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

[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.

[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		

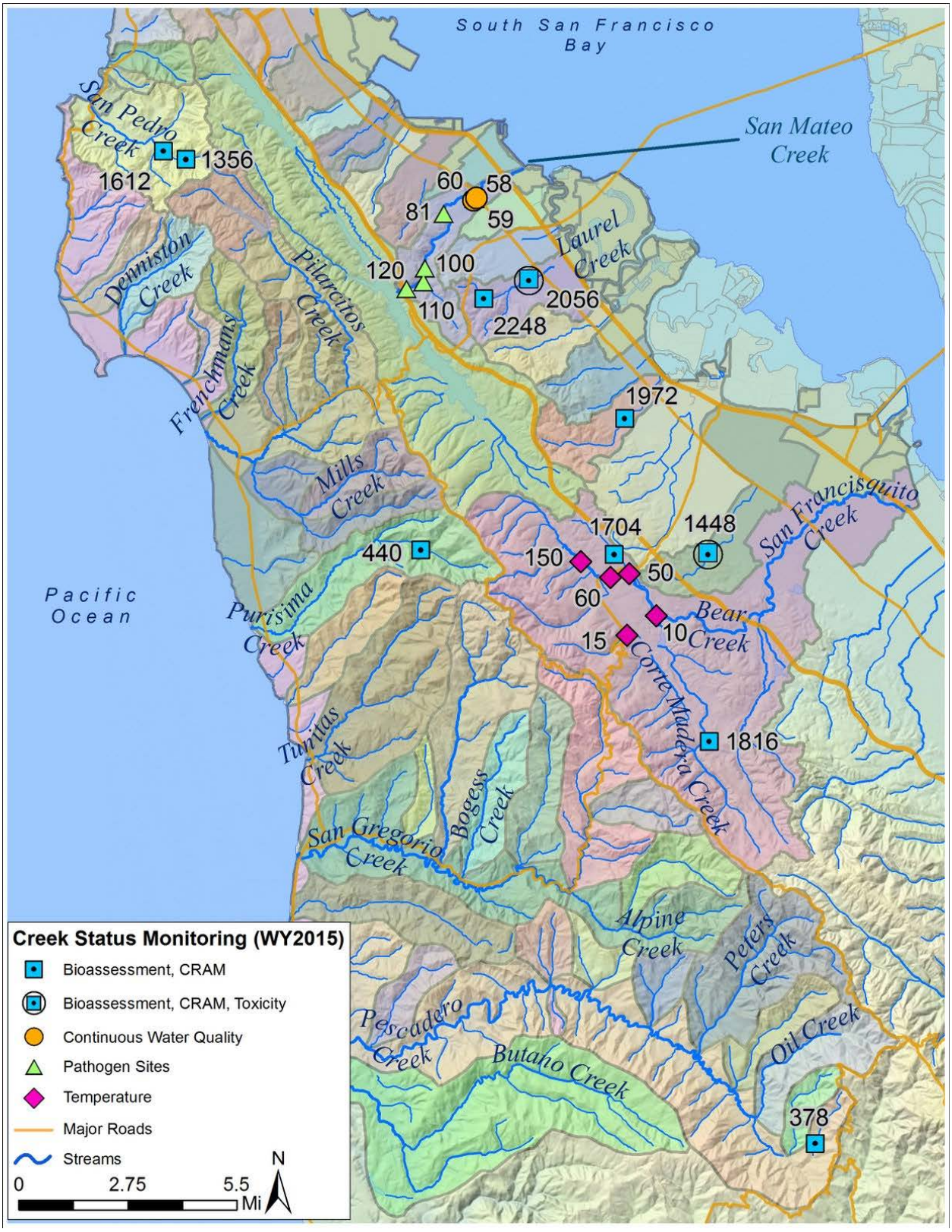

Figure 1.1. Map of SMCWPPP sites monitored in WY2015.

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.

[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.

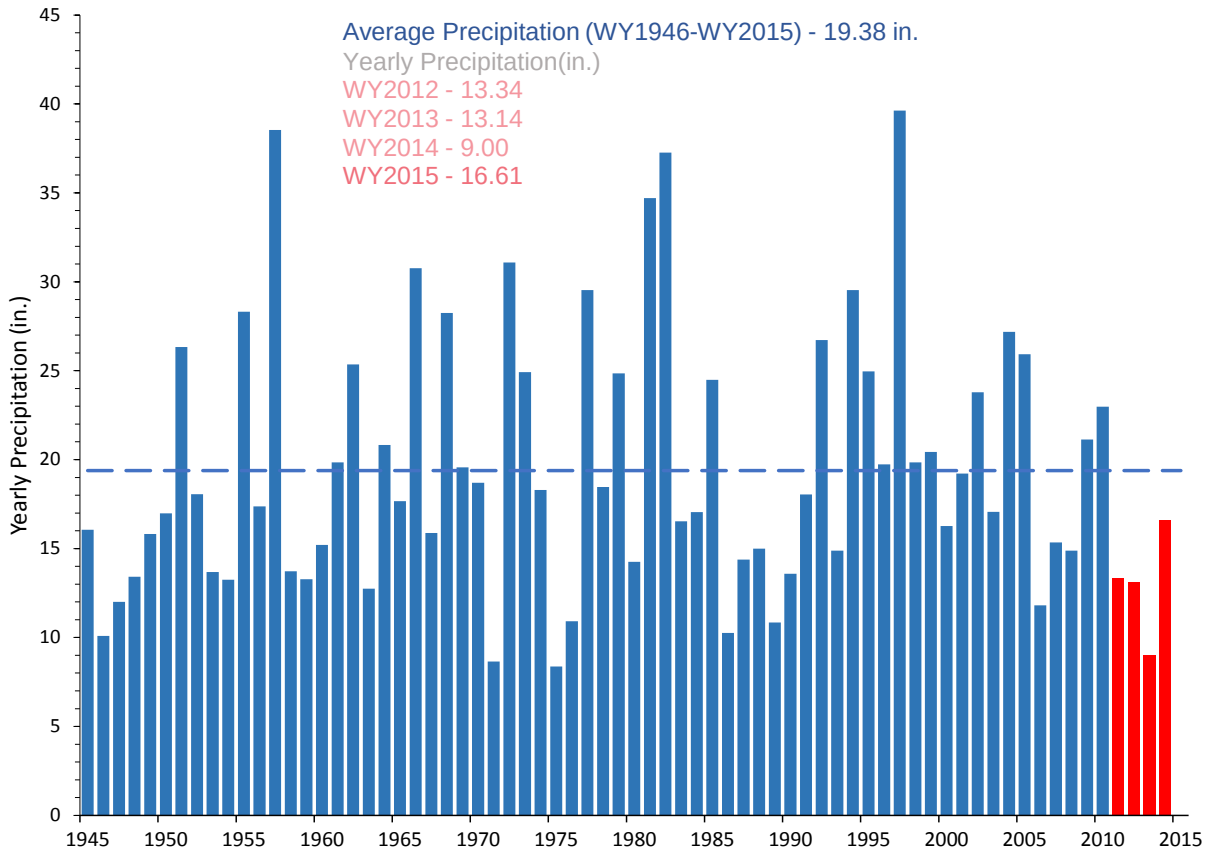

Figure 1.3. Annual rainfall recorded at the San Francisco International Airport, WY1946 – WY2015.

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.

[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

[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

[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™ 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

[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

[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	≥ 0.92	0.79 – 0.92	0.63 – 0.79	< 0.63
Benthic Algae				
D18 Score	≥ 72	62 - 72	49 - 62	< 49
Riparian Habitat Condition				
Total CRAM Score	≥ 79	72 - 79	63 - 72	< 63
Total PHAB Score	≥ 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

[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.

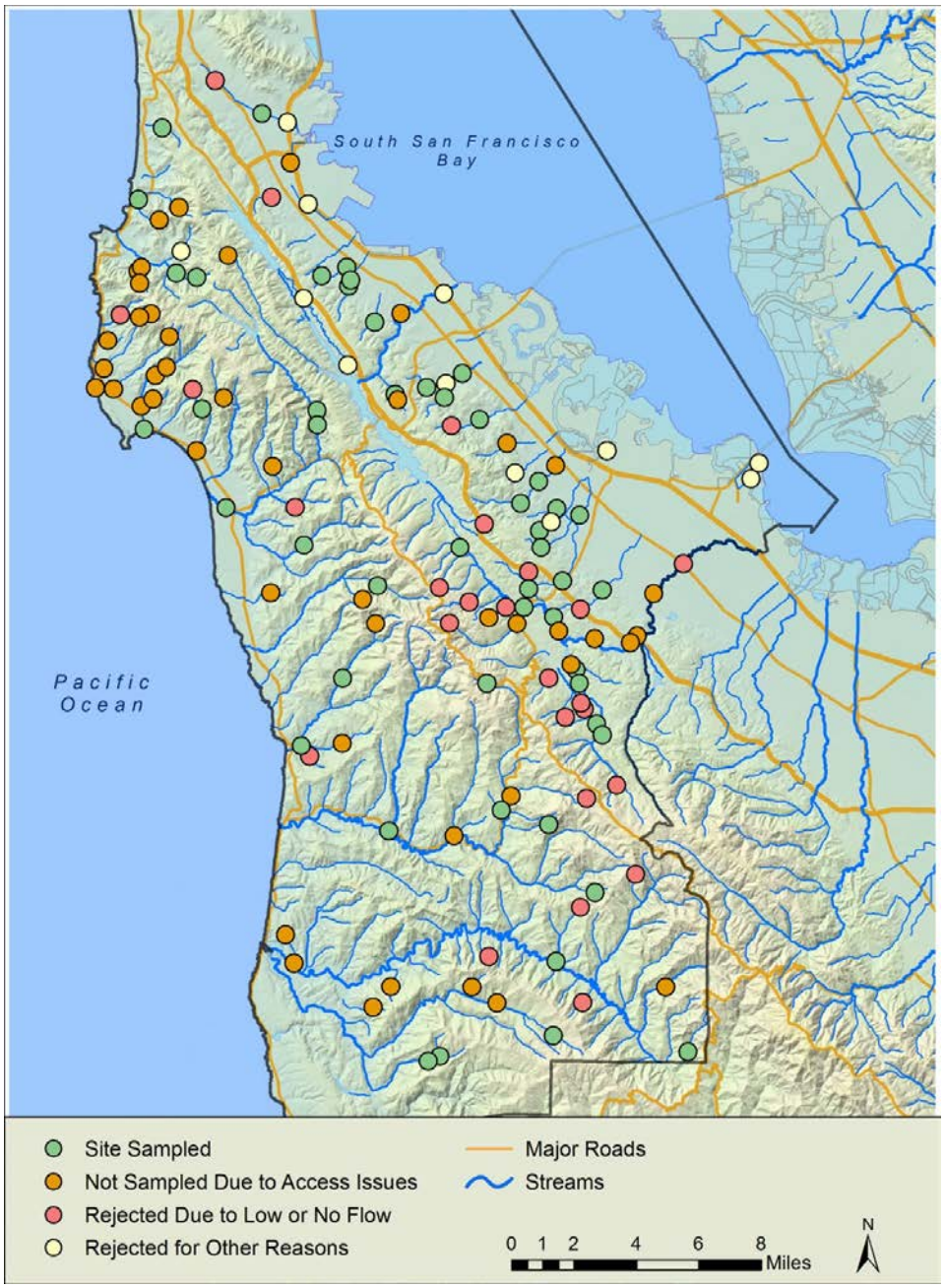

Figure 2.1. Site evaluation results for RMC probabilistic sites (n=133) conducted WY2012 – WY 2015 in San Mateo County.

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.

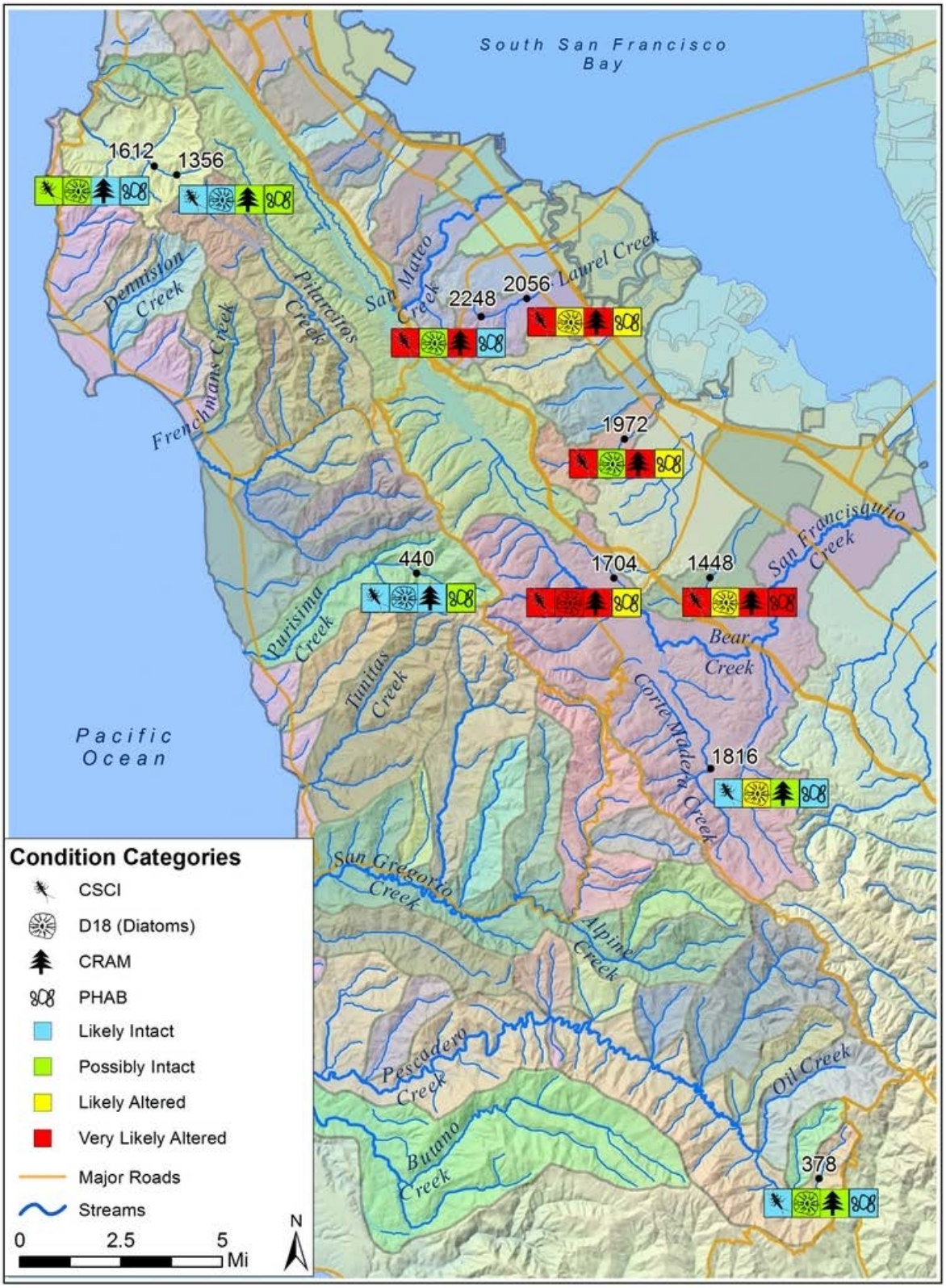

Figure 2.2. Condition category as represented by CSCI, D18, total CRAM, and total PHAB scores for ten probabilistic sites sampled in San Mateo County in WY2015.

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.

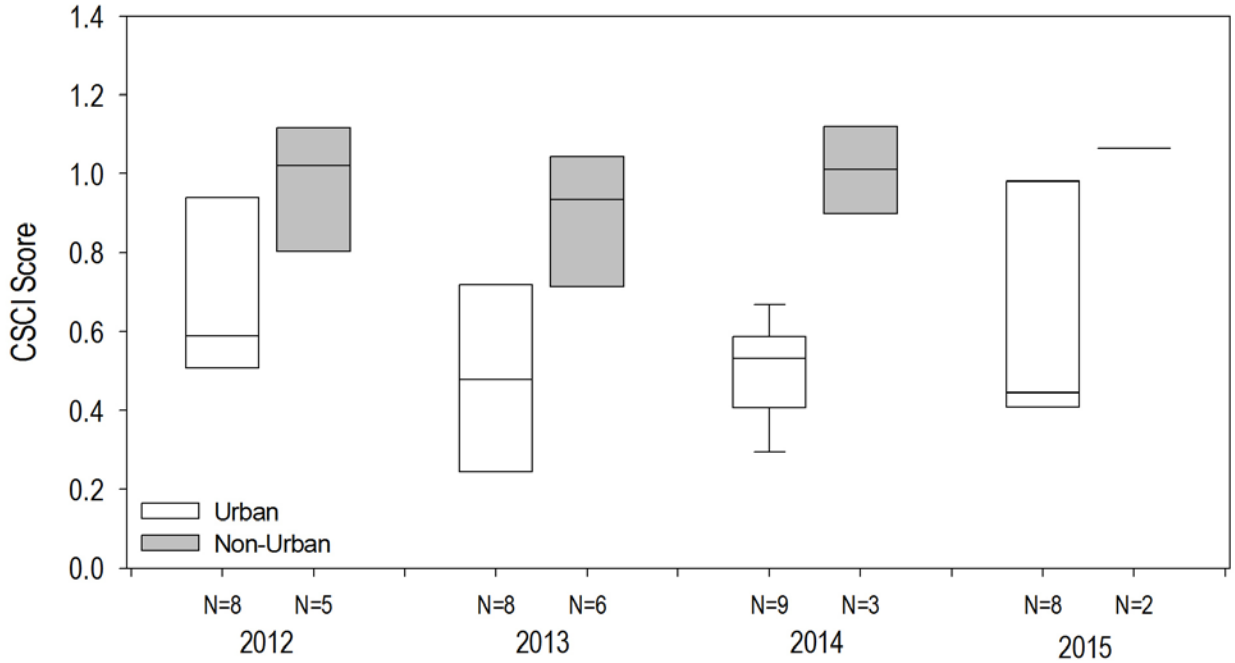

Figure 2.3. Box plots showing CSCI scores grouped by land use classification, for 50 bioassessment sites in San Mateo County, WY2012 - WY2015.

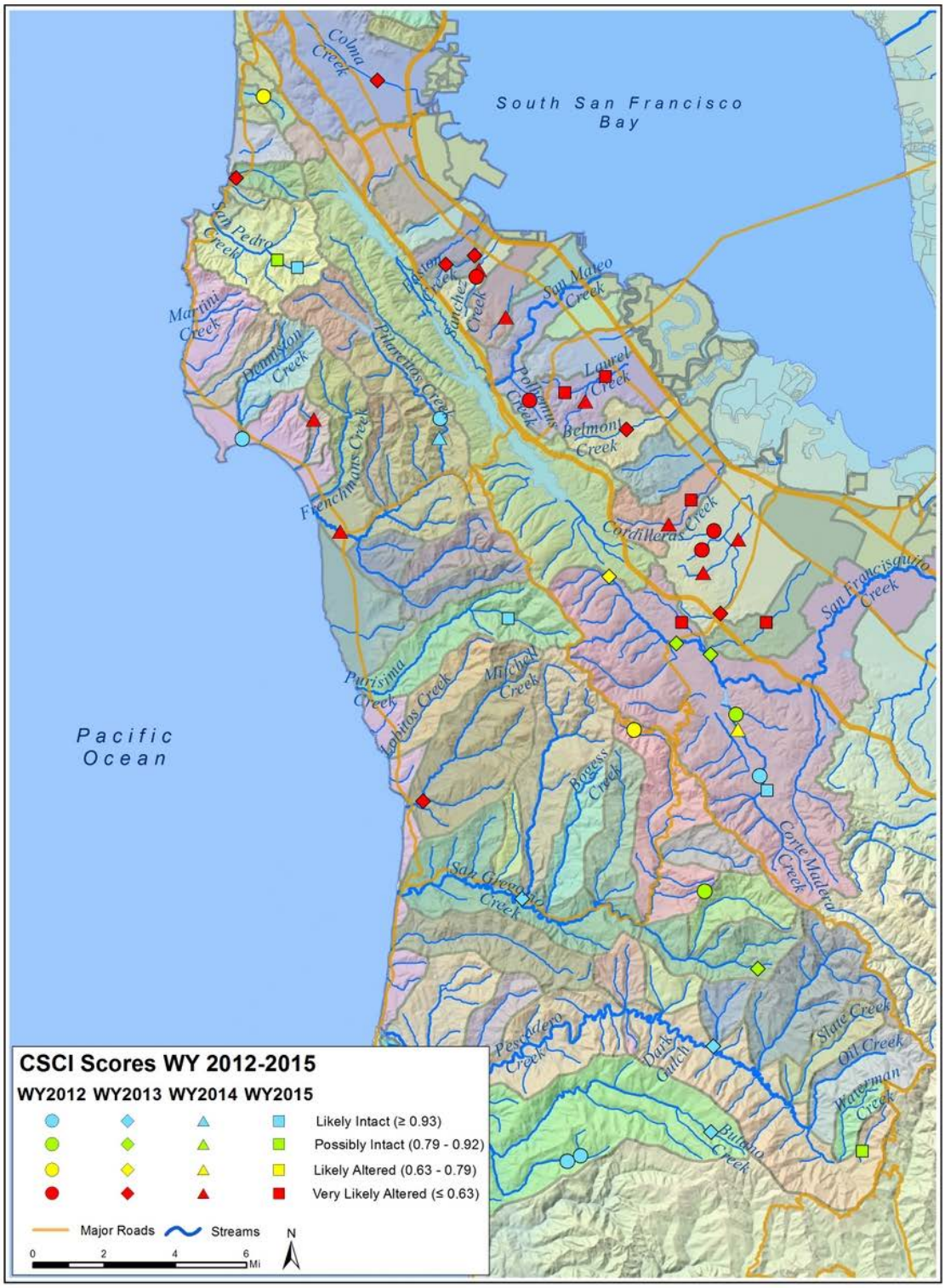

Figure 2.4. Biological condition based on CSCI scores for 50 sites sampled by SMCWPPP and SFRWQCB in San Mateo County between WY2012 and WY2015.

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.

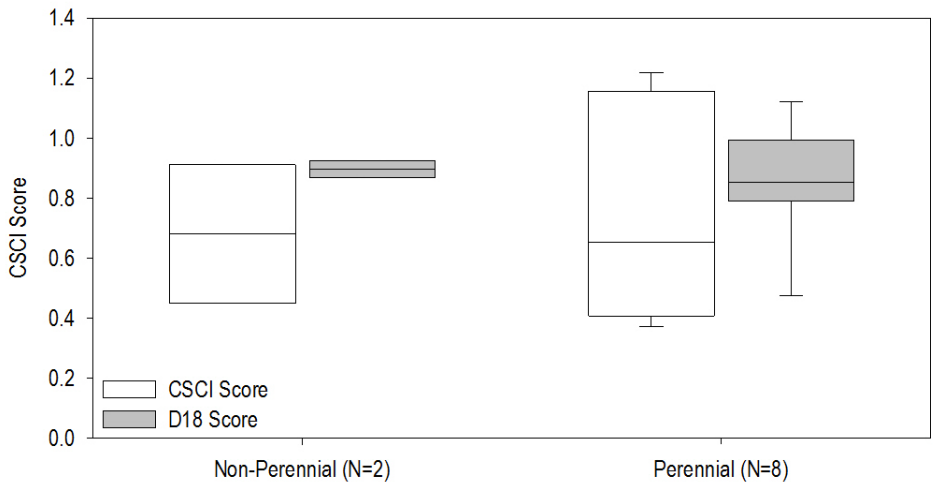

Figure 2.5. Box plots showing CSCI and algae IBI scores, grouped by flow classification, for 10 bioassessment sites sampled in San Mateo in WY2015.

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.

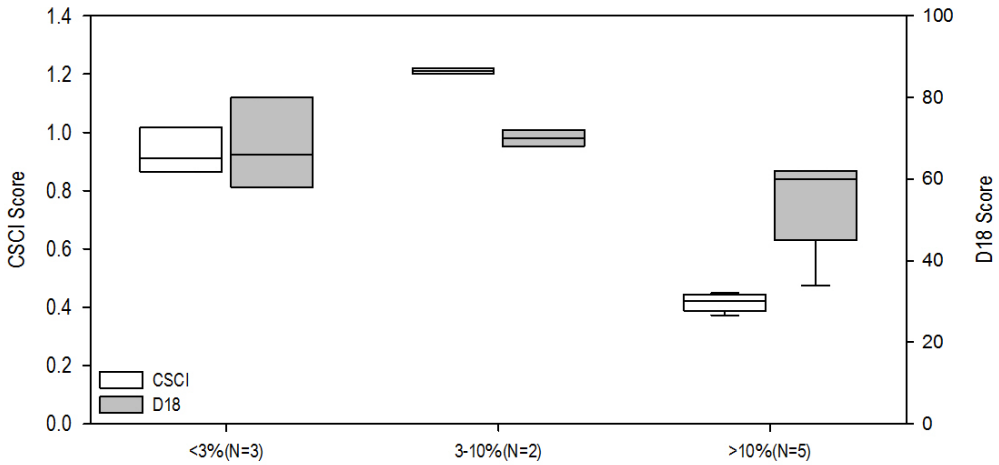

Figure 2.6. Box plots showing CSCI and algae IBI scores, grouped by percent impervious area, for 10 bioassessment sites sampled in San Mateo County in WY2015.

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.

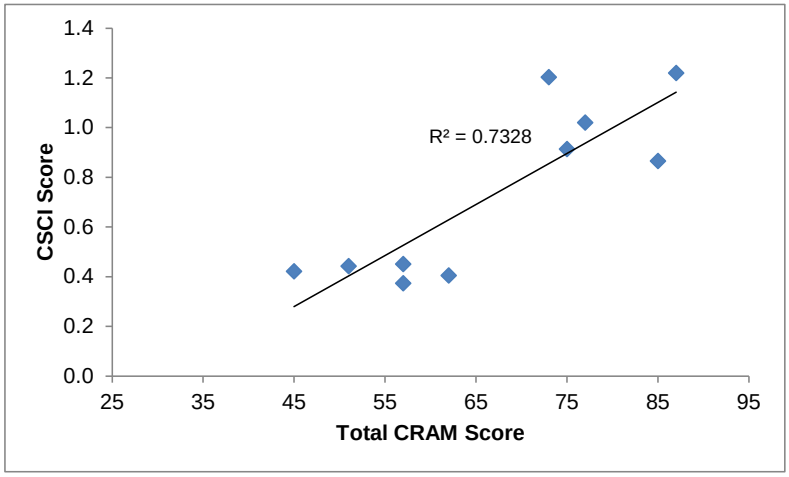

Figure 2.7. Total PHAB scores compared to CSCI scores at 10 bioassessment sites sampled in San Mateo County in WY2015.

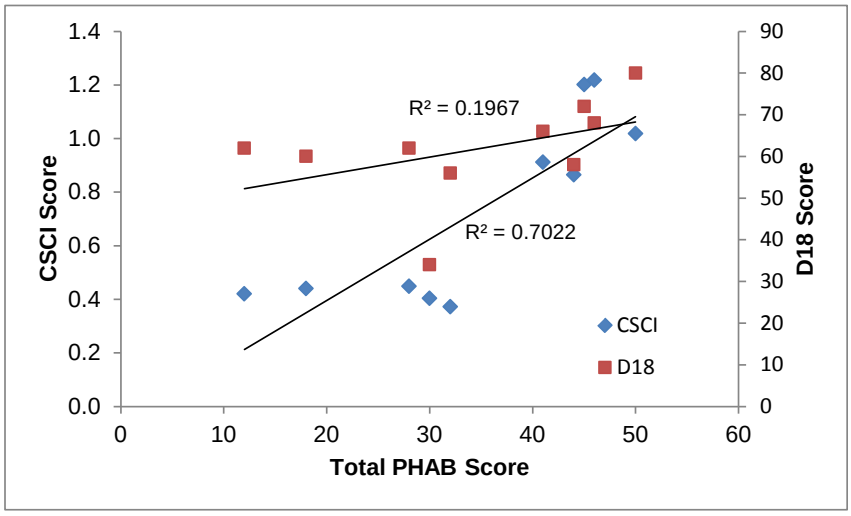

Figure 2.8. D18 and CSCI scores plotted with PHAB score for 10 bioassessment sites sampled in San Mateo County in WY2015.

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.

[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

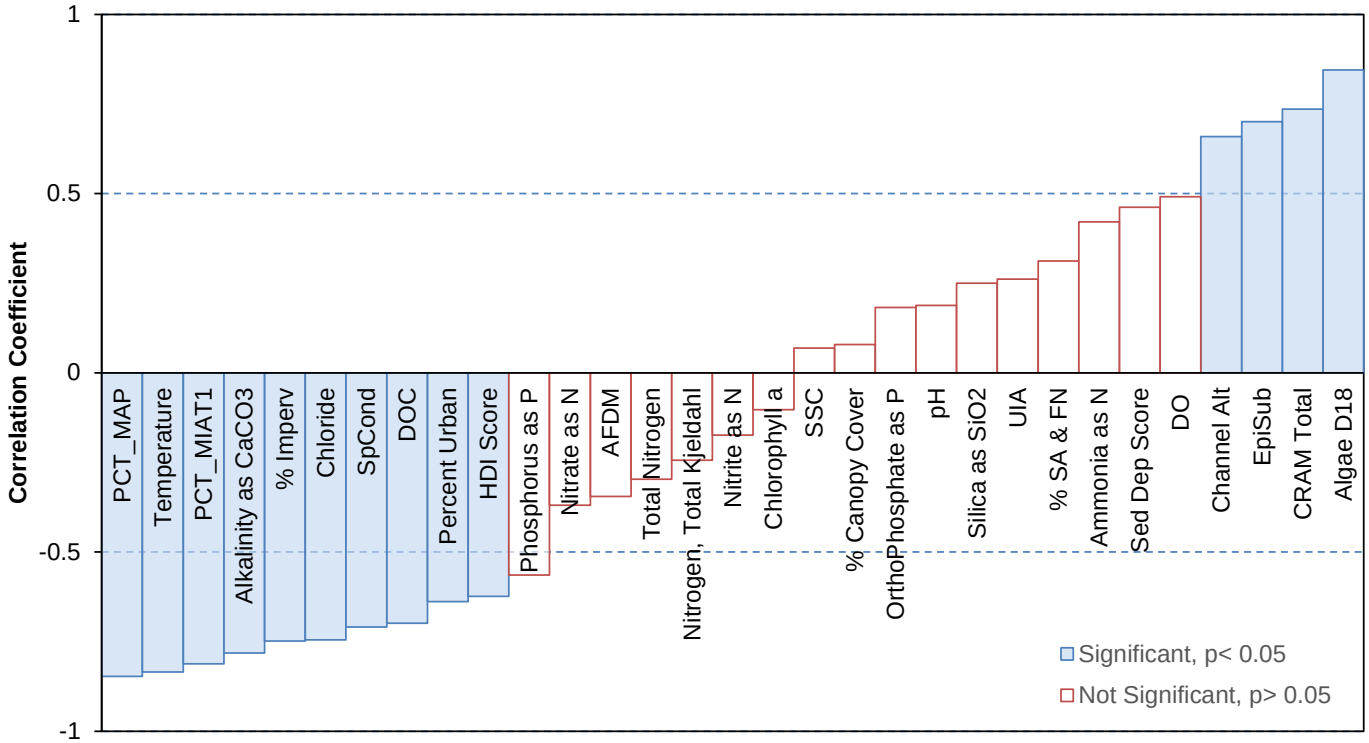

Figure 2.9. Spearman Rank Correlation for CSCI scores and stressor variable data collected at ten sites in San Mateo County in WY2015.

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).

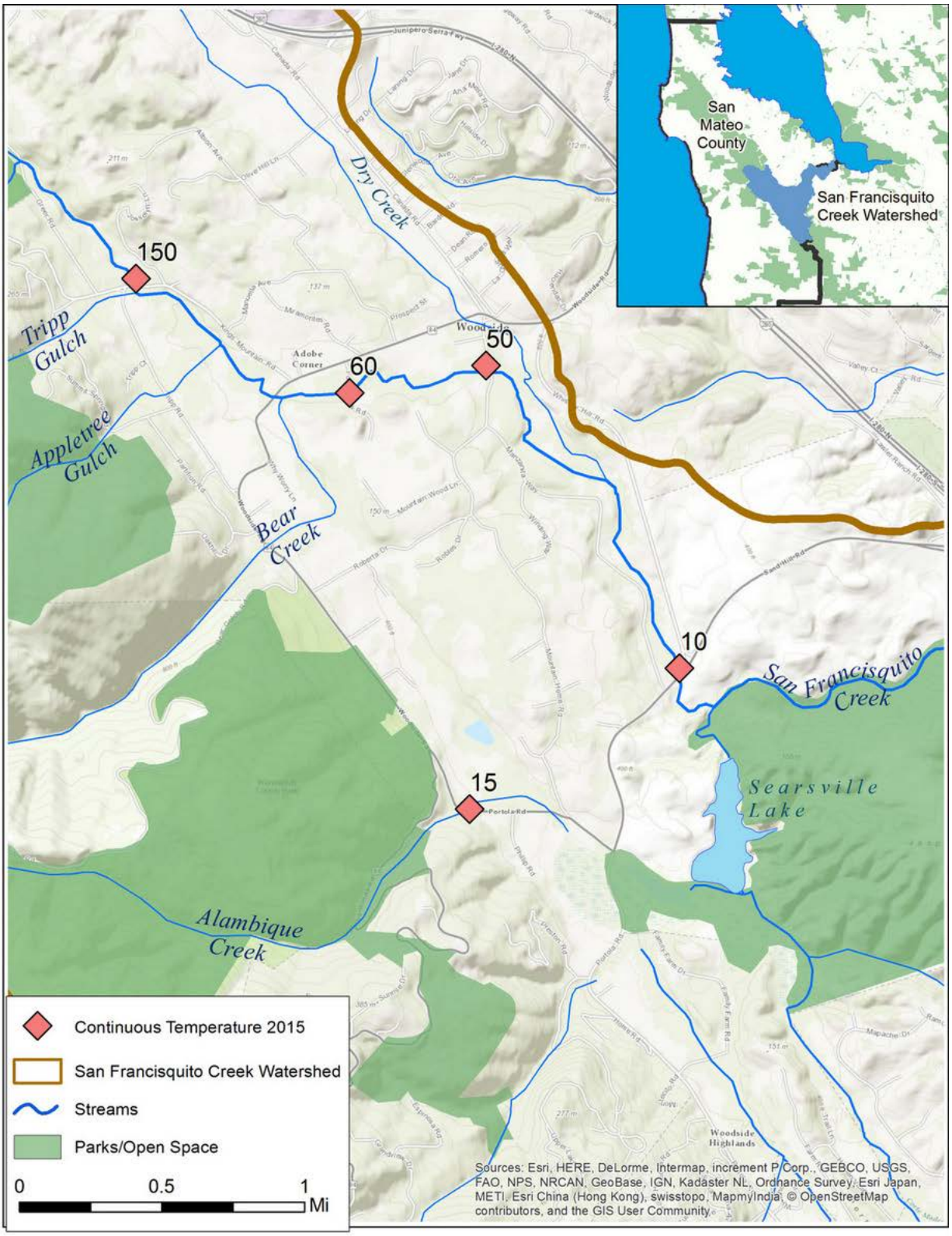

Figure 3.1. Continuous temperature stations in Alambique, Bear, and West Union Creeks, San Mateo County, WY2015.

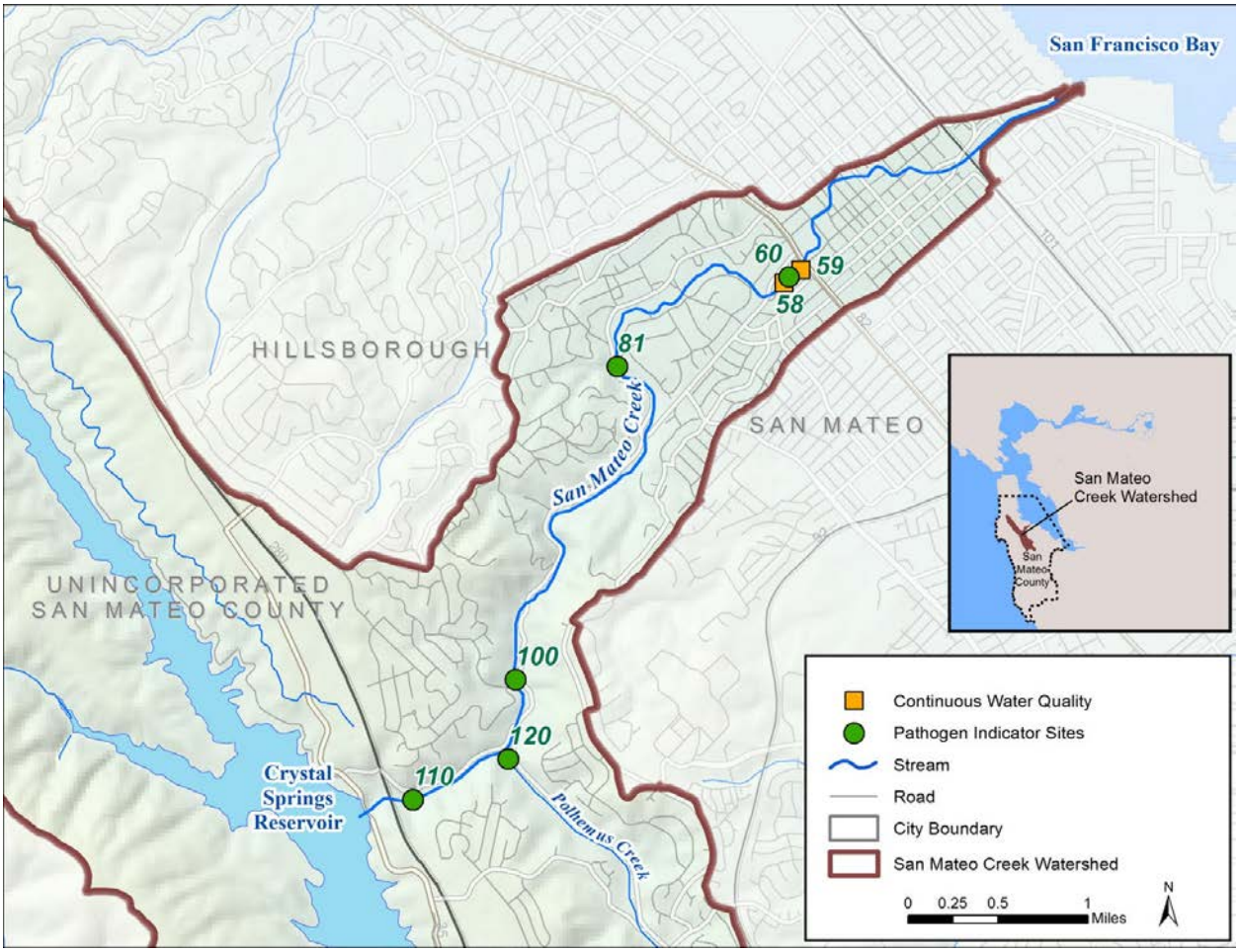

Figure 3.2. General water quality and pathogen indicator monitoring sites, San Mateo Creek, WY2015.

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.	^{0}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.

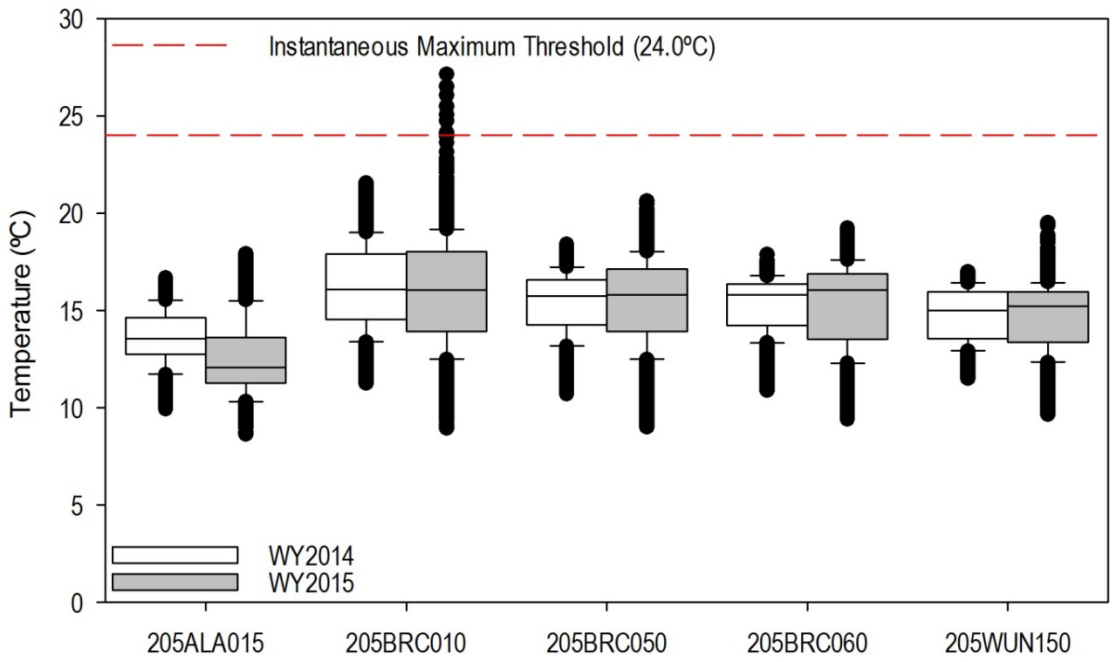

Figure 3.3. Box plots of water temperature data collected at five sites in the San Francisquito Creek watershed from April through September, WY2014 and WY2015.

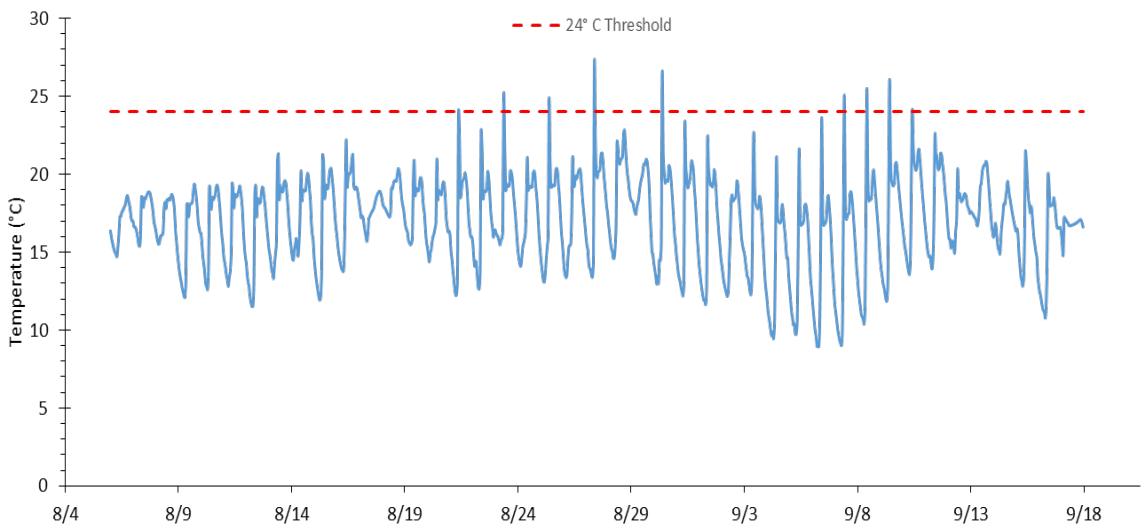

Figure 3.4 Hourly temperature recorded at site 205BRC010 (Bear Creek at Sand Hill Road) from August 7 to September 18, 2015. The cause of the daily temperature spikes is unknown.

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.

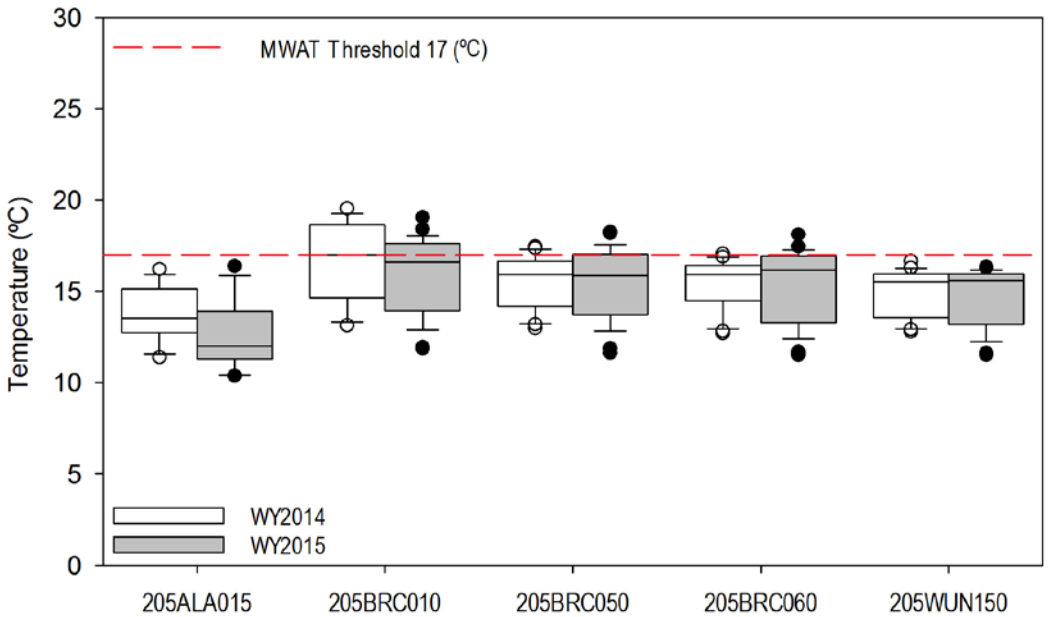

Figure 3.5. Box plots of water temperature data calculated as a weekly (7-day) average, recorded at five sites in the San Francisquito Creek watershed, from April through September WY2014 and WY2015.

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

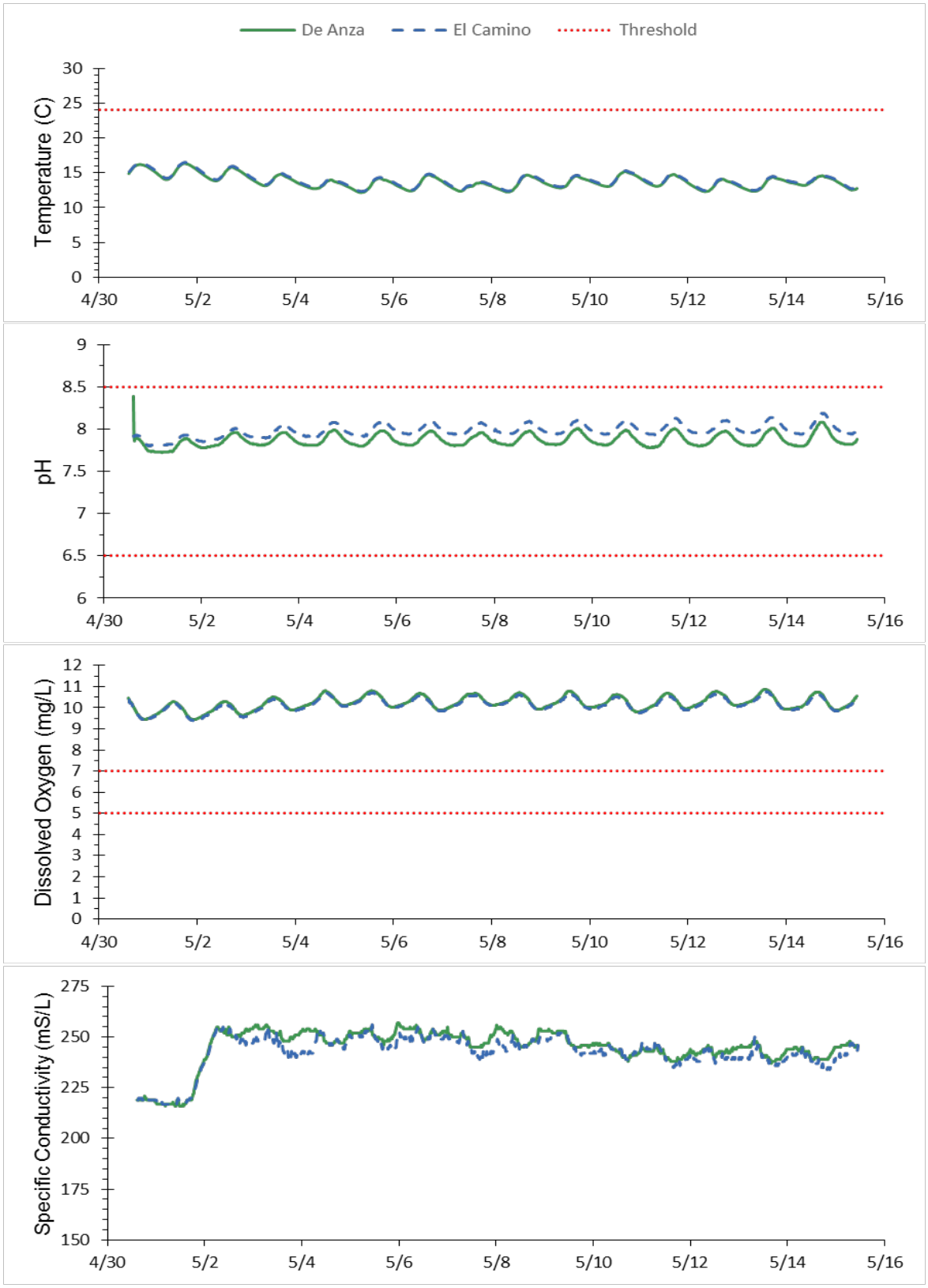

Figure 3.6 Continuous water quality data (temperature, pH, dissolved oxygen, and specific conductance) collected at two sites in San Mateo Creek during May 1 - 16, 2015 (Event 1).

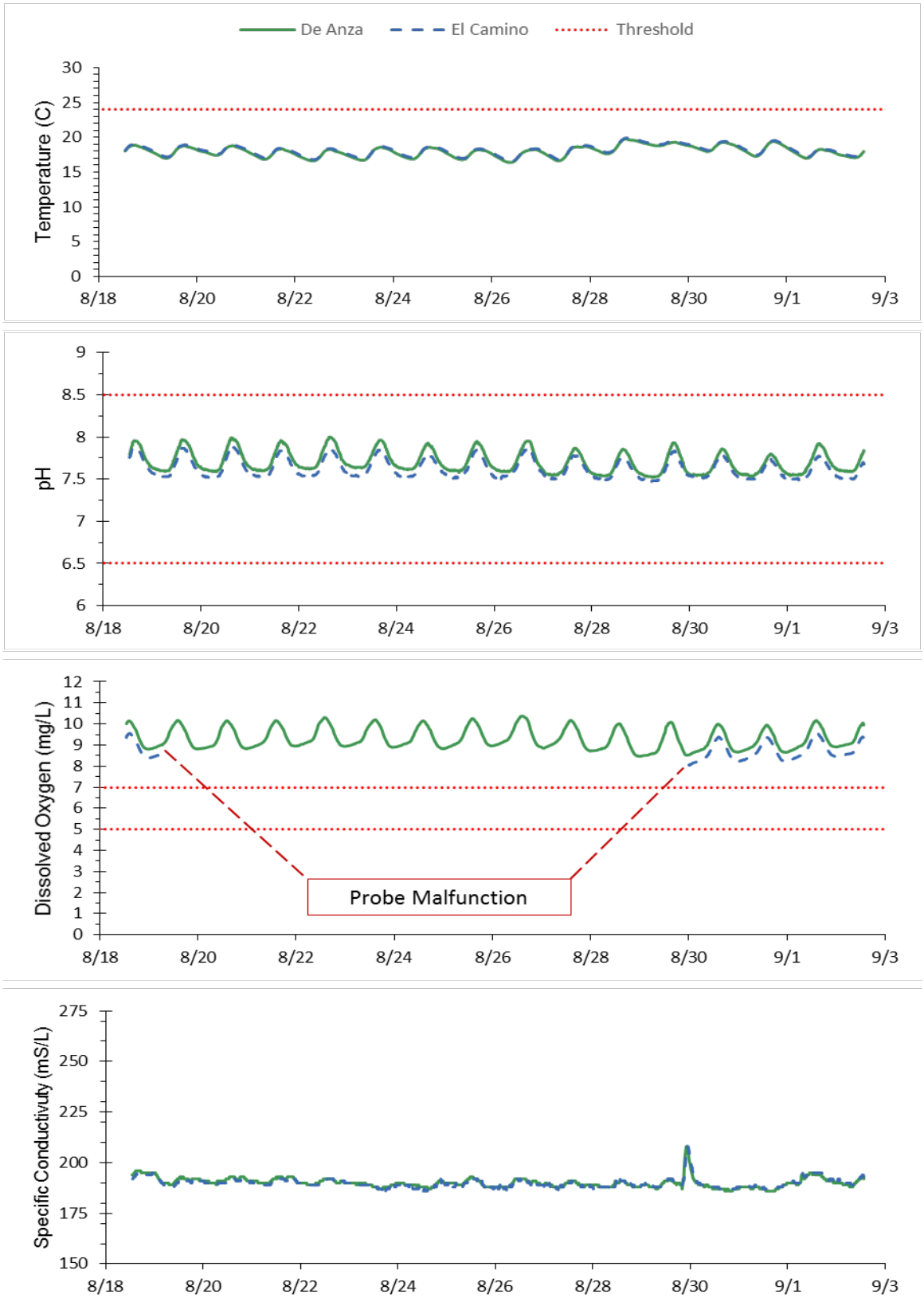

Figure 3.7 Continuous water quality data (temperature, pH, dissolved oxygen, and specific conductance) collected at two sites in San Mateo Creek during August 19 - September 3, 2015 (Event 2).

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.

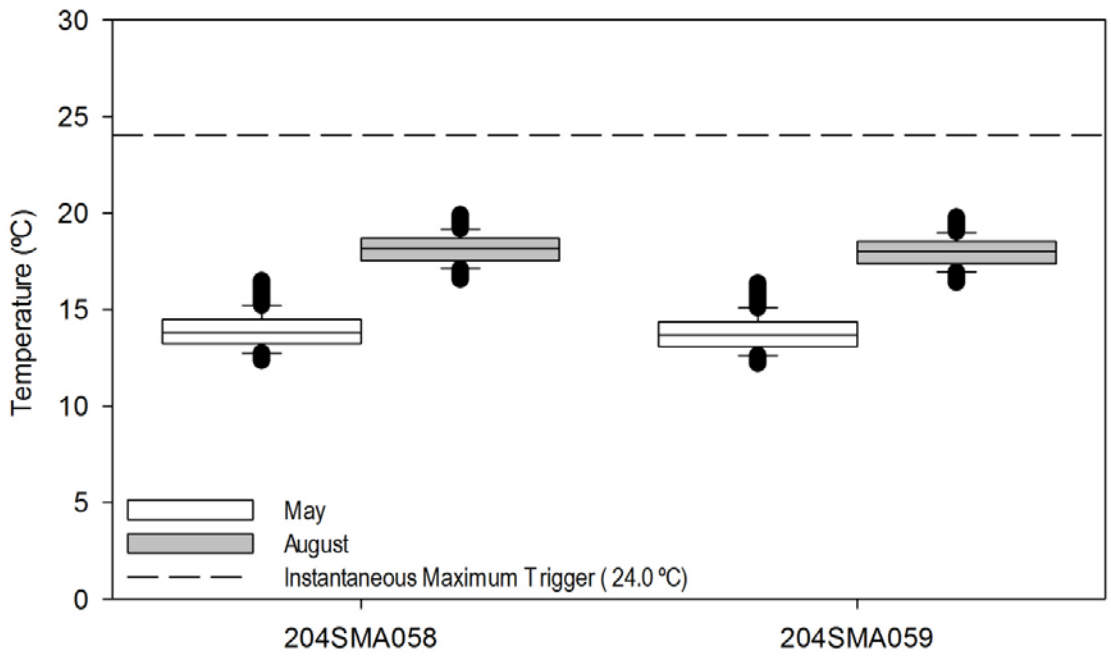

Figure 3.8. Box plots of water temperature data, measured during two sampling events in WY2015 at two sites in San Mateo Creek compared to the instantaneous maximum temperature trigger.

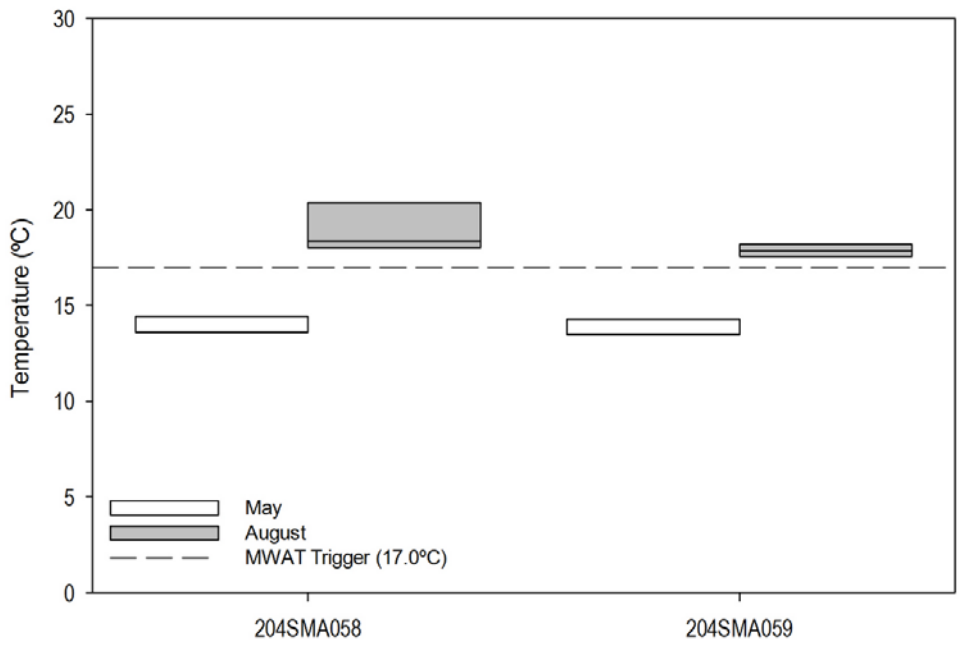

Figure 3.9. Box plots of water temperature data, calculated as a 7-day non-rolling average, collected during two sampling events in WY2015 at two sites in San Mateo Creek compared to the MWAT threshold.

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).

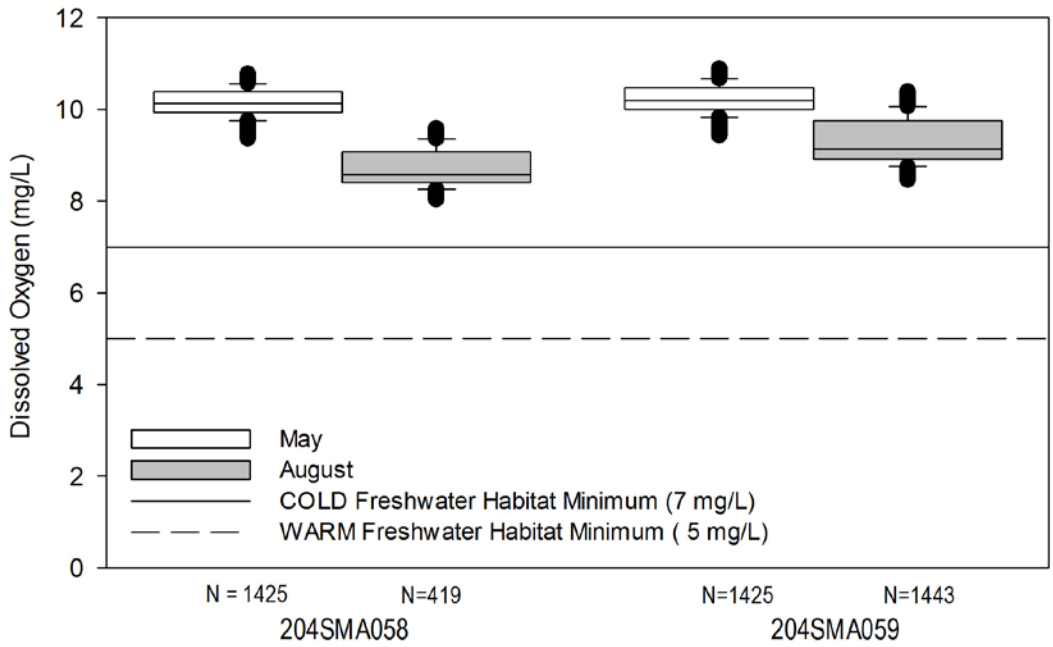

Figure 3.10. Box plots of dissolved oxygen data collected using sondes during two sampling events at sites in San Mateo Creek compared to Basin Plan Water Quality Objectives.

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.

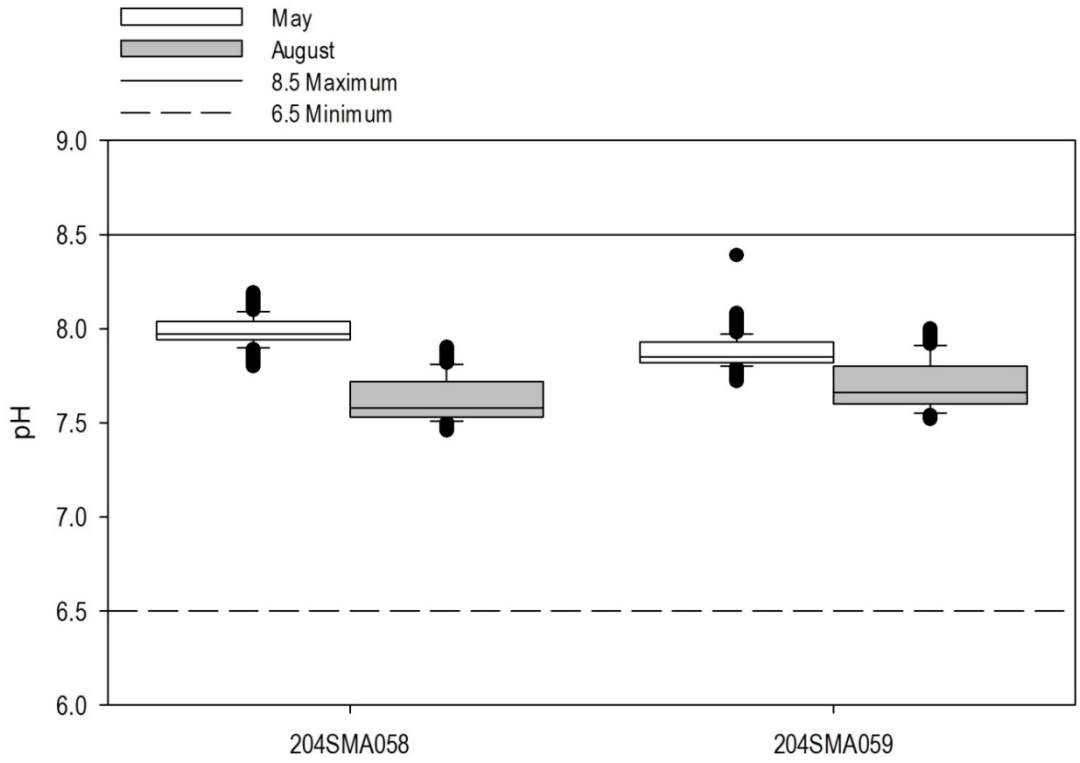

Figure 3.11. Box plots of pH data measured during two sampling events at sites in San Mateo Creek compared to Basin Plan WQOs.

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.

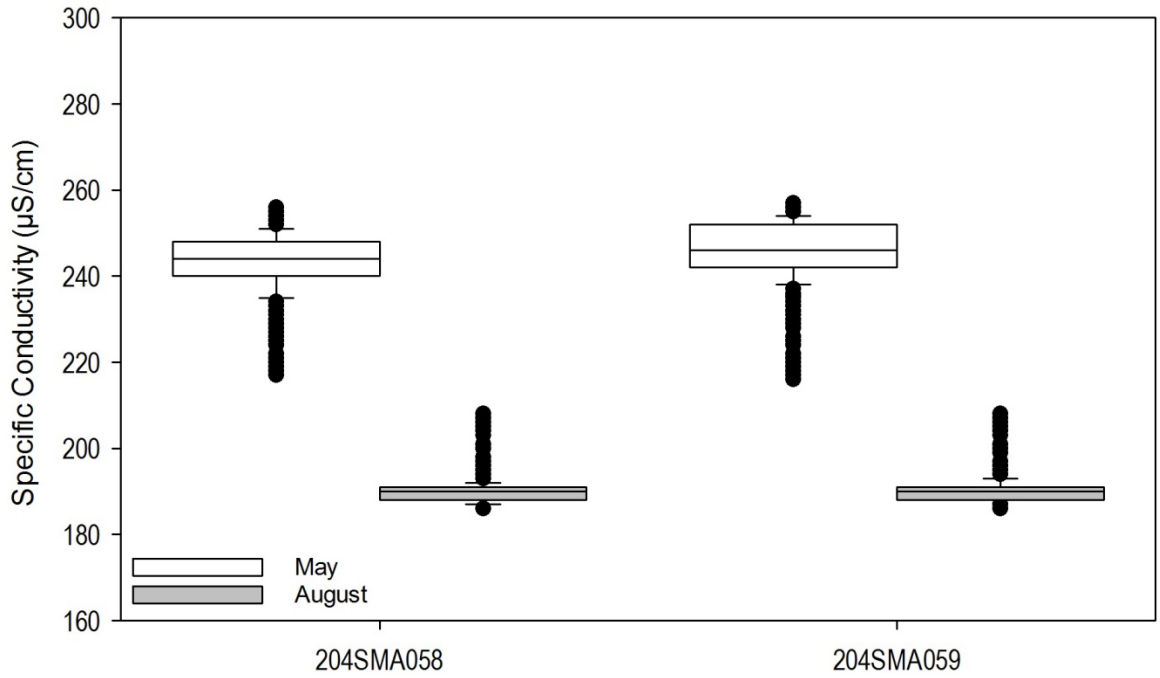

Figure 3.12. Box plots of specific conductance measurements recorded during two sampling events at sites in San Mateo Creek, WY2015.

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

[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

[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		204R01448	204R02056
Creek	TEC	Atherton Cr	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.

Pyrethroid	Units	LC50	204R01448 Atherton Cr	204R02056 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™ 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.

[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

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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.

[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:

$$PR = MV / EV \times 100\%$$

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

For matrix spikes, percent recovery is calculated as:

$$PR = [(MV - NV) / SV] \times 100\%$$

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 ^{o}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™ 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™ 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

[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 ºC 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

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