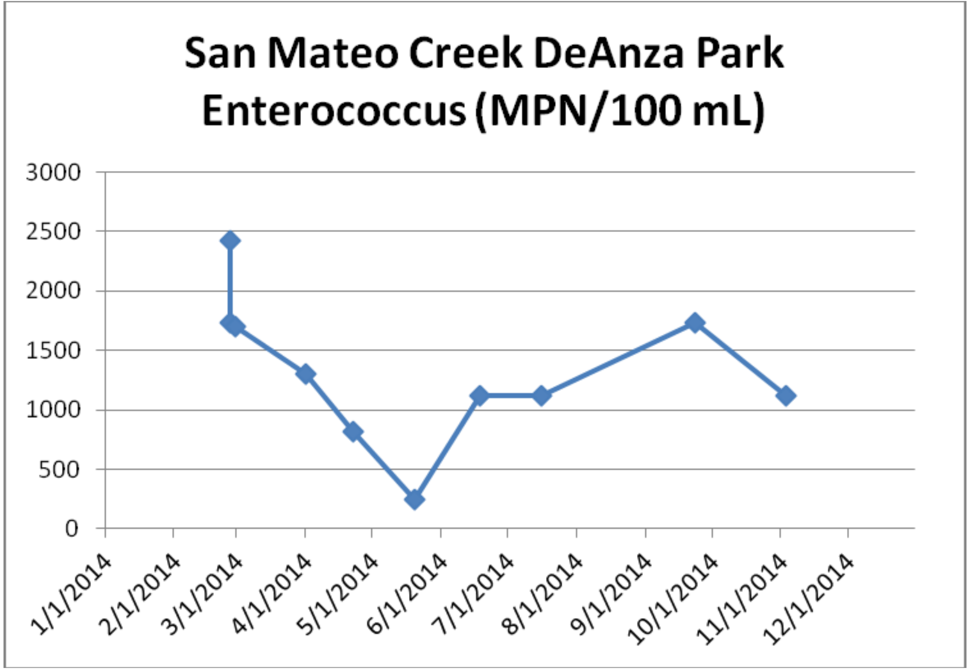


Figure 4

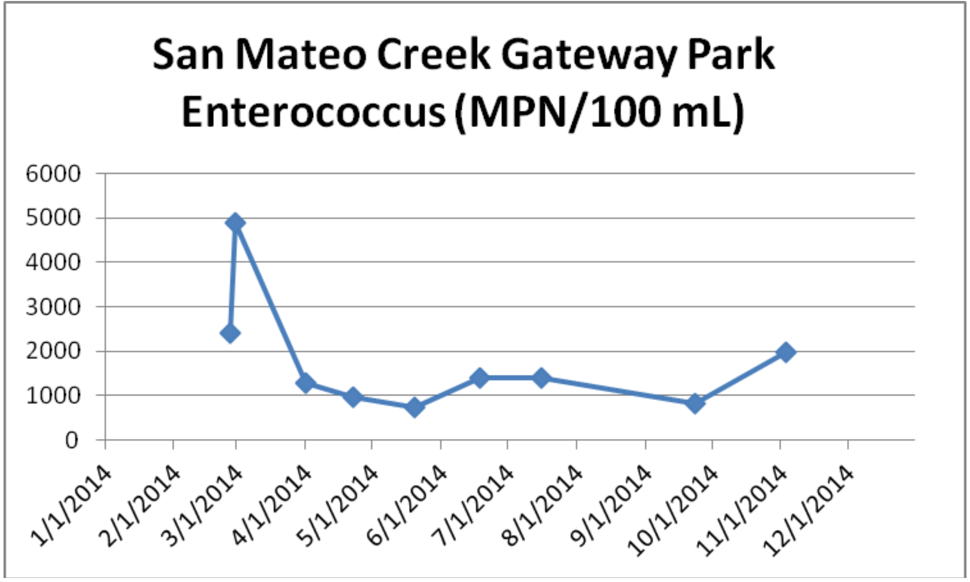


Table 2

Enterococcus DeAnza			Enterococcus Gateway	
	MPN/100 mL			MPN/100 mL
Mean	1331		Mean	1773
Median	1210		Median	1414
Minimum	249		Minimum	727
Maximum	2419		Maximum	4900

Indicator Data – The Bacteroidales

The bacteroidales were originally selected as they represent a significant part of the mammalian gut microbial population. Further, there are analytical techniques available that can detect and differentiate these organisms by the animal source from environmental samples. The technique used was real-time polymerase chain reaction (rt-PCR). Initially the analysis was for the detection of the general genetic marker (GEN-BAC) for the bacteroidales group (US EPA Method B, 2010; SCCWRP, 2013). Subsequent to identifying those areas that were positive for the presence of the GEN-BAC, analysis was requested for the human genetic marker (HF) also (SCCWRP, 2013; Lamendella et al, 2006) and for dog marker (Bernhard and Field, 2000). A standard from a human source was run with each set and arbitrarily set at a declining concentration scheme of 100,000, 10,000, 1,000, 100 and 10. All values were then compared against this standard to provide a relative association of HF to GEN-BAC.

In summary, the GEN-BAC and HF markers were detected at all sample sites during all sample periods throughout the study. The relative abundance of HF marker to GEN-BAC marker was used to provide a general assessment of distribution of these organisms within the bacteroidales group.

A summary of the data is presented in Figures 5 and 6.

Figure 5.

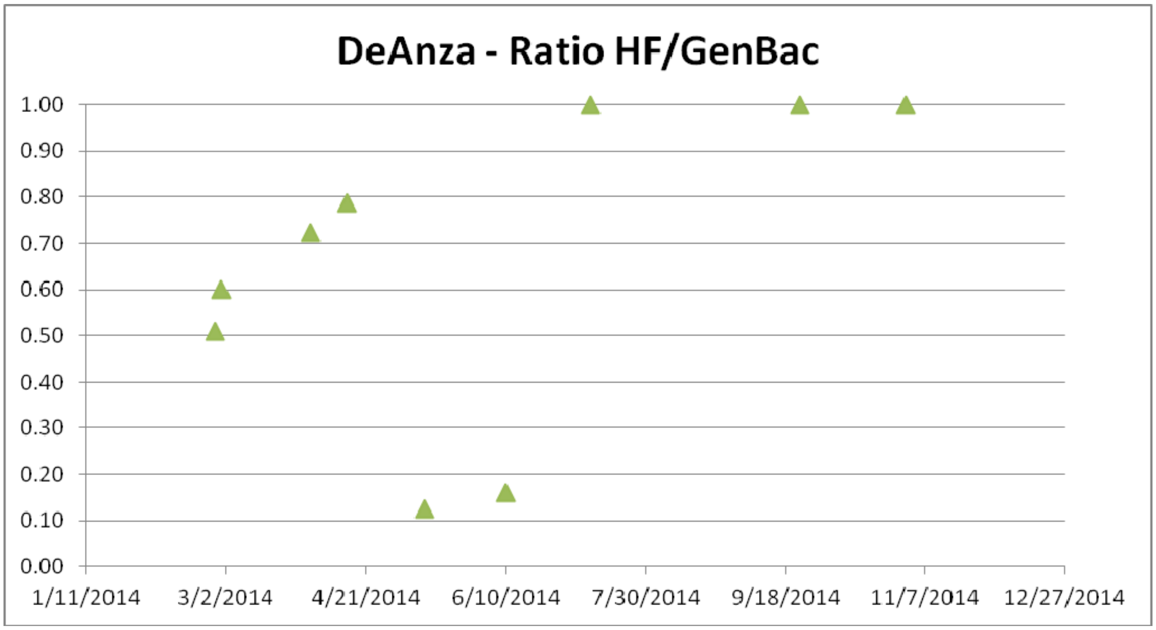
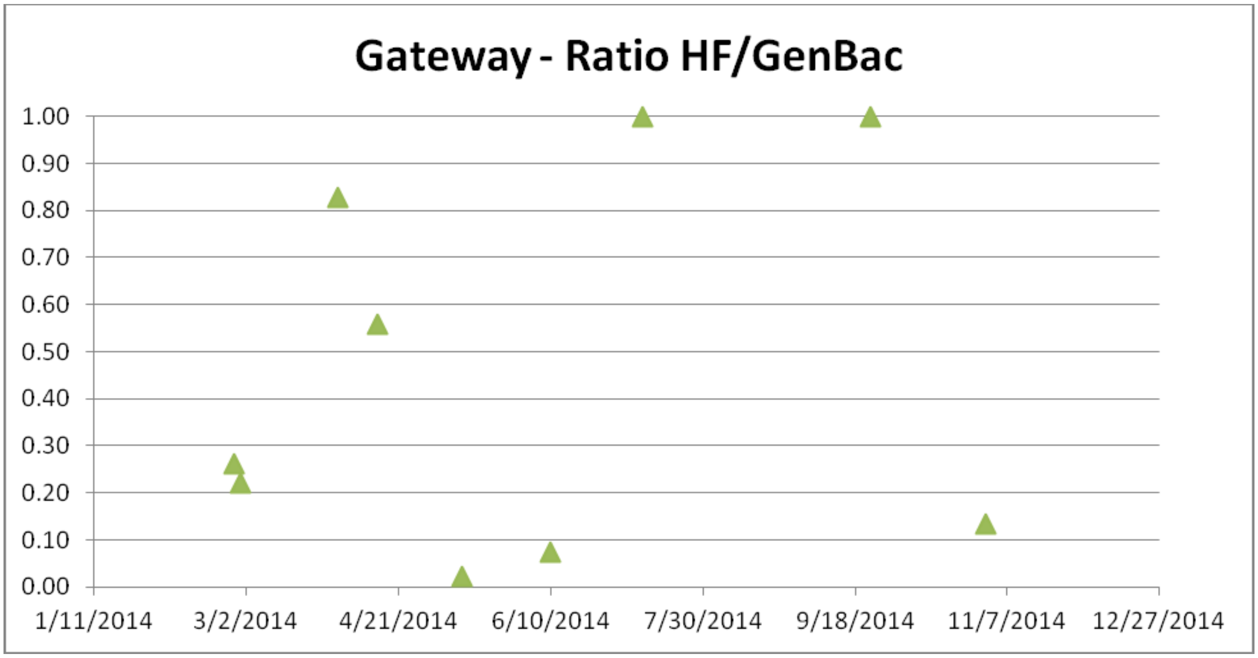


Figure 6



For DeAnza, the HF marker made up less of the Bacteroidales group detected in the samples during or following a rainfall (2/26/2014 and 2/28/2014) with the exception of 10/31/2014. During the dry season sampling the HF and the GEN-BAC were of equal value. For Gateway, a similar distribution was observed, with the exception that on 10/31/2014, the HF marker was similar to previous rain-effected samples. For the two observations at 5/12/2014 and 6/10/2014, the low ratios are more due to the relatively low concentration of the bacteroidales relative to the other occasions.

Since there is much domestic canine activity at both parks, it was desired to determine what, if any, impact canine feces may have on the creek. There was evidence of canine feces being deposited at both parks. However, the canine marker was detected only following storm events with the exception of one additional observation at Gateway Park (Table 3). This indicates that during the study period canine feces was a contributor to fecal pollution from the runoff from the streets and parks.

Finding higher ratio of HF marker during the dry season indicates that the wild and domestic animal fecal material that is on the periphery of creek is not being transported into the creek at those times. During dry season the Bacteroidales that are being detected appears to be associated with human-related sources.

The Bacteroidales bacteria do not readily replicate outside of the animal host, and in fact, their survival outside the host is quit short. Therefore, detecting these bacteria is an indication of recent introduction into the environment.

Table 3. Dog Marker

	Sample Number	Date Collected	Result
DeAnza	140291-001	2/26/2014	+
	140286-001	2/28/2014	+
	140472-001	4/1/2014	ND
	140539-001	4/22/2014	ND
	140697-002	5/20/2014	ND
	140874-001	6/18/2014	ND
	141012-001	7/16/2014	ND
	141380-001	9/23/2014	ND
	141575-001	11/4/2014	+

	Sample Number	Date Collected	Result
Gateway	140291-003	2/26/2014	+
	140286-002	2/28/2014	+
	140472-002	4/1/2014	ND
	140539-002	4/22/2014	+
	140697-001	5/20/2014	ND
	140874-002	6/18/2014	ND
	141012-002	7/16/2014	ND
	141380-002	9/23/2014	ND
	141575-002	11/4/2014	+

There are a series of controls that are performed with RT-PCR analysis that are crucial to demonstrate that the reaction was successful. Positive and negative controls are performed to monitor the performance of the PCR machine (Qiagen, Rotorgene Q) and to check on false positive outcomes as a result of sample handling, respectively. A source of bacteroidales was added to samples as a nucleic acid extract control in order to determine if matrix inhibitors had been carried over into the reaction, or, for matrix inhibition in recovery.

References

Standard Methods for the Examination of Water and Wastewater, APHA-AWWA-WEF (on-line)

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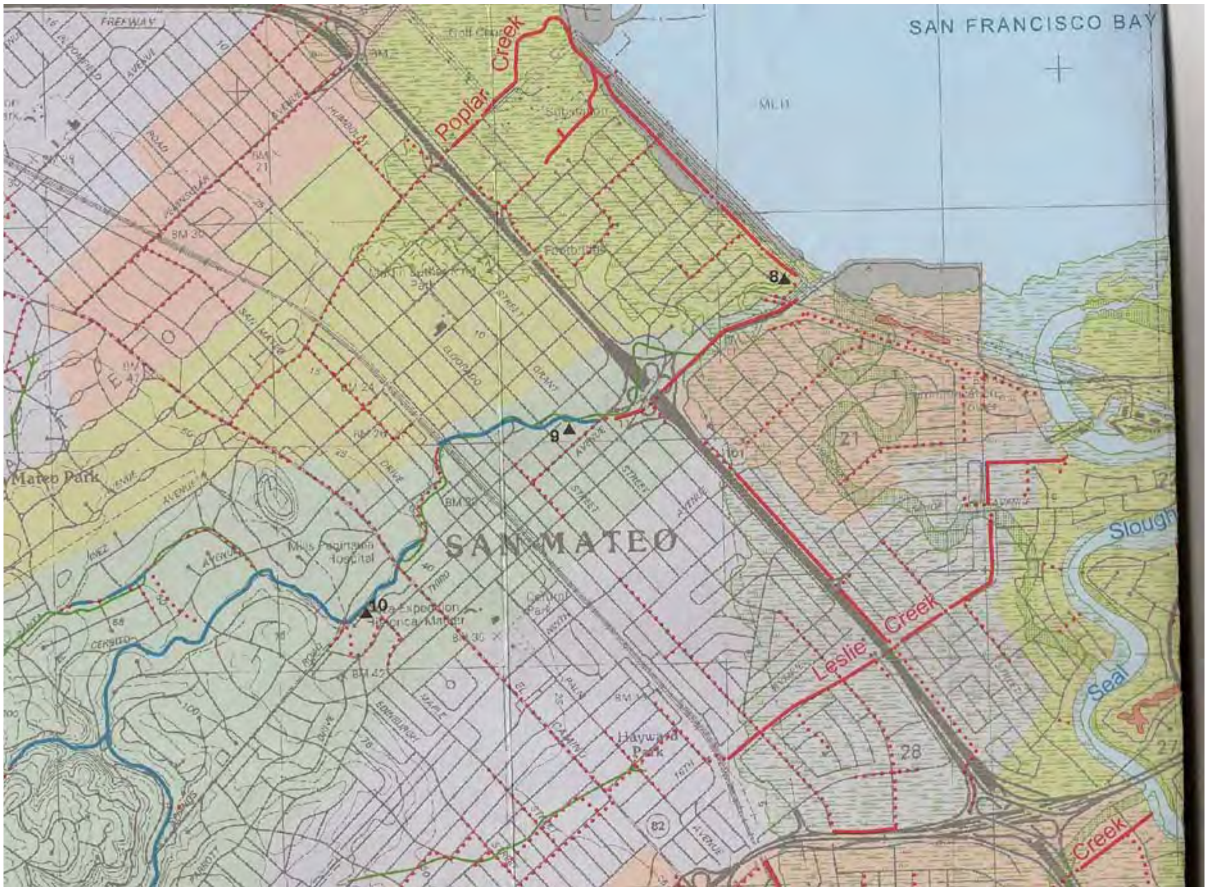
The California Microbial Source Identification Manual: A Tiered Approach to Identifying Fecal Pollution Sources to Beaches. Griffith, J.F., B.A. Layton, A.B. Boehm, P.A. Holden, J.A. Jay, C Hagedorn, C.D. McGee, and S.B. Weisberg. SCCWRP Tech Report 804. December 2013.

Bernhard, A.E. and K.G. Field. 2000. A PCR Assay to Discriminate human and Ruminant feces on the basis of host differences in *Bacteroides-Prevotella* Genes Encoding 16SRNA. Appl. Environ. Microbiol. 66:4571-4574.

Figure 7. Map of study area. DeAnza Park (Station 10) and Gateway Park (Station 9)



ATTACHMENT A – Microbiological Data

Sample	Date	Test	Method	Location	NumericResult	Units	Bacteroidales	HUM183	Dog
140291-001	2/26/2014	Coliform, E.coli,	SM9221	De Anza 1	8000	MPN/100ml	P	P	P
140291-001	2/26/2014	Enterococci	Quantitray / Enterolert	De Anza 1	2419.2	MPN/100ml			
140291-002	2/26/2014	Coliform, E.coli,	SM9221	De Anza 2	8000	MPN/100ml	P	P	P
140291-002	2/26/2014	Enterococci	Quantitray / Enterolert	De Anza 2	1732.9	MPN/100ml			
140291-003	2/26/2014	Coliform, E.coli,	SM9221	Gateway 1	24000	MPN/100ml	P	P	P
140291-003	2/26/2014	Enterococci	Quantitray / Enterolert	Gateway 1	>2419.2[1]	MPN/100ml			
140286-001	2/28/2014	E. coli	SM9221	DeAnza 1	5300	MPN/100ml	P	P	P
140286-001	2/28/2014	Enterococci	Quantitray / Enterolert	DeAnza 1	1700	MPN/100ml			
140286-002	2/28/2014	E. coli	SM9221	Gateway 1	4700	MPN/100ml	P	P	P
140286-002	2/28/2014	Enterococci	Quantitray / Enterolert	Gateway 1	4900	MPN/100ml			
140472-001	4/1/2014	E. coli	SM9221	DeAnza	800	MPN/100ml	P	P	ND
140472-001	4/1/2014	Enterococci	Quantitray / Enterolert	DeAnza	1300	MPN/100ml			
140472-002	4/1/2014	E. coli	SM9221	Gateway	2200	MPN/100ml	P	P	ND
140472-002	4/1/2014	Enterococci	Quantitray / Enterolert	Gateway	1300	MPN/100ml			
140539-001	4/22/2014	E. coli	SM9221	DeAnza 1	1700	MPN/100ml	P	P	ND
140539-001	4/22/2014	Enterococci	Quantitray / Enterolert	DeAnza 1	816.4	MPN/100ml			
140539-002	4/22/2014	E. coli	SM9221	Gateway	5000	MPN/100ml	P	P	P
140539-002	4/22/2014	Enterococci	Quantitray / Enterolert	Gateway	980.4	MPN/100ml			
140697-001	5/20/2014	E. coli	SM9221	Gateway near bridge	500	MPN/100ml	P	P	ND
140697-001	5/20/2014	Enterococci	Quantitray / Enterolert	Gateway near bridge	727	MPN/100ml			
140697-002	5/20/2014	E. coli	SM9221	DeAnza Creek	300	MPN/100ml	P	P	ND
140697-002	5/20/2014	Enterococci	Quantitray / Enterolert	DeAnza Creek	248.9	MPN/100ml			
140874-001	6/18/2014	E. coli	SM9221	DeAnza 1	1100	MPN/100ml	P	P	ND
140874-001	6/18/2014	Enterococci	Quantitray / Enterolert	DeAnza 1	1119.9	MPN/100ml			
140874-002	6/18/2014	E. coli	SM9221	Gateway	1100	MPN/100ml	P	P	ND
140874-002	6/18/2014	Enterococci	Quantitray / Enterolert	Gateway	1413.6	MPN/100ml			
141012-001	7/16/2014	E. coli	SM9221	DeAnza 1	1400	MPN/100ml	P	P	ND
141012-001	7/16/2014	Enterococci	Quantitray / Enterolert	DeAnza 1	1119.9	MPN/100ml			

141012-002	7/16/2014	E. coli	SM9221	Gateway	1400	MPN/100ml	P	P	ND
141012-002	7/16/2014	Enterococci	Quantitray / Enterolert	Gateway	1413.6	MPN/100ml			
141380-001	9/23/2014	E. coli	SM9221	DeAnza 1	9000	MPN/100ml	P	P	ND
141380-001	9/23/2014	Enterococci	Quantitray / Enterolert	DeAnza 1	1733	MPN/100ml			
141380-002	9/23/2014	E. coli	SM9221	Gateway	5000	MPN/100ml	P	P	ND
141380-002	9/23/2014	Enterococci	Quantitray / Enterolert	Gateway	816	MPN/100ml			
141575-001	11/4/2014	E. coli	SM9221	DeAnza 1	1100	MPN/100ml	P	P	P
141575-001	11/4/2014	Enterococci	Quantitray / Enterolert	DeAnza 1	1119.9	MPN/100ml			
141575-002	11/4/2014	E. coli	SM9221	Gateway	800	MPN/100ml	P	P	P
141575-002	11/4/2014	Enterococci	Quantitray / Enterolert	Gateway	1986.3	MPN/100ml			

ND = Not Detected

1. Amended #140291-3, Enterococcus, 04/09/2015

ATTACHMENT B – CHAIN OF CUSTODY FORMS AND FIELD DATA

BioVir LABORATORIES®

SAMPLE DATA SHEET

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA CALIFORNIA 94510
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Business Hours: Monday through Friday - 8:30 AM to 5:00 PM

EOA001

11.1°C 291-1-3

COMPANY OR UTILITY: **EOA, Inc., 1410 Jackson Street, Oakland, CA 94612**
Attn: Bonnie de Berry
TELEPHONE#: (510) 832-2852 EXT#: 123 MOBILE#: (415) 336-4458 FAX#: (510) 832-2856

NAME OF SAMPLER: **(Please print and sign - REQUIRED)** RE Dal Danielson

DATE OF SAMPLING: 2.26.14

PURCHASE ORDER #:

Matrix: [✓ Creek Water] Drinking Water Wastewater Biosolid OTHER:

Weather Conditions:

	SAMPLE ID#	TIME	VOLUME	TREATMENT	SAMPLING LOCATION	ANALYSIS REQUESTED
①	De Anza 1	1250	0.5L	—	De Anza Park	E.coli, Enterococci + MST
②	De Anza 2	1250	0.5L	—	De Anza Park	
③	Gateway 1	1320	0.5L	—	Gateway Park	

Observations – (Measure temp and specific conductance [SC]; walk the park looking for signs of fecal contamination or its sources)

De Anza TEMP (°C): / SC (µmhos/cm): /

DUCKS: [✓ Y] / N COUNT: 1 LOCATION: @ HISTORIC MARKER

DOGS: Y / [✓ N] COUNT: LOCATION:

HUMANS: [✓ Y] / N COUNT: 1 LOCATION: BENCH BY CREEK

OTHER: COUNT: LOCATION:

FECAL MATTER: [✓ Y] / N COUNT: 1 LOCATION: CURB ABOVE STORM DRAIN

OTHER OBSERVATIONS (e.g., odors, [✓ debris], [✓ active runoff], [✓ flowing storm drains], encampments):
flowing

Gateway TEMP (°C): SC (µmhos/cm):

DUCKS: [✓ Y] N COUNT: 23 LOCATION: w/in 50 yds upstream sample pt

DOGS: Y / [✓ N] COUNT: LOCATION:

HUMANS: [✓ Y] / N COUNT: 4 LOCATION: playground

OTHER: COUNT: LOCATION:

FECAL MATTER: Y / [✓ N] COUNT: LOCATION:

OTHER OBSERVATIONS (e.g., odors, [✓ debris], [✓ active runoff], [✓ flowing storm drains], encampments):

RELINQUISHED BY (SIGNED)	DATE/TIME	RECEIVED BY (SIGNED)	DATE/TIME
	2.26.14 1430		2/26/14 14:30

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SAMPLE DATA SHEET

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1-800-GIARDIA (442-7342) FAX: 707-747-1751
Business Hours: Monday through Friday - 8:30 AM to 5:00 PM

EOA001
286-1-2
9.9°C

COMPANY OR UTILITY: **EOA, Inc., 1410 Jackson Street, Oakland, CA 94612**
Attn: Bonnie de Berry
TELEPHONE#: (510) 832-2852 EXT#: 123 MOBILE#: (415) 336-4458 FAX#: (510) 832-2856

DATE OF SAMPLING: 2.28.14

PURCHASE ORDER #:

NAME OF SAMPLER: **(Please print and sign - REQUIRED)** RE Danielson

Matrix: [✓ Creek Water] Drinking Water Wastewater Biosolid OTHER:

Weather Conditions: raining

SAMPLE ID#	TIME	VOLUME	TREATMENT	SAMPLING LOCATION	ANALYSIS REQUESTED
① DeAnza 1	1210	0.5 L		DeAnza Park	E.coli/Enterococci/MST
② Gateway 1	1230	0.5 L		~~De Anza~~ Gateway Park	" " "

Observations – (Measure temp and specific conductance [SC]; walk the park looking for signs of fecal contamination or its sources)

De Anza TEMP (°C): 13.5° SC (µmhos/cm): 220

DUCKS: [✓ Y] N COUNT: 7 LOCATION: throughout

DOGS: Y [✓ N] COUNT: LOCATION:

HUMANS: Y [✓ N] COUNT: LOCATION:

OTHER: COUNT: LOCATION:

FECAL MATTER: Y [✓ N] COUNT: LOCATION:

OTHER OBSERVATIONS (e.g., odors, [✓ debris], [✓ active runoff], [✓ flowing storm drains], encampments):

Gateway TEMP (°C): 13.4 SC (µmhos/cm): 190

DUCKS: [✓ Y] N COUNT: 18 LOCATION: throughout from bridge

DOGS: [✓ Y] N COUNT: 1 LOCATION: throughout

HUMANS: [✓ Y] N COUNT: 6 LOCATION: throughout

OTHER: COUNT: LOCATION:

FECAL MATTER: [✓ Y]/N COUNT: LOCATION: Duck

OTHER OBSERVATIONS (e.g., odors, [✓ debris], [✓ active runoff], [✓ flowing storm drains], encampments):

COPY

RELINQUISHED BY (SIGNED)	DATE/TIME	RECEIVED BY (SIGNED)	DATE/TIME
	2.28.14 1350	Jmc	2/28/14 13:50

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140472 1,2
EOA 001

COMPANY OR UTILITY: EOA, Inc., 1410 Jackson Street, Oakland, CA 94612
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TELEPHONE#: (510) 832-2852 EXT#: 123 MOBILE#: (415) 336-4458 FAX#: (510) 832-2856

DATE OF SAMPLING: 4 | 1 | 14

PURCHASE ORDER #:

NAME OF SAMPLER: (Please print and sign - REQUIRED)
CRAIG JOHNSON

Matrix: [✓ Creek Water] Drinking Water Wastewater Biosolid OTHER:

Weather Conditions: Intermittent Showers.

	SAMPLE ID#	TIME	VOLUME	TREATMENT	SAMPLING LOCATION	ANALYSIS REQUESTED
①	DEANZA	10:10	500mL		Creek mmp 4.1.14	Microbial. ~~Microbable~~ source tracking
②	Gateway	10:47	500mL		Creek.	↓
						E. coli
						Entercocci

Observations – (Measure temp and specific conductance [SC]; walk the park looking for signs of fecal contamination or its sources)

De Anza 10:10	TEMP (°C): 10.4C	SC (µmhos/cm): 334	**Gateway** 10:47	TEMP (°C): 11,2	SC (µmhos/cm): 296

De Anza			Gateway		
DUCKS: [✓ Y] / N	COUNT: 8	LOCATION:	DUCKS: [✓ Y] / N	COUNT: 9	LOCATION: creek
DOGS: Y / [✓ N]	COUNT:	LOCATION:	DOGS: Y / [✓ N]	COUNT:	LOCATION:
HUMANS: Y / [✓ N]	COUNT:	LOCATION:	HUMANS: [✓ Y] / ~~N~~	COUNT: 1	LOCATION: Playstructure.
OTHER:	COUNT:	LOCATION:	OTHER:	COUNT:	LOCATION:
FECAL MATTER: [✓ Y] / N	COUNT:	LOCATION: By Historical Marker.	FECAL MATTER: [✓ Y] / N	COUNT:	LOCATION: Walkway Duck, Dog

OTHER OBSERVATIONS (e.g., odors, debris, active runoff, flowing storm drains, encampments):
Deer? see photo

OTHER OBSERVATIONS (e.g., odors, debris, active runoff, flowing storm drains, encampments):

RELINQUISHED BY (SIGNED)	DATE/TIME	RECEIVED BY (SIGNED)	DATE/TIME
	12:00 4/1/14	Mary	4/1/14 1200

11.6°C

SAMPLE DATA SHEET

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EOA001

539-1-3

COMPANY OR UTILITY: EOA, Inc., 1410 Jackson Street, Oakland, CA 94612 Attn: Bonnie de Berry TELEPHONE#: (510) 832-2852 EXT#: 123 MOBILE#: (415) 336-4458 FAX#: (510) 832-2856	DATE OF SAMPLING: 4/22/14 PURCHASE ORDER #:
NAME OF SAMPLER: (Please print and sign - REQUIRED) RE DANIELSON RE Dal	Matrix: [✓ Creek Water] Drinking Water Wastewater Biosolid OTHER: Weather Conditions:

SAMPLE ID#	TIME	VOLUME	TREATMENT	SAMPLING LOCATION	ANALYSIS REQUESTED	
① DeAnza 1	1200	500 mL		DeAnza	Ecoli Enterococcus MST	11.5°
② Gateway	1230	500 mL		Gateway	" " "	11.5°C
③ received from Pete Dellabette	1300	100 mL		Raw Influent	MST	17.6°C

Observations – (Measure temp and specific conductance [SC]; walk the park looking for signs of fecal contamination or its sources)

De Anza	TEMP (°C): 12.5	SC (μmhos/cm): 396	**Gateway**	TEMP (°C): 14.3	SC (μmhos/cm): 404
DUCKS: [✓ Y] / N	COUNT: 6	LOCATION: 50 yds upstream	DUCKS: [✓ Y] / N	COUNT: 10	LOCATION: Immediate area + throughout
DOGS: Y / [✓ N]	COUNT:	LOCATION:	DOGS: Y / [✓ N]	COUNT:	LOCATION:
HUMANS: Y / N	COUNT: 10	LOCATION: throughout	HUMANS: [✓ Y] / N	COUNT: 8	LOCATION: Playground
OTHER:	COUNT:	LOCATION:	OTHER:	COUNT:	LOCATION:
FECAL MATTER: [✓ Y] / N	COUNT: 1	LOCATION: DEER ≈ 80-90 yds upstream	FECAL MATTER: Y / N	COUNT:	LOCATION:
OTHER OBSERVATIONS (e.g., odors, debris, active runoff, flowing storm drains, encampments): Two homeless persons + material Dog feces in gutter 25 yds up in street			OTHER OBSERVATIONS (e.g., odors, debris, active runoff, flowing storm drains, encampments): recent weed abatement + lawn maintenance > 36 debris items upstream - balls, bags, wrappers, etc.		

COPY

①

RELINQUISHED BY (SIGNED)	DATE/TIME	RECEIVED BY (SIGNED)	DATE/TIME
RED	4/22/14 1410	Jmc	4/22/14 14:10

③ - Raw wastewater - Jmc

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SAMPLE DATA SHEET

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EOA001
697-1
15.7°C

COMPANY OR UTILITY: EOA, Inc., 1410 Jackson Street, Oakland, CA 94612
Attn: Bonnie de Berry
TELEPHONE#: (510) 832-2852 EXT#: 123 MOBILE#: (415) 336-4458 FAX#: (510) 832-2856

NAME OF SAMPLER: **(Please print and sign - REQUIRED)** Craig Johnson

DATE OF SAMPLING: 5/20/14

PURCHASE ORDER #:

Matrix: [✓ Creek Water] Drinking Water Wastewater Biosolid OTHER:

Weather Conditions:

SAMPLE ID#	TIME	VOLUME	TREATMENT	SAMPLING LOCATION	ANALYSIS REQUESTED
① Gateway near Bridge	11:25	500mL			

Observations – (Measure temp and specific conductance [SC]; walk the park looking for signs of fecal contamination or its sources)

De Anza	TEMP (°C):	SC (µmhos/cm):	[✓ **Gateway**]	TEMP (°C): 16.0	SC (µmhos/cm): 309
DUCKS: Y / N	COUNT:	LOCATION:	DUCKS: [✓ Y] / N	COUNT: 6	LOCATION: In Creek
DOGS: Y / N	COUNT:	LOCATION:	DOGS: Y / [✓ N]	COUNT:	LOCATION:
HUMANS: Y / N	COUNT:	LOCATION:	HUMANS: [✓ Y] / N	COUNT: 8	LOCATION: picnic tables / playstructure
OTHER:	COUNT:	LOCATION:	OTHER:	COUNT:	LOCATION: - 1 DOG - creekside
FECAL MATTER: Y / N	COUNT:	LOCATION:	FECAL MATTER: [✓ Y] / N	COUNT:	LOCATION: Duck creekside
OTHER OBSERVATIONS (e.g., odors, debris, active runoff, flowing storm drains, encampments):			OTHER OBSERVATIONS (e.g., odors, debris, active runoff, flowing storm drains, encampments):		

RELINQUISHED BY (SIGNED)	DATE/TIME	RECEIVED BY (SIGNED)	DATE/TIME
	12:30 5/20/14	Jmc	5/20/14 12:35

1/2

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EOA001
697-2-3
15.7°C

COMPANY OR UTILITY: EOA, Inc., 1410 Jackson Street, Oakland, CA 94612
Attn: Bonnie de Berry
TELEPHONE#: (510) 832-2852 EXT#: 123 MOBILE#: (415) 336-4458 FAX#: (510) 832-2856

DATE OF SAMPLING: 5/20/14

PURCHASE ORDER #:

NAME OF SAMPLER: **(Please print and sign - REQUIRED)**
Craig Johnson

Matrix: [✓ Creek Water] Drinking Water Wastewater Biosolid OTHER:

Weather Conditions:

	SAMPLE ID#	TIME	VOLUME	TREATMENT	SAMPLING LOCATION	ANALYSIS REQUESTED
②	DeAnza Creek	11:10	500mL			
③	Deer Poop (Scat)	11:00	SWAB			

Observations – (Measure temp and specific conductance [SC]; walk the park looking for signs of fecal contamination or its sources)

De Anza	TEMP (°C): 15.5	SC (µmhos/cm): 295	**Gateway**	TEMP (°C):	SC (µmhos/cm):
DUCKS: [✓ Y] / N	COUNT: 7	LOCATION: Creekside/In-Creek	DUCKS: Y / N	COUNT:	LOCATION:
DOGS: [✓ Y] / N	COUNT: 1	LOCATION: Roadside Near Sampling Pt. Pooped While I watched	DOGS: Y / N	COUNT:	LOCATION:
HUMANS: [✓ Y] / N	COUNT: 1	LOCATION: Roadside	HUMANS: Y / N	COUNT:	LOCATION:
OTHER: Deer	COUNT: 3	LOCATION: Creekside/In Creek	OTHER:	COUNT:	LOCATION:
FECAL MATTER: [✓ Y] / N	COUNT:	LOCATION: Deer DOG	FECAL MATTER: Y / N	COUNT:	LOCATION:

OTHER OBSERVATIONS (e.g., odors, debris, active runoff, flowing storm drains, encampments):
Moma Deer: 2 Babies in Creek

OTHER OBSERVATIONS (e.g., odors, debris, active runoff, flowing storm drains, encampments):

RELINQUISHED BY (SIGNED)	DATE/TIME	RECEIVED BY (SIGNED)	DATE/TIME
	1230 5/20/14		5/20/14 12:35

2/2

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SAMPLE DATA SHEET

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA CALIFORNIA 94510
1-800-GIARDIA (442-7342) FAX: 707-747-1751
Business Hours: Monday through Friday - 8:30 AM to 5:00 PM

EOA001
874-1-2
17.6°C

COMPANY OR UTILITY: **EOA, Inc., 1410 Jackson Street, Oakland, CA 94612**
Attn: Bonnie de Berry
TELEPHONE#: (510) 832-2852 EXT#: 123 MOBILE#: (415) 336-4458 FAX#: (510) 832-2856

DATE OF SAMPLING: 6.18.14

PURCHASE ORDER #:

NAME OF SAMPLER: **(Please print and sign - REQUIRED)** RE DANIELSON

Matrix: [✓ Creek Water] Drinking Water Wastewater Biosolid OTHER:

Weather Conditions: Clear, Warm, Dry, Temp 20°C

	SAMPLE ID#	TIME	VOLUME	TREATMENT	SAMPLING LOCATION	ANALYSIS REQUESTED
①	DeAnza 1	1030	500 W/ ~~≈100 250~~mL	—	DeAnza Park	Enterococcus, Ecoli MST
②	Gateway 1	1100	500		Gateway Park	" "

Observations – (Measure temp and specific conductance [SC]; walk the park looking for signs of fecal contamination or its sources)

De Anza TEMP (°C): 15.5 SC (µmhos/cm): 227

DUCKS: [✓ Y] / N COUNT: 2 LOCATION: ≈ 60 YDS UPSTREAM

DOGS: [✓ Y] / N COUNT: ~~3~~ 2 LOCATION: FECES ON STREET UPSTREAM

HUMANS: [✓ Y] / N COUNT: 10 ~~6K~~ 2 LOCATION: ≈ 60 YDS UPSTREAM

OTHER: DEER COUNT: 3 LOCATION: ≈ 80 YDS UPSTREAM

FECAL MATTER: [✓ Y] / N COUNT: 1 LOCATION: DOG FECES

OTHER OBSERVATIONS (e.g., odors, debris, active runoff, flowing storm drains, encampments):
Slow moving, strong sewer odor @ street

Gateway TEMP (°C): 16.5 SC (µmhos/cm): 221

DUCKS: [✓ Y] N COUNT: 6 LOCATION: @ Playground

DOGS: Y [✓ N] COUNT: 0 LOCATION:

HUMANS: Y [✓ N] COUNT: 0 LOCATION:

OTHER: COUNT: 0 LOCATION:

FECAL MATTER: [✓ Y] / N COUNT: 1 LOCATION: DOG, on bank upstream

OTHER OBSERVATIONS (e.g., odors, debris, active runoff, flowing storm drains, encampments):
Debris, slow moving

RELINQUISHED BY (SIGNED)	DATE/TIME	RECEIVED BY (SIGNED)	DATE/TIME
	6/18/14 1300	JMC	6/18/14 13:00

BioVir LABORATORIES ®

SAMPLE DATA SHEET

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA CALIFORNIA 94510
1-800-GIARDIA (442-7342) FAX: 707-747-1751
Business Hours: Monday through Friday - 8:30 AM to 5:00 PM

EOA001
1012-1-2
12.8°C

COMPANY OR UTILITY: EOA, Inc., 1410 Jackson Street, Oakland, CA 94612
Attn: Bonnie de Berry
TELEPHONE#: (510) 832-2852 EXT#: 123 MOBILE#: (415) 336-4458 FAX#: (510) 832-2856

DATE OF SAMPLING: 7.16.14
PURCHASE ORDER #:

NAME OF SAMPLER: (Please print and sign - REQUIRED) Danielson

Matrix: [✓ Creek Water] Drinking Water Wastewater Biosolid OTHER:
Weather Conditions: overcast 17.3°C

SAMPLE ID#	TIME	VOLUME	TREATMENT	SAMPLING LOCATION	ANALYSIS REQUESTED
DeAnza 1	0845	500 mL	—	DeAnza	E.coli, Enterococcus, MST
Gateway 2	0830	500 mL	—	Gateway	" " "

Observations – (Measure temp and specific conductance [SC]; walk the park looking for signs of fecal contamination or its sources)

De Anza TEMP (°C): ~~18.0~~ 17.4 RED 7.16.14 SC (µmhos/cm): 291
DUCKS: Y / N COUNT: IIII LOCATION:
DOGS: [✓ Y] N COUNT: 1 LOCATION: STREET 40 yds N of sample point
HUMANS: [✓ Y] N COUNT: 1 LOCATION: BENCH
OTHER: DEER COUNT: 1 LOCATION: @ sample point
FECAL MATTER: [✓ Y] N COUNT: DOG 1 DEER - HHT III LOCATION: @ ARROYO CT INTERSECTON STREET Along Creek Bank - 150 yds W
OTHER OBSERVATIONS (e.g., odors, debris, active runoff, flowing storm drains, encampments):

Gateway TEMP (°C): 18.1 SC (µmhos/cm): 357
DUCKS: Y [✓ N] COUNT: LOCATION:
DOGS: Y [✓ N] COUNT: LOCATION:
HUMANS: Y [✓ N] COUNT: LOCATION:
OTHER: COUNT: LOCATION:
FECAL MATTER: [✓ Y] N COUNT: 2 LOCATION: ① 30 yds N of bridge; ② @ Bridge above creek
OTHER OBSERVATIONS (e.g., odors, debris, active runoff, flowing storm drains, encampments):
debris

COPY

RELINQUISHED BY (SIGNED)	DATE/TIME	RECEIVED BY (SIGNED)	DATE/TIME
	7.16.14 1000		7/16/14 10:08

BioVir LABORATORIES

SAMPLE DATA SHEET

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA CALIFORNIA 94510
1-800-GIARDIA (442-7342) FAX: 707-747-1751
® **Business Hours: Monday through Friday - 8:30 AM to 5:00 PM**

EOA001
1380-1-2 8.3'

COMPANY OR UTILITY: EOA, Inc., 1410 Jackson Street, Oakland, CA 94612
Attn: Bonnie de Berry
TELEPHONE#: (510) 832-2852 EXT#: 123 MOBILE#: (415) 336-4458 FAX#: (510) 832-2856

DATE OF SAMPLING: 9.23.14

PURCHASE ORDER #:

NAME OF SAMPLER: **(Please print and sign - REQUIRED)**
Paul Randall Paul Randall

Matrix: [✓ Creek Water] Drinking Water Wastewater Biosolid OTHER:

Weather Conditions: ~~Clear~~ Overcast - fog, warm

	SAMPLE ID#	TIME	VOLUME	TREATMENT	SAMPLING LOCATION	ANALYSIS REQUESTED
①	Gateway	8:30	500 ml	—	Gateway Park	Enterococcus, E.coli, MST
②	DeAnza	9:10	500 ml		De Anza Park	" "

Observations – (Measure temp and specific conductance [SC]; walk the park looking for signs of fecal contamination or its sources)

De Anza	TEMP (°C): 16.8	SC (µmhos/cm): 255.5	**Gateway**	TEMP (°C): 17.4	SC (µmhos/cm): 259
DUCKS: Y [✓ N]	COUNT:	LOCATION:	DUCKS: [✓ Y] / N	COUNT: 22	LOCATION: Tules near bridge (3rd st
DOGS: Y [✓ N]	COUNT:	LOCATION:	DOGS: [✓ Y] ~~N~~	COUNT: 2	LOCATION: and playground park, leashed w/ owner
HUMANS: [✓ Y] N	COUNT: 2	LOCATION: park bench	HUMANS: [✓ Y] / N	COUNT: 2	LOCATION: 3rd St bridge - getting cans in creek
OTHER: Deer	COUNT: 2	LOCATION: east end of park	OTHER:	COUNT: 0	LOCATION:
FECAL MATTER [✓ Y] N	COUNT: 1	LOCATION: dog poop in plastic	FECAL MATTER [✓ Y] N	COUNT: 1	LOCATION: human - under footbridge

OTHER OBSERVATIONS (e.g., odors, debris, active runoff, flowing storm drains, encampments): bag near outfall
Clear, flowing, min trash

OTHER OBSERVATIONS (e.g., odors, debris, active runoff, flowing storm drains, encampments):
Trash at footbridge, tules above 3rd St bridge
barely flowing - 1 hour after low tide

RELINQUISHED BY (SIGNED)	DATE/TIME	RECEIVED BY (SIGNED)	DATE/TIME
Paul Randall	9.23.14 10:15	Liz Barriga	9/23/14 1050

rec'd in lab Jme 9/23/14 @ 11:55

SAMPLE DATA SHEET

BioVir LABORATORIES ®

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA CALIFORNIA 94510
1-800-GIARDIA (442-7342) FAX: 707-747-1751
Business Hours: Monday through Friday - 8:30 AM to 5:00 PM

EOA001
141575 21°C

COMPANY OR UTILITY: **EOA, Inc., 1410 Jackson Street, Oakland, CA 94612**
Attn: Bonnie de Berry
TELEPHONE#: (510) 832-2852 EXT#: 123 MOBILE#: (415) 336-4458 FAX#: (510) 832-2856

DATE OF SAMPLING: **11/4/2014**

PURCHASE ORDER #:

NAME OF SAMPLER: **(Please print and sign - REQUIRED)**
Richard Danielson

Matrix: **Creek Water** Drinking Water Wastewater Biosolid OTHER:
Weather Conditions: CLEAR ≈ 73°F

SAMPLE ID#	TIME	VOLUME	TREATMENT	SAMPLING LOCATION	ANALYSIS REQUESTED
1415~~47~~75-1 DeAnza 1	1530	500 mL	None	DeAnza Park	E. coli; Enterococci, Source Tracking
1415~~47~~75-2 Gateway 1	1600	500mL	None	Gateway Park	E. coli; Enterococci, Source Tracking
RS 11.4.14					

Observations – (Measure temp and specific conductance [SC]; walk the park looking for signs of fecal contamination or its sources)

De Anza	TEMP (°C):	SC (µmhos/cm): 135

DUCKS: [✓ Y] / N COUNT: 3 LOCATION: 70 YDS WEST OF SITE
DOGS: Y / [✓ N] COUNT: LOCATION:
HUMANS: Y / [✓ N] COUNT: LOCATION:
OTHER: DEER COUNT: 3 ♀ + 1 ♂ LOCATION: @ sample site & 60 yds west
FECAL MATTER: [✓ Y] / N COUNT: many LOCATION: DEER, WEST OF SITE
OTHER OBSERVATIONS (e.g., odors, debris, active runoff, flowing storm drains, encampments):
slow moving

Gateway	TEMP (°C):	SC (µmhos/cm): 136

DUCKS: [✓ Y] / N COUNT: 16 LOCATION: @ SITE
DOGS: Y / N COUNT: LOCATION:
HUMANS: [✓ Y] / N COUNT: 6 LOCATION: THROUGHOUT PARK
OTHER: COUNT: LOCATION:
FECAL MATTER: Y / N COUNT: LOCATION:
OTHER OBSERVATIONS (e.g., odors, debris, active runoff, flowing storm drains, encampments):
SLOW MOVING

RELINQUISHED BY (SIGNED)	DATE/TIME	RECEIVED BY (SIGNED)	DATE/TIME
	11/4/14 1820 –	RS	11/5/14 08:30

ATTACHMENT C – PHOTOGRAPHS FROM THE FIELD SITES

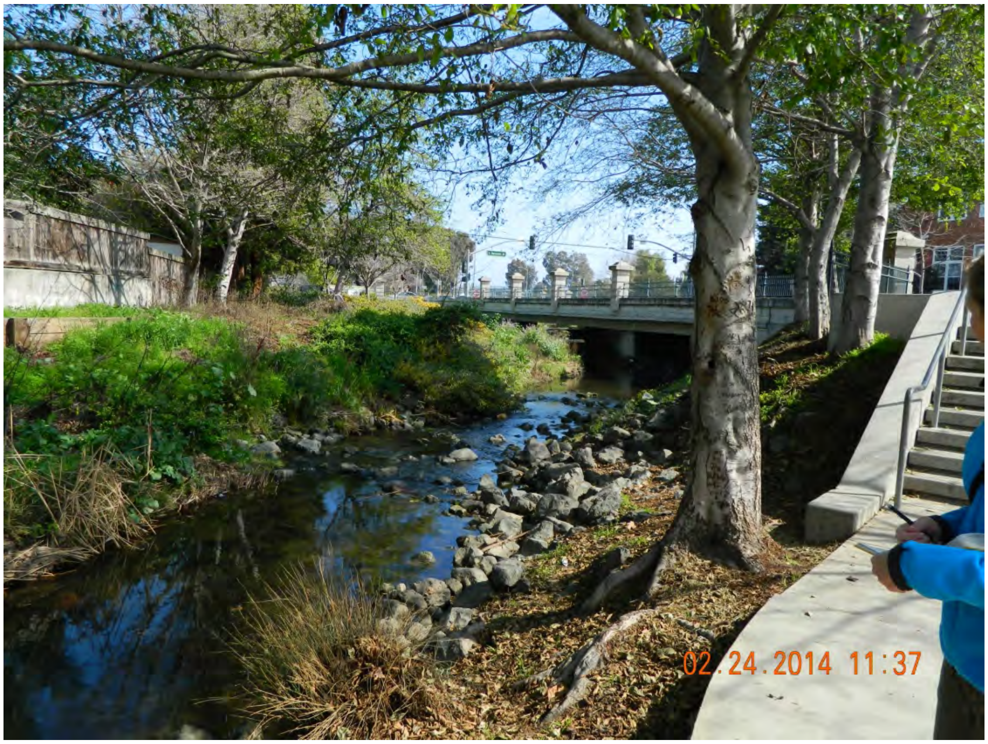
DeAnza Park Sample Site Location

Rain Event February 2014

Dog and Bird Feces on street near storm drain above DeAnza sampling location

Deer Inhabitant at DeAnza Park

Gateway Sample Site Location

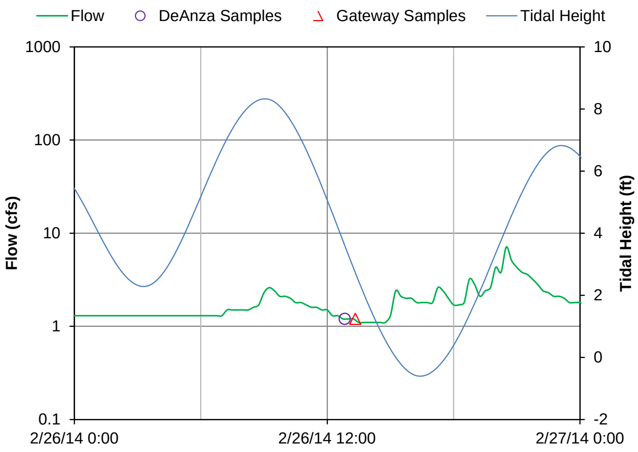


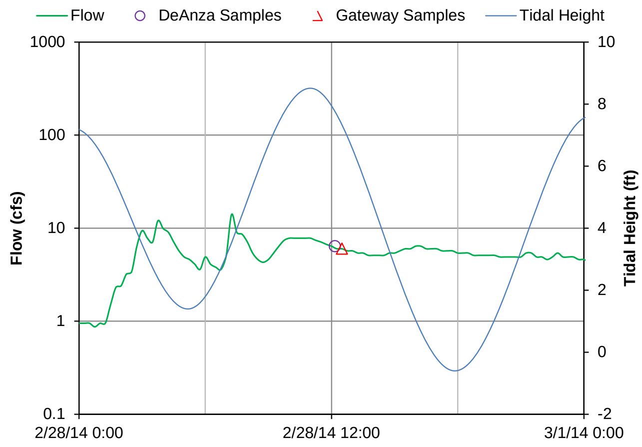
Gateway Sampling

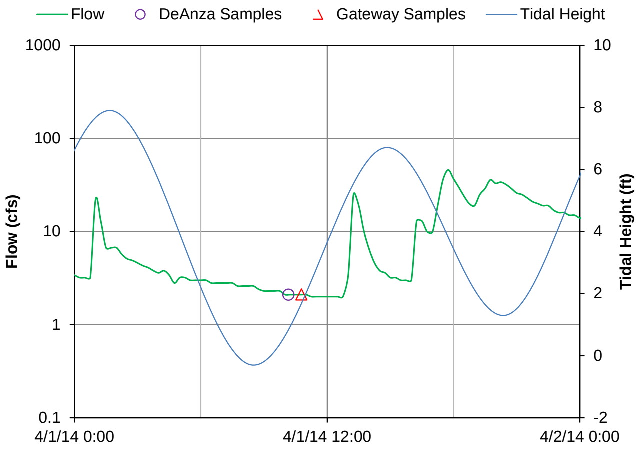
Gateway Ducks just Upstream of Sample Site

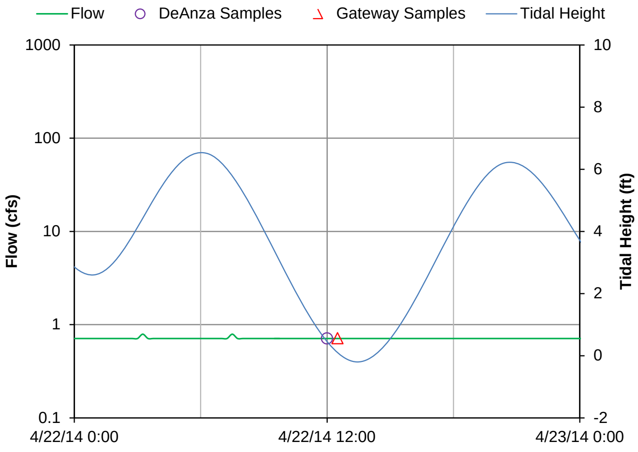
Gateway Rain Event February 2014

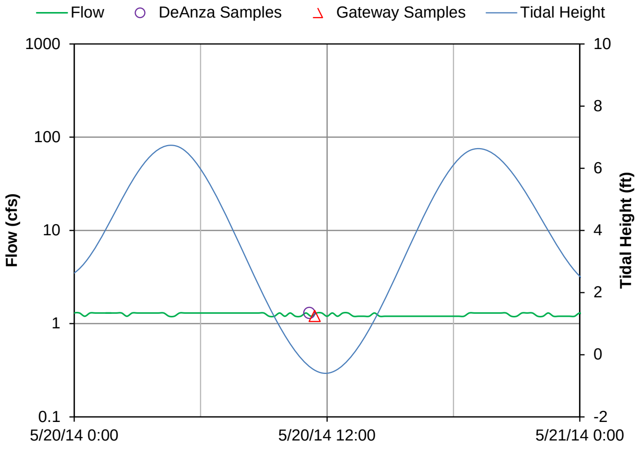
San Mateo Creek Flow below Lower Crystal Springs Reservoir (USGS 11162753), and tidal height at Coyote Point Marina (NOAA 9414449)

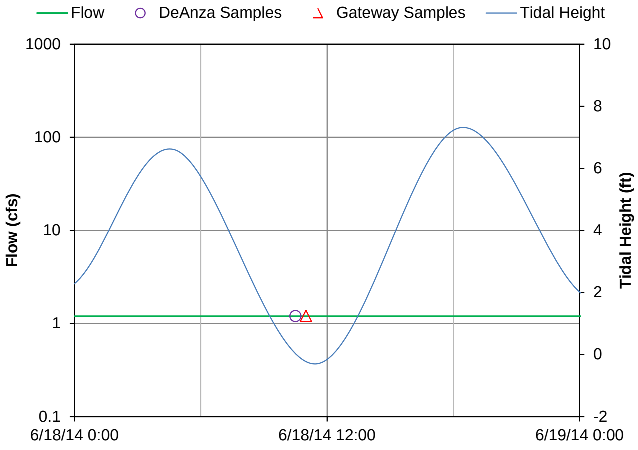


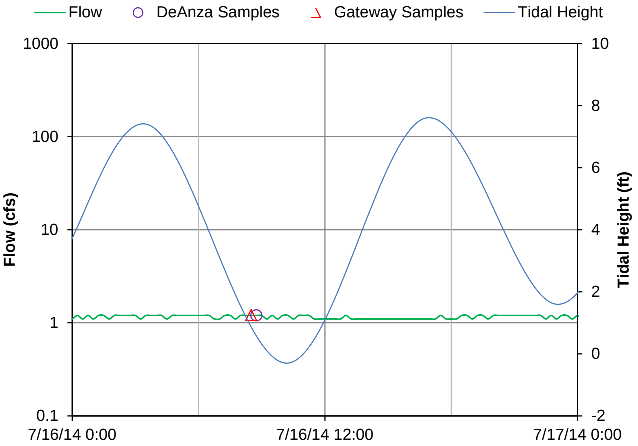


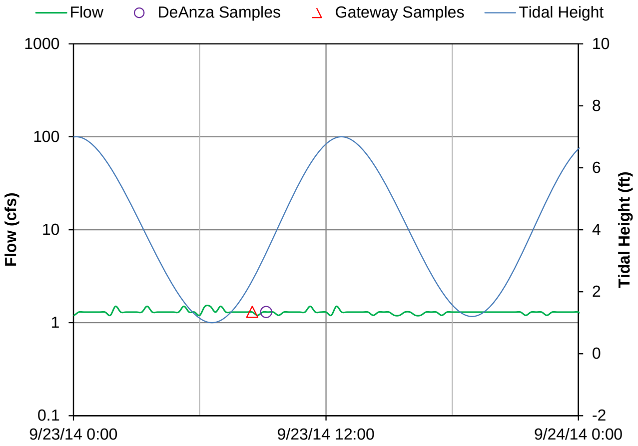


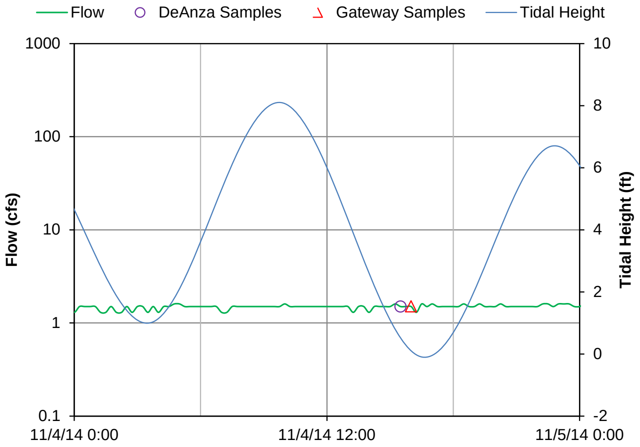







Flow
DeAnza Samples
Gateway Samples
Tidal Height
1000
100
10
1
0.1
10
8
6
4
2
0
-2
Flow (cfs)
Tidal Height (ft)
7/16/14 0:00
7/16/14 12:00
7/17/14 0:00


Flow
DeAnza Samples
Gateway Samples
Tidal Height
1000
100
10
1
0.1
10
8
6
4
2
0
-2
Flow (cfs)
Tidal Height (ft)
9/23/14 0:00
9/23/14 12:00
9/24/14 0:00


Flow
DeAnza Samples
Gateway Samples
Tidal Height
1000
100
10
1
0.1
10
8
6
4
2
0
-2
Flow (cfs)
Tidal Height (ft)
11/4/14 0:00
11/4/14 12:00
11/5/14 0:00

Appendix D

Regional SSID Project Summary Table

BASMAA Regional Monitoring Coalition

2010-2016 Stressor/Source Identification (SSID) Project Locations, Rationales, Status

Updated February 2016

SSID Project ID	**Date Updated**	**County/ Program**	**Creek/Channel Name**	**Site Code(s) or alternative site ID**	**Primary Creek Status Indicator(s) Triggering Stressor/Source ID Project**									**Creek Status Indicator Result Summary**	**Rationale for Proposing/Selecting Project**	**Current Status of SSID Project**
					Bioassess	General WQ	Chlorine	Temp	Water Tox	Sed Tox	Sed Chem	Pathogen Indicators	Other			
AL-1	3/23/15	Alameda/ ACCWP	Castro Valley Creek	204R00047	X						X			IBI Score = 24 (Poor); Relatively high bifenthrin (pyrethroid) in sediment; >3 chemicals exceed TECs	Triad triggers were accompanied by *Hyalella azteca* water toxicity that did not reach trigger on retest. Potential sources for investigation in small watershed include freeway and urban land use areas.	SSID Project began in 2013 with sediment sampling and watershed records review; No specific sources to local MS4 identified during 2014. Pesticides as the primary stressor are supported by additional WY 2015 sediment chemistry/toxicity results from another site higher in this watershed that also showed high Hyalella mortality in wet season water toxicity. March 2016 UCMR includes Appendix 4A summary report describing BMPs implemented and completion of the site-specific elements of this project.
AL-2	3/23/15	Alameda/ ACCWP	Dublin Creek	204R00084	X		X				X			IBI Score = 17 (Very Poor); Relatively high bifenthrin (pyrethroid) in sediment; >3 chemicals exceed TECs	Potential sources for different triad triggers may be separable by monitoring between freeway and urban land use areas, altered vs. natural channels.	SSID Project began in 2013 with sediment sampling, watershed records review and bioassessment sampling at RMC plus a supplemental site. Bioassessment impacts were strongly associated with channel alteration and habitat quality. Review of inspection information identified no specific sources of pesticides or metals to sediment. March 2016 UCMR includes Appendix 4B progress report with schedule for review of land use inputs and freeway runoff.
AL-3	3/23/15	Alameda/ ACCWP	Crow Creek	204CRW030		X								67% of DO results < 7 mg/L in September	Potentially significant stressor on COLD beneficial use; Potential source for investigation from lake discharge or nutrient sources.	SSID Project began in 2013 with DO and water sampling; initial hypothesis regarding reservoir runoff not supported by first year's special study. Further monitoring in WY 2014 and 2015 indicated there may have been episodic contributions from urban runoff to low DO incidents observed in WY2014 but not during WY2015. March 2016 UCMR includes Appendix 4C progress report with updated WY2016 monitoring plan to evaluate summer inflows using continuous monitoring of conductivity as well as temperature.

BASMAA Regional Monitoring Coalition
2010-2016 Stressor/Source Identification (SSID) Project Locations, Rationales, Status
Updated February 2016

SSID Project ID	**Date Updated**	**County/ Program**	**Creek/Channel Name**	**Site Code(s) or alternative site ID**	**Primary Creek Status Indicator(s) Triggering Stressor/Source ID Project**									**Creek Status Indicator Result Summary**	**Rationale for Proposing/Selecting Project**	**Current Status of SSID Project**
					Bioassess	General WQ	Chlorine	Temp	Water Tox	Sed Tox	Sed Chem	Pathogen Indicators	Other			
CC-1	1/7/16	Contra Costa/ CCCWP	Grayson Creek	207R00011	X				X	X	X			32% survival of *Hyalella azteca* in water during spring of 2012; 43.8% survival of *Hyalella azteca* in sediment during summer 2012; relatively high bifenthrin in sediment; IBI Score = 13 (Very Poor). Water toxicity confirmed by retest, 2013.	Evidence of water and sediment toxicity to *Hyalella azteca*, with concurrent high concentration of bifenthrin in sediment. Recent publications by CASQA and others indicate pyrethroid pesticide-caused toxicity is a pervasive problem in urban areas of CA. Investigation of sources and solutions could be widely beneficial.	SSID Project Part A completed, WY 2014, including testing of water and sediments from sites upstream and downstream of original Grayson Creek site. Only water samples were toxic to *Hyalella*. Water TIE and concurrent chemistry point to pyrethroid pesticides as likely causes of Hyalella toxicity in waters of Grayson Creek. SSID Project Part B completed, WY 2015, computing urban use amounts for six pyrethroid pesticides detected in Part A monitoring. Based on the compiled pesticide use data from 2009-2013, it appears that uses of the most toxic and impactful pyrethroids (bifenthrin and cyfluthrin) have increased in urban areas in Contra Costa County in recent years. Urban uses account for most of the annual use amounts for those six pyrethroids in Contra Costa County.
CC-2	1/7/16	Contra Costa/ CCCWP	Dry Creek	544R00025	X		X		X	X	X			60% survival of *Hyalella azteca* in sediment during summer, 2012; 0% survival of *Hyalella azteca* in water during spring of 2012; relatively high bifenthrin in sediment; IBI Score = 3 (Very Poor). Water toxicity confirmed by retest, 2013.	Evidence of water and sediment toxicity to *Hyalella azteca*, with concurrent high concentration of bifenthrin in sediment. Recent publications by CASQA and others indicate pyrethroid pesticide-caused toxicity is a pervasive problem in urban areas of CA. Investigation of sources and solutions could be widely beneficial.	SSID Project Part A completed, WY 2014, including testing of water and sediments from sites upstream and downstream of original Dry Creek site. All samples were toxic to *Hyalella*. Water and sediment TIEs and concurrent chemistry point to pyrethroid pesticides as likely causes of Hyalella toxicity in water and sediments of Dry Creek. SSID Project Part B completed, WY 2015, computing urban use amounts for six pyrethroid pesticides detected in Part A monitoring. Based on the compiled pesticide use data from 2009-2013, it appears that uses of the most toxic and impactful pyrethroids (bifenthrin and cyfluthrin) have increased in urban areas in Contra Costa County in recent years. Urban uses account for most of the annual use amounts for those six pyrethroids in Contra Costa County.

BASMAA Regional Monitoring Coalition
2010-2016 Stressor/Source Identification (SSID) Project Locations, Rationales, Status
Updated February 2016

SSID Project ID	Date Updated	County/ Program	Creek/Channel Name	Site Code(s) or alternative site ID	Primary Creek Status Indicator(s) Triggering Stressor/Source ID Project									Creek Status Indicator Result Summary	Rationale for Proposing/Selecting Project	Current Status of SSID Project
					Bioassess	General WQ	Chlorine	Temp	Water Tox	Sed Tox	Sed Chem	Pathogen Indicators	Other			
CC-1	3/17/15	Contra Costa/ CCCWP	Grayson Creek	207R00011	X				X	X	X			32% survival of *Hyalella azteca* in water during spring of 2012; 43.8% survival of *Hyalella azteca* in sediment during summer 2012; relatively high bifenthrin in sediment; IBI Score = 13 (Very Poor). Water toxicity confirmed by retest, 2013.	Evidence of water and sediment toxicity to *Hyalella azteca*, with concurrent high concentration of bifenthrin in sediment. Recent publications by CASQA and others indicate pyrethroid pesticide-caused toxicity is a pervasive problem in urban areas of CA. Investigation of sources and solutions could be widely beneficial.	SSID Project Part A completed, WY 2014, including testing of water and sediments from sites upstream and downstream of original Grayson Creek site. Only water samples were toxic to *Hyalella*. Water TIE and concurrent chemistry point to pyrethroid pesticides as likely causes of Hyalella toxicity in waters of Grayson Creek.
CC-2	3/17/15	Contra Costa/ CCCWP	Dry Creek	544R00025	X		X		X	X	X			60% survival of *Hyalella azteca* in sediment during summer, 2012; 0% survival of *Hyalella azteca* in water during spring of 2012; relatively high bifenthrin in sediment; IBI Score = 3 (Very Poor). Water toxicity confirmed by retest, 2013.	Evidence of water and sediment toxicity to *Hyalella azteca*, with concurrent high concentration of bifenthrin in sediment. Recent publications by CASQA and others indicate pyrethroid pesticide-caused toxicity is a pervasive problem in urban areas of CA. Investigation of sources and solutions could be widely beneficial.	SSID Project Part A completed, WY 2014, including testing of water and sediments from sites upstream and downstream of original Dry Creek site. All samples were toxic to *Hyalella*. Water and sediment TIEs and concurrent chemistry point to pyrethroid pesticides as likely causes of Hyalella toxicity in water and sediments of Dry Creek.
SC-1	5/11/15	Santa Clara/ SCVURPPP	Coyote Creek	205COY235 (Coyote Cr. - Watson Park to Julian St.)		X								100% < 5mg/L D.O. in spring and summer periods 2012; and Pre-MRP Data	Coyote Creek supports a productive fish community and the project reach exhibits depressed dissolved oxygen that could cause biological impacts.	Project began in 2011 and was completed in 2013. Summary report was submitted in March 2014 as Appendix B1 in Part A of the Integrated Monitoring Report.
SC-2	5/11/15	Santa Clara/ SCVURPPP	Guadalupe River (and Alviso Slough)										X	Fish kills observed in 2008, 2009 & 2010.	The Guadalupe River supports a productive fish community and the project reaches exhibited fish kills that are a concern to local agencies.	Project began in 2011 and was completed in 2013. Summary report was submitted in March 2014 as Appendix B2 in Part A of the Integrated Monitoring Report.

SSID Project ID	Date Updated	County/ Program	Creek/Channel Name	Site Code(s) or alternative site ID	Primary Creek Status Indicator(s) Triggering Stressor/Source ID Project									Creek Status Indicator Result Summary	Rationale for Proposing/Selecting Project	Current Status of SSID Project
					Bioassess	General WQ	Chlorine	Temp	Water Tox	Sed Tox	Sed Chem	Pathogen Indicators	Other			
SC-3	5/11/15	Santa Clara/ SCVURPPP	Upper Penitencia Creek	205R00035	X									IBI Score = 23 (Poor)	Upper Penitencia Creeks supports one of the most productive steelhead communities in the Santa Clara Valley. Poor biological integrity scores may indicate impacts to steelhead and other biological communities.	Work plan was developed to assess existing data sources for potential causes for low biological condition and identify future monitoring actions. Work plan was submitted in March 2015 as Appendix B of the Urban Creeks Monitoring Report. Monitoring activities have been delayed due to the drought. Monitoring will begin in spring season of 2016.
SM-1	2/10/16	San Mateo/ SMCWPPP	San Mateo Creek	204SMA059		X								Pre-MRP data demonstrating temperatures > 19°C and DO < 7mg/L. WY2013 creek status data confirmed DO < 7 mg/L at 204SMA059 but not at 204SMA122 located approximately 4 miles upstream. Temperatures in WY2013 rarely exceeded the 19°C threshold.	San Mateo Creek is one of two creeks on the Bay-side of San Mateo County that supports a productive coldwater community. Warm temperatures and/or low DO levels may impact this valuable community.	WY2014 monitoring was conducted to investigate spatial and temporal extent of low DO. Monitoring consisted of sonde installments and a creek walk. Low DO was not observed in WY2014. Review of flow data at USGS gage below Crystal Springs Reservoir confirmed higher dry season flows in WY2014 compared to WY2013. The higher flows were the result of a new SFPUC release schedule following dam improvements that will continue into perpetuity. It appears that higher dry season flows result in reduced water temperatures and higher DO levels. Confirmation monitoring conducted in WY2015 supported the findings. Final Project Report was submitted to RWQCB staff on 7/9/15 and with the WY2015 UCMR.
SM-2	2/10/16	San Mateo/ SMCWPPP	San Mateo Creek	204SMA060								X		Pre-MRP data and WY2012 creek status grab samples had pathogen indicator (fecal coliform) densities exceeding the REC-1 WQO.	San Mateo Creek is a perennial creek with two Creekside parks. It flows through residential and commercial areas and discharges to San Francisco Bay just north of Marina Lagoon which is 303(d)-listed for bacteria.	WY2014 monitoring was conducted to investigate the magnitude and seasonal variability pathogen indicator densities. Microbial source tracking methodologies (i.e., Bacteroidales) were employed to investigate whether human and/or dog markers were present in the samples. Final Project Report submitted with the WY2015 UCMR.

Appendix E

BMP Effectiveness Investigation at Bransten Road, City of San Carlos

BMP EFFECTIVENESS INVESTIGATION AT BRANSTEN ROAD, CITY OF SAN CARLOS

Prepared in support of provision C.8.d.ii of
NPDES Permit # CAS612008

Report

San Mateo Countywide Water Pollution Prevention Program

San Mateo Countywide Water Pollution Prevention Program

March 31, 2016

TABLE OF CONTENTS

FIGURES

TABLES

1.0 Introduction

Provision C.8.d.ii (BMP Effectiveness Investigation) of the San Francisco Bay Region National Pollutant Discharge Elimination System (NPDES) Municipal Regional Permit (MRP) for discharges of stormwater runoff requires that Permittees investigate the effectiveness of one best management practice (BMP) for stormwater treatment or hydrograph modification control. The MRP encourages fulfillment of the requirement via investigation of BMP(s) used to fulfill requirements of Provisions C.3.b.iii, C.11.e, and C.12.e, provided the BMP Effectiveness Investigation includes the range of pollutants generally found in urban runoff.

The San Mateo Countywide Water Pollution Prevention Program (SMCWPPP) selected a bioretention/biofiltration facility in the City of San Carlos as the subject of the BMP Effectiveness Investigation (BMP Project). The BMP Project was coordinated with an existing study that is part of the U.S. EPA grant-funded Clean Watersheds for a Clean Bay (CW4CB) project currently being implemented by the Bay Area Stormwater Management Agencies Association (BASMAA). The CW4CB project was designed to pilot test a number of different control measures aimed at reducing polychlorinated biphenyls (PCBs) and mercury in stormwater runoff from urban areas pursuant to MRP Provisions C.11 and C.12. Additional constituents generally found in stormwater runoff (e.g., nutrients, cadmium, chromium, copper, nickel, zinc) were added by SMCWPPP to supplement the CW4CB investigation.

Results from the supplemental data collection are presented in this report, which is intended to satisfy requirements in Provision C.8.d.ii of the MRP. Monitoring results from the CW4CB project are scheduled to be reported separately in the future.

2.0 Background

In November 2013, the City of San Carlos constructed seven bioretention/biotreatment curb extension facilities (or cells) along a short section of Bransten Road. Each cell consists of a permeable strip of area consisting of rock and soil materials and planted with vegetation. The permeable area is bordered by a curb that extends into the roadway and contains openings to allow surface runoff to move through the cell. Three of the seven cells have an underdrain to transport the treated water into the storm drain pipe.

Two of the Bransten Road biofiltration facilities were selected as monitoring locations (i.e., sites PUL-3 and PUL-7) for the CW4CB project. The CW4CB project collected paired influent and effluent[1] samples and volume/flow measurements to provide data needed to calculate PCBs and mercury load reductions (BASMAA 2013). The CW4CB analytical constituents include suspended sediments, total organic carbon, lead, mercury, and PCBs. The stormwater runoff constituents (i.e., additional metals and nutrients) supplemented to the CW4CB project by SMCWPPP for Provision C.8.d.ii compliance were collected only at site PUL-7.

Recent reports regarding installation that was inconsistent with the design, resulting in localized flooding and potential system performance issues at the Bransten Road facility, may have affected its pollutant removal performance. These concerns are currently under investigation.

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[1] The biofiltration facility at site PUL-3 was not constructed with an underdrain, thus no effluent samples were collected at this site.

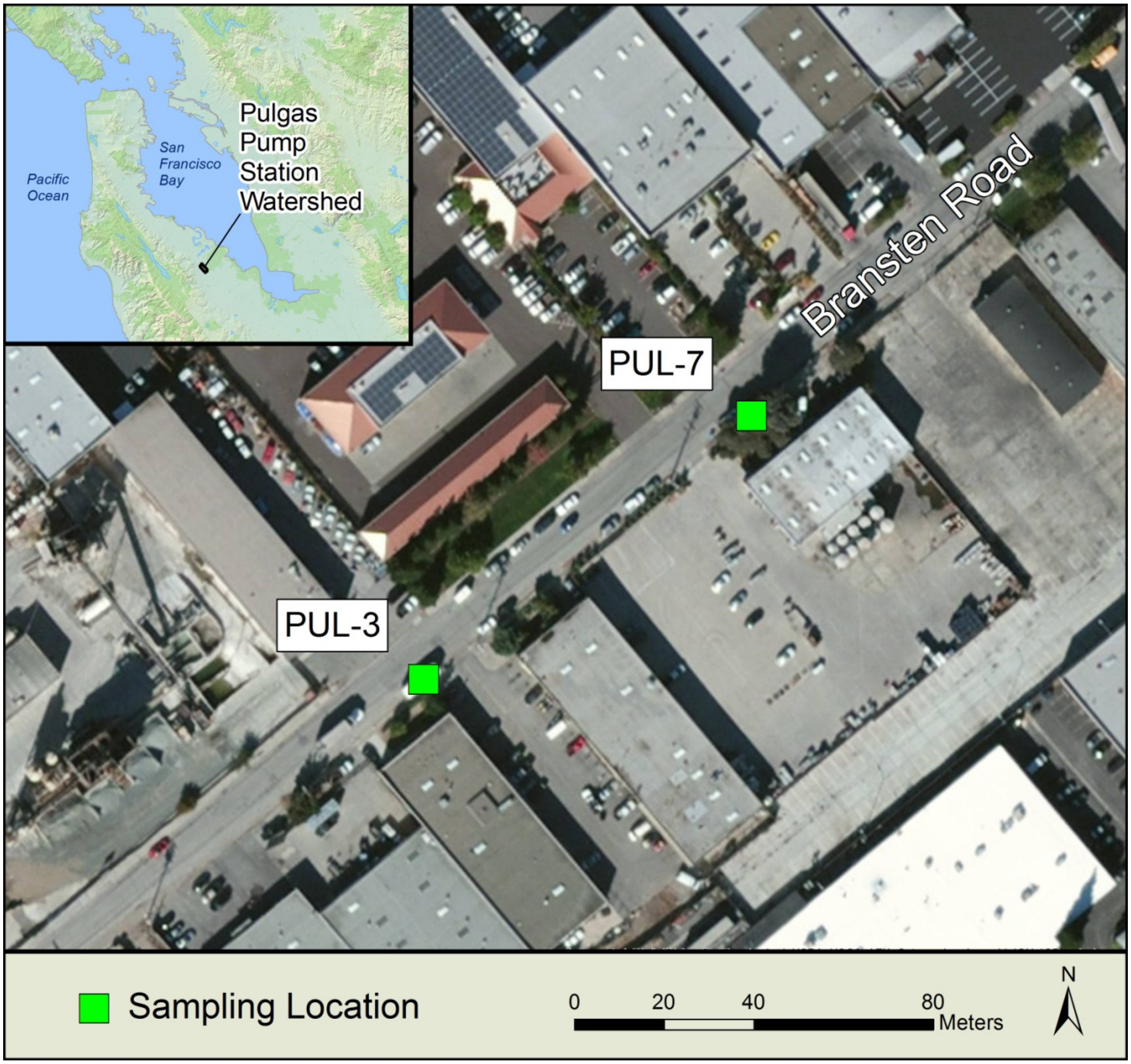

Figure 1. Location of BMP Effectiveness Monitoring for CW4CB project (sites PUL-3 and PUL-7) on Bransten Road, City of San Carlos.

3.0 Methods

3.1 Field Sampling

This section summarizes sampling procedures, as described in the Draft Field Sampling and Analysis Plan for the CW4CB Project (AMS and ADH 2014) that were applied specifically to site PUL-7 on Bransten Road. All sampling conformed to protocols identified in the Regional Monitoring Coalition (RMC) Creek Status Monitoring Standard Operating Procedure (SOP) FS-2, *Manual Collection of Water Samples for Chemical Analysis, Bacteriological Analysis, and Toxicity Testing* (EOA et al., 2014). The “clean hands / dirty hands” sampling techniques described in SOP FS-2 were used since mercury was one of the analytes to be measured. Data quality for laboratory and field sampling procedures conformed to the Clean Watersheds for a Clean Bay (CW4CB) QAPP (AMS 2012).

Water samples were collected by ADH Environmental (ADH) located in Santa Cruz, California. All samples were collected using a peristaltic pump sampler operated in manual mode. Each pump was fitted with cleaned Teflon® and C-Flex® tubing. Eight to ten discrete sample aliquots were collected in equal time intervals, targeted to coincide with the rising limb and peak of the storm hydrograph. These discrete sample aliquots were composited into one sample, per analyte, per sampling location, at the laboratory prior to analysis.

The influent sample was collected along the curb/gutter conveyance about ten feet upstream of the cell. The sample intake tubing was secured to the curb and gutter with a stainless steel rod so that the intake point was positioned in the centroid of flow (Figure 2). The effluent sample was collected from a vertical riser that provided access to the underdrain. The monitoring protocols were altered following the first sampling event to address flooding that caused the bypass flow to mingle with treated flow within the effluent stream being monitored. To avert future flooding during storm events, monitoring personnel temporarily attached a 12” PVC extension to the existing riser for each monitoring event, and removed riser at the end of each event (Figure 2).

Samples were collected and flow volumes were measured at site PUL-7 during three storm events in water year 2014 (WY2014) and one storm event in WY2015 (note: due to low precipitation in WY2014, the monitoring project was extended through WY2015).

Figure 2. Influent (left) and effluent (right) sampling locations at site PUL-7 on Bransten Road, City of San Carlos.

3.2 Laboratory Analysis

Water samples were analyzed by ALS Environmental Laboratory in Kelso, Washington. Analytical laboratory methods, reporting limits and holding times for chemical water quality parameters are presented in Appendix A. The data review for Quality Assurance/Quality Control is presented in Appendix B.

3.3 Data Analysis

For this report, a pollutant removal efficiency ratio (ER) (David et al. 2014) was used to analyze changes in concentrations between the influent samples (taken in the gutter upstream of the biofiltration facility) and the effluent samples (taken from the underdrain) as a percentage of inflow concentration using the following equation:

$$\text{ER} = (\text{influent conc.} - \text{effluent conc./influent conc.}) \text{ X } 100$$

The ER was calculated for each storm event. Results are presented as percent difference (% Diff) in Tables 3 and 4.

Hydrologic data (i.e., flow rates) were not available (as of February 2016) to calculate flow weighted mean concentrations, loading rates, or pollutant removal efficiencies for the pollutants added by SMCWPPP for Provision C.8.d.ii compliance.

4.0 Results

The hydrologic data needed to calculate pollutant removal efficiencies of the stormwater constituents added to the CW4CB project by SMCWPPP for Provision C.8.d.ii compliance are not available at this time. Therefore, this report compares pollutant concentrations in both the paired influent and effluent samples for a given storm, and across storms using mean influent and effluent concentrations. Limitations to this approach in evaluating BMP performance include that it does not account for overall loading into and out of the BMP.

Summary statistics for analyte concentrations measured in the influent and effluent samples collected during four storm events are shown in Table 1 and Table 2. Effluent mean concentrations of total metals were consistently lower compared to the influent mean concentrations, with the exception of arsenic (Table 1). In contrast, all of the dissolved metals and nutrients had similar or higher mean concentrations in the group of effluent samples compared to the group of influent samples, with the exception of cadmium, chromium and zinc which were slightly lower (Table 2).

Table 1. Summary statistics for total metal concentrations in samples collected above (influent) and below (effluent) the biofiltration facility (PUL-7).

Total Metals	Influent (n=4)			Effluent (n=4)		
	Range	Mean	SD	Range	Mean	SD
Arsenic (ug/L)	3.5 - 6.7	4.4	1.5	3.4 - 5.2	4.4	0.8
Cadmium (ug/L)	0.16 - 0.41	0.3	0.1	0.12 - 0.24	0.2	0.1
Chromium (ug/L)	16 - 39	23.8	10.4	8.3 - 16	11.1	3.5
Copper (ug/L)	30 - 62	45.3	16.6	15 - 24	20.8	4.0
Lead (ug/L)	7.9 - 19	13.0	5.0	3.8 - 8.1	5.6	1.9
Nickel (ug/L)	15 - 39	22.8	11.0	9.3 - 16	12.1	3.1
Zinc (ug/L)	86 - 270	149	82.2	21 - 40	29.5	7.9

n = number of samples, SD = standard deviation

Table 2. Summary statistics for dissolved metal and nutrient concentrations in samples collected above (influent) and below (effluent) the biofiltration facility (PUL-7).

Dissolved Metals and Nutrients	Influent (n=4)			Effluent (n=4)		
	Range	Mean	SD	Range	Mean	SD
Metals						
Arsenic (ug/L)	0.08 - 2	1.3	1.1	0.08 - 3	1.8	1.5
Cadmium (ug/L)	0.03 - 2.6	1.3	1.8	0.04 - 1.9	0.7	1.1
Chromium (ug/L)	1.5 - 15	6.8	7.2	1.4 - 9.2	4.6	4.1
Copper (ug/L)	12 - 120	52	59.2	9.8 - 130	51.6	67.9
Hardness	0.1- 80	50	43.5	0.14 - 180	96.7	90.7
Lead (ug/L)	0.06 -1.8	0.7	1.0	0.22 - 2.4	1.1	1.2
Nickel (ug/L)	0.5 - 2.5	1.5	1.0	0.32 - 3.9	2.5	1.9
Zinc (ug/L)	6.9 - 8.3	7.6	1.0	4.7 - 6	5.4	0.9
Nutrients						
Nitrate as N (mg/L)	0.15 - 0.68	0.4	0.3	0.17 - 0.7	0.4	0.3
Orthophosphate as P (mg/L)	0.1 - 3.7	1.3	2.1	0.12 - 3.6	1.3	2.0

n = number of samples, SD = standard deviation

The total and dissolved metals, hardness, nitrate, and orthophosphate concentrations measured in water samples collected at the paired influent and effluent locations at site PUL-7 during each of the four storm events are presented in Tables 3 and 4. The change in concentration, expressed as percent difference, is presented for each analyte. Total metal concentrations for both influent and effluent samples collected over the four storm events are shown in Figure 3.

Table 3. Total metal concentrations from influent and effluent samples collected at site PUL-7 during four storm events.
"I" and "E" represents influent and effluent sample concentrations, respectively, and "% Diff" is the percent difference between samples.

Analyte	2/26/2014			3/26/2014			3/29/2014			2/6/2015		
	I	E	% Diff	I	E	% Diff	I	E	% Diff	I	E	% Diff
Arsenic (ug/L)	3.6	4.8	33%	6.7	5.2	-22%	3.9	4.1	5%	3.5	3.4	-3%
Cadmium (ug/L)	0.41	0.24	-41%	0.33	0.21	-36%	0.16	0.13	-19%	0.21	0.12	-43%
Chromium (ug/L)	21	11	-48%	39	16	-59%	19	8.9	-53%	16	8.3	-48%
Copper (ug/L)	32	21	-34%	62	24	-61%	30	15	-50%	57	23	-60%
Hardness	88	220	150%	120	130	8%	70	180	157%	80	110	38%
Lead (ug/L)	15	5.9	-61%	19	8.1	-57%	7.9	3.8	-52%	10	4.7	-53%
Nickel (ug/L)	18	13	-28%	39	16	-59%	15	9.3	-38%	19	10	-47%
Zinc (ug/L)	270	30	-89%	120	40	-67%	86	21	-76%	120	27	-78%

Table 4. Dissolved metal and nutrient concentrations from influent and effluent samples collected at site PUL-7 during four storm events.
"I" and "E" represents influent and effluent sample concentrations, respectively, and "% Diff" is the percent difference between samples.

Analyte	2/26/2014			3/26/2014			3/29/2014			2/6/2015		
	I	E	% Diff	I	E	% Diff	I	E	% Diff	I	E	% Diff
Arsenic (ug/L)	0.86	2.8	226%	2.1	3.2	52%	1.8	3	67%	2	2.3	15%
Cadmium (ug/L)	0.033	0.064	94%	0.082	0.082	0%	<0.025	0.075	300%	0.03	0.04	33%
Chromium (ug/L)	3.2	2.6	-19%	2.6	1.9	-27%	3.9	3.1	-21%	1.5	1.4	-7%
Copper (ug/L)	11	11	0%	15	9.2	-39%	12	9.8	-18%	24	15	-38%
Lead (ug/L)	0.14	0.2	43%	0.099	0.14	41%	0.061	0.62	916%	0.1	0.22	120%
Nickel (ug/L)	1.8	4.5	150%	1.8	2.4	33%	1.6	3.9	144%	2.5	3.3	32%
Zinc (ug/L)	15	4.6	-69%	3.7	3.6	-3%	8.3	6	-28%	6.9	4.7	-32%
Nitrate as N (mg/L)	0.43	0.26	-40%	0.5	0.32	-36%	0.33	0.21	-36%	0.68	0.73	7%
Orthophosphate as P (mg/L)	0.094	0.17	81%	0.15	0.17	13%	0.1	0.16	60%	0.1	0.12	20%

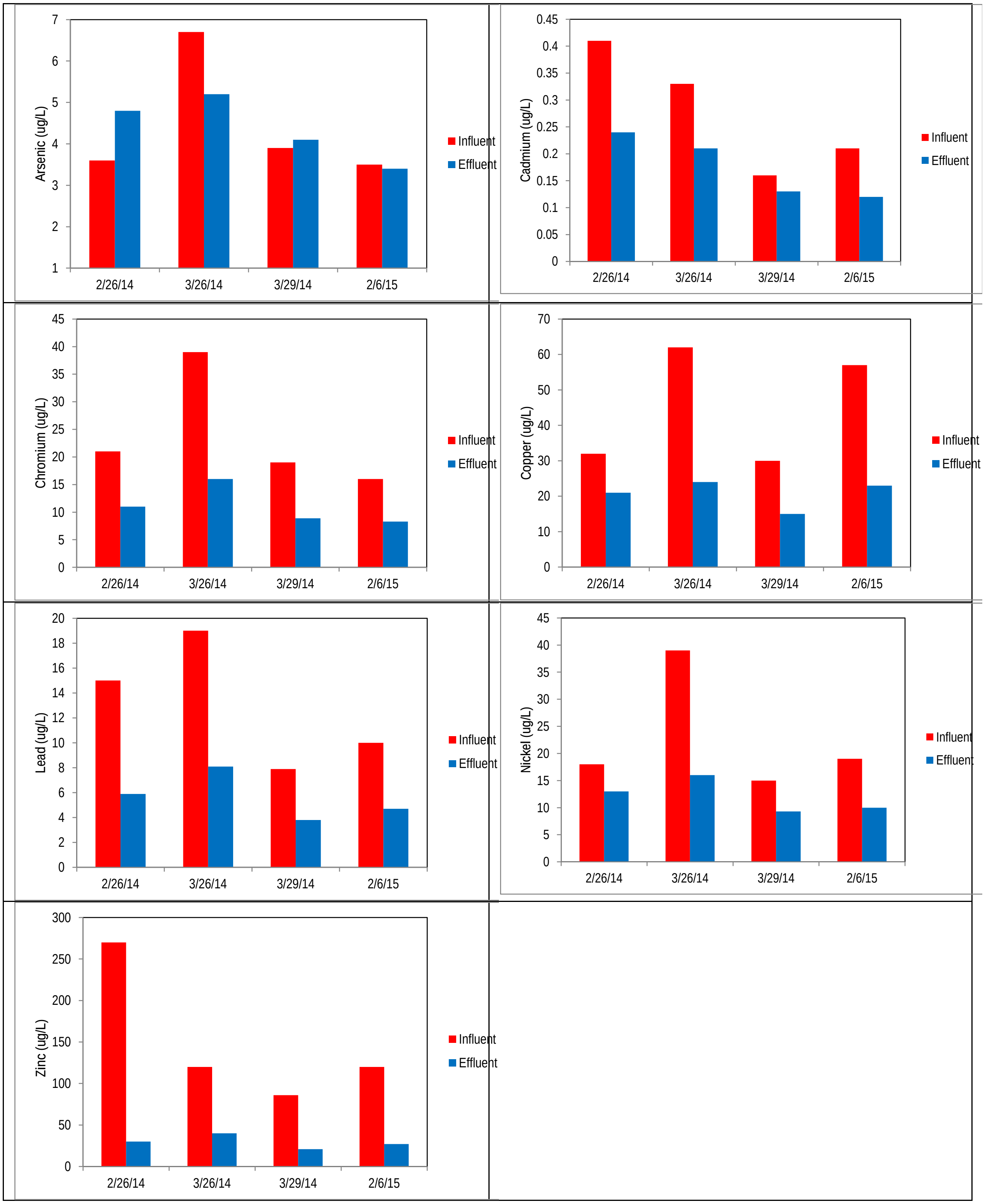

Figure 3. Total metal concentrations for influent and effluent samples collected at Bransten Road BMP during four storm events.

Total zinc concentrations had the highest percent difference for all events (-67% to -89%) (Table 3 and Figure 3). Percent difference in total copper concentrations ranged -34% to -61% across the four storm events (Table 3 and Figure 3). The dissolved metal concentrations were generally higher in the effluent samples compared to the influent samples, with the exception of chromium, copper and zinc, which had lower levels in the effluent samples at three of the four storms events (Table 4). Dissolved nitrate (as nitrogen) had lower concentrations (ranging -36% to -40%) in the effluent samples from three of the four storms events (Table 4). In contrast, dissolved orthophosphate (as phosphorus) concentrations were always higher in the water samples collected at the effluent location (Table 4).

One factor contributing to these results is that the BMP would be expected to have much lower efficiencies in removing trace metals and nutrients in the dissolved fraction compared to the total fraction because dissolved constituents are less likely to be trapped or absorbed by filtration materials or vegetation during a runoff event. These results were consistent with results from other BMP effectiveness studies reported in the International BMP Database (Geosyntec and Wright Water Engineers 2014). In general, other BMP studies showed statistically significant reductions for most trace metals in the total fraction, but not in the dissolved fraction. However, metal and nutrient concentrations in both the influent and effluent samples were generally higher at the Bransten Road BMP in comparison to the median concentrations found in other BMP studies[2]. The results suggest that observed percent removal may be more reflective of how "dirty" the influent water is than BMP performance.

Evaluation of biofiltration effectiveness for removal of contaminants is challenging due to a wide range of factors that affect removal efficiency, including variability in input concentrations and fine sediment, precipitation, and potential hydrologic losses to groundwater (David et al. 2014). Evaluation of reductions should also incorporate flow measurements associated with paired influent and effluent samples to calculate flow-weighted mean concentrations, loading estimates, and pollutant removal efficiencies.

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[2] Influent/effluent concentrations measured at "bioretention" type of BMPs were used for comparison to the Bransten Road BMP.

5.0 Conclusions

Initial analyses of results presented in this report suggest that the biofiltration cell at site PUL-7 on Bransten Road was generally effective at reducing concentrations of total metals in stormwater. Reductions in mean total concentrations were observed for six of the seven metals. These results were consistent with paired influent and effluent concentrations for all four storm events. In contrast, dissolved metals and nutrients concentrations were often higher in the effluent samples compared to the influent samples. Higher concentrations for analytes in dissolved fraction have been found in other BMP effectiveness studies (Geosyntec and Wright Water Engineers 2014).

Overall efficiency of the system will be affected by factors such as the level of precipitation and associated flow volumes and rates (i.e., residence time of surface runoff in the cell) and influent pollutant and sediment concentrations. In addition, continued maintenance of the biofiltration cell (e.g., mulching) and maturation of plants will be important to maintain and potentially increase the removal efficiency over time. Plants at the Bransten Road BMP were established between 3 months and 15 months prior to four sampling events.

Recent reports regarding installation that was inconsistent with the design, resulting in localized flooding and potential system performance issues at the Bransten Road facility, may have affected its pollutant removal performance. These concerns are currently under investigation. If appropriate, SMCWPPP will calculate loadings and removal efficiencies for the constituents after the concerns at the site are better understood and resolved and any CW4CB hydrologic data are published. However, any assessment of overall BMP effectiveness should be interpreted with caution due to a limited number of samples that were collected soon after construction of the bioretention facility.

6.0 References

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APPENDIX A

Analytes, Methods and Detection Limits

Table 1. Analytes, Methods and Reporting Limits.

Analyte	Method	Reporting Limit
Total phosphorus	SM4500-P E	0.01 mg/L as P
Dissolved orthophosphate*	SM4500-P E	0.01 mg/L as P
Nitrate	EPA 300.0	0.1 mg/L as N
Ammonia	EPA 350.1	0.1 mg/L as N
TKN	EPA 351.3	0.5 mg/L as N
Total metals **	EPA 200.8	See Table 2
Dissolved metals ***	EPA 200.8	See Table 2
Hardness	SM 2340B	5 mg/L as CaCO3

*Dissolved orthophosphate is to be filtered by the lab

**Total metals (arsenic, cadmium, chromium, copper, lead, nickel, and zinc)

***Dissolved metals (arsenic, cadmium, chromium, copper, lead, nickel, and zinc) – to be filtered by the lab

Table 2. Reporting Limits for metals.

Analyte	RL	Units
Arsenic	0.5	ug/L
Cadmium	0.2	ug/L
Chromium	0.5	ug/L
Copper	0.5	ug/L
Lead	0.2	ug/L
Nickel	0.5	ug/L
Zinc	1.0	ug/L

APPENDIX B

QA Data Analysis

ALS Environmental Laboratories analyzed all water chemistry samples for the project and performed all internal QA/QC requirements for Inorganic Analytes in Water as specified in the CW4CB QAPP (BASMAA 2014a). The lab MQO for RPDs was 20% and for the QAPP it was 25%. Summary results of QA are shown in Table 1.

Table 1. QA Results.

Analyte	Method Used	Target RL	RL	MDL	PR	RPD
Lead	EPA 200.8	0.01 ug/L	0.2 ug/L	0.032 ug/L	75-125%	25
Arsenic	EPA 200.8	None		0.050	75-125%	25
Cadmium	EPA 200.8	None		0.025	75-125%	25
Chromium	EPA 200.8	None		0.050	75-125%	25
Copper	EPA 200.8	None		0.084	75-125%	25
Hardness	SM 2340 B	None	5.0	0.50	80-120%	25
Nickel	EPA 200.8	None		0.050	75-125%	25
Nitrate	EPA 200.8	None		0.020	80-120%	25
Orthophosphate	EPA 200.8	None		0.0010	80-120%	25
Zinc	EPA 200.8	None		0.10	75-125%	25

A limited number of lab sample results for inorganic analytes in water were flagged due to minor QA/QC issues. These results were not thought to affect the validity of sample results and were not rejected. Included were the following:

- There were no RPD or PR problems for LCS, LCD, Reference, MS, MSD, or duplicate samples. Two blanks were above the method detection limit for several metals, but all were below reporting limits. One duplicate sample exceeded the MQO for RPD (28%), but concentrations were far below the reporting limit (for nickel).

Appendix F

Regional Monitoring Program (RMP) POC Reconnaissance Monitoring Progress Report, Water Year 2015

Pollutants of concern (POC) reconnaissance monitoring draft final progress report, water year (WY) 2015

Prepared by

Lester McKee, Alicia Gilbreath, Don Yee and Jennifer Hunt

San Francisco Estuary Institute, Richmond, California

On

February 29, 2016

For

Regional Monitoring Program for Water Quality in San Francisco Bay (RMP)
Sources Pathways and Loadings Workgroup (SPLWG)
Small Tributaries Loading Strategy (STLS)

Preface

WY 2015 reconnaissance monitoring was completed with funding provided by the Regional Monitoring Program for Water Quality in San Francisco Bay (RMP). This report is designed to be updated each year until completion of the study (at least two winter monitoring seasons: Water Year (WY) 2015 and WY 2016). This version of the report was submitted to BASMAA in support of materials being submitted on or before March 31st 2016 in compliance with the Municipal Regional Stormwater Permit (MRP) Order No. R2-2015-0049. Possible further changes may be made in response to SPLWG and TRC review comments before a final version is submitted to the RMP Steering Committee for approval.

Acknowledgements

We appreciate the support and guidance from members of the Sources, Pathways and Loadings Workgroup of the Regional Monitoring Program for Water Quality in San Francisco Bay. The detailed work plan behind this work was developed through the Small Tributaries Loading Strategy (STLS) during a series of meetings in the summer of 2014. Local members on the STLS at that time were Arleen Feng (for the Alameda Countywide Clean Water Program), Bonnie de Berry (for the San Mateo Countywide Water Pollution Prevention Program), Lucile Paquette (for the Contra Costa Clean Water Program) and Chris Sommers (for the Santa Clara Valley Urban Runoff Pollution Prevention Program); and Richard Looker, and Jan O'Hara (for the Regional Water Board). San Francisco Estuary Institute (SFEI) field and logistical support over the first year of the project was provided by Patrick Kim, Carolyn Doehring and Phil Trowbridge. SFEI's data management team is acknowledged for their diligent delivery of quality assured well-managed data. Over the first year of this project, this team included: Cristina Grosso, Amy Franz, John Ross, Don Yee, Adam Wong, and Michael Weaver. Arleen Feng, Kristine Corneillie, Bonnie de Berry, and Chris Sommers provided helpful written reviews of this report.

Suggested citation:

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Executive Summary

The San Francisco Bay mercury and PCB TMDLs called for implementation of control measures to reduce PCB and mercury loads entering the Bay via stormwater. Subsequently, the San Francisco Bay Regional Water Quality Control Board (Regional Water Board) issued the first combined Municipal Regional Stormwater Permit (MRP). This first MRP contained provisions aimed at improving information on stormwater pollutant loads in selected watersheds (Provision C.8.) and piloted a number of management techniques to reduce PCB and Hg loading entering the Bay from smaller urbanized tributaries (Provisions C.11. and C.12.). In November 2015, the Regional Water Board issued the second MRP. "MRP 2.0" places an increased focus on finding watersheds, sources areas, and source properties that are potentially more polluted and are therefore more likely to be cost effective areas for addressing load reduction requirements through implementation of control measures.

To support this increased focus, a stormwater characterization monitoring program was developed and implemented beginning in Water Year (WY) 2015. This same design is being implemented in the winter of WY 2016 by the RMP and the San Mateo Countywide Water Pollution Prevention Program and the Santa Clara Valley Urban Runoff Pollution Prevention Program. In addition, the RMP is piloting a project to explore the use of alternative un-manned "remote" suspended sediment samplers. During WY 2015, composite stormwater samples were collected from 20 watershed locations. At three of these locations, data were also collected using two remote suspended sediment sampler devices both of which are designed to enhance settling and capture of suspended sediment particles from the water column. This report summarizes and provides a preliminary interpretation of data collected during WY 2015. The data collected is contributing to a broader based effort to identify potential management areas. The report is designed to be updated in subsequent years as more data are collected.

Total PCB concentrations measured in the composite water samples collected from the 20 sites varied 27-fold between 2,033-55,503 pg/L. When normalized by suspended sediment concentrations (SSC) to generate particle ratios, the three sites with highest particle ratios were the Outfall to Lower Silver Creek in San Jose (783 ng/g), Ridder Park Drive Storm Drain in San Jose (488 ng/g) and Line-3A-M at Line 3A-D in Hayward (337 ng/g). Particle ratios of this magnitude are relatively elevated but lower than some of the previous highest observations made during the reconnaissance study of WY 2011 (Santa Fe Channel (1,403 ng/g), Pulgas Creek Pump Station-North (1,050 ng/g), Ettie St. Pump Station (745 ng/g))[1].

Total Hg (HgT) concentrations in composite water samples ranged 6-fold between sites from 13.7-85.9 ng/L. The greatest HgT concentrations were observed in Line-3A-M at Line 3A-D in Hayward, East Gish Rd Storm Drain in San Jose, and Meeker Slough in Richmond. When the data were normalized by SSC, the three most highly ranked sites were Meeker Slough in Richmond (1.3 µg/g), Line-3A-M at Line 3A-D in Hayward (1.2 µg/g), and Rock Springs Drive Storm Drain in San Jose (0.93 µg/g). Particle ratios of this magnitude are similar to the upper range of those observed previously (mainly in WY 2011). The six

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[1] Note the concentrations and particle ratios for these three sites have been modified slightly since publication in 2011 to reflect a new method of computing the central tendency of the data (see the methods section in this report: Derivations of central tendency for comparisons with past data).

highest ranking sites for PCBs based on particle ratios only ranked 12th, 16th, 2nd, 7th, 14th, and 8th respectively in relation to HgT.

Both of the remote suspended sediment sampler types generally characterized sites similarly to the composite stormwater sampling methods (higher concentrations matching higher and lower matching lower), but further testing is needed to determine the overall reliability and practicality of deploying these instruments instead of or to augment manual composite stormwater sampling.

Based on data collated from all sampling programs completed by SFEI since WY 2003 on stormwater in the Bay Area and the use of a Spearman Rank correlation analysis, PCB particle ratios appear to positively correlate with impervious cover, old industrial land use, and HgT. PCBs inversely correlate with watershed area and the other trace metals analyzed (As, Cu, Cd, Pb, and Zn). Total mercury does not appear to correlate with any of the other trace metals and showed similar but weaker relationships to impervious cover, old industrial land use, and watershed area than did PCBs. In contrast, the trace metals all appear to correlate with each other more generally. Overall, the data collected to date do not support the use of any of the trace metals analyzed as a tracer for either PCB or HgT pollution sources.

Climatic conditions may affect the interpretations of relative ranking between watersheds. WY 2015 was a drier than average year. This challenge accepted, a total of 45 sites have so far been sampled for PCBs and HgT in stormwater by SFEI during various field sampling efforts since WY 2003. About 19.2% of the old industrial land use in the region has been sampled to date. The largest sample size so far has occurred in Santa Clara County (61% of this land use has been sampled), followed by Alameda County (17%), San Mateo County (9%), and Contra Costa County (3%). The disproportional coverage in Santa Clara County is due to a number of larger watersheds being sampled and because there were older industrial areas of land use further upstream in the Coyote Creek and Guadalupe River watersheds. Of the remaining older industrial land use yet to be sampled, 48% of it lies within 1 km of the Bay and 65% of it is within 2 km of the Bay. These areas are more likely to be tidal, likely to include heavy industrial areas that were historically serviced by rail and ship based transport, and are often very difficult to sample due to a lack of public right of ways. A different sampling strategy may be needed to effectively determine what pollution might be associated with these areas.

Contents

Introduction

The San Francisco Bay mercury and polychlorinated biphenyl (PCB) total maximum daily load plans (TMDLs) (SFBRWQCB, 2006; 2007) called for implementation of control measures to reduce stormwater PCB loads from about 20 kg to 2 kg by 2030 and to reduce stormwater total mercury (HgT) loads from about 160 kg down to 80 kg by 2028 with an interim milestone of 120 kg by 2018. Subsequently, the San Francisco Bay Regional Water Quality Control Board (Regional Water Board) issued the first combined Municipal Regional Stormwater Permit (MRP) for MS4 phase I stormwater agencies (SFBRWQCB, 2009; 2011(update)). MRP 1.0, as it came to be known, contained provisions aimed at improving information on stormwater loads in selected watersheds (Provision C.8.) and piloting a number of management techniques to reduce PCB and Hg loading entering the Bay from smaller urbanized tributaries (Provisions C.11. and C.12.). To help address these information needs, a Small Tributaries Loading Strategy (STLS) was developed that outlined four key management questions (MQs) about loadings and a general plan to address these questions (SFEI, 2009). These questions were developed to be consistent with Provision C.8.e of MRP 1.0.

MQ1. Which Bay tributaries (including stormwater conveyances) contribute most to Bay impairment from pollutants of concern (POCs);

MQ2. What are the annual loads or concentrations of POCs from tributaries to the Bay;

MQ3. What are the decadal-scale loading or concentration trends of POCs from small tributaries to the Bay; and,

MQ4. What are the projected impacts of management actions (including control measures) on tributaries and where should these management actions be implemented to have the greatest beneficial impact.

During the first term of the MRP (2009-15) for MS4 Phase I stormwater permittees[2], expenditure of RMP funds continued to focus on refining pollutant loadings but with additional emphasis on finding and prioritizing potential “high leverage” watersheds and subwatersheds (those with disproportionally high concentrations or loads with connections to sensitive Bay margins). These efforts included

1. a 2009/2010 study to explore relationships between watershed characteristics (Greenfield et al., 2010),
2. a 2009/2010 study to explore optimal sampling design for loads and trends (Melwani et al., 2010),
3. a reconnaissance study in water year 2011 to characterize concentrations during winter storms at 17 locations (McKee et al., 2012),
4. the completion of a number of “pollutant profiles” describing what is known about the sources and release processes for each pollutant (McKee et al., 2014),

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[2] For a full list of permittees that included cities and special districts, the reader is referred to the individual countywide program websites or the MRP (SFRWQCB, 2009).

5. the development and operation of a loads monitoring program at six fixed station locations for water years 2012-2014 (Gilbreath et al., 2015a), and
6. further refinement of geographic information about land uses and source areas of PCBs and Hg and the development of a regional watershed spreadsheet model (2010-present) (Wu et al., 2016).

These efforts were consistent with implementation plans outlined in the PCBs and Hg policy documents. As a result, sufficient pollutant data have been collected at sites with discharge measurements to make computations of pollutant loads of varying degrees of certainty at Mallard Island on the Sacramento River and 11 urban sites (McKee et al. 2015) and the a reasonable calibration of the regional watershed spreadsheet model (RWSM) has been achieved for water, Cu, and PCBs (Wu et al., 2016)[3].

Discussions between the Bay Area Stormwater Management Agencies Association (BASMAA)[4] and the SFBRWQCB regarding the second term of the MRP, and parallel discussions at the October 2013 and May 2014 Sources Pathways and Loadings Workgroup (SPLWG) meetings, highlighted the need for an increasing focus on finding watersheds and land areas within watersheds that have relatively higher unit area load production or higher particle ratios or sediment pollutant concentrations at a scale paralleling management efforts (areas as small as subwatersheds, areas of old industrial land use, or source properties). This changing focus is consistent with the management trajectory outlined in the Fact Sheet (MRP Appendix I) issued with the November 2011 revision of the October 2009 MRP (SFRWQCB, 2009; 2011). The Fact Sheet described a transition from pilot-testing in a few specific locations during the first MRP term to a greater amount of focused implementation in areas where benefits would be most likely to accrue in the second MRP term.

During 2014 and early 2015, the SPLWG and Small Tributaries Loadings Strategy (STLS) Team discussed alternative monitoring designs that can address this focus and discussion is still ongoing through the development of a STLS Trend Strategy. In November 2015, the Regional Water Board issued the second MRP (Water Board, 2016). “MRP 2.0” places an increased focus on finding watersheds, source areas, and source properties that are potentially more polluted and located upstream from sensitive Bay margin areas (potential high leverage). Specifically the permit states that effort should be made to better understand contributions to Bay impairment by identifying watershed source areas that contribute most to the impairment of San Francisco Bay beneficial uses (due to source intensity and sensitivity of discharge location). To help support this focus, the Sources Pathways and Loadings Workgroup (SPLWG) and the STLS local team developed and implemented a stormwater characterization monitoring program in Water Year (WY) 2015. The methods employed were modified from those first proposed at the October 2004 SPLWG meeting (study proposal #2), discussed again by the workgroup in 2005/06 as an alternative option to a loading study at Zone 4 Line A in Hayward, Alameda County, and implemented for the first time in WY 2011 (McKee et al., 2012). The nimble design implemented during the winter of WY 2015 benefited from lessons learned during the WY 2011 effort and provides data primarily to support identification of potential high leverage areas as part of multiple

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[3] The calibration of the RWSM for Hg still remains a challenge. Work in early 2016 may help to resolve this.

[4] BASMAA is made up of a number of programs which represent Permittees and other local agencies

lines of evidence being considered by the stormwater programs. The data also support improved calibration of the RWSM being developed to estimate regional scale watershed loads. This same design is being implemented in the winter of WY 2016 by the RMP, the San Mateo Countywide Water Pollution Prevention Program, and the Santa Clara Valley Urban Runoff Pollution Prevention Program.

In parallel, the STLS team is designing a sampling program for monitoring stormwater loading trends in response to management efforts. Data collected using the characterization design may also help to provide baseline data for observing concentration or particle ratio trends through time if the trends monitoring design effort provides evidence of suitability for that purpose.

This report summarizes and provides a preliminary interpretation of data collected during WY 2015. The data collected and presented here is contributing to a broader based effort to identify potential management areas. The report is designed to be updated annually in subsequent years as more data are collected.

Sampling methods

Methods selection

Water Year 2014 saw the conclusion of three years of pollutant loads monitoring at six fixed locations near the Bay margins for suspended sediment, total organic carbon (TOC), PCBs, HgT, total methylmercury (MeHgT), nitrate (NO_3), phosphate (PO_4)[5], and total phosphorus (TP). In addition, a fewer number of samples were gathered at the loading sites to characterize polybrominated diphenyl ether (PBDEs), polyaromatic hydrocarbons (PAHs), toxicity, pyrethroid pesticides, copper (Cu), and selenium (Se) (Gilbreath et al., 2015a). With the increasing focus of management efforts to identify areas of elevated PCBs (and mercury), a new monitoring design was needed to broaden the spatial coverage of information gathering and allow for relative comparisons of PCB and mercury concentrations across the region. In order to collect this information, a reconnaissance design was selected. This type of design is efficient, cost-effective, allows for a larger number of sites monitored, and can be used on a relative scale for identifying drainages with high PCB and mercury concentrations (McKee et al., 2012; SPLWG, May 2014; McKee et al., 2015).

The WY 2015 design was based on a previous monitoring design (WY 2011) in which multiple sites were visited during 1-2 storm events and stormwater samples were collected for a number of POCs. Based on discussions at the May 2014, SPLWG meeting, modifications were made to the WY 2011 design to increase cost-effectiveness. At the SPLWG meeting an analysis of previously collected stormwater sample data from both reconnaissance and fixed station monitoring was presented. An analysis of three sampling designs (1, 2, and 4 storms: functionally 4, 8, and 16 discrete samples) showed that, for Guadalupe River at Hwy 101, PCB particle ratios could vary from 45-287 ng/g (1 storm design), 59-257 ng/g (2 storm design), and 74-183 ng/g (4 storm design). Although the Guadalupe River at Hwy 101 represents a more extreme example of variability due to larger storms causing runoff from the upper

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[5] Is also often referred to as dissolved orthophosphate or dissolved reactive phosphorous (DRP) or dissolved inorganic phosphorous (DIP). All these terms are functionally equivalent and refer to a sample that is filtered before analysis and analysis is completed using the ascorbic acid + molybdate blue reagents.

cleaner areas of the watershed, this analysis was used to imply that the number of storms sampled for a given system would have had quite a large influence on the resulting particle ratio and the potential relative ranking among sites. A similar analysis was then presented for the other fixed loads monitoring sites (Pulgas Creek Pump Station-South, Sunnyvale East Channel, North Richmond Pump Station, San Leandro Creek, Zone 4 Line A, and Lower Marsh Creek) to explore the relative ranking based on a random 1-storm composite or 2-storm composite design. This analysis highlighted the potential for a false negative that could occur due to a lower number of sampled storms in Sunnyvale East Channel (3 of the 8 storms represented were < 200 ng/g which would have ranked it only slightly more polluted than San Leandro Creek, Zone 4 Line A or Guadalupe River at Hwy 101). This further highlighted the tradeoff between generating information about water quality at fewer sites with more certainty or more sites with less certainty. The SPLWG agreed that a 1-storm composite per site design was preferable since the design has the flexibility to return to a site if the initial results did not make sense (either because the storm intensity was low or other information suggested potential sources).

In addition to collection of stormwater composites, a pilot study exploring in-line suspended sediment samplers based on enhanced water column settling was designed and implemented. Four sampler types were initially considered (single-stage siphon sampler, the CLAM sampler, the Hamlin sampler, and the Walling tube). After SPLWG discussion, the single-stage siphon sampler was dropped from consideration because it allowed for collection of only a single stormwater sample at a single time point, which offers no advantage over collecting a single manual stormwater sample, yet would require more effort and expense to set up. The CLAM sampler also has some limitations that affect interpretation of the data, primarily the lack of ability to estimate the volumes of water passing through the filters and the lack of performance tests in high turbidity environments. The remaining two sampler types (the Hamlin sampler and the Walling tube) were selected for the pilot study based on previous studies showing use of these devices in similar systems (velocities and analytes). However, there was a lot of discussion about how to analyze the samples and how to ensure their comparability to the composite water sample design. To test the comparability of sampling methods, the SPLWG Science Advisors recommended piloting the samplers at 12 locations[6] where manual water composites would be collected in parallel.

Watershed physiography and sampling locations

In the May 2014 SPLWG meeting, sample site selection rationale was discussed. The potential site selection rationales fall into four basic categories.

1. Identifying potential high leverage watersheds and subwatersheds (distributed across Phase I permittees)
    a. Watersheds with suspected high pollution
    b. Sites with ongoing or planned management actions
    c. Identifying sources within a larger watershed of known concern (nested sampling design)

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[6] Note that only 3 locations could be sampled during WY 2015 due to climatic constraints. The remaining nine samples are planned for WY 2016.

2. Sampling strategic large watersheds with USGS gauges to provide first order loading estimates and to support calibration of the RWSM
3. Validating unexpected low (potential false negative) concentrations (to address the possibility of a single storm composite poorly characterizing a sampling location)
4. Filling gaps along environmental gradients or source areas (to support the RWSM)

It was agreed that the majority of samples each year (60-70% of the effort) would be dedicated to identifying potential high leverage watersheds and subwatersheds. The remaining resources would be allocated to addressing the other three rationales. In order to address this focus, SFEI worked with the respective Countywide Clean Water Programs to identify priority drainages including storm drains, ditches/culverts, tidally influenced areas, and natural areas for monitoring. A larger pool of sites was visited during summer 2014 to survey each for safety, logistical constraints, and identification of feasible drainage line entry points. From this larger set, a final set of 25 sites were identified for monitoring during WY 2015. Of these 25 sites, 20 sites were sampled despite climatic constraints (Figure 1; Table 1). The remaining five sites were carried over for possible sampling in WY 2016.

It is seen, from Figure 1 and Table 1, that watershed sites with a wide variety of characteristics were sampled in WY 2015. In total, eight sites were sampled in Santa Clara County, six sites in San Mateo County, five sites in Alameda County, and just one site in Contra Costa County[7]. Areas upstream from sample locations ranged between 0.11 km^2 and 11.50 km^2 and were characterized by a high degree of imperviousness (53%-85%: mean = 74%). The percentage of the watersheds designated as old industrial[8] range between 2% and 78% and average 30%. Although the sites were mainly selected to address site selection rationale number one (identifying potential high leverage watersheds and subwatersheds), Lower Penitencia Creek represents an example of a site that was previously sampled and where the resulting concentrations appeared to be surprisingly low and therefore warranting re-sampling. In addition, the wide variety of imperviousness and industrial characteristics of these watersheds will help to broaden the environmental gradient of watershed characteristics that will potentially support an improved calibration of the RWSM (Wu et al., 2016). A matrix of site characteristics for potentially sampling strategic larger watersheds was also developed (Table 2). However, none of these could be sampled during WY 2015 because climatic conditions for rainfall and flow were not met.

Field methods

Mobilization and preparing to sample

Based on a minimum rainfall weather forecast for at least a quarter inch[9] over six hours, sampling teams were deployed to each of the sampling sites, ideally reaching the sampling site about one hour before

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[7] Two additional sites in Contra Costa County had been identified for WY 2015 but were not sampled because they are tidally influenced with only short sampling windows. Storms in WY 2015 did not align with these short periods.

[8] Note the definition of “old Industrial” land use used here is based on definitions developed by the Santa Clara Valley Urban Run-off Pollution Prevention Program (SCVURPPP) building on GIS development work completed during the development of the RWSM (Wu et al., 2016).

[9] Note, this was relaxed due to a lack of larger storms. Ideally, mobilization would only proceeded with a 0.5” forecast.

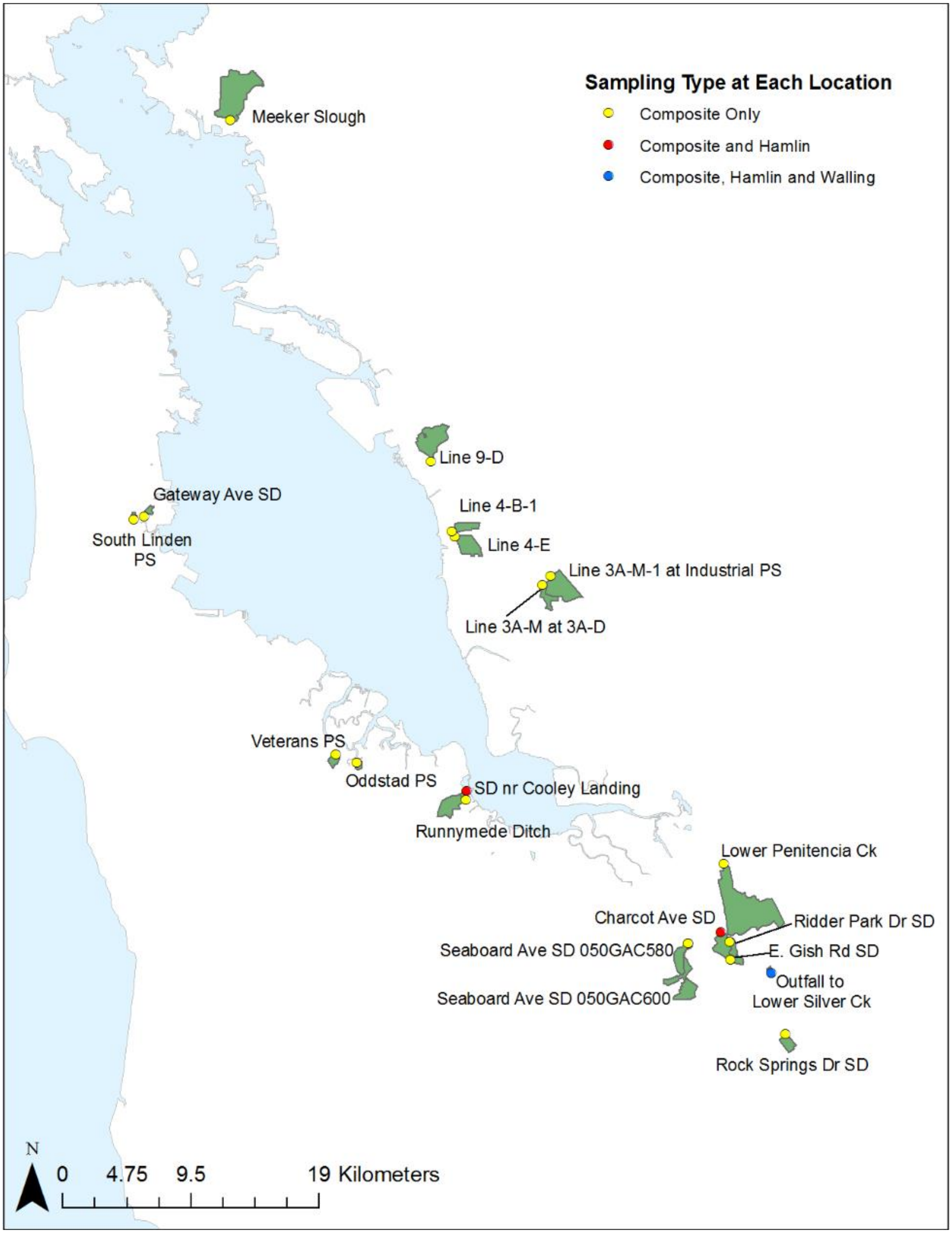

Figure 1. Sampling locations (marked by the dots), watershed boundaries (shown in green) and sampler type (color of the dots).

Table 1. Key characteristics of WY 2015 sampling locations.

County Program	City	Watershed name	Catchment Code	Latitude	Longitude	Year Sampled	Watershed area (sq km)	Impervious cover (%)	Old Industrial (%)
Alameda	Hayward	Line3A-M-1 at Industrial PS	AC-Line3A-M-1	37.618933	-122.05949	WY 2015	3.44	78%	26%
Alameda	Hayward	Line-3A-M at 3A-D	AC-Line-3A-M	37.612853	-122.06629	WY 2015	0.88	73%	12%
Alameda	Hayward	Line4-B-1	AC-Line4-B-1	37.647519	-122.14362	WY 2015	0.96	85%	28%
Alameda	Hayward	Line4-E	AC-Line4-E	37.64415	-122.14127	WY 2015	2.00	81%	27%
Alameda	San Leandro	Line9-D	AC-Line9-D	37.693833	-122.16248	WY 2015	3.59	78%	46%
Contra Costa	Richmond	Meeker Slough	Meeker Slough	37.917861	-122.33838	WY 2015	7.34	64%	6%
Santa Clara	Milpitas	Lower Penitencia Ck	Lower Penitencia	37.429853	-121.90913	WY 2011, 2015	11.50	65%	2%
Santa Clara	Santa Clara	Seabord Ave SD SC-050GAC580	SC-050GAC580	37.376367	-121.93793	WY 2015	1.35	81%	68%
Santa Clara	Santa Clara	Seabord Ave SD SC-050GAC600	SC-050GAC600	37.376356	-121.93767	WY 2015	2.80	62%	18%
Santa Clara	San Jose	Charcot Ave SD	SC-051CTC275	37.384128	-121.91076	WY 2015	1.79	79%	25%
Santa Clara	San Jose	Ridder Park Dr SD	SC-051CTC400	37.377836	-121.90302	WY 2015	0.50	72%	57%
Santa Clara	San Jose	E. Gish Rd SD	SC-066GAC550	37.366322	-121.90203	WY 2015	0.44	84%	71%
Santa Clara	San Jose	Outfall to Lower Silver Ck	SC-067SCL080	37.357889	-121.86741	WY 2015	0.17	79%	78%
Santa Clara	San Jose	Rock Springs Dr SD	SC-084CTC625	37.317511	-121.85459	WY 2015	0.83	80%	10%
San Mateo	Redwood City	Oddstad PS	SM-267	37.491722	-122.21886	WY 2015	0.28	74%	11%
San Mateo	South San Francisco	Gateway Ave SD	SM-293	37.652444	-122.40257	WY 2015	0.36	69%	52%
San Mateo	South San Francisco	South Linden PS	SM-306	37.650175	-122.41127	WY 2015	0.14	83%	22%
San Mateo	Redwood City	Veterans PS	SM-337	37.497231	-122.23693	WY 2015	0.52	67%	7%
San Mateo	East Palo Alto	Runnymede Ditch	SM-70	37.468828	-122.12701	WY 2015	2.05	53%	2%
San Mateo	East Palo Alto	SD near Cooley Landing	SM-72	37.474922	-122.1264	WY 2015	0.11	73%	39%

Table 2. Characteristics of larger watersheds to be monitored, proposed sampling location, and proposed sampling trigger. None of these watersheds could be sampled during WY 2015 because climatic conditions for flow and rainfall were not met.

Proposed sampling location							Relevant USGS gauge for 1st order loads computations	
Watershed system	**Watershed area (sq mi)**	**Impervious surface (%)**	**Industrial (%)**	**Sampling objective**	**Commentary**	**Proposed sampling triggers**	**Gauge number**	**Area at USGS gauge (sq mi)**
Alameda Creek at EBRPD Bridge at Quarry Lakes	352	8.5	0.4	2, 4	Operating flow and sediment gauge at Niles just upstream will allow the computation of 1st order loads to support the calibration of the RWSM for a large, urbanizing type watershed.	7” of antecedent rainfall in Livermore (reliable web published rain gauge), after at least an annual storm has already occurred (~2000 cfs at the Niles gauge), and a decent forecast for the East Bay interior valley's (2-3” over 12 hrs).	11179000	633
Dry Creek at Arizona Street (Purposely downstream from historic industrial influences)	9.8	3.5	0.2	2, 4	Operating flow gauge at Union City just upstream will allow the computation of 1st order loads to support the calibration of the RWSM for mostly undeveloped land use type watersheds.	7” of antecedent rainfall in Union City, after at least a common annual storm has already occurred (~200 cfs at the Union City gauge), and a decent forecast for the East Bay Hills (2-3” over 12 hrs).	11180500	9.39
San Francisquito Creek at University Avenue (as far down as possible to capture urban influence upstream from tide)	42.7	6.9	0.3	2, 4	Operating flow gauge at Stanford upstream will allow the computation of 1st order loads to support the calibration of the RWSM for larger mixed land use type watersheds.	7” of antecedent rainfall in Palo Alto, after at least a common annual storm has already occurred (~1000 cfs at the Stanford gauge), and a decent forecast for the Peninsula Hills (3-4” over 12 hrs).	11164500	37.4
Matadero Creek at Waverly Street (purposely downstream from the railroad)	9.8	22.4	3.3	2, 4	Operating flow gauge at Palo Alto upstream will allow the computation of 1st order loads to support the calibration of the RWSM for mixed land use type watersheds. Sample pair with San Francisquito Ck.	7” of antecedent rainfall in Palo Alto, after at least a common annual storm has already occurred (~200 cfs at the Palo Alto gauge), and a decent forecast for the Peninsula Hills (3-4” over 12 hrs).	11166000	7.26
Colma Creek at West Orange Avenue (location strategically downstream from historic industrial influence but still upstream from tide)	10.6	38	0.5	2, 4 (possibly 1)	Historic flow gauge (ending 1996) in the park a few hundred feet upstream will allow the computation of 1st order loads estimates to support the calibration of the RWSM for mixed land use type watersheds.	Since this is a very urban watershed, precursor conditions more relaxed: 4” of antecedent rainfall, and a decent forecast (2-3” over 12 hrs). Measurement of discharge and manual staff plate readings during sampling will verify the historic rating.	11162720	10.8

Key for sampling objectives: 1. Identify potential high leverage watersheds; 2. Strategic watersheds with USGS gauges for loads computations and RWSM model calibration/verification; 3. Validating false negative finding or unexpected concentrations; 4. Filling gaps along environmental gradients or source areas.

the onset of rainfall[10]. When possible, one team sampled two sites in close proximity to one another to increase sample capture efficiency and decrease staffing costs to the program. Once arriving on site, the team worked together to assemble the equipment and carry out final safety checks. Sampling equipment varied between sites depending on the characteristics of the access point to the drainage line. Some sites were sampled by attaching laboratory prepared trace metal clean Teflon sampling tubing to a painters pole and a peristaltic pump (also installed with lab cleaned silicone pump roller tubing) (Figure 2a). During sampling, the tube was dipped into the channel or drainage line aiming for mid-channel mid-depth (if shallow) or depth integrating if the depth was more than about 0.5 m. In other cases, a DH 84 (Teflon) sampler was used that had also been cleaned prior to sampling, also aiming for mid-channel, mid-depth, or depth integrated depending on channel conditions.

Manual time-paced composite stormwater sampling procedures

At each site, a time-paced composite sample was collected comprising a variable number of sub-samples, or aliquots. Depending on the weather forecast, the prevailing on site conditions, and radar imagery, staff estimated the duration of the storm and selected the aliquot size and number to ensure that the minimum volume requirements for each analyte would be reached before the storm's end (Table 3). Because the minimum volume requirements were less than the size of the sample bottle, there was flexibility built into the sub-sampling program to add aliquots in the event that the storm ended up longer than predicted (e.g., minimally 5 aliquots but up to 10 aliquots could be collected; Table 3). The final decision on the aliquot volume was made just before the first aliquot was taken and remained fixed for the rest of the event. The ultimate number of aliquots, as along as the minimum volume was reached, was usually adjusted depending upon how the rain event progressed. All aliquots for the sample were collected into the same bottle throughout the storm, which was kept in a cooler on ice.

Remote suspended sediment sedimentation sampling procedures

The Hamlin and Walling tube remote suspended sediment samplers were deployed approximately mid-channel/ storm drain. The Hamlin sampler sat flush with the bed of either the stormdrain or concrete channel[11], and was weighted down to the bed either by itself (the sampler weighs approximately 25 lbs) or additionally using Olympic weights bungee-corded to the sampler (see Figure 2b). The Walling tube could not be deployed in storm drains due to its size and requirement for staying horizontal, but was secured in open channels either by being weighted down to a concrete bed using hose clamps to secure Olympic weights, or secured to a natural bed using hose clamps attached to temporarily installed rebar. To minimize the chances of sampler loss, both samplers were additionally secured via a stainless steel cord attached on one end to the sampler and on the other end to a temporary rebar anchor or another object such as a tree or fence post.

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[10] Antecedent dry-weather was not considered prior to deployment. Although this would likely have a bearing on the concentration of certain build-up/wash-off pollutants like metals and perhaps even mercury, for PCBs, atmospheric and other ongoing sources are less important than the mobilization of in-situ legacy sources.

[11] In future years, if the Hamlin is deployed within a natural bed channel, elevating the sampler off the bed may be necessary but was not the case in WY 2015.

Figure 2. Sampling equipment used in the field. (a) Painters pole, Teflon tubing and an ISCO used as a slave pump; alternatively a Teflon bottle is attached to the end of a painters pole (DH84) and used for sample water collection as opposed to using an ISCO as a pump (b) Hamlin suspended sediment sampler; and (c) the Walling tube suspended sediment sampler.

The suspended sediment sedimentation samplers were deployed for the duration of the manual water quality sampling (Table 4 for site list and success rate). At the end of water quality sampling at a site with a remote sampler, the remote sedimentation sampler was removed from the channel bed /storm drain bottom at approximately the same time as the last water quality sample aliquot. Water and sediments collected into the sedimentation sampler were decanted into one or two large glass bottles. Staff flushed all sediments into the collection bottles. When additional water was needed to flush the settled sediments from the remote samplers into the collection bottles, site water from the sampled channel was used. The samples were taken back to SFEI and refrigerated upon arrival until processing. Samples were split and placed into laboratory containers and then shipped to the laboratory for analysis. Three samples were analyzed as whole water samples and one was analyzed as separated dissolved and sediment fractions.

Laboratory analytical methods

All samples were labeled, placed on ice, transferred back to SFEI, and refrigerated at 4 °C until transport to the laboratory for analysis, except for TOC/DOC. DOC has a 24-hour hold time for filtration. Samples were mostly dropped to the analytical laboratory within the 24-hour filtration hold time. In those cases where the laboratory was not open during the 24-hour hold time window, SFEI staff filtered DOC samples using a Hamilton 50 mm glass syringe with a 25 mm, 0.45 um filter. Laboratory methods shown in Table 5 were used to ensure the optimal combination of method detection limits, accuracy and precision, and costs (BASMAA, 2011; 2012) (Table 5).

Table 3. Sub-sample sizes in relation to analytes and sample container volumes.

Analyte	**Bottle size (L)**	**Minimum volume (L)**	**Aliquots (sub-samples) (minimum to maximum number, and required volumes in milliliters (mL)**					
			3 to 6	**4 to 8**	**5 to 10**	**6 to 12**	**7 to 14**	**8 to 16**
HgT/ trace metals	2	0.25	333	250	200	167	143	125
SSC	1	0.3	167	125	100	83	71	63
PCBs	2.5	1	333	250	200	167	143	125
Grain size	2	1	333	250	200	167	143	125
TOC	1	0.25	167	125	100	83	71	63

Table 4. Locations where remote sediment samplers were pilot tested.

Site	Date	Sampler(s) deployed	Comments
Meeker Slough	11/2015	Hamlin and Walling	Sampling effort was unsuccessful due to very high velocities. Both samplers washed downstream because they were not weighted down enough and debris caught on the securing lines.
Outfall to Lower Silver Creek	2/06/15	Hamlin and Walling	Sampling effort was successful. This sample was analyzed as a water sample.
Charcot Ave Storm Drain	4/07/15	Hamlin	Sampling effort was successful. This sample was analyzed as separate dissolved and sediment (particulate) samples.
Cooley Landing Storm Drain	2/06/15	Hamlin	Sampling effort was successful. This sample was analyzed as a water sample.

Table 5. Laboratory analysis methods for 2015 samples.

Analysis	**Matrix**	**Analytical Method**	**Lab**	**Filtered**	**Field preservation**	**Contract Lab / Preservation hold time**
PCBs (40)-Dissolved	Water	EPA 1668	AXYS	Yes	NA	NA
PCBs (40)-Total	Water	EPA 1668	AXYS	No	NA	NA
PCBs (40)-Particulate	Water	EPA 1668	AXYS	Yes	NA	NA
SSC	Water	ASTM D3977	USGS	No	NA	NA
Grain size	Water	USGS GS method	USGS	No	NA	NA
Mercury-Total	Water	EPA 1631E	BRL	No	BrCl	BRL preservation within 28 days
Metals-Total (As, Cd, Pb, Cu, Zn)	Water	EPA 1638 mod	BRL	No	HNO_3	BRL preservation with Nitric acid within 14 days
Mercury-Dissolved	Water	EPA 1631E	BRL	Yes	BrCl	BRL preservation within 28 days
Mercury-Particulate	Water	EPA 1631E	BRL	Yes	BrCl	BRL preservation within 28 days
Organic carbon-Total	Water	5310 C	EB mud	No	HCL	NA
Organic carbon-Dissolved	Water	5310 C	EB mud	Yes	HCL	NA
Mercury	Sediment	EPA 1631E, Appendix	BRL	NA	NA	
PCBs	Sediment	EPA 1668	AXYS	NA	NA	NA

Interpretive methods

Particle normalized concentrations

It has previously been shown that stormwater concentrations tend to vary more at a site than particle ratios, depending on storm characteristics. Since each site was only monitored at the characterization level and there was no averaging of data for a site across many storm events and suspended sediment erosion and concentrations in stormwater vary greatly between sites, it was argued that the particle ratio from a single sample is likely a better summary of water quality of a site than a single water concentration (McKee et al., 2012). But even so, it is noted that, in addition to sediment variability, climatic conditions can influence the interpretations of relative ranking between watersheds although the absolute nature of that influence may differ between watershed locations. For example, for some watersheds, dry years or lower storm intensity might cause a greater particle ratio if transport of the sources of polluted sediments are activated and entrained into runoff but overall less diluted by lower erosion rates of cleaner particles from other parts of the watershed. For other watersheds, the source may be a remote patch of polluted soil that can only be eroded and transported when antecedent conditions and/ or rainfall intensity reach some threshold. In this instance, a false negative could occur during a dry year. Only with many years of data during many types of storms could such processes be teased out. WY 2015 was a drier than average year. For example, the San Francisco gauge (047772) recorded 18.2 in or 82% of the 40 year (1976-2015) normal. However, most of this rainfall (11.7 in) fell in December. In contrast, WY 2011 (when the last spatially intensive sampling occurred) was a wetter year with 130% of the 40 year San Francisco normal. These climatic challenges acknowledged, the particle ratio (PR) (mass of a given pollutant of concern in relation to mass of suspended sediment) was computed for each composite water sample collected for each analyte at each site by taking the water concentration (mass per unit volume) and dividing it by its suspended sediment concentration pair (mass of suspended sediment per unit volume) (Equation 1).

Equation 1 (example PCBs):

$$PR\ (\frac{ng}{mg}) = \frac{PCB\ (\frac{ng}{L})}{SSC\ (\frac{mg}{L})}$$

These ratios where then used as the primary method for comparisons between sites without regard to climate or rainfall intensity. Such comparisons are assumed valid for providing evidence to differentiate a group of sites with higher pollutant concentrations from a contrasting group with lower pollutant concentrations. To generate information on the absolute relative ranking between individual sites, a much more rigorous sampling campaign sampling many storms over many years would be required (c.f. the Guadalupe River study: McKee et al., 2006, or the Zone 4 Line A study: Gilbreath et al., 2012a).

Derivations of central tendency for comparisons with past data

As commonly discussed in water quality literature, mean, median, geomean, or flow-weighted mean can be used measures of central tendency of a dataset. In the Bay Area, the average or median of water concentrations at a site had sometimes been used, or the average or median of the particle ratios (McKee et al., 2012; McKee et al., 2014; Wu et al., 2016). To best compare WY 2015 results with past data (always collected as discrete stormwater samples rather than composite samples), a different technique was used to estimate the central tendency than had been done in the past. It was reasoned that a water composite collected over a single storm is equivalent to taking several discrete samples collected over multiple storms and mixing them all into a single bottle for analysis. In order to calculate the equivalent of a single storm composite particle ratio for an analyte, for previous studies that resulted in multiple stormwater samples, all of the water concentration samples were summed together for the analyte and divided that by the sum of all the suspended sediment concentrations for the site (note: this method is mathematically not equivalent to averaging together the particle ratios of each discrete sample paired with its SSC). Due to the use of this alternate method for estimating the central tendency of the data for a site, particle ratios reported here will differ slightly from those reported previously for the same site (e.g. McKee et al., 2012; McKee et al., 2014; Wu et al., 2016).

Quality assurance

The sections below reports on WY 2015 data only. The data were reviewed using the quality assurance (QA) program developed for the San Francisco Bay Regional Monitoring Program for Water Quality (Yee et al., 2015). Yee et al. (2015) describes how RMP data are reviewed for concerns in relation to hold times, sensitivity, blank contamination, precision, accuracy, comparison of dissolved and total phases, magnitude of concentrations versus concentrations from previous years, other similar local studies or studies described from elsewhere in peer-reviewed literature, and PCB (or other organics) fingerprinting. Data handling procedures and acceptance criteria differ among programs, however, the underlying data were never discarded. The results for “censored” data were maintained so the impacts of applying different QA protocols can be assessed by a future analyst if desired. Quality assurance (QA) summary tables can be found in Appendix A in addition to the following narrative.

Suspended Sediment Concentration and Particle Size Distribution

The SSC and particle size distribution (PSD)[12] data from USGS-PCMSC were acceptable. Samples were all analyzed within hold time. Minimum detection limits (MDLs) were generally sufficient with <20% non-detects reported for SSC and the more abundant Clay, Silt, and Very Fine Sand fractions. Extensive non-detects (>50% NDs) were generally reported for the coarser fractions, with 100% NDs for the coarsest (Granule + Pebble/2.0 to <64 mm) fraction. Method blanks and spiked samples are not typically reported for SSC and PSD. The blind field replicate sample was used to evaluate precision in the absence of any other replicates. Particle size fractions had average relative standard deviation (RSD) ranging from 12% for Silt to 62% for Fine Sand. Although both SSC and some individual fractions had average percent difference (RPD) or RSDs >40%, suspended sediments in runoff (and particle size distributions within that SSC) can be highly variable even separated by minutes, so results were flagged as estimated values, rather than rejected. Fines represented the largest proportion (~85%) of the results. Average results could not be compared to previous years, except for SSC, because particle size has not been measured before in POC water samples. Excluding three results from Hamlin (suspended sediment trap) samplers, the mean SSC concentration was 102 mg/L, 78% of the average concentration of the 2012-2014 POC water samples, suggesting similar flow regimes and/or sediment sources.

Total Organic Carbon and Dissolved Organic Carbon

Reported TOC and DOC data from EBMUD were acceptable. TOC samples were field acidified on collection, DOC samples field or lab filtered as soon as practical (usually within a day) and acidified after, so were generally within the recommended 24-hour holding time. MDLs were sufficient with no non-detects reported for any field samples. TOC was detected in only one method blank (0.026 mg/L), just above the MDL (0.024 mg/L), but the average blank concentration (0.013 mg/L) was still below the MDL, so results were not flagged. Matrix spike samples were used to evaluate accuracy, although many were not spiked at high enough concentrations (at least 2x) the parent sample to evaluate. Recoveries in the remaining matrix spikes for DOC were generally good, with an average 9% error, below the 10% target measurement quality objective (MQO). TOC averaged 14% error, above the 10% MQO, and was therefore qualified but not censored. Lab replicate samples were used to evaluate precision, with average RSD of 2% for DOC and TOC, well within the target MQO (10%). RSDs even including field replicates remained below the target MQO of 10% (RSDs were 3% and 9% for DOC and TOC, respectively), so no precision qualifiers were needed. TOC samples averaged 82% of the average for 2012-2014 POC water samples. DOC was not measured in previous POC project water samples so could not be compared.

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[12] Data of particle size was captured for % Clay (<0.0039 mm), % Silt (0.0039 to <0.0625 mm), % V. Fine Sand (0.0625 to <0.125 mm), % Fine Sand (0.125 to <0.25 mm), % Medium Sand (0.25 to <0.5 mm), % Coarse Sand (0.5 to <1.0 mm), % V. Coarse Sand (1.0 to <2.0 mm), and % Granule + Pebble (>2.0 mm). The raw data can be found in appendix B.

PCBs in Water and Sediment

Overall the water (whole water and dissolved) and sediment (separately analyzed particulate) PCB data from AXYS were acceptable. EPA 1668 methods for PCBs recommend analysis within a year, and all samples were analyzed well within that time (maximum 64 days). MDLs were sufficient with no non-detects reported for any of the PCB congeners measured. Some blank contamination was found in method blanks for about 20 of the more abundant congeners, with only two PCB 008 water results censored for blank contamination exceeding 1/3 the concentration in field samples. Many of the same congeners were detected in the field blank, but at concentrations <1% the average found in the field samples. Three target analytes, PCB 105, 118, and 156, and numerous non-RMP 40 congeners were reported in laboratory control samples (LCS) to evaluate accuracy, with good recovery (average error on target compounds always <16%, well within the target MQO of 35%). A laboratory control material (modified NIST 1493) was also reported, with error 22% or better for all congeners. Average RSDs for congeners in the field replicate were all <18%, within the MQO target of 35%, and LCS RSDs were ~2% or getter. PCB concentrations have not been analyzed in remote sediment sampler sediments for previous POC studies, so no direct comparison could be made. PCB concentrations in water samples were similar to previous years (2012-2014) ranging from 25% to 323% of previous averages, depending on the congener. Ratios of congeners generally followed expected abundances in the environment.

Trace Elements in Water

Overall the water trace elements (As, Cd, Pb, Cu, Zn, Hg) data from Brooks Rand Labs (BRL) were acceptable. MDLs were sufficient with no non-detects reported for any field samples. Arsenic was detected in one method blank, and mercury in 4 method blanks, but the results were blank corrected, and blank variation was <MDL. Also, no analytes were detected in the field blank. Recoveries in certified reference materials (CRMs) were good, averaging 2% error for mercury up to 5% for zinc, all well below the target MQOs (35% for arsenic and mercury; 25% for all others). Matrix spike and LCS sample errors all averaged below 10%, well within the accuracy MQOs. Precision was evaluated in lab replicates, except for mercury which was evaluated in certified reference material replicates (no mercury lab replicates were analyzed). RSDs on lab replicates ranged from <1% for zinc up to 4% for arsenic, well within target MQOs (35% for arsenic and mercury; 25% for all the other analytes). Mercury CRM replicate RSD was 1%, also well within the target MQO. Matrix spike and laboratory control sample replicates similarly had average RSDs well within their respective target MQOs. Even including the field heterogeneity from blind field replicates, precision MQOs were easily met. Average concentrations were up to 12 times higher than the average concentrations of 2012-2014 POC water samples, but whole water composite samples were in a similar range as previous years.

Trace Elements in Sediment

A single sediment sample was obtained from fractionating one Hamlin sampler and analyzing for As, Cd, Pb, Cu, Zn, and Hg concentration on sediment. Overall the data were acceptable. MDLs were sufficient with no non-detects for any analytes in field samples. Arsenic was detected in one method blank (0.08 mg/kg dw) just above the MDL (0.06 mg/kg dw), but results were blank corrected and the blank standard deviation was less than the MDL so results were not blank flagged. All other analytes were not detected in method blanks. CRM recoveries showed average errors ranging from 1% for copper to 24%

for mercury, all within their target MQOs (35% for arsenic and mercury; 25% for others). Matrix spike and LCS average recoveries were also within target MQOs when spiked at least 2x the native concentrations. Lab replicate RSDs were good, averaging from <1% for zinc to 5% for arsenic, all well within the target MQOs (35% for arsenic and mercury; 25% for others). Matrix spike RSDs were all 5% or less, also well within target MQOs. Average results ranged from 1 to 14 times higher than the average concentrations for the RMP Status and Trend sediment samples (2009-2014), which might be expected given runoff samples' likely greater proximity to terrestrial anthropogenic metal sources.

Results and Discussion

This section presents the data in the context of two key questions.

a) What are the concentrations and particle ratios observed at each of the sites based on the composite water samples?
b) How do the particle ratios observed at each of the sites based on the composite water samples compare to particle ratios derived from the remote sedimentation based samplers?

The reader is reminded that the data collected and presented here is contributing to a broader based effort to identify potential management areas. The rankings provided here based on either stormwater concentration or particle ratios are part of a weight of evidence approach being used for locating and managing areas in the landscape that may be disproportionally impacting downstream water quality.

Suspended Sediment Concentrations

Concentrations of suspended sediments ranged between 29-265 mg/L (Table 6). Concentrations of this magnitude are typical of urban stormwater runoff in the Bay Area. For example, concentrations of between 1.4-2,700 mg/L with a flow-weighted mean concentration of 160 mg/L have been observed in Zone 4 Line A, a small urban drainage in Hayward (Gilbreath et al. 2012a). McKee et al. (2012) reported mean concentrations of 38.4-484 mg/L for 14 out of 16 urban tributaries in the Bay Area (excluding Marsh Creek and Walnut Creek that exhibited high concentrations associated with rural areas). McKee et al. (2015) reported flow-weighted mean concentrations (FWMC) of 34 mg/L, 28 mg/L, 171 mg/L, and 66 mg/L for North Richmond Pump Station, San Leandro Creek, Sunnyvale East Channel, and Pulgas Creek Pump Station-South, respectively.

Total Organic Carbon and Dissolved Organic Carbon

TOC ranged from 3.1-20 mg/L. At all but three sites, TOC was composed of more than 90% dissolved phase (DOC). The three exceptions were Ridder Park Dr Storm Drain (88%), Line4-E (78%), and Meeker Slough (83%). On average, TOC was 98% transported in dissolved phase, functionally DOC. These concentrations are also similar to those observed previously. For example, McKee et al., (2012) observed a range of 2.1-13 mg/L for 16 tributaries around the Bay Area. FWMCs for TOC of 9.7 mg/L, 6.4 mg/L, 7.6 mg/L, and 9.4 mg/L have been observed for North Richmond Pump Station, San Leandro Creek, Sunnyvale East Channel, and Pulgas Creek Pump Station-South respectively (McKee et al., 2015). There was no correlation between SSC and TOC, probably due to the high proportion in the dissolved phase but also perhaps because the production of organic carbon in an urban landscape is

Table 6. Concentrations of total mercury, sum of PCBs (RMP 40), selected trace metals, and ancillary constituents measured at each of the sites during winter storms of water year 2015. Both the sum of PCBs and total mercury are also expressed at a particle ratio (mass of pollutant divided by mass of suspended sediment). The table was sorted from high to low based on PCB particle ratios.

	SSC	DOC	TOC	PCBs				Total Hg				As	Cd	Cu	Pb	Zn
	(mg/L)	(mg/L)	(mg/L)	(pg/L)	Rank	(ng/g)	Rank	(ng/L)	Rank	(µg/g)	Rank	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)
Outfall to Lower Silver Ck	57.0	8.6	8.3	44,643	2	783	1	24.1	17	0.423	12	2.11	0.267	21.8	5.43	337
Ridder Park Dr SD	114	7.7	8.8	55,503	1	488	2	37.1	12	0.326	16	2.66	0.335	19.6	11.0	116
Line-3A-M at 3A-D	73.6	9.5	7.3	24,791	5	337	3	85.9	1	1.17	2	2.08	0.423	19.9	17.3	118
Seabord Ave SD SC-050GAC580	84.5	9.5	10	19,915	6	236	4	46.7	8	0.553	7	1.29	0.295	27.6	10.2	168
Line4-E	170	2.8	3.6	37,350	3	219	5	59.0	5	0.346	14	2.12	0.246	20.6	13.3	144
Seabord Ave SD SC-050GAC600	72.5	7.9	8.6	13,472	9	186	6	38.3	10	0.528	8	1.11	0.187	21.0	8.76	132
South Linden PS	43.0	7.4	7.4	7,814	15	182	7	29.2	15	0.679	4	0.792	0.145	16.7	3.98	141
Line9-D	68.5	5.0	4.6	10,451	10	153	8	16.6	19	0.242	18	0.470	0.0530	6.24	0.910	67.0
Meeker Slough	60.3	4.4	5.3	8,560	14	142	9	76.4	3	1.27	1	1.75	0.152	13.6	14.0	85.1
Rock Springs Dr SD	41.0	11	11	5,252	17	128	10	38.0	11	0.927	3	0.749	0.0960	20.4	2.14	99.2
Charcot Ave SD	121	20	20	14,927	7	123	11	67.4	4	0.557	6	0.623	0.0825	16.1	2.02	115
Veterans PS	29.2	5.9	6.3	3,520	19	121	12	13.7	20	0.469	9	1.32	0.0930	8.83	3.86	41.7
Gateway Ave SD	45.0	9.9	10	5,244	18	117	13	19.6	18	0.436	10	1.18	0.0530	24.3	1.04	78.8
Runnymede Ditch	265	16	16	28,549	4	108	14	51.5	7	0.194	20	1.84	0.202	52.7	21.3	128
E. Gish Rd SD	145	12	13	14,365	8	99.2	15	84.7	2	0.585	5	1.52	0.552	23.3	19.4	152
Line3A-M-1 at Industrial PS	93.1	4.2	4.5	8,923	12	95.8	16	31.2	14	0.335	15	1.07	0.176	14.8	7.78	105
SD near Cooley Landing	82.0	13	13	6,473	16	78.9	17	35.0	13	0.427	11	1.74	0.100	9.66	1.94	48.4
Oddstad PS	148	8.0	7.5	9,204	11	62.4	18	54.8	6	0.372	13	2.45	0.205	23.8	5.65	117
Line4-B-1	152	2.8	3.1	8,674	13	57.0	19	43.0	9	0.282	17	1.46	0.225	17.7	8.95	108
Lower Penitencia Ck	144	5.9	6.1	2,033	20	14.1	20	29.0	16	0.202	19	2.39	0.113	16.4	4.71	64.6
Minimum	29	2.8	3.1	2,033		14.1		13.7		0.194		0.470	0.053	6.24	0.910	41.7
Maximum	265	20	20	55,503		783		85.9		1.27		2.66	0.552	52.7	21.3	337

likely complex and associated with vegetation debris, pet wastes, soot carbon from combustion of fossil fuels, and the organic components of human derived trash rather than from erosion of low carbon soils (<10%) which would be more typical of rural soils and watersheds of the Bay area.

PCBs Concentrations and Particle Ratios

Total PCB concentrations measured in the composite water samples across the 20 watershed sampling sites ranged 27-fold from 2,033-55,503 pg/L (Table 6). The highest concentration was observed in Ridder Park Dr. Storm Drain in San Jose, a site with 57% of its estimated drainage area in old industrial land use. This concentration was relatively high in relation to previous observations in the Bay Area (e.g., Zone 4 Line A FWMC = 14,500 pg/L: Gilbreath et al., 2012a; Ettie Street Pump Station mean = 59,000 pg/L; Pulgas Creek Pump Station-North: 60,300 pg/L: McKee et al., 2012). When normalized to SSC to generate particle ratios, the three highest ranking sites were the Outfall to Lower Silver Creek in San Jose (783 ng/g) (78% old industrial), Ridder Park Drive Storm Drain in San Jose (488 ng/g) (57% old industrial), and Line-3A-M at 3A-D in Hayward (337 ng/g) (12% old industrial). Particle ratios of this magnitude are relatively elevated but lower than some of the more extreme examples in the Bay Area that have been previously sampled (Santa Fe Channel (1,403 ng/g) (3% old industrial), Pulgas Creek Pump Station-North (1,050 ng/g) (52% old industrial), Pulgas Creek Pump Station-South (906 ng/g) (54% old industrial), Ettie St. Pump Station (745 ng/g) (22% old industrial): McKee et al., 2012)[13]. Line 4-B-1 in Hayward and Lower Penitencia Creek in Milpitas were ranked the lowest using PCB particle ratios. The sample taken in Lower Penitencia Creek corroborates a similar finding that was previously reported (McKee et al., 2012). In general, on average, the particle ratios for the WY 2015 sampling effort were greater than those from WY 2011 (McKee et al., 2012). This likely resulted from a much greater average imperviousness and proportion of old industrial land use in the catchment areas of the WY 2015 sites.

Mercury Concentrations and Particle Ratios

Total Hg concentrations in composite water samples varied 6-fold between the 20 watershed sampling sites from 14-86 ng/L (Table 6). This relatively small variation between sites is quite a change from the previous reconnaissance effort in WY 2011 when mean HgT concentrations were observed to vary by 36-fold between sites (McKee et al., 2012). This lower variation at least in part reflects the lower variation in SSC between sites (36-fold for sites observed in WY 2011 and just 9-fold for WY 2015 sites). The greatest HgT concentrations were observed in Line-3A-M at 3A-D in Hayward (12% old industrial), E. Gish Rd Storm Drain in San Jose (71% old industrial), and Meeker Slough in Richmond (6% old industrial). This helps to illustrate that mercury concentrations don’t appear to follow a strong relationship with old industrial land use. When the data were normalized to SSC, the five most highly ranked sites were Meeker Slough in Richmond (6% old industrial), Line-3A-M at 3A-D in Hayward (12% old industrial), Rock Springs Dr. Storm Drain in San Jose (10% old industrial), South Linden Pump Station in South San Francisco (22% old industrial), and E. Gish Rd Storm Drain in San Jose (71% old industrial). Particle ratios at these sites were 1.3, 1.3, 0.93, 0.68, and 0.59 µg/g, respectively. Particle ratios of this magnitude are

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[13] Note, these particle ratios do not match those in Table 8 of this report because of the slightly different method of computing the central tendency of the data (see the methods section of this report above) and, in the case of Pulgas Creek Pump Station – South, because of the extensive additional sampling that has occurred since McKee et al. (2012) reported the reconnaissance results from the WY 2011 field season.

similar to the upper range of those observed during the WY 2011 sampling campaign (Pulgas Creek Pump Station-South: 0.83 µg/g, San Leandro Creek: 0.80 µg/g, Ettie Street Pump Station: 0.78 µg/g, and Santa Fe Channel: 0.68 µg/g) (McKee et al., 2012).$^{\text{see footnote 12 above}}$

Since there was much lower variation in SSC among the sites, the choice of ranking method for both PCBs and HgT was less important within the WY 2015 dataset than it was when interpreting the 2011 data set (McKee et al., 2012). But as will be discussed further below, when making comparisons between all the data collected in the Bay Area to date, the particle ratio method of normalization remains the most reliable tool for ranking sites in relation to potential management follow-up. In general there was only a weak but positive relationship between observed PCB and HgT concentrations. The six highest ranking sites for PCBs based on particle ratios ranked 12th, 16th, 2nd, 7th, 14th, and 8th, respectively, for HgT. This observation contrasts with the conclusions drawn from the WY 2011 dataset where there appeared to be more of a general correlation (McKee et al., 2012). This might reflect a stronger focus on PCBs during the WY 2015 site selection process and the resulting focus on smaller watersheds with higher imperviousness and old industrial land use, or perhaps it might be an artifact of small datasets. This observation will be explored further below.

Trace metal (As, Cd, Cu, Pb, and Zn) Concentrations

Concentrations of As, Cd, Cu, Pb, and Zn ranged between 0.47-2.7 µg/L, 0.053-0.55 µg/L, 6.2-53 µg/L, 0.91-21 µg/L, and 42-337 µg/L respectively (Table 6). Total As concentrations of this magnitude have been measured in the Bay Area before (Guadalupe River at Hwy 101: mean=1.9 µg/L; Zone 4 Line A: mean=1.6 µg/L) but appear much lower than were observed in North Richmond Pump Station (mean=11 µg/L) (see Appendix A3 in McKee et al., 2015). The Cd concentrations observed at sites during the WY 2015 effort also appear similar to mean concentrations of Cd measured in Guadalupe River at Hwy 101 (0.23 µg/L), North Richmond Pump Station (0.32 µg/L), and Zone 4 Line A (0.25 µg/L) (see Appendix A3 in McKee et al., 2015). Similarly the Cu and Pb concentrations observed during the WY 2015 sampling effort also appear typical of other Bay Area watersheds (Guadalupe River at Hwy 101: Cu 19 µg/L, Pb 14 µg/L; Lower Marsh Creek: Cu 14 µg/L; North Richmond Pump Station: Cu 16 µg/L, Pb 1.8 µg/L; Pulgas Creek Pump Station-South: Cu 44 µg/L; San Leandro Creek: Cu 16 µg/L; Sunnyvale East Channel: Cu 18 µg/L; and Zone 4 Line A: Cu 16 µg/L, Pb 12 µg/L) (see Appendix A3 in McKee et al., 2015). In contrast, Zn measurements at 12 of the sites measured during the WY 2015 sampling effort exceeded the greatest mean concentration observed in the Bay Area previously (Zone 4 Line A: 105 µg/L) (Gilbreath et al., 2012a; see Appendix A3 in McKee et al., 2015). The sites exhibiting the highest Zn concentrations in order from higher to lower were the Outfall to Lower Silver Creek in San Jose (79% imperviousness; 78% old industrial), the Seabord Ave Storm Drain in San Jose (81% imperviousness; 68% old industrial), the E. Gish Rd Storm Drain in San Jose (84% imperviousness; 71% old industrial), the Line4-E in Hayward (81% imperviousness; 27% old industrial). These sites ranked 2nd, 6th, 8th and 3rd using PCB concentrations, 1st, 4th, 5th and 15th using PCB particle ratios, 17th, 8th, 5th and 2nd using HgT concentrations, and 12th, 7th, 14th and 5th using HgT particle ratios. It is not clear from these comparisons what might be the cause of the elevated Zn concentrations in these watersheds.

Comparisons between Composite Water and Remote Sediment Sampling Methods

The four results from remote (primarily suspended sediment trapping) sedimentation samplers that were successfully gathered in WY 2015 were compared to the results from water composite samples collected in parallel at those sites for the same storm events. Results for the remote samplers are all compared on a particle ratio basis, whether analyzed as whole water or separate dissolved and sediment fractions. Although most of the remotely collected samples included reported suspended sediment concentrations, these are not environmentally linked SSCs, but rather the total mass of sediment collected and slurried in an arbitrary volume of water needed to wash the sediment into a collection jar. However, due to the arbitrary volume of water used to slurry the sample, rather than SSC, a more environmentally linkable measure in remote samplers is the total mass of sediment collected. A first order metric of the effectiveness of the remote sampler sediment collection is the volume of composite water that would need to be filtered to generate the same collected sediment mass. These are inexact estimates due to the possibility of different grain sizes captured by the remote sampler and composite stormwater samples, but differences between the Hamlin and Walling are qualitatively consistent with their different cross sectional areas at the sample entry points. Table 7 shows the site water composite SSC, and the total mass of sediment (dry weight (dw) basis) collected in the remote sampler, and the water volume equivalent that the remote sampler sediment represents.

Table 7. Remote sampler collected sediment mass and volume equivalent (relative to composite).

Sampler	Site	Composite SSC (mg/L)	Remote sediment mass (g)	Remote volume equivalent (liters (L))
Hamlin	Charcot Ave Storm Drain	121	93.3	771
Hamlin	Storm Drain near Cooley Landing	82	53.9	657
Hamlin	Outfall to Lower Silver Creek	57	5.9	104
Walling	Outfall to Lower Silver Creek	57	0.48	8.4

For the Hamlin samplers, higher SSC in the separately collected composite stormwater samples consistently translated to larger masses of sediment collected, but in a non-linear fashion. Some of the differences may be related to deployment site geometry, as well as the particle size distribution of sediment carried in the flow. The composite samples, whether collected via peristaltic pump or using a DH-81, could only sample ~5 cm or more above the channel bed, and attempts were made for integrated collection throughout the water column. In contrast, the Hamlin samplers sat directly on the channel bed, or slightly elevated (~3 cm) when attached atop a weighted plate. The Hamlin samples therefore would be more likely than the composited stormwater samples to capture coarser grained near-bed or bedload sediment. Similarly, although the inlet for the Walling tube would be above the channel bed (~5 cm minimum, much like the DH-81), rather than integrating throughout the water column, it would remain fixed at that depth throughout the collection, and thus more of the flow passing through the sampler would be nearer to the bed than the flow captured by the composite water sampling techniques. In addition, the finest grained sediments would likely remain suspended within and wash out from both Hamlin and Walling samplers, leading to samples that could disproportionately over-sample coarser sediments and under-sample finer grained sediments. The remote sampler from one site (Charcot Ave SD) had large amounts of coarse grained material, but whether that was appreciably different from that seen in composite water samples (~15% sand) was not visually determinable. Future collections using remote samplers will measure grainsize in the laboratory to verify these hypotheses.

Figure 4 shows remote sampler particle ratio results for PCBs and mercury plotted versus particle ratios for composited stormwater samples. The data generally show some correlation, i.e., higher remote sampler particle ratios occur for sites with higher particle ratios obtained from composite stormwater samples, although based on the small number of samples, the correlation for PCBs is not quite significant (p~0.09) at alpha=0.05. Both figures show a 1:1 line, which would occur if all the contaminant in composite water samples occurred in the sediment phase for those sites.

Results for PCBs showed that most of the composited stormwater samples had lower particle ratios than those obtained from remote samplers. Prior settling experiments using collected runoff (Yee and McKee, 2010) showed a majority of PCBs in a sediment phase settled out of a 30 cm water column within 20 minutes or less in contrast to the results for HgT which showed generally lower settling rates. If this trend holds true for other systems in the Bay Area, PCB results would therefore generally be less influenced by a bias of including the dissolved phase in calculating particle ratios for composited stormwater samples with lower suspended sediments. Secondly, remote samplers affixed to the bed of discharge channels would preferentially sample heavier and larger particles near-bed load, compared to composited stormwater samples that represent more of the entire water column. Thus the results might be conceptually reasonable. Three of the four remote samplers showed PCB particle ratios higher than those from corresponding composited stormwater samples. The exception (from a Hamlin sampler at Cooley Landing) showed only a modest excursion in the opposite direction, with a particle ratio 13% lower than that in the composited stormwater sample from that site. Overall, the differences between remotely collected and composited stormwater samples was generally small for PCBs, with particle ratios differing by <20% except for one pair differing 2-fold. These preliminary interpretations are only initial hypotheses being used to help refine the sampling and analytical program. Care must be taken when interpreting general patterns with such a small number of samples.

In contrast, the results for mercury showed that some of the composited stormwater water samples had greater particle ratios than those obtained from remote samplers. For mercury, the highest particle ratios occurred in the samples collected from Charcot Avenue Storm Drain in San Jose for both the composite of stormwater samples as well as a sample analyzed as sediment collected with a Hamlin sampler. Interestingly, results for Charcot ran counter to our general expectations and results for other sites, namely that the mercury particle ratios for the remote samplers would be lower than those for composited stormwater samples collected at the same sites. This latter pattern would be expected at most sites because the particle ratio includes any dissolved phase mercury measured. Composited stormwater samples would be expected to show higher particle ratios than from remote samplers, due

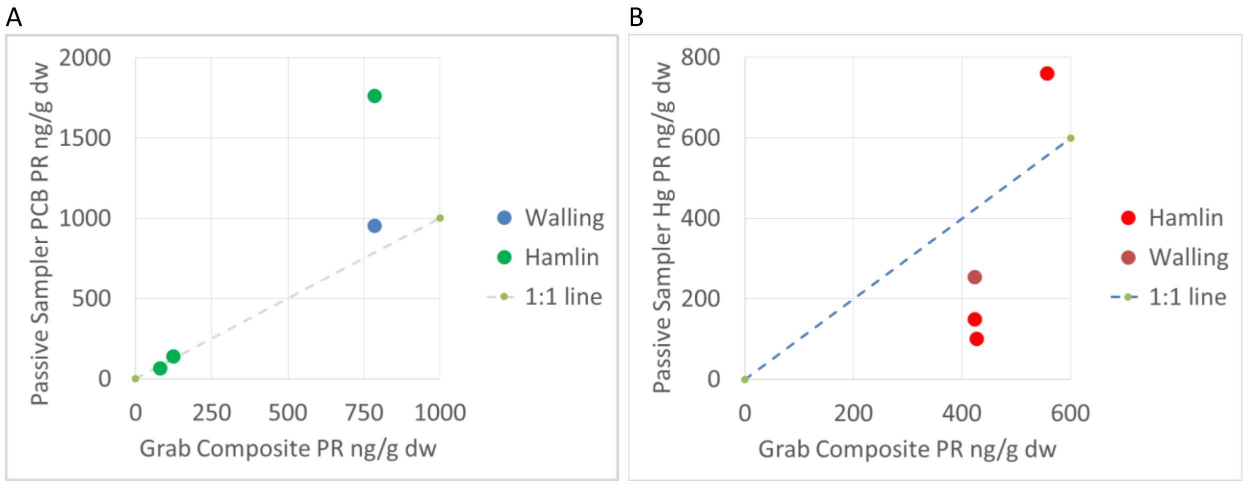

Figure 4. Particle Ratio (PR) comparisons between remote (sediment) versus composite (water) samples for A) PCBs and B) total mercury.

to lower sediment content and thus a greater relative proportion of mercury in the dissolved phase or on fine particles biasing the calculated particle ratio higher. Even if the Charcot Avenue Storm Drain composite sample contained high suspended solids, a similar but smaller high bias (nearer the 1:1 line) would still be accepted. Although conclusions are hard to draw based on data from just three sites, the contrary results for the Charcot Avenue Storm Drain sample could be either associated with differing sources or environmental processes for mercury at that site at least for this one event, or alternatively, greater variability in the subsampling of its composite water sample (e.g., if the composite subsample analyzed for SSC contained more sediment than that for mercury, a lower apparent particle ratio would result). The differences in particle ratio were lowest for Charcot Avenue (25%), which is similar to a plausible degree of subsampling and analytical variation. The particle ratios for other sites differed up to 4-fold (as noted previously, with the composited stormwater samples biased higher). This difference cannot be accounted for through sub-sampling or analytical errors and the representativeness of the composite sample (time paced with a limited number of sub-samples) is ruled out by the Hg results from the remote samplers being lower than 1:1. Also, the Charcot Avenue Storm Drain composite water sample contained 15% sand, versus the other two sites with primarily clays and silts and little sand (<0.1%). This may have also influenced the comparison, as water samples with higher sand content are more difficult to subsample uniformly; if the field sampling crew or the analytical labs biased differently in the fraction of sand captured in mercury versus SSC analyses, random variations in particle ratio (either up or down) could result. The possibility of a coarse sediment associated mercury source (similar to the case for most sites for PCBs) also cannot be totally ruled out but is counter to the hypothesis put forward previously by Yee and McKee (2010) that mercury is more dominantly transported on finer particles than PCBs.

Although only a limited number of samples were able to be collected using the remote samplers during the WY 2015 sampling effort, the results obtained thus far show some promise at least as a qualitative site ranking tool. For both PCBs and mercury, the samples with the highest particle ratios for composited stormwater samples were also the highest in the remote samplers. For PCBs, the site with the lowest particle ratio for a composited stormwater sample also had the lowest for a remote sampler. The remaining mercury results were more difficult to distinguish, with particle ratios in the composited stormwater samples nearly identical (differing ~1%), while results for remotely collected samples differed from the composited stormwater samples by 1.7- to 4-fold (including differences for paired Hamlin (2.8x) and Walling (1.7x) samplers at Lower Silver Creek).

These variable results indicate some challenges in interpretation of data collected by composite versus remote methods. The composited stormwater water samples conflate some dissolved load in the indicator (particle ratio) where concentrations based on whole water samples were normalized to suspended sediment. In addition, the composite water collection method likely either did not sample or at least under-sampled near-bed transport of sediment and pollutants. Although no samples were collected for different events at any site, the differences among sites for the composited and remote particle ratios suggest the potential for large differences among events even within a site, depending on storm event and site characteristics. These differences also present some challenges in applications beyond ranking and prioritization. Partly due to a small data set so far, there was no consistent direction of bias between the manual stormwater composite and remote methods, and even within PCBs (the more consistent analyte), for the Hamlin sampler, the particle ratio ranged from 87% to 230% of the composite sample result. The ability to find differences among sites or within a site with less than a two-fold difference would therefore seem unlikely at this point. Although this is also true for the water composite methodology, there is always going to be more certainty that the sample for water composites better represents transport through the majority of a sample site cross section. The other challenge with samples gathered using the remote samplers is that the data cannot be used to estimate loads without corresponding sediment load estimates. Since sediment loads are not readily available for individual watersheds and, after failures to calibrate the RWSM for suspended sediments, or for PCB and HgT using a sediment model as the basis (McKee et al., 2014), the RWSM is now being calibrated with some success using flow and water-based stormwater concentrations (Wu et al., 2016). Although perhaps cheaper to deploy or logistically possible to deploy in situations where staffing a site is not possible due to logistical constraints, the data derived from the sediment remote samplers are overall less versatile and more challenging to interpret.

With these concerns raised, the sampling program for WY 2016 will continue to build out the dataset for comparing samples derived from composite and remote suspended sediment sampling methods. Based on a full set of a further nine planned sample pairs, better confidence maybe be obtained about how to characterize the range of differences and biases among the methods, as well as to identify some causes of these artifacts, either generally or specific to certain site (land use) or/and event characteristics (storm intensity, duration, sample grain size, organic carbon). The data obtained to date from remote samplers show some promise as relative ranking or prioritization tools; if the data from additional planned sample pairs continue to show similar relationships to stormwater composite samples, future monitoring strategies could be envisioned, first using remote samplers as a low-cost screening and ranking tool, to be followed up by site occupation and active water sampling for the highest priority locations. In the event that after the pilot study is completed and a total of 12 samples have been collected and data still does not show reasonable comparability or explainable differences between the stormwater composite and suspended sediment remote sampler methods, future efforts to further improve these methods might need to consider additional factors such as inter-storm variation, site cross-sectional variation, and relative contributions of near-bed load to total pollutant discharge.

What is the cost/benefit and pros/cons of all sampling methods including remote samplers practiced to date?

The pilot study to assess effectiveness of remote samplers is still in the early stages. Due to a low number of storm events during WY 2015, these devices were only successfully deployed at three locations. A more comprehensive analysis of effectiveness and cost versus benefit of this method will be completed after the sampling effort for the winter of WY 2016 is completed. Generally speaking, it is anticipated that non-manual sampling methods will be more cost-effective. Conceptually, this method will allow multiple sites to be monitored during a single storm event where devices are deployed prior to the storm and retrieved after the storm. There will be initial capital costs to purchase the equipment and labor will be required to deploy and process samples. In addition, there will always be logistical constraints (such as turbulence or tidal influences) that negate the use of the remote settling devices and cause the need for manual monitoring at a particular site, and as mentioned above, the data derived from the remote sampling methodologies will be less easy to interpret and overall will have less versatility for other uses outside ranking sites for relative pollution, for example loadings estimates. But used as a companion to manual monitoring methods, costs will most likely be reduced and data suitable for other purposes will continue to be collected. Factoring in the more limited data uses in the cost-effectiveness analysis will be challenging.

Preliminary site rankings based on all available data

The PCB and HgT load allocations of 2 and 80 kg respectively translate to a mean concentration of 1.33 ng/L (PCBs) and 53 ng/L (HgT) (assuming an annual average flow from small tributaries of 1.5 km^3 (Lent et al., 2012)) and mean annual particle ratio of 1.4 ng/g (PCBs) and 0.058 µg/g (HgT) (assuming an average annual suspended sediment load of 1.4 million metric tons) (McKee et al., 2013). Keeping in mind that the estimates of regional flow and regional sediment loads are subject to change is further interpretations are completed, only one sampling location (Gellert Park bioretention influent stormwater) observed to date has a composite averaged PCB concentration of < 1.33 ng/L (Table 8) and none out of 45 sampling locations have composite averaged PCB particle ratios <1.4 ng/g (Table 8; Figure 5 and 6). The elevated PCB concentrations and particle ratios measured in WY 2015 may be due, in part, to the site selection process which focused on finding potential higher leverage areas for PCBs. The lowest observed PCB particle ratio to date was at Marsh Creek (2.9 ng/g).

Although there are always challenges associated with interpreting data in relation to highly variable climate including antecedent conditions, storm specific rainfall intensity, and watershed specific source-release-transport processes, the objective here is to provide evidence to help differentiate watersheds

Table 8. PCB and HgT concentrations and particle ratios observed in the Bay area based on all data collected in stormwater since WY 2003 that focused on urban sources (45 sites in total for PCBs and HgT). Data for both PCBs and HgT were sorted high to low based on particle ratio to provide preliminary information on potential leverage.

Watershed/ Catchment	County	Water Year sampled	Area (km^2)	Impervious cover (%)	Old Industrial land use (%)	Polychlorinated biphenyls (PCBs)				Total Mercury (HgT)			
						Particle Ratio		Composite /mean water concentration		Particle Ratio	Rank (HgT PR)	Composite /mean water concentration	
						(ng/g)	Rank	(pg/L)	Rank	(µg/g)	Rank	(ng/L)	Rank
Pulgas Creek Pump Station-South	San Mateo	2011-2014	0.584	87%	54%	8222	1	447984	1	0.35	24	19	40
Santa Fe Channel	Contra Costa	2011	3.26	69%	3%	1295	2	197923	2	0.57	14	86	7
Pulgas Creek Pump Station-North	San Mateo	2011	0.552	84%	52%	893	3	60320	4	0.40	22	24	36
Outfall to Lower Silver Creek	Santa Clara	2015	0.171	79%	78%	783	4	44643	7	0.42	21	24	37
Ettie Street Pump Station	Alameda	2011	4.03	75%	22%	759	5	58951	5	0.69	10	55	19
Ridder Park Dr Storm Drain	Santa Clara	2015	0.497	72%	57%	488	6	55503	6	0.33	27	37	30
El Cerrito Bioretention Influent	Contra Costa	2011	0.00408	74%	0%	442	7	37690	8	0.19	37	16	43
Sunnyvale East Channel	Santa Clara	2011	14.5	59%	4%	343	8	96572	3	0.20	35	50	22
Line-3A-M at 3A-D	Alameda	2015	0.881	73%	12%	337	9	24791	12	1.17	4	86	8
North Richmond Pump Station	Contra Costa	2011-2014	1.96	62%	18%	241	10	13226	20	0.81	9	47	23
Seabord Ave Storm Drain SC-050GAC580	Santa Clara	2015	1.35	81%	68%	236	11	19915	15	0.55	16	47	24
Line4-E	Alameda	2015	2.00	81%	27%	219	12	37350	9	0.35	25	59	14
Glen Echo Creek	Alameda	2011	5.45	39%	0%	191	13	31078	10	0.21	34	73	12
Seabord Ave Storm Drain SC-050GAC600	Santa Clara	2015	2.80	62%	18%	186	14	13472	19	0.53	17	38	28
South Linden Pump Station	San Mateo	2015	0.137	83%	22%	182	15	7814	31	0.68	11	29	35
Line 9-D	Alameda	2015	3.59	78%	46%	153	16	10451	23	0.24	30	17	42

Watershed/ Catchment	County	Water Year sampled	Area (km^2)	Impervious cover (%)	Old Industrial land use (%)	Polychlorinated biphenyls (PCBs)				Total Mercury (HgT)			
						Particle Ratio		Composite /mean water concentration		Particle Ratio	Rank (HgT PR)	Composite /mean water concentration	
						(ng/g)	Rank	(pg/L)	Rank	(µg/g)	Rank	(ng/L)	Rank
Meeker Slough	Contra Costa	2015	7.34	64%	6%	142	17	8560	29	1.27	3	76	11
Rock Springs Dr Storm Drain	Santa Clara	2015	0.829	80%	10%	128	18	5252	34	0.93	7	38	29
Charcot Ave Storm Drain	Santa Clara	2015	1.84	79%	24%	123	19	14927	17	0.56	15	67	13
Veterans Pump Station	San Mateo	2015	0.522	67%	7%	121	20	3520	38	0.47	18	14	44
Gateway Ave Storm Drain	San Mateo	2015	0.356	69%	52%	117	21	5244	35	0.44	19	20	39
Guadalupe River at Hwy 101	Santa Clara	2003-2006, 2010, 2012-2014	233	39%	3%	115	22	23736	13	3.60	2	603	1
Runnymede Ditch	San Mateo	2015	2.05	53%	2%	108	23	28549	11	0.19	36	52	21
E. Gish Rd Storm Drain	Santa Clara	2015	0.447	84%	70%	99	24	14365	18	0.59	12	85	9
Line 3A-M-1 at Industrial Pump Station	Alameda	2015	3.44	78%	26%	96	25	8923	25	0.34	26	31	33
Zone 4 Line A	Alameda	2007-2010	4.17	68%	12%	82	26	18442	16	0.17	39	30	34
Storm Drain near Cooley Landing	San Mateo	2015	0.108	73%	39%	79	27	6473	32	0.43	20	35	31
San Leandro Creek	Alameda	2011-2014	8.94	38%	0%	66	28	8614	28	0.86	8	117	5
Oddstad Pump Station	San Mateo	2015	0.280	74%	11%	62	29	9204	24	0.37	23	55	18
Line 4-B-1	Alameda	2015	0.963	85%	28%	57	30	8674	27	0.28	29	43	26
Fremont Osgood Road Bioretention Influent	Alameda	2012, 2013	0.000804	76%	0%	45	31	2906	40	0.12	43	10	45
Gellert Park Daly City Library Bioretention Influent	San Mateo	2009	0.0153	40%	0%	36	32	725	44	1.01	6	22	38
Lower Coyote Creek	Santa Clara	2005	327	22%	1%	30	33	4576	36	0.24	31	34	32

Watershed/ Catchment	County	Water Year sampled	Area (km^2)	Impervious cover (%)	Old Industrial land use (%)	Polychlorinated biphenyls (PCBs)				Total Mercury (HgT)			
						Particle Ratio		Composite /mean water concentration		Particle Ratio	Rank (HgT PR)	Composite /mean water concentration	
						(ng/g)	Rank	(pg/L)	Rank	(µg/g)	Rank	(ng/L)	Rank
Calabazas Creek	Santa Clara	2011	50.1	44%	3%	29	34	11493	22	0.15	42	59	15
San Lorenzo Creek	Alameda	2011	125	13%	0%	25	35	12870	21	0.18	38	41	27
Stevens Creek	Santa Clara	2011	26.0	38%	1%	23	36	8160	30	0.22	33	77	10
Guadalupe River at Foxworthy Road/ Almaden Expressway	Santa Clara	2010	107	22%	0%	19	37	3120	39	4.09	1	529	2
Lower Penitencia Creek	Santa Clara	2011, 2015	11.5	65%	2%	16	38	1588	42	0.16	41	17	41
Borel Creek	San Mateo	2011	3.23	31%	0%	15	39	6129	33	0.16	40	58	17
San Tomas Creek	Santa Clara	2011	108	33%	0%	14	40	2825	41	0.28	28	59	16
Zone 5 Line M	Alameda	2011	8.05	34%	5%	13	41	21120	14	0.57	13	505	3
Belmont Creek	San Mateo	2011	7.22	27%	0%	13	42	3599	37	0.22	32	53	20
Walnut Creek	Contra Costa	2011	232	15%	0%	7	43	8830	26	0.07	45	94	6
Lower Marsh Creek	Contra Costa	2011-2014	83.6	10%	0%	3	44	1445	43	0.11	44	44	25
San Pedro Storm Drain	Santa Clara	2006	1.27	72%	16%	No data				1.12	5	160	4

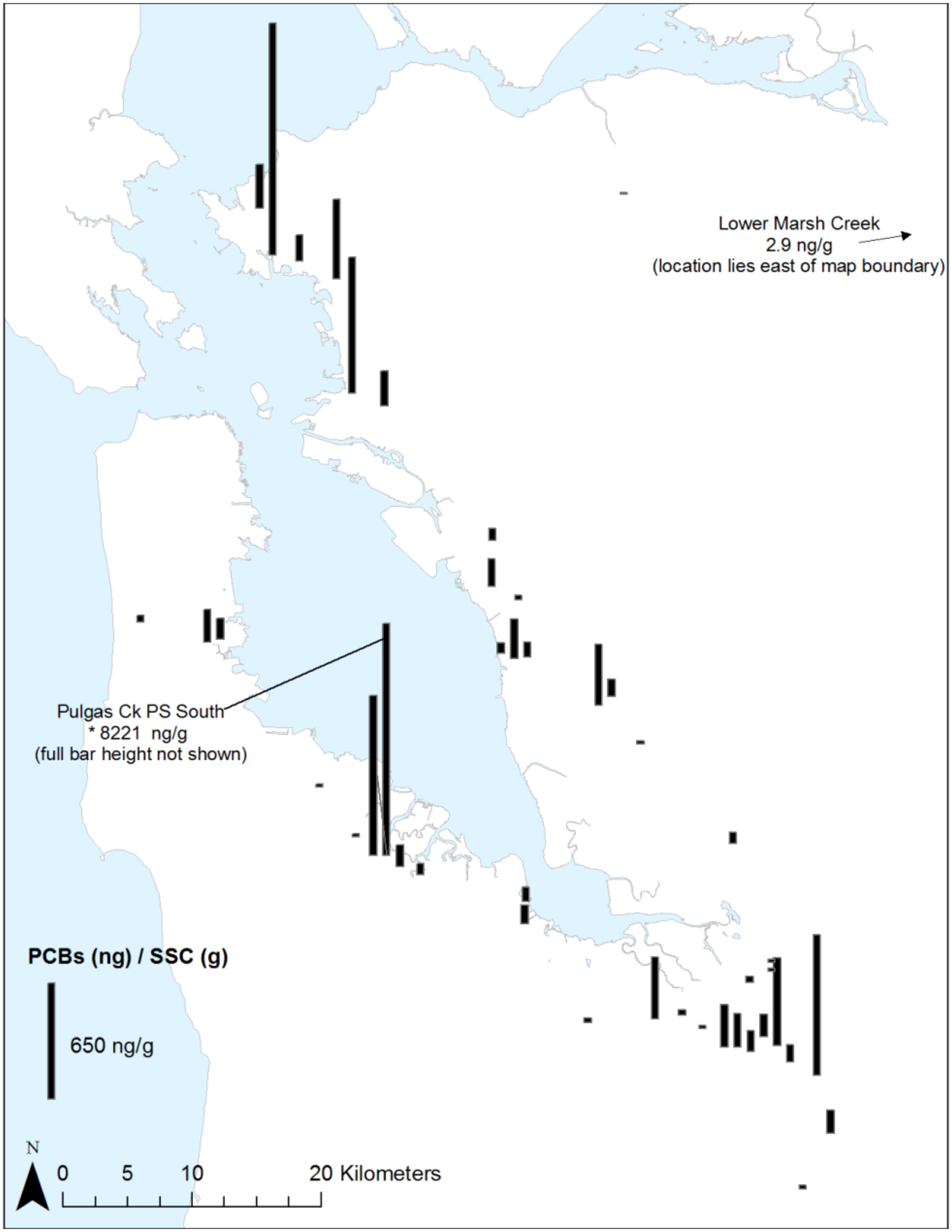

Figure 5. Regional distribution of particle ratios of polychlorinated biphenyl (PCB) in stormwater samples collected to date.

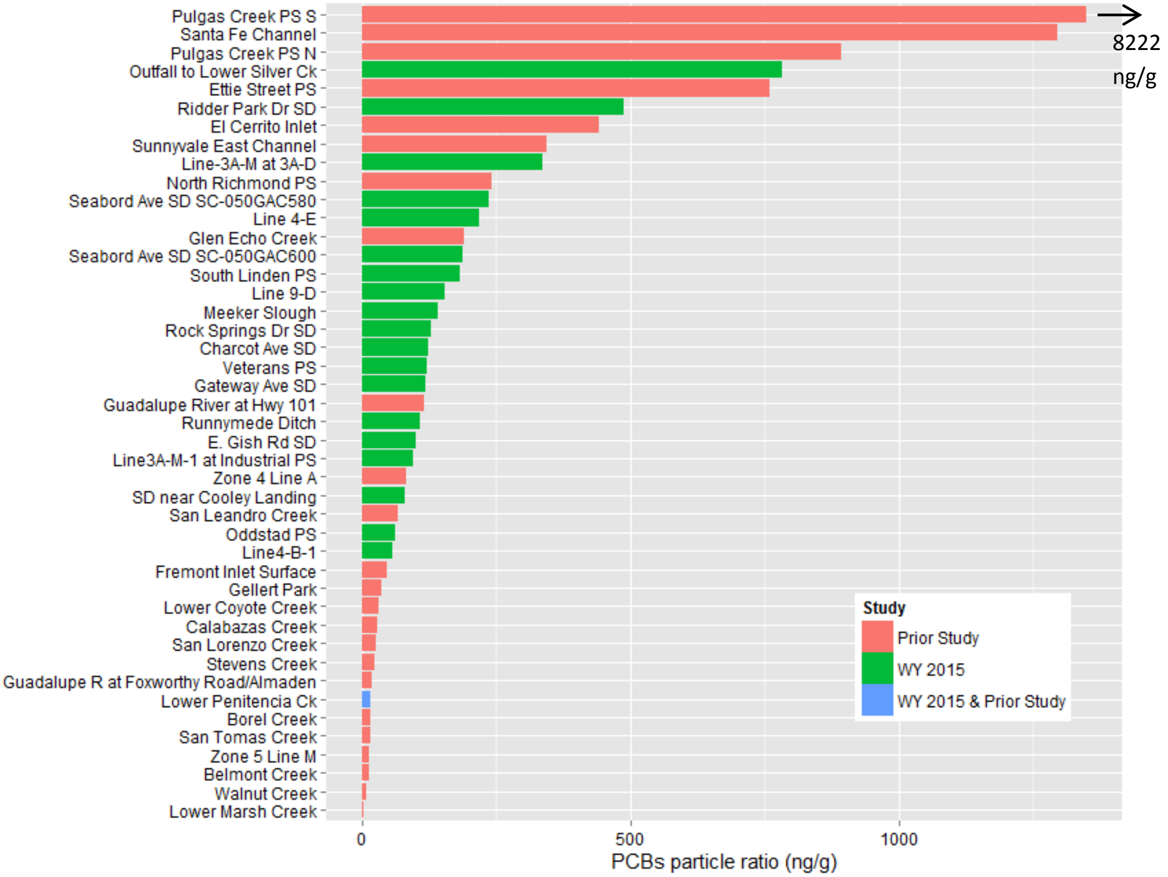

Figure 6. All watershed sampling locations measured to date ranked using PCB particle ratios. Note Pulgas Creek Pump Station-South is beyond the extent of this graph at 8,222 ng/g.

that might be disproportionately elevated in PCB or Hg concentrations or particle ratios from those with lower pollutant signatures. Given the nature of the reconnaissance sampling design, the absolute rank is much less certain. With these caveats in mind, the relative ranking was generated for PCBs and Hg based on both water concentrations and particle ratios for all the available data most of which was collected during WYs 2011 (a slightly wetter than average year) and WY 2015 (a slightly drier than average year).

Based on water composite concentrations for all available data, the ten most polluted sites for PCBs appear to be (in order from higher to lower): Pulgas Creek Pump Station-South, Santa Fe Channel, Sunnyvale East Channel, Pulgas Creek Pump Station-North, Ettie Street Pump Station, Ridder Park Dr Storm Drain, Outfall to Lower Silver Creek, Line4-E , Glen Echo Creek, and Runnymede Ditch (Figure 6). Using PCB particle ratios, the ten most polluted sites appear to be: Pulgas Creek Pump Station-South, Santa Fe Channel, Pulgas Creek Pump Station-North, Outfall to Lower Silver Ck, Ettie Street Pump Station, Ridder Park Dr Storm Drain, Sunnyvale East Channel, Line-3A-M at 3A-D, North Richmond Pump

Station and Seabord Ave Storm Drain. Seven of these locations were similarly selected based on water concentrations but three of the sites with elevated water concentrations dropped to lower rank due to high sediment production and three new sites were ranked in the top ten based on the relative nature of PCB mass in the water and lower suspended sediment mass (Line-3A-M at 3A-D, North Richmond Pump Station, and Seabord Ave Storm Drain). In addition to identification of four new top-10 ranked PCB particle ratio sites, the WY 2015 stormwater sampling effort also identified a large number of sites with moderate particle ratios (Figure 6). This additional large cohort of sites with moderately elevated particle ratios was likely a result of the site selection process that targeted watershed areas with greater imperviousness and older industrial influences.

Comparisons between the ranking methodologies provide a hint as to the main vector for transport at each of the sites (contaminated soil erosion versus emulsion of liquid PCBs). For example, a high ranking for water concentration but low ranking for particle ratio can indicate high rates of erosion of relatively clean sediment, which is more typical of a larger watershed, but in a small watershed, when coupled with low suspended sediment concentrations, it would indicate sediment is not the dominant vector for transport and that PCB emulsions are possibly in transport. Conversely, a lower ranking for concentration coupled with a higher ranking for particle ratio can indicate erosion of highly contaminated particles. If this occurs in a smaller watershed, this would indicate sediment transport is the main vector. Therefore, at smaller site scales, these hints could be instructive for helping to consider main source areas and release processes.

There are a number of watersheds that appear to show relatively low Hg concentrations. In contrast to PCBs, 26 out of 45 sampling locations have composite averaged HgT water concentrations less than 53 ng/L (Table 8), the regionally averaged concentration derived from the TMDL target. These lower ranking sites based on water concentrations ranged in impervious cover between 10-87% with a median of 72%. However, none of the locations sampled to date have composite averaged HgT particle ratios <0.058 µg/g (the regionally averaged particle ratio based on the TMDL target combined with estimated average annual regional total suspended sediment loads[14]); the lowest observation so far has been Walnut Creek at 0.073 µg/g (0.07 mg/kg) (Table 8; Figure 7). But 16 sites measured to-date (Line9-D , Lower Coyote Creek, Belmont Creek, Stevens Creek, Glen Echo Creek, Sunnyvale East Channel, Runnymede Ditch, El Cerrito Inlet, San Lorenzo Creek, Zone 4 Line A Storm Drain, Fremont tree Well Filter Inlet, Borel Creek, Lower Penitencia Creek, Calabazas Creek, Lower Marsh Creek, and Walnut Creek) do have particle ratios <0.25 µg/g that, given error bars of 25% around our measurements, could be considered equivalent to or less than 0.2 µg/g of Hg on suspended solids (the particulate Hg concentration that was specified in the Bay and Guadalupe River TMDLs) (SFRWQCB, 2006; 2008).

There have been several studies in the Bay Area on atmospheric deposition rates for HgT (Tsai and Hoenicke, 2001; Steding and Flegal, 2002). These studies measured very similar wet deposition rates of

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[14] Again the reader is reminded that these regional estimates total suspended sediment loads are subject to change if future interpretations are completed.

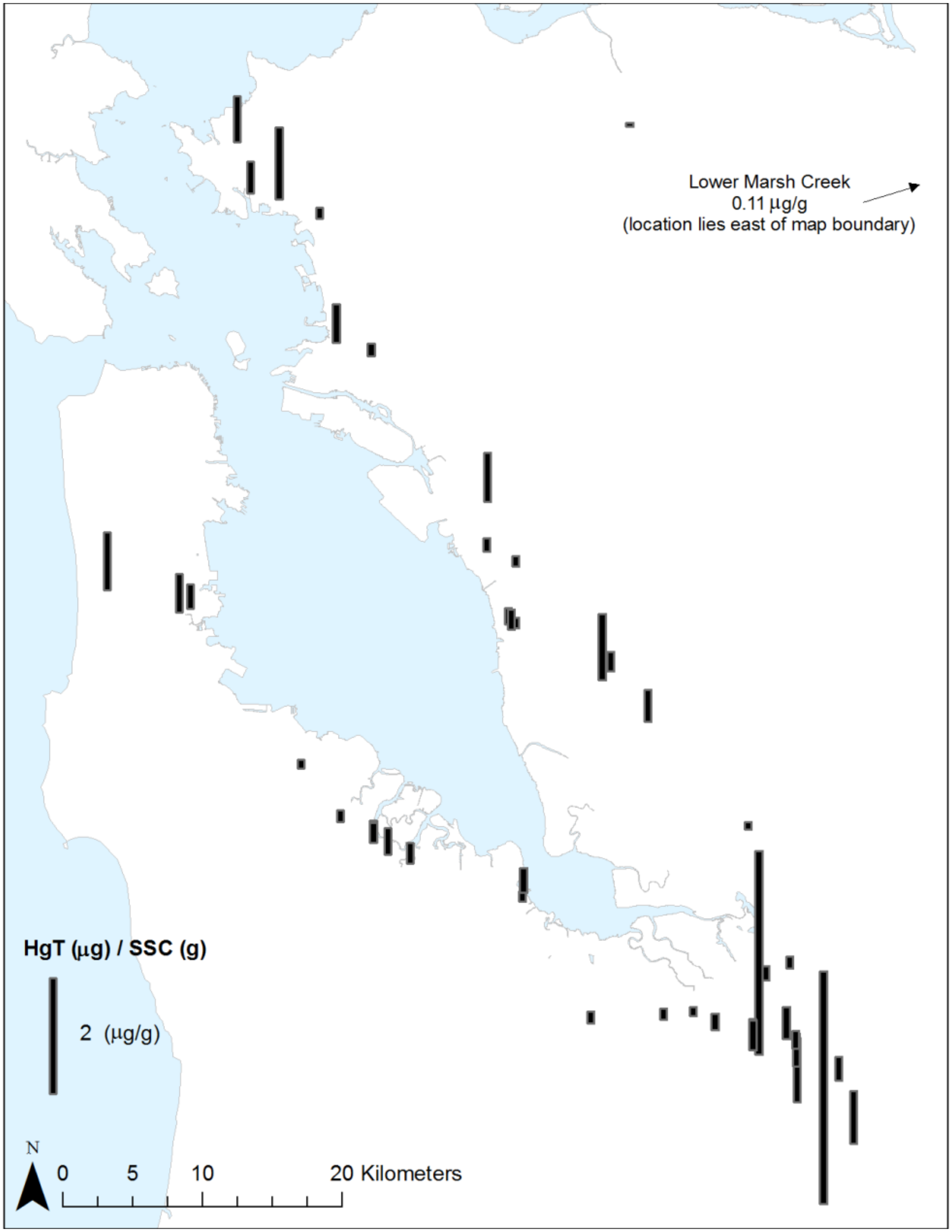

Figure 7. Regional distribution of sites and particle ratios of total mercury (HgT) in stormwater samples collected to date.

4.2 µg/m^2/y (Tsai and Hoenicke, 2001) and 4.4 µg/m^2/y (Steding and Flegal, 2002) with Tsai and Hoenicke reporting a total (wet + dry) deposition rate of 18-21 µg/m^2/y. Tsai and Hoenicke observed volume-weighted average mercury concentrations in precipitation based on 59 samples collected across the Bay Area of 8.0 ng/L. They reported that wet deposition comprised 18% of total annual deposition thus scaled to volume of runoff, an equivalent stormwater concentration of 44 ng/L can be derived. If a runoff coefficient (the proportion of rainfall that manifests as runoff) equivalent to the impervious cover of a watershed is assumed, it can be hypothesized that all of the runoff from the sites exhibiting composite averaged concentration of <53 ng/L could be accounted for by atmospheric deposition alone; indeed a high proportion of the runoff from any watershed exhibiting concentrations in stormwater of, for example, < 100 ng/L could also be atmospherically derived. This is not to say that there are no other sources in these watersheds, but rather that loads from any other sources are diluted out by cleaner runoff sustained by relatively low but relatively constant atmospheric deposition rates. Thus, a number of watersheds have been sampled for Hg that show relatively low concentrations and will likely continue to do so in alignment with atmospheric deposition. Given the data set now amassed, it is likely that many future sampling locations would show similar outcomes. However, this may not be the case for methylmercury, where in situ production in anoxic saturated zones may provide additional input not directly correlating to atmospheric loads.

On the other end of the spectrum, there are some watersheds that display elevated HgT concentrations that, if the sources could be found and treated, would help to reduce HgT loads entering the Bay (Table 8). Based on composite averaged HgT water concentrations, the ten most polluted sites (ranked in order from high to lower) would include the Guadalupe River mainstem, Zone 5 Line M, San Pedro Storm Drain, San Leandro Creek, Walnut Creek, Santa Fe Channel (also ranked high for PCB concentrations in composite averaged stormwater), Line-3A-M at 3A-D, E. Gish Rd SD, Stevens Creek, and Meeker Slough.

As discussed above and introduced by McKee et al. (2012), given the atmospheric sources of Hg and highly variable sediment erosion in Bay Area watersheds, it is possible to get very elevated HgT stormwater concentrations but very low particle ratios. The best example of this is Walnut Creek that was ranked 5th highest in terms of stormwater composite averaged concentrations but lowest (45th out of 45 watershed locations) in terms of particle ratios. Thus, much more care is needed when ranking the sites for HgT than for PCBs (for which the atmospheric pathway plays less of a role in dispersion). This is consistent with the relative results from the most recent calibration of the RWSM based on the hydrology where a better calibration for PCBs than for Hg has been achieved (Wu et al., 2016); a sediment model basis may be more appropriate for Hg.

Based on particle ratios (the preferred method), the 10 most polluted sites appear to be (in addition to the two Guadalupe River mainstem sites) Meeker Slough, Line-3A-M at 3A-D, San Pedro Storm Drain, Gellert Park bioretention inlet, Rock Springs Dr Storm Drain, San Leandro Creek, North Richmond Pump Station, Ettie Street Pump Station, South Linden Pump Station, and E. Gish Rd Storm Drain (Table 8; Figure 8). Management in these watersheds might be most cost effective for HgT. The Daly City library bioretention demonstration project appears to have been placed (quite by accident) in a cost effective manner and appears to be functioning reasonably well for HgT removal, however, there were some

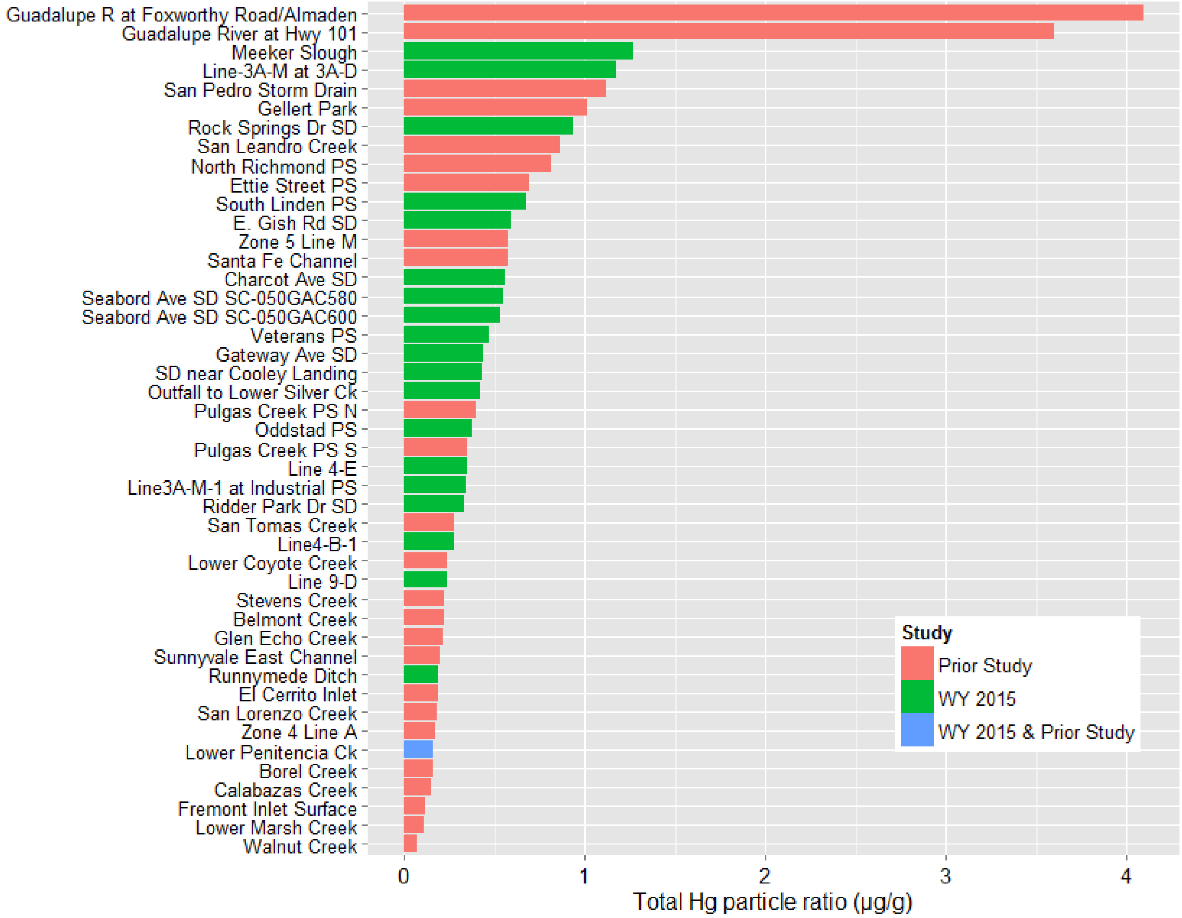

Figure 8. All watershed sampling locations measured to data ranked using total mercury (HgT) particle ratios.

concerns about methylmercury production (David et al., 2015). Three of these locations were also identified as elevated for PCB particle ratios (Ettie Street Pump Station, Line-3A-M at 3A-D, North Richmond Pump Station) providing the opportunity for multiple benefits. Thus the reconnaissance sampling methods coupled with the use of particle ratio in the interpretative process has indicated a number of watersheds with elevated HgT.

Relationships between PCBs and Hg and other trace substances and land cover attributes

The data can be used to explore relationships between pollutants and with landscape attributes. Beginning in WY 2003, a number of sites have been evaluated for not only PCB and HgT concentrations in stormwater but also for a range of trace elements. These sites have included the fixed station loads monitoring sites on Guadalupe River at Hwy 101 (McKee et al., 2006), Zone 4 Line A (Gilbreath et al., 2012a), North Richmond Pump Station (Hunt et al., 2012) and for Cu only (Lower Marsh Creek, San

Leandro Creek, Pulgas Creek Pump Station-South, and Sunnyvale East Channel) (Gilbreath et al., 2015a). Copper data have also been collected at the inlets to several pilot performance studies for bioretention (El Cerrito: Gilbreath et al., 2012b); Fremont: Gilbreath et al., 2015b) and Cu, Cd, Pb, and Zn data were collected at the Daly City Library Gellert Park demonstration bioretention site (David et al., 2015). In addition, during WY 2015, trace element data were collected at an additional 20 locations (See Table 6 earlier in this report). All these data (n=30 sites for Cu; n=24 for Cd, Pb, and Zn; n=23 for As) were pooled to complete an analysis of relationships between observed particle ratios of PCBs and HgT, trace elements, and impervious land cover and old industrial land use using a Spearman Rank correlation analysis (Table 9). In the case of Guadalupe River, the HgT data were removed from the analysis due the historic mining influence in that watershed[15]. Particle ratios were chosen for this analysis for the same reasons as described above and in McKee et al. (2012); the influence of variable sediment production across Bay Area watersheds is best normalized out so that variations in the influence of pollutant sources and mobilization can be more easily observed between sites.

A variety of relationships have been found but the relationships to trace metals are weak for both PCBs and Hg. Based on the available appropriate data and the particle ratio method, PCBs appear to positively correlate with impervious cover, old industrial land use and HgT. PCBs appear to inversely correlate with watershed area. These observations are consistent with previous analysis (McKee et al., 2012) and make conceptual sense given larger watersheds tend to have mixed land use and thus a lower proportional amount of PCB source areas. The positive but relatively weak correlation between PCBs and HgT also makes sense given the general relationships with impervious cover and old industrial land use but the larger role of atmospheric recirculation in the mercury cycle. PCBs appear to inversely correlate with all the trace metals analyzed (As, Cu, Cd, Pb, and Zn) since these also inversely correlate with impervious cover and old industrial land use. Total mercury does not appear to correlate with any of the other trace metals and shows similar but weaker relationships to impervious cover, old industrial land use, and watershed area than does PCBs. In contrast, the trace metals all appear to correlate with each other more generally. The strongest correlations appear to be between Cu and Zn perhaps because they are both vehicular related (see discussion in McKee et al., 2012) and between Pb and Cd perhaps because of the strong atmospheric pathway of these two metals (Davis et al., 2001). Overall, based on this analysis using the available pooled data, there is no support for the use of these trace metals as a tracer for either PCB or HgT pollution sources.

Sampling progress in relation to data uses

Sampling completed in older industrial areas can be used as an indicator of progress towards identifying areas for potential management. It has been argued previously (McKee et al., 2012; McKee et al., 2015) that old industrial land use and the specific source areas found within or in association with older industrial areas are likely to exhibit higher concentrations and loads with respect to PCBs and HgT. A total of 45 sites have been sampled for PCBs and HgT during various field sampling efforts since WY

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[15] Historic mining in the Guadalupe River watershed is known to cause a unique positive relationship between Hg, Cr, and Ni and it is known that there are unique inverse correlations between Hg and other typical urban metals such as Cu and Pb (McKee et al., 2005).

Table 9. Spearman Rank correlation matrix based on stormwater samples collected in the Bay Area since WY 2003 (see text for data source and exclusions).

	PCBs (ng/g)	*HgT (µg/g)*	*Arsenic (µg/mg)*	*Cadmium (µg/mg)*	*Copper (µg/mg)*	*Lead (µg/mg)*	*Zinc (µg/mg)*	*Area (km^2)*	*% Impervious cover*	*% Old Industrial land use*	*% Clay (<0.004 mm)*	*% Silt (0.004 to <0.0625 mm)*	*% Sands (0.0625 to <2.0 mm)*	*TOC (mg/mg)*
PCBs (ng/g)	1.00													
HgT (µg/g)	0.44	1.00												
Arsenic (µg/mg)	-0.61	-0.13	1.00											
Cadmium (µg/mg)	-0.38	0.12	0.75	1.00										
Copper (µg/mg)	-0.15	0.05	0.71	0.67	1.00									
Lead (µg/mg)	-0.37	0.04	0.73	0.89	0.60	1.00								
Zinc (µg/mg)	-0.37	0.19	0.47	0.65	0.88	0.55	1.00							
Area (km^2)	-0.47	-0.38	0.06	-0.06	-0.33	0.17	-0.26	1.00						
% Impervious cover	0.64	0.36	-0.28	-0.13	0.10	-0.27	0.18	-0.71	1.00					
% Old Industrial land use	0.58	0.40	-0.34	-0.28	-0.29	-0.41	-0.14	-0.43	0.75	1.00				
% Clay (<0.004 mm)	0.47	0.16	-0.28	-0.05	-0.40	-0.16	-0.40	-0.31	0.11	0.41	1.00			
% Silt (0.004 to <0.0625 mm)	-0.03	0.22	-0.04	-0.12	0.39	0.03	0.36	0.29	-0.12	-0.19	-0.02	1.00		
% Sands (0.0625 to <2.0 mm)	0.06	0.08	0.17	-0.07	-0.10	0.06	0.06	-0.21	0.36	0.35	-0.80	-0.34	1.00	
TOC (mg/mg)	0.28	0.32	0.59	0.44	0.86	0.30	0.66	-0.48	0.45	0.26	-0.50	0.31	0.28	1.00

2003. The sampling locations have been selected to help answer a variety of questions, in some cases to make measurements of loads to the Bay from selected watersheds and in other cases to help characterize concentrations of PCBs, HgT and other trace pollutants in stormwater. Although land redevelopment is occurring at a rapid pace, the currently available old industrial land use layer that was based on the overlay of ABAG, 2005 industrial land use and an older urban land use coverage from 1968 (e.g. Wu et al., 2016) was used to evaluate the proportion of old industrial land use within each sampled watershed in relation to the regional and county based totals. In this way, progress towards characterizing concentrations in these areas was evaluated. This analysis (which excluded nested sampling sites) showed that about 19.2% of the so defined old industrial land use in the region has been sampled to date. The best effort so far has occurred in Santa Clara County (where 61% of this land use has been sampled), followed by Alameda County (17%), San Mateo County (9%), and Contra Costa County (3%). The disproportional coverage in Santa Clara County is due to a number of larger watersheds being sampled (Lower Penitencia Creek, Lower Coyote Creek, Guadalupe River at Hwy 101, Sunnyvale East Channel, Stevens Creek, and San Tomas Creek) and also because there were older industrial land use areas further upstream in the Coyote Creek and Guadalupe River watersheds. Of the remaining older industrial land use yet to be sampled, 48% of it lies within 1 km of the Bay and 65% of it is within 2 km of the Bay. These areas are more likely to be tidal, likely to include heavy industrial areas that were historically serviced by rail and ship based transport, and military areas, and are often very difficult to sample due to a lack of public right of ways. A different sampling strategy may be needed to effectively determine what pollution might be associated with these areas to further progress towards identifying areas for potential management.

Data collected will also be used to calibrate the Regional Watershed Spreadsheet Model (RWSM) (Wu et al., 2016). The present version of the model was calibrated using data from 22 watershed areas. Parameterization of the model is currently limited because many of the key source areas are not present in sufficient amounts within the calibration watersheds to strongly influence the calibration procedures. For example, various forms of waste recycling (general waste, metals, auto, drum) only produce an estimated <1% of the runoff within the calibration watersheds and were present in <10 of the 22 watersheds (Wu et al., 2016). Based on the extended dataset (now 45 watersheds), the number of watersheds where these types of source areas are present has increased (Table 10) compared to data available mainly reported by McKee et al., (2010). For example, waste-recycle was present in just nine watersheds, auto-recycle was present in just 10 watersheds, and metals recycle was present in just 5 watersheds within the 22 sample sites previously available for model calibration; these numbers have now increased to 16, 19, and 11 respectively (Table 10). In addition, many of the new watersheds characterized in WY 2015 (described for the first time in this current report) are much smaller in size (0.108-7.34 km^2) compared to previous characterization or loading based sampling efforts (0.552-327 km^2) and as such are less heterogeneous in relation to land uses and source areas. This may also help the model to calibrate better by placing stronger constraints on the calibration process for key source areas. Thus, apart from the use of the data to support watershed characterization in relation to pollution sources and higher potential leverage (along with other evidence being generated by the stormwater programs), another use of the data is for improving the calibration of the RWSM and by extension improved estimates of regional scale watershed loads.

Table 10. Land uses and source areas sampled in relation to potential use for calibration of the Regional Watershed Spreadsheet Model (RWSM) (Wu et al., 2016).

Land use or source area	**% volume contribution**	**Number of watersheds**	**Conceptual largest influence (Combined rank)**	**Potential use in the RWSM**
LU Open	36%	33	1189	Likely high calibration influence. Can likely be used as either a single or group parameter
LU Old Transportation	20%	38	750	
LU Old Residential	15%	35	540	
LU Old Commercial	9.6%	37	354	
LU Old Industrial	2.8%	33	93	
LU New Industrial	2.5%	35	87	
LU New Transportation	4.9%	16	79	
SA TranspRail	1.8%	29	51	
LU New Residential	4.3%	11	48	
LU New Commercial	2.4%	15	37	
SA RecycWaste	1.2%	16	19	Likely moderate calibration influence. Can best be used in a grouped parameter
LU Agriculture	1.7%	8	13	
SA ManufMetals	0.2%	21	5.2	
SA RecycAuto	0.2%	19	4.3	
SA ElectricTransf	0.1%	16	0.94	Likely low calibration influence but could be grouped with other source areas as part of a global parameter that would not influence the calibration but could influence the regional loads estimates
SA RecycMetals	0.1%	11	0.81	
SA TranspAir	0.3%	2	0.59	
SA ElectricPower	0.1%	3	0.25	
SA RecycDrums	0.0%	3	0.024	
SA Military	0.0%	1	0.0016	

Summary and Recommendations for Improved Sampling Design

Despite climatically challenging conditions resulting in a limited number of storms of appropriate magnitude for sample capture, a total of 20 additional sites were sampled during WY 2015. At these sites, 20 composite water samples collected during one storm event were analyzed for PCBs, HgT, SSC, selected trace metals, organic carbon, and grain size. Sampling efficiency was increased by sampling two sites during a single storm that had similar runoff characteristics and were near enough to each other to allow safe and rapid transport and reoccupation repeatedly during a rain event. At three of these locations, simultaneous samples were also collected using a Hamlin remote suspended sediment sampler and at one site a third method (the Walling tube remote suspended sediment sampler) was also trialed successfully. Based on this dataset, a number of sites with elevated PCB and Hg concentrations and particle ratios were successfully identified, in part based on an improved effort of site selection focusing on older industrial and highly impervious landscapes. With careful selection of sample timing relative to tides, some success even occurred at tidal sties, but overall, tidal sites remain the most challenging to sample. Although optimism remains about future applications, the remote suspended sediment samplers that were trialed showed mixed results and need further testing.

Based on the WY 2015 results, the following recommendations were made:

- Continue to select sites based on the four main selection rationales (Section 2.2). The majority of the samples should be devoted to identifying areas of potential high leverage (indicated by high unit areas loads or particle ratios/ concentrations relative to other sites) with a smaller number of sites allocated to sampling potentially cleaner and variably-sized watersheds to help broaden the dataset for regional model calibration and to inform consideration of cleanup potential. The method of selection of sites of potentially higher leverage focusing on older industrial and highly impervious landscapes appears successful and should continue.

- Continue to use the composite water sampling design as developed and applied during WY 2015 with no further modifications. In the event of a higher rainfall wet season, greater success may even occur at sites influenced by tidal processes since, with more storms to choose from, there will be a greater likelihood that more storm events will fall within the needed tidal windows.
- Continue to trial both the Hamlin and Walling remote suspended sediment samplers to amass a full dataset of 12 side-by-side sample pairs for comparison to the composite water column sampling design with the objective of evaluating usefulness and comparability of the data obtained in relation to the management questions.

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Appendices

Appendix A – Detailed QA information

Table A1: Summary of QA data at all sites.

Analyte	Unit	Average Lab Blank	Detection Limit (MDL) (range; mean)	Average Reporting Limit (RL)	RSD of Lab Duplicates (% range; % mean)	RSD of Field Duplicates (% range; % mean)	Percent Recovery of CRM (% range; % mean)	Percent Recovery of Matrix Spike (% range; % mean)
SSC	mg/L	-	0.5-0.5; 0.5	1	NA	5.16-5.16; 5.16	NA	NA
DOC	µg/L	0	52-520; 256	NA	0.00-6.02; 1.91	0.00-10.13; 3.97	NA	100.00-112.50; 107.18
TOC	mg/L	0.00289	0.096-0.48; 0.129	NA	0.00-3.93; 2.16	0.00-35.79; 11.89	NA	100.00-141.25; 107.49
Total Arsenic	µg/L	0.00358	0.013-0.013; 0.013	0.032	2.74-2.74; 2.74	1.81-4.04; 2.89	96.32-101.76; 98.32	91.56-102.34; 93.65
Total Cadmium	µg/L	0	0.007-0.037; 0.0118	0.0344	1.89-4.29; 3.09	0.93-8.00; 3.74	99.90-105.59; 102.66	80.27-101.05; 95.83
Total Cu	µg/L	0	0.042-0.211; 0.116	0.349	0.87-1.04; 0.95	0.75-1.36; 1.06	100.28-104.55; 103.00	91.83-103.60; 95.98
Total Hg	µg/L	0.000129	0.00253-0.00263; 0.00258	0.0103	NA	16.66-16.66; 16.66	100.58-103.34; 101.77	93.75-103.82; 98.54
Total Lead	µg/L	0	0.006-0.032; 0.0174	0.0726	0.00-1.75; 0.82	0.00-7.85; 2.93	99.00-104.12; 101.92	97.21-101.10; 99.33
Total Zinc	µg/L	0	0.06-0.32; 0.174	0.58	0.31-0.59; 0.48	0.05-2.64; 0.97	101.11-108.34; 105.43	86.35-101.14; 92.89

Analyte	Unit	Average Lab Blank	Detection Limit (MDL) (range; mean)	Average Reporting Limit (RL)	RSD of Lab Duplicates (% range; % mean)	RSD of Field Duplicates (% range; % mean)	Percent Recovery of CRM (% range; % mean)	Percent Recovery of Matrix Spike (% range; % mean)
Dissolved PCB 008	ng/L	-	0.000814-0.000814; 0.000814	NA	NA	NA	NA	NA
Dissolved PCB 018	ng/L	-	0.000528-0.000528; 0.000528	NA	NA	NA	NA	NA
Dissolved PCB 028	ng/L	-	0.00599-0.00599; 0.00599	NA	NA	NA	NA	NA
Dissolved PCB 031	ng/L	-	0.00535-0.00535; 0.00535	NA	NA	NA	NA	NA
Dissolved PCB 033	ng/L	-	0.00546-0.00546; 0.00546	NA	NA	NA	NA	NA
Dissolved PCB 044	ng/L	-	0.000907-0.000907; 0.000907	NA	NA	NA	NA	NA
Dissolved PCB 049	ng/L	-	0.000823-0.000823; 0.000823	NA	NA	NA	NA	NA
Dissolved PCB 052	ng/L	-	0.00102-0.00102; 0.00102	NA	NA	NA	NA	NA
Dissolved PCB 056	ng/L	-	0.0084-0.0084; 0.0084	NA	NA	NA	NA	NA
Dissolved PCB 060	ng/L	-	0.0083-0.0083; 0.0083	NA	NA	NA	NA	NA
Dissolved PCB 066	ng/L	-	0.00759-0.00759; 0.00759	NA	NA	NA	NA	NA
Dissolved PCB 070	ng/L	-	0.00776-0.00776; 0.00776	NA	NA	NA	NA	NA
Dissolved PCB 087	ng/L	-	0.00236-0.00236; 0.00236	NA	NA	NA	NA	NA

Analyte	Unit	Average Lab Blank	Detection Limit (MDL) (range; mean)	Average Reporting Limit (RL)	RSD of Lab Duplicates (% range; % mean)	RSD of Field Duplicates (% range; % mean)	Percent Recovery of CRM (% range; % mean)	Percent Recovery of Matrix Spike (% range; % mean)
Dissolved PCB 095	ng/L	-	0.00267-0.00267; 0.00267	NA	NA	NA	NA	NA
Dissolved PCB 099	ng/L	-	0.00291-0.00291; 0.00291	NA	NA	NA	NA	NA
Dissolved PCB 101	ng/L	-	0.00238-0.00238; 0.00238	NA	NA	NA	NA	NA
Dissolved PCB 105	ng/L	-	0.0311-0.0311; 0.0311	NA	NA	NA	NA	NA
Dissolved PCB 110	ng/L	-	0.00196-0.00196; 0.00196	NA	NA	NA	NA	NA
Dissolved PCB 118	ng/L	-	0.0238-0.0238; 0.0238	NA	NA	NA	NA	NA
Dissolved PCB 128	ng/L	-	0.0152-0.0152; 0.0152	NA	NA	NA	NA	NA
Dissolved PCB 132	ng/L	-	0.0198-0.0198; 0.0198	NA	NA	NA	NA	NA
Dissolved PCB 138	ng/L	-	0.0152-0.0152; 0.0152	NA	NA	NA	NA	NA
Dissolved PCB 141	ng/L	-	0.0171-0.0171; 0.0171	NA	NA	NA	NA	NA
Dissolved PCB 149	ng/L	-	0.0172-0.0172; 0.0172	NA	NA	NA	NA	NA
Dissolved PCB 151	ng/L	-	0.000869-0.000869; 0.000869	NA	NA	NA	NA	NA
Dissolved PCB 153	ng/L	-	0.014-0.014; 0.014	NA	NA	NA	NA	NA

Analyte	Unit	Average Lab Blank	Detection Limit (MDL) (range; mean)	Average Reporting Limit (RL)	RSD of Lab Duplicates (% range; % mean)	RSD of Field Duplicates (% range; % mean)	Percent Recovery of CRM (% range; % mean)	Percent Recovery of Matrix Spike (% range; % mean)
Dissolved PCB 156	ng/L	-	0.0138-0.0138; 0.0138	NA	NA	NA	NA	NA
Dissolved PCB 158	ng/L	-	0.0118-0.0118; 0.0118	NA	NA	NA	NA	NA
Dissolved PCB 170	ng/L	-	0.00157-0.00157; 0.00157	NA	NA	NA	NA	NA
Dissolved PCB 174	ng/L	-	0.0013-0.0013; 0.0013	NA	NA	NA	NA	NA
Dissolved PCB 177	ng/L	-	0.00143-0.00143; 0.00143	NA	NA	NA	NA	NA
Dissolved PCB 180	ng/L	-	0.00117-0.00117; 0.00117	NA	NA	NA	NA	NA
Dissolved PCB 183	ng/L	-	0.00138-0.00138; 0.00138	NA	NA	NA	NA	NA
Dissolved PCB 187	ng/L	-	0.00131-0.00131; 0.00131	NA	NA	NA	NA	NA
Dissolved PCB 194	ng/L	-	0.00327-0.00327; 0.00327	NA	NA	NA	NA	NA
Dissolved PCB 195	ng/L	-	0.0036-0.0036; 0.0036	NA	NA	NA	NA	NA
Dissolved PCB 201	ng/L	-	0.000686-0.000686; 0.000686	NA	NA	NA	NA	NA
Dissolved PCB 203	ng/L	-	0.000843-0.000843; 0.000843	NA	NA	NA	NA	NA
Total PCB 008	ng/L	0.00248	0.000282-0.00212; 0.000883	NA	NA	NA	NA	NA

Analyte	Unit	Average Lab Blank	Detection Limit (MDL) (range; mean)	Average Reporting Limit (RL)	RSD of Lab Duplicates (% range; % mean)	RSD of Field Duplicates (% range; % mean)	Percent Recovery of CRM (% range; % mean)	Percent Recovery of Matrix Spike (% range; % mean)
Total PCB 018	ng/L	0.0022	0.000282-0.000782; 0.000447	NA	NA	NA	NA	NA
Total PCB 028	ng/L	0.00389	0.000319-0.0323; 0.00212	NA	NA	NA	NA	NA
Total PCB 031	ng/L	0.00206	0.000319-0.03; 0.00198	NA	NA	NA	NA	NA
Total PCB 033	ng/L	0.000879	0.000319-0.0302; 0.00201	NA	NA	NA	NA	NA
Total PCB 044	ng/L	0.00221	0.000282-0.00215; 0.00055	NA	NA	NA	NA	NA
Total PCB 049	ng/L	0.00149	0.000282-0.00196; 0.000524	NA	NA	NA	NA	NA
Total PCB 052	ng/L	0.00831	0.000282-0.00225; 0.000558	NA	NA	NA	NA	NA
Total PCB 056	ng/L	0	0.000319-0.0846; 0.00644	NA	NA	NA	NA	NA
Total PCB 060	ng/L	0	0.000319-0.085; 0.00646	NA	NA	NA	NA	NA
Total PCB 066	ng/L	0.000589	0.000319-0.0824; 0.00623	NA	NA	NA	NA	NA
Total PCB 070	ng/L	0.00319	0.000319-0.157; 0.00916	NA	NA	NA	NA	NA
Total PCB 087	ng/L	0.00097	0.000319-0.0511; 0.00466	NA	NA	NA	NA	NA
Total PCB 095	ng/L	0.00353	0.000344-0.0391; 0.00447	NA	NA	NA	NA	NA

Analyte	Unit	Average Lab Blank	Detection Limit (MDL) (range; mean)	Average Reporting Limit (RL)	RSD of Lab Duplicates (% range; % mean)	RSD of Field Duplicates (% range; % mean)	Percent Recovery of CRM (% range; % mean)	Percent Recovery of Matrix Spike (% range; % mean)
Total PCB 099	ng/L	0.000725	0.000354-0.0425; 0.0048	NA	NA	NA	NA	NA
Total PCB 101	ng/L	0.00122	0.000319-0.0533; 0.0048	NA	NA	NA	NA	NA
Total PCB 105	ng/L	0.00128	0.000601-0.63; 0.0362	NA	NA	NA	NA	NA
Total PCB 110	ng/L	0.00123	0.000319-0.0442; 0.004	NA	NA	NA	NA	NA
Total PCB 118	ng/L	0.00135	0.000555-0.554; 0.0321	NA	NA	NA	NA	NA
Total PCB 128	ng/L	0.000236	0.000475-0.29; 0.0241	NA	NA	NA	NA	NA
Total PCB 132	ng/L	0	0.000608-0.365; 0.0303	NA	NA	NA	NA	NA
Total PCB 138	ng/L	0.00116	0.000476-0.317; 0.0252	NA	NA	NA	NA	NA
Total PCB 141	ng/L	0.000241	0.00054-0.328; 0.0272	NA	NA	NA	NA	NA
Total PCB 149	ng/L	0.00226	0.000528-0.313; 0.0259	NA	NA	NA	NA	NA
Total PCB 151	ng/L	0.000853	0.000282-0.00454; 0.000844	NA	NA	NA	NA	NA
Total PCB 153	ng/L	0.000882	0.000426-0.259; 0.0214	NA	NA	NA	NA	NA
Total PCB 156	ng/L	0	0.000517-0.301; 0.0243	NA	NA	NA	NA	NA

Analyte	Unit	Average Lab Blank	Detection Limit (MDL) (range; mean)	Average Reporting Limit (RL)	RSD of Lab Duplicates (% range; % mean)	RSD of Field Duplicates (% range; % mean)	Percent Recovery of CRM (% range; % mean)	Percent Recovery of Matrix Spike (% range; % mean)
Total PCB 158	ng/L	0	0.000373-0.226; 0.0188	NA	NA	NA	NA	NA
Total PCB 170	ng/L	0	0.000299-0.00696; 0.00124	NA	NA	NA	NA	NA
Total PCB 174	ng/L	0	0.000302-0.00624; 0.00112	NA	NA	NA	NA	NA
Total PCB 177	ng/L	0	0.000311-0.00651; 0.00117	NA	NA	NA	NA	NA
Total PCB 180	ng/L	0.000357	0.000282-0.00549; 0.00099	NA	NA	NA	NA	NA
Total PCB 183	ng/L	0	0.00029-0.00608; 0.00109	NA	NA	NA	NA	NA
Total PCB 187	ng/L	0.000353	0.000282-0.0058; 0.00104	NA	NA	NA	NA	NA
Total PCB 194	ng/L	0	0.000446-0.013; 0.00176	NA	NA	NA	NA	NA
Total PCB 195	ng/L	0	0.000483-0.0141; 0.00189	NA	NA	NA	NA	NA
Total PCB 201	ng/L	0	0.000282-0.00211; 0.000657	NA	NA	NA	NA	NA
Total PCB 203	ng/L	0	0.000282-0.00277; 0.000885	NA	NA	NA	NA	NA

1201

1202 Table A2: Field blank data from all sites.

Analyte	Unit	Average MDL	RL	Minimum Field Blank	Maximum Field Blank	Average Field Blank
Total As	µg/L	0.013	0.032	ND	ND	ND
Total Cd	µg/L	0.007	0.021	ND	ND	ND
Total Cu	µg/L	0.211	0.632	ND	ND	ND
Total Hg	µg/L	0.0001	4E-04	ND	ND	ND
Total Pb	µg/L	0.006	0.026	ND	ND	ND
Total Zn	µg/L	0.32	1.05	ND	ND	ND
PCB 008	ng/L	0.000185	-	0.00304	0.00304	0.00304
PCB 018	ng/L	0.000185	-	0.00251	0.00251	0.00251
PCB 028	ng/L	0.000185	-	0.00514	0.00514	0.00514
PCB 031	ng/L	0.000185	-	0.00394	0.00394	0.00394
PCB 033	ng/L	0.000185	-	0.00274	0.00274	0.00274
PCB 044	ng/L	0.000185	-	0.00352	0.00352	0.00352
PCB 049	ng/L	0.000185	-	0.00152	0.00152	0.00152
PCB 052	ng/L	0.000185	-	0.00677	0.00677	0.00677
PCB 056	ng/L	0.000185	-	0.00159	0.00159	0.00159
PCB 060	ng/L	0.000185	-	0.000579	0.000579	0.000579
PCB 066	ng/L	0.000185	-	0.00175	0.00175	0.00175
PCB 070	ng/L	0.000185	-	0.00344	0.00344	0.00344
PCB 087	ng/L	0.000229	-	0.00216	0.00216	0.00216
PCB 095	ng/L	0.000259	-	0.00283	0.00283	0.00283
PCB 099	ng/L	0.000268	-	0.00124	0.00124	0.00124
PCB 101	ng/L	0.000232	-	0.00262	0.00262	0.00262
PCB 105	ng/L	0.000213	-	0.00124	0.00124	0.00124
PCB 110	ng/L	0.000197	-	0.00341	0.00341	0.00341
PCB 118	ng/L	0.000227	-	0.0023	0.0023	0.0023
PCB 128	ng/L	0.000185	-	0.00111	0.00111	0.00111

Table A2 (continued): Field blank data from all sites.

Analyte	Unit	Average MDL	RL	Minimum Field Blank	Maximum Field Blank	Average Field Blank
PCB 132	ng/L	0.000218	-	0.00222	0.00222	0.00222
PCB 138	ng/L	0.000185	-	0.00435	0.00435	0.00435
PCB 141	ng/L	0.000188	-	0.000699	0.000699	0.000699
PCB 149	ng/L	0.000188	-	0.00294	0.00294	0.00294
PCB 151	ng/L	0.000185	-	0.0012	0.0012	0.0012
PCB 153	ng/L	0.000185	-	0.00202	0.00202	0.00202
PCB 156	ng/L	0.000185	-	0.000417	0.000417	0.000417
PCB 158	ng/L	0.000185	-	0.000391	0.000391	0.000391
PCB 170	ng/L	0.000185	-	0.000938	0.000938	0.000938
PCB 174	ng/L	0.000185	-	0.0011	0.0011	0.0011
PCB 177	ng/L	0.000185	-	0.000651	0.000651	0.000651
PCB 180	ng/L	0.000185	-	0.0015	0.0015	0.0015
PCB 183	ng/L	0.000185	-	0.000699	0.000699	0.000699
PCB 187	ng/L	0.000185	-	0.00113	0.00113	0.00113
PCB 194	ng/L	0.000458	-	ND	ND	ND
PCB 195	ng/L	0.000303	-	ND	ND	ND
PCB 201	ng/L	0.000185	-	ND	ND	ND
PCB 203	ng/L	0.000678	-	ND	ND	ND

Table A3: Average RSD of field and lab duplicates at each site.

	Charcot Avenue SD SC-051CTC275		SD near Cooley Landing SM-72		Line 3A-M-1 at Industrial PS		Line 4-B-1		Line 4-E	
Analyte	RSD Lab	RSD Field	RSD Lab	RSD Field	RSD Lab	RSD Field	RSD Lab	RSD Field	RSD Lab	RSD Field
SSC	-	-	-	-	-	-	-	-	-	-
DOC	-	-	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-	-
TOC	-	-	0.00%	0.00%	-	-	-	-	3.90%	3.90%
Total As	-	-	-	-	-	-	-	-	-	-
Total Cd	4.30%	4.30%	-	-	-	-	1.90%	1.90%	-	-
Total Cu	-	0.70%	-	-	-	-	1.00%	1.00%	-	-
Total Hg	-	-	-	-	-	-	-	-	-	-
Total Pb	0.00%	0.00%	-	-	-	-	0.70%	0.70%	-	-
Total Zn	0.30%	0.30%	-	-	-	-	0.60%	0.60%	-	-
PCB 008	-	-	-	-	-	-	-	-	-	-
PCB 018	-	-	-	-	-	-	-	-	-	-
PCB 028	-	-	-	-	-	-	-	-	-	-
PCB 031	-	-	-	-	-	-	-	-	-	-
PCB 033	-	-	-	-	-	-	-	-	-	-
PCB 044	-	-	-	-	-	-	-	-	-	-
PCB 049	-	-	-	-	-	-	-	-	-	-
PCB 052	-	-	-	-	-	-	-	-	-	-
PCB 056	-	-	-	-	-	-	-	-	-	-
PCB 060	-	-	-	-	-	-	-	-	-	-
PCB 066	-	-	-	-	-	-	-	-	-	-
PCB 070	-	-	-	-	-	-	-	-	-	-
PCB 087	-	-	-	-	-	-	-	-	-	-
PCB 095	-	-	-	-	-	-	-	-	-	-
PCB 099	-	-	-	-	-	-	-	-	-	-
PCB 101	-	-	-	-	-	-	-	-	-	-
PCB 105	-	-	-	-	-	-	-	-	-	-
PCB 110	-	-	-	-	-	-	-	-	-	-
PCB 118	-	-	-	-	-	-	-	-	-	-
PCB 128	-	-	-	-	-	-	-	-	-	-
PCB 132	-	-	-	-	-	-	-	-	-	-
PCB 138	-	-	-	-	-	-	-	-	-	-
PCB 141	-	-	-	-	-	-	-	-	-	-
PCB 149	-	-	-	-	-	-	-	-	-	-
PCB 151	-	-	-	-	-	-	-	-	-	-
PCB 153	-	-	-	-	-	-	-	-	-	-
PCB 156	-	-	-	-	-	-	-	-	-	-
PCB 158	-	-	-	-	-	-	-	-	-	-
PCB 170	-	-	-	-	-	-	-	-	-	-
PCB 174	-	-	-	-	-	-	-	-	-	-
PCB 177	-	-	-	-	-	-	-	-	-	-
PCB 180	-	-	-	-	-	-	-	-	-	-
PCB 183	-	-	-	-	-	-	-	-	-	-
PCB 187	-	-	-	-	-	-	-	-	-	-
PCB 194	-	-	-	-	-	-	-	-	-	-
PCB 195	-	-	-	-	-	-	-	-	-	-
PCB 201	-	-	-	-	-	-	-	-	-	-
PCB 203	-	-	-	-	-	-	-	-	-	-

Table A3 (continued): Average RSD of field and lab duplicates at each site.

	Line 9-D		Outfall to Lower Silver		Meeker Slough		Oddstad PS SM-267		Rock Springs Dr SD	
Analyte	RSD Lab	RSD Field	RSD Lab	RSD Field	RSD Lab	RSD Field	RSD Lab	RSD Field	RSD Lab	RSD Field
SSC	-	5.20%	-	-	-	-	-	-	-	-
DOC	6.00%	10.10%	-	-	-	-	3.50%	3.50%	-	-
TOC	1.30%	35.80%	3.90%	3.90%	0.00%	0.00%	-	-	-	-
Total As	-	1.80%	-	-	-	4.00%	-	-	2.70%	2.70%
Total Cd	-	8.00%	-	-	-	0.90%	-	-	-	2.90%
Total Cu	-	1.40%	-	-	-	1.20%	-	-	0.90%	0.90%
Total Hg	-	16.70%	-	-	-	-	-	-	-	-
Total Pb	-	7.90%	-	-	-	1.20%	-	-	1.70%	1.70%
Total Zn	-	2.60%	-	-	-	0.00%	-	-	0.50%	0.50%
PCB 008	-	6.50%	-	-	-	-	-	-	-	-
PCB 018	-	5.30%	-	-	-	-	-	-	-	-
PCB 028	-	9.00%	-	-	-	-	-	-	-	-
PCB 031	-	7.10%	-	-	-	-	-	-	-	-
PCB 033	-	7.40%	-	-	-	-	-	-	-	-
PCB 044	-	2.90%	-	-	-	-	-	-	-	-
PCB 049	-	3.40%	-	-	-	-	-	-	-	-
PCB 052	-	5.50%	-	-	-	-	-	-	-	-
PCB 056	-	7.70%	-	-	-	-	-	-	-	-
PCB 060	-	8.60%	-	-	-	-	-	-	-	-
PCB 066	-	4.50%	-	-	-	-	-	-	-	-
PCB 070	-	2.40%	-	-	-	-	-	-	-	-
PCB 087	-	4.20%	-	-	-	-	-	-	-	-
PCB 095	-	10.80%	-	-	-	-	-	-	-	-
PCB 099	-	9.00%	-	-	-	-	-	-	-	-
PCB 101	-	9.40%	-	-	-	-	-	-	-	-
PCB 105	-	9.60%	-	-	-	-	-	-	-	-
PCB 110	-	8.80%	-	-	-	-	-	-	-	-
PCB 118	-	11.30%	-	-	-	-	-	-	-	-
PCB 128	-	17.50%	-	-	-	-	-	-	-	-
PCB 132	-	5.60%	-	-	-	-	-	-	-	-
PCB 138	-	3.90%	-	-	-	-	-	-	-	-
PCB 141	-	2.80%	-	-	-	-	-	-	-	-
PCB 149	-	2.30%	-	-	-	-	-	-	-	-
PCB 151	-	0.80%	-	-	-	-	-	-	-	-
PCB 153	-	1.20%	-	-	-	-	-	-	-	-
PCB 156	-	5.70%	-	-	-	-	-	-	-	-
PCB 158	-	6.10%	-	-	-	-	-	-	-	-
PCB 170	-	4.60%	-	-	-	-	-	-	-	-
PCB 174	-	6.10%	-	-	-	-	-	-	-	-
PCB 177	-	6.80%	-	-	-	-	-	-	-	-
PCB 180	-	4.90%	-	-	-	-	-	-	-	-
PCB 183	-	9.70%	-	-	-	-	-	-	-	-
PCB 187	-	7.70%	-	-	-	-	-	-	-	-
PCB 194	-	4.70%	-	-	-	-	-	-	-	-
PCB 195	-	3.80%	-	-	-	-	-	-	-	-
PCB 201	-	10.80%	-	-	-	-	-	-	-	-
PCB 203	-	7.90%	-	-	-	-	-	-	-	-

Appendix B – Additional data results

Table B1. PCB congener results data appendix.

Sampling Location	Analyte Name	Fraction Name	Result	Unit
Charcot Ave SD	PCB 008	Dissolved	649	pg/L
Charcot Ave SD	PCB 018	Dissolved	1630	pg/L
Charcot Ave SD	PCB 028	Dissolved	3170	pg/L
Charcot Ave SD	PCB 031	Dissolved	2490	pg/L
Charcot Ave SD	PCB 033	Dissolved	1630	pg/L
Charcot Ave SD	PCB 044	Dissolved	3070	pg/L
Charcot Ave SD	PCB 049	Dissolved	1770	pg/L
Charcot Ave SD	PCB 052	Dissolved	3460	pg/L
Charcot Ave SD	PCB 056	Dissolved	715	pg/L
Charcot Ave SD	PCB 060	Dissolved	373	pg/L
Charcot Ave SD	PCB 066	Dissolved	1410	pg/L
Charcot Ave SD	PCB 070	Dissolved	2930	pg/L
Charcot Ave SD	PCB 087	Dissolved	2340	pg/L
Charcot Ave SD	PCB 095	Dissolved	2990	pg/L
Charcot Ave SD	PCB 099	Dissolved	1610	pg/L
Charcot Ave SD	PCB 101	Dissolved	3030	pg/L
Charcot Ave SD	PCB 105	Dissolved	1240	pg/L
Charcot Ave SD	PCB 110	Dissolved	3870	pg/L
Charcot Ave SD	PCB 118	Dissolved	2490	pg/L
Charcot Ave SD	PCB 128	Dissolved	747	pg/L
Charcot Ave SD	PCB 132	Dissolved	2080	pg/L
Charcot Ave SD	PCB 138	Dissolved	5900	pg/L
Charcot Ave SD	PCB 141	Dissolved	1170	pg/L
Charcot Ave SD	PCB 149	Dissolved	4890	pg/L
Charcot Ave SD	PCB 151	Dissolved	2130	pg/L
Charcot Ave SD	PCB 153	Dissolved	4710	pg/L
Charcot Ave SD	PCB 156	Dissolved	566	pg/L
Charcot Ave SD	PCB 158	Dissolved	607	pg/L
Charcot Ave SD	PCB 170	Dissolved	2290	pg/L
Charcot Ave SD	PCB 174	Dissolved	2740	pg/L
Charcot Ave SD	PCB 177	Dissolved	1470	pg/L
Charcot Ave SD	PCB 180	Dissolved	5840	pg/L

Sampling Location	Analyte Name	Fraction Name	Result	Unit
Charcot Ave SD	PCB 183	Dissolved	2060	pg/L
Charcot Ave SD	PCB 187	Dissolved	2900	pg/L
Charcot Ave SD	PCB 194	Dissolved	1880	pg/L
Charcot Ave SD	PCB 195	Dissolved	701	pg/L
Charcot Ave SD	PCB 201	Dissolved	348	pg/L
Charcot Ave SD	PCB 203	Dissolved	1810	pg/L
Charcot Ave SD	PCB 008	Total	167	pg/L
Charcot Ave SD	PCB 018	Total	307	pg/L
Charcot Ave SD	PCB 028	Total	600	pg/L
Charcot Ave SD	PCB 031	Total	495	pg/L
Charcot Ave SD	PCB 033	Total	332	pg/L
Charcot Ave SD	PCB 044	Total	492	pg/L
Charcot Ave SD	PCB 049	Total	277	pg/L
Charcot Ave SD	PCB 052	Total	552	pg/L
Charcot Ave SD	PCB 056	Total	163	pg/L
Charcot Ave SD	PCB 060	Total	86.8	pg/L
Charcot Ave SD	PCB 066	Total	286	pg/L
Charcot Ave SD	PCB 070	Total	614	pg/L
Charcot Ave SD	PCB 087	Total	516	pg/L
Charcot Ave SD	PCB 095	Total	500	pg/L
Charcot Ave SD	PCB 099	Total	298	pg/L
Charcot Ave SD	PCB 101	Total	592	pg/L
Charcot Ave SD	PCB 105	Total	292	pg/L
Charcot Ave SD	PCB 110	Total	805	pg/L
Charcot Ave SD	PCB 118	Total	588	pg/L
Charcot Ave SD	PCB 128	Total	138	pg/L
Charcot Ave SD	PCB 132	Total	359	pg/L
Charcot Ave SD	PCB 138	Total	1100	pg/L
Charcot Ave SD	PCB 141	Total	212	pg/L
Charcot Ave SD	PCB 149	Total	779	pg/L
Charcot Ave SD	PCB 151	Total	322	pg/L
Charcot Ave SD	PCB 153	Total	834	pg/L
Charcot Ave SD	PCB 156	Total	110	pg/L
Charcot Ave SD	PCB 158	Total	109	pg/L

Sampling Location	Analyte Name	Fraction Name	Result	Unit
Charcot Ave SD	PCB 170	Total	332	pg/L
Charcot Ave SD	PCB 174	Total	431	pg/L
Charcot Ave SD	PCB 177	Total	212	pg/L
Charcot Ave SD	PCB 180	Total	834	pg/L
Charcot Ave SD	PCB 183	Total	260	pg/L
Charcot Ave SD	PCB 187	Total	371	pg/L
Charcot Ave SD	PCB 194	Total	238	pg/L
Charcot Ave SD	PCB 195	Total	80.7	pg/L
Charcot Ave SD	PCB 201	Total	38	pg/L
Charcot Ave SD	PCB 203	Total	204	pg/L
E. Gish Rd SD	PCB 008	Total	62.3	pg/L
E. Gish Rd SD	PCB 018	Total	154	pg/L
E. Gish Rd SD	PCB 028	Total	269	pg/L
E. Gish Rd SD	PCB 031	Total	228	pg/L
E. Gish Rd SD	PCB 033	Total	155	pg/L
E. Gish Rd SD	PCB 044	Total	292	pg/L
E. Gish Rd SD	PCB 049	Total	158	pg/L
E. Gish Rd SD	PCB 052	Total	378	pg/L
E. Gish Rd SD	PCB 056	Total	101	pg/L
E. Gish Rd SD	PCB 060	Total	55	pg/L
E. Gish Rd SD	PCB 066	Total	183	pg/L
E. Gish Rd SD	PCB 070	Total	429	pg/L
E. Gish Rd SD	PCB 087	Total	550	pg/L
E. Gish Rd SD	PCB 095	Total	586	pg/L
E. Gish Rd SD	PCB 099	Total	294	pg/L
E. Gish Rd SD	PCB 101	Total	658	pg/L
E. Gish Rd SD	PCB 105	Total	255	pg/L
E. Gish Rd SD	PCB 110	Total	846	pg/L
E. Gish Rd SD	PCB 118	Total	543	pg/L
E. Gish Rd SD	PCB 128	Total	167	pg/L
E. Gish Rd SD	PCB 132	Total	389	pg/L
E. Gish Rd SD	PCB 138	Total	1140	pg/L
E. Gish Rd SD	PCB 141	Total	243	pg/L
E. Gish Rd SD	PCB 149	Total	910	pg/L

Sampling Location	Analyte Name	Fraction Name	Result	Unit
E. Gish Rd SD	PCB 151	Total	407	pg/L
E. Gish Rd SD	PCB 153	Total	936	pg/L
E. Gish Rd SD	PCB 156	Total	122	pg/L
E. Gish Rd SD	PCB 158	Total	114	pg/L
E. Gish Rd SD	PCB 170	Total	360	pg/L
E. Gish Rd SD	PCB 174	Total	463	pg/L
E. Gish Rd SD	PCB 177	Total	239	pg/L
E. Gish Rd SD	PCB 180	Total	1000	pg/L
E. Gish Rd SD	PCB 183	Total	337	pg/L
E. Gish Rd SD	PCB 187	Total	498	pg/L
E. Gish Rd SD	PCB 194	Total	336	pg/L
E. Gish Rd SD	PCB 195	Total	115	pg/L
E. Gish Rd SD	PCB 201	Total	60.8	pg/L
E. Gish Rd SD	PCB 203	Total	332	pg/L
Gateway Ave SD	PCB 018	Total	27.5	pg/L
Gateway Ave SD	PCB 028	Total	64.9	pg/L
Gateway Ave SD	PCB 031	Total	48.4	pg/L
Gateway Ave SD	PCB 033	Total	33.6	pg/L
Gateway Ave SD	PCB 044	Total	86.9	pg/L
Gateway Ave SD	PCB 049	Total	45.3	pg/L
Gateway Ave SD	PCB 052	Total	126	pg/L
Gateway Ave SD	PCB 056	Total	42.5	pg/L
Gateway Ave SD	PCB 060	Total	22.8	pg/L
Gateway Ave SD	PCB 066	Total	87.8	pg/L
Gateway Ave SD	PCB 070	Total	175	pg/L
Gateway Ave SD	PCB 087	Total	208	pg/L
Gateway Ave SD	PCB 095	Total	214	pg/L
Gateway Ave SD	PCB 099	Total	143	pg/L
Gateway Ave SD	PCB 101	Total	276	pg/L
Gateway Ave SD	PCB 105	Total	136	pg/L
Gateway Ave SD	PCB 110	Total	386	pg/L
Gateway Ave SD	PCB 118	Total	285	pg/L
Gateway Ave SD	PCB 128	Total	91.5	pg/L
Gateway Ave SD	PCB 132	Total	173	pg/L

Sampling Location	Analyte Name	Fraction Name	Result	Unit
Gateway Ave SD	PCB 138	Total	526	pg/L
Gateway Ave SD	PCB 141	Total	95.9	pg/L
Gateway Ave SD	PCB 149	Total	341	pg/L
Gateway Ave SD	PCB 151	Total	127	pg/L
Gateway Ave SD	PCB 153	Total	367	pg/L
Gateway Ave SD	PCB 156	Total	61.1	pg/L
Gateway Ave SD	PCB 158	Total	54.5	pg/L
Gateway Ave SD	PCB 170	Total	113	pg/L
Gateway Ave SD	PCB 174	Total	124	pg/L
Gateway Ave SD	PCB 177	Total	66.9	pg/L
Gateway Ave SD	PCB 180	Total	274	pg/L
Gateway Ave SD	PCB 183	Total	86.8	pg/L
Gateway Ave SD	PCB 187	Total	153	pg/L
Gateway Ave SD	PCB 194	Total	80.7	pg/L
Gateway Ave SD	PCB 195	Total	26.9	pg/L
Gateway Ave SD	PCB 201	Total	12.5	pg/L
Gateway Ave SD	PCB 203	Total	60.9	pg/L
Line-3A-M at 3A-D	PCB 008	Total	145	pg/L
Line-3A-M at 3A-D	PCB 018	Total	620	pg/L
Line-3A-M at 3A-D	PCB 028	Total	842	pg/L
Line-3A-M at 3A-D	PCB 031	Total	634	pg/L
Line-3A-M at 3A-D	PCB 033	Total	386	pg/L
Line-3A-M at 3A-D	PCB 044	Total	801	pg/L
Line-3A-M at 3A-D	PCB 049	Total	421	pg/L
Line-3A-M at 3A-D	PCB 052	Total	1070	pg/L
Line-3A-M at 3A-D	PCB 056	Total	274	pg/L
Line-3A-M at 3A-D	PCB 060	Total	156	pg/L
Line-3A-M at 3A-D	PCB 066	Total	490	pg/L
Line-3A-M at 3A-D	PCB 070	Total	1210	pg/L
Line-3A-M at 3A-D	PCB 087	Total	1200	pg/L
Line-3A-M at 3A-D	PCB 095	Total	1300	pg/L
Line-3A-M at 3A-D	PCB 099	Total	755	pg/L
Line-3A-M at 3A-D	PCB 101	Total	1560	pg/L
Line-3A-M at 3A-D	PCB 105	Total	659	pg/L

Sampling Location	Analyte Name	Fraction Name	Result	Unit
Line-3A-M at 3A-D	PCB 110	Total	1950	pg/L
Line-3A-M at 3A-D	PCB 118	Total	1460	pg/L
Line-3A-M at 3A-D	PCB 128	Total	342	pg/L
Line-3A-M at 3A-D	PCB 132	Total	670	pg/L
Line-3A-M at 3A-D	PCB 138	Total	1920	pg/L
Line-3A-M at 3A-D	PCB 141	Total	327	pg/L
Line-3A-M at 3A-D	PCB 149	Total	1160	pg/L
Line-3A-M at 3A-D	PCB 151	Total	397	pg/L
Line-3A-M at 3A-D	PCB 153	Total	1240	pg/L
Line-3A-M at 3A-D	PCB 156	Total	254	pg/L
Line-3A-M at 3A-D	PCB 158	Total	210	pg/L
Line-3A-M at 3A-D	PCB 170	Total	322	pg/L
Line-3A-M at 3A-D	PCB 174	Total	281	pg/L
Line-3A-M at 3A-D	PCB 177	Total	159	pg/L
Line-3A-M at 3A-D	PCB 180	Total	663	pg/L
Line-3A-M at 3A-D	PCB 183	Total	197	pg/L
Line-3A-M at 3A-D	PCB 187	Total	303	pg/L
Line-3A-M at 3A-D	PCB 194	Total	181	pg/L
Line-3A-M at 3A-D	PCB 195	Total	58.2	pg/L
Line-3A-M at 3A-D	PCB 201	Total	25.5	pg/L
Line-3A-M at 3A-D	PCB 203	Total	148	pg/L
Line3A-M-1 at Industrial PS	PCB 008	Total	150	pg/L
Line3A-M-1 at Industrial PS	PCB 018	Total	368	pg/L
Line3A-M-1 at Industrial PS	PCB 028	Total	559	pg/L
Line3A-M-1 at Industrial PS	PCB 031	Total	453	pg/L
Line3A-M-1 at Industrial PS	PCB 033	Total	299	pg/L
Line3A-M-1 at Industrial PS	PCB 044	Total	542	pg/L
Line3A-M-1 at Industrial PS	PCB 049	Total	297	pg/L
Line3A-M-1 at Industrial PS	PCB 052	Total	528	pg/L
Line3A-M-1 at Industrial PS	PCB 056	Total	143	pg/L
Line3A-M-1 at Industrial PS	PCB 060	Total	78.1	pg/L
Line3A-M-1 at Industrial PS	PCB 066	Total	267	pg/L
Line3A-M-1 at Industrial PS	PCB 070	Total	514	pg/L
Line3A-M-1 at Industrial PS	PCB 087	Total	297	pg/L

Sampling Location	Analyte Name	Fraction Name	Result	Unit
Line3A-M-1 at Industrial PS	PCB 095	Total	321	pg/L
Line3A-M-1 at Industrial PS	PCB 099	Total	191	pg/L
Line3A-M-1 at Industrial PS	PCB 101	Total	354	pg/L
Line3A-M-1 at Industrial PS	PCB 105	Total	159	pg/L
Line3A-M-1 at Industrial PS	PCB 110	Total	496	pg/L
Line3A-M-1 at Industrial PS	PCB 118	Total	318	pg/L
Line3A-M-1 at Industrial PS	PCB 128	Total	85.3	pg/L
Line3A-M-1 at Industrial PS	PCB 132	Total	164	pg/L
Line3A-M-1 at Industrial PS	PCB 138	Total	484	pg/L
Line3A-M-1 at Industrial PS	PCB 141	Total	86.2	pg/L
Line3A-M-1 at Industrial PS	PCB 149	Total	309	pg/L
Line3A-M-1 at Industrial PS	PCB 151	Total	117	pg/L
Line3A-M-1 at Industrial PS	PCB 153	Total	329	pg/L
Line3A-M-1 at Industrial PS	PCB 156	Total	60.1	pg/L
Line3A-M-1 at Industrial PS	PCB 158	Total	52.2	pg/L
Line3A-M-1 at Industrial PS	PCB 170	Total	105	pg/L
Line3A-M-1 at Industrial PS	PCB 174	Total	106	pg/L
Line3A-M-1 at Industrial PS	PCB 177	Total	58.1	pg/L
Line3A-M-1 at Industrial PS	PCB 180	Total	250	pg/L
Line3A-M-1 at Industrial PS	PCB 183	Total	73.5	pg/L
Line3A-M-1 at Industrial PS	PCB 187	Total	131	pg/L
Line3A-M-1 at Industrial PS	PCB 194	Total	79.1	pg/L
Line3A-M-1 at Industrial PS	PCB 195	Total	25.1	pg/L
Line3A-M-1 at Industrial PS	PCB 201	Total	11.1	pg/L
Line3A-M-1 at Industrial PS	PCB 203	Total	63.4	pg/L
Line4-B-1	PCB 008	Total	14.7	pg/L
Line4-B-1	PCB 018	Total	37.2	pg/L
Line4-B-1	PCB 028	Total	71.5	pg/L
Line4-B-1	PCB 031	Total	53.2	pg/L
Line4-B-1	PCB 033	Total	32.7	pg/L
Line4-B-1	PCB 044	Total	126	pg/L
Line4-B-1	PCB 049	Total	63	pg/L
Line4-B-1	PCB 052	Total	189	pg/L
Line4-B-1	PCB 056	Total	60.7	pg/L

Sampling Location	Analyte Name	Fraction Name	Result	Unit
Line4-B-1	PCB 060	Total	30	pg/L
Line4-B-1	PCB 066	Total	105	pg/L
Line4-B-1	PCB 070	Total	242	pg/L
Line4-B-1	PCB 087	Total	339	pg/L
Line4-B-1	PCB 095	Total	370	pg/L
Line4-B-1	PCB 099	Total	217	pg/L
Line4-B-1	PCB 101	Total	444	pg/L
Line4-B-1	PCB 105	Total	192	pg/L
Line4-B-1	PCB 110	Total	619	pg/L
Line4-B-1	PCB 118	Total	412	pg/L
Line4-B-1	PCB 128	Total	140	pg/L
Line4-B-1	PCB 132	Total	285	pg/L
Line4-B-1	PCB 138	Total	846	pg/L
Line4-B-1	PCB 141	Total	164	pg/L
Line4-B-1	PCB 149	Total	630	pg/L
Line4-B-1	PCB 151	Total	248	pg/L
Line4-B-1	PCB 153	Total	629	pg/L
Line4-B-1	PCB 156	Total	90.5	pg/L
Line4-B-1	PCB 158	Total	84.6	pg/L
Line4-B-1	PCB 170	Total	215	pg/L
Line4-B-1	PCB 174	Total	245	pg/L
Line4-B-1	PCB 177	Total	142	pg/L
Line4-B-1	PCB 180	Total	524	pg/L
Line4-B-1	PCB 183	Total	173	pg/L
Line4-B-1	PCB 187	Total	311	pg/L
Line4-B-1	PCB 194	Total	133	pg/L
Line4-B-1	PCB 195	Total	46.9	pg/L
Line4-B-1	PCB 201	Total	23.3	pg/L
Line4-B-1	PCB 203	Total	126	pg/L
Line4-E	PCB 008	Total	41.1	pg/L
Line4-E	PCB 018	Total	109	pg/L
Line4-E	PCB 028	Total	294	pg/L
Line4-E	PCB 031	Total	106	pg/L
Line4-E	PCB 033	Total	53.7	pg/L

Sampling Location	Analyte Name	Fraction Name	Result	Unit
Line4-E	PCB 044	Total	490	pg/L
Line4-E	PCB 049	Total	282	pg/L
Line4-E	PCB 052	Total	445	pg/L
Line4-E	PCB 056	Total	100	pg/L
Line4-E	PCB 060	Total	44.8	pg/L
Line4-E	PCB 066	Total	238	pg/L
Line4-E	PCB 070	Total	433	pg/L
Line4-E	PCB 087	Total	508	pg/L
Line4-E	PCB 095	Total	870	pg/L
Line4-E	PCB 099	Total	407	pg/L
Line4-E	PCB 101	Total	1060	pg/L
Line4-E	PCB 105	Total	277	pg/L
Line4-E	PCB 110	Total	975	pg/L
Line4-E	PCB 118	Total	666	pg/L
Line4-E	PCB 128	Total	387	pg/L
Line4-E	PCB 132	Total	1100	pg/L
Line4-E	PCB 138	Total	3930	pg/L
Line4-E	PCB 141	Total	967	pg/L
Line4-E	PCB 149	Total	3080	pg/L
Line4-E	PCB 151	Total	1300	pg/L
Line4-E	PCB 153	Total	3870	pg/L
Line4-E	PCB 156	Total	281	pg/L
Line4-E	PCB 158	Total	339	pg/L
Line4-E	PCB 170	Total	1920	pg/L
Line4-E	PCB 174	Total	1860	pg/L
Line4-E	PCB 177	Total	1130	pg/L
Line4-E	PCB 180	Total	4610	pg/L
Line4-E	PCB 183	Total	1280	pg/L
Line4-E	PCB 187	Total	1780	pg/L
Line4-E	PCB 194	Total	1030	pg/L
Line4-E	PCB 195	Total	388	pg/L
Line4-E	PCB 201	Total	120	pg/L
Line4-E	PCB 203	Total	578	pg/L
Line9-D	PCB 008	Total	34.9	pg/L

Sampling Location	Analyte Name	Fraction Name	Result	Unit
Line9-D	PCB 018	Total	52.45	pg/L
Line9-D	PCB 028	Total	133.5	pg/L
Line9-D	PCB 031	Total	102.85	pg/L
Line9-D	PCB 033	Total	78.85	pg/L
Line9-D	PCB 044	Total	147	pg/L
Line9-D	PCB 049	Total	74.1	pg/L
Line9-D	PCB 052	Total	194.5	pg/L
Line9-D	PCB 056	Total	76.25	pg/L
Line9-D	PCB 060	Total	41.75	pg/L
Line9-D	PCB 066	Total	127	pg/L
Line9-D	PCB 070	Total	297	pg/L
Line9-D	PCB 087	Total	424.5	pg/L
Line9-D	PCB 095	Total	301	pg/L
Line9-D	PCB 099	Total	195.5	pg/L
Line9-D	PCB 101	Total	399.5	pg/L
Line9-D	PCB 105	Total	183.5	pg/L
Line9-D	PCB 110	Total	519.5	pg/L
Line9-D	PCB 118	Total	392.5	pg/L
Line9-D	PCB 128	Total	121	pg/L
Line9-D	PCB 132	Total	280	pg/L
Line9-D	PCB 138	Total	933	pg/L
Line9-D	PCB 141	Total	203	pg/L
Line9-D	PCB 149	Total	636.5	pg/L
Line9-D	PCB 151	Total	258.5	pg/L
Line9-D	PCB 153	Total	763.5	pg/L
Line9-D	PCB 156	Total	84.8	pg/L
Line9-D	PCB 158	Total	89.8	pg/L
Line9-D	PCB 170	Total	380.5	pg/L
Line9-D	PCB 174	Total	460	pg/L
Line9-D	PCB 177	Total	237.5	pg/L
Line9-D	PCB 180	Total	932	pg/L
Line9-D	PCB 183	Total	263	pg/L
Line9-D	PCB 187	Total	467.5	pg/L
Line9-D	PCB 194	Total	253.5	pg/L

Sampling Location	Analyte Name	Fraction Name	Result	Unit
Line9-D	PCB 195	Total	87.85	pg/L
Line9-D	PCB 201	Total	34.55	pg/L
Line9-D	PCB 203	Total	188.5	pg/L
Lower Penitencia Ck	PCB 008	Total	4.36	pg/L
Lower Penitencia Ck	PCB 018	Total	11.3	pg/L
Lower Penitencia Ck	PCB 028	Total	18.3	pg/L
Lower Penitencia Ck	PCB 031	Total	13.5	pg/L
Lower Penitencia Ck	PCB 033	Total	8.58	pg/L
Lower Penitencia Ck	PCB 044	Total	30.4	pg/L
Lower Penitencia Ck	PCB 049	Total	15.2	pg/L
Lower Penitencia Ck	PCB 052	Total	43.9	pg/L
Lower Penitencia Ck	PCB 056	Total	12	pg/L
Lower Penitencia Ck	PCB 060	Total	6.12	pg/L
Lower Penitencia Ck	PCB 066	Total	22	pg/L
Lower Penitencia Ck	PCB 070	Total	50.1	pg/L
Lower Penitencia Ck	PCB 087	Total	79.9	pg/L
Lower Penitencia Ck	PCB 095	Total	91.5	pg/L
Lower Penitencia Ck	PCB 099	Total	49.8	pg/L
Lower Penitencia Ck	PCB 101	Total	106	pg/L
Lower Penitencia Ck	PCB 105	Total	46.6	pg/L
Lower Penitencia Ck	PCB 110	Total	152	pg/L
Lower Penitencia Ck	PCB 118	Total	96.4	pg/L
Lower Penitencia Ck	PCB 128	Total	35.6	pg/L
Lower Penitencia Ck	PCB 132	Total	67.4	pg/L
Lower Penitencia Ck	PCB 138	Total	203	pg/L
Lower Penitencia Ck	PCB 141	Total	37	pg/L
Lower Penitencia Ck	PCB 149	Total	140	pg/L
Lower Penitencia Ck	PCB 151	Total	52.1	pg/L
Lower Penitencia Ck	PCB 153	Total	142	pg/L
Lower Penitencia Ck	PCB 156	Total	23	pg/L
Lower Penitencia Ck	PCB 158	Total	21.6	pg/L
Lower Penitencia Ck	PCB 170	Total	53.5	pg/L
Lower Penitencia Ck	PCB 174	Total	54.7	pg/L
Lower Penitencia Ck	PCB 177	Total	30.2	pg/L

Sampling Location	Analyte Name	Fraction Name	Result	Unit
Lower Penitencia Ck	PCB 180	Total	128	pg/L
Lower Penitencia Ck	PCB 183	Total	36	pg/L
Lower Penitencia Ck	PCB 187	Total	63	pg/L
Lower Penitencia Ck	PCB 194	Total	37.9	pg/L
Lower Penitencia Ck	PCB 195	Total	14	pg/L
Lower Penitencia Ck	PCB 201	Total	4.97	pg/L
Lower Penitencia Ck	PCB 203	Total	31.3	pg/L
Meeker Slough	PCB 008	Total	7.26	pg/L
Meeker Slough	PCB 018	Total	26.6	pg/L
Meeker Slough	PCB 028	Total	64.8	pg/L
Meeker Slough	PCB 031	Total	47.3	pg/L
Meeker Slough	PCB 033	Total	23.8	pg/L
Meeker Slough	PCB 044	Total	105	pg/L
Meeker Slough	PCB 049	Total	56	pg/L
Meeker Slough	PCB 052	Total	178	pg/L
Meeker Slough	PCB 056	Total	53.6	pg/L
Meeker Slough	PCB 060	Total	27.5	pg/L
Meeker Slough	PCB 066	Total	95.4	pg/L
Meeker Slough	PCB 070	Total	245	pg/L
Meeker Slough	PCB 087	Total	349	pg/L
Meeker Slough	PCB 095	Total	360	pg/L
Meeker Slough	PCB 099	Total	242	pg/L
Meeker Slough	PCB 101	Total	463	pg/L
Meeker Slough	PCB 105	Total	244	pg/L
Meeker Slough	PCB 110	Total	661	pg/L
Meeker Slough	PCB 118	Total	512	pg/L
Meeker Slough	PCB 128	Total	166	pg/L
Meeker Slough	PCB 132	Total	280	pg/L
Meeker Slough	PCB 138	Total	928	pg/L
Meeker Slough	PCB 141	Total	165	pg/L
Meeker Slough	PCB 149	Total	540	pg/L
Meeker Slough	PCB 151	Total	189	pg/L
Meeker Slough	PCB 153	Total	663	pg/L
Meeker Slough	PCB 156	Total	113	pg/L

Sampling Location	Analyte Name	Fraction Name	Result	Unit
Meeker Slough	PCB 158	Total	94	pg/L
Meeker Slough	PCB 170	Total	203	pg/L
Meeker Slough	PCB 174	Total	194	pg/L
Meeker Slough	PCB 177	Total	108	pg/L
Meeker Slough	PCB 180	Total	487	pg/L
Meeker Slough	PCB 183	Total	135	pg/L
Meeker Slough	PCB 187	Total	215	pg/L
Meeker Slough	PCB 194	Total	146	pg/L
Meeker Slough	PCB 195	Total	45.7	pg/L
Meeker Slough	PCB 201	Total	19.8	pg/L
Meeker Slough	PCB 203	Total	107	pg/L
Oddstad PS	PCB 008	Total	15	pg/L
Oddstad PS	PCB 018	Total	42.4	pg/L
Oddstad PS	PCB 028	Total	89.6	pg/L
Oddstad PS	PCB 031	Total	48.2	pg/L
Oddstad PS	PCB 033	Total	23.4	pg/L
Oddstad PS	PCB 044	Total	156	pg/L
Oddstad PS	PCB 049	Total	87.6	pg/L
Oddstad PS	PCB 052	Total	198	pg/L
Oddstad PS	PCB 056	Total	66.5	pg/L
Oddstad PS	PCB 060	Total	33.3	pg/L
Oddstad PS	PCB 066	Total	117	pg/L
Oddstad PS	PCB 070	Total	201	pg/L
Oddstad PS	PCB 087	Total	288	pg/L
Oddstad PS	PCB 095	Total	398	pg/L
Oddstad PS	PCB 099	Total	213	pg/L
Oddstad PS	PCB 101	Total	411	pg/L
Oddstad PS	PCB 105	Total	139	pg/L
Oddstad PS	PCB 110	Total	533	pg/L
Oddstad PS	PCB 118	Total	289	pg/L
Oddstad PS	PCB 128	Total	115	pg/L
Oddstad PS	PCB 132	Total	241	pg/L
Oddstad PS	PCB 138	Total	722	pg/L
Oddstad PS	PCB 141	Total	149	pg/L

Sampling Location	Analyte Name	Fraction Name	Result	Unit
Oddstad PS	PCB 149	Total	677	pg/L
Oddstad PS	PCB 151	Total	295	pg/L
Oddstad PS	PCB 153	Total	624	pg/L
Oddstad PS	PCB 156	Total	66.7	pg/L
Oddstad PS	PCB 158	Total	66.6	pg/L
Oddstad PS	PCB 170	Total	238	pg/L
Oddstad PS	PCB 174	Total	334	pg/L
Oddstad PS	PCB 177	Total	174	pg/L
Oddstad PS	PCB 180	Total	754	pg/L
Oddstad PS	PCB 183	Total	239	pg/L
Oddstad PS	PCB 187	Total	470	pg/L
Oddstad PS	PCB 194	Total	289	pg/L
Oddstad PS	PCB 195	Total	88.3	pg/L
Oddstad PS	PCB 201	Total	45.9	pg/L
Oddstad PS	PCB 203	Total	266	pg/L
Outfall to Lower Silver Ck	PCB 008	Total	68.6	pg/L
Outfall to Lower Silver Ck	PCB 008	Total	2020	pg/L
Outfall to Lower Silver Ck	PCB 008	Total	63.8	pg/L
Outfall to Lower Silver Ck	PCB 018	Total	105	pg/L
Outfall to Lower Silver Ck	PCB 018	Total	3980	pg/L
Outfall to Lower Silver Ck	PCB 018	Total	195	pg/L
Outfall to Lower Silver Ck	PCB 028	Total	308	pg/L
Outfall to Lower Silver Ck	PCB 028	Total	21500	pg/L
Outfall to Lower Silver Ck	PCB 028	Total	782	pg/L
Outfall to Lower Silver Ck	PCB 031	Total	217	pg/L
Outfall to Lower Silver Ck	PCB 031	Total	13500	pg/L
Outfall to Lower Silver Ck	PCB 031	Total	572	pg/L
Outfall to Lower Silver Ck	PCB 033	Total	168	pg/L
Outfall to Lower Silver Ck	PCB 033	Total	9340	pg/L
Outfall to Lower Silver Ck	PCB 033	Total	429	pg/L
Outfall to Lower Silver Ck	PCB 044	Total	516	pg/L
Outfall to Lower Silver Ck	PCB 044	Total	56700	pg/L
Outfall to Lower Silver Ck	PCB 044	Total	1900	pg/L
Outfall to Lower Silver Ck	PCB 049	Total	250	pg/L

Sampling Location	Analyte Name	Fraction Name	Result	Unit
Outfall to Lower Silver Ck	PCB 049	Total	28000	pg/L
Outfall to Lower Silver Ck	PCB 049	Total	901	pg/L
Outfall to Lower Silver Ck	PCB 052	Total	720	pg/L
Outfall to Lower Silver Ck	PCB 052	Total	86300	pg/L
Outfall to Lower Silver Ck	PCB 052	Total	2970	pg/L
Outfall to Lower Silver Ck	PCB 056	Total	498	pg/L
Outfall to Lower Silver Ck	PCB 056	Total	44200	pg/L
Outfall to Lower Silver Ck	PCB 056	Total	1520	pg/L
Outfall to Lower Silver Ck	PCB 060	Total	267	pg/L
Outfall to Lower Silver Ck	PCB 060	Total	18300	pg/L
Outfall to Lower Silver Ck	PCB 060	Total	741	pg/L
Outfall to Lower Silver Ck	PCB 066	Total	840	pg/L
Outfall to Lower Silver Ck	PCB 066	Total	77400	pg/L
Outfall to Lower Silver Ck	PCB 066	Total	2660	pg/L
Outfall to Lower Silver Ck	PCB 070	Total	1560	pg/L
Outfall to Lower Silver Ck	PCB 070	Total	155000	pg/L
Outfall to Lower Silver Ck	PCB 070	Total	5660	pg/L
Outfall to Lower Silver Ck	PCB 087	Total	2130	pg/L
Outfall to Lower Silver Ck	PCB 087	Total	240000	pg/L
Outfall to Lower Silver Ck	PCB 087	Total	8260	pg/L
Outfall to Lower Silver Ck	PCB 095	Total	1570	pg/L
Outfall to Lower Silver Ck	PCB 095	Total	187000	pg/L
Outfall to Lower Silver Ck	PCB 095	Total	6920	pg/L
Outfall to Lower Silver Ck	PCB 099	Total	1170	pg/L
Outfall to Lower Silver Ck	PCB 099	Total	144000	pg/L
Outfall to Lower Silver Ck	PCB 099	Total	4990	pg/L
Outfall to Lower Silver Ck	PCB 101	Total	2630	pg/L
Outfall to Lower Silver Ck	PCB 101	Total	315000	pg/L
Outfall to Lower Silver Ck	PCB 101	Total	10600	pg/L
Outfall to Lower Silver Ck	PCB 105	Total	1760	pg/L
Outfall to Lower Silver Ck	PCB 105	Total	147000	pg/L
Outfall to Lower Silver Ck	PCB 105	Total	5970	pg/L
Outfall to Lower Silver Ck	PCB 110	Total	3800	pg/L
Outfall to Lower Silver Ck	PCB 110	Total	417000	pg/L

Sampling Location	Analyte Name	Fraction Name	Result	Unit
Outfall to Lower Silver Ck	PCB 110	Total	14300	pg/L
Outfall to Lower Silver Ck	PCB 118	Total	3570	pg/L
Outfall to Lower Silver Ck	PCB 118	Total	316000	pg/L
Outfall to Lower Silver Ck	PCB 118	Total	12300	pg/L
Outfall to Lower Silver Ck	PCB 128	Total	967	pg/L
Outfall to Lower Silver Ck	PCB 128	Total	70700	pg/L
Outfall to Lower Silver Ck	PCB 128	Total	2800	pg/L
Outfall to Lower Silver Ck	PCB 132	Total	1600	pg/L
Outfall to Lower Silver Ck	PCB 132	Total	142000	pg/L
Outfall to Lower Silver Ck	PCB 132	Total	6000	pg/L
Outfall to Lower Silver Ck	PCB 138	Total	5310	pg/L
Outfall to Lower Silver Ck	PCB 138	Total	466000	pg/L
Outfall to Lower Silver Ck	PCB 138	Total	17500	pg/L
Outfall to Lower Silver Ck	PCB 141	Total	865	pg/L
Outfall to Lower Silver Ck	PCB 141	Total	70800	pg/L
Outfall to Lower Silver Ck	PCB 141	Total	3020	pg/L
Outfall to Lower Silver Ck	PCB 149	Total	2690	pg/L
Outfall to Lower Silver Ck	PCB 149	Total	230000	pg/L
Outfall to Lower Silver Ck	PCB 149	Total	9890	pg/L
Outfall to Lower Silver Ck	PCB 151	Total	874	pg/L
Outfall to Lower Silver Ck	PCB 151	Total	85700	pg/L
Outfall to Lower Silver Ck	PCB 151	Total	3490	pg/L
Outfall to Lower Silver Ck	PCB 153	Total	3230	pg/L
Outfall to Lower Silver Ck	PCB 153	Total	250000	pg/L
Outfall to Lower Silver Ck	PCB 153	Total	11300	pg/L
Outfall to Lower Silver Ck	PCB 156	Total	659	pg/L
Outfall to Lower Silver Ck	PCB 156	Total	55700	pg/L
Outfall to Lower Silver Ck	PCB 156	Total	2290	pg/L
Outfall to Lower Silver Ck	PCB 158	Total	596	pg/L
Outfall to Lower Silver Ck	PCB 158	Total	48000	pg/L
Outfall to Lower Silver Ck	PCB 158	Total	1900	pg/L
Outfall to Lower Silver Ck	PCB 170	Total	852	pg/L
Outfall to Lower Silver Ck	PCB 170	Total	55500	pg/L
Outfall to Lower Silver Ck	PCB 170	Total	2740	pg/L

Sampling Location	Analyte Name	Fraction Name	Result	Unit
Outfall to Lower Silver Ck	PCB 174	Total	735	pg/L
Outfall to Lower Silver Ck	PCB 174	Total	50200	pg/L
Outfall to Lower Silver Ck	PCB 174	Total	2500	pg/L
Outfall to Lower Silver Ck	PCB 177	Total	426	pg/L
Outfall to Lower Silver Ck	PCB 177	Total	28800	pg/L
Outfall to Lower Silver Ck	PCB 177	Total	1400	pg/L
Outfall to Lower Silver Ck	PCB 180	Total	1710	pg/L
Outfall to Lower Silver Ck	PCB 180	Total	102000	pg/L
Outfall to Lower Silver Ck	PCB 180	Total	5350	pg/L
Outfall to Lower Silver Ck	PCB 183	Total	490	pg/L
Outfall to Lower Silver Ck	PCB 183	Total	33300	pg/L
Outfall to Lower Silver Ck	PCB 183	Total	1650	pg/L
Outfall to Lower Silver Ck	PCB 187	Total	782	pg/L
Outfall to Lower Silver Ck	PCB 187	Total	45400	pg/L
Outfall to Lower Silver Ck	PCB 187	Total	2140	pg/L
Outfall to Lower Silver Ck	PCB 194	Total	362	pg/L
Outfall to Lower Silver Ck	PCB 194	Total	17900	pg/L
Outfall to Lower Silver Ck	PCB 194	Total	963	pg/L
Outfall to Lower Silver Ck	PCB 195	Total	127	pg/L
Outfall to Lower Silver Ck	PCB 195	Total	6140	pg/L
Outfall to Lower Silver Ck	PCB 195	Total	336	pg/L
Outfall to Lower Silver Ck	PCB 201	Total	34.5	pg/L
Outfall to Lower Silver Ck	PCB 201	Total	2310	pg/L
Outfall to Lower Silver Ck	PCB 201	Total	128	pg/L
Outfall to Lower Silver Ck	PCB 203	Total	186	pg/L
Outfall to Lower Silver Ck	PCB 203	Total	9710	pg/L
Outfall to Lower Silver Ck	PCB 203	Total	556	pg/L
Ridder Park Dr SD	PCB 008	Total	8.91	pg/L
Ridder Park Dr SD	PCB 018	Total	33.9	pg/L
Ridder Park Dr SD	PCB 028	Total	82.8	pg/L
Ridder Park Dr SD	PCB 031	Total	62.2	pg/L
Ridder Park Dr SD	PCB 033	Total	32.6	pg/L
Ridder Park Dr SD	PCB 044	Total	205	pg/L
Ridder Park Dr SD	PCB 049	Total	98.1	pg/L

Sampling Location	Analyte Name	Fraction Name	Result	Unit
Ridder Park Dr SD	PCB 052	Total	336	pg/L
Ridder Park Dr SD	PCB 056	Total	114	pg/L
Ridder Park Dr SD	PCB 060	Total	58.5	pg/L
Ridder Park Dr SD	PCB 066	Total	201	pg/L
Ridder Park Dr SD	PCB 070	Total	432	pg/L
Ridder Park Dr SD	PCB 087	Total	684	pg/L
Ridder Park Dr SD	PCB 095	Total	1610	pg/L
Ridder Park Dr SD	PCB 099	Total	341	pg/L
Ridder Park Dr SD	PCB 101	Total	1860	pg/L
Ridder Park Dr SD	PCB 105	Total	355	pg/L
Ridder Park Dr SD	PCB 110	Total	1530	pg/L
Ridder Park Dr SD	PCB 118	Total	865	pg/L
Ridder Park Dr SD	PCB 128	Total	552	pg/L
Ridder Park Dr SD	PCB 132	Total	1850	pg/L
Ridder Park Dr SD	PCB 138	Total	5760	pg/L
Ridder Park Dr SD	PCB 141	Total	1670	pg/L
Ridder Park Dr SD	PCB 149	Total	5460	pg/L
Ridder Park Dr SD	PCB 151	Total	2550	pg/L
Ridder Park Dr SD	PCB 153	Total	5890	pg/L
Ridder Park Dr SD	PCB 156	Total	388	pg/L
Ridder Park Dr SD	PCB 158	Total	502	pg/L
Ridder Park Dr SD	PCB 170	Total	2540	pg/L
Ridder Park Dr SD	PCB 174	Total	3160	pg/L
Ridder Park Dr SD	PCB 177	Total	1730	pg/L
Ridder Park Dr SD	PCB 180	Total	6170	pg/L
Ridder Park Dr SD	PCB 183	Total	2050	pg/L
Ridder Park Dr SD	PCB 187	Total	3450	pg/L
Ridder Park Dr SD	PCB 194	Total	1260	pg/L
Ridder Park Dr SD	PCB 195	Total	510	pg/L
Ridder Park Dr SD	PCB 201	Total	190	pg/L
Ridder Park Dr SD	PCB 203	Total	911	pg/L
Rock Springs Dr SD	PCB 008	Total	16.9	pg/L
Rock Springs Dr SD	PCB 018	Total	22.4	pg/L
Rock Springs Dr SD	PCB 028	Total	47.6	pg/L

Sampling Location	Analyte Name	Fraction Name	Result	Unit
Rock Springs Dr SD	PCB 031	Total	38.7	pg/L
Rock Springs Dr SD	PCB 033	Total	27.8	pg/L
Rock Springs Dr SD	PCB 044	Total	76.3	pg/L
Rock Springs Dr SD	PCB 049	Total	34.7	pg/L
Rock Springs Dr SD	PCB 052	Total	113	pg/L
Rock Springs Dr SD	PCB 056	Total	33.1	pg/L
Rock Springs Dr SD	PCB 060	Total	17.2	pg/L
Rock Springs Dr SD	PCB 066	Total	60.3	pg/L
Rock Springs Dr SD	PCB 070	Total	158	pg/L
Rock Springs Dr SD	PCB 087	Total	295	pg/L
Rock Springs Dr SD	PCB 095	Total	203	pg/L
Rock Springs Dr SD	PCB 099	Total	153	pg/L
Rock Springs Dr SD	PCB 101	Total	290	pg/L
Rock Springs Dr SD	PCB 105	Total	203	pg/L
Rock Springs Dr SD	PCB 110	Total	442	pg/L
Rock Springs Dr SD	PCB 118	Total	406	pg/L
Rock Springs Dr SD	PCB 128	Total	127	pg/L
Rock Springs Dr SD	PCB 132	Total	190	pg/L
Rock Springs Dr SD	PCB 138	Total	592	pg/L
Rock Springs Dr SD	PCB 141	Total	95.4	pg/L
Rock Springs Dr SD	PCB 149	Total	277	pg/L
Rock Springs Dr SD	PCB 151	Total	107	pg/L
Rock Springs Dr SD	PCB 153	Total	331	pg/L
Rock Springs Dr SD	PCB 156	Total	79.1	pg/L
Rock Springs Dr SD	PCB 158	Total	69	pg/L
Rock Springs Dr SD	PCB 170	Total	97.1	pg/L
Rock Springs Dr SD	PCB 174	Total	85.6	pg/L
Rock Springs Dr SD	PCB 177	Total	48.6	pg/L
Rock Springs Dr SD	PCB 180	Total	205	pg/L
Rock Springs Dr SD	PCB 183	Total	59	pg/L
Rock Springs Dr SD	PCB 187	Total	102	pg/L
Rock Springs Dr SD	PCB 194	Total	68.8	pg/L
Rock Springs Dr SD	PCB 195	Total	22.7	pg/L
Rock Springs Dr SD	PCB 201	Total	8.34	pg/L

Sampling Location	Analyte Name	Fraction Name	Result	Unit
Rock Springs Dr SD	PCB 203	Total	49	pg/L
Runnymede Ditch	PCB 008	Total	74.8	pg/L
Runnymede Ditch	PCB 018	Total	177	pg/L
Runnymede Ditch	PCB 028	Total	378	pg/L
Runnymede Ditch	PCB 031	Total	284	pg/L
Runnymede Ditch	PCB 033	Total	177	pg/L
Runnymede Ditch	PCB 044	Total	586	pg/L
Runnymede Ditch	PCB 049	Total	336	pg/L
Runnymede Ditch	PCB 052	Total	865	pg/L
Runnymede Ditch	PCB 056	Total	223	pg/L
Runnymede Ditch	PCB 060	Total	113	pg/L
Runnymede Ditch	PCB 066	Total	499	pg/L
Runnymede Ditch	PCB 070	Total	1020	pg/L
Runnymede Ditch	PCB 087	Total	1170	pg/L
Runnymede Ditch	PCB 095	Total	1400	pg/L
Runnymede Ditch	PCB 099	Total	884	pg/L
Runnymede Ditch	PCB 101	Total	1630	pg/L
Runnymede Ditch	PCB 105	Total	660	pg/L
Runnymede Ditch	PCB 110	Total	2140	pg/L
Runnymede Ditch	PCB 118	Total	1480	pg/L
Runnymede Ditch	PCB 128	Total	425	pg/L
Runnymede Ditch	PCB 132	Total	876	pg/L
Runnymede Ditch	PCB 138	Total	2460	pg/L
Runnymede Ditch	PCB 141	Total	431	pg/L
Runnymede Ditch	PCB 149	Total	1760	pg/L
Runnymede Ditch	PCB 151	Total	679	pg/L
Runnymede Ditch	PCB 153	Total	1780	pg/L
Runnymede Ditch	PCB 156	Total	268	pg/L
Runnymede Ditch	PCB 158	Total	250	pg/L
Runnymede Ditch	PCB 170	Total	490	pg/L
Runnymede Ditch	PCB 174	Total	602	pg/L
Runnymede Ditch	PCB 177	Total	315	pg/L
Runnymede Ditch	PCB 180	Total	1430	pg/L
Runnymede Ditch	PCB 183	Total	460	pg/L

Sampling Location	Analyte Name	Fraction Name	Result	Unit
Runnymede Ditch	PCB 187	Total	889	pg/L
Runnymede Ditch	PCB 194	Total	537	pg/L
Runnymede Ditch	PCB 195	Total	160	pg/L
Runnymede Ditch	PCB 201	Total	98.4	pg/L
Runnymede Ditch	PCB 203	Total	542	pg/L
SD near Cooley Landing	PCB 008	Total	14.2	pg/L
SD near Cooley Landing	PCB 008	Total	4590	pg/L
SD near Cooley Landing	PCB 018	Total	32.2	pg/L
SD near Cooley Landing	PCB 018	Total	5000	pg/L
SD near Cooley Landing	PCB 028	Total	72.4	pg/L
SD near Cooley Landing	PCB 028	Total	11400	pg/L
SD near Cooley Landing	PCB 031	Total	51.6	pg/L
SD near Cooley Landing	PCB 031	Total	8850	pg/L
SD near Cooley Landing	PCB 033	Total	31.8	pg/L
SD near Cooley Landing	PCB 033	Total	6190	pg/L
SD near Cooley Landing	PCB 044	Total	78.7	pg/L
SD near Cooley Landing	PCB 044	Total	15200	pg/L
SD near Cooley Landing	PCB 049	Total	41.7	pg/L
SD near Cooley Landing	PCB 049	Total	6970	pg/L
SD near Cooley Landing	PCB 052	Total	105	pg/L
SD near Cooley Landing	PCB 052	Total	22100	pg/L
SD near Cooley Landing	PCB 056	Total	40.4	pg/L
SD near Cooley Landing	PCB 056	Total	6840	pg/L
SD near Cooley Landing	PCB 060	Total	20.7	pg/L
SD near Cooley Landing	PCB 060	Total	3620	pg/L
SD near Cooley Landing	PCB 066	Total	85.4	pg/L
SD near Cooley Landing	PCB 066	Total	14800	pg/L
SD near Cooley Landing	PCB 070	Total	156	pg/L
SD near Cooley Landing	PCB 070	Total	29100	pg/L
SD near Cooley Landing	PCB 087	Total	192	pg/L
SD near Cooley Landing	PCB 087	Total	40300	pg/L
SD near Cooley Landing	PCB 095	Total	225	pg/L
SD near Cooley Landing	PCB 095	Total	56000	pg/L
SD near Cooley Landing	PCB 099	Total	130	pg/L

Sampling Location	Analyte Name	Fraction Name	Result	Unit
SD near Cooley Landing	PCB 099	Total	27100	pg/L
SD near Cooley Landing	PCB 101	Total	258	pg/L
SD near Cooley Landing	PCB 101	Total	54900	pg/L
SD near Cooley Landing	PCB 105	Total	132	pg/L
SD near Cooley Landing	PCB 105	Total	26300	pg/L
SD near Cooley Landing	PCB 110	Total	419	pg/L
SD near Cooley Landing	PCB 110	Total	89600	pg/L
SD near Cooley Landing	PCB 118	Total	281	pg/L
SD near Cooley Landing	PCB 118	Total	57500	pg/L
SD near Cooley Landing	PCB 128	Total	112	pg/L
SD near Cooley Landing	PCB 128	Total	29300	pg/L
SD near Cooley Landing	PCB 132	Total	215	pg/L
SD near Cooley Landing	PCB 132	Total	56800	pg/L
SD near Cooley Landing	PCB 138	Total	703	pg/L
SD near Cooley Landing	PCB 138	Total	190000	pg/L
SD near Cooley Landing	PCB 141	Total	126	pg/L
SD near Cooley Landing	PCB 141	Total	38000	pg/L
SD near Cooley Landing	PCB 149	Total	479	pg/L
SD near Cooley Landing	PCB 149	Total	131000	pg/L
SD near Cooley Landing	PCB 151	Total	178	pg/L
SD near Cooley Landing	PCB 151	Total	54200	pg/L
SD near Cooley Landing	PCB 153	Total	479	pg/L
SD near Cooley Landing	PCB 153	Total	146000	pg/L
SD near Cooley Landing	PCB 156	Total	66.5	pg/L
SD near Cooley Landing	PCB 156	Total	16300	pg/L
SD near Cooley Landing	PCB 158	Total	72.6	pg/L
SD near Cooley Landing	PCB 158	Total	18800	pg/L
SD near Cooley Landing	PCB 170	Total	184	pg/L
SD near Cooley Landing	PCB 170	Total	63900	pg/L
SD near Cooley Landing	PCB 174	Total	205	pg/L
SD near Cooley Landing	PCB 174	Total	72300	pg/L
SD near Cooley Landing	PCB 177	Total	110	pg/L
SD near Cooley Landing	PCB 177	Total	41000	pg/L
SD near Cooley Landing	PCB 180	Total	473	pg/L

Sampling Location	Analyte Name	Fraction Name	Result	Unit
SD near Cooley Landing	PCB 180	Total	144000	pg/L
SD near Cooley Landing	PCB 183	Total	148	pg/L
SD near Cooley Landing	PCB 183	Total	46600	pg/L
SD near Cooley Landing	PCB 187	Total	262	pg/L
SD near Cooley Landing	PCB 187	Total	88800	pg/L
SD near Cooley Landing	PCB 194	Total	138	pg/L
SD near Cooley Landing	PCB 194	Total	41900	pg/L
SD near Cooley Landing	PCB 195	Total	44.8	pg/L
SD near Cooley Landing	PCB 195	Total	15100	pg/L
SD near Cooley Landing	PCB 201	Total	18.5	pg/L
SD near Cooley Landing	PCB 201	Total	6010	pg/L
SD near Cooley Landing	PCB 203	Total	91.7	pg/L
SD near Cooley Landing	PCB 203	Total	28800	pg/L
Seabord Ave SD SC-050GAC580	PCB 008	Total	98.9	pg/L
Seabord Ave SD SC-050GAC580	PCB 018	Total	206	pg/L
Seabord Ave SD SC-050GAC580	PCB 028	Total	283	pg/L
Seabord Ave SD SC-050GAC580	PCB 031	Total	231	pg/L
Seabord Ave SD SC-050GAC580	PCB 033	Total	169	pg/L
Seabord Ave SD SC-050GAC580	PCB 044	Total	895	pg/L
Seabord Ave SD SC-050GAC580	PCB 049	Total	401	pg/L
Seabord Ave SD SC-050GAC580	PCB 052	Total	392	pg/L
Seabord Ave SD SC-050GAC580	PCB 056	Total	141	pg/L
Seabord Ave SD SC-050GAC580	PCB 060	Total	81.6	pg/L
Seabord Ave SD SC-050GAC580	PCB 066	Total	238	pg/L
Seabord Ave SD SC-050GAC580	PCB 070	Total	460	pg/L
Seabord Ave SD SC-050GAC580	PCB 087	Total	498	pg/L
Seabord Ave SD SC-050GAC580	PCB 095	Total	734	pg/L
Seabord Ave SD SC-050GAC580	PCB 099	Total	335	pg/L
Seabord Ave SD SC-050GAC580	PCB 101	Total	845	pg/L
Seabord Ave SD SC-050GAC580	PCB 105	Total	234	pg/L
Seabord Ave SD SC-050GAC580	PCB 110	Total	733	pg/L
Seabord Ave SD SC-050GAC580	PCB 118	Total	438	pg/L
Seabord Ave SD SC-050GAC580	PCB 128	Total	195	pg/L
Seabord Ave SD SC-050GAC580	PCB 132	Total	520	pg/L

Sampling Location	Analyte Name	Fraction Name	Result	Unit
Seabord Ave SD SC-050GAC580	PCB 138	Total	1610	pg/L
Seabord Ave SD SC-050GAC580	PCB 141	Total	349	pg/L
Seabord Ave SD SC-050GAC580	PCB 149	Total	1570	pg/L
Seabord Ave SD SC-050GAC580	PCB 151	Total	811	pg/L
Seabord Ave SD SC-050GAC580	PCB 153	Total	1380	pg/L
Seabord Ave SD SC-050GAC580	PCB 156	Total	127	pg/L
Seabord Ave SD SC-050GAC580	PCB 158	Total	143	pg/L
Seabord Ave SD SC-050GAC580	PCB 170	Total	658	pg/L
Seabord Ave SD SC-050GAC580	PCB 174	Total	762	pg/L
Seabord Ave SD SC-050GAC580	PCB 177	Total	430	pg/L
Seabord Ave SD SC-050GAC580	PCB 180	Total	1620	pg/L
Seabord Ave SD SC-050GAC580	PCB 183	Total	488	pg/L
Seabord Ave SD SC-050GAC580	PCB 187	Total	831	pg/L
Seabord Ave SD SC-050GAC580	PCB 194	Total	456	pg/L
Seabord Ave SD SC-050GAC580	PCB 195	Total	180	pg/L
Seabord Ave SD SC-050GAC580	PCB 201	Total	63.7	pg/L
Seabord Ave SD SC-050GAC580	PCB 203	Total	308	pg/L
Seabord Ave SD SC-050GAC600	PCB 008	Total	26.9	pg/L
Seabord Ave SD SC-050GAC600	PCB 018	Total	48.4	pg/L
Seabord Ave SD SC-050GAC600	PCB 028	Total	96.6	pg/L
Seabord Ave SD SC-050GAC600	PCB 031	Total	75.5	pg/L
Seabord Ave SD SC-050GAC600	PCB 033	Total	47.7	pg/L
Seabord Ave SD SC-050GAC600	PCB 044	Total	252	pg/L
Seabord Ave SD SC-050GAC600	PCB 049	Total	150	pg/L
Seabord Ave SD SC-050GAC600	PCB 052	Total	386	pg/L
Seabord Ave SD SC-050GAC600	PCB 056	Total	73.6	pg/L
Seabord Ave SD SC-050GAC600	PCB 060	Total	33.5	pg/L
Seabord Ave SD SC-050GAC600	PCB 066	Total	161	pg/L
Seabord Ave SD SC-050GAC600	PCB 070	Total	380	pg/L
Seabord Ave SD SC-050GAC600	PCB 087	Total	555	pg/L
Seabord Ave SD SC-050GAC600	PCB 095	Total	630	pg/L
Seabord Ave SD SC-050GAC600	PCB 099	Total	365	pg/L
Seabord Ave SD SC-050GAC600	PCB 101	Total	728	pg/L
Seabord Ave SD SC-050GAC600	PCB 105	Total	295	pg/L

Sampling Location	Analyte Name	Fraction Name	Result	Unit
Seabord Ave SD SC-050GAC600	PCB 110	Total	959	pg/L
Seabord Ave SD SC-050GAC600	PCB 118	Total	649	pg/L
Seabord Ave SD SC-050GAC600	PCB 128	Total	193	pg/L
Seabord Ave SD SC-050GAC600	PCB 132	Total	404	pg/L
Seabord Ave SD SC-050GAC600	PCB 138	Total	1190	pg/L
Seabord Ave SD SC-050GAC600	PCB 141	Total	245	pg/L
Seabord Ave SD SC-050GAC600	PCB 149	Total	872	pg/L
Seabord Ave SD SC-050GAC600	PCB 151	Total	348	pg/L
Seabord Ave SD SC-050GAC600	PCB 153	Total	936	pg/L
Seabord Ave SD SC-050GAC600	PCB 156	Total	127	pg/L
Seabord Ave SD SC-050GAC600	PCB 158	Total	123	pg/L
Seabord Ave SD SC-050GAC600	PCB 170	Total	315	pg/L
Seabord Ave SD SC-050GAC600	PCB 174	Total	417	pg/L
Seabord Ave SD SC-050GAC600	PCB 177	Total	216	pg/L
Seabord Ave SD SC-050GAC600	PCB 180	Total	833	pg/L
Seabord Ave SD SC-050GAC600	PCB 183	Total	291	pg/L
Seabord Ave SD SC-050GAC600	PCB 187	Total	529	pg/L
Seabord Ave SD SC-050GAC600	PCB 194	Total	211	pg/L
Seabord Ave SD SC-050GAC600	PCB 195	Total	77.3	pg/L
Seabord Ave SD SC-050GAC600	PCB 201	Total	40.4	pg/L
Seabord Ave SD SC-050GAC600	PCB 203	Total	192	pg/L
South Linden PS	PCB 018	Total	21.7	pg/L
South Linden PS	PCB 028	Total	48.5	pg/L
South Linden PS	PCB 031	Total	38.8	pg/L
South Linden PS	PCB 033	Total	17.5	pg/L
South Linden PS	PCB 044	Total	73.2	pg/L
South Linden PS	PCB 049	Total	35.3	pg/L
South Linden PS	PCB 052	Total	107	pg/L
South Linden PS	PCB 056	Total	39.4	pg/L
South Linden PS	PCB 060	Total	22	pg/L
South Linden PS	PCB 066	Total	76.1	pg/L
South Linden PS	PCB 070	Total	165	pg/L
South Linden PS	PCB 087	Total	207	pg/L
South Linden PS	PCB 095	Total	200	pg/L

Sampling Location	Analyte Name	Fraction Name	Result	Unit
South Linden PS	PCB 099	Total	122	pg/L
South Linden PS	PCB 101	Total	257	pg/L
South Linden PS	PCB 105	Total	131	pg/L
South Linden PS	PCB 110	Total	360	pg/L
South Linden PS	PCB 118	Total	276	pg/L
South Linden PS	PCB 128	Total	110	pg/L
South Linden PS	PCB 132	Total	156	pg/L
South Linden PS	PCB 138	Total	539	pg/L
South Linden PS	PCB 141	Total	105	pg/L
South Linden PS	PCB 149	Total	362	pg/L
South Linden PS	PCB 151	Total	145	pg/L
South Linden PS	PCB 153	Total	431	pg/L
South Linden PS	PCB 156	Total	52.8	pg/L
South Linden PS	PCB 158	Total	58.5	pg/L
South Linden PS	PCB 170	Total	142	pg/L
South Linden PS	PCB 174	Total	214	pg/L
South Linden PS	PCB 177	Total	105	pg/L
South Linden PS	PCB 180	Total	721	pg/L
South Linden PS	PCB 183	Total	202	pg/L
South Linden PS	PCB 187	Total	583	pg/L
South Linden PS	PCB 194	Total	682	pg/L
South Linden PS	PCB 195	Total	90.5	pg/L
South Linden PS	PCB 201	Total	93.4	pg/L
South Linden PS	PCB 203	Total	824	pg/L
Veterans PS	PCB 008	Total	3.98	pg/L
Veterans PS	PCB 018	Total	17.1	pg/L
Veterans PS	PCB 028	Total	27	pg/L
Veterans PS	PCB 031	Total	20.4	pg/L
Veterans PS	PCB 033	Total	8.94	pg/L
Veterans PS	PCB 044	Total	36.2	pg/L
Veterans PS	PCB 049	Total	23	pg/L
Veterans PS	PCB 052	Total	61.5	pg/L
Veterans PS	PCB 056	Total	17.3	pg/L
Veterans PS	PCB 060	Total	9.45	pg/L

Sampling Location	Analyte Name	Fraction Name	Result	Unit
Veterans PS	PCB 066	Total	33.5	pg/L
Veterans PS	PCB 070	Total	77	pg/L
Veterans PS	PCB 087	Total	112	pg/L
Veterans PS	PCB 095	Total	118	pg/L
Veterans PS	PCB 099	Total	91.3	pg/L
Veterans PS	PCB 101	Total	160	pg/L
Veterans PS	PCB 105	Total	78.4	pg/L
Veterans PS	PCB 110	Total	227	pg/L
Veterans PS	PCB 118	Total	164	pg/L
Veterans PS	PCB 128	Total	60.2	pg/L
Veterans PS	PCB 132	Total	94.2	pg/L
Veterans PS	PCB 138	Total	379	pg/L
Veterans PS	PCB 141	Total	66.1	pg/L
Veterans PS	PCB 149	Total	210	pg/L
Veterans PS	PCB 151	Total	83.8	pg/L
Veterans PS	PCB 153	Total	316	pg/L
Veterans PS	PCB 156	Total	42.8	pg/L
Veterans PS	PCB 158	Total	31.5	pg/L
Veterans PS	PCB 170	Total	97.9	pg/L
Veterans PS	PCB 174	Total	97.3	pg/L
Veterans PS	PCB 177	Total	54.6	pg/L
Veterans PS	PCB 180	Total	287	pg/L
Veterans PS	PCB 183	Total	73.5	pg/L
Veterans PS	PCB 187	Total	140	pg/L
Veterans PS	PCB 194	Total	86.6	pg/L
Veterans PS	PCB 195	Total	25	pg/L
Veterans PS	PCB 201	Total	13.4	pg/L
Veterans PS	PCB 203	Total	74.7	pg/L

Table B2. Grain size results data appendix.

Sampling Location	**<0.0039 mm**	**0.0039 to <0.0625 mm**	**<0.0625 mm**	**0.0625 to <2.0 mm**	**2.0 to <64 mm**	**V. Fine 0.0625 to <0.125 mm**	**Fine 0.125 to <0.25 mm**	**Medium 0.25 to <0.5 mm**	**Coarse 0.5 to <1.0 mm**	**V. Coarse 1.0 to <2.0 mm**
Charcot Ave SD	11.2	29.2	40.4	7.03	0.000	4.12	1.34	1.22	0.341	0.000
Ridder Park Dr SD	39.3	26.4	65.7	1.36	0.000	0.194	0.682	0.428	0.0537	0.000
E. Gish Rd SD	23.5	34.7	58.1	0.345	0.000	0.345	0.000	0.000	0.000	0.000
Seabord Ave SD SC-050GAC580	10.3	16.0	26.3	0.0633	0.000	0.0633	0.000	0.000	0.000	0.000
Seabord Ave SD SC-050GAC600	1.89	3.35	5.24	0.107	0.000	0.000	0.000	0.000	0.000	0.000
Line-3A-M at 3A-D	16.7	7.82	24.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Line4-B-1	37.5	68.5	106.0	16.3	0.000	10.5	5.18	0.646	0.000	0.000
Line4-E	36.0	54.2	90.2	0.117	0.000	0.117	0.000	0.000	0.000	0.000
Line3A-M-1 at Industrial PS	13.0	22.0	35.0	7.88	0.000	3.25	3.37	1.26	0.000	0.000
SD near Cooley Landing	17.3	23.9	41.3	0.0260	0.000	0.0260	0.000	0.000	0.000	0.000
Rock Springs Dr SD	1.17	2.19	3.36	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Gateway Ave SD	0.380	0.681	1.06	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Lower Penitencia Ck	37.5	58.8	96.3	2.02	0.000	1.11	0.904	0.00727	0.000	0.000
Outfall to Lower Silver Ck	7.34	7.52	14.9	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Meeker Slough	4.85	9.77	14.6	0.437	0.000	0.437	0.000	0.000	0.000	0.000
Oddstad PS	9.89	17.0	26.9	84.1	0.000	10.0	17.0	21.0	26.3	9.78
Runnymede Ditch	57.7	111	169	4.89	0.000	4.87	0.0243	0.000	0.000	0.000
Line9-D	3.39	5.25	8.64	2.10	0.000	0.621	0.914	0.325	0.244	0.000
South Linden PS	2.64	3.97	6.61	0.00927	0.000	0.00927	0.000	0.000	0.000	0.000
Veterans PS	0.0348	0.0503	0.0851	6.98	0.000	0.229	2.52	4.23	0.000	0.000

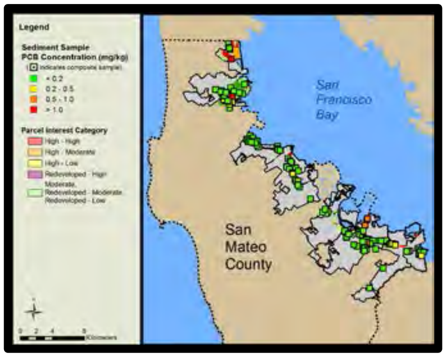
Appendix G

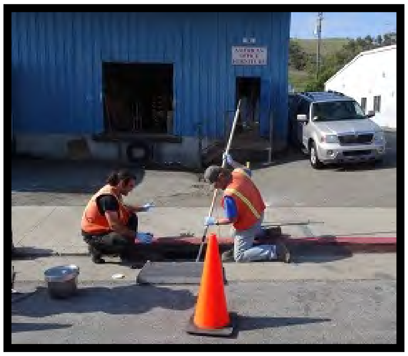
SMCWPPP PCBs and Mercury Source Area Identification, Water Year 2015 POC Monitoring Report

SAN MATEO COUNTYWIDE
Water Pollution
Prevention Program

PCBs and Mercury Source Area Identification

WATER YEAR 2015 POC MONITORING REPORT





Submitted in Compliance with
NPDES Permit No. CAS612008, Provision C.8.e.i
Pollutants of Concern Loads Monitoring

September 2015

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LIST OF ABBREVIATIONS

BASMAA	Bay Area Stormwater Management Agencies Association
BMPs	Best Management Practices
COC	Chain of Custody
CW4CB	Clean Watersheds for a Clean Bay
CWA	Clean Water Act
DTSC	California Department of Toxic Substances
FD	Field Duplicate
LCS	Laboratory Control Samples
MQO	Measurement Quality Objective
MRP	Municipal Regional Permit
MS	Matrix Spike
MS4	Municipal Separate Storm Sewer System
MSD	Matrix Spike Duplicate
NPDES	National Pollution Discharge Elimination System
PCBs	Polychlorinated Biphenyls
PCJPB	Peninsula Corridor Joint Powers Board
POC	Pollutant of Concern
RCRA	Resource Conservation and Recovery Act
RPD	Relative Percent Difference
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
SAP	Sampling and Analysis Plan
SMCWPPP	San Mateo Countywide Water Pollution Prevention Program
STLS	Small Tributaries Loading Study
USEPA	United States Environmental Protection Agency
TMDL	Total Maximum Daily Load
WY	Water Year

EXECUTIVE SUMMARY

In Water Year 2015 the San Mateo Countywide Water Pollution Prevention Program (SMCWPPP) conducted a targeted reconnaissance sediment sampling program on behalf of its Permittees in compliance with Provision C.8.e.i (Pollutants of Concern Loads Monitoring) of the Municipal Regional Stormwater National Pollutant Discharge Elimination system Program (NPDES) Permit (MRP; Order R2-2009-0074). Over one hundred bedded sediment samples were collected for polychlorinated biphenyls (PCBs) and mercury analysis (these pollutants are often found bound to sediments in the environment) to screen for areas in the urban environment with elevated pollutant concentrations. The general goal was to continue identifying potential source areas for further study. These areas are potential opportunity areas for implementing controls to reduce stormwater discharges of PCBs and mercury.

Samples were distributed among the nine municipalities that collectively encompass 93% of the old industrial land use in San Mateo County that drains to San Francisco Bay. Sample stations were sited in locations considered most likely to contain PCBs based on nearby current and historical land use (e.g., PCB-related activities, presence of heavy or electrical equipment, recycling operations) and housekeeping (e.g., pavement in poor condition, evidence of sediment track out) conditions. Areas with already confirmed PCBs contamination were specifically excluded from the program. Bedded sediment samples from the urban storm drainage system (e.g., beneath manholes, storm drain inlets) and public right-of-way surfaces (e.g., street gutters) were collected using methods detailed in the Sampling and Analysis Plan (SAP) for PCBs and Mercury Opportunity Area Analysis and Implementation Planning (SMCWPPP 2015).

Total PCBs (i.e., sum of 40 PCB congeners) concentrations ranged from less than 0.01 mg/kg to 1.46mg/kg with an average of 0.11 mg/kg and a median of 0.04 mg/kg. A total of five samples exceeded the 0.5 mg/kg threshold that was selected by the Bay Area Stormwater Management Agencies Association (BASMAA) Monitoring and Pollutants of Concern Committee as an approximate benchmark for identifying areas that should be considered for future investigation (e.g., additional sampling, records review). Total mercury concentrations ranged from 0.03 mg/kg to 3.59 mg/kg with an average of 0.22 mg/kg and a median of 0.10 mg/kg. There is currently no comparable BASMAA benchmark for mercury; however, two samples exceeded 1.0 mg/kg. The primary objective of this project was not to identify specific source properties, but to identify areas where further investigation is warranted. SMCWPPP anticipates further investigation of the five areas with elevated PCB concentrations during the next term of the MRP.

The sampling design specifically targeted sample stations within the old industrial landscape that are influenced by parcels that were classified and prioritized as having relatively higher potential to be sources of PCBs. However, a strong correlation between the land use analysis and sampling results was lacking, and only five percent of the samples had total PCBs concentrations exceeding the 0.5 mg/kg threshold. This suggests that continuing to identify additional source areas and properties in San Mateo County may be challenging. The remainder of the PCB load appears to be coming from sources that are less elevated and more diffuse and will likely be more challenging to control. Thus data collected to-date suggests that the diffuse nature of PCB contamination within the urban landscape may require a rethinking of the approach and timeline needed to meet TMDL load reduction goals.

SMCWPPP plans to continue working with other Bay Area countywide stormwater programs (through the BASMAA MPC Committee) to evaluate the results of the ongoing efforts in the Bay Area to identify PCBs and mercury source areas and plan next steps in San Mateo County. Follow-up monitoring will be

conducted in coordination with compliance with Provision C.8.f (Pollutants of Concern Monitoring) of the reissued MRP. Monitoring under Provision C.8.f is intended to address a number of management questions related to priority pollutants such as mercury and PCBs, including helping to identify pollutant source areas. The overall objectives of follow-up efforts to address PCBs and mercury under Provisions C.11, C.12 and C.8.f of the reissued MRP will include continuing to identify which pollutant source areas in San Mateo County provide the greatest opportunities for implementing controls to reduce discharges of these pollutants.

1.0 INTRODUCTION

Pollutants of Concern (POC) loads monitoring is required by Provision C.8.e.i of the Municipal Regional Stormwater National Pollutant Discharge Elimination System (NPDES) Permit (Order R2-2009-0074, NPDES Permit No. CAS612008), referred to as MRP 1.0. In Water Year 2015, the San Mateo Countywide Water Pollution Prevention Program (SMCWPPP or Program) and its Regional Monitoring Coalition (RMC) partners implemented a revised alternative approach to POC loads monitoring. This alternative monitoring approach was approved by members of the Regional Monitoring Program (RMP) Small Tributaries Loading Strategy (STLS) Team, including San Francisco Bay Area Regional Water Quality Control Board (Regional Water Board) staff, as the best approach to addressing near-term high priority information needs regarding polychlorinated biphenyls (PCBs) and mercury sources, trends, and loadings.

This report describes the results from the targeted reconnaissance sediment sampling conducted in San Mateo County by SMCWPP on behalf of its Permittees in compliance with Provision C.8.e.i of MRP 1.0. The sampling design and methodologies are presented in detail in the Sampling and Analysis Plan (SAP) for PCBs and Mercury Opportunity Area Analysis and Implementation Planning (SMCWPPP 2015). The overall project is attempting to characterize polychlorinated biphenyls (PCBs) and mercury concentrations throughout San Mateo County with the goal of identifying areas of high interest for further study and possible implementation of pollutant controls, such as referral of source properties to regulatory agencies for remediation. Therefore, a reconnaissance approach was implemented to maximize the area characterized by the sampling program within existing budget and schedule constraints. Approximately 100 sediment samples were collected and analyzed in Water Year 2015 through this sampling program. PCBs and mercury are often found bound to sediments in the environment.

Methods used to select sample stations and collect and analyze the samples are summarized in Section 2.0 of this report. Section 3.0 describes the sampling results. Recommendations for next steps in the PCBs and Mercury Opportunity Area Analysis are included in Section 4.0. Cited references are listed in Section 5.0.

1.1. Background

Fish tissue monitoring in San Francisco Bay has revealed bioaccumulation of PCBs, mercury, and other pollutants. The levels found are thought to pose a health risk to people consuming fish caught in the Bay. As a result of these findings, California has issued an interim advisory on the consumption of fish from the Bay. The advisory led to the Bay being designated as an impaired water body on the Clean Water Act (CWA) "Section 303(d) list" due to PCBs, mercury, and other pollutants. In response, the Regional Water Board has developed Total Maximum Daily Load (TMDL) water quality restoration programs targeting PCBs and mercury in the Bay. The general goals of the TMDLs are to identify sources of PCBs and mercury to the Bay and implement actions to control the sources and restore water quality.

The PCBs and mercury TMDLs indicate that a 90% reduction in PCBs and 50% reduction in mercury in discharges from urban stormwater runoff to the Bay are needed to achieve water quality standards and restore beneficial uses. Provisions C.11 and C.12 of MRP 1.0 required Permittees to implement pilot-scale control measures during the permit term to reduce PCBs and mercury discharges from Municipal Separate Storm Sewer Systems (MS4s). These pilot studies were intended to enhance our collective knowledge about the costs and benefits of different Best Management Practices (BMPs) to control PCBs and mercury. The reissued NPDES permit (i.e., MRP 2.0) was released as a Tentative Order on May 11, 2015 and is anticipated to be adopted in late 2015 following a series of public workshop hearings and a written comment period. The MRP 2.0 Tentative Order requires municipal agencies to move from pilot-scale work to focused implementation and defined load reduction goals (e.g., 3 kg/year region wide for PCBs). The strategies and BMPs that will be applied to meet the load reduction goals are anticipated to include:

- Source property identification and referral for investigation and abatement;
- Green infrastructure/treatment controls; and
- Management of PCBs in building materials during demolition.

In preparation for reissuance of the MRP, SMCWPPP and Permittee staff participated in dialogue with Regional Water Board staff through the MRP 2.0 Steering Committee and its workgroups. One outcome was a preliminary framework for focused implementation requirements addressing PCBs and mercury during the MRP 2.0 timeframe. The framework assumes that all areas in the urban landscape that drain to the Bay fall within one of three PCBs/mercury source area types that will eventually be categorized as load reduction opportunity area types.

PCBs/mercury source area types have the following characteristics:

1. **High Source Areas** – Areas mainly within old industrial land uses with known PCBs/mercury sources (e.g., where PCBs/mercury were used, transported or recycled). High source areas have relatively high concentrations of PCBs/mercury in street dirt and sediment removed from the MS4 (e.g., ≥ 0.5 mg/kg PCBs), or in stormwater runoff.
2. **Moderate Source Areas** – Land uses in the moderate source area category include old urban land uses and old industrial areas that do not fall into the high source area category and have not been redeveloped into other land use types. Moderate source areas have moderate concentrations of PCBs/mercury in street dirt and sediment removed from the MS4 (e.g., 0.2-0.5 mg/kg PCBs), or in stormwater runoff.
3. **Low/No Source Areas** – Land uses in the low/no source category include newly urbanized areas, redeveloped areas, open spaces, and parks where it is unlikely that PCBs/mercury were used, transported or recycled. PCBs/mercury concentrations in street dirt and sediment removed from the MS4, or in stormwater runoff from these areas are less than about 0.2 mg/kg PCBs.

PCBs/mercury load reduction opportunity areas consider the likelihood that load reductions could eventually be achieved. Opportunity area types have the following characteristics:

1. **High Opportunity Areas** – These areas (located primarily within old industrial land uses) have relatively high or moderate PCBs/mercury yields and provide relatively high opportunity for cost effective controls such as referrals to the Regional Water Board or other agencies for subsequent remediation.
2. **Moderate Opportunity Areas** - These are areas (located primarily within old urban and old industrial land uses) that have relatively moderate PCBs/mercury yields and provide relatively moderate opportunity for cost effective controls. These include areas where additional PCBs/mercury load reductions could be achieved as the urban landscape is potentially redeveloped and/or retrofitted with Green Infrastructure, providing the opportunity for integration of PCBs/mercury load reductions with other drivers and funding sources such as transportation projects.

3. **Low Opportunity Areas** - These areas have relatively low PCB/mercury yields and provide low or no opportunity for cost-effective controls.

The data presented in this this report will be used to better delineate *High* and *Moderate* source areas where opportunity analyses could be conducted to assess the feasibility of implementing control measures in the future.

2.0 METHODS

This section provides a brief overview of the sampling design and field methods. A detailed discussion is included in the SAP for this project (SMCWPPP 2015).

2.1. Potential PCBs and Mercury Source Area Maps and Data Spreadsheets

PCBs and mercury source and opportunity areas are being identified and classified using a map-based GIS platform through an informal iterative framework developed by the Bay Area Stormwater Management Agencies Association (BASMAA) Monitoring and Pollutants of Concern Committee. This iterative process includes the steps listed in Table 1 to identify high interest PCBs or mercury **source** areas. **Opportunity** analyses for the confirmed likely *High* source areas is a likely future step that will be based on factors such as property ownership, cost of oversight, regulatory authority, and likelihood of rapid benefit.

Table 1. Iterative framework to identify high interest PCB or mercury source areas.

Step	Description[1]	Status
Step 1	Identify parcels that were industrial in or prior to 1980 (i.e., old industrial parcels), or have other land uses associated with PCBs or mercury. See Appendix A of the SAP (SMCWPPP 2015) for a full description of these areas. These parcels are referred to as potential *High* interest source areas.	*Completed* in collaboration with Permittees using County Assessor's Parcel GIS datalayer.
Step 2	Classify potential *High* interest source areas into *High*, *Moderate* and *Low* interest source areas based on the evaluation of existing information on current land uses and practices (e.g., extent and quality of pavement, redevelopment status, level of current housekeeping, presence of heavy equipment).	*Completed* in collaboration with Permittees using local institutional knowledge combined with windshield/Google Street View/aerial photo surveys.
Step 3	Conduct sediment and/or water sampling in the public right-of-way (i.e., streets or stormwater conveyance system) near or downstream of *High* interest source areas and analyze samples for PCBs and mercury.	*Ongoing*. The sediment sampling results documented in this report add to a growing database in development since 2000.
Step 4	Reclassify *High* interest source areas based on sampling results and existing information on current and historical land uses and PCB/mercury sources.	*Ongoing*. As knowledge about land uses and the presence of PCBs and mercury grows, the maps and data spreadsheets are updated.

[1] See the Opportunity Area Analysis SAP (SMCWPPP 2015) for a complete description of the process.

Results of Step 1 and Step 2 are summarized in Table 2 which lists the number of parcels and/or acreage for each source area category. The nine SMCWPPP Permittees that collectively encompass 93% of the old industrial land use in San Mateo County that drains to San Francisco Bay are shown in Table 2.

Moderate and *No/Low* interest source areas include primarily old urban, open space, and new urban land uses. *High* interest source areas are those with old industrial land uses that have not been redeveloped into a different land use category since 1980 (i.e., roughly when PCBs were banned) that also have one or more of the following characteristics:

- Unpaved areas;
- Pavement in poor condition or sediment is seen or suspected to move off site;
- A lack of "good housekeeping" in its outdoors areas;
- A history of PCB-related activities (e.g., identified in the United States Environmental Protection Agency (USEPA) PCB Transformer Registration Database, Envirostor, or Geotracker);
- A current or past last use associated with possible PCB use (e.g., metals manufacturing, transportation/shipping, recycling, electrical, port, railroad);
- Heavy or electrical equipment observed on-site;
- Hazardous waste storage;
- Recent stormwater violations; or
- Monitoring results from adjacent areas that have elevated PCB concentrations (≥ 0.5 mg/kg).

Table 2. Source area interest classification for SMCWPPP Permittees.

Permittee	High Interest Source Areas		Moderate and No/Low Interest Source Areas (Acres)					Total Area (Acres)
	Parcels	Area (Acres)	Old Industrial	Old Urban	Open Space	New Urban	Other	
Brisbane	76	605	205	399	540	68	0	1,817
Burlingame	125	181	165	2,223	109	103	0	2,781
East Palo Alto	125	92	23	1,170	98	13	0	1,397
Menlo Park	94	271	155	3,283	478	169	0	4,355
Redwood City	192	299	183	4,528	799	1,211	1	7,022
San Carlos	169	191	216	2,501	376	61	85	3,430
San Mateo	167	173	91	6,497	558	314	0	7,633
South San Francisco	287	580	886	3,555	390	228	187	5,824
Unincorporated San Mateo County	225	494	89	4,251	10,312	143	1,884	17,173
Other[1]	133	186	152	20,435	6,391	1,392	26	28,582
TOTAL	**1,593**	**3,072**	**2,165**	**48,842**	**20,051**	**3,702**	**2,183**	**80,014**

[1] Other includes Atherton, Belmont, Colma, Daly City, Foster City, Hillsborough, Millbrae, Portola Valley, San Bruno, and Woodside. These Permittees were not asked to participate in the classification process because of the small amount of old industrial land use in their jurisdictions.

2.1.1. Priority Ranking

A system was developed by Program staff to rank the 1,593 *High* interest source area parcels. The priority ranking scheme utilized parcel information collated to-date in collaboration with Permittees, and included in the source area database. The scheme scores a number of parcel characteristics related to the potential for contributions of PCBs or mercury from a parcel to the MS4. A total score was developed for each parcel by summing the scores of each characteristic.

Of the 1,460 *High* interest source area parcels in the nine targeted municipalities, 246 were identified as the highest priority (i.e., *High - High*), 464 as moderate priority (i.e., *High - Moderate*), 667 as low priority (i.e., *High - Low*), and 83 as *Redeveloped - High*. *Redeveloped - High* parcels are those that have been partially or fully redeveloped since 1980 but still meet the criteria associated with high interest source areas.

2.2. Sampling Stations

The primary goal of the sampling program was to characterize sediment chemistry (i.e., PCBs and mercury concentrations) in areas screened as *High* interest source areas of PCBs to MS4s. Therefore, a targeted reconnaissance approach was implemented to maximize the area characterized by the sampling program within existing budget and schedule constraints. A total of 101 samples were collected during this Water Year 2015 investigation.

A total of 1,460 parcels (2,885 acres) in San Mateo County were screened as *High* Interest Source Areas of PCBs to MS4s according to the criteria listed in Section 2.1. Because the number of *High* interest source parcels (1,460) far exceeded the number samples that could be collected within the available budget, not all parcels were targeted for sediment/soil sampling in Water Year 2015. Therefore, tentative locations for sampling stations were identified based on the priority ranking (e.g., *High - High*) process described in Section 2.1.1 above. Furthermore, the number of samples targeted for each of the nine Permittees included in the mapping and data spreadsheet development was based on their relative contribution to the total number of *High* interest source area parcels and acreage.

Prior to initiating the field effort, Program staff identified tentative sampling stations using the *High* interest source area maps and available geographic information on the location of the stormwater conveyance system and its access points. Field reconnaissance maps and worksheets were developed for each potential sampling location. These maps and worksheets allowed field crews to identify the optimal locations to sample given the area that the sample was intended to represent. Field crews then used discretion to alter locations based on actual site conditions (e.g., accessibility, incorrectly mapped storm drain inlets, presence of sufficient sediment for sample collection). If a planned location could not be sampled due to a lack of sediment, safety concerns, or the inability to locate sediment associated with a high interest source area, alternative *High* interest source areas were sampled.

When possible, sample stations were selected that characterized multiple *High* interest source area parcels by capturing sediment at a point in the MS4 that drained multiple *High* interest parcels (e.g., from a line beneath a manhole). In areas where sediment from stormwater drainage lines could not be obtained, sample stations were located in storm drain inlets or on street surfaces receiving drainage from or directly adjacent to *High* interest source areas. To increase the area characterized by inlet or street surface samples, multiple nearby samples were composited.

2.2.1. Known Pollution Sources

Significant effort has already been devoted to the identification of *High* source areas and high opportunity areas in San Mateo County and the larger San Francisco Bay region. These efforts include (but are not limited to) sampling of bedded sediments collected from urban storm drains in 2000 and 2001 (KLI & EOA 2002), wet weather water quality characterization of 17 watersheds (McKee et al. 2012), and the ongoing Clean Watersheds for a Clean Bay (CW4CB) project (unpublished to date) funded by a grant from the U. S. Environmental Protection Agency (USEPA).

Certain areas within San Mateo County had previously been identified as having elevated concentrations of PCBs (e.g., the Pulgas Creek Pump Station watershed and the Delta Star facility area). These areas were explicitly excluded from this sampling project, as the goal of this project was to discover additional source areas and broadly characterize PCB and mercury concentrations in *High* interest source areas.

2.3. Sample Collection Methods

Sediment/soil sample collection methods, equipment decontamination procedures, sample handling and shipping procedures, disposal of residual materials, sample documentation, quality control, and field health and safety procedures followed the Sample and Analysis Plan and Quality Assurance Project Plan developed for Task 3 of the Clean Watersheds for a Clean Bay (CW4CB) – Implementing the San Francisco Bay's PCBs and Mercury TMDLs with a Focus on Urban Runoff program (AMS 2012 and AMS 2013). These procedures are summarized in the sections below.

Kinetic Laboratories Incorporated (KLI) conducted the sample collection for this project with guidance from Program staff. General sampling locations were identified via the process described in the project's SAP. Consistent with CW4CB procedures, exact soil/sediment sampling locations were determined in the field based on sediment availability, site accessibility, signs of sediment accumulation/wash off, visible signs of potential contamination (e.g., stained soils), and topographical features. Soil sample locations and coordinates were recorded on field datasheets as sampling was completed.

Sediment samples were collected using methods that minimize contamination, losses, and changes to the chemical form of the analytes of interest. Samples were collected in the field using pre-cleaned equipment (e.g., brushes, large spoons, extension poles) into pre-cleaned sample containers (provided by the analytical laboratory). Sampling technique varied at the discretion of the field crew depending on the location and sample type. Samples with field duplicates were collected into a pre-cleaned compositing bucket, where they were thoroughly homogenized in the field, and then aliquoted into separate jars for chemical analysis.

Field crews collected the surface soil/sediment samples using the general procedures described in the RMC SOP FS-6 *Collection of Bedded Sediment Samples for Chemical Analysis & Toxicity* (BASMAA 2014). Additional details are described in the CW4CB Quality Assurance Project Plan (QAPP) (AMS 2013). Additional detail regarding the field methods can be found in the SAP (SMCWPPP 2015).

2.3.1. Laboratory Analytical Methods

Each soil/sediment sample was analyzed for PCB congeners and mercury by ALS Environmental in Kelso, WA. Ancillary methods include sieving to 2 mm and measuring bulk density. PCB and mercury analyses are conducted on the 2 mm fraction. Bulk density measurements were applied to calculate concentrations as mg/kg. Measurement Quality Objectives (MQOs) for laboratory analyses were based on the CW4CB QAPP (AMS 2013) but modified for differing laboratory analytical methods. ALS is involved with the CW4CB program and was asked to conform to those MQOs for this study.

Although USEPA analytical method 1668A for PCBs (as congeners) has been used for previous sediment sampling, loads monitoring and analyses of Bay water and sediments, USEPA method 8082M for PCBs (as congeners) was selected as the method of choice for this study. Method 8082M was identified as the optimal method for this effort based on a thorough review of analytical detection limits. It allows for the collection of screening-level PCB data at a much greater number of sampling sites due to lower analytical laboratory costs. Consistent with the recommendations in *PCBs in San Francisco Bay: Assessment of the Current State of Knowledge and Priority Information Gaps* (Davis et al. 2014), a subset of 40 PCB congeners were analyzed. These are referred to as the Regional Monitoring Program (RMP) 40. A more thorough discussion of the reasons for selecting method 8082M can be found in the SAP (SMCWPPP 2015).

2.3.2. Quality Assurance and Quality Control

Field personnel adhered to Section 11 of the CW4CB QAPP (AMS 2013) to ensure the collection of representative, uncontaminated samples.

- **Field Blanks**. No field blanks were analyzed as part of this project as they are considered to be of limited value to the quality control process.

- **Field Duplicates**. Consistent with the CW4CB SAP (AMS 2012), field duplicate samples were collected at a rate of ten percent of sample locations or once per day, whichever was less frequent. Field crews had the discretion to select duplicate stations based upon schedule or site conditions. A separate sample number was assigned to each duplicate, and a total of ten duplicate samples were submitted blind to the laboratory. The purpose of the field duplicates was to better understand the degree of heterogeneity associated with the sediment/soil samples collected for this project and therefore variability within analytical results. Field duplicate samples assist with the interpretation of analytical results by providing an indication of this variability.

- **Method Comparison**. A total of ten samples were submitted for analysis of PCB congeners (i.e., RMP 40) using USEPA analytical method 1668A. Both methods (8082M and 1668A) quantify PCB congeners, however, method 1668A has a higher resolution and lower detection limits. The results of the two methods were compared to verify the accuracy of the 8082M results.

3.0 SAMPLING RESULTS

In January and February, 2015, 101 sediment samples were collected from high interest source areas throughout San Mateo County. The results of the sampling and related quality assurance and quality control (QA/QC) are presented in this section.

Countywide PCB sample analysis results are first presented followed by Permittee-specific results including a detailed examination of samples yielding a total PCB concentration of over 0.5 mg/kg. Mercury sampling results are briefly presented in this section, but are not the focus of this report. An evaluation of QA/QC results from field duplicates, laboratory blanks, matrix spikes, and alternative lab methods are included at the end of this section.

3.1. PCB Sampling Results

A total of 101 sediment samples were collected in San Mateo County during this Water Year 2015 investigation, all within the nine jurisdictions listed in Table 2. The samples consisted of sediments that were collected from the storm drainage system (e.g., beneath manholes, storm drain inlets, pump stations) or from locations where they could potentially reach the storm drainage system (e.g., sediment in street gutters, driveways and other surface sediments). Fifty-five (55) of the samples were composites of more than one location. The sum of the RMP 40 PCB congeners (i.e., total PCBs) concentrations ranged from 0.003 mg/kg to a maximum of 1.46 mg/kg. Two samples had total PCBs concentrations higher than 1.0 mg/kg, three samples had concentrations between 0.5 and 1.0 mg/kg, nine samples ranged from 0.2 to 0.5 mg/kg, and the remaining 87 samples had concentrations below 0.2 mg/kg. All of the nine sampled jurisdictions except for Burlingame and San Carlos had at least one sample over 0.2 mg/kg, and each of the five samples over 0.5 mg/kg fell within a different jurisdiction. Appendix A contains detailed documentation for each sample including location coordinates, sample location type (i.e., inlet, street dirt, manhole, pump station), and total PCBs and mercury concentrations measured.

3.1.1. Bay Area Sampling Comparison

Over the past 15 years over 950 sediment samples from the Bay Area have been analyzed for total PCBs. When compared to prior PCB sampling conducted in the Bay Area, a smaller percent of samples from this project had elevated PCB concentrations (i.e., above 0.5 mg/kg). Two samples from this study (2.0%) had concentrations over 1.0 mg/kg compared with 10.2% for the full Bay Area dataset, and three samples (3.0%) had concentrations between 0.5 and 1.0 mg/kg compared with 6.4% for the full Bay Area dataset. The percentage of samples with concentrations between 0.2 and 0.5 mg/kg from this study was similar to the full Bay Area dataset at roughly 9%. The higher rate of elevated samples in prior sampling may partly be attributed to past sampling efforts including further characterization of areas of known PCBs pollution. Such areas include the Pulgas Creek pump station catchment in San Carlos, the Ettie Street pump station catchment in Oakland, the Leo Avenue catchment in San Jose, and the Lauritzen and Parr Channel catchments in Richmond. A disproportionate number of samples with PCB concentrations over 1.0 mg/kg are located in Oakland, with 43% of the total.

The results of the samples in this project relative to the full Bay Area dataset is illustrated in Table 3 and Figure 1. The median total PCBs concentration for both datasets is 0.04 mg/kg, indicating that while there is a higher proportion of samples over 0.5 mg/kg in the full Bay Area dataset, there is also a higher proportion of samples that fall below 0.01 mg/kg. Seventy-four of the samples from this project (73%) have concentrations between 0.01 and 0.1 mg/kg. This group of samples is relatively uniformly distributed on a logarithmic scale which is characteristic of skewed environmental contaminant data with elevated samples among relatively widespread low level background concentrations (i.e., of PCBs in the study area).

Table 3. PCB Results by City and Concentration Category

Permittee	Total PCBs (mg/kg)					Number of Samples				
	Max	Mean	Percentile			> 1 (mg/kg)	0.5 - 1.0 (mg/kg)	0.2 - 0.5 (mg/kg)	< 0.2 (mg/kg)	Total
			50th	75th	90th					
Brisbane	1.22	0.03	0.04			1			4	5
Burlingame	0.15	0.17	0.05						11	11
East Palo Alto	0.34	0.06	0.05					2	5	7
Menlo Park	0.57	0.17	0.03				1*	2	6	9
Redwood City	0.57	0.09	0.04				1	1	15	17
San Carlos	0.1	0.06	0.04						5	5
San Mateo	0.23	0.06	0.05					1	9	10
South San Francisco	1.46	0.15	0.04			1		3	21	25
Unincorporated San Mateo County	0.93	0.11	0.04				1		11	12
Total	1.46	0.11	0.04	0.09	0.29	2	3	9	87	101
Full Bay Area dataset	193	0.77	0.04	0.19	0.93	101	65	98	804	1068

*The sediment in this sample appeared to at least partially originate from within Redwood City.

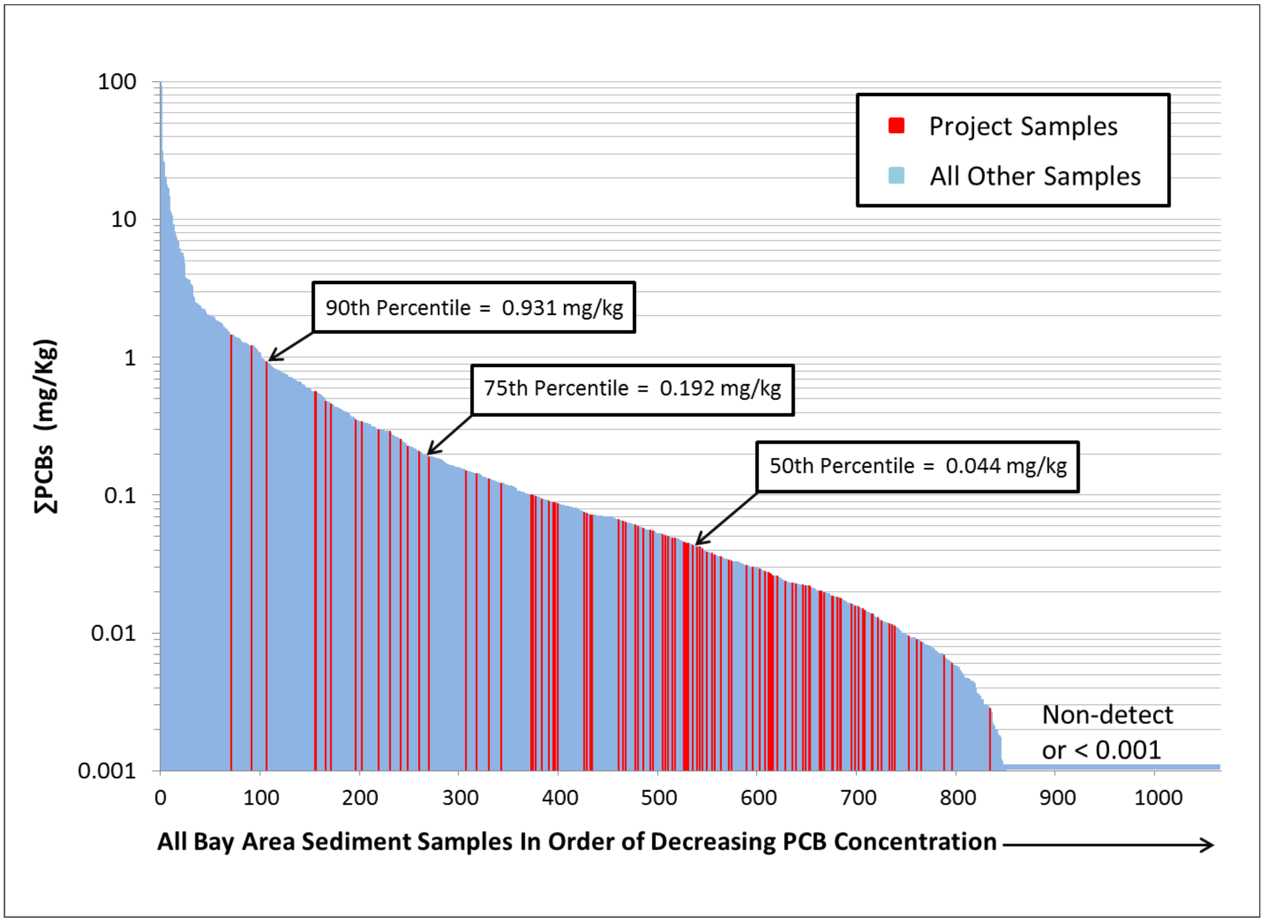

Figure 1. PCB results of the 101 samples from this project compared to the full Bay Area dataset.

3.1.2. Sample Catchment Area Mapping

The contributing area for each individual sample station was approximately delineated using GIS. These catchment areas represent the potential source area for sediment at the sample stations and range from 0.5 to 181 acres with a median size of 11 acres. For the majority of samples, the catchment area was delineated using GIS storm drain data in conjunction with field notes. If the sample was collected from a driveway, the catchment area of that station was assumed to be all or a portion of the parcel from which the sediment could have been tracked.

Of the 5,237 acres of old industrial parcels in San Mateo County that drain to the Bay, approximately 1,560 acres were characterized through sediment sampling as part of this project. The five samples from this study with total PCB concentrations greater than 0.5 mg/kg mostly drain areas characterized as *High - Low*, *Moderate*, and *Redeveloped - High* interest. Table 4 contains the sampling results cross-referenced to the parcel interest category.

There did not appear to be a trend toward parcels of higher interest contributing runoff to sediment sample stations with higher concentrations of PCBs. Possible explanations for this somewhat unexpected finding include:

- There are many uncertainties and areas of subjectivity in the process to screen for higher interest areas before sampling, including the limited amount and quality of historical land use data available, and challenges related to aerial photograph and field reconnaissance results interpretation.

- One characteristic that may result in export of PCBs from a parcel, but was not screened for, was the potential contribution associated with sealants, caulks and other materials that may contain PCBs found in certain types of buildings primarily constructed in the 1950s through the 1970s.
- Parcels that potentially contribute a large quantity of sediment to the storm drainage system were targeted because of their potential to contribute a relatively large mass of pollutants that bind to sediments such as PCBs and mercury. However, the classification and priority ranking processes may have placed too much weight on unpaved parcels. For example, many parcels are of a higher interest category simply because of the presence of unpaved areas or vehicle tracking, regardless of other factors that would contribute to a higher PCB concentration on the parcel.
- For some catchments, the majority of a sample catchment area may exhibit background levels of PCB concentration, with a relatively small area within the catchment having elevated concentrations. Therefore, PCB concentrations may be diluted at the sample station, especially for sample locations draining larger catchments. Thus it may be necessary to characterize smaller catchments with each sample, which would increase the ratio of the number of samples collected to the area characterized, resulting in a higher cost per unit area characterized. However, it should be noted that a relatively clear signal has been found from some relatively large catchments in the past, including the Pulgas Creek pump station watershed, which has an area of approximately 250 acres.

Table 4. Acres of PCB concentration category by parcel interest category

Parcel Interest Category	Approximate Area Draining to Sample Location (acres)					Not Sampled	Total Area
	> 1.0 mg/kg	0.5 - 1.0 mg/kg	0.2 - 0.5 mg/kg	< 0.2 mg/kg	Total		
High - High	0.0	1.0	65.8	160.2	227.0	913.6	1,140.6
High - Moderate	2.5	4.8	22.4	131.0	160.8	766.4	927.2
High - Low	12.6	5.5	39.9	251.8	309.8	395.4	705.2
Moderate	36.1	15.1	43.2	397.4	491.8	798.6	1,290.4
Redeveloped - High	0.0	22.4	1.3	40.6	64.3	235.0	299.4
Redeveloped - Moderate	0.0	1.0	7.5	42.3	50.8	102.2	153.0
Redeveloped - Low	8.0	4.0	5.1	238.4	255.4	465.7	721.1
Total	59.2	53.7	185.2	1,261.8	1,559.9	3,676.9	5,236.8

3.2. PCB Sampling Results by Permittee

This section describes the PCBs sampling results for each of the nine Permittees where samples were collected. A map of sample locations is included for each Permittee along with a general description of land uses. The five samples with total PCBs concentrations over 0.5 mg/kg are shown in **bold** font and examined in detail. These sample locations and their corresponding catchment areas could potentially be targeted by future source investigations. Additional investigation would involve taking additional samples, collecting field data, interviewing property managers, and researching historical data.

3.2.1. Brisbane

A total of 810 acres of old industrial parcels[1] was mapped in the City of Brisbane. Of these, 605 acres were classified as *High* interest potential source areas and 254 acres were prioritized as *High - High*. Since 1980, 39 acres of old industrial were redeveloped; four of those acres were prioritized as Redeveloped-High.

The City of Brisbane contains what is known as the Brisbane Baylands[2], an area of approximately 660 acres between Bayshore Boulevard and Highway 101 that was prioritized mostly as *High - High* or *High - Moderate* interest. Approximately 140 acres of the Brisbane Baylands contains a former large railroad yard and the current Caltrain (Peninsula Corridor Joint Powers Board or PCJPB) right-of-way. On the east side of the railroad and to the west of Highway 101, are several large parcels including a soil processing facility that imports and exports large quantities of recycled soil and is located on top of an old landfill[3]. This facility has stormwater treatment and is required to test the soil for PCBs and many other pollutants. Most of the area is not publically accessible and does not appear to have many suitable locations for sampling. Moreover, the former railyard area and surroundings are currently being remediated for various pollutants not including PCBs, and the entire Brisbane Baylands is expected to eventually be redeveloped into a mix of commercial development, parkland, and open space (CDM, 2005). Given the scale of the planned redevelopment, no sampling from the Brisbane Baylands area was recommended for this study.

Five samples were collected in Brisbane, with three located along Industrial Way. These sample locations drain a total area of approximately 80 acres. PCB sampling results for sediments collected in the City of Brisbane are mapped in Figure 2.

- Sample **SM-BRI-02-A**, collected from a manhole near the intersection of Valley Drive and Park Lane (Figure 3), was the only elevated (greater than 0.5 mg/kg) sample from Brisbane and had a total PCBs concentration of 1.22 mg/kg (0.51 mg/kg with USEPA method 1668A). This manhole accesses a large storm drainage pipe approximately 10 feet in diameter along the north side of Valley Drive that closely parallels a second pipe of equal diameter on the south side of Valley Drive. From where the sample was taken, these pipes do not appear to be connected, but may be connected upstream such that they would share a large portion of their drainage area. Together these two pipes drain a very large area including approximately 190 acres of light industrial land uses, two relatively new residential subdivisions, a large quarry, and over 700 acres of open space (Figure 3). The City of Brisbane does not have GIS or CAD data available for their storm drain network, making delineation of the sample catchment area relatively

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[1] In this discussion and in descriptions for other Permittees, “old industrial” includes other land uses associated with PCBs or mercury (e.g., recycling, railroads, military) that were compiled as part of Step 1 of the iterative process described in Section 2.1.

[2] Additional information can be found at: http://www.ci.brisbane.ca.us/baylands-information

[3] Additional information can be found at: http://thebaylands.com/

challenging. The storm drain lines shown in Figure 3 were obtained from the GIS data files available for download that were created by the Oakland Museum of California and appear in the Creek & Watershed Map of Daly City & Vicinity (Givler et al. 2006). These GIS data files only include storm drain lines greater than 24 inches in diameter and are not drawn at a resolution to determine the catchment area for this sample. Therefore, a first step in further investigation of elevated PCB concentrations in this area should be working with City staff to better understand the storm drain network and to improve the catchment area delineation.

The area of old industrial land use in the catchment area consists of large light industrial lots developed in the 1960s and 1970s, as well as a network of old railroad right-of-ways that have mostly been converted to multi-use recreational trails and remain unpaved. The catchment is primarily composed of parcels classified as *Moderate* interest, with the old railroad parcels and three others classified and prioritized as *High - Moderate* or *High - Low*. The sample itself had the smell of both petroleum and sulfides and was black in color.

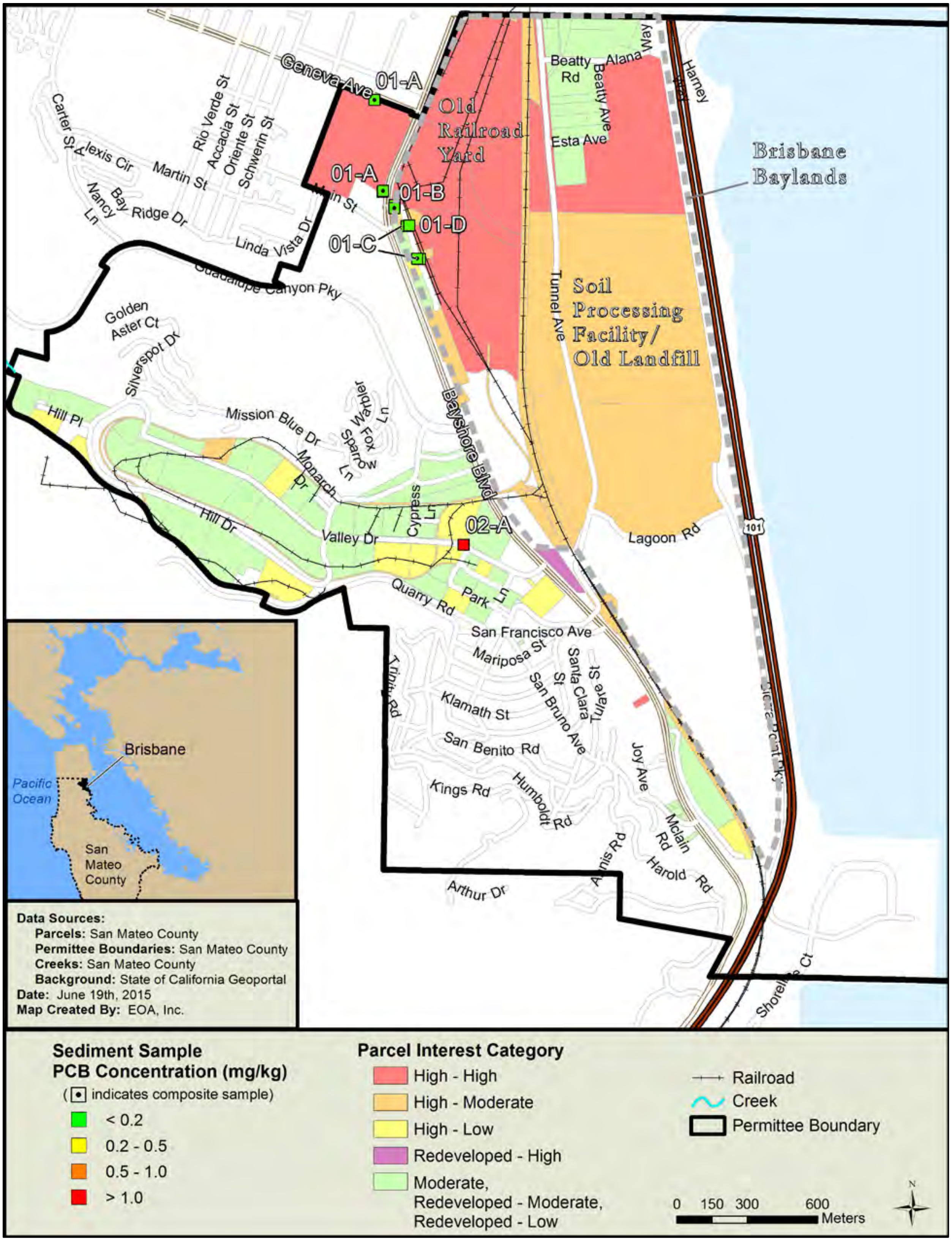

Figure 2. Map of PCB sampling results for the City of Brisbane.

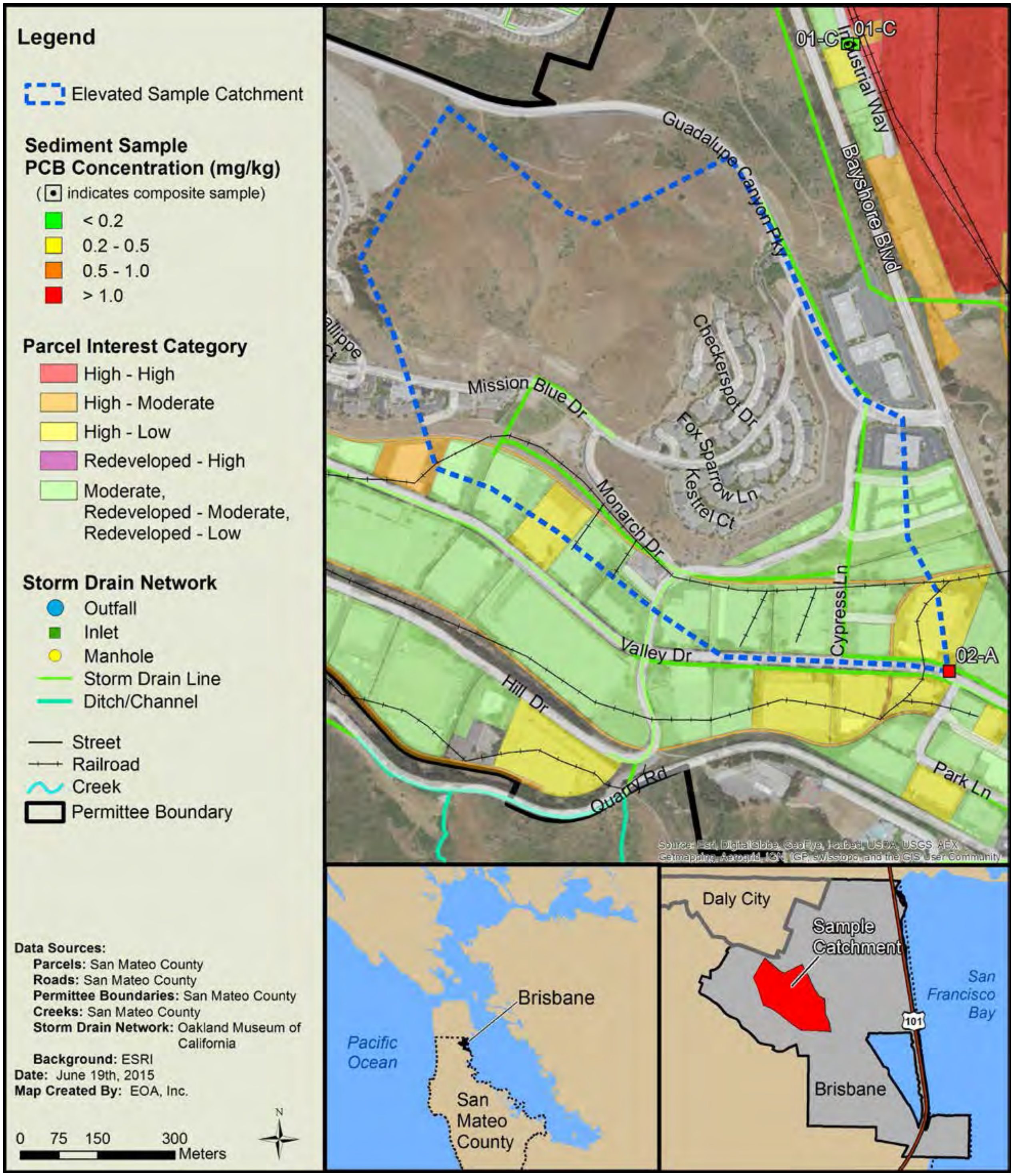

Figure 3. Map of the approximate catchment area for elevated sample SM-BRI-02-A, City of Brisbane.

3.2.2. Burlingame

A total of 346 acres of old industrial parcels were mapped in the City of Burlingame. Of these, 181 acres were classified as *High* interest potential source areas and three acres were prioritized as *High - High*. Since 1980, 34 acres of old industrial were redeveloped; three of those acres were prioritized as *Redeveloped-High*. The industries within Burlingame are primarily not heavy industrial (e.g., metal manufacturing, parts fabrication) or recycling, and therefore less likely to have a history of PCB use. Many of the industrial zoned properties contain businesses that are not normally considered industrial such as food production, office space, retail, gymnasiums, and restaurants.

Eleven samples were collected in Burlingame, at locations that drain a total of approximately 208 acres. None of the samples were elevated (i.e. greater than 0.5 mg/kg), with the highest total PCBs concentration in a sample being 0.15 mg/kg. Three of the eleven samples were collected from pump station wet wells, with the highest of these samples having a concentration of 0.06 mg/kg. PCB sampling results for sediments collected in the City of Burlingame are mapped in Figure 4.

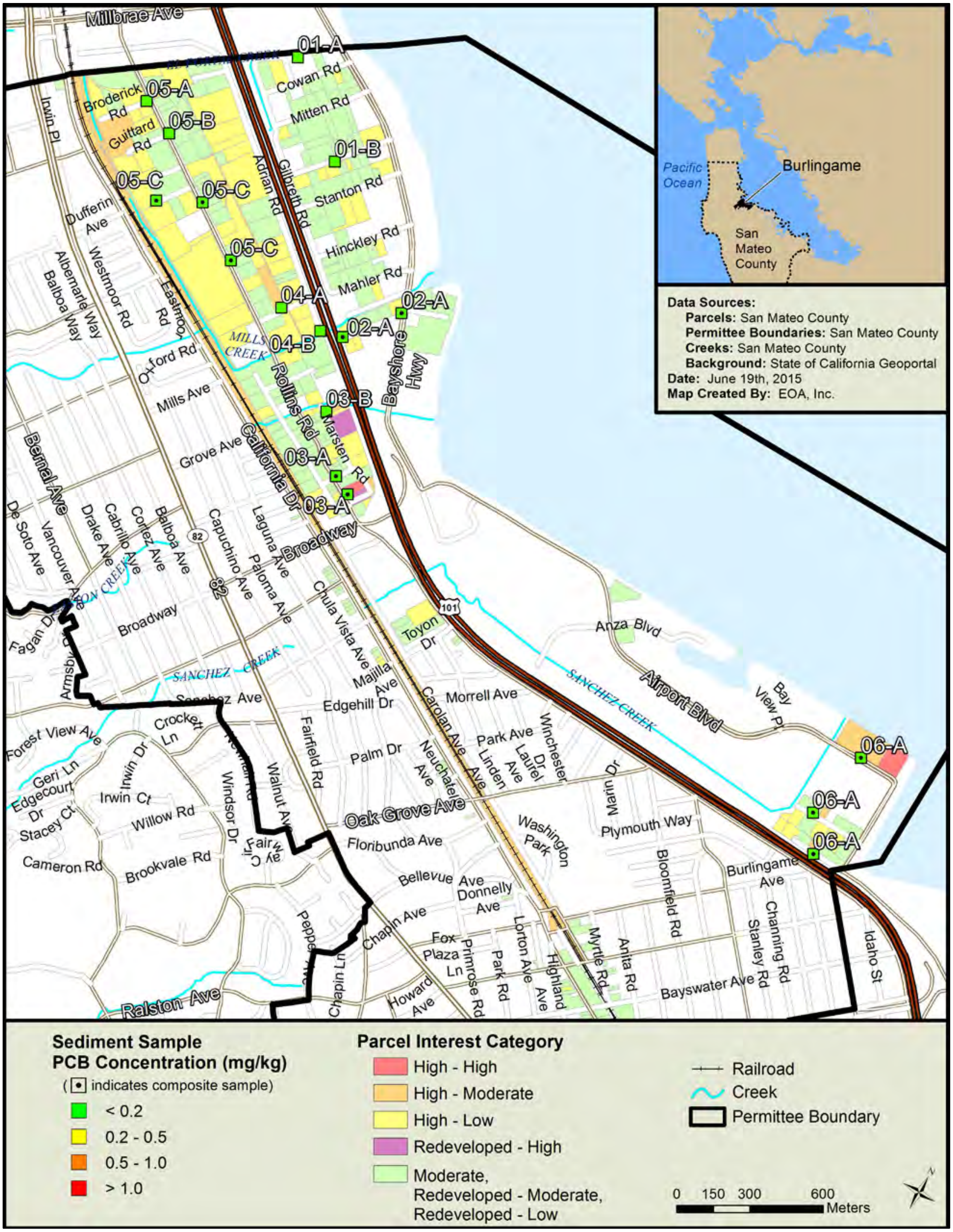

Figure 4. Map of PCB sampling results for the City of Burlingame.

3.2.3. East Palo Alto

A total of 115 acres of old industrial parcels were mapped in the City of East Palo Alto. Of these, 92 acres were classified as *High* interest potential source areas and 37 acres were prioritized as *High - High*. Since 1980, 28 acres of old industrial were redeveloped; 17 of those acres were prioritized as *Redeveloped-High*. Seven samples were collected in East Palo Alto at locations that drain a total of approximately 56 acres.

Along Bay Road in the northeast corner of the industrial area of East Palo Alto is the closed Romic Environmental Technologies Corporation site, a 12.6-acre property closed in 2007 that handled hazardous waste, and is known to contain PCB contaminated soil. The property is undergoing remediation by the USEPA in partnership with the California Department of Toxic Substances (DTSC), and is a Resource Conservation and Recovery Act (RCRA) site. Stormwater from the site is treated and released directly to the Bay without entering East Palo Alto's storm drainage system. Sample SM-EPA-01-C, which was a composite of four locations near the boundary of the site, contained low concentrations of PCBs (0.02 mg/kg).

Many of the *High – High* and *High – Moderate* parcels within East Palo Alto are currently vacant and a large area between Bay Road, Weeks Street, and Pulgas Ave will soon be redeveloped. PCB sampling results for sediments collected in the City of East Palo Alto are mapped in Figure 5.

None of the seven samples had elevated total PCBs concentrations (greater than 0.5 mg/kg) and two samples were between 0.2 and 0.5 mg/kg (Figure 5).

- Sample SM-EPA-02-D had a concentration of 0.34 mg/kg, and was collected from a manhole that drains a relatively large area along Weeks Street and to the north along Pulgas Avenue. Sample SM-EPA-02-A was collected from the manhole immediately upstream of SM-EPA-02-D along Pulgas Avenue and had a relatively low total PCBs concentration (0.05 mg/kg), suggesting that the source of PCBs could be along Weeks Street. The three large *High – Moderate* priority sites along Weeks Street have never contained industrial businesses, but are all classified as "site with open/active remediation and deed restriction" by the City suggesting existing pollution concerns (Figure 6) (DTSC 2005). Deed restrictions often will prevent a parcel from being developed into land uses such as residential, hospitals, schools, and day care centers, but will allow the development of land uses such as industrial, office, or commercial spaces.
- Sample SM-EPA-01-A had a concentration of 0.21 mg/kg (0.25 mg/kg with USEPA method 1668A), and was collected from a manhole that receives drainage from nearly all of Demeter Street. The sediment collected was black with a hydrogen sulfide smell, and the water surface had an oily sheen.

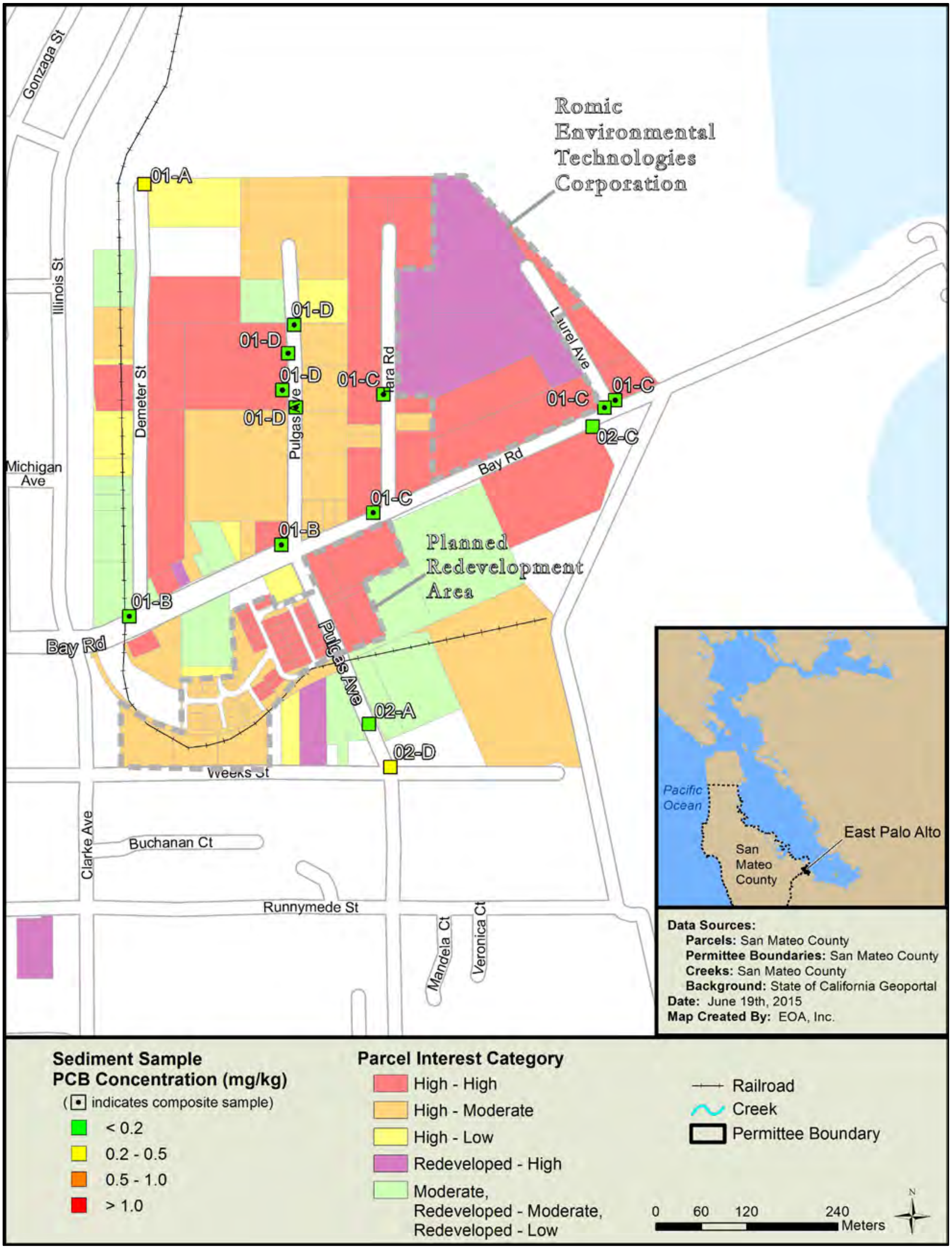

Figure 5. Map of PCB sampling results for the City of East Palo Alto

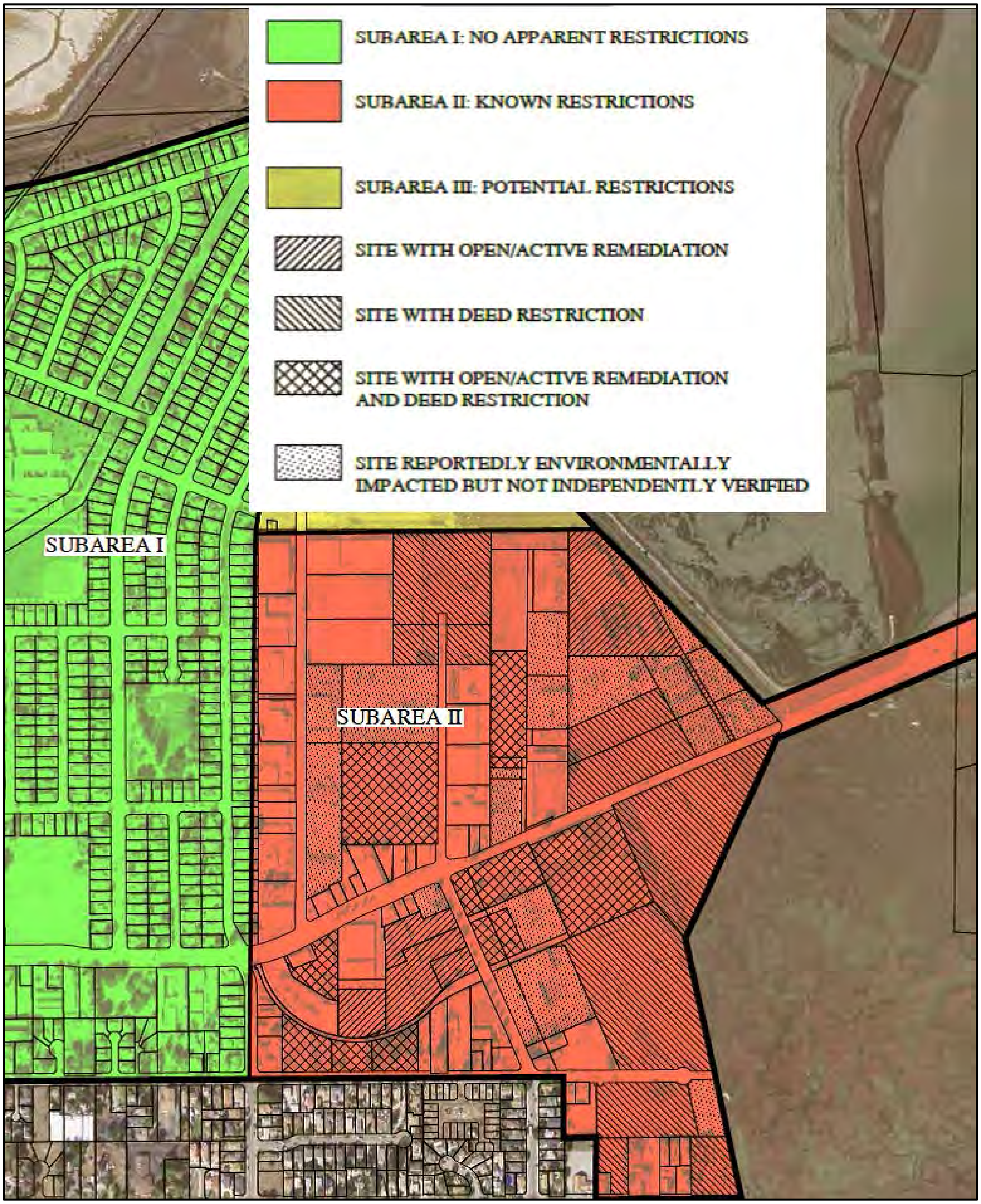

Figure 6. Building Restrictions within the City of East Palo Alto
Map Source: Michelle Daher, Environmental Coordinator, City of East Palo Alto

3.2.4. Menlo Park

A total of 426 acres of old industrial parcels were mapped in the City of Menlo Park. Of these, 271 acres were classified as *High* interest potential source areas and 126 acres were prioritized as *High - High*. Since 1980, 70 acres of old industrial were redeveloped; 35 of those acres were prioritized as *Redeveloped - High*.

Facebook is has recently finished redeveloping a large industrial property between Highway 84 and the Dumbarton railroad right-of-way formerly owned by Raychem and Tyco Electronics Corporation (Atkins 2012). The large *High - High* interest property to the west of the new Facebook campus is owned by Tyco Electronics Corporation. Both of these properties have been historically polluted with PCBs, but remediation has occurred (Atkins 2012). Portions of these properties drain to a ditch that runs along the south side of Highway 84 and eventually discharges directly to the Bay without entering the City of Menlo Park's storm drainage network. There is also a large multifamily development being built on the south side of the railroad right-of-way along Hamilton Avenue that is replacing a number of old industrial parcels of higher interest. An effort was made to sample along Hamilton Avenue, Campbell Avenue, and Scott Drive, but sediment was not found in the storm drainage system along these streets.

Nine samples were collected in the City of Menlo Park at locations that drain a total of approximately 150 acres. Two samples had total PCBs concentrations in the 0.2 – 0.5 mg/kg range and one in the elevated (0.5 – 1.0 mg/kg) range. PCB sampling results for sediments collected in the City of Menlo Park are mapped in Figure 7.

- Sample SM-MPK-04-E was a composite from two manholes located near the main entrance of Tyco Electronics Corporation and had a total PCBs concentration of 0.29 mg/kg. Half of the sample was collected from a large pipe near Highway 84 that appears to drain part of the Tyco Electronics parcel. The other half of the sample was collected at Chilco Street and Constitution Drive, a location that drains a small catchment without any parcels prioritized as High-High.

- Sample SM-MPK-04-D was collected from an inlet near 188 Constitution Drive and had a total PCBs concentration of 0.25 mg/kg. The inlet connects to a 30-inch diameter inflow and outflow pipe and drains a catchment that includes all of Constitution Drive to the east including a small portion of the Tyco Electronics Corporation property near its entrance.

- Sample **SM-MPK-02-B** is a composite sample from two locations in Menlo Park on the Redwood City border (Figure 8). The sample had a total PCBs concentration of 0.57 mg/kg (1.14 mg/kg with USEPA method 1668A). A field duplicate of this sample had a total PCBs concentration of 0.76 mg/kg (method 8082M). Half of the sample came from an inlet in front of a large 394-unit housing development that is currently being built and will reportedly be finished by the spring of 2016[4]. The inlet has three pipes flowing into it, the largest of which is a 24-inch diameter pipe originating across the street in Redwood City. The current construction site appears to be a source of sediment to the storm drainage system, although most of the sediment collected was inside of the Redwood City pipe, and did not appear to come from the construction site. The sediment in the sample was black and there was a sheen observed on the water when the sediments were disturbed. The other half of the sample was collected from a manhole at the entrance to Haven Court just before the storm drain line empties into a vault and then into Atherton Channel. The catchment for this half of the sample is only what flows into two inlets

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[4] Additional information can be found at: http://menlopark.org/892/St-Anton

located at the same intersection including two *High-High* interest parcels on the north side of Haven Avenue.

- Sample SM-RCY-10-A was collected from an inlet in front of 3562 Haven Avenue in Redwood City that drains an area that is a subset of the catchment area of sample **SM-MPK-02-B**. Sample SM-RCY-10-A had a total PCBs concentration of 0.04 mg/kg. Therefore, it is unlikely that the elevated concentrations measured in sample **SM-MPK-02-B** originate in this portion of the catchment area, which is shown in crosshatching on the map in Figure 8.

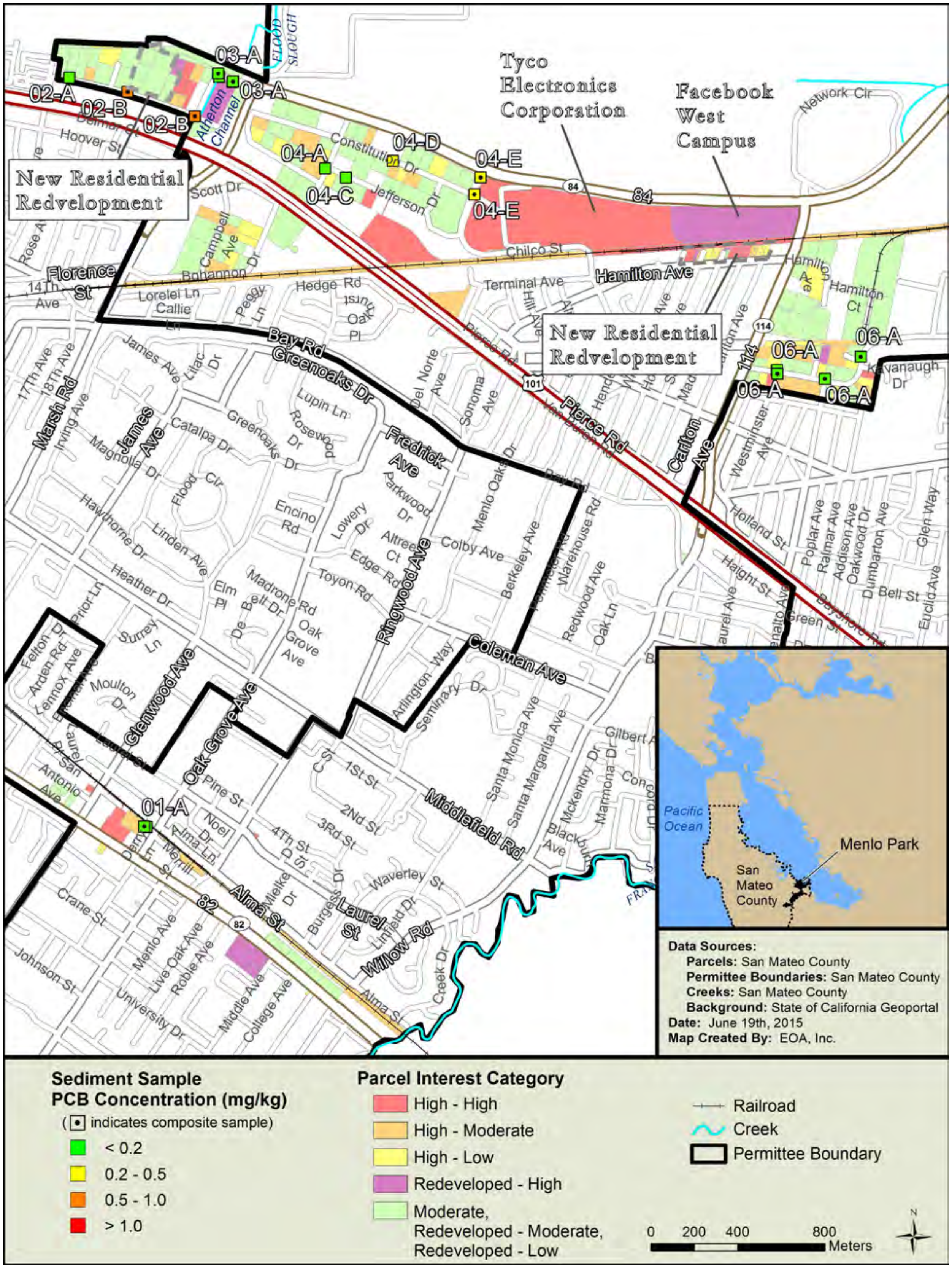

Figure 7. Map of PCB sampling results for the City of Menlo Park.

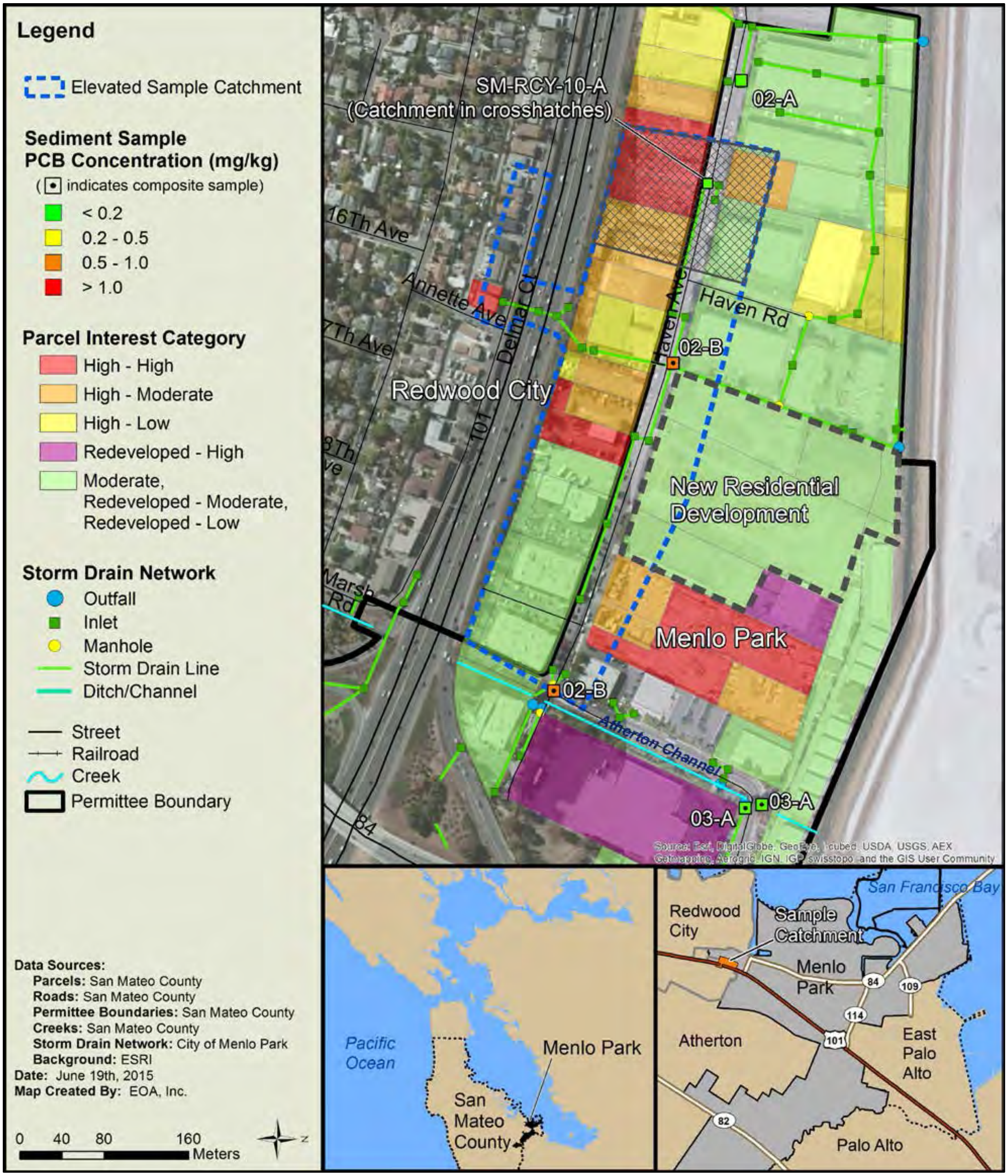

Figure 8. Map of the catchment for sample SM-MPK-02-B, City of Menlo Park.

3.2.5. Redwood City

A total of 482 acres of old industrial parcels were mapped in the City of Redwood City. Of these, 299 acres were classified as *High* interest potential source areas and 106 acres were prioritized as *High - High*. Since 1980, 203 acres of old industrial were redeveloped; 114 of those acres were prioritized as *Redeveloped-High*.

Seventeen samples were collected in Redwood City at locations that drain a total of approximately 129 acres. One of these samples had an elevated PCBs concentration (greater than 0.5 mg/kg) and one sample had a total PCBs concentration in the 0.2 – 0.5 mg/kg range. PCB sampling results for sediments collected in the City of Redwood City are mapped in Figure 9.

- Sample SM-RCY-07-B was collected from a manhole along Douglas Avenue near the intersection of Broadway Street, and had a total PCBs concentration of 0.25 mg/kg. This manhole accessed a large 36-inch pipe that drains a catchment area of approximately 117 acres including the 22-acre catchment area for sample **SM-SMC-06-C** which is located in the unincorporated community of North Fair Oaks. **SM-SMC-06-C** had a total PCBs concentration of 0.93 mg/kg and is discussed is more detail in Section 3.2.8, which describes sampling results from unincorporated San Mateo County.

- Sample **SM-RCY-05-A** was a composite of three locations in a drainage ditch that parallels most of the Port of Redwood City between Frontage Road and the industries along the Port (Figure 10). The sample had a total PCBs concentration of 0.57 mg/kg (1.26 mg/kg with USEPA method 1668A). The most northerly third of the sample was collected near a small substation, another third was collected outside of Sims Metal Management, and the final third of the sample was collected from a ditch adjacent to a large lot that has been vacant for at least a year. The ditch drains both north though the large sand and gravel business near the end of the Port and south to the Sequoia Yacht Club.

  Sims Metal Management is a large international metal recycling company that also has locations in Hayward, Richmond, San Francisco, and San Jose. On August 25, 2011 USEPA inspectors took eight samples on the Sims Metal Management property, including the ditch along the eastern border of the property where sample **SM-RCY-05-A** was taken (Garcia-Bakarich and Nagle 2011)[5]. The resulting total PCBs concentrations ranged from 0.09 mg/kg to 35.83 mg/kg, with all but the one in the ditch being over 1.0 mg/kg. High levels of mercury, lead, copper, and zinc were also reported. Since then, the USEPA has required the cleanup of some of the polluted areas, and has required measures to prevent future pollution. All stormwater from the property is treated onsite before it is discharged directly into the bay. The Sims Metal Management property does not currently drain to the ditch.

A recently released environmental report investigating PCBs pollution around the former Pentair Thermal Management site in Redwood City (2201 Bay Road) suggests there may be at least two additional sources of PCBs in Redwood City: one along Bay Road at the now vacant Pentair Thermal Management site and one along Spring Street just north of Highway 84 (AMEC 2015). Concentrations of total PCBs in two sediment samples collected from storm drain inlets in these locations were both over 1.0 mg/kg. However, a sample from the pump station downstream of these sites had a concentration of 0.07 mg/kg, indicating that average concentration of total PCBs from this storm drain line may be near Bay Area background levels.

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[5] Additional information can be found at: http://www.epa.gov/region9/mediacenter/sims-metal/

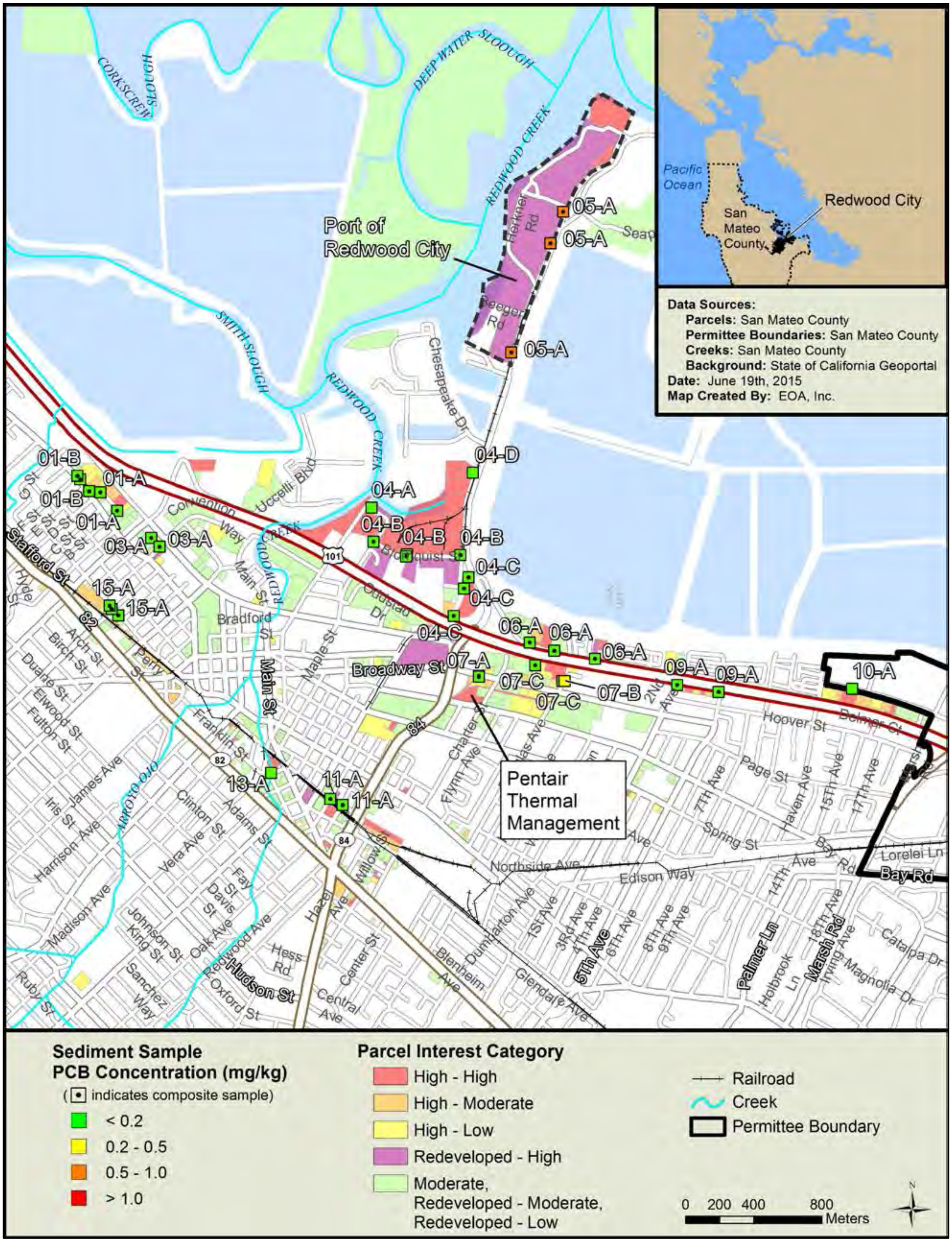

Figure 9. Map of PCB sampling results for the City of Redwood City.

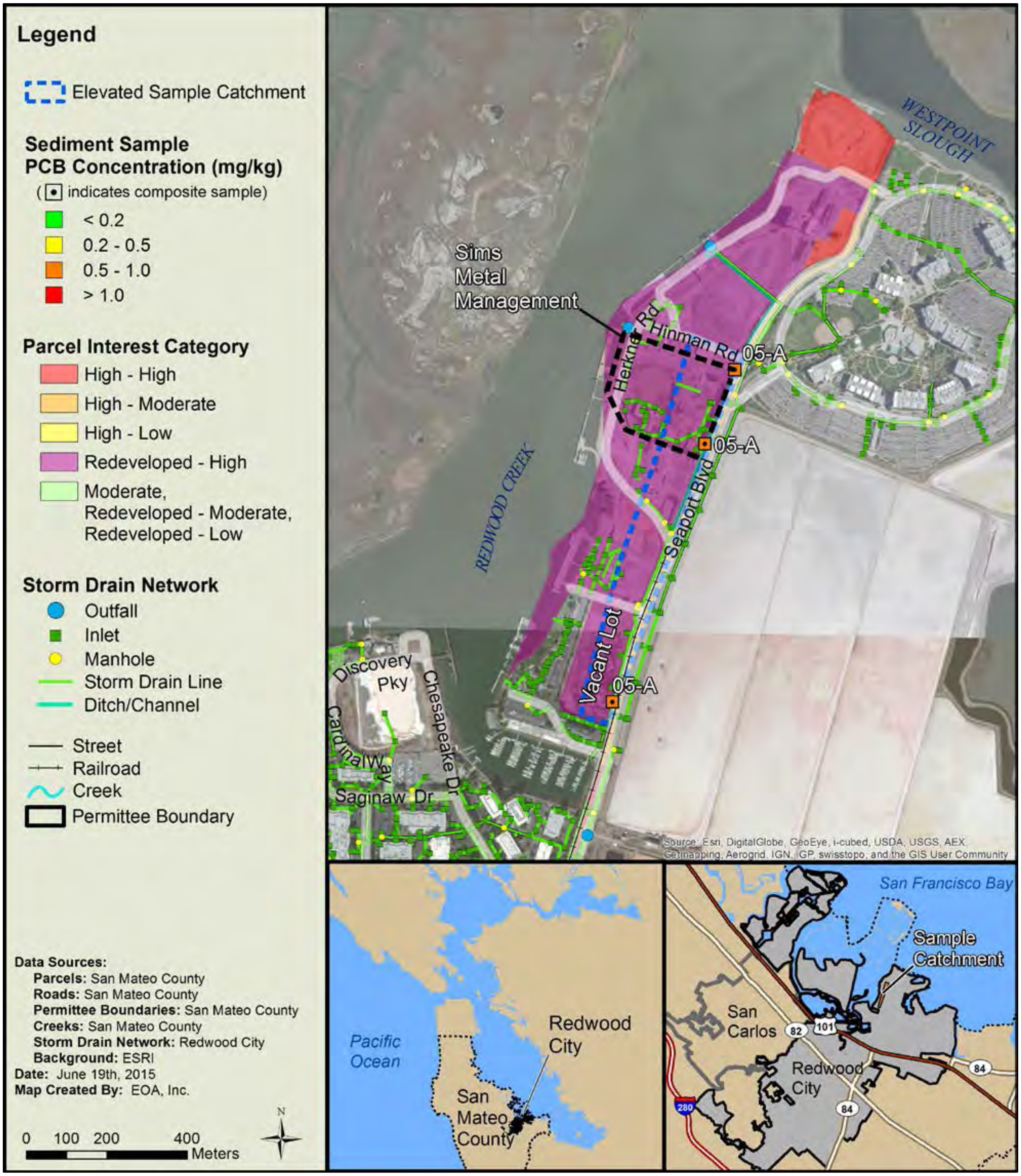

Figure 10. Map of the catchment for sample SM-RCY-05-A, City of Redwood City.

3.2.6. San Carlos

A total of 407 acres of old industrial parcels were mapped in the City of San Carlos. Of these, 191 acres were classified as *High* interest potential source areas and 44 acres were prioritized as *High - High*. Since 1980, 141 acres of old industrial were redeveloped; 32 of those acres were prioritized as *Redeveloped - High*.

There were five samples collected in San Carlos in locations that drain a total of approximately 62 acres. The highest total PCBs concentration was 0.10 mg/kg. PCB sampling results for sediments collected in the City of San Carlos are mapped in Figure 11.

A little more than half of the old industrial area of San Carlos is within the Pulgas Creek pump station catchment, which is known to contain multiple areas of elevated PCB concentration. This catchment has been the subject of a separate investigation, and therefore was not included in this project. North of the Pulgas Creek pump station catchment area along Industrial Road is a PG&E facility and Delta Star Incorporated, a property where transformers that contained PCBs were formerly manufactured. Remediation for PCBs and other pollutants at this site occurred from June 1989 to January 1991 (DTSC, 2003). Eight hundred cubic yards of contaminated soil were removed, clean soil was brought in, and the site was capped. Subsequent testing in 1998 found that the adjacent property, Tiegel Manufacturing Company (495 Bragato Road), was also contaminated with PCBs among other pollutants along its shared border with Delta Star. The Regional Water Board adopted site cleanup requirements (Order No. 99-062) for the site, and additional remediation occurred from October 2001 to February 2002 involving the removal of 1,283 tons of soil. Storm drain sampling conducted in 2001 found very elevated levels of PCBs (20 mg/kg) in a sample collected in piping beneath a manhole along Industrial Road next to the Tiegel property (KLI and EOA, 2002). As a result of that sample, in 2003 SMCWPPP referred the Delta Star site to the Regional Water Board for further investigation and cleanup.

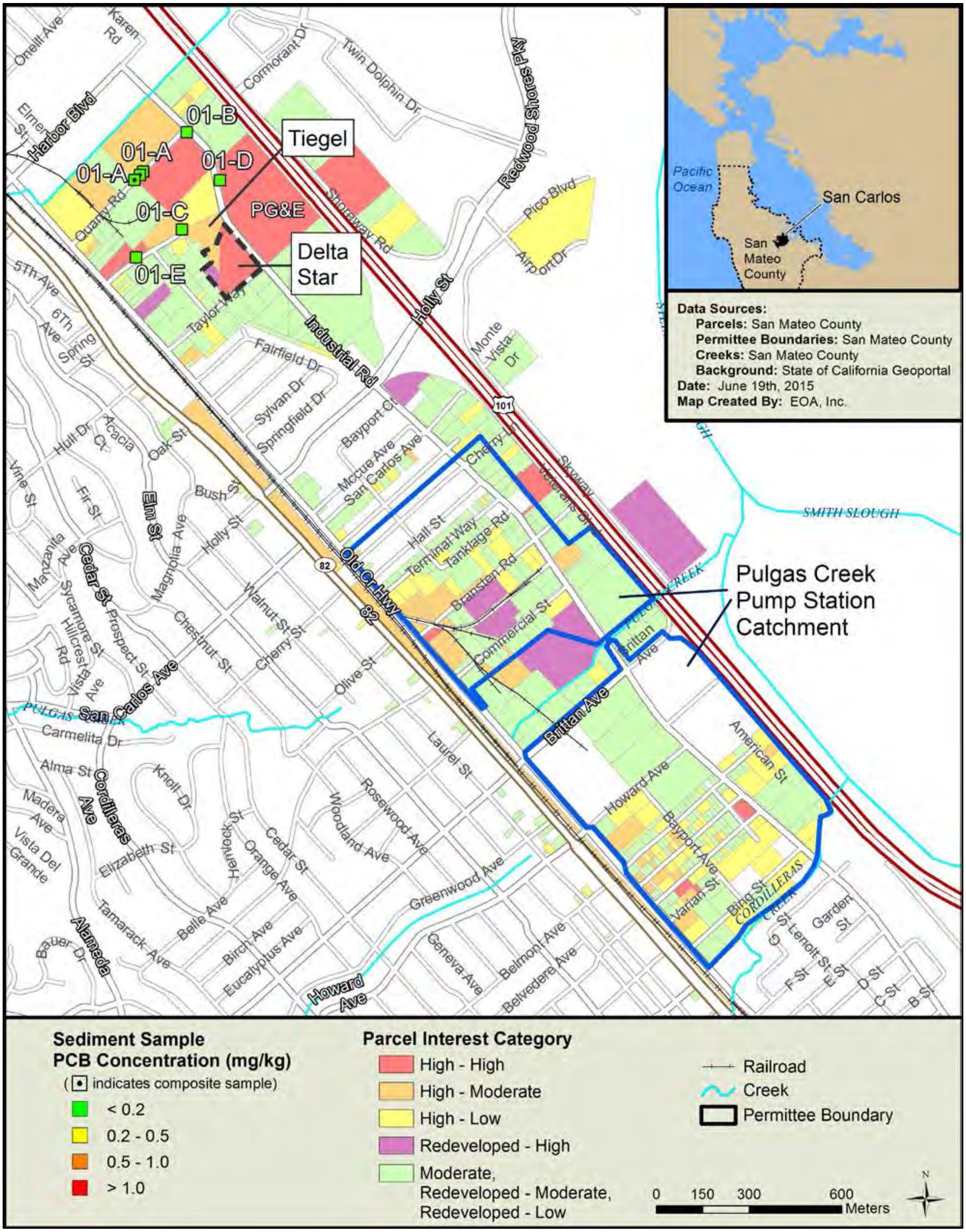

Figure 11. Map of PCB sampling results for the City of San Carlos.

3.2.7. San Mateo

A total of 264 acres of old industrial parcels were mapped in the City of San Mateo. Of these, 173 acres were classified as *High* interest potential source areas and 78 acres were prioritized as *High - High*. Since 1980, 63 acres of old industrial were redeveloped; 26 of those acres were prioritized as *Redeveloped - High*. The large *High - High* interest parcel in northern San Mateo on East Poplar Avenue near the Bay is a PG&E substation. The substation has stormwater treatment on site and drains directly to the Bay.

Ten samples were collected in the City of San Mateo at locations that drain a total of approximately 38 acres. None of these samples had an elevated total PCBs concentration (greater than 0.5 mg/kg). PCB sampling results for sediments collected in the City of San Mateo are mapped in Figure 12.

- Sample SM-SMO-06-A (0.23 mg/kg) was a composite of three locations, two inlets along Claremont Street and a ditch that drains the Caltrain (PCJPB) right-of-way. Both the ditch and one of the inlets appeared to lack an outlet, and a local resident told the field crew that the inlet floods when it rains.

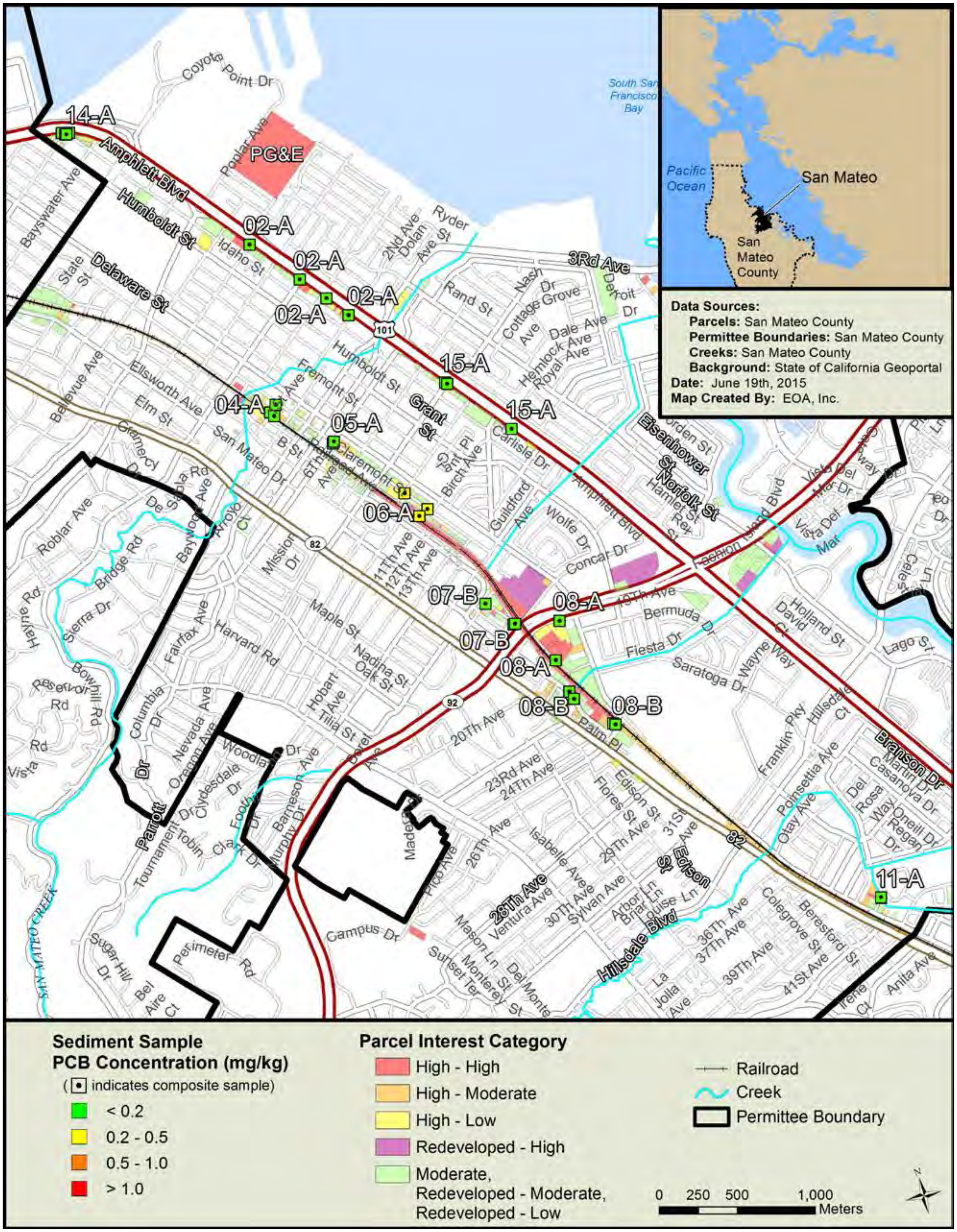

Figure 12. Map of PCB sampling results for the City of San Mateo.

3.2.8. San Mateo County Unincorporated

A total of 583 acres of old industrial parcels were mapped in unincorporated San Mateo County. Of these, 583 acres were classified as *High* interest potential source areas and 376 acres were prioritized as *High - High*. Since 1980, 17 acres of old industrial were redeveloped. None of those acres were prioritized as *Redeveloped - High*.

Twelve samples were collected in unincorporated areas of San Mateo County at locations that drain a total of approximately 66 acres. The majority of the *High* interest potential source areas are in the community of North Fair Oaks near Redwood City, and nine of the twelve samples were collected here (Figures 13 and 14). Sample **SM-SMC-06-C** on Bay Road near Douglas Ave had a total PCBs concentration of 0.93 mg/kg, and is discussed below. The remaining eleven samples had relatively low concentrations (less than 0.1 mg/kg).

- Sample **SM-SMC-06-C** was collected from a pipe beneath a manhole along Bay Road just southeast of the intersection with Douglas Ave and had a total PCBs concentration of 0.93 mg/kg (Figure 15). The catchment area for this sample station is approximately 22 acres, primarily in the unincorporated community of North Fair Oaks, and partially in Redwood City. None of the properties in the unincorporated area appeared to have private drainage infrastructure but instead appeared to drain directly out to the street. Flow into the sampled pipe originates from three inlets a block away at the intersection of Hurlingame Avenue and Bay Road. A fourth inlet in front of 2610 Bay Road also flows into this pipe at the manhole that was sampled.

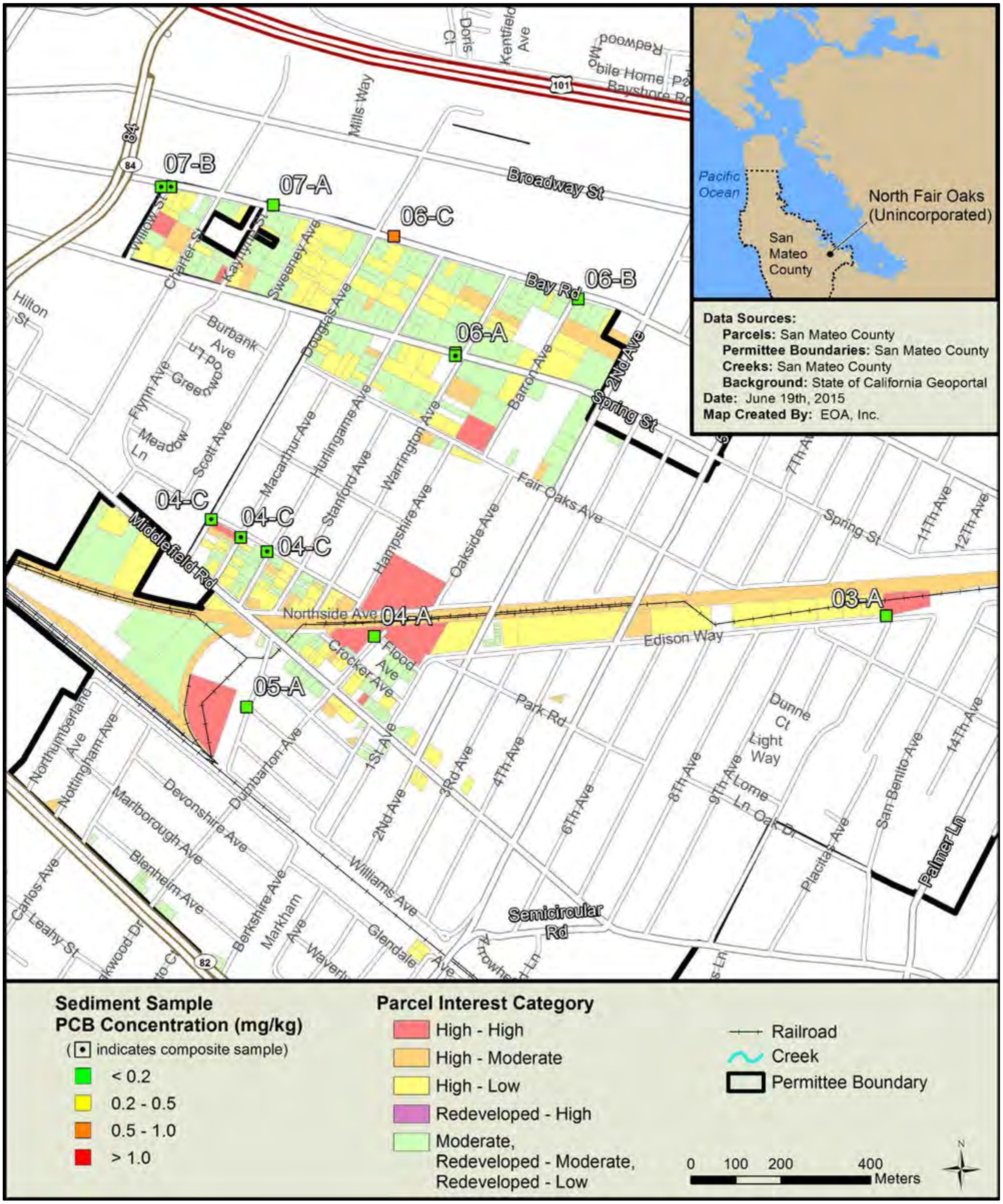

Figure 13. Map of PCB sampling results for the unincorporated community of North Fair Oaks

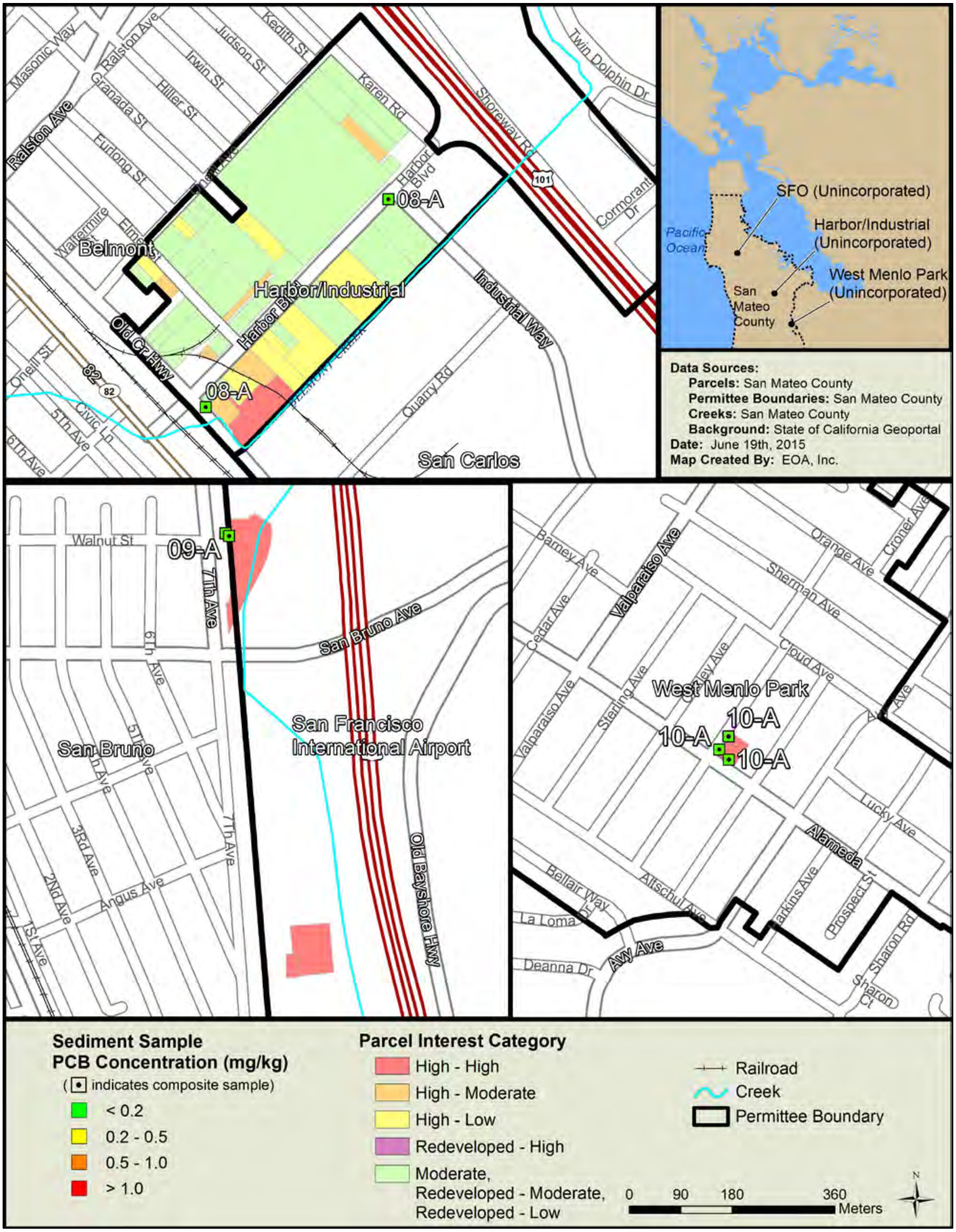

Figure 14. Map of PCB sampling results for other unincorporated communities in San Mateo County.

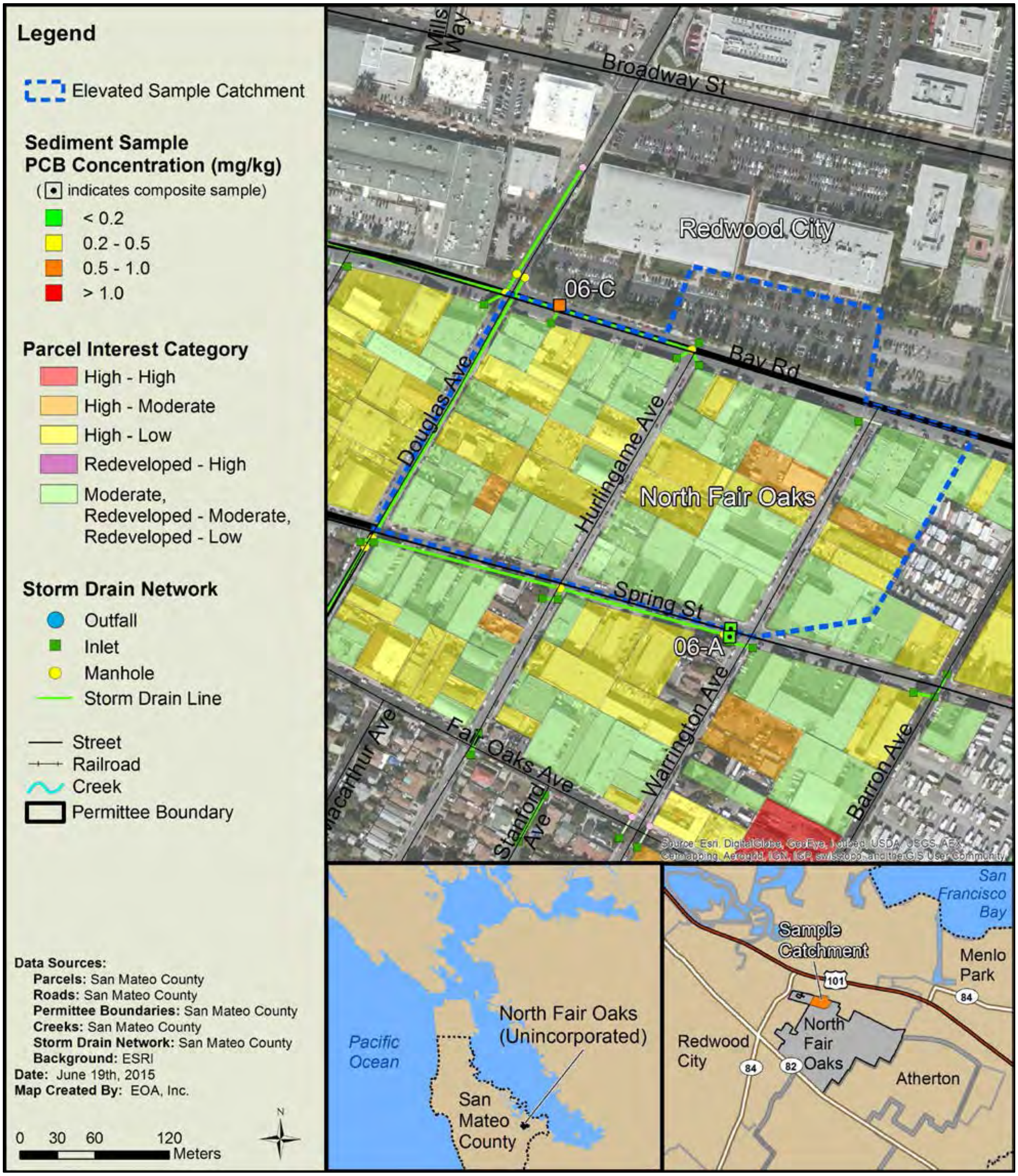

Figure 15. Map of the catchment for sample SM-SMC-06-A, unincorporated community of North Fair Oaks.

3.2.9. South San Francisco

A total of 1,466 acres of old industrial parcels were mapped in the City of South San Francisco the Permittee with the most acres of old industrial land uses in San Mateo County. Of these, 580 acres were classified as *High* interest potential source areas and 73 acres were prioritized as *High - High*. Since 1980, 551 acres of old industrial were redeveloped; 66 of those acres were prioritized as *Redeveloped - High*.

Twenty-five samples were collected in the City of South San Francisco at locations that drain a total of approximately 748 acres including 19 within the City of San Bruno. One elevated (greater than 0.5 mg/kg) sample was collected in South San Francisco which had a total PCBs concentration of 1.46 mg/kg. Three additional samples had total PCBs concentrations between 0.2 and 0.5 mg/kg. PCB sampling results for sediments collected in the City of South San Francisco are mapped in Figure 16.

- Sample SM-SSF-05-A had a concentration of 0.46 mg/kg (0.48 mg/kg with USEPA method 1668A), and was a composite of three inlets along Shaw Road.

- Sample SM-SSF-06-B also had total PCBs concentration of 0.48 mg/kg (0.72 mg/kg with USEPA method 1668A). This sample was a composite from two locations: an inlet with sediment that originated from a ditch along the Caltrain railroad, and sediment from a trench drain that drains two parcels containing multiple businesses including a construction supply company, a tour bus company, an architecture firm, and a recycling facility.

- Both sample SM-SSF-05-A and SM-SSF-06-B are slightly under 0.5 mg/kg threshold for additional investigation; however, it is likely that one of the composite locations for each sample was over 0.5 mg/kg.

- Sample **SM-SSF-04-A** had a total PCBs concentration of 1.46 mg/kg (Figure 17). It was collected from an inlet on the south side of Utah Avenue close to the outfall into Colma Creek. The inlet is tidal and was filled with about eight feet of water at the time the sample was taken. It is unknown if any sediment in the sample may have originated from Colma Creek and washed up into the storm drain line during the tidal cycle. Much of the storm drainage system near the Bay in South San Francisco is tidal, making it challenging to delineate sample catchment areas for inlets which may contain water and sediment from down along a storm drainage system.

- Sample SM-SSF-04-B had a total PCBs concentration of 0.30 mg/kg. The catchment includes the southern half of Beacon Street, and drains mostly parcels of *Moderate* interest.

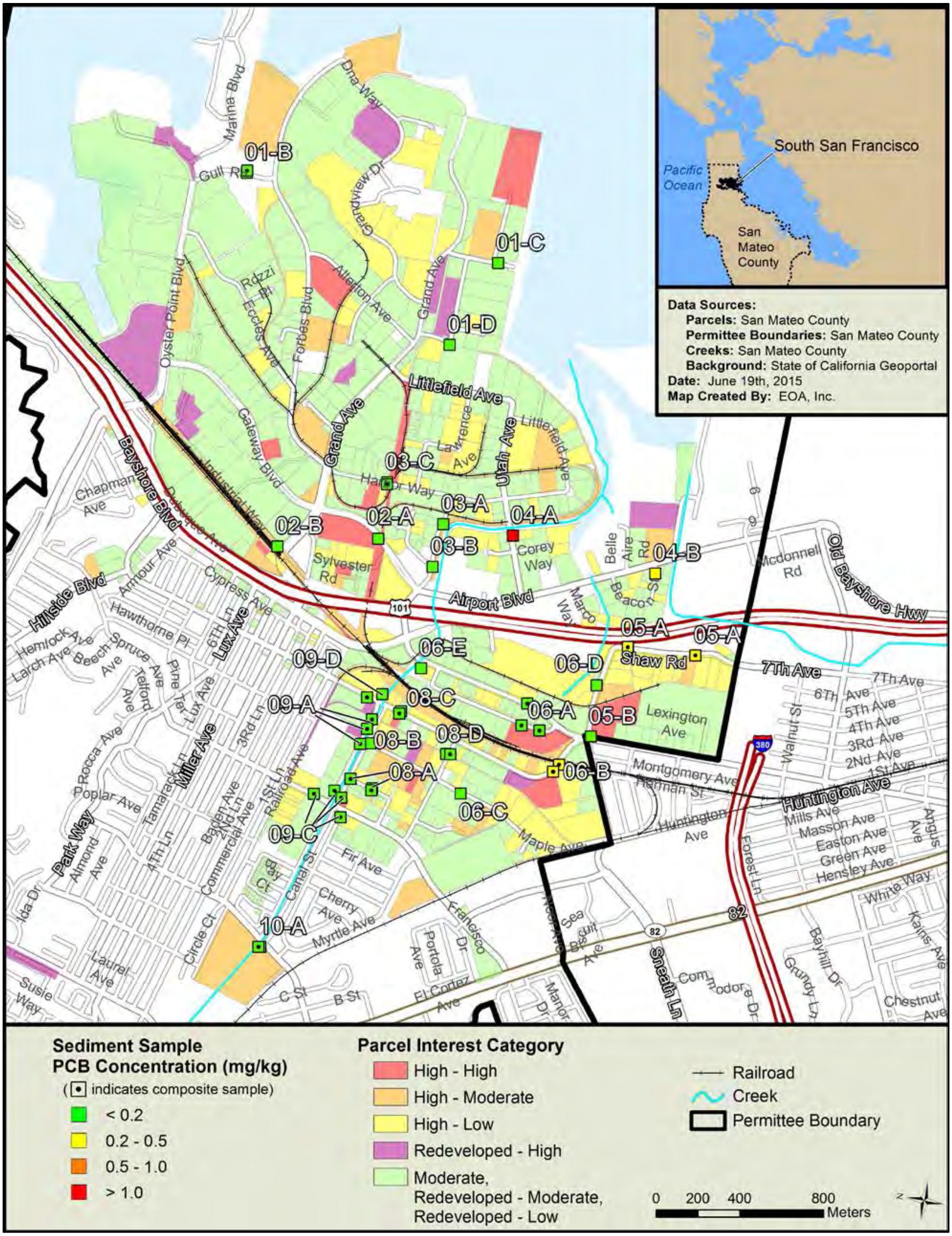

Figure 16. Map of PCB sampling results for the City of South San Francisco

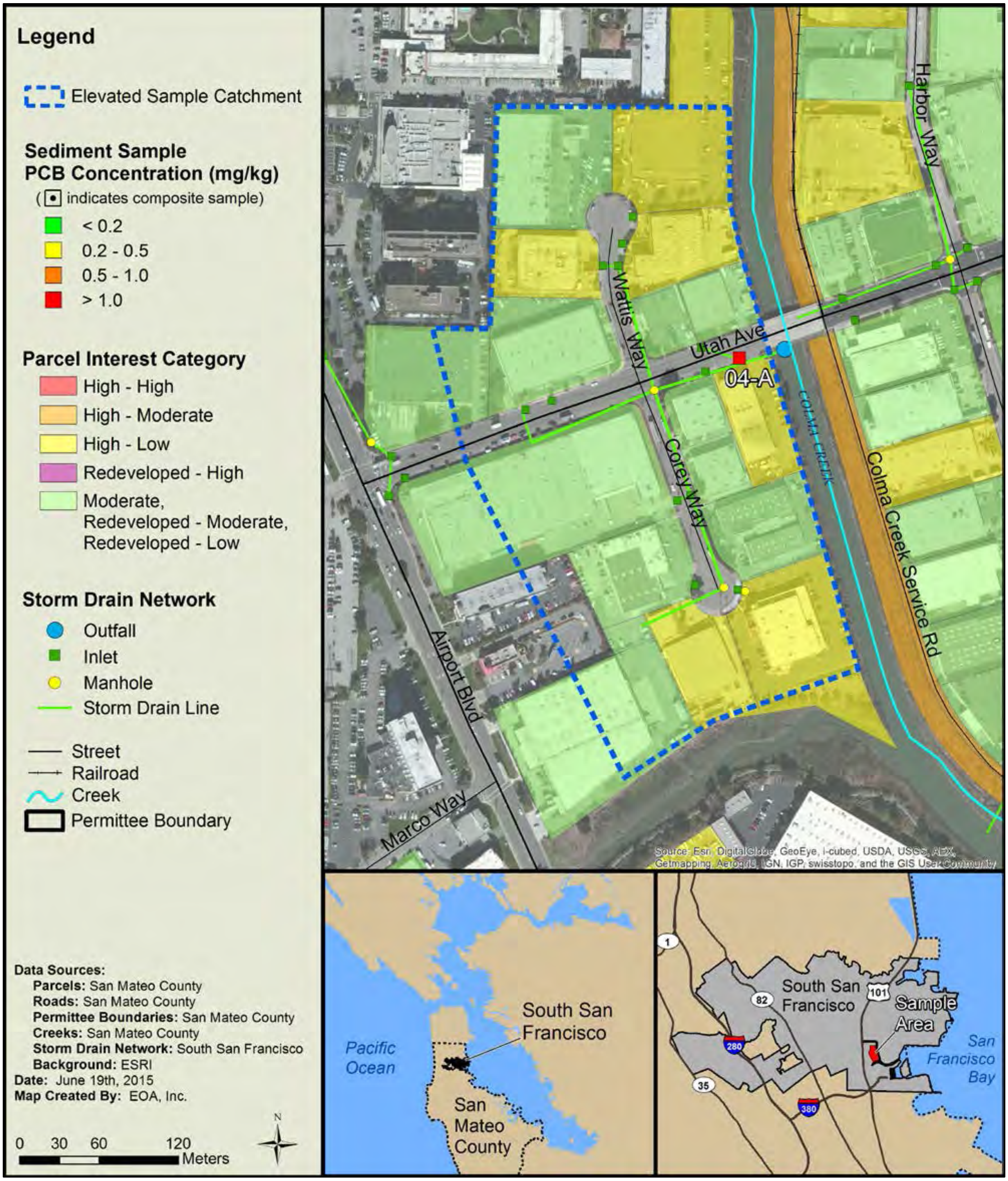

Figure 17. Map of the approximate catchment for sample SM-SSF-04-A, City of South San Francisco.

3.3. Mercury Sampling Results

Total mercury concentrations were analyzed for each of the 101 samples. Five samples had concentrations over 0.5 mg/kg of which two had concentrations over 1.0 mg/kg (Table 5). At this time there is no BASMAA threshold for further investigation comparable to the PCBs threshold discussed previously. However, the samples with mercury concentrations exceeding 1.0 mg/kg are discussed in the Section 3.3.1 below.

Median, 75th and 90th percentile mercury concentrations from this study were all lower compared to the full Bay Area dataset. For example, the median concentration for this study was 0.10 mg/kg compared to 0.16 mg/kg for the full Bay Area dataset. The analytical results from this project are compared to the full Bay Area dataset in Table 5 and Figure 18.

Table 5. Mercury results by Permittee and concentrations category

Permittee	Mercury (mg/kg)					Number of Samples				
	Max	Mean	Percentile			> 1 (mg/kg)	0.5 - 1.0 (mg/kg)	0.2 - 0.5 (mg/kg)	< 0.2 (mg/kg)	Total
			50th	75th	90th					
Brisbane	0.17	0.08	0.06						5	5
Burlingame	0.83	0.25	0.17				1	4	6	11
East Palo Alto	0.45	0.18	0.22					4	3	7
Menlo Park	0.21	0.13	0.10					1	8	9
Redwood City	0.96	0.17	0.09				1	3	13	17
San Carlos	0.17	0.08	0.08						5	5
San Mateo	0.63	0.15	0.10				1	1	8	10
South San Francisco	3.59	0.40	0.14			2*		4	19	25
Unincorporated San Mateo County	0.39	0.12	0.10					1	11	12
Total	3.59	0.22	0.10	0.18	0.33	2	3	18	78	101
Full Bay Area dataset	15.0	0.42	0.16	0.31	0.78	68	74	228	530	900

*The sediment in one sample appeared to at least partially originate from within San Bruno.

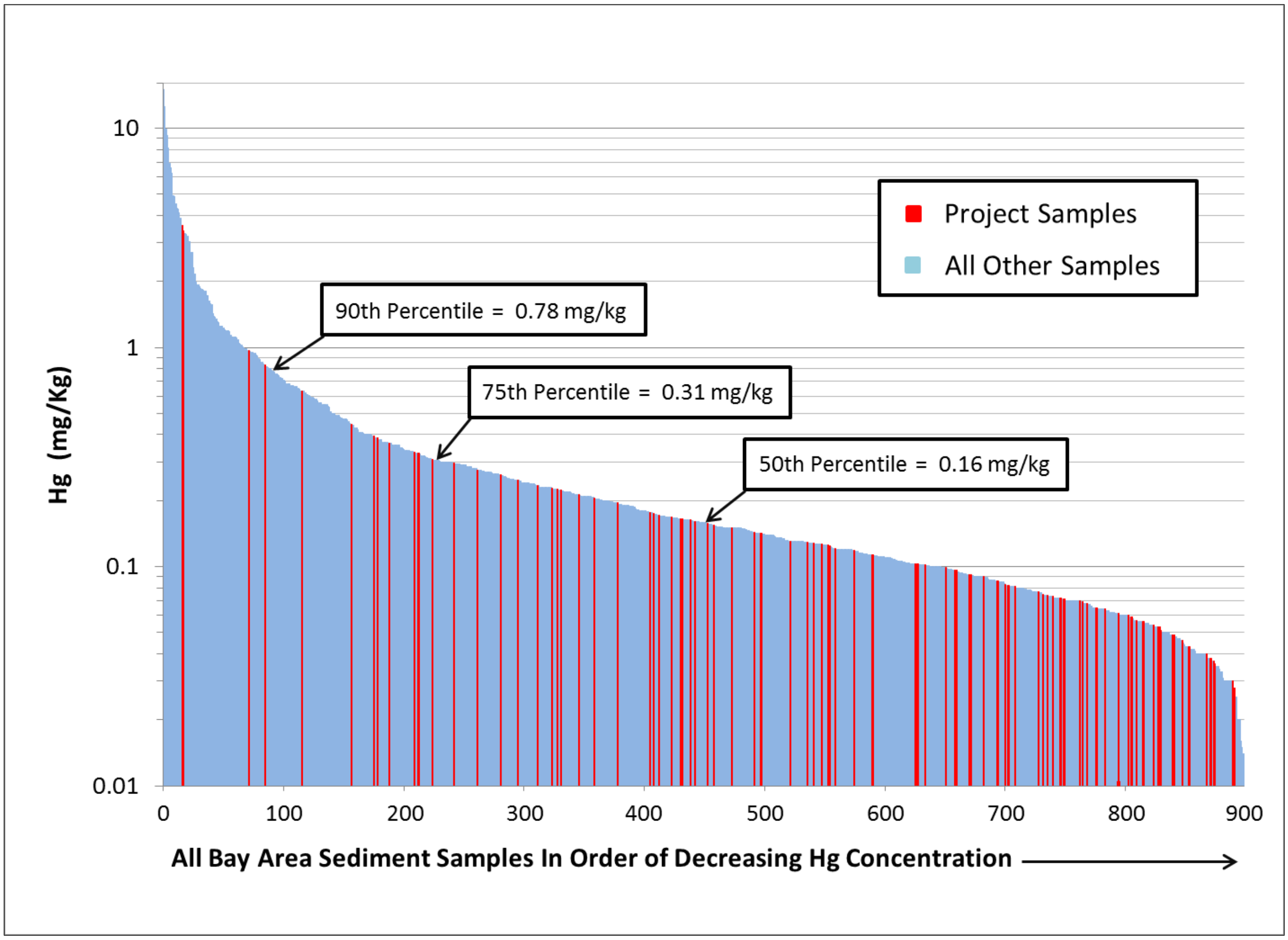

Figure 18. Mercury results of the 101 samples from this project compared to the full Bay Area dataset.

3.3.1. Elevated Mercury Results

Two mercury samples had concentrations over 1.0 mg/kg, both located relatively close to each other in the City of South San Francisco (Figure 19).

- Sample SM-SSF-06-D was collected from a manhole on the north side of Shaw Road near the outfall for the catchment into Colma Creek and had a concentration of 3.40 mg/kg. Two large pipes (at least 36 inches in diameter) enter the vault under the manhole. The inflow pipes were difficult to see because the vault was nearly full with sediment and tidal water at the time of sampling. This sample station has a relatively large catchment area that includes an industrial area of South San Francisco and a mixture of industrial, residential, and retail from the City of San Bruno. There are a number of *High - High* and *High - Moderate* interest parcels within the catchment area including the Shaw Business Center, the Caltrain (PCJPB) right-of-way, and other old railroad parcels. The catchment area for sample SM-SSF-05-B, located on the corner of Shaw Road and San Mateo Avenue, is within the catchment area for SM-SSF-06-D. The mercury concentration for SM-SSF-05-B was relatively low (0.09 mg/kg), suggesting that the source of mercury in sample SM-SSF-06-D may be outside of the SM-SSF-06-B sub-catchment (i.e., not south along San Mateo Avenue).

- Sample SM-SSF-06-E was collected from the wet well of a small stormwater pump station near San Mateo Avenue on the south side of Colma Creek and had a mercury concentration of 3.59 mg/kg, the highest of the 101 samples taken. Although the exact catchment area is not known at this time, it is clear that this pump station drains a small portion of San Mateo Avenue. There is a storm drain flowing north along San Mateo Avenue with an outfall at the bridge over Colma Creek that does not drain to this pump station. Any future investigation into the sources of elevated mercury here would require working with the City to better delineate the catchment area.

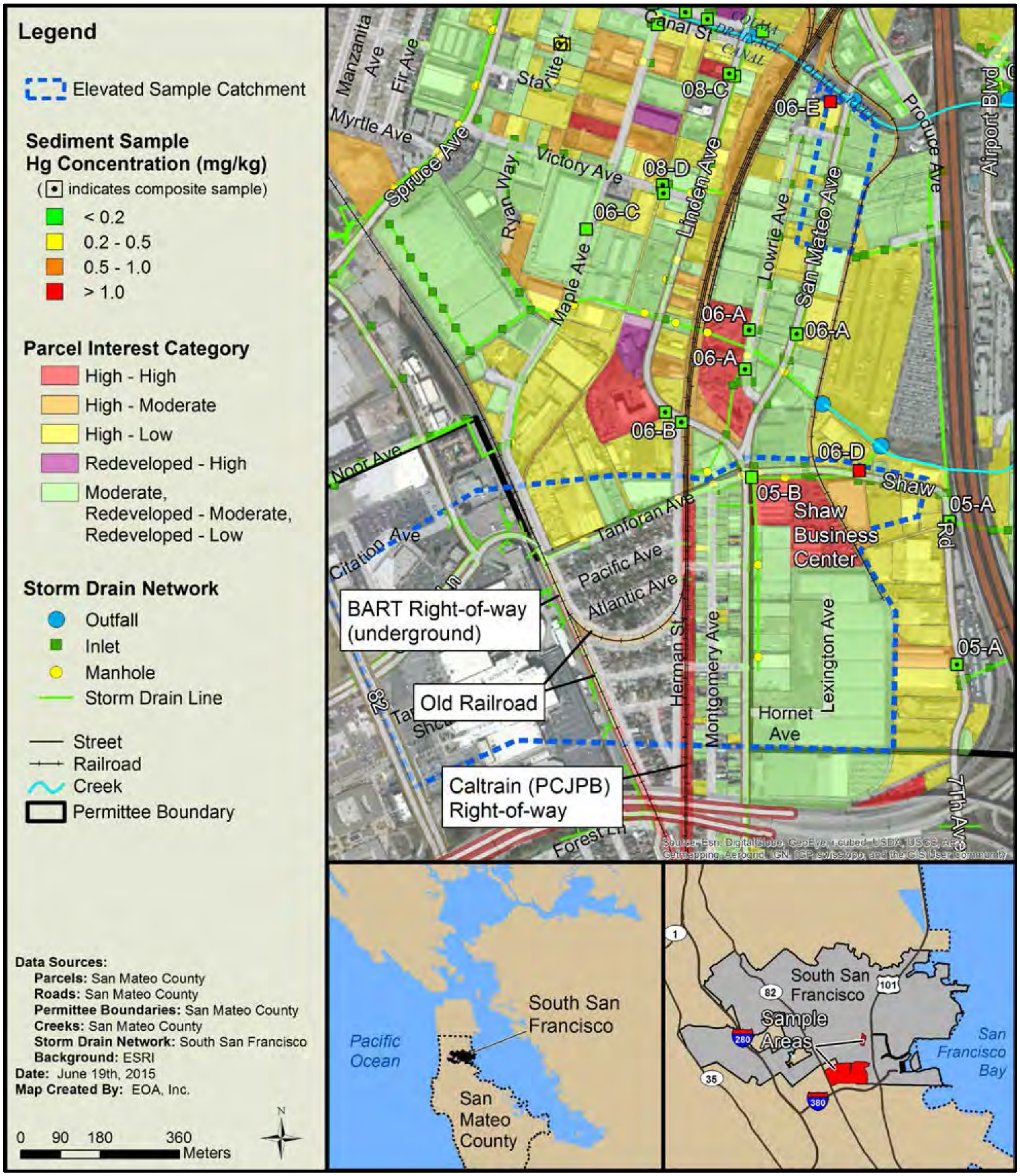

Figure 19. Map of the catchment areas for mercury samples SM-SSF-06-D and SM-SSF-06-E, City of South San Francisco.

3.4. Quality Assurance Results

This project used the CW4CB QAPP (AMS 2013) as a basis for Quality Assurance and Quality Control (QA/QC) procedures. Unlike CW4CB, this project used USEPA method 8082M instead of method 1668A for PCB congener analysis, resulting in higher reporting limits. However, the difference in methods did not impact the measurement quality objects (MQOs), which remained the same as in the CW4CB QAPP. The MQOs for PCBs and mercury are summarized in Table 6. Further details regarding the QA/QC review are provided in the remainder of this section. Overall, the results of the QA/QC review suggest that the sediment chemistry data generated during this study was of sufficient quality for the screening level purposes of the project. While some data was flagged in the project database, none of the data was rejected.

Table 6. Measurement quality objectives of the Clean Watersheds for a Clean Bay (CW4CB) Quality Assurance Project Plan

	PCBs	Mercury
Laboratory Blank	< Reporting Limit	< Reporting Limit
Reference Material **(Laboratory Control Sample)**	50-150% recovery (70-130% recovery if certified)	75-125% recovery
Matrix Spike	50-150% recovery	75-125% recovery
Matrix Spike Duplicate	50-150% recovery Relative Percent Difference < 25%	75-125% recovery Relative Percent Difference < 25%

3.4.1. Reporting Limits

The project SAP (SMCWPPP 2015) identified 0.5 mg/kg as an elevated total PCBs concentration threshold for sites to be considered for additional investigation. In the absence of a defined reporting limit for Method 1882 in the project QAPP, the project applied a reporting limit of 10 ppb (µg/kg) for each PCB congener for this study. This project-specific reporting limit is 2% of the elevated concentration of 0.5 mg/kg.

A large number of congener samples (328 out of 4040) did not meet the reporting limit requirement of 10 µg/kg. However, the majority of these exceedances are explained by dilutions necessary to conduct the analysis, resulting in elevated reporting limits. Only a small minority (22, or 7%) of the samples that did not meet the reporting limit requirements were not diluted, and therefore, did not have a justification for the elevated reporting limits. Only four out of forty congeners were affected – PCBs 60, 95, 99, and 101.

The target method reporting limit for mercury, 0.30 mg/kg, was met for all but one sample, and in most cases the reporting limit was less than the target. The one sample whose reporting limit was greater than 0.3 mg/kg was diluted and its reporting limit was only marginally elevated at 0.39 mg/kg.

3.4.2. Lab Blanks

All laboratory blanks were less than the reporting limit and method detection limit for both PCBs and mercury.

3.4.3. Laboratory Control Samples (LCS)

The CW4CB MQO for Synthetic Organic Compounds in sediment (i.e., PCB congeners) specifies a 70-130% recovery for reference material if certified or 50-150% recovery otherwise. The laboratory had a much smaller acceptable range for laboratory control samples (LCS) recovery, and as a result, some of the QA samples that were qualified by the laboratory were within the QAPP MQO range. Samples associated with these QA samples were not qualified. Samples were qualified if their batch was associated with QA samples whose percent recovery exceeded the MQOs. Only 2% of all LCS samples exceeded the MQOs specified by the CW4CB QAPP.

3.4.4. Matrix Spikes and Matrix Spike Duplicates

The majority (92%) of matrix spike (MS) and matrix spike duplicates (MSD) met the MQOs specified in the CW4CB QAPP. The relative percent difference (RPD) between matrix spikes and their duplicates met MQOs for the majority of samples. Only 17% of these RPDs exceeded 25%.

3.4.5. Field Duplicates

Ten field duplicates were collected during this project. Field duplicate sampling methods included homogenization of the sediment samples in a pre-cleaned, stainless steel bucket and then separation into two sample containers. The duplicate sample was run as a blind duplicate by the laboratory. A comparison of the PCB and mercury samples and their respective duplicates is shown in Table 7.

Table 7. Total PCBs relative percent difference (RPD) for ten field duplicates.

Site ID	Site Duplicate Sample ID	Total PCBs				Mercury			
		Result (mg/kg)		RPD[6]	Meets MQO?	Result (mg/kg)		RPD	Meets MQO?
		Sample	Duplicate			Sample	Duplicate		
SM-BRI-01-C	SM-BRI-01-G	0.04	0.03	8%	Yes	0.06	0.07	9%	Yes
SM-BUR-04-A	SM-BUR-04-C	0.10	0.11	8%	Yes	0.39	0.41	6%	Yes
SM-EPA-02-D	SM-EPA-02-E	0.34	0.34	0%	Yes	0.45	0.43	5%	Yes
SM-MPK-02-B	**SM-MPK-02-C**	**0.57**	**0.76**	**30%**	**No**	**0.13**	**0.27**	**70%**	**No**
SM-RCY-04-C	SM-RCY-04-E	0.01	0.02	12%	Yes	**0.23**	**0.09**	**89%**	**No**
SM-SCS-01-C	SM-SCS-01-F	0.04	0.04	12%	Yes	0.17	0.15	9%	Yes
SM-SMC-07-A	SM-SMC-07-C	0.06	0.07	4%	Yes	**0.20**	**0.11**	**54%**	**No**
SM-SMO-08-B	**SM-SMO-08-C**	**0.01**	**0.01**	**38%**	**No**	0.07	0.06	14%	Yes
SM-SSF-01-C	**SM-SSF-01-E**	**0.01**	**0.00**	**65%**	**No**	**0.24**	**8.51**	**189%**	**No**
SM-SSF-08-B	**SM-SSF-08-E**	**0.04**	**0.02**	**55%**	**No**	**0.06**	**0.09**	**37%**	**No**

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[6] RPD = ABS([X1 - X2] / [(X1 + X2) / 2]) where X1 is the first sample result and X2 is the duplicate sample result. Sites that exceeded the measurement quality objective of 25 % are bolded

The relative percent difference (RPD) for four of the ten samples and their corresponding duplicates exceeded MQOs for total PCBs. However, the concentrations of total PCBs at three of the sites were lower than QA/QC threshold of 0.1 mg/kg, and their high RPDs are attributed to concentrations being close to detection limits. Both the sample and duplicate concentrations at the fourth site, SM-MPK-02-B, exceeded the SAP's high concentration threshold of 0.5 mg/kg, and as a result, the sample was reanalyzed via the USEPA 1668A method to confirm the concentration. However, the concentration of total PCBs in both samples is within the same concentration category (0.5 to 1.0 mg/kg).

Five of the ten sites did not meet the MQO for RPD for Mercury. Three of these sites also did not meet the RPD MQO for total PCBs. SM-SSF-01-C, had an RPD of 189%, and the duplicate sample had a mercury concentration of 8.51 mg/kg, a very high result. The absolute differences between the samples and their duplicates were generally higher than expected, possibly from heterogeneity of concentrations within the sample rather than laboratory techniques. The samples and their duplicates are all well mixed in the field, and so these results are somewhat surprising.

3.4.6. 1668A Method Comparison

A total of ten samples from San Mateo County were also analyzed using USEPA method 1668A, which has higher resolution and lower detection limits for PCB congeners. Samples re-analyzed using this method were validated using the same MQOs as method 8082M. As a result of the lower detection limits, several laboratory blanks had PCB congener concentrations greater than the method detection limit[7]. Most were below the reporting limit, but 11 individual congeners and coelutions[8] were also above the reporting limit. Data were qualified accordingly with flags in the database.

In addition to resolution and detection limits differences for the two methods, there are small differences in the individual congeners analyzed. Method 8082M identifies the RMP 40 congeners individually; whereas, method 1668A identifies 22 individual congeners and 17 coelutions. Consequently, results from the two methods are not identical but are considered comparable. The sums of the PCB congeners (e.g., total PCBs) were compared and the relative percent difference was calculated for each sample (Table 8).

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[7] The presence of PCBs in laboratory blanks associated with method 1668A is common and highlights the theory that PCBs are ubiquitous in the environment (City of Spokane 2015).

[8] Coelution is the process whereby two or more chemical compounds (e.g., PCB congeners) elute from the chromatographic column at the same time, making separation and identification difficult.

Table 8. Comparison of Total PCBs analyzed with both USEPA 1668A and 8082M, and their relative percent difference.

Site ID	Total PCBs Method 1668A (mg/kg)	Total PCBs Method 8082M (mg/kg)	Relative Percent Difference
SM-BRI-01-C	0.041	0.037	11%
SM-BRI-02-A	**0.513**	**1.217**	**81%**
SM-BUR-04-C	0.117	0.109	7%
SM-EPA-01-A	0.253	0.209	19%
SM-MPK-02-B	**1.140**	**0.565**	**67%**
SM-MPK-02-C	**0.421**	**0.764**	**58%**
SM-RCY-05-A	**1.260**	**0.565**	**76%**
SM-SSF-03-C	0.200	0.191	5%
SM-SSF-05-A	0.476	0.459	4%
SM-SSF-06-B	**0.721**	**0.483**	**40%**

Of the ten samples collected in San Mateo County that were analyzed using both methods, the relative percent difference (RPD) for five of the samples exceeded the MQO (greater than 25% difference). Higher RPDs were noted for samples with higher concentrations, while there was generally good agreement amongst samples with lower concentrations (i.e., less than 0.5 mg/kg), which suggests that the two methods may be more comparable at lower concentrations.

Overall, total PCB concentrations were higher for method 1668A. Only two of the ten samples had higher concentrations of total PCBs for method 8082M. These samples also exceeded the RPD measurement quality objective. No data were rejected as a result of these differences.

4.0 DISCUSSION AND NEXT STEPS

The MRP 2.0 Tentative Order requires Permittees to work toward a cumulative Bay Area goal to reduce PCBs in stormwater. To calculate reductions in PCB loads, an accounting methodology is being developed where Permittees are given reduction credits based on implementing BMP programs such as:

- Source property identification and abatement;
- Green infrastructure/treatment controls; and
- Management of PCBs in building materials during demolition.

Identifying pollutant source areas is a challenging and often a multi-year process. The 101 sediment samples analyzed during this project in combination with historical sediment and stormwater runoff samples are part of an ongoing effort to identify areas in San Mateo County of high interest for further study and the potential opportunity to implement pollutant controls. The primary objective of this project was not to identify specific source properties, but to identify areas where further investigation is warranted. It is important to note that a variety of chemical and geomorphic processes lead to high spatial and temporal variability in the concentrations of PCBs and other pollutants found in embedded sediment samples. Thus this type of monitoring is best used to screen for potential elevated areas rather than attempting to verify that any particular area is not a source of pollutants.

The sampling design specifically targeted sample stations within the old industrial landscape that are influenced by parcels that were classified and prioritized as having relatively higher potential to be sources of PCBs. However, a strong correlation between the land use analysis and sampling results was lacking, and only five percent of the samples had total PCBs concentrations exceeding the 0.5 mg/kg threshold. This suggests that continuing to identify additional source areas and properties in San Mateo County may be challenging. The remainder of the PCB load appears to be coming from sources that are less elevated and more diffuse and will likely be more challenging to control. Thus data collected to-date suggests that the diffuse nature of PCB contamination within the urban landscape may require a rethinking of the approach and timeline needed to meet TMDL load reduction goals.

SMCWPPP plans to continue working with other Bay Area countywide stormwater programs (through the BASMAA MPC Committee) to evaluate the results of the ongoing efforts in the Bay Area to identify PCBs and mercury source areas and plan next steps. Types of potential follow-up work include additional research into historical land uses and refinement of associated GIS layers, collection and analysis of additional water and sediment samples, and analysis of individual PCBs congener data in an attempt to identify pollutant “fingerprints.” Follow-up sediment and water monitoring should be conducted in coordination with compliance with Provision C.8.f (Pollutants of Concern Monitoring) of the reissued MRP. Monitoring under Provision C.8.f is intended to address a number of management questions related to priority pollutants such as mercury and PCBs, including assessing inputs to the Bay from urban runoff, assessing trends in pollutant loading, and helping to identify pollutant source areas. The requirements in C.8.f will be finalized with adoption of the reissued permit, which is anticipated in November 2015.

To help plan for compliance with Provisions C.8.f, C.11 (mercury controls), and C.12 (PCBs controls) of the reissued MRP, SMCWPPP will review water and sediment sampling results for PCBs and mercury conducted to-date in San Mateo County and associated ancillary data (e.g., historical land use research). SMCWPPP will then develop a framework for follow-up efforts to continue identifying which pollutant source areas in San Mateo County provide the greatest opportunities for implementing controls to reduce discharges of mercury and PCBs.

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Appendix A

Sampling Locations and Results

Permittee	Sample	Map Label	Subsample	Latitude	Longitude	Date	Time	Sample Location Type	Mercury (mg/kg)	Total PCBs 8082M (mg/kg)	Total PCBs 1668A (mg/kg)
Legend (shading):					< 0.2 mg/kg (none)		0.2 - 0.5 mg/kg (yellow)		0.5 - 1.0 mg/kg (orange)		≥ 1.0 mg/kg (red)
Brisbane	SM-BRI-01-A	01-A	SM-BRI-01-A-2	37.70151	-122.40867	2/18/2015	11:38	Inlet	0.17	0.04	
			SM-BRI-01-A-3	37.70155	-122.40866	2/18/2015	11:38	Inlet			
			SM-BRI-01-A-4	37.70502	-122.40917	2/18/2015	11:38	Street Dirt			
	SM-BRI-01-B	01-B	SM-BRI-01-B-1	37.70102	-122.40810	2/18/2015	9:56	Inlet	0.04	0.01	
			SM-BRI-01-B-2	37.70090	-122.40811	2/18/2015	9:56	Inlet			
	SM-BRI-01-C	01-C	SM-BRI-01-C-1	37.69897	-122.40682	2/18/2015	10:18	Inlet	0.06	0.04	0.04
			SM-BRI-01-C-2	37.69898	-122.40696	2/18/2015	10:18	Inlet			
			SM-BRI-01-C-4	37.70023	-122.40750	2/18/2015	10:18	Inlet			
	SM-BRI-01-G (Dup of 01-C)								0.07	0.03	
	SM-BRI-01-D	01-D	SM-BRI-01-D-4	37.70024	-122.40736	2/18/2015	10:40	Inlet	0.04	0.01	
	SM-BRI-02-A	02-A	SM-BRI-02-A-5	37.68806	-122.40444	2/18/2015	9:11	Manhole	0.07	1.22	0.51
Burlingame	SM-BUR-01-A	01-A	SM-BUR-01-A-3	37.60249	-122.37588	2/12/2015	10:14	Pump Station	0.16	0.03	
	SM-BUR-01-B	01-B	SM-BUR-01-B-3	37.59990	-122.37191	2/11/2015	10:30	Inlet	0.17	0.03	
	SM-BUR-02-A	02-A	SM-BUR-02-A-1	37.59449	-122.36737	2/11/2015	11:10	Inlet	0.30	0.10	
			SM-BUR-02-A-3	37.59637	-122.36560	2/11/2015	11:10	Inlet			
	SM-BUR-03-A	03-A	SM-BUR-03-A-3	37.58995	-122.36429	2/11/2015	14:35	Manhole	0.33	0.15	
			SM-BUR-03-A-4	37.58960	-122.36340	2/11/2015	14:35	Street Dirt			
	SM-BUR-03-B	03-B	SM-BUR-03-B-4	37.59182	-122.36623	2/12/2015	9:27	Pump Station	0.09	0.06	
	SM-BUR-04-A	04-A	SM-BUR-04-A-4	37.59425	-122.37052	2/11/2015	13:55	Manhole	0.39	0.10	
	SM-BRI-01-C (Dup of 04-A)								0.41	0.11	0.12
	SM-BUR-04-B	04-B	SM-BUR-04-B-3	37.59425	-122.36840	2/12/2015	9:47	Pump Station	0.06	0.01	
	SM-BUR-05-A	05-A	SM-BUR-05-A-5	37.59821	-122.38085	2/11/2015	12:00	Inlet	0.31	0.05	
	SM-BUR-05-B	05-B	SM-BUR-05-B-5	37.59762	-122.37918	2/11/2015	12:20	Inlet	0.83	0.09	
	SM-BUR-05-C	05-C	SM-BUR-05-C-1	37.59524	-122.37808	2/11/2015	12:45	Inlet	0.10	0.04	
			SM-BUR-05-C-2	37.59608	-122.37619	2/11/2015	12:45	Inlet			
			SM-BUR-05-C-3	37.59478	-122.37367	2/11/2015	12:45	Inlet			
	SM-BUR-06-A	06-A	SM-BUR-06-A-1	37.59107	-122.33662	2/11/2015	9:30	Inlet	0.14	0.05	

Permittee	Sample	Map Label	Subsample	Latitude	Longitude	Date	Time	Sample Location Type	Mercury (mg/kg)	Total PCBs 8082M (mg/kg)	Total PCBs 1668A (mg/kg)
Legend (shading):					< 0.2 mg/kg (none)		0.2 - 0.5 mg/kg (yellow)		0.5 - 1.0 mg/kg (orange)		≥ 1.0 mg/kg (red)
			SM-BUR-06-A-3	37.58842	-122.33721	2/11/2015	9:30	Inlet			
			SM-BUR-06-A-5	37.58712	-122.33620	2/11/2015	9:30	Inlet			
East Palo Alto	SM-EPA-01-A	01-A	SM-EPA-01-A-1	37.47722	-122.13418	1/19/2015	11:20	Manhole	0.22	0.21	0.25
	SM-EPA-01-B	01-B	SM-EPA-01-B-2	37.47208	-122.13429	1/19/2015	11:50	Inlet	0.12	0.02	
			SM-EPA-01-B-3	37.47296	-122.13204	1/19/2015	11:50	Inlet			
	SM-EPA-01-C	01-C	SM-EPA-01-C-1	37.47475	-122.12710	1/19/2015	10:00	Street Dirt	0.08	0.02	
			SM-EPA-01-C-2	37.47466	-122.12726	1/19/2015	10:00	Street Dirt			
			SM-EPA-01-C-3	37.47477	-122.13056	1/19/2015	10:00	Street Dirt			
			SM-EPA-01-C-4	37.47336	-122.13068	1/19/2015	10:00	Street Dirt			
	SM-EPA-01-D	01-D	SM-EPA-01-D-2	37.47558	-122.13191	1/19/2015	10:45	Street Dirt	0.10	0.06	
			SM-EPA-01-D-3	37.47524	-122.13199	1/19/2015	10:45	Street Dirt			
			SM-EPA-01-D-4	37.47480	-122.13207	1/19/2015	10:45	Street Dirt			
			SM-EPA-01-D-5	37.47460	-122.13186	1/19/2015	10:45	Street Dirt			
	SM-EPA-02-A	02-A	SM-EPA-02-A-1	37.47085	-122.13069	1/19/2015	8:40	Manhole	0.26	0.05	
	SM-EPA-02-C	02-C	SM-EPA-02-C-1	37.47443	-122.12743	1/19/2015	9:30	Inlet	0.33	0.02	
	SM-EPA-02-D	02-D	SM-EPA-02-D-1	37.47034	-122.13036	1/19/2015	8:55	Manhole	0.45	0.34	
	SM-EPA-02-E (Dup of 02-D)								0.43	0.34	
Menlo Park	SM-MPK-01-A	01-A	SM-MPK-01-A-1	37.45565	-122.18395	1/20/2015	15:20	Inlet	0.07	0.02	
			SM-MPK-01-A-2	37.45566	-122.18408	1/20/2015	15:20	Street Dirt			
	SM-MPK-02-A	02-A	SM-MPK-02-A-2	37.48664	-122.18868	1/20/2015	2:45	Inlet	0.04	0.03	
	SM-MPK-02-B	02-B	SM-MPK-02-B-1	37.48610	-122.18564	1/20/2015	13:50	Inlet	0.13	0.57	1.14
			SM-MPK-02-B-5	37.48513	-122.18212	1/20/2015	13:50	Manhole			
	SM-MPK-02-C (Dup of 02-B)								0.27	0.76	0.42
	SM-MPK-03-A	03-A	SM-MPK-03-A-1	37.48678	-122.18090	1/22/2015	11:45	Inlet	0.04	0.02	
			SM-MPK-03-A-5	37.48658	-122.18019	1/22/2015	11:45	Manhole			
			SM-MPK-03-A-6	37.48659	-122.18016	1/22/2015	11:45	Inlet			
			SM-MPK-03-A-7	37.48692	-122.18094	1/22/2015	11:45	Creek sediment			

Permittee	Sample	Map Label	Subsample	Latitude	Longitude	Date	Time	Sample Location Type	Mercury (mg/kg)	Total PCBs 8082M (mg/kg)	Total PCBs 1668A (mg/kg)
				Legend (shading):	< 0.2 mg/kg (none)		0.2 - 0.5 mg/kg (yellow)		0.5 - 1.0 mg/kg (orange)		≥ 1.0 mg/kg (red)
Menlo Park	SM-MPK-04-A	04-A	SM-MPK-04-A-3	37.48307	-122.17529	1/20/2015	10:20	Inlet	0.21	0.03	
	SM-MPK-04-C	04-C	SM-MPK-04-C-4	37.48270	-122.17420	1/20/2015	10:45	Manhole	0.12	0.01	
	SM-MPK-04-D	04-D	SM-MPK-04-D-1	37.48342	-122.17178	1/19/2015	15:20	Inlet	0.03	0.25	
	SM-MPK-04-E	04-E	SM-MPK-04-E-1	37.48281	-122.16719	1/19/2015	14:55	Manhole	0.10	0.29	
			SM-MPK-04-E-4	37.48210	-122.16749	1/19/2015	14:55	Manhole			
	SM-MPK-06-A	06-A	SM-MPK-06-A-3	37.47566	-122.14726	1/19/2015	13:15	Inlet	0.12	0.06	
			SM-MPK-06-A-5	37.47471	-122.14910	1/19/2015	13:15	Ditch			
			SM-MPK-06-A-6	37.47505	-122.15160	1/19/2015	13:15	Street Dirt			
			SM-MPK-06-A-7	37.47489	-122.15158	1/19/2015	13:15	Street Dirt			
Redwood City	SM-RCY-01-A	01-A	SM-RCY-01-A-1	37.49505	-122.23654	2/10/2015	10:30	Manhole	0.33	0.03	
			SM-RCY-01-A-2	37.49601	-122.23766	2/10/2015	10:30	Inlet			
	SM-RCY-01-B	01-B	SM-RCY-01-B-1	37.49607	-122.23841	2/10/2015	11:12	Inlet	0.09	0.05	
			SM-RCY-01-B-4	37.49668	-122.23903	2/10/2015	11:12	Manhole			
			SM-RCY-01-B-5	37.49687	-122.23921	2/10/2015	11:12	Inlet			
	SM-RCY-03-A	03-A	SM-RCY-03-A-1	37.49366	-122.23425	2/10/2015	10:00	Manhole	0.13	0.02	
			SM-RCY-03-A-2	37.49321	-122.23367	2/10/2015	10:00	Inlet			
	SM-RCY-04-A	04-A	SM-RCY-04-A-2	37.49548	-122.21968	1/22/2015	12:45	Inlet	0.07	0.02	
	SM-RCY-04-B	04-B	SM-RCY-04-B-2	37.49304	-122.21726	1/22/2015	11:30	Inlet	0.10	0.01	
			SM-RCY-04-B-4	37.49305	-122.21372	1/22/2015	11:30	Inlet			
			SM-RCY-04-B-5	37.49367	-122.21949	1/22/2015	11:30	Inlet			
			SM-RCY-04-B-6	37.49293	-122.21731	1/22/2015	11:30	Street Dirt			
	SM-RCY-04-C	04-C	SM-RCY-04-C-1	37.49129	-122.21345	1/22/2015	10:30	Inlet	0.23	0.01	
			SM-RCY-04-C-2	37.49189	-122.21315	1/22/2015	10:30	Street Dirt			
			SM-RCY-04-C-3	37.48983	-122.21408	1/22/2015	10:30	Street Dirt			
	SM-RCY-04-E (Dup of 04-C)								0.09	0.02	
	SM-RCY-04-D	04-D	SM-RCY-04-D-1	37.49742	-122.21299	1/22/2015	13:15	Street Dirt	0.07	0.02	
	SM-RCY-05-A	05-A	SM-RCY-05-A-1	37.50961	-122.20813	1/22/2015	13:35	Ditch	0.96	0.57	1.26
			SM-RCY-05-A-2	37.50380	-122.21060	1/22/2015	13:35	Ditch			
			SM-RCY-05-A-3	37.51128	-122.20732	1/22/2015	13:35	Ditch			

Permittee	Sample	Map Label	Subsample	Latitude	Longitude	Date	Time	Sample Location Type	Mercury (mg/kg)	Total PCBs 8082M (mg/kg)	Total PCBs 1668A (mg/kg)
				Legend (shading):	< 0.2 mg/kg (none)		0.2 - 0.5 mg/kg (yellow)		0.5 - 1.0 mg/kg (orange)		≥ 1.0 mg/kg (red)
Redwood City	SM-RCY-06-A	06-A	SM-RCY-06-A-1	37.48850	-122.20902	1/22/2015	9:45	Inlet	0.07	0.09	
			SM-RCY-06-A-2	37.48810	-122.20738	1/22/2015	9:45	Inlet			
			SM-RCY-06-A-3	37.48771	-122.20467	1/22/2015	9:45	Inlet			
	SM-RCY-07-A	07-A	SM-RCY-07-A-4	37.48670	-122.21235	1/21/2015	14:30	Manhole	0.08	0.10	
			SM-RCY-07-A-5	37.48666	-122.21235	1/21/2015	14:30	Street Dirt			
	SM-RCY-07-B	07-B	SM-RCY-07-B-2	37.48650	-122.20665	1/21/2015	15:20	Manhole	0.21	0.25	
	SM-RCY-07-C	07-C	SM-RCY-07-C-1	37.48651	-122.20681	1/21/2015	14:55	Inlet	0.08	0.13	
			SM-RCY-07-C-2	37.48731	-122.20862	1/21/2015	14:55	Inlet			
	SM-RCY-09-A	09-A	SM-RCY-09-A-3	37.48607	-122.19643	1/22/2015	9:00	Inlet	0.06	0.05	
			SM-RCY-09-A-4	37.48640	-122.19919	1/22/2015	9:00	Street Dirt			
	SM-RCY-10-A	10-A	SM-RCY-10-A-1	37.48637	-122.18757	1/20/2015	14:20	Inlet	0.06	0.04	
	SM-RCY-11-A	11-A	SM-RCY-11-A-1	37.48006	-122.22206	1/22/2015	14:40	Inlet	0.16	0.03	
			SM-RCY-11-A-3	37.47975	-122.22122	1/22/2015	14:40	Street Dirt			
	SM-RCY-13-A	13-A	SM-RCY-13-A-1	37.48136	-122.22602	1/22/2015	15:20	Inlet	0.10	0.01	
	SM-RCY-15-A	15-A	SM-RCY-15-A-5	37.48953	-122.23632	2/10/2015	9:30	Street Dirt	0.08	0.05	
			SM-RCY-15-A-6	37.48986	-122.23677	2/10/2015	9:30	Street Dirt			
			SM-RCY-15-A-7	37.49005	-122.23692	2/10/2015	9:30	Street Dirt			
San Carlos	SM-SCS-01-A	01-A	SM-SCS-01-A-2	37.51799	-122.26640	2/10/2015	13:45	Manhole	0.05	0.10	
			SM-SCS-01-A-3	37.51789	-122.26651	2/10/2015	13:45	Manhole			
			SM-SCS-01-A-4	37.51774	-122.26671	2/10/2015	13:45	Manhole			
	SM-SCS-01-B	01-B	SM-SCS-01-B-3	37.51915	-122.26483	2/10/2015	14:20	Inlet	0.05	0.09	
	SM-SCS-01-C	01-C	SM-SCS-01-C-1	37.51632	-122.26494	2/10/2015	12:35	Manhole	0.17	0.04	
	SM-RCY-01-F (Dup of 01-C)								0.15	0.04	
	SM-SCS-01-D	01-D	SM-SCS-01-D-4	37.51778	-122.26358	2/10/2015	15:05	Street Dirt	0.08	0.02	
	SM-SCS-01-E	01-E	SM-SCS-01-E-1	37.51548	-122.26660	2/10/2015	13:15	Inlet	0.09	0.03	
Unincorporated San Mateo County	SM-SMC-03-A	03-A	SM-SMC-03-A-3	37.47682	-122.19520	1/21/2015	9:20	Street Dirt	0.03	0.00	
	SM-SMC-04-A	04-A	SM-SMC-04-A-1	37.47622	-122.20808	1/21/2015	9:38	Inlet	0.11	0.09	
	SM-SMC-04-C	04-C	SM-SMC-04-C-4	37.47851	-122.21224	1/21/2015	10:35	Street Dirt	0.13	0.06	
			SM-SMC-04-C-5	37.47816	-122.21149	1/21/2015	10:35	Street Dirt			

Permittee	Sample	Map Label	Subsample	Latitude	Longitude	Date	Time	Sample Location Type	Mercury (mg/kg)	Total PCBs 8082M (mg/kg)	Total PCBs 1668A (mg/kg)
				Legend (shading):	< 0.2 mg/kg (none)		0.2 - 0.5 mg/kg (yellow)		0.5 - 1.0 mg/kg (orange)		≥ 1.0 mg/kg (red)
Unincorporated San Mateo County			SM-SMC-04-C-6	37.47788	-122.21082	1/21/2015	10:35	Inlet			
	SM-SMC-05-A	05-A	SM-SMC-05-A-2	37.47476	-122.21126	1/21/2015	10:00	Manhole	0.10	0.03	
	SM-SMC-06-A	06-A	SM-SMC-06-A-1	37.48194	-122.20616	1/21/2015	11:10	Manhole	0.05	0.02	
			SM-SMC-06-A-5	37.48188	-122.20617	1/21/2015	11:10	Inlet			
	SM-SMC-06-B	06-B	SM-SMC-06-B-1	37.48307	-122.20310	1/21/2015	11:45	Inlet	0.06	0.02	
	SM-SMC-06-C	06-C	SM-SMC-06-C-1	37.48426	-122.20777	1/21/2015	12:55	Manhole	0.39	0.93	
	SM-SMC-07-A	07-A	SM-SMC-07-A-4	37.48484	-122.21082	1/21/2015	13:25	Manhole	0.20	0.06	
	SM-SMC-07-C (Dup of 07-A)								0.11	0.07	
	SM-SMC-07-B	07-B	SM-SMC-07-B-2	37.48517	-122.21341	1/21/2015	13:55	Inlet	0.14	0.07	
			SM-SMC-07-B-4	37.48517	-122.21365	1/21/2015	13:55	Inlet			
	SM-SMC-08-A	08-A	SM-SMC-08-A-3	37.51758	-122.27088	2/10/2015	15:30	Inlet	0.10	0.02	
			SM-SMC-08-A-4	37.52092	-122.26734	2/10/2015	15:30	Inlet			
	SM-SMC-09-A	09-A	SM-SMC-09-A-1	37.63283	-122.40533	2/17/2015	10:55	Inlet	0.05	0.01	
			SM-SMC-09-A-2	37.63279	-122.40526	2/17/2015	10:55	Street Dirt			
	SM-SMC-10-A	10-A	SM-SMC-10-A-2	37.43302	-122.20285	1/20/2015	9:20	Street Dirt	0.06	0.04	
			SM-SMC-10-A-3	37.43281	-122.20303	1/20/2015	9:20	Street Dirt			
			SM-SMC-10-A-4	37.43265	-122.20284	1/20/2015	9:20	Street Dirt			
San Mateo	SM-SMO-02-A	02-A	SM-SMO-02-A-1	37.57746	-122.32173	2/11/2015	15:20	Inlet	0.13	0.03	
			SM-SMO-02-A-2	37.57480	-122.31881	2/11/2015	15:20	Inlet			
			SM-SMO-02-A-4	37.57212	-122.31598	2/11/2015	15:20	Inlet			
			SM-SMO-02-A-5	37.57337	-122.31724	2/11/2015	15:20	Street Dirt			
	SM-SMO-04-A	04-A	SM-SMO-04-A-1	37.56775	-122.32320	2/18/2015	13:43	Inlet	0.11	0.06	
			SM-SMO-04-A-2	37.56810	-122.32269	2/18/2015	13:43	Inlet			
			SM-SMO-04-A-4	37.56748	-122.32298	2/18/2015	13:43	Inlet			
	SM-SMO-05-A	05-A	SM-SMO-05-A-1	37.56514	-122.31933	2/12/2015	11:28	Inlet	0.07	0.05	
			SM-SMO-05-A-3	37.56521	-122.31921	2/12/2015	11:28	Inlet			
	SM-SMO-06-A	06-A	SM-SMO-06-A-2	37.56134	-122.31515	2/18/2015	14:23	Inlet	0.25	0.23	
			SM-SMO-06-A-4	37.56012	-122.31382	2/18/2015	14:23	Inlet			
			SM-SMO-06-A-5	37.55986	-122.31449	2/18/2015	14:23	Ditch			

Permittee	Sample	Map Label	Subsample	Latitude	Longitude	Date	Time	Sample Location Type	Mercury (mg/kg)	Total PCBs 8082M (mg/kg)	Total PCBs 1668A (mg/kg)
				Legend (shading):	< 0.2 mg/kg (none)		0.2 - 0.5 mg/kg (yellow)		0.5 - 1.0 mg/kg (orange)		≥ 1.0 mg/kg (red)
San Mateo	SM-SMO-07-B	07-B	SM-SMO-07-B-1	37.55247	-122.30973	2/12/2015	13:20	Inlet	0.04	0.04	
			SM-SMO-07-B-3	37.55401	-122.31136	2/12/2015	13:20	Inlet			
			SM-SMO-07-B-5	37.55249	-122.30963	2/12/2015	13:20	Manhole			
	SM-SMO-08-A	08-A	SM-SMO-08-A-1	37.54987	-122.30739	2/12/2015	14:53	Inlet	0.04	0.03	
			SM-SMO-08-A-3	37.55203	-122.30645	2/12/2015	14:53	Street Dirt			
	SM-SMO-08-B	08-B	SM-SMO-08-B-1	37.54553	-122.30445	2/12/2015	13:51	Inlet	0.07	0.01	
			SM-SMO-08-B-2	37.54544	-122.30430	2/12/2015	13:51	Inlet			
			SM-SMO-08-B-3	37.54792	-122.30697	2/12/2015	13:51	Street Dirt			
			SM-SMO-08-B-4	37.54744	-122.30678	2/12/2015	13:51	Street Dirt			
	SM-SMO-08-C (Dup of 08-B)								0.06	0.01	
	SM-SMO-11-A	11-A	SM-SMO-11-A-3	37.53201	-122.28861	2/18/2015	15:17	Manhole	0.13	0.08	
			SM-SMO-11-A-4	37.53204	-122.28861	2/18/2015	15:17	Street Dirt			
	SM-SMO-14-A	14-A	SM-SMO-14-A-1	37.58632	-122.33303	2/12/2015	10:55	Inlet	0.63	0.07	
			SM-SMO-14-A-2	37.58622	-122.33253	2/12/2015	10:55	Inlet			
			SM-SMO-14-A-3	37.58618	-122.33281	2/12/2015	10:55	Inlet			
			SM-SMO-14-A-4	37.58618	-122.33273	2/12/2015	10:55	Inlet			
	SM-SMO-15-A	15-A	SM-SMO-15-A-1	37.56701	-122.31035	2/12/2015	11:50	Inlet	0.08	0.02	
			SM-SMO-15-A-2	37.56690	-122.31023	2/12/2015	11:50	Inlet			
			SM-SMO-15-A-3	37.56348	-122.30647	2/12/2015	11:50	Inlet			
South San Francisco	SM-SSF-01-B	01-B	SM-SSF-01-B-5	37.66032	-122.38511	2/16/2015	12:07	Inlet	0.07	0.12	
			SM-SSF-01-B-6	37.66032	-122.38500	2/16/2015	12:07	Outfall			
	SM-SSF-01-C	01-C	SM-SSF-01-C-3	37.64896	-122.38728	2/16/2015	13:21	Manhole	0.24	0.01	
	SM-SSF-01-E (Dup of 01-C)								8.51	0.00	
	SM-SSF-01-D	01-D	SM-SSF-01-D-4	37.65032	-122.39213	2/16/2015	13:52	Manhole	0.14	0.02	
	SM-SSF-02-A	02-A	SM-SSF-02-A-3	37.65172	-122.40318	2/16/2015	10:50	Manhole	0.37	0.07	
	SM-SSF-02-B	02-B	SM-SSF-02-B-1	37.65591	-122.40464	2/16/2015	11:11	Manhole	0.07	0.01	
	SM-SSF-03-A	03-A	SM-SSF-03-A-3	37.64910	-122.40172	2/16/2015	10:06	Manhole	0.28	0.07	
	SM-SSF-03-B	03-B	SM-SSF-03-B-4	37.64919	-122.40410	2/16/2015	9:50	Inlet	0.15	0.09	

Permittee	Sample	Map Label	Subsample	Latitude	Longitude	Date	Time	Sample Location Type	Mercury (mg/kg)	Total PCBs 8082M (mg/kg)	Total PCBs 1668A (mg/kg)
Legend (shading):					< 0.2 mg/kg (none)		0.2 - 0.5 mg/kg (yellow)		0.5 - 1.0 mg/kg (orange)		≥ 1.0 mg/kg (red)
South San Francisco	SM-SSF-03-C	03-C	SM-SSF-03-C-1	37.65181	-122.40008	2/16/2015	10:26	Inlet	0.18	0.19	0.20
			SM-SSF-03-C-3	37.65181	-122.40020	2/16/2015	10:26	Inlet			
	SM-SSF-04-A	04-A	SM-SSF-04-A-3	37.64606	-122.40160	2/16/2015	9:26	Inlet	0.15	1.46	
	SM-SSF-04-B	04-B	SM-SSF-04-B-1	37.63974	-122.40212	2/16/2015	9:07	Inlet	0.09	0.30	
	SM-SSF-05-A	05-A	SM-SSF-05-A-2	37.63735	-122.40605	2/17/2015	10:10	Inlet	0.05	0.46	0.48
			SM-SSF-05-A-3	37.64028	-122.40633	2/17/2015	10:10	Inlet			
	SM-SSF-05-B	05-B	SM-SSF-05-B-1	37.64110	-122.41145	2/17/2015	9:37	Manhole	0.09	0.02	
	SM-SSF-06-A	06-A	SM-SSF-06-A-1	37.64412	-122.41159	2/16/2015	14:22	Inlet	0.06	0.02	
			SM-SSF-06-A-3	37.64406	-122.41036	2/16/2015	14:22	Inlet			
			SM-SSF-06-A-4	37.64331	-122.41168	2/16/2015	14:22	Inlet			
	SM-SSF-06-B	06-B	SM-SSF-06-B-3	37.64220	-122.41329	2/17/2015	11:35	Inlet	0.07	0.48	0.71
			SM-SSF-06-B-4	37.64240	-122.41371	2/17/2015	11:35	Street Dirt			
	SM-SSF-06-C	06-C	SM-SSF-06-C-3	37.64612	-122.41585	2/13/2015	14:55	Inlet	0.05	0.05	
	SM-SSF-06-D	06-D	SM-SSF-06-D-4	37.64128	-122.40868	2/17/2015	9:15	Manhole	3.40	0.14	
	SM-SSF-06-E	06-E	SM-SSF-06-E-1	37.64884	-122.40961	2/13/2015	9:50	Pump Station	3.59	0.03	
	SM-SSF-08-A	08-A	SM-SSF-08-A-1	37.65089	-122.41622	2/13/2015	13:50	Manhole	0.23	0.02	
			SM-SSF-08-A-3	37.64990	-122.41651	2/13/2015	13:50	Inlet			
			SM-SSF-08-A-4	37.64991	-122.41662	2/13/2015	13:50	Inlet			
	SM-SSF-08-B	08-B	SM-SSF-08-B-6	37.65035	-122.41412	2/13/2015	12:26	Manhole	0.06	0.04	
	SM-SSF-08-E (Dup of 01-B)								0.09	0.02	
	SM-SSF-08-C	08-C	SM-SSF-08-C-1	37.64932	-122.41211	2/13/2015	11:14	Inlet	0.04	0.01	
			SM-SSF-08-C-4	37.64937	-122.41224	2/13/2015	11:14	Street Dirt			
	SM-SSF-08-D	08-D	SM-SSF-08-D-3	37.64706	-122.41390	2/13/2015	14:28	Inlet	0.17	0.04	
			SM-SSF-08-D-4	37.64689	-122.41387	2/13/2015	14:28	Street Dirt			
	SM-SSF-09-A	09-A	SM-SSF-09-A-2	37.65047	-122.41284	2/17/2015	13:15	Inlet	0.18	0.02	
			SM-SSF-09-A-4	37.65087	-122.41172	2/17/2015	13:15	Inlet			
			SM-SSF-09-A-5	37.65078	-122.41426	2/17/2015	13:15	Inlet			
			SM-SSF-09-A-6	37.65061	-122.41340	2/17/2015	13:15	Inlet			
	SM-SSF-09-C	09-C	SM-SSF-09-C-3	37.65148	-122.41703	2/17/2015	14:05	Inlet	0.16	0.02	

Permittee	Sample	Map Label	Subsample	Latitude	Longitude	Date	Time	Sample Location Type	Mercury (mg/kg)	Total PCBs 8082M (mg/kg)	Total PCBs 1668A (mg/kg)
Legend (shading):					< 0.2 mg/kg (none)		0.2 - 0.5 mg/kg (yellow)		0.5 - 1.0 mg/kg (orange)		≥ 1.0 mg/kg (red)
South San Francisco			SM-SSF-09-C-5	37.65231	-122.41741	2/17/2015	14:05	Street Dirt			
			SM-SSF-09-C-6	37.65113	-122.41731	2/17/2015	14:05	Street Dirt			
			SM-SSF-09-C-7	37.65100	-122.41837	2/17/2015	14:05	Inlet			
	SM-SSF-09-D	09-D	SM-SSF-09-D-1	37.65026	-122.41140	2/13/2015	10:11	Pump Station	0.07	0.04	
	SM-SSF-10-A	10-A	SM-SSF-10-A-2	37.65329	-122.42609	2/17/2015	15:40	Inlet	0.05	0.01	
			SM-SSF-10-A-4	37.65338	-122.42612	2/17/2015	15:40	Street Dirt			

Appendix B

Blank KLI Sampling Form

PCB/Hg Sampling Form

Contractor:

City:

Date (mm/dd/yyyy): / /

Personnel:

Sample ID:

Arrival Time:

Departure Time:

*Sample Time (1st sample):

Photos (Y / N)

Photo IDs:

GPS Device:

Env. Conditions

WIND DIRECTION (from):

N
W E
S

Beaufort Scale:

SKY CODE:	Clear, Partly Cloudy, Overcast, Fog, Smoky, Hazy
SITE ODOR:	None, Sulfides, Sewage, Petroleum, Smoke, Other_________________
PRECIP:	None, Fog, Drizzle, Rain
PRECIP (last 24 hrs):	None, Unknown, < 0.1", 0.1 - 0.25", > 0.25"
SOIL ODOR:	None, Sulfides, Sewage, Petroleum, Mixed, Other_________________
SOIL COLOR:	Colorless, Green, Yellow, Brown
SOIL COMPOSITION:	Silt/Clay, Sand, Gravel, Cobble, Mixed, Debris
SOIL POSITION	Submerged, Exposed

Address, Location, and Sketches

Samples Taken

Field Dup at Site? YES / NO: (create separate datasheet for FDs, with unique IDs (i.e., blind samples)) **Field Dup ID:**

COLLECTION DEVICE: Equipment type used: Scoop (SS / PC / PE), Core (SS / PC / PE), Grab (Van Veen / Eckman / Petite Ponar), Broom (nylon, natural fiber)

SubSampleID	MH / Inlet / Street Dirt / Other	DepthCollec (cm)	Composite / Grab (C / G)	# Containers Filled	PCBs	Hg	Other	Latitude (dd.ddddd)	Longitude (ddd.ddddd)

SITE/SAMPLING DESCRIPTION AND COMMENTS:

Appendix C

Blank EOA Sampling Form

POC Sampling Form

Staff: ____________________________________ Sample ID: _____________________________

City: _________________________________ Date:_______________________ Time: _______________

Photo IDs: ____

Address 1: ____ Latitude: ____________________________

MH / CB / SED / Other: ______________ Subsample ID: _____________Longitude: ___________________________

Address 2: ____ Latitude: ____________________________

MH / CB / SED / Other: ______________ Subsample ID: _____________Longitude: ___________________________

Address 3: ____ Latitude: ____________________________

MH / CB / SED / Other: ______________ Subsample ID: _____________Longitude: ___________________________

Address 4: ____ Latitude: ____________________________

MH / CB / SED / Other: ______________ Subsample ID: _____________Longitude: ___________________________

Composite: yes / no Field Duplicate: yes / no ID: ______________________ Time: ___________

Notes: (Electrical/Heavy equipment, drums, scrap metal, oil stains, sediment transport, drainage patterns, etc.)

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Sketch: (include north arrow, street names, inflow/outflow pipes with diameters, private inlets, flow directions, etc.)