SAN MATEO COUNTYWIDE
Water Pollution
Prevention Program

Appendix A

SMCWPPP Creek Status Monitoring Report

Water Year 2016 (October 2015 – September 2016)

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

March 31, 2017

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 Municipal Regional National Pollutant Discharge Elimination System (NPDES) Stormwater Permit (in this document the permit is referred to as MRP)[1]. The RMC includes the following participants:

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

This Creek Status Monitoring Report complies with provision C.8.h.iii of the MRP for reporting of all data in Water Year 2016 (October 1, 2015 through September 30, 2016). Data were collected pursuant to provisions C.8.d (Creek Status Monitoring) and C.8.g (Pesticides & Toxicity Monitoring) of the MRP. 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, 2016a) and BASMAA RMC Standard Operating Procedures (SOPs; BASMAA, 2016b). 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 the MRP.

---

[1] The San Francisco Bay Regional Water Quality Control Board (SFRWQCB or Regional Water Board) issued the MRP to 76 cities, counties and flood control districts (i.e., Permittees) in the Bay Area on October 14, 2009 (SFRWQCB 2009). On November 19, 2015, the Regional Water Board updated and reissued the MRP (SFRWQCB 2015). 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 Countywide Clean Water Program
AFDM	Ash Free Dry Mass
AFS	American Fisheries Society
BASMAA	Bay Area Stormwater Management Agency Association
BMI	Benthic Macroinvertebrate
CAP	Conservation Action Plan
C/CAG	City/County Association of Governments
CCCWP	Contra Costa Clean Water Program
COLD	Cold Freshwater Habitat
CSCI	California Stream Condition Index
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
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
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
SRP	Stormwater Resource Plan
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
WARM	Warm Freshwater Habitat
WQO	Water Quality Objective
WY	Water Year

Table of Contents

List of Figures

List of Tables

Attachments

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 for Bay Area municipalities referred to as the Municipal Regional Permit (MRP). The MRP was first adopted by the San Francisco Regional Water Quality Control Board (SFRWQCB or Regional Water Board) on October 14, 2009 as Order R2-2009-0074 (SFRWQCB 2009). On November 19, 2015, the SFRWQCB updated and reissued the MRP as Order R2-2015-0049 (SFRWQCB 2015). This report fulfills the requirements of provision C.8.h.iii of the MRP for comprehensively interpreting and reporting all Creek Status and Pesticides & Toxicity monitoring data collected during the foregoing October 1 – September 30 (i.e., Water Year 2016) [3]. Data were collected pursuant to water quality monitoring requirements in provisions C.8.d (Creek Status Monitoring) and C.8.g (Pesticides & Toxicity Monitoring) of the MRP. 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).[4]

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** – Biological condition assessment and stressor analysis at probabilistic sites
- **Section 3.0** – General water quality monitoring (continuous temperature, continuous general water quality, and pathogen indicators) at targeted sites
- **Section 4.0** – Chlorine monitoring at probabilistic sites
- **Section 5.0** – Pesticides & Toxicity monitoring
- **Section 6.0** – Conclusions and recommendations

1.1 Monitoring Goals

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

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

---

[3] Monitoring data collected pursuant to other C.8 provisions (e.g., Pollutants of Concern Monitoring, Stressor/Source Identification Monitoring Projects) are reported in the SMCWPPP Urban Creeks Monitoring Report (UCMR) for WY 2016 to which this Creek Status Monitoring Report is appended.

[4] http://water100.waterboards.ca.gov/ceden/sfei.shtml.

Creek Status and Pesticides & Toxicity monitoring parameters, methods, occurrences, durations and minimum number of sampling sites are described in provisions C.8.d and C.8.g of the MRP, respectively. The monitoring requirements in the 2015 MRP are similar to the 2009 MRP requirements (which began implementation on October 1, 2011) and build upon earlier monitoring conducted by SMCWPPP. Creek Status and Pesticides & Toxicity monitoring is coordinated through the Regional Monitoring Coalition (RMC). Monitoring results are evaluated to determine whether triggers are met and further investigation is warranted as a potential Stressor/Source Identification (SSID) Project, as described in provision C.8.e of the MRP. Results of Creek Status Monitoring conducted in Water Years 2012 through 2014 were submitted in prior reports (SMCWPPP 2016, SMCWPPP 2015, SMCWPPP 2014).

1.2 Regional Monitoring Coalition

Provision C.8.a (Compliance Options) of the MRP 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 Management 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]. Implementation of the RMC's Creek Status and Long-Term Trends Monitoring Plan (BASMAA 2012) allows Permittees and the Regional Water Board to 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.

[5] The San Francisco Bay Regional Water Quality Control Board (SFRWQCB) issued the first 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.

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
Alameda Countywide Clean Water Program (ACCWP)	Cities of Alameda, Albany, Berkeley, Dublin, Emeryville, Fremont, Hayward, Livermore, Newark, Oakland, Piedmont, Pleasanton, San Leandro, and Union City; Alameda County; Alameda County Flood Control and Water Conservation District; and, Zone 7
Contra Costa Clean Water Program (CCCWP)	Cities of Antioch, Brentwood, Clayton, Concord, El Cerrito, Hercules, Lafayette, Martinez, Oakley, Orinda, Pinole, Pittsburg, Pleasant Hill, Richmond, San Pablo, San Ramon, Walnut Creek, Danville, and Moraga; Contra Costa County; and, Contra Costa County Flood Control and Water Conservation District
San Mateo 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 Creek Status monitoring 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 the MRP.

Table 1.2. Creek Status Monitoring parameters in compliance with MRP 2.0 provision C.8.d (Creek Status Monitoring) and C.8.g (Pesticides & Toxicity Monitoring) and associated monitoring component.

Monitoring Elements	Monitoring Component		Report Section
	Regional Ambient (Probabilistic)	Local (Targeted)	
Creek Status Monitoring (C.8.d)			
Bioassessment & Physical Habitat Assessment	X	(X)[1]	2.0
Nutrients	X	(X)[1]	2.0
General Water Quality (Continuous)		X	3.0
Temperature (Continuous)		X	3.0
Pathogen Indicators		X	3.0
Chlorine	X	(X)[2]	4.0
Pesticides & Toxicity Monitoring (C.8.g)			
Water Toxicity		X	5.0
Sediment Toxicity		X	5.0
Sediment Chemistry		X	5.0

Notes:
[1] Provision C.8.d.i.(6) allows for up to 20% of sample locations to be selected on a targeted basis.
[2] Provision C.8.d.ii.(2) provides options for probabilistic or targeted site selection.

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 2016b) and associated Quality Assurance Project Plan (QAPP; BASMAA 2016a). 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/qaprp082209.pdf

1.3.2 Laboratory Analysis Methods

RMC participants, including SMCWPPP, agreed to use the same laboratories for individual parameters (excepting pathogen indicators), developed standards for contracting with the labs, and coordinated quality assurance samples. 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 2016a). Analytical laboratory methods, reporting limits and holding times for chemical water quality parameters are also described in BASMAA (2016a). Analytical laboratory contractors included:

- BioAssessment Services, Inc. – Benthic macroinvertebrate (BMI) identification
- EcoAnalysts, Inc. – Algae identification
- CalTest, Inc. – Sediment chemistry, nutrients, chlorophyll a, ash free dry mass
- Pacific EcoRisk, Inc. - Water and sediment toxicity
- San Jose-Santa Clara Regional Wastewater Facility – Pathogen indicators

1.3.3 Data Analysis Methods

Water and sediment chemistry and toxicity data generated during WY 2016 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). Creek Status Monitoring and Pesticides and Toxicity Monitoring data must be evaluated with respect to numeric thresholds, specified in the “Followup” sections in Provision C.8.d and C.8.g of the MRP (SFRWQCB 2015) that, if not met, require consideration for further evaluation as part of a Stressor/Source Identification (SSID) project. SSID projects are intended to be oriented toward taking action(s) to alleviate stressors and reduce sources of pollutants. A stepwise process for conducting SSID projects is described in Provision C.8.e.iii.

In compliance with provision C.8.e.i of the MRP, 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 WY 2016 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 WY 2016 in San Mateo County.

Map ID	Station Number	Bayside or Coastside	Watershed	Creek Name	Land Use	Latitude	Longitude	Probabilistic		Targeted		
								Bioassessment, Nutrients, Chlorine, General WQ	Toxicity, Sediment Chemistry	Temp	Cont. WQ	Pathogen Indicators
488	202R00488	Coastside	Tunitas Creek	Tunitas Creek	NU	37.38001	-122.37482	X				
506	202R00506	Coastside	Pescadero Creek	Peters Creek	NU	37.28940	-122.17619	X				
2332	202R02332	Coastside	Pilarcitos Creek	Pilarcitos Creek	U	37.47000	-122.44116	X				
2228	204R02228	Bayside	San Mateo Creek	San Mateo Creek	U	37.56114	-122.33698	X				
2504	204R02504	Bayside	San Mateo Creek	Polhemus Creek	U	37.53015	-122.34871	X				
2548	204R02548	Bayside	Cordilleras Creek	Cordilleras Creek	U	37.49544	-122.24336	X				
2408	205R02408	Bayside	San Francisquito Cr	Bull Run Creek	U	37.38400	-122.23499	X				
2728	205R02728	Bayside	San Francisquito Cr	Dry Creek	U	37.42452	-122.24954	X				
2920	205R02920	Bayside	San Francisquito Cr	Bear Creek	U	37.42376	-122.25112	X				
3032	205R03032	Bayside	San Francisquito Cr	West Union	U	37.43720	-122.28319	X				
10	204LAU010	Bayside	Laurel Creek	Laurel Creek	U	37.53556	122.29750		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
119	204SMA119	Bayside	San Mateo Creek	San Mateo Creek	U	37.52959	-122.35836					X
110	204SMA110	Bayside	San Mateo Creek	Polhemus Creek	U	37.53235	-122.3508					X
68	205ALA015	Bayside	San Francisquito Cr	Alambique Creek	U	37.40443	-122.25430			X		
71	205BCR010	Bayside	San Francisquito Cr	Bear Creek	U	37.41179	-122.24106			X	X	
69	205BCR050	Bayside	San Francisquito Cr	Bear Creek	U	37.42702	-122.25378			X		
72	205BCR060	Bayside	San Francisquito Cr	Bear Creek	U	37.42550	-122.26243			X		
70	205WUN150	Bayside	San Francisquito Cr	West Union Creek	U	37.431117	-122.27622			X	X	

NU = non-urban, U = urban

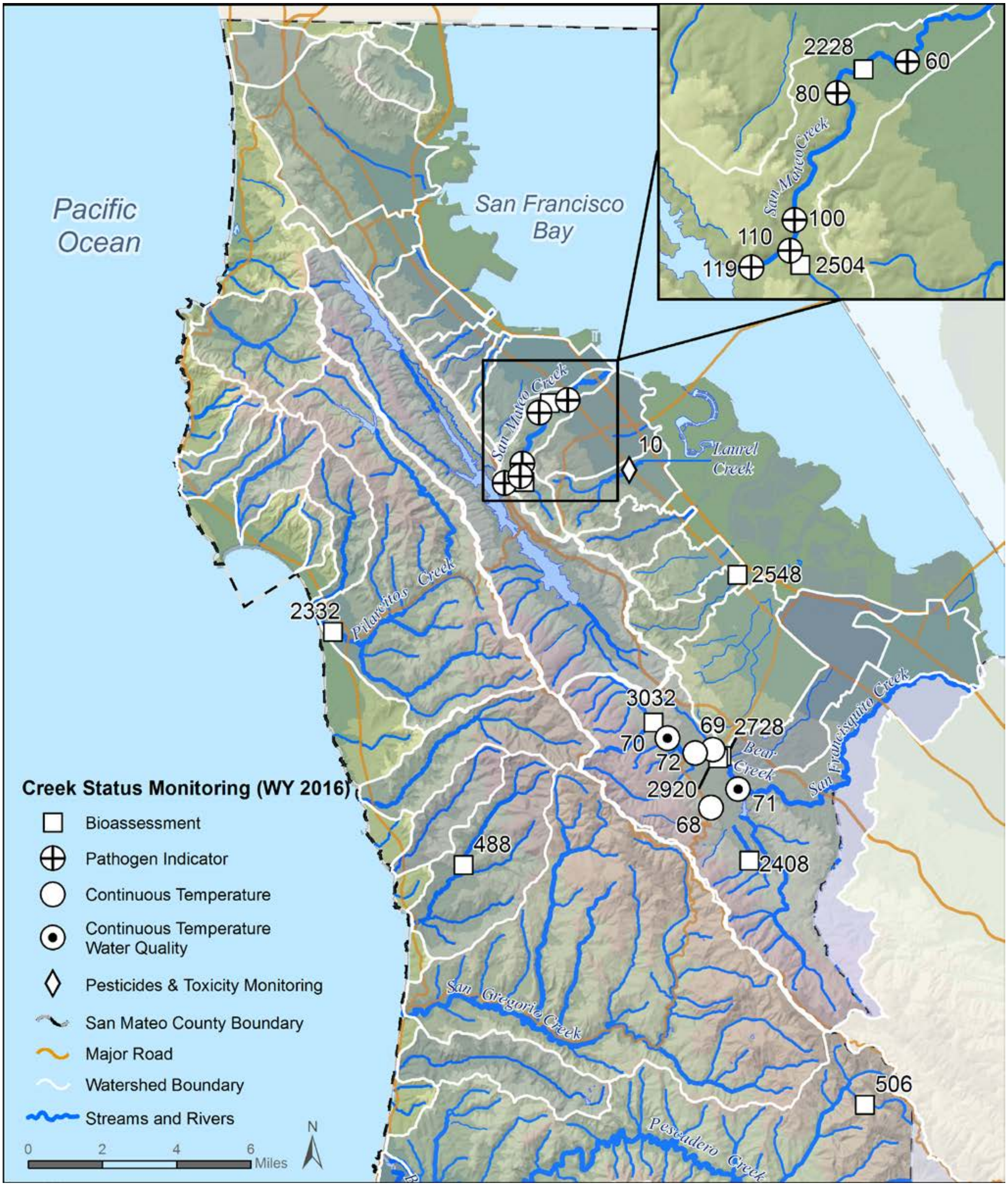

Figure 1.1. Map of SMCWPPP sites monitored in WY 2016.

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 WY 2016.

Table 1.4. Creeks Monitored by SMCWPPP in WY2016 and their Beneficial Uses (SFRWQCB 2013).

Waterbody	AGR	MUN	FRSH	GWR	IND	PROC	COMM	SHELL	COLD	EST	MAR	MIGR	RARE	SPWN	WARM	WILD	REC-1	REC-2	NAV
Bayside Creeks																			
Alambique Creek									E						E	E	E	E	
Bear Creek		E							E			E	E	E	E	E	E	E	
Bull Run Creek[1]									E						E	E	E	E	
Cordilleras Creek															E	E	E	E	
Dry Creek													E		E	E	E	E	
Laurel Creek															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									E			E	E	E	E	E	E	E	
Coastside Creeks																			
Tunitas Creek	E	E							E			E	E	E	E	E	E	E	
Peters Creek									E				E	E	E	E	E	E	
Pilarcitos Creek		E							E				E	E	E	E	E	E	

[1] No Beneficial Uses listed specifically for waterbody. Table shows Beneficial Uses for receiving waterbody.
E = Existing Use

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

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 WY 1946 to WY 2016. Creek Status Monitoring in compliance with the MRP began in WY 2012 which was the first year of an ongoing severe drought on a statewide and local basis. Some climate scientists suggest the current drought began as early as WY 2006, punctuated by two slightly above average years in WY 2009 and WY 2010 (UCLA Water Resources Group[8]).

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

---

[7] http://www.prism.oregonstate.edu/normals/
[8] http://www.environment.ucla.edu/water/drought

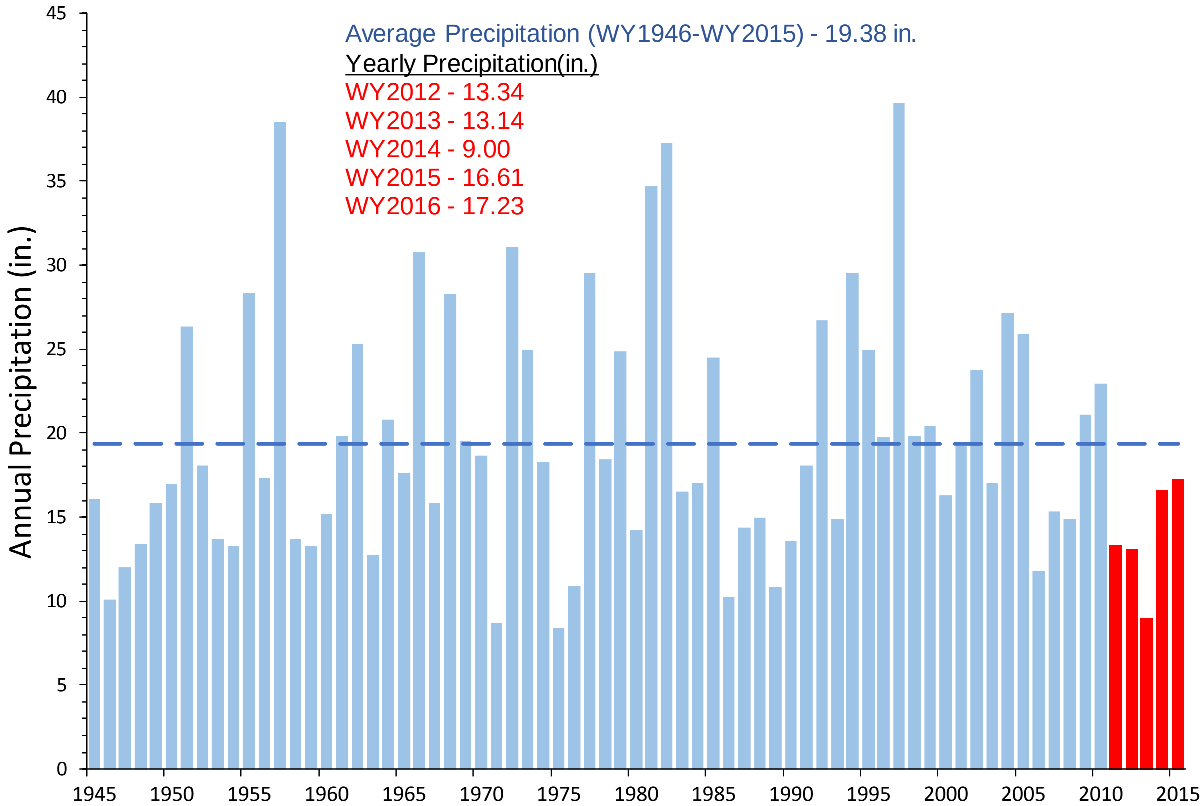

Figure 1.3. Annual rainfall recorded at the San Francisco International Airport, WY 1946 – WY 2016.

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. These longer drought periods 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. Furthermore, in response to prolonged drought, the relative proportion of pool habitat can increase at the expense of riffle habitat. 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 longer *periods* of extended drought on IBIs which would require analysis of a dataset with a much longer period of record. The Herbst Lab at the Sierra Nevada Aquatic Research Laboratory, University of California Santa Barbara is currently exploring how changing climate affects Sierra Nevada stream ecosystems.

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, 2016a), and monitoring was performed according to protocols specified in the BASMAA RMC SOPs) (BASMAA, 2016b), and in conformity with methods specified by the SWAMP QAPP[9]. A detailed QA/QC report is included as Attachment 1.

Based on the QA/QC review, some of the WY 2016 data were flagged. However, overall, WY 2016 data met QA/QC objectives.

[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 Biological Condition Assessment

2.1 Introduction

In compliance with Creek Status Monitoring Provision C.8.d.i, SMCWPPP conducted bioassessment monitoring in WY 2016. All bioassessment monitoring was performed at sites selected randomly using the probabilistic monitoring design. 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 (i.e., *What is the condition of aquatic life in creeks in the RMC?*) 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 five years, SMCWPPP and the Regional Water Board have sampled 60 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 (i.e., *What are major stressors to aquatic life in the RMC area?*) 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

[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).

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

The last question (i.e., *What are the long-term trends in water quality in creeks over time?*) 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 five 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 WY 2016. A preliminary analysis of biological indicator and stressor data collected in San Mateo County over the past five years (WY 2012 – WY 2016) is also presented. It is anticipated that the BASMAA RMC will conduct a regional analysis of biological condition using the five-year data set (WY 2012 – WY 2016) in Fiscal Year 2017/18.

2.2 Methods

2.2.1 Probabilistic 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. In addition, between WY 2012 and WY 2015, the

SFRWQCB SWAMP conducted 34 bioassessments throughout the RMC region at non-urban probabilistic sites selected from the sample frame, including 10 sites in San Mateo County[11]. Bioassessment data collected by SWAMP from the San Mateo County sites are included in this report.

2.2.2 Site Evaluations

Sites identified in the regional sample draw are evaluated by each RMC participant in chronological order using a two-step process described in RMC Standard Operating Procedure FS-12 (BASMAA 2016b), consistent with the procedure described by Southern California Coastal Water Research Project (SCCWRP) (2012). Each site is evaluated to determine if it meets 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. The overall percent of sites classified into the three categories will eventually be

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

[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.

evaluated to determine the statistical significance of local and regional average ambient conditions calculated from the multi-year dataset.

2.2.3 Field Sampling Methods

Biological sample collection and processing was consistent with the BASMAA RMC QAPP (BASMAA 2016a) and SOPs (BASMAA 2016b).

In accordance with the RMC QAPP (BASMAA 2016a) 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. In WY 2016, bioassessments were initiated on May 9th, approximately 30 days following a storm event on April 8-9.

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 11 evenly spaced transects using the Reachwide Benthos (RWB) method described in the SWAMP SOP (Ode et al. 2016). The most recent SWAMP SOP (i.e., Ode et al. 2016) combines the BMI and algae methods that are referenced in the MRP (Ode et al. 2007, Fetscher 2009), provides additional guidance, and adds two new physical habitat analytes (assess scour and engineered channels). The full suite of physical habitat data were collected within the sample reach using methods described in Ode et al. (2016). The presence of micro- and macroalgae was assessed during the pebble counts following methods described in Ode et al. (2016).

Immediately prior to biological and physical habitat data collection, water samples were collected for nutrients, conventional analytes, ash free dry mass, and chlorophyll a analysis using the Standard Grab Sample Collection Method as described in SOP FS-2 (BASMAA 2016b). Water samples were also collected and analyzed for free and total chlorine using a Pocket Colorimeter^{TM} II and DPD Powder Pillows according to SOP FS-3 (BASMAAS 2016b) (see Section 4.0 for chlorine monitoring 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 laboratories for analysis. The laboratory analytical methods used for BMIs followed Woodward et al. (2012), using the Southwest Association of Freshwater Invertebrate Taxonomists (SAFIT) 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 SWAMP master taxonomic list. Taxa that were not on the SWAMP list were flagged and identified for future potential harmonization work.

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 benthic (i.e., bottom-dwelling) macroinvertebrates collected through this monitoring program are organisms that live on, under, and around the rocks and sediment in the stream bed. Examples include dragonfly and stonefly larvae, snails, worms, and beetles. Different BMIs respond differently to changes in water chemistry and physical habitat. Some are relatively sensitive; others more tolerant of poor habitat and pollution. Therefore, the abundance and variety of BMIs in a stream indicates the biological condition of the stream.

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[14]. 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 (Mazor et al. 2016).

The State Board is continuing to evaluate the performance of CSCI in a regulatory context. In the current MRP, 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

Similar to BMI's, the abundance and type of benthic algae species living on a streambed can indicate stream health. Biological indices based on benthic algae can provide a more complete picture of the streams biological condition because algae respond most directly to nutrients and water chemistry; whereas, BMIs are more responsive to physical habitat.

The State Board and Southern California Coastal Water Research Project (SCCWRP) are currently developing and testing a statewide index using benthic algae data as a measure of biological condition for streams in California. The statewide algae IBI is expected to be completed in 2017. The statewide algae index will build upon studies by Fetscher et al. (2014) that developed and tested algal indices of biological integrity (IBIs) for streams in Southern California (SoCal Algae IBI). The SoCal Algae IBIs were developed from data comprised of

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

either single-assemblage metrics (i.e., either diatoms or soft algae) or combinations of metrics presenting both assemblages (i.e, "hybrid" IBI).

Algae data collected in San Mateo County were evaluated using the existing SWAMP Algae Reporting Module, (Algae RM) which was developed in 2012 using the SoCal Algae IBI as the basis for metric and IBI calculations (Marco Sigala, personal communication). Three algal IBIs that performed well against stressor gradients at sites in Southern California were calculated using the algae data collected in San Mateo County. These include a soft algae index (S2), a diatom index (D18) and a soft algae-diatom hybrid index (H20). The interpretation of algae data collected in San Mateo County is considered preliminary since the IBIs were developed and tested on data collected in Southern California.

New taxa (i.e., not on the SWAMP master list) are typically identified by SWAMP laboratory each year. Additional new taxa are identified by contracting labs for stormwater projects and, depending on available resources, may be "harmonized" with taxa on the SWAMP master list. Each year, SWAMP updates the taxa list used to calculate metrics in the Algae RM. The trait attributes table, used to associate taxa response to environmental stressors, has not been updated since May 2013 (Marco Sigala, personal communication). As a result, some of the taxa identified in samples collected since 2013 are not included in the IBI calculations. Thus, the SoCal Algae IBI scores should be considered preliminary until all possible taxa and their trait attributes are incorporated into the Algae RM.

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). 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).

Table 2.1. Condition categories used to evaluate CSCI and Algae IBI scores.

Index	Likely Intact (>30th PCTL)	Possibly Intact (10th – 30th PCTL)	Likely Altered (1st – 10th PCTL)	Very Likely Altered (< 1st PCTL)
Benthic Macroinvertebrates (BMI)				
CSCI Score	≥ 0.92	0.79 – 0.92	0.63 – 0.79	< 0.63
Benthic Algae				
S2 Score	≥ 60	47 - 60	29 - 47	< 29
D18 Score	≥ 72	62 - 72	49 - 62	< 49
H20 Score	≥ 70	63 - 70	54 - 63	< 54

PCTL = percentile

A CSCI score below 0.795 is referenced in the MRP 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

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 annual median value of 0.025 mg/L provided in the San Francisco Basin Water Quality Control Plan (Basin Plan) (SFRWQCB 2013). Although this standard is not typically applied to individual sample, no instantaneous maximum water quality objective is available. 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 (1000 km^2, 5000 km^2 and entire watershed).

Another potential stressor is the lower than average precipitation and stream flow during the five years of probabilistic bioassessment sampling. Future sampling during wetter years will provide useful information to evaluate the impacts of drought on biological integrity of the streams.

2.2.4.4 Stressor Thresholds

In compliance with Provision C.8.h.iii.(4), water chemistry data collected at the bioassessment sites during WY 2016 were compared to stressor thresholds and applicable water quality standards (Table 2.2). Thresholds for pH, specific conductance, dissolved oxygen, and temperature (for waters with COLD Beneficial Use only) are listed in Provision C.8.d.iv of the MRP. With the exception of temperature, these conform to Water Quality Objectives (WQOs) in the Basin Plan (SFRWQCB 2013). Of the eleven nutrients analyzed synoptically with bioassessments, WQOs only exist for three: ammonia (unionized form), and chloride and nitrate (for waters with MUN Beneficial Use only). See Table 1.4 for a list designated Beneficial Uses of creeks monitored in WY 2016.

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

	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, instantaneous maximum	°C	24	Increase	MRP
Specific Conductance	µScm	2000	Increase	MRP

* Nitrate and chloride WQOs only apply to waters with MUN designated Beneficial Uses.

2.2.4.5 Stressor Association with Biological Conditions

Statistical tests were conducted to evaluate which potential stressors (i.e., physical habitat measurements, water chemistry) have the most significant relationships with biological indicator data (i.e., CSCI scores, algae IBIs). The tests were conducted using all probabilistic data collected in San Mateo County over the past 5 years (n=60) which is considered sufficient sample size to estimate ambient biological condition. Two statistical methods were used:

- Correlations between biological indicator data and potential stressors were evaluated 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.

- The random forest method was applied to assess which potential stressors are most important in explaining variability in CSCI scores. Random forest is a bootstrap method that combines many regression trees. It is able to discover more complex dependencies and works well with non-linear data, many variables, outliers, and small datasets. We used the randomForest package in R. The random forest script did not run with missing data; the five-year dataset was culled to remove sites with missing data. Many of the culled sites were those provided by SWAMP which generally did not include laboratory results.

The extent and relative risk of stressors at a regional scale can be assessed using probabilistic datasets. This is one of the benefits of the probabilistic component of the Creek Status Monitoring design that was initiated in WY 2012. 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 and will be explored as part of the regional analysis anticipated in FY 2017/18.

2.3 Results and Discussion

2.3.1 Site Evaluations

During WY 2016, SMCWPPP conducted site evaluations at a total of 36 potential probabilistic sites in San Mateo County that were drawn from the master list. Of these sites, a total of ten were sampled in WY 2016 (rejection rate of 72%). Twenty percent of the sampled sites were classified as non-urban land use (n=2). Land use classification, sampling location, and date for each sampled site are listed are Table 2.3.

Three of the ten sites were in coastal watersheds draining into the Pacific Ocean; the remaining seven sites were located in urban watersheds draining into the San Francisco Bay. Four of the urban sites were located in tributaries to San Francisquito Creek. Two sites were located in the San Mateo Creek watershed. One site was located in Cordilleras Creek just upstream of the tidally influenced reach near the San Francisco Bay.

Table 2.3. Bioassessment sampling date and locations in San Mateo County in WY 2016.

Station Code	Creek	Program	Land Use	Sample Date	Latitude	Longitude
202R00488	Tunitas Creek	SMCWPPP	NU	5/10/2016	37.38001	-122.37482
202R00506	Peters Creek	SMCWPPP	NU	5/9/2016	37.28940	-122.17619
202R02332	Pilarcitos Creek	SMCWPPP	U	5/10/2016	37.47000	-122.44116
204R02228	San Mateo Creek	SMCWPPP	U	5/11/2016	37.56114	-122.33698
204R02504	Polhemus Creek	SMCWPPP	U	5/11/2016	37.53015	-122.34871
204R02548	Cordilleras Creek	SMCWPPP	U	5/17/2016	37.49544	-122.24336
205R02408	Bull Run Creek	SMCWPPP	U	5/17/2016	37.38400	-122.23499
205R02728	Dry Creek	SMCWPPP	U	5/12/2016	37.42452	-122.24954
205R02920	Bear Gulch Creek	SMCWPPP	U	5/12/2016	37.42376	-122.25112
205R03032	West Union	SMCWPPP	U	5/16/2016	37.43720	-122.28319

NU = non-urban, U = urban

Since WY 2012, a total of 60 probabilistic sites were sampled by SMCWPPP (n=50) and SWAMP (n=10) in San Mateo County. During the five-year sampling period, SMCWPPP sampled 41 urban site and 9 non-urban sites; SWAMP sampled 10 non-urban sites. A total of 168 total sites were evaluated to obtain 60 samples, an overall rejection rate of 64%[15]. Refer to Section 2.2.2 for list of criteria used to reject sites. The number of sites (and percentage of total evaluated sites) rejected for each criterion are presented in Table 2.4. The location and site evaluation results for all 168 sites are shown in Figure 2.1.

Table 2.4. Probabilistic site evaluation results in San Mateo County, WY 2012 – WY 2016.

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	41 (38%)	42 (34%)	17 (17%)	19 (11%)	119
Non-Urban	19 (39%)	21 (43%)	7 (14%)	2 (4%)	49
Total	60 (36%)	63 (38%)	24 (14%)	21 (12%)	168

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

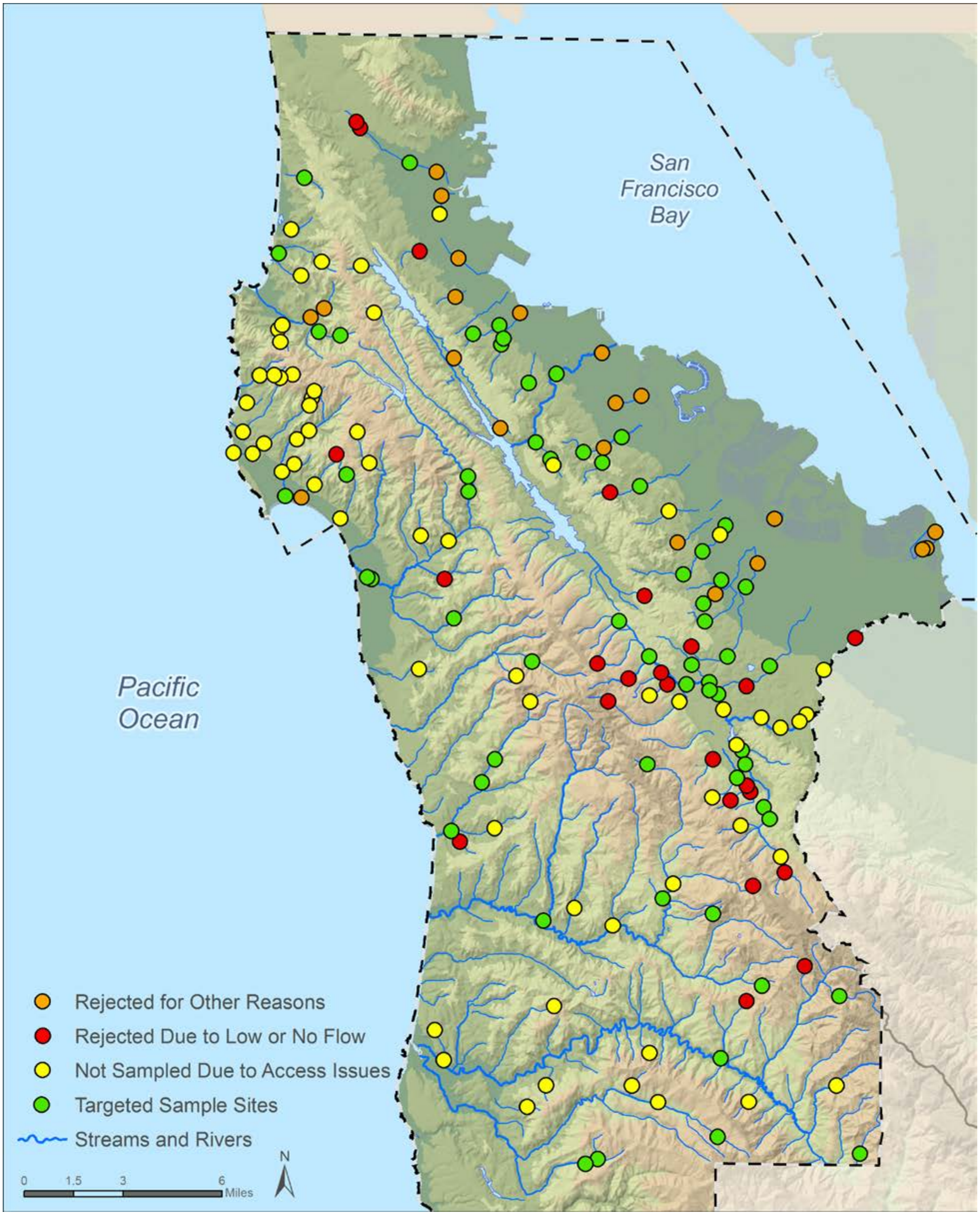

Figure 2.1. Site evaluation results for probabilistic sites in San Mateo County (n=168), WY 2012 – WY 2016.

Access issues (e.g., physical barriers, permission not granted) were the most common reason for not sampling a site (38% 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; the majority of creeks in San Mateo urban areas are privately owned.

Low or no flow conditions were the second most common reason for site rejection (14% of all sites). 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 five years of Creek Status Monitoring likely resulted in low flow conditions in reaches that would be perennial during normal years of rainfall. The remaining sites were rejected for a variety of reasons, including site location not on a creek or site was tidally influenced.

2.3.2 Biological Condition Assessment

This section presents the results of the biological condition assessment conducted in WY 2016 and compiles those data with results from water years 2012 through 2015.

2.3.2.1 WY 2016 Results

A total of 111 unique BMI taxa were identified in samples collected at ten bioassessment sites in San Mateo County during WY 2016. A total of 132 benthic algae taxa were identified in samples collected at the same sites, including 120 diatom and 12 soft algae taxa. The total number of unique BMI, diatom, and soft algae taxa identified at each bioassessment location is presented in Table 2.5. BMIs and diatoms were relatively well represented across all sites, with BMIs ranging from 14 to 57 taxa, and diatoms ranging from 21 to 61 taxa. Soft algae taxa were less common across sites, ranging from 1 to 7 taxa. In WY 2016, four of the ten sites (40%) had three or less soft algae taxa.

Table 2.5. The total number of unique BMI, diatom, and soft algae taxa identified in samples collected at 10 bioassessment sites in San Mateo County during WY 2016.

Station ID	Creek	Land Use	BMIs	Diatoms	Soft Algae
202R00488	Tunitas Creek	NU	25	32	3
202R00506	Peters Creek	NU	57	38	4
202R02332	Pilarcitos Creek	U	13	61	4
204R02228	San Mateo Creek	U	26	45	4
204R02504	Polhemus Creek	U	20	35	2
204R02548	Cordilleras Creek	U	14	30	7
205R02408	Bull Run Creek	U	30	36	1
205R02728	Dry Creek	U	26	21	2
205R02920	Bear Gulch Creek	U	38	37	4
205R03032	West Union	U	35	36	4

NU = non-urban, U = urban

Biological condition, as represented by CSCI scores and algae IBI scores (S2, D18 and H20), for the ten probabilistic sites sampled by SMCWPPP in WY 2016 is presented in Table 2.6. Scores for each indicator that were in the two higher condition categories are indicated in bold. The condition categories for three of the biological indicator scores (CSCI, D18 and H20) and PHAB scores, as defined in Table 2.1, are illustrated for the ten sites in Figure 2.2. The two main components of the CSCI score, O over E and MMI scores, are listed for each site in Attachment 2.

Table 2.6. Biological condition scores, presented as CSCI, SoCal Algae IBIs (S2, D18 and H20), and total PHAB score, for ten probabilistic sites sampled in San Mateo County during WY 2016. Site characteristics related to channel modification and flow condition are also presented. Scores in the two higher condition categories are indicated in bold.

Station Code	Creek	Elevation (ft)	Land Use	Modified Channel[1]	Flow[2]	CSCI Score	Soft Algae "S2" IBI Score	Diatom "D18" IBI Score	Hybrid "H20" IBI Score	Total PHAB Score
202R00488	Tunitas Creek	228	NU	No	P	0.55	7	44	32	40
202R00506	Peters Creek	1272	NU	No	P	1.11	67	52	58	54
202R02332	Pilarcitos Creek	23	U	No	P	0.51	0	54	NR	22
204R02228	San Mateo Creek	51	U	Yes	P	0.56	0	60	38	23
204R02504	Polhemus Creek	207	U	Yes	P	0.45	8	50	31	30
204R02548	Cordilleras Creek	20	U	No	NP	0.41	67	68	49	25
205R02408	Bull Run Creek	457	U	No	NP	0.64	0	38	49	37
205R02728	Dry Creek	340	U	No	P	0.39	0	68	42	39
205R02920	Bear Gulch Creek	338	U	No	P	0.75	17	30	19	37
205R03032	West Union	531	U	No	NP	0.58	7	52	32	40

[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

The CSCI scores ranged from 0.39 to 1.11 across the ten bioassessment sites sampled in WY 2016 (Table 2.6). One of the ten (10%) sites had CSCI scores in the two higher condition categories - "possibly intact" and "likely intact." The combined classifications are above the MRP trigger threshold value of 0.795 and are herein referred to as "good" biological condition in this report. The "good" site had a score that was over 1.0, which is typically a score for reference sites. Two sites were ranked as likely altered (0.63 to 0.795) and the remaining seven sites were ranked as very likely altered (< 0.63). Sites with CSCI scores below 0.795 will be considered as candidates for SSID projects.

Benthic algae taxa identified in the ten samples collected in San Mateo County were used to calculate scores for three SoCal Algae IBIs (S2, D18 and H20) (Table 2.5). Of the 132 total taxa identified in samples collected in WY 2016, there were four diatom and two soft algae taxa that did not match the SWAMP master taxa list. The Algae Reporting Module excluded these taxa from the IBI calculations. The individual metrics and scores for all three algae IBIs are presented in Attachment 2.

There were two sites that were ranked "likely intact" based on D18 scores (Table 2.5). There were also two sites that received a high S2 IBI score (67 at both sites). One of these sites (204R02548) had the highest S2 and D18 IBI scores, 67 and 68, respectively, but also had the lowest CSCI score (0.42). Eight of the ten sites (80%), however, had low S2 IBI scores, ranging 0 to 17, which ranked as "very likely altered" condition. There were insufficient algae data to calculate a H20 IBI score at site 202R02332. All the remaining sites received H20 IBI scores that were ranked in the two lower condition classes (i.e., no sites ranked as good condition based H20 IBI score). Low numbers of soft algae taxa are likely one important reason for low S2 and H20 scores observed at the bioassessment sites (note: the Algae Reporting Module does not indicate when data is insufficient for calculating an individual metric score)

Although the total number of soft algae taxa identified in samples collected in WY 2016 was higher (12 taxa) than the previous year (3 taxa), the overall number of soft algal taxa still appears low. Reasons for the lack of soft algae at San Mateo County sites are unknown but may be related to range of factors, including: 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 across all ten sites.

Individual metric and total PHAB scores assessed at ten bioassessment sites are presented in Table 2.7. Total PHAB scores were better correlated with CSCI scores (r^2=0.50, p value = 0.012) compared to H20 scores (r^2=0.25, p value = 0.5) and D18 scores (r^2=0.09, p value = 0.5), suggesting that physical habitat (e.g., substrate quality, channel alteration) has a greater influence on the BMI community compared to the diatoms assemblage (Figure 2.3). These results are consistent with bioassessment data collected in Southern California, which found high CSCI scores were rarely found in engineered channels, but high algae IBI scores (particularly D18) frequently occurred in highly modified channels (Rafael Mazor, SCCWRP, personal communication). These results suggest that algae indices have some ability to respond to water quality gradients in highly modified channels.

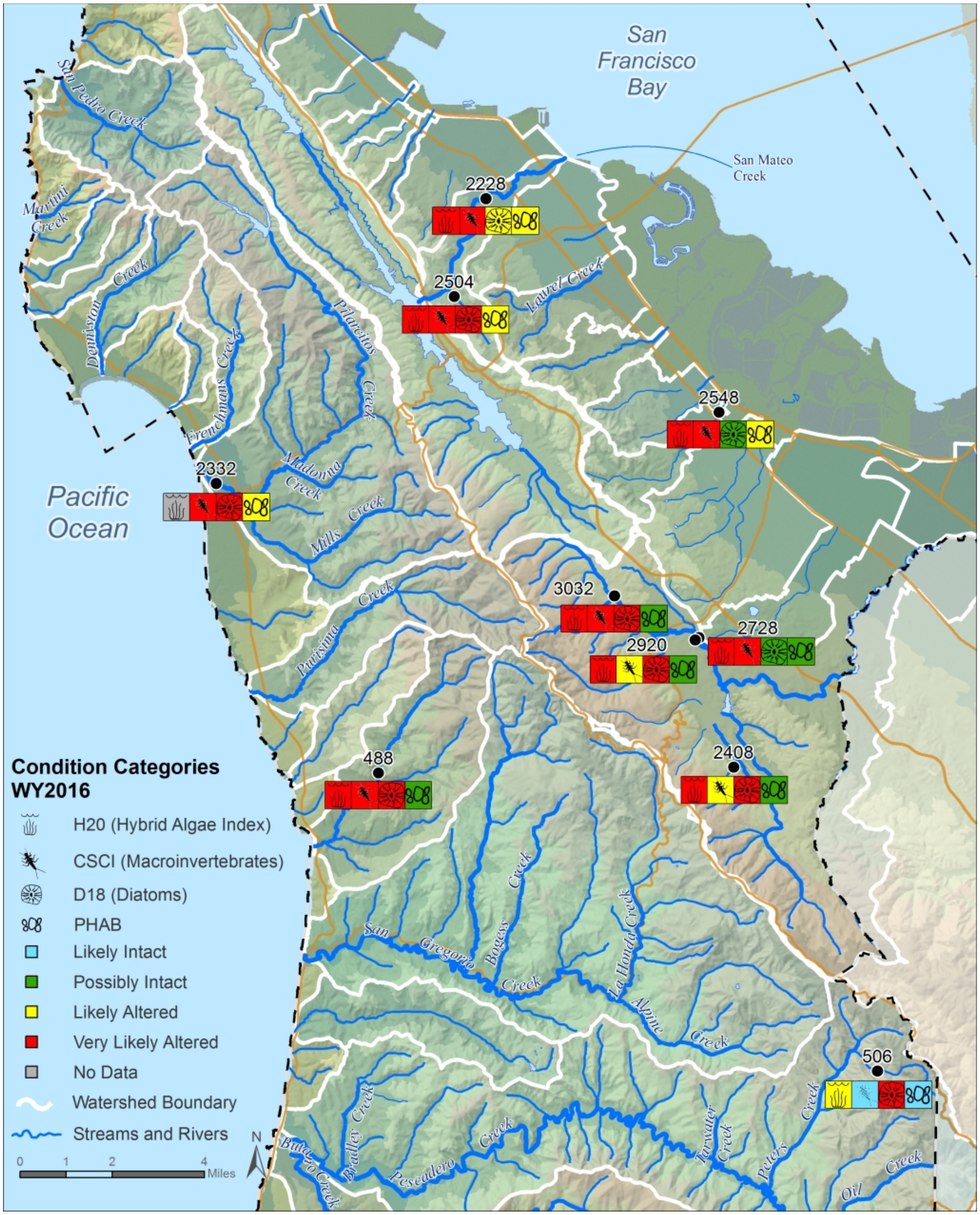

Figure 2.2. Condition category as represented by CSCI, D18, H20 and PHAB for ten probabilistic sites sampled in San Mateo County in WY2016.

Table 2.7. Physical habitat (PHAB) for ten probabilistic sites in San Mateo County sampled in WY 2016.

Station Code	Creek Name	PHAB			
		Channel Alteration Score	Epifaunal Substrate Score	Sediment Deposition Score	Total Score
202R00488	Tunitas Creek	18	16	6	40
202R00506	Peters Creek	20	18	16	54
202R02332	Pilarcitos Creek	15	5	2	22
204R02228	San Mateo Creek	11	7	5	23
204R02504	Polhemus Creek	7	15	8	30
204R02548	Cordilleras Creek	12	7	6	25
205R02408	Bull Run Creek	19	14	4	37
205R02728	Dry Creek	19	12	8	39
205R02920	Bear Gulch Creek	19	11	7	37
205R03032	West Union	15	16	9	40

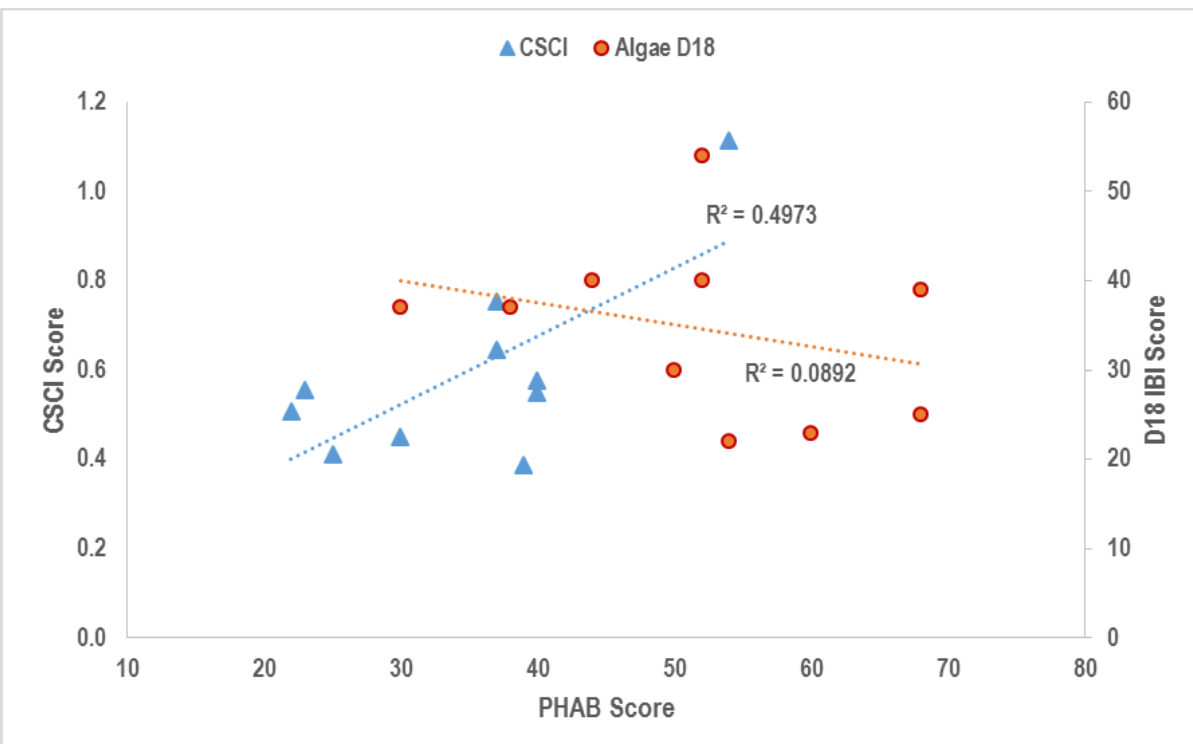

Figure 2.3. CSCI and D18 scores plotted with PHAB score for ten bioassessment sites sampled during WY 2016.

2.3.2.2 WY 2012 through WY 2016 Results

Biological indicator data were compiled for all of the probabilistic sites sampled by SMCWPPP and SWAMP in San Mateo county (n=60) over the past five years. Biological condition, based on CSCI score, for all 60 probabilistic sites sampled over the previous five years (WY 2012-WY 2016) are shown geographically in Figure 2.4.

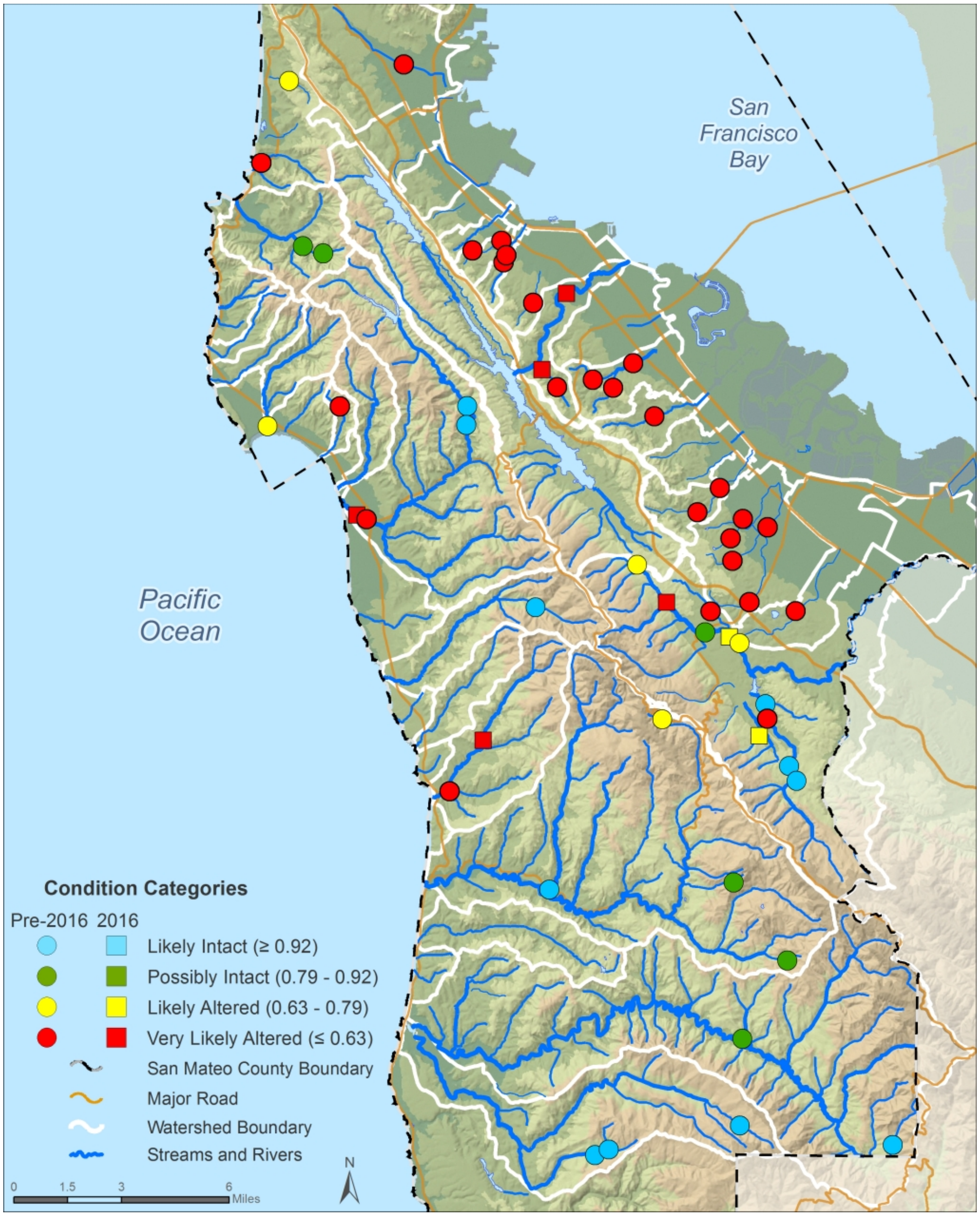

Figure 2.4. Biological condition based on CSCI scores for 60 sites sampled by SMCWPPP and SWAMP in San Mateo County between WY 2012 and WY 2016.

In general, biological condition, based on CSCI scores, was classified as “likely intact” or “possibly intact” at a majority of sites in watersheds that drain into the Pacific Ocean, with the exception of a few bottom of the watershed sites. In contrast, a majority of bioassessment sites located in watersheds draining into the San Francisco Bay were classified as “very likely altered”. The exception were several sites located in tributaries to San Francisquito Creek.

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. In general, the CSCI scoring tool appears to have higher median scores at non-perennial sites compared to perennial sites (Figure 2.5). The SoCal Algae indices are also generally higher at non-perennial sites compared to perennial sites. All of the non-perennial bioassessment sites were characterized with unmodified channels and half of these sites had relatively low percent urban land uses (≤ 5% impervious watershed area). All of the non-perennial sites that were ranked as good biological condition were located in coastal watersheds.

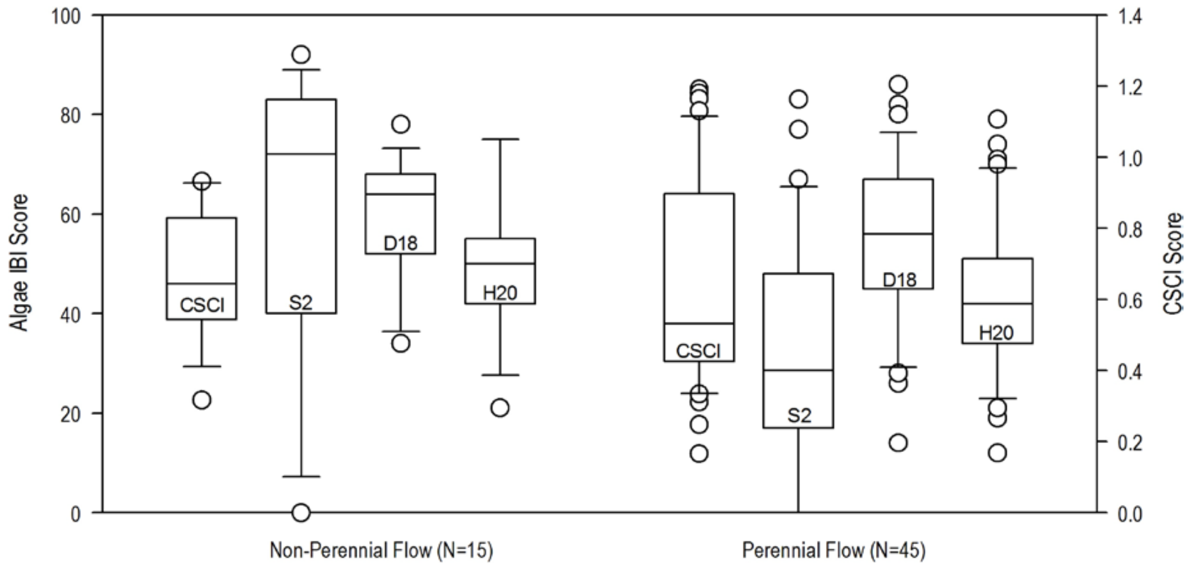

Figure 2.5. Box plots showing CSCI and algae IBI scores, grouped by flow classification, for 60 bioassessment sites in San Mateo County, WY 2012 – WY 2016.

A beanplot is a variation of a box plot that shows the variable density of data and highlights the mean result, rather than the median shown in box plots. Figure 2.6 shows beanplot distributions of CSCI scores for perennial and non-perennial sites. The beanplots illustrate that, although mean values are similar, non-perennial sites have a somewhat bi-modal distribution of CSCI scores.

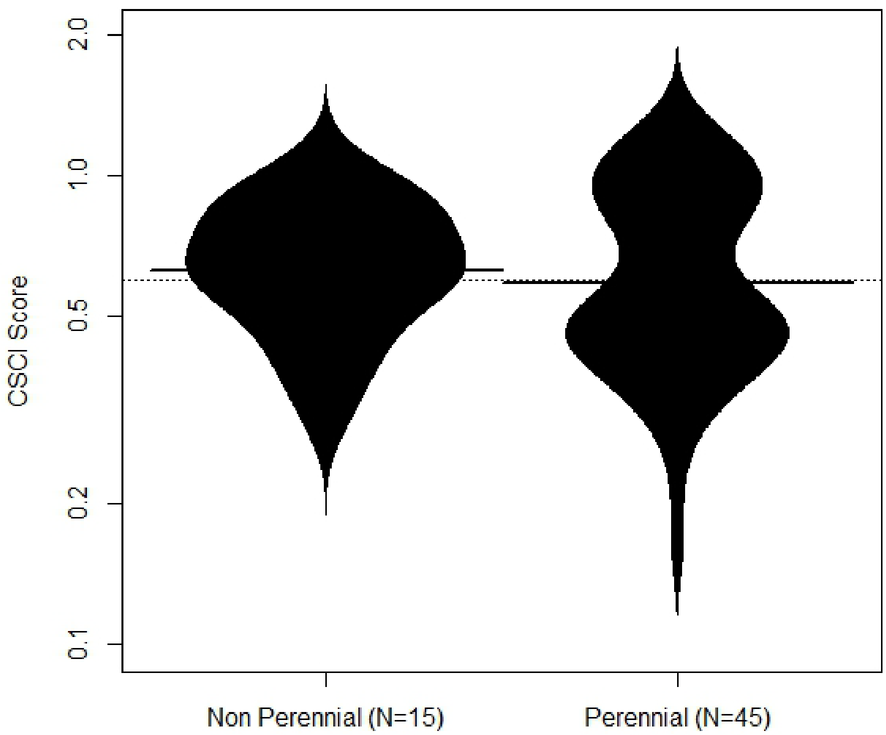

Figure 2.6. Beanplots showing CSCI scores grouped by flow classification for 60 bioassessment sites in San Mateo County, WY 2012 – WY 2016.

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 2.7). Decreasing biological condition with increasing urbanization was less apparent with the Algae IBI scores. Beanplots of CSCI scores for the three different imperviousness groupings are shown in Figure 2.8.

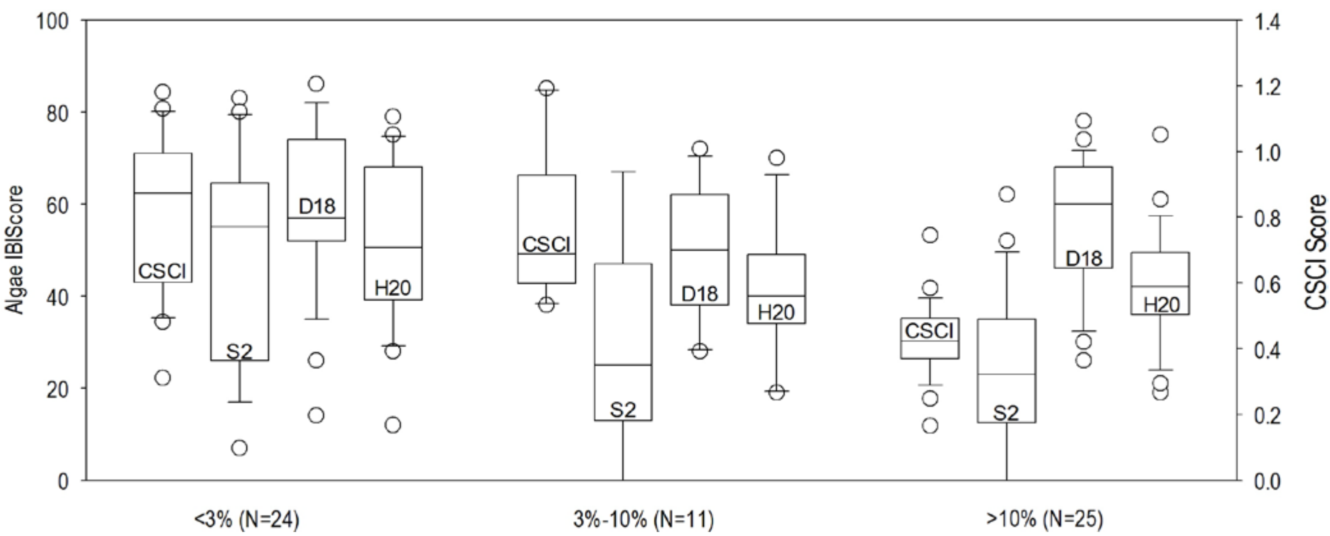

Figure 2.7. Box plots showing CSCI and algae IBI scores, grouped by percent impervious area, for 60 bioassessment sites in San Mateo County, WY 2012 – WY 2016.

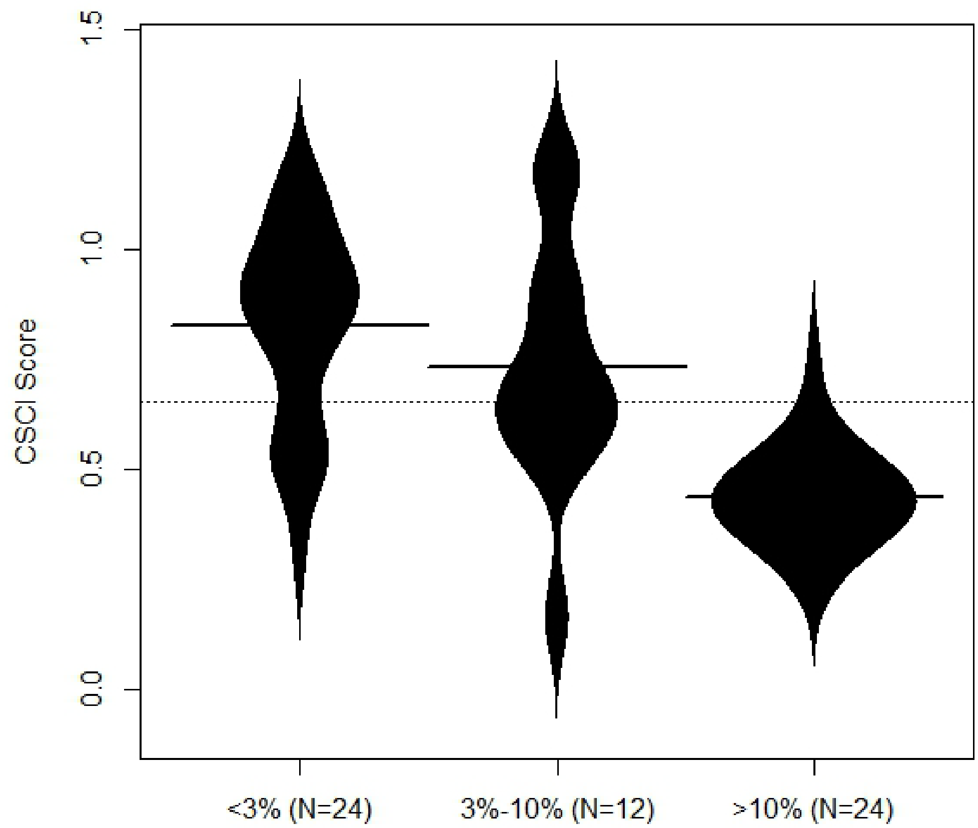

Figure 2.8. Beanplots showing CSCI scores grouped by percent impervious area for 60 bioassessment sites in San Mateo County, WY 2012 – WY 2016.

2.3.3 Stressor Assessment

2.3.3.1 Stressor Data (WY 2016)

Nutrient and conventional analyte concentrations measured in water samples collected at the ten bioassessment sites in San Mateo County during WY 2016 are listed in Table 2.8. There were no exceedances of water quality objectives (WQOs). See Table 2.2 for a list of WQOs.

Physical habitat data and general water quality measurements collected at the bioassessment sites in WY 2016 are listed in Table 2.9. No MRP triggers or WQOs were exceeded. GIS calculations of percent urbanization of the drainage area upstream of each sampling location are also listed in Table 2.9.

Table 2.8. Nutrient and conventional constituent concentrations in water samples collected at ten sites in San Mateo County during WY 2016. No water quality objectives were exceeded. See Table 2.1 for WQO values.

Station Code	Creek	Ammonia as N	Unionized Ammonia (as N)	Chloride	AFDM	Chlorophyll a	Nitrate as N	Nitrite as N	Total Kjeldahl Nitrogen As N	Total Nitrogen	Ortho-Phosphate as P	Phosphorus as P	Silica as SiO2
		mg/L	mg/L	mg/L	g/m2	mg/m2	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Water Quality Objective		NA	0.025	250 [a]	NA	NA	10[a]	NA	NA	NA	NA	NA	NA
202R00488	Tunitas Creek	0.03	0.001	45	39	-3	0.95	0.002	0.26	1.21	0.05	0.05	22
202R00506	Peters Creek	0.06	0.002	86	28	5	0.01	0.001	0.48	0.49	0.05	0.04	22
202R02332	Pilarcitos Creek	0.03	0.000	16	112	11	0.03	0.001	0.31	0.34	0.08	0.09	23
204R02228	San Mateo Creek	0.05	0.002	20	NA	NA	0.04	0.002	0.4	0.44	0.02	0.02	10
204R02504	Polhemus Creek	0.03	0.001	79	NA	NA	0.01	0.002	0.57	0.58	0.08	0.08	21
204R02548	Cordilleras Creek	0.02	0.001	75	48	64	0.22	0.001	0.97	1.19	0.11	0.12	17
205R02408	Bull Run Creek	0.02	0.001	66	263	6	0.06	0.001	0.53	0.59	0.09	0.09	19
205R02728	Dry Creek	0.06	0.002	45	54	27	0.23	0.001	0.4	0.63	0.03	0.14	18
205R02920	Bear Gulch Creek	0.05	0.001	69	42	72	0.01	0.002	0.57	0.58	0.08	0.10	18
205R03032	West Union	0.05	0.001	44	64	3	0.01	0.001	0.48	0.49	0.01	0.00	14
Number of exceedances		NA	0	0	NA	NA	0	NA	NA	NA	NA	NA	NA

NA = not applicable

a. Chloride and nitrate WQOs only apply to waters with MUN designated Beneficial Uses.

Table 2.9. Selected physical habitat variables and general water quality measurements collected at ten sites in San Mateo County during WY 2016. No water quality objectives were exceeded. 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 (waters hed)	% Imperv (waters hed)	Temp (C)	DO (mg/L)	pH	Specific Cond (uS/cm)
202R00488	Tunitas Creek	0	1	91.3	35.2	0.7	0%	1%	12.1	10.3	8.3	829
202R00506	Peters Creek	0	0	82.2	13.3	0.1	3%	3%	11.2	10.5	8.2	412
202R02332	Pilarcitos Creek	0	4.8	84.9	60	1.7	4%	3%	12.7	10.3	7.9	570
204R02228	San Mateo Creek	1.9	8.6	83.2	35.2	1.4	18%	9%	15.5	10.7	8.1	309
204R02504	Polhemus Creek	1	44.8	84.1	13.3	1.8	61%	33%	13	11.0	8.0	1077
204R02548	Cordilleras Creek	1	21	85.8	16.2	3.2	76%	28%	18.1	7.8	8.0	976
205R02408	Bull Run Creek	0	0	90.2	21.9	1	37%	6%	12.9	10.1	8.3	1106
205R02728	Dry Creek	0	13.3	88.8	29.5	1.1	80%	13%	14.3	8.8	8.2	945
205R02920	Bear Gulch Creek	0	33.3	84.1	21.9	0.7	20%	5%	16.1	10.3	8.0	585
205R03032	West Union	0	1.9	88.9	21.9	1.3	3%	2%	12.9	10.0	7.8	532
Water Quality Objective		NA	NA	NA	NA	NA	NA	NA	NA	5 or 7	6.5 to 8.5	NA
Number of exceedances		NA	NA	NA	NA	NA	NA	NA	NA	0	0	NA

2.3.3.2 Stressor Data (WY 2012 - 2016)

Nutrient data were compiled for all bioassessment sites sampled during the past five years (WY 2012 – WY 2016) in San Mateo County. Total nitrogen and phosphorus concentrations, grouped by three classes of percent imperviousness of the area draining to monitoring site, are presented as box plots in Figure 2.9. In general, urban sites had slightly higher concentrations compared to sites with less urban area for both total nitrogen and total phosphorus.

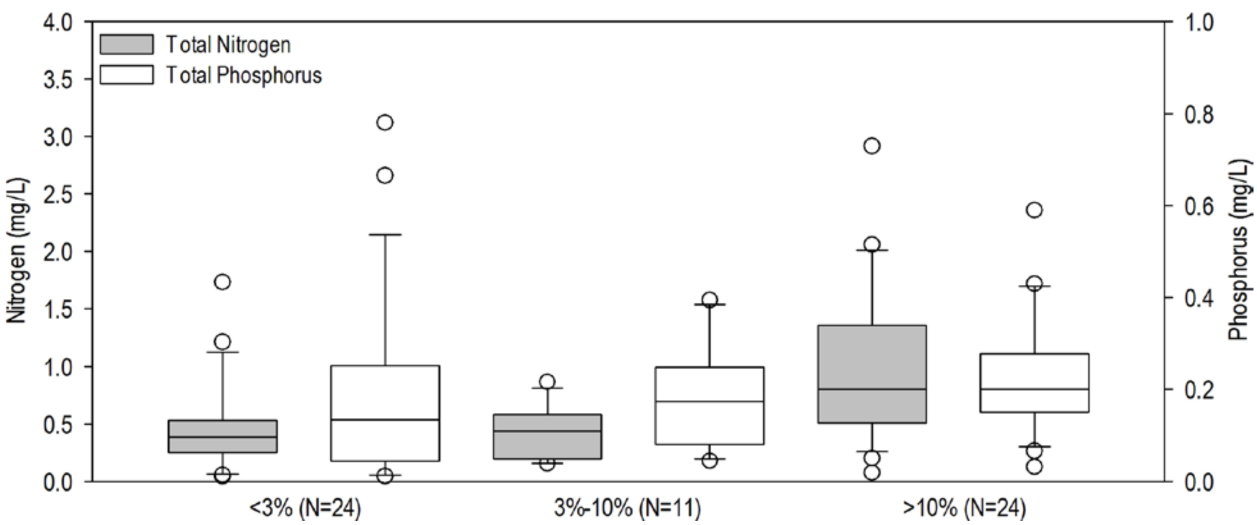

Figure 2.9. Total nitrogen and total phosphorus concentrations measured in water samples collected at bioassessment sites (n=60) by SMCWPPP and SWAMP between WY 2012 and WY 2016.

Box plots for total nitrogen and total phosphorus, grouped by subwatershed, are presented for Pacific Ocean watersheds (Figures 2.10) and San Francisco Bay watersheds (Figure 2.11). The site with the highest concentrations for both total nitrogen (9.52 mg/L) and total phosphorus (6 mg/L) for all bioassessment sites sampled the past 5 years was located in Calera Creek, just downstream of the Calera Creek Water Recycling Plant in Pacifica, CA (Figure 2.10). Elevated concentrations of total nitrogen were also observed at sampling locations in Colma Creek, Laurel Creek and Redwood Creek watershed (Figure 2.11)

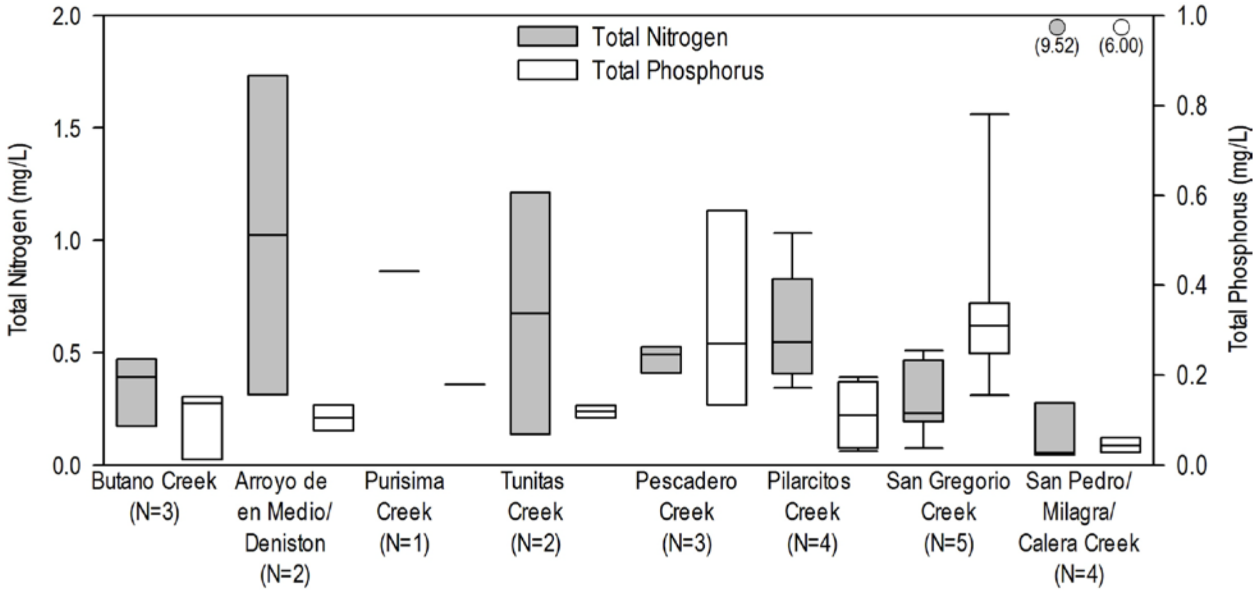

Figure 2.10. Total nitrogen and total phosphorus concentrations measured in water samples collected in watersheds that drain into the Pacific Ocean between WY 2012 and WY 2016.

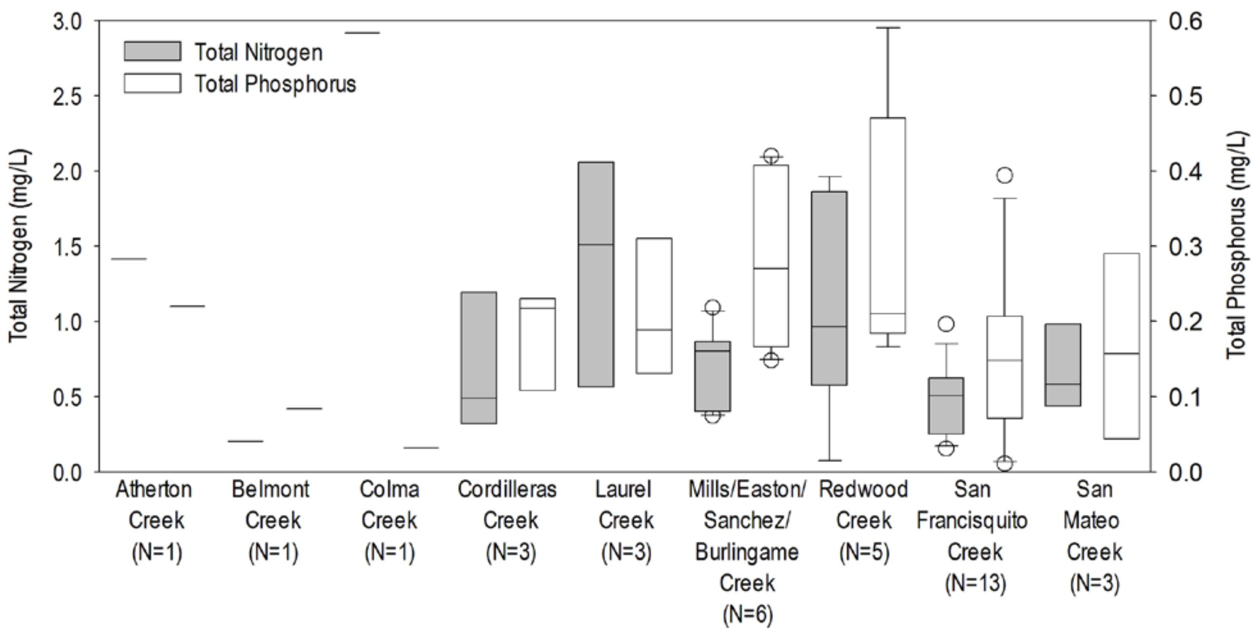

Figure 2.11. Total nitrogen and total phosphorus concentrations measured in water samples collected in watersheds that drain into the San Francisco Bay between WY 2012 and WY 2016.

2.3.3.3 Stressor Association with Biological Condition

Spearman

Spearman Rank Correlations for environmental variables associated with CSCI scores for all bioassessment sites sampled past five years (WY 2012-WY 2016) are presented in Figure 2.12[16]. Statistically significant variables are indicated as shaded columns. Coefficients values greater than ±0.5 indicate a strong relationship between the variables. CSCI scores are negatively correlated with land use variables (percent impervious, percent urban), total nitrogen, algal cover (PCTMAT), canopy cover, human disturbance index (HDI), and DOC. CSCI scores had significant positive correlations with two PHAB qualitative index scores (channel alteration and epifaunal substrate).

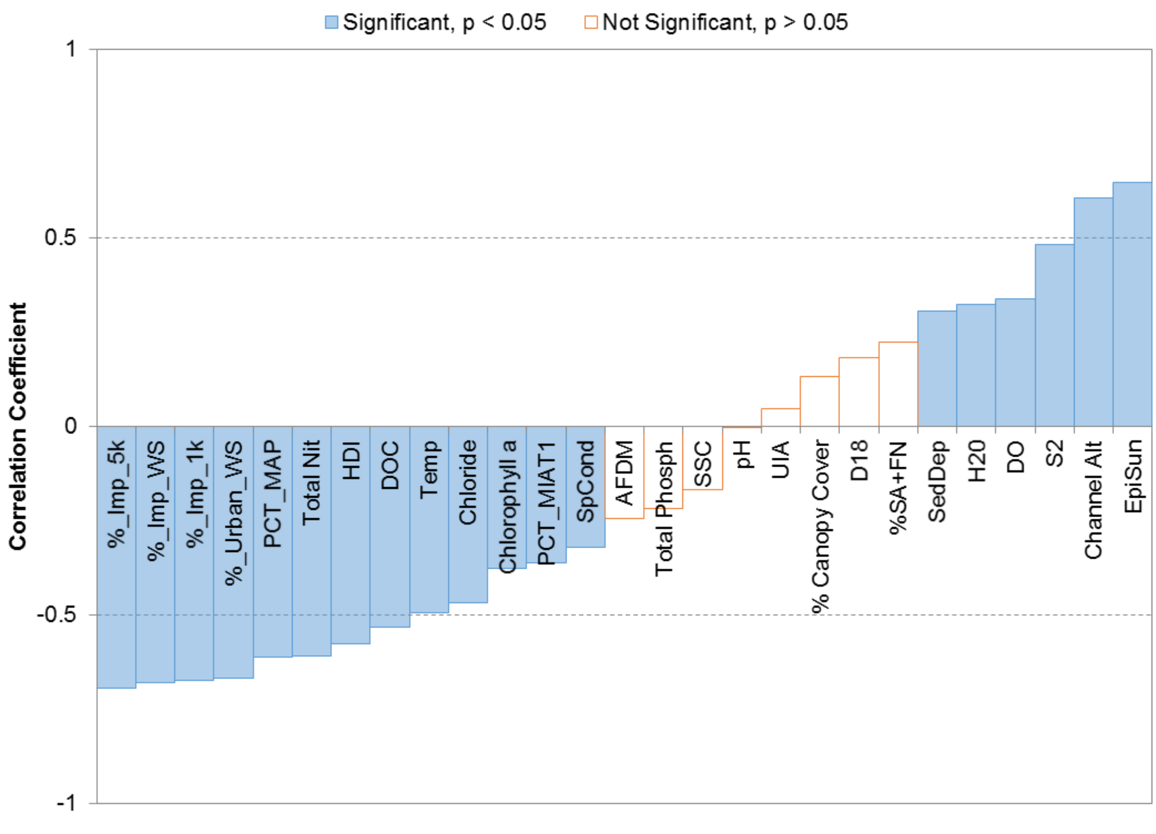

Figure 2.12. Spearman Rank Correlation for CSCI scores and stressor variable data collected at ten sites in San Mateo County in WY 2016.

16 A similar figure for Algae IBI scores is not shown because there were no statistically significant variables with coefficient values greater than ±0.5.

Random Forests

Figure 2.13 shows variable importance plots for potential stressors from the random forest analysis. The random forest analysis was able to explain 53 percent of the variance in CSCI scores. Stressors with mean square error (%IncMSE) values are more important in explaining variability in CSCI scores. The node purity (IncNodePurity) value relates to the loss function in the regression tree and is not as robust a measure of importance as %IncMSE. In this analysis, the five most important stressors are: percent impervious in the watershed, percent urban in the watershed, total nitrogen concentration, elevation, and S2 algae IBI score. These are not necessarily the same stressors identified through the Spearman Rank correlation analysis. Some of the differences may be explained by how the two analyses were set up. For example, in early runs, the random forest method selected mainly stressors associated with urbanization; therefore, the percent impervious and percent urban at the 1 km and 5 km scales were removed from the analysis. Also, elevation was not included in the Spearman analysis. Overall, both methods point to urbanization and nitrogen as important stressors.

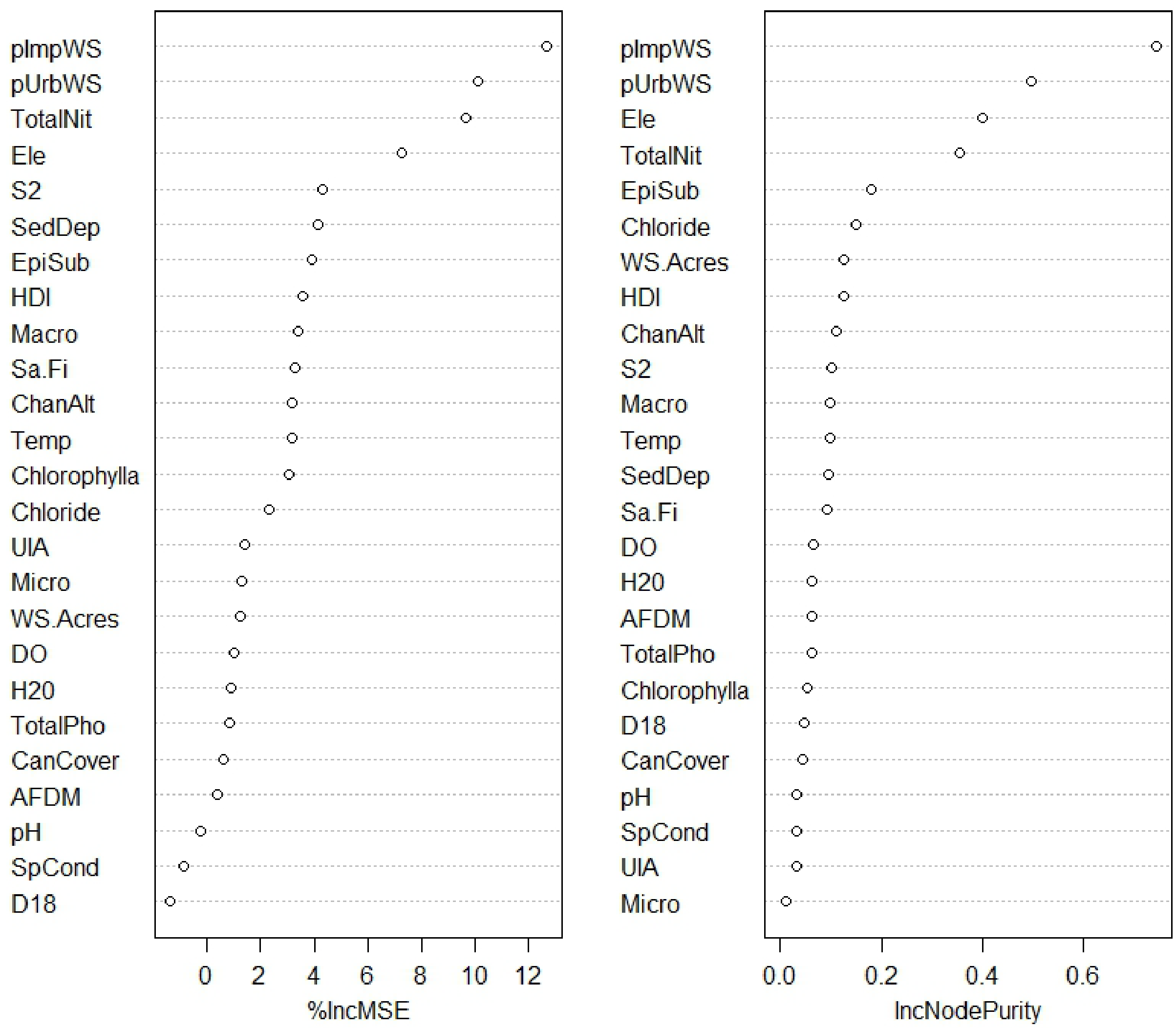

Figure 2.13. Variable importance for CSCI scores in San Mateo County, WY 2012 – WY 2016.

2.4 Conclusions and Recommendations

Bioassessment monitoring in WY 2016 was conducted in compliance with Provision C.8.d.i of the MRP. Ten sites were sampled for BMIs, benthic algae, PHAB observations, and nutrients. Stations were randomly selected using a probabilistic monitoring design.

Conclusions and recommendations from bioassessment monitoring conducted during WY 2016 in San Mateo County are organized below according to the following management questions:

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?*
4. *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?*
5. *What are the long-term trends in water quality in creeks over time?*

Probabilistic Survey Design

- Site evaluations were conducted at a total of 36 potential probabilistic sites in San Mateo County during WY 2016. Of these sites, a total of ten were sampled in WY 2016 (rejection rate of 72%). Two of the ten sites (20%) were classified as non-urban land use.
- Between WY 2012 and WY 2016, a total of 60 probabilistic sites were sampled by SMCWPPP (n=50) and SWAMP (n=10) in San Mateo County, including 41 urban and 19 non-urban sites. There is 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 (WY 2016)

- The California Stream Condition Index (CSCI) tool was used to assess biological condition. The CSCI translates benthic macroinvertebrate data into an overall measure of stream health. Of the ten sites monitored in WY 2016, two sites were rated in good condition (CSCI score $\geq$ 0.795), three sites rated as likely altered conditions (CSCI score 0.635 – 0.795), and five sites rated as very likely altered condition (CSCI score $\leq$ 0.635).

- The eight sites with CSCI scores less than the trigger threshold of 0.795 will be added to the list of candidate SSID projects.
- Benthic algae data was collected synoptically with BMIs at all probabilistic sites. Diatoms taxa (n=120) were well represented, but few soft algae taxa (n=12) were identified in the ten samples. As a result, the majority of sites had low biological condition based on algae indices that incorporate soft algae (S2 and H20). Two sites were ranked in good biological condition based on diatom (D18) IBI scores.
- Total PHAB scores were better correlated with CSCI scores than they were with D18 scores, suggesting that physical habitat (e.g., substrate quality, channel alteration) has a greater influence on the BMI community than the diatoms assemblage. For this reason, algae may provide useful data to assess water quality issues at urban sites with poor habitat.

Biological Condition Assessment (WY 2012 – WY 2016)

- CSCI scores were calculated for the five-year San Mateo County probabilistic data set (n=60). Good biological condition scores (CSCI score > 0.795) occurred at 17% of the urban sites and 74% of non-urban sites.
- The median CSCI scores were higher at non-perennial sites (0.74) compared to perennial (0.55) sites. A similar pattern was observed with all three SoCal Algae IBI scores. Non-perennial sites were typically located in non-urban areas in the upper reaches of watersheds draining into Pacific Ocean or tributaries to San Francisquito Creek (draining into the San Francisco Bay), which may explain the higher scores.
- CSCI scores generally decrease in response to increasing urbanization (calculated as percent impervious area).

Stressor Assessment

- Potential stressors such as nutrients, physical habitat, algal biomass indicators, and other conventional analytes were measured during bioassessments or analyzed in samples collected concurrently with bioassessments. Some potential stressors, such as urbanization indicators (e.g., percent impervious area in watershed), were calculated using GIS.
- CSCI scores have a significant negative correlation with land use variables (percent impervious and urban), total nitrogen, algal cover, canopy cover, human disturbance index (HDI) and DOC and a positive correlation with two PHAB parameters (epifaunal substrate score and channel alteration score).
- Concentrations of unionized ammonia, nitrate, and chloride were compared to WQOs. No WQOs 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 WY 2016 (October 1, 2014 – September 30, 2015) water temperature, general water quality, and pathogen indicators were monitored in compliance with Creek Status Monitoring Provisions C.8.d.iii – v of the MRP. Monitoring was conducted at selected sites using a targeted design based on the directed principle[17] 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 reaches.

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 Provisions C.8.d.iii of the MRP, temperature was monitored at a minimum of four sites, general water quality was monitored at two sites, and pathogen indicator samples were collected at five sites. 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 2016[18]. 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 WY 2014 and WY 2015 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.

[17] 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."

[18] 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, previous monitoring over the past three years 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 one station in Bear Creek and one station in West Union Creek during two two-week sampling events in WY2015 (Figure 3.1). Both creeks are in the San Francisquito Creek watershed and have historically supported juvenile steelhead rearing and spawning habitat (Leidy et al. 2005). Sample Events 1 and 2 were conducted in May and September, 2016, respectively.

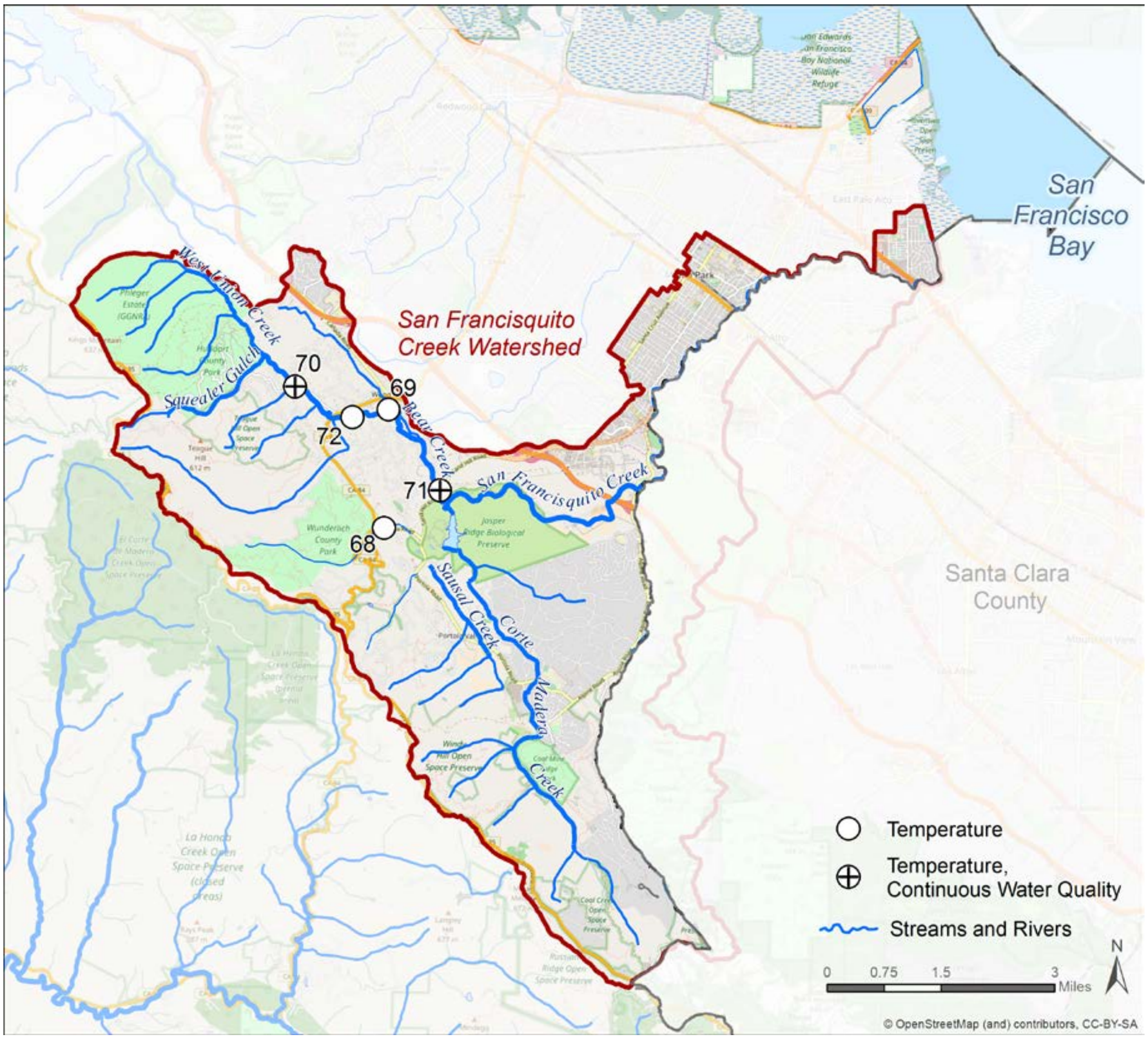

Figure 3.1. Continuous temperature and water quality stations in the San Francisquito Creek watershed, San Mateo County, WY 2016.

3.2.3 Pathogen Indicators

Pathogen indicator densities were measured during one sampling event in WY 2016 at the same five stations in the San Mateo Creek watershed that were sampled in WYs 2014 and 2015 (Figure 3.2). Both creeks sampled (San Mateo Creek and Polhemus Creek) 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 followup on the SSID study investigating the extent and source of pathogen indicators in San Mateo Creek (SMCWPPP 2015).

Figure 3.2. Pathogen indicator monitoring sites, San Mateo Creek, WY 2016.

3.3 Methods

Water quality data were collected in accordance with SWAMP-comparable methods and procedures described in the BASMAA RMC SOPs (BASMAA 2016b) and associated QAPP (BASMAA 2016a). Data were evaluated with respect to the MRP Provision C.8.d "Followup" triggers for each parameter.

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 2016. Procedures used for calibrating, deploying, programming and downloading data are described in RMC SOP FS-5 (BASMAA 2016b).

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 2016. Procedures used for calibrating, deploying, programming and downloading data are described in RMC SOP FS-4 (BASMAA 2016b).

3.3.3 Pathogen Indicators

Water samples were collected during the dry season. Sampling techniques for pathogen indicators (Enterococci and *E. coli*) include direct filling of containers at targeted sites and 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 2016b).

3.3.4 Data Evaluation

Trigger Comparison

Continuous temperature, water quality, and pathogen indicator data generated during WY 2016 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 the MRP (SFRWQCB 2015), 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.	^{o}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			
Enterococci	≥ 130	cfu/ 100ml	EPA's statistical threshold value for estimated illness rate of 36 per 1000 primary contact recreators
E. coli	≥ 410	cfu/ 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 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 2016, the National Marine Fisheries Service (NMFS) released the Coastal Multispecies Final Recovery Plan for California 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.

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. Therefore, 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 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, in an effort to develop a more meaningful understanding of the temperature data within the local context, SMCWPPP also compared the results to the 20°C MWMT threshold proposed by NMFS (2016) CAP.

3.4 Results and Discussion

3.4.1 Continuous Temperature

Temperature loggers were deployed in five sites on April 1, 2016, checked on June 30, and removed on September 20, 2016. The Alambique Creek station was completely dry during the retrieval field visit. A review of data from this logger suggests that Alambique Creek dried up on August 20, 2016. The other four sites remained wet during the entire sampling period.

Summary statistics for the water temperature data collected at the five sites are listed 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 15.4 °C to 16.6 °C. Temperatures at the Alambique Creek site were slightly cooler (median temperature was 14.9 °C). Plots showing the distribution of water temperature data at the five sites are shown in Figure 3.3. The instantaneous maximum temperature threshold (24.0 °C) is shown for reference. There were no exceedances of the instantaneous maximum temperature threshold at any of the sites during monitoring in WY 2016.

Table 3.2 Descriptive statistics for continuous water temperature measured at five sites in San Mateo County from April 1 through September 20, 2016. Recording of data at Alambique Creek ended on August 20th, 2016 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		4/1/2016	4/1/2016	4/1/2016	4/1/2016	4/1/2016
End Date		8/20/2016	9/20/2016	9/20/2016	9/20/2016	9/20/2016
Temperature (ºC)	Min	10.6	12.0	11.9	12.0	11.5
	Median	14.9	16.6	15.7	15.5	15.4
	Mean	14.2	16.2	15.5	15.2	15.1
	Max	16.6	18.8	18.1	17.6	17.6
	Max 7-day mean	16.0	18.4	17.5	17.0	17.3
	N	3382	4129	4129	4128	4128

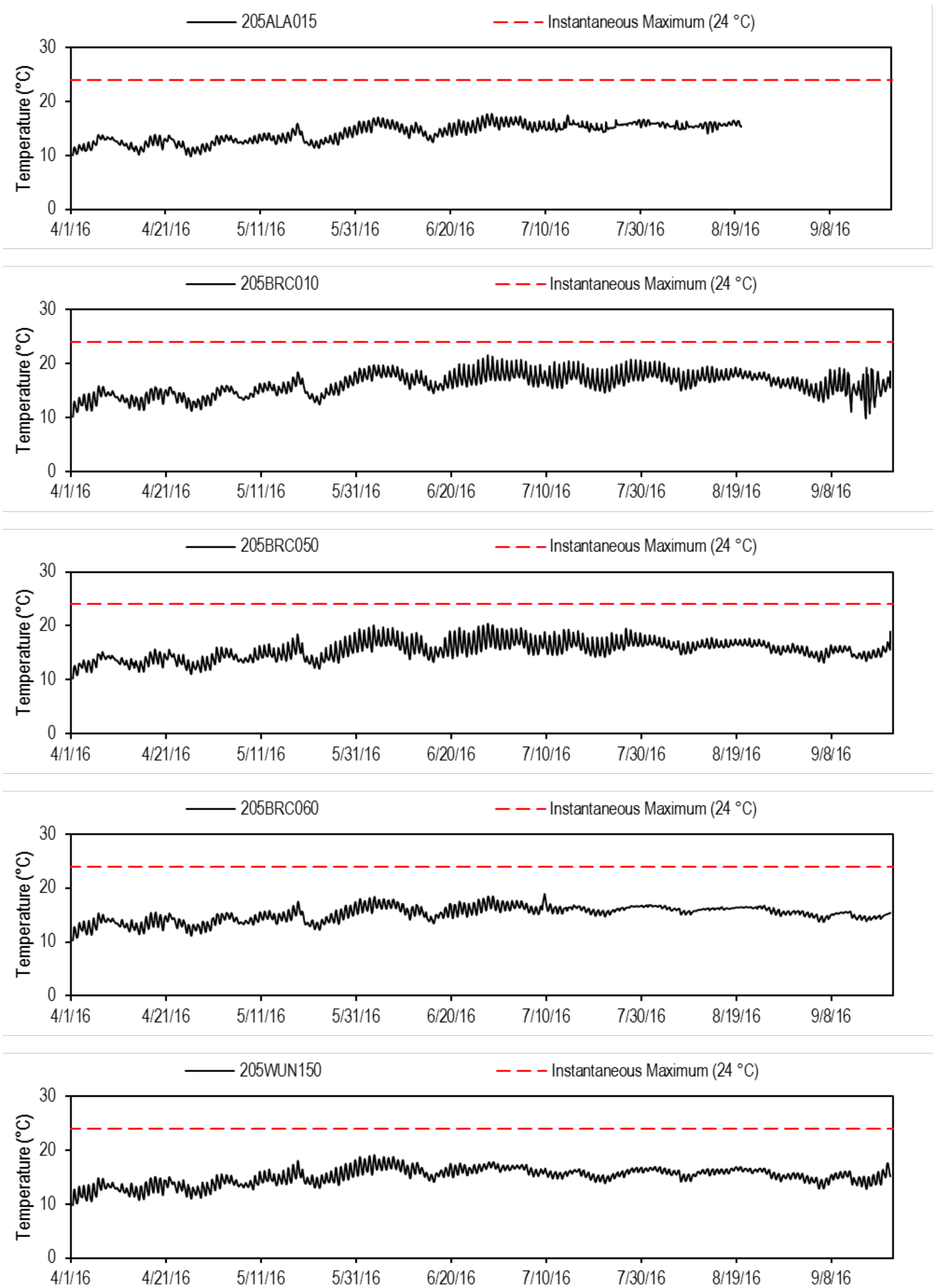

Figure 3.3. Plots of temperature data collected sites in Alambique Creek, Bear Creek, and West Union Creek during WY 2016.

Consistent with MRP requirements, the MWAT was calculated for non-overlapping, 7-day periods. The MWAT value for each week and at each site is listed in Table 3.3. Values that exceeded the MRP trigger threshold (17°C) are shown in bold. The total number of weeks that exceeded the MWAT is indicated for each site. Two sites (205BRC010 and 205BRC050) exceeded the MRP trigger of having two or more weeks with MWAT > 17°C.

The MWMT was also calculated for non-overlapping, 7-day periods. A threshold of 20°C for the MWMT was used to evaluate the data, similar to the temperature threshold for this criterion that was used by NMFS to evaluate the level of protection for summer juvenile steelhead populations in the Central Coastal Steelhead Recovery Plan. The MWMT value for each station over the monitoring period is listed in Table 3.3. The threshold of 20°C for MWMT was never exceeded for any of the weeks at any of the station suggesting that temperature is likely not a limiting factor in the monitored reaches.

The MWAT values calculated from temperatures recorded at five stations are plotted in Figure 3.4. Temperatures frequently exceeded the MRP threshold for MWAT at site 205BRC010 between the beginning of June and the end of August.

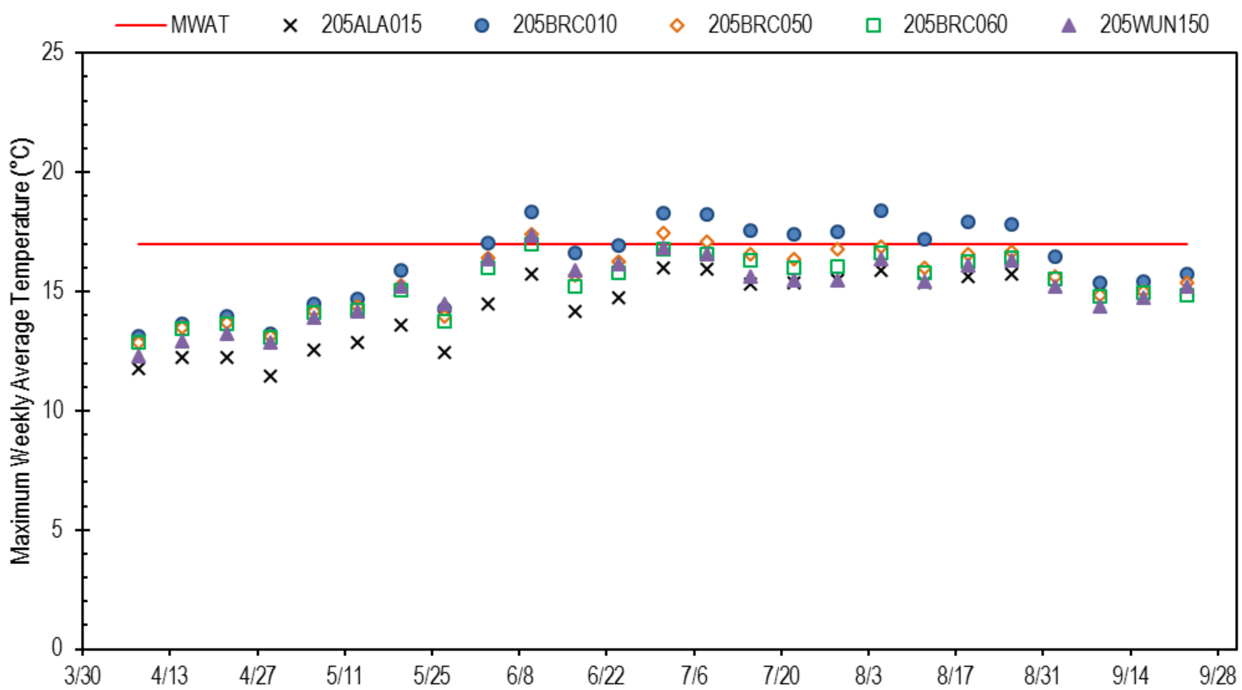

Figure 3.4 Plot showing MWAT values calculated for water temperature collected at five sites in San Francisquito Creek watershed in WY 2016.

Table 3.3. MWAT and MWMT values for water temperature data collected at five monitoring sites in the San Francisquito Creek Watershed, San Mateo County during WY2016. MWAT values that exceed the MRP trigger (17°C) and MWMT values that exceed the threshold (20°C) are indicated in bold. Weeks with no data due to dry channel are indicated by “a”.

Date	205ALA015		205BRC010		205BRC050		205BRC060		205WUN150	
	MWAT	MWMT	MWAT	MWMT	MWAT	MWMT	MWAT	MWMT	MWAT	MWMT
4/8/2016	11.8	13.3	13.1	14.9	12.9	14.5	12.9	14.3	12.3	13.7
4/15/2016	12.3	13.1	13.7	14.5	13.5	14.2	13.4	14.1	12.9	13.5
4/22/2016	12.2	13.1	13.9	14.9	13.7	14.6	13.7	14.6	13.2	14.1
4/29/2016	11.4	12.8	13.2	14.8	13.1	14.4	13.1	14.4	12.9	14.0
5/6/2016	12.5	13.1	14.5	15.4	14.2	14.9	14.1	14.9	13.9	14.6
5/13/2016	12.9	13.4	14.7	15.8	14.4	15.2	14.2	15.0	14.2	15.1
5/20/2016	13.6	14.8	15.9	17.1	15.3	16.4	15.1	16.1	15.2	16.2
5/27/2016	12.4	13.0	14.3	15.2	13.9	14.9	13.7	14.6	14.5	15.2
6/3/2016	14.5	15.4	**17.1**	18.2	16.4	17.4	16.0	16.9	16.4	17.3
6/10/2016	15.7	16.2	**18.4**	18.6	**17.4**	17.6	**17.0**	17.2	**17.3**	17.6
6/17/2016	14.2	15.1	16.6	17.3	15.7	16.6	15.2	15.9	15.9	16.6
6/24/2016	14.8	15.3	16.9	17.6	16.2	16.9	15.8	16.3	16.2	16.6
7/1/2016	16.0	16.6	**18.3**	18.8	**17.5**	18.1	16.8	17.4	16.8	17.3
7/8/2016	15.9	16.4	**18.2**	18.7	**17.1**	17.7	16.6	17.0	16.6	16.9
7/15/2016	15.3	16.2	**17.5**	18.1	16.6	17.2	16.3	17.6	15.6	16.1
7/22/2016	15.4	15.9	**17.4**	18.4	16.3	17.2	16.0	16.5	15.4	16.2
7/29/2016	15.5	16.1	**17.5**	18.4	16.7	17.5	16.0	16.6	15.5	16.4
8/5/2016	15.9	16.2	**18.4**	18.7	16.9	17.2	16.6	16.8	16.4	16.6
8/12/2016	15.4	15.7	**17.2**	17.8	16.0	16.5	15.8	16.1	15.4	16.0
8/19/2016	15.6	16.0	**17.9**	18.3	16.6	16.8	16.2	16.4	16.1	16.5
8/26/2016	15.7	16.0	**17.8**	18.3	16.7	16.8	16.4	16.5	16.3	16.6
9/2/2016	a	a	16.5	16.8	15.6	15.8	15.5	15.8	15.2	15.4
9/9/2016	a	a	15.3	16.2	14.8	15.6	14.8	15.2	14.4	15.2
9/16/2016	a	a	15.4	16.5	15.0	15.7	15.0	15.6	14.8	15.6
9/23/2016	a	a	15.7	16.7	15.4	16.3	14.8	15.4	15.2	16.2
Total Weeks	21		25		25		25		25	
> Thresholds	0	0	11	0	3	0	1	0	1	0
MRP Trigger	N		Y		Y		N		N	

Temperature data collected in WY 2016 have similar patterns to data collected during the previous two years of monitoring at the same locations. Temperatures remained below the instantaneous maximum threshold at all stations for all three years, with the exception of site 205BRC010 in WY 2015 (Figure 3.5). MWAT calculations for temperature data collected at stations for all three years indicate that the MRP threshold (17°C) is periodically exceeded at one or more sites in Bear Creek (Figure 3.6).

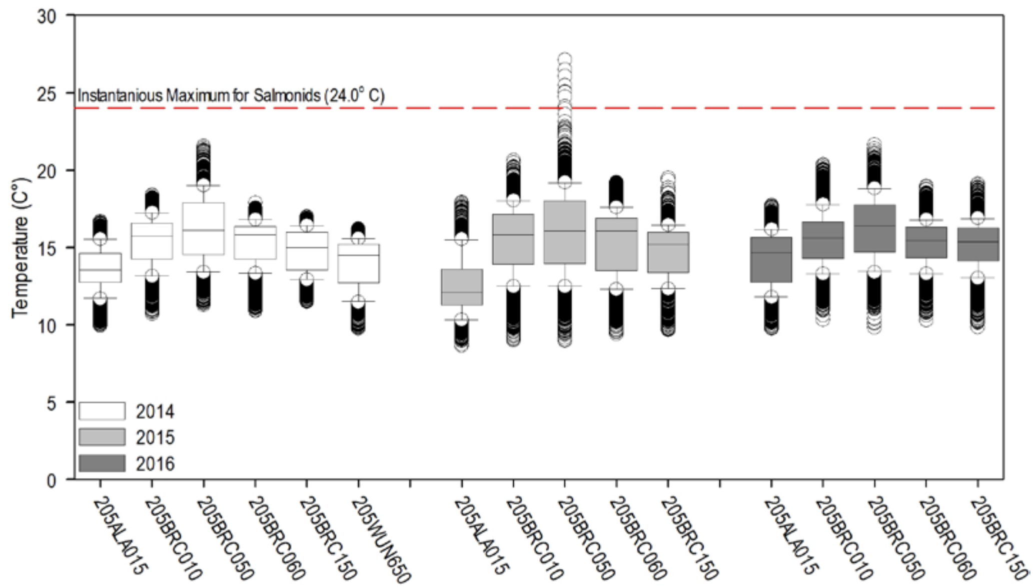

Figure 3.5. Box plots of water temperature data collected at five sites in the San Francisquito Creek watershed from April through September for three consecutive years (WY 2014, WY 2015 and WY 2016).

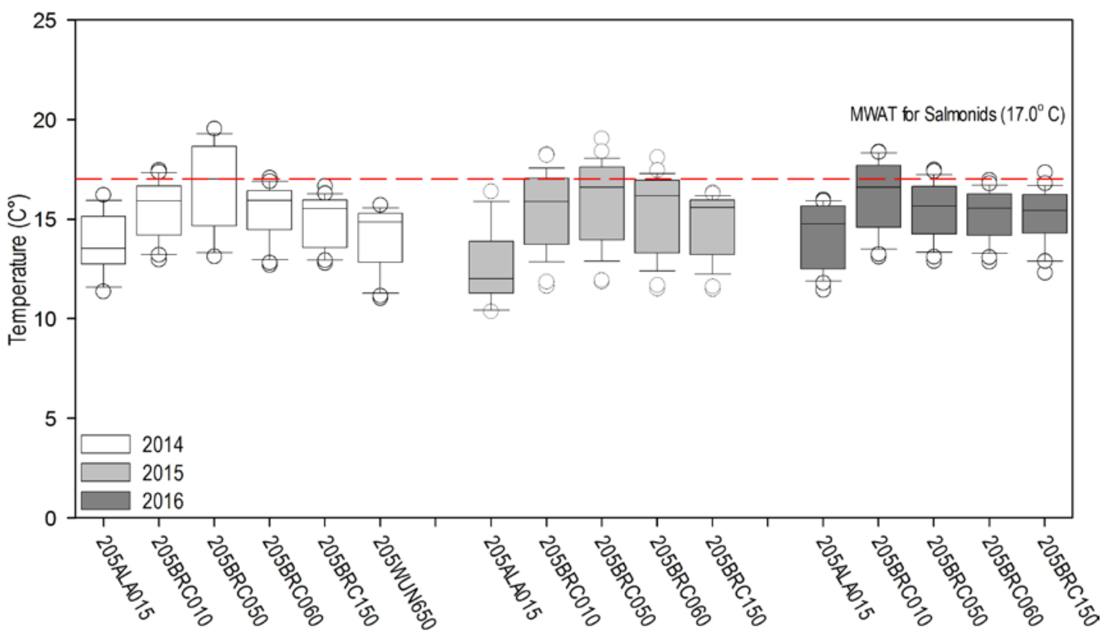

Figure 3.6. Box plots of MWAT calculated from temperature data collected at five sites in the San Francisquito Creek watershed from April through September for three consecutive years (WY 2014, WY 2015 and WY 2016).

A summary of the MRP trigger analyses for water temperature collected in WY 2016 is presented in Table 3.4.

Table 3.4. Trigger analysis of WY2016 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	**11**	**Yes**	0	No
205BCR050		Mountain Home Rd	**3**	**Yes**	0	No
205BCR060		Fox Hollow Rd	0	No	0	No
205WUN150	West Union Creek	Kings Mountain Rd	1	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 MWAT trigger of 17.0 ºC was exceeded at the two lowest elevation stations on Bear Creek, 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 WY 2016 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 one station in Bear Creek and one station in West Union Creek during two sampling events in WY 2016 are listed in Table 3.5. Time series plots of the data for Event 1 and Event 2 are shown in Figures 3.7 and 3.8, respectively. Station locations are mapped in Figure 3.2.

Table 3.5. Descriptive statistics for continuous water temperature, dissolved oxygen, pH, and specific conductance measured at sites in San Mateo County during WY2 016. Data were collected every 15 minutes over a two two-week time periods during May (Event 1) and September (Event 2).

Parameter	Data Type	205BRC010 Bear Creek at Sandhill Road		205WUN150 West Union Creek at Kings Mountain Rd	
		May WY16	Sept WY16	May WY16	Sept WY16
Temperature (°C)	Min	12.4	13.2	12.8	12.8
	Median	15.4	16.8	14.8	15.5
	Mean	15.4	16.6	14.9	15.4
	Max	18.5	18.6	17.8	16.8
	% > 24	0%	0%	0%	0%
Dissolved Oxygen (mg/L)	Min	7.4	1.4	8.8	3.3
	Median	9.4	3.2	9.4	5.4
	Mean	9.4	3.2	9.4	5.5
	Max	11.3	6.4	10.0	8.5
	% < 7	0%	100%	0%	95%
pH	Min	7.5	7.0	7.5	6.0
	Median	7.9	7.2	7.5	6.8
	Mean	8.0	7.2	7.6	6.8
	Max	8.1	7.5	7.7	7.1
	% < 6.5 or 8.5	0%	0%	0%	7%
Specific Conductivity (uS/cm)	Min	672	920	500	618
	Median	683	941	514	624
	Mean	684	939	515	624
	Max	716	964	526	629
	% > 2000	0%	0%	0%	0%
Total number of data points (N)		1343	1531	1346	1530

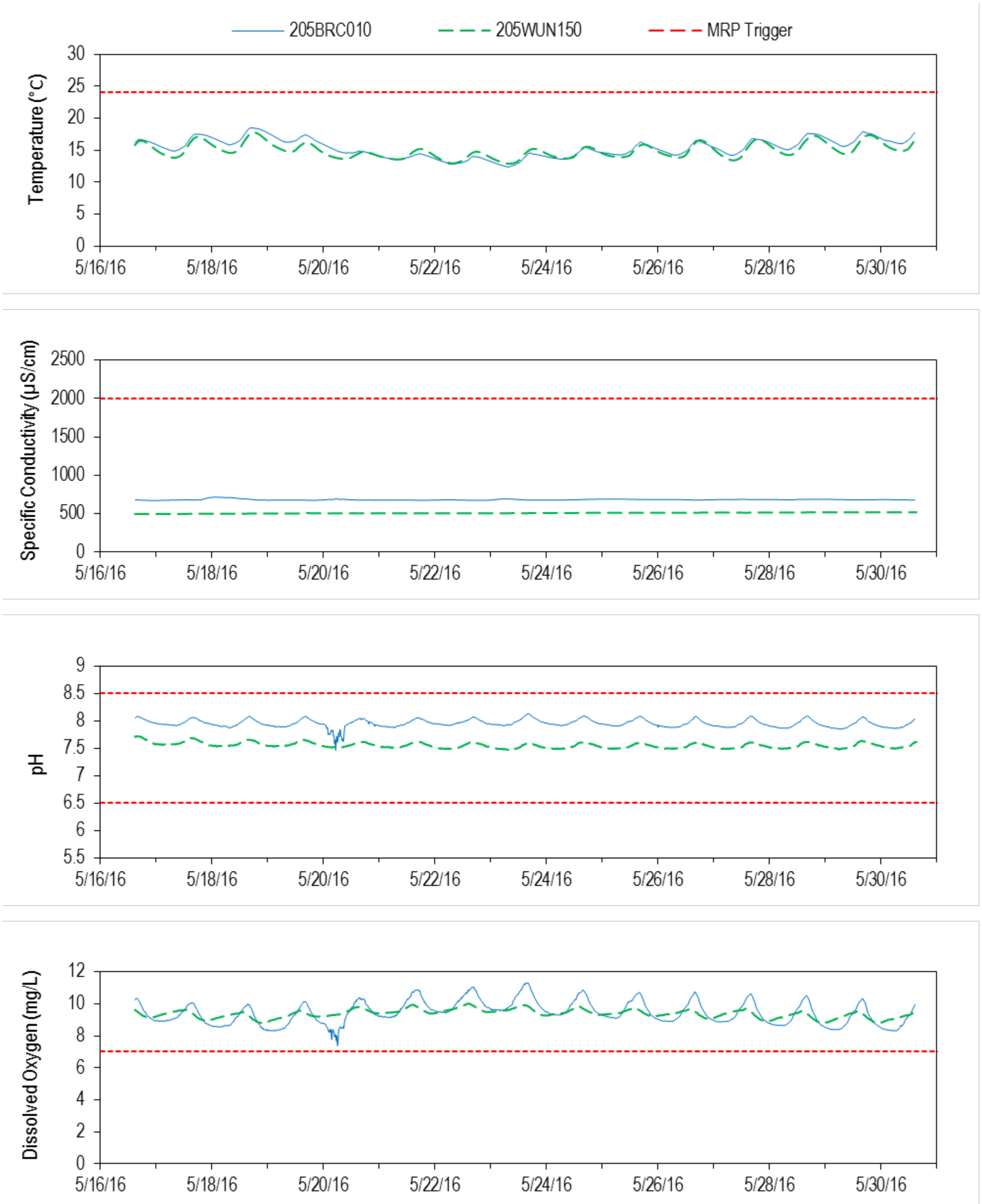

Figure 3.7 Continuous water quality data (temperature, specific conductance, pH, and dissolved oxygen) collected at Bear Creek at Sandhill Rd (205BRC010) and at West Union Creek at Kings Mountain Road (205WUN150) during May 16 - 30, 2016 (Event 1).

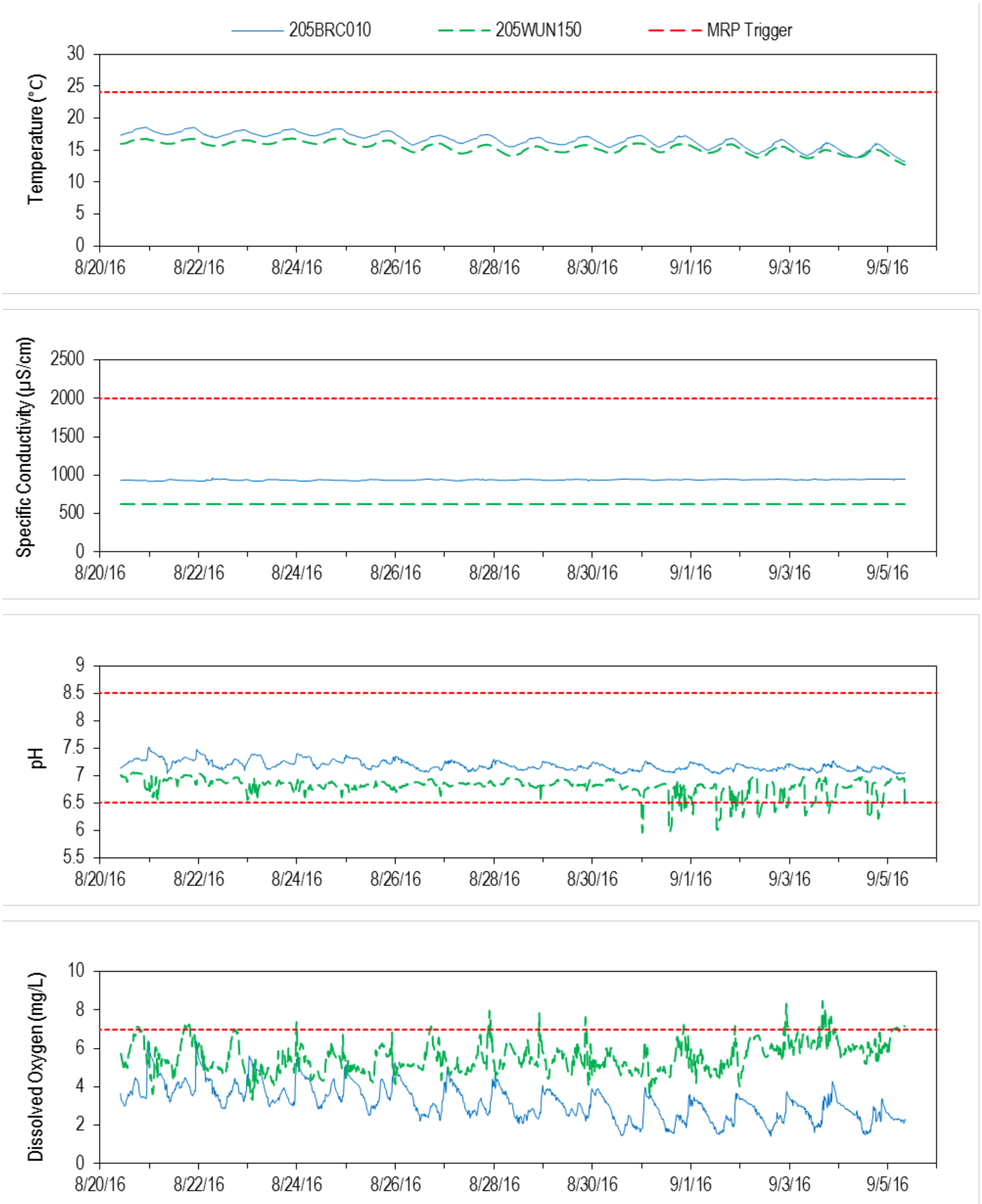

Figure 3.8 Continuous water quality data (temperature, specific conductance, pH, and dissolved oxygen) collected at Bear Creek at Sandhill Rd (205BRC010) and at West Union Creek at Kings Mountain Road (205WUN150) during August 20 – September 5, 2016 (Event 2).

Temperature

Water temperatures never exceeded the 24°C acute threshold for salmonids at any of the sites for either sampling event (Table 3.6). MWAT was not calculated for temperature data collected by sondes due to limited number of data points (requires at least two 7 day periods to determine MRP trigger). However, MWAT was calculated for temperature data collected by hobos at both sonde locations and MRP trigger exceedances were observed at Bear Creek at Sandhill Road (205BRC010) (see Section 3.4.1).

Dissolved Oxygen

Dissolved oxygen (DO) concentrations were above the Basin Plan minimum WQOs for WARM (5.0 mg/L) and COLD (7.0 mg/L) at both sites during Event 1. In contrast, the DO levels were consistently below WARM and COLD WQOs at both sites during Event 2 (Table 3.6). During the dry season, the sampling locations became isolated pools sondes with just a trickle or no surface flow entering the pool from the upstream channel. These pools would provide the only refugia for juvenile steelhead and other native fishes. Thus, the measured low DO levels would not likely support steelhead, especially if they were cut off from reaches with better habitat and water quality. Both sites will be added to the list for potential SSID projects for low DO.

pH

The pH measured during the two sampling events in WY 2016 fell within the Basin Plan WQOs for pH (< 6.5 and/or > 8.5), with the exception of site 205WUN150 (West Union Creek) during Event 2 (Table 3.6). The pH frequently dropped below 6.5 during the first week of September (Figure 3.7). The cause of low pH in this pool is unknown but may be associated with lack of flow, desiccating conditions, and algal blooms. This site will be added to the list for potential SSID projects for pH.

Specific Conductivity

Specific conductance was generally higher at the lower elevation site at Sandhill Road compared to the higher elevation site at Mountain Home Road. The lower elevation site has more influence from runoff associated with urban land uses. The specific conductance was also higher during Event 2 compared to Event 1. The MRP identifies the trigger for specific conductance as 2000 us/cm. There were no measurements above the MRP trigger at either station for either sampling event (Table 3.6).

Table 3.6. Analyses of MRP triggers for general water quality data collected at one station in Bear Creek and one station in West Union Creek, San Mateo County during WY 2016.

Site ID	Site Location	Monitoring Event	Temperature	Dissolved Oxygen	pH	Specific Conductivity
			Acute Trigger >20% results exceed 24˚C	< 7 mg/L or < 5 mg/L	> 8.5 or < 6.5	> 2000 µS
205BRC010	Sandhill Rd	May	No	No	No	No
		Aug/Sept	No	Yes	No	No
205WUN150	Mountain Home Rd	May	No	No	No	No
		Aug/Sept	No	Yes	Yes	No

3.4.3 Pathogen Indicators

Pathogen indicator densities measured in water samples in WY 2016 are listed in Table 3.7. Stations are mapped in Figure 3.2. During this one grab sampling event, there was an increase in pathogen indicator densities in the downstream direction. None of the samples exceeded the MRP trigger for *E. coli*; however the two downstream stations (204SMA060 and 204SMA080) exceeded MRP trigger for enterococcus. These data are consistent with the findings from the SSID study investigating the extent and source(s) of pathogen indicators in San Mateo Creek. The SSID Project Report was included as Appendix C to the WY 2015 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. These efforts should be coordinated with the County of San Mateo’s public outreach program that targets pet waste and other sources of bacteria. County actions include flowstobay webpage and Facebook postings and dog bag dispenser giveaways.

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 2012b).

Table 3.7. Enterococcus and *E. coli* levels measured in San Mateo County during WY 2016.

Site ID	Creek Name	Site Name	*Enterococcus (cfu/100ml) (MPN/100ml)*[1]	*E. Coli (cfu/100ml) (MPN/100ml)*[1]	Sample Date
MRP Trigger Threshold (USEPA 2012b)			*130*	*410*	
204SMA060	San Mateo Creek	DeAnza Park	440	280	6/22/16
204SMA080		Sierra Drive	290	160	6/22/16
204SMA100		Tartan Trail	52	30	6/22/16
204SMA119		USGS Gage	3	14	6/22/16
204SMA110	Polhemus Creek	At Mouth	6	3	6/22/16

[1] USEPA 2012 water quality criteria are given in cfu/100ml; whereas, the analytical method used by the Program gives results in MPN/100ml. These units are used interchangeably in this analysis.

3.5 Conclusions and Recommendations

Targeted monitoring in WY 2016 was conducted in compliance with Provisions C.8.d.iii – v of the MRP. Hourly temperature measurements were recorded at five sites in the San Francisquito Creek watershed from April through September. Continuous (15-minute) general water quality measurements (pH, DO, specific conductance, temperature) were recorded at two sites in the San Francisquito Creek watershed during two 2-week periods in May (Event 1) and September (Event 2). Pathogen indicator grab samples were collected at five sites in the San Mateo Creek watershed during a sampling event in June. Stations were deliberatively selected using the Directed Monitoring Design Principle.

Conclusions and recommendations from targeted monitoring in WY 2016 are listed below. The sections below are organized on the basis of the management questions listed at the beginning of this section:

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?*

Spatial and Temporal Variability of Water Quality Conditions

- There was minimal spatial variability in water temperature across the four stations in the Bear Creek branch of the San Francisquito Creek watershed. Temperature was slightly lower at the station in Alambique Creek.

- The same stations were monitored for temperature in WYs 2014 and 2015. Temperature monitoring results in WY 2016 were similar to results from prior years.

- Dissolved oxygen concentrations were reduced during Event 2 compared to Event 1 at both sites. Changes in DO are likely caused by decreasing flow in the late summer and water quality conditions associated with isolated pools.

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, and temperature) collected at two targeted stations.
- Two temperature stations in Bear Creek exceeded the MRP trigger threshold of having two or more weeks where the maximum weekly average temperature (MWAT) exceeded 17°C. 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 Nation Marine Fisheries Service 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 beneficial uses (i.e., 7.0 mg/L) was frequently exceeded at both water quality stations during Event 2. The water quality conditions were associated with isolated pools during low or no flow conditions. Both sites will be added to list of potential SSID projects.
- Values for pH measured at one site in WY 2016 (205BCR010 - Bear Creek Sandhill Road) did not meet the lower WQO for pH during Event 2. This site will be added to list of potential SSID projects. The pH excursion was likely related to low/no flow conditions resulting in an isolated pool at the monitoring station.
- Specific conductance concentrations recorded at the two stations in WY 2016 were below the MRP trigger threshold of 2000 us/cm.

Potential Impacts to Water Contact Recreation

- In WY 2016, pathogen indicator sites were located in the San Mateo Creek watershed where a bacteria SSID study was previously conducted. Pathogen indicator triggers for enterococcus were exceeded at two of the five sites. Triggers for *E. coli* were not exceeded.
- 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.
- Municipalities in the lower San Mateo Creek watershed are currently implementing prescribed actions to reduce or eliminate conditions in the sanitary sewer collection system that cause or contribute to SSOs. The County of San Mateo also has a public

outreach program targeting pet waste[19] and other sources of bacteria. Actions include webpage and Facebook postings and dog bag dispenser giveaways.

[19] http://www.flowstobay.org/petwaste.

4.0 Chlorine Monitoring

4.1 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.

In compliance with Creek Status Monitoring Provision C.8.d.ii and to assess whether the chlorine in receiving waters is potentially toxic to the aquatic life living there, SMCWPPP measured total and free chlorine residual in creeks where bioassessments were conducted. 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.

4.2 Methods

In accordance with the MRP and the BASMAA RMC Creek Status and Long-Term Trends Monitoring Plan (BASMAA 2012), WY 2016 field testing for free chlorine and total chlorine residual was conducted at all ten probabilistic sites concurrent with spring bioassessment sampling (April-May). 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 2016b), which are comparable to those specified in the SWAMP QAPP. Per SOP FS-3 (BASMAAS 2016b), 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 0.1 mg/L, the site was immediately resampled. Per Provision C.8.d.ii(4) of the MRP, "if the resample is still greater than 0.1 mg/L, then Permittees report the observation 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."

4.3 Results

In WY 2016, SMCWPPP monitored the ten probabilistic sties for free chlorine and total chlorine residual. These measurements were compared to the MRP trigger threshold of 0.1 mg/L. Results are listed in Table 4.1. Original and repeat measurements are listed.

Trigger thresholds were exceeded at three of the ten stations sampled. The exceedances, all of which were free chlorine, ranged from 0.11 to 0.24 mg/L. The values are flagged for possible QA problems inasmuch as the corresponding total chlorine residual values were at or below the 0.1 mg/L threshold. Nevertheless, in compliance with Provision C.8.d.ii(4), SMCWPPP staff immediately informed local illicit discharge staff of the exceedances for followup.

Table 4.1. Summary of SMCWPPP chlorine testing results compared to MRP trigger of 0.1 mg/L, WY 2016.

Station Code	Creek	Date	Free Chlorine (mg/L)[1, 2]	Total Chlorine Residual (mg/L)[1, 2]	Exceeds Trigger?[3] (0.1 mg/L)
202R00488	Tunitas Creek	5/10/2016	0.18 / 0.13	0.07	Yes
202R00506	Peters Creek	5/9/2016	0.05	0.07	No
202R02332	Pilarcitos Creek	5/10/2016	0.11 / 0.11	0.08	Yes
204R02228	San Mateo Creek	5/11/2016	0.03	<0.02	No
204R02504	Polhemus Creek	5/11/2016	0.02	0.05	No
204R02548	Cordilleras Creek	5/17/2016	0.06	0.05	No
205R02408	Bull Run Creek	5/17/2016	0.24 / 0.18	0.1 / 0.05	Yes
205R02728	Dry Creek	5/12/2016	0.04	< 0.02	No
205R02920	Bear Gulch Creek	5/12/2016	0.05	0.03	No
205R03032	West Union	5/16/2016	0.05 / < 0.02	0.02 / < 0.02	No
Number of sites exceeding 0.1 mg/L:			3	0	--

[1] The method detection limit is 0.02 mg/L; however, the Statewide General Permit for Drinking Water Discharges (Order WQ 2014-0194-DWQ) uses 0.1 mg/L as a reporting limit (minimum level) for field measurements of total chlorine residual.
[2] Original and repeat samples are reported where conducted. The first value is the original result.
[3] The MRP trigger threshold applies to both free chlorine and total chlorine residual measurements.

4.4 Conclusions and Recommendations

While chlorine residual is generally not a concern in San Mateo County creeks, WY 2016 and prior monitoring results suggest there are occasional free chlorine and total chlorine exceedances in the County. Exceedances may be the result of one-time potable water discharges and it is generally very difficult to determine the source of elevated chlorine from such episodic discharges. The Program will continue to monitor chlorine in compliance with the MRP and will follow-up with illicit discharge staff as needed.

5.0 Toxicity and Sediment Chemistry Monitoring

5.1 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.

Provision C.8.g of the MRP requires both wet and dry weather monitoring of pesticides and toxicity in urban creeks.

Dry Weather

The Program is required to conduct water toxicity and sediment chemistry and toxicity monitoring at one location per year during the dry season, each year of the permit term beginning in WY 2016. The water and sediment samples do not necessarily need to be collected at the same locations. The permit provides examples of possible monitoring locations, including sites with suspected or past toxicity results, or existing bioassessment sites.

- Toxicity testing in water is required using five species: *Ceriodaphnia* dubia (chronic survival and reproduction), *Pimephales promelas* (larval survival and growth), *Selenastrum capricornutum* (growth), *Hyalella azteca* (survival) and *Chironomus dilutes* (survival).
- Toxicity testing in sediment is required using two species: *Hyella azteca* (survival) and *Chironomus dilutes* (survival).
- Sediment chemistry analytes include pyrethroids, fipronil, carbaryl, total polycyclic aromatic hydrocarbons (PAHs), metals, Total Organic Carbon (TOC) and sediment grain size.

Wet Weather

The wet weather monitoring requirements include collection of water column samples for toxicity testing and analysis of pyrethroids, fipronil, imidacloprid and indoxacarb. The permit states that sample event(s) must occur during wet weather, but does not specify whether a “storm event” must be sampled. The permit states that monitoring locations should be representative of urban watersheds (i.e., bottom of watersheds).

The permit states that if the wet season monitoring is conducted by the RMC on behalf of all Permittees, a total of ten samples are required over the permit term, with at least six samples collected by WY 2018. At the RMC Monitoring Workgroup meeting on January 25, 2016, RMC members agreed to collaborate on implementation of the wet weather monitoring requirements. The first wet weather samples will occur in WY 2018. The RMC is still in the process of allocating sample sites and developing a monitoring approach. The assumption is that SMCWPPP will be responsible for collecting two wet weather samples during the permit term.

Toxicity and pesticides monitoring methods and results are described in the sections below.

5.2 Methods

5.2.1 Site Selection

In WY 2016, in compliance with MRP Provision C.8.g.i, water and sediment toxicity and sediment chemistry samples were collected from one creek during dry weather: Laurel Creek (see Figure 1.2). The site was selected to represent and mixed-land use urban watershed that was not already being monitored for toxicity or pesticides by other programs, such as the SWAMP Stream Pollution Trends (SPoT) program. The specific station within the watershed was identified based on the likelihood that it would contain fine depositional sediments during dry season sampling and would be safe to access during potential future wet weather sampling. It is anticipated that SMCWPPP will select a different creek to target for dry weather pesticides and toxicity monitoring during each year of the permit term with the goal of building a geographically diverse dataset.

5.2.2 Sample Collection

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.

Water samples were collected using standard grab sampling methods. The required number of 4-L labeled amber glass bottles were filled and placed on ice to cool to < 6C. The laboratory was notified of the impending sampling delivery to meet 24-hour sample hold time. Procedures used for sampling and transporting water samples are described in SOP FS-2 (BASMAA 2016b).

Sediment samples were collected from the top 2 cm at each sub-site beginning at the downstream-most location and continuing upstream. Sediment 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 2016b).

Sample were submitted to respective laboratories and field data sheets were reviewed per SOP FS-13 (BASMAA 2016b).

5.2.3 Data Evaluation

Water and Sediment Toxicity

Data evaluation required by the MRP involves first determining whether the samples are toxic to the test organisms relative to the laboratory control treatment via statistical comparison using the Test of Significant Toxicity (TST) statistical approach. For samples with toxicity (i.e., those that “failed” the TST), the Percent Effect is evaluated. The Percent Effect compares sample endpoints (survival, reproduction, growth) to the laboratory control endpoints. Follow-up sampling is required if any test organism is reported as “fail” and the Percent Effect is ≥ 50 % Percent Effect. Both the TST result and the Percent Effect are determined by the laboratory.

Sediment Chemistry

In compliance with MRP provision, C.8.g.iv, sediment sample results are compared to Probable Effects Concentrations (PECs) and Threshold Effects Concentrations (TECs) as defined by

MacDonald et al. (2000). PEC and TEC quotients are calculated as the ratio of the measured concentration to the respective PEC and TEC 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 fornon-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. All 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. These conditions will be considered when making decisions about SSID projects.

The current MRP does not require consideration of pyrethroid, fipronil, or carbaryl sediment chemistry data for follow-up SSID projects, perhaps because pyrethroids are ubiquitous in the urban environment and little is known about fipronil and carbaryl distribution. However, SMCWPPP computed toxicity unit (TU) equivalents for individual pyrethroid and fipronil results, based on available literature values for pyrethroids in sediment LC50 values.[20],[21] Because organic carbon mitigates the toxicity of pyrethroid and fipronil pesticides in sediments, the LC50 values were derived on the basis of TOC-normalized concentrations. Therefore, the pesticide 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 constituent. 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.

5.3 Results and Discussion

5.3.1 Toxicity

Table 5.1 provides a summary of toxicity testing results for WY 2016 dry weather water and sediment samples. Based on the results, it is not necessary to add Laurel Creek to the list of potential SSID projects.

The water sample was significantly toxic to three of the test organisms (*C. dubia, C. dilutus, H. azteca*) and the sediment sample was significantly toxic to one test organism (*C dilutus*); however, the Percent Effect did not exceed the 50% threshold for followup. The cause of the water and sediment toxicity is unknown. The midge, *C. dilutus*, has been shown to be the most sensitive species to new classes of pesticides such as imidacloprid (a neonicotinoid) and fipronil and its degradates (SWAMP 2016). Imidacloprid is not included in the list of required dry weather analytical constituents but will be required in water samples collected during wet weather. Fipronil was analyzed in WY 2016 dry weather sediment samples. The fipronil

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

[21] No LC50 is published for carbaryl.

concentration was well below the LC50. The cause of the *H. azteca* toxicity may be due to bifenthrin concentrations which exceeded the LC50. See Section 5.3.2 for more information on sediment chemistry.

Table 5.1. Summary of SMCWPPP water toxicity results, WY 2016.

Site	Organism	Test Type	Unit	Results		TST Value	% Effect	Follow up needed (TST "Fail" and **≥50%)**
				Lab Control	Organism Test			
205LAU10 Laurel Creek	Water							
	Ceriodaphnia dubia	Survival	%	90	90	Pass [1]	0%	No
		Reproduction	Num/Rep	34.7	24	Fail	30.8%	No
	Pimephales promelas	Survival	%	92.5	85	Pass	8.11%	No
		Growth	mg/ind	0.626	0.66	Pass	-5.47%	No
	Chironomus dilutus	Survival	%	100	90	Fail	10%	No
	Hyalella azteca	Survival	%	98	70	Fail	28.6%	No
	Selenastrum capricornutum	Growth	cells/ml	1620000	5480000	Pass	-238%	No
	Sediment							
	Chironomus dilutus	Survival	%	92.5	80	Fail	13.5%	No
	Hyalella azteca	Survival	%	100	97.5	Pass	2.5%	No

[1] TST analysis is not performed for survival endpoint - a percent effect <25% is considered a "Pass", and a percent effect ≥25% is considered a "Fail"

5.3.2 Sediment Chemistry

Sediment chemistry results are evaluated as potential stressors based on TEC quotients and PEC quotients according to criteria in provision C.8.g.iv of the MRP. SMCWPPP also evaluated TU equivalents of pyrethroids.

Table 5.2 lists TEC quotients for sediment chemistry constituents (metals and PAHs), calculated as the measured concentration divided by the highly conservative TEC value, per MacDonald et al. (2000)[22]. TECs are extremely conservative and are intended to identify concentrations below which harmful effects on sediment-dwelling organisms are unlikely to be observed. The site on Laurel Creek exceeded the relevant trigger criterion from the MRP of having at least one result exceeding the TEC and will be added to the list of potential SSID projects. However, the TEC exceedances were of chromium and nickel as expected in watersheds draining hillsides underlain by serpentinite formations.

Table 5.3 provides PEC quotients for sediment chemistry constituents (metals and PAHs), calculated as the measured concentration divided by the PEC value, per MacDonald et al. (2000). PECs are intended to identify concentrations above which toxicity to benthic-dwelling organisms are predicted to be probable. The PEC quotient for nickel was greater than 1.0.

Table 5.4 provides a summary of the calculated TU equivalents for pesticides measured in sediment samples[23]. Because organic carbon mitigates the toxicity of pyrethroids and fipronil in sediments, the LC50 values were derived on the basis of TOC-normalized pyrethroid concentrations. Similarly, the constituent 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. The TU equivalent for bifenthrin exceeded 1.0. Bifenthrin is considered to be the leading cause of pyrethroid-related toxicity in urban areas (Ruby 2013).

In compliance with the MRP, a grain size analysis was conducted on the sediment sample (Table 5.5). The Laurel Creek sample was 9% fines (i.e., 4% clay and 5% silt). It unknown whether the percent fines influenced the toxicity tests or sediment chemistry analyses.

[22] MacDonald et al. (2000) does not provide TEC or PEC values for pyrethroids, fipronil, or carbaryl. Pyrethroids are compared to LC50 values in Table 5.4. However, LC50 values for fipronil and carbaryl in sediment have not been published.

[23] Although an LC50 value has not been published for carbaryl, the carbaryl concentration is included in Table 5.4.

Table 5.2. Threshold Effect Concentration (TEC) quotients for WY 2016 sediment chemistry constituents. Bolded and shaded values indicate TEC quotient ≥ 1.0.

Site ID / Creek	TEC	204LAU010 / Laurel Creek
Metals (mg/kg DW)		
Arsenic	9.79	0.47
Cadmium	0.99	0.24
Chromium	43.4	**1.01**
Copper	31.6	0.85
Lead	35.8	0.42
Nickel	22.7	**2.56**
Zinc	121	0.99
PAHs (ug/kg DW)		
Anthracene	57.2	0.09
Fluorene	77.4	0.52
Naphthalene	176	0.01 [a]
Phenanthrene	204	0.10
Benz(a)anthracene	108	0.09
Benzo(a)pyrene	150	0.04
Chrysene	166	0.19
Dibenz[a,h]anthracene	33.0	0.05 [a]
Fluoranthene	423	0.12
Pyrene	195	0.2
Total PAHs	1,610	0.15 [c]

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 5.3. Probably Effect Concentration (PEC) quotients for WY 2016 sediment chemistry constituents. Bolded and shaded values indicate TEC quotient ≥ 1.0.

Site ID		204LAU010
Creek	PEC	Laurel Creek
Metals (mg/kg DW)		
Arsenic	33.0	0.14
Cadmium	4.98	0.05
Chromium	111	0.40
Copper	149	0.18
Lead	128	0.12
Nickel	48.6	**1.19**
Zinc	459	0.26
PAHs (ug/kg DW)		
Anthracene	845	0.01
Fluorene	536	0.07
Naphthalene	561	0.00 [c]
Phenanthrene	1170	0.02
Benz(a)anthracene	1050	0.01
Benzo(a)pyrene	1450	0.00
Chrysene	1290	0.02
Fluoranthene	2230	0.02
Pyrene	1520	0.03
Total PAHs	22,800	0.01

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 5.4. Calculated toxic unit (TU) equivalents for WY 2016 pesticide concentrations.

Pyrethroid	Units	LC50	WY2016 204LAU010 ~~Atherton Creek~~
Bifenthrin	µg/g dw	0.52	1.37
Cyfluthrin	µg/g dw	1.08	0.36
Cypermethrin	µg/g dw	0.38	0.23 [b]
Deltamethrin	µg/g dw	0.79	0.51
Esfenvalerate	µg/g dw	1.54	0.02 [a]
Lambda-Cyhalothrin	µg/g dw	0.45	0.09 [b]
Permethrin	µg/g dw	10.83	0.05
Other Pesticides			
Carbaryl	mg/Kg dw	NA[c]	NA [c]
Fipronil	ng/g dw	410	0.01 [b]

[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).
[c] Currently there is no available LC50 value for Carbaryl, however the observed concentration was below the detection limit.

Table 5.5. Summary of Grain Size for site 204LAU010 in San Mateo County during WY 2016.

Grain Size (%)		204LAU010 Laurel Creek
Clay	<0.0039 mm	4%
Silt	0.0039 to <0.0625 mm	5%
Sand	V. Fine 0.0625 to <0.125 mm	5%
	Fine 0.125 to <0.25 mm	15%
	Medium 0.25 to <0.5 mm	32%
	Coarse 0.5 to <1.0 mm	27%
	V. Coarse 1.0 to <2.0 mm	12%
Granule	2.0 to <4.0 mm	5%
Pebble	Small 4 to <8 mm	2%
	Medium 8 to <16 mm	0%
	Large 16 to <32 mm	0%
	V. Large 32 to <64 mm	0%

5.4 Conclusions and Recommendations

Statistically significant toxicity to *C. dubia, C. dilutus,* and/or *H. azteca* was observed in both water and sediment samples collected during the dry season. However, the magnitude of the toxic effects in the samples compared to laboratory controls were not great and did not exceed MRP trigger criteria of 50 Percent Effect.

TEC and PEC quotients were calculated for all metals and PAHs measured in sediment samples. Two TEC and one PEC quotients exceeded 1.0. In compliance with the MRP, Laurel Creek will therefore be placed on the list of candidate SSID projects. Decisions about which SSID projects to pursue should be informed by the fact that the TEC and PEC quotient exceedances are related to naturally occurring chromium and nickel due to serpentine soils in local watersheds.

6.0 Conclusions and Recommendations

In WY 2016, in compliance with Provisions C.8.d and C.8.g of the MRP 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 WY 2012. The strategy includes a regional ambient/"probabilistic" bioassessment monitoring component and a component based on local "targeted" monitoring for general water quality parameters and pesticides/toxicity. 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 and Pesticides/Toxicity Monitoring conducted during WY 2016 in San Mateo County are based on the management questions presented in Section 1.0 of this report:

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 and targeted monitoring data with respect to the triggers defined in the MRP. 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 explain the variation in biological condition scores.

6.1 Conclusions

6.1.1 Bioassessment Monitoring

Bioassessment monitoring in WY 2016 was conducted in compliance with Provision C.8.d.i of the MRP. Ten sites were sampled for BMIs, benthic algae, PHab observations, and nutrients. Stations were randomly selected using a probabilistic monitoring design.

Conclusions and recommendations from bioassessment monitoring conducted during WY 2016 in San Mateo County are organized below according to the following detailed management questions that build off the management questions listed above:

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?*

Probabilistic Survey Design

- Site evaluations were conducted at a total of 36 potential probabilistic sites in San Mateo County during WY 2016. Of these sites, ten were sampled in WY 2016 (rejection rate of 72%). Two of the ten sites (20%) were classified as non-urban land use.
- Between WY 2012 and WY 2016, a total of 60 probabilistic sites were sampled by SMCWPPP (n=50) and SWAMP (n=10) in San Mateo County, including 41 urban and 19 non-urban sites. There is 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 (WY 2016)

- The California Stream Condition Index (CSCI) tool was used to assess biological condition. The CSCI translates benthic macroinvertebrate data into an overall measure of stream health. Of the ten sites monitored in WY 2016, two sites were rated in good condition (CSCI score $\geq$ 0.795), three sites rated as likely altered conditions (CSCI score 0.635 – 0.795), and five sites rated as very likely altered condition (CSCI score $\leq$ 0.635).
- The eight sites with CSCI scores less than the trigger threshold of 0.795 will be added to the list of candidate SSID projects.
- Benthic algae data was collected synoptically with BMIs at all probabilistic sites. Diatoms taxa (n=120) were well represented, but few soft algae taxa (n=12) were identified in the ten samples. As a result, the majority of sites had low biological condition based on algae indices that incorporate soft algae (S2 and H20). Two sites were ranked in good biological condition based on diatom (D18) IBI scores.
- Total PHAB scores were better correlated with CSCI scores than they were with D18 scores, suggesting that physical habitat (e.g., substrate quality, channel alteration) has a greater influence on the BMI community than the diatoms assemblage. For this reason, algae may provide useful data to assess water quality issues at urban sites with poor habitat.

Biological Condition Assessment (WY 2012 – WY 2016)

- CSCI scores were calculated for the five-year San Mateo County probabilistic data set (n=60). Good biological condition scores (CSCI score > 0.795) occurred at 17% of the urban sites and 74% of non-urban sites.
- The median CSCI scores were higher at non-perennial sites (0.74) compared to perennial (0.55) sites. A similar pattern was observed with all three SoCal Algae IBI scores. Non-perennial sites were typically located in non-urban areas in the upper reaches of watersheds draining into Pacific Ocean or tributaries to San Francisquito Creek (draining into the San Francisco Bay), which may explain the higher scores.
- CSCI scores generally decrease in response to increasing urbanization (calculated as percent impervious area).

Stressor Assessment

- Potential stressors such as nutrients, physical habitat, algal biomass indicators, and other conventional analytes were measured during bioassessments or analyzed in samples collected concurrently with bioassessments. Some potential stressors, such as urbanization indicators (e.g., percent impervious in watershed), were calculated using GIS.
- CSCI scores have a significant negative correlation with land use variables (percent impervious and urban), total nitrogen, algal cover, canopy cover, human disturbance index (HDI) and DOC and a positive correlation with two PHAB parameters (epifaunal substrate score and channel alteration score).
- Concentrations of unionized ammonia, nitrate, and chloride were compared to WQOs. No WQOs 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.

6.1.2 Targeted Monitoring for Temperature and General Water Quality

Targeted monitoring in WY 2016 was conducted in compliance with Provisions C.8.d.iii – v of the MRP. Hourly temperature measurements were recorded at five sites in the San Francisquito Creek watershed from April through September. Four of the temperature stations were located in the Bear Creek subwatershed and one in Alambique Creek. Continuous (15-minute) general water quality measurements (pH, DO, specific conductance, temperature) were recorded at two sites in the Bear Creek subwatershed during two 2-week periods in May (Event 1) and September (Event 2). Pathogen indicator grab samples were collected at five sites in the San Mateo Creek watershed during a sampling event in June. Stations were deliberatively selected using the Directed Monitoring Design Principle.

Conclusions and recommendations from targeted monitoring in WY 2016 are listed below. The sections below are organized on the basis of three 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?*

Spatial and Temporal Variability of Water Quality Conditions

- There was minimal spatial variability in water temperature across the four stations in the Bear Creek branch of the San Francisquito Creek watershed. Temperature was slightly lower at the station in Alambique Creek.

- The same stations were monitored for temperature in WYs 2014 and 2015. Temperature monitoring results in WY 2016 were similar to results from prior years.

- Dissolved oxygen concentrations were reduced during Event 2 compared to Event 1 at both sites. Changes in DO are likely caused by decreasing flow in the late summer and water quality conditions associated with isolated pools.

Potential Impacts to Aquatic Life

- Potential impacts to aquatic life were assessed through analysis of continuous temperature data collected at five stations and continuous general water quality data (pH, dissolved oxygen, specific conductance, and temperature) collected at two stations.
- Two temperature stations in Bear Creek exceeded the MRP trigger threshold of having two or more weeks where the maximum weekly average temperature (MWAT) exceeded 17°C. 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 National Marine Fisheries Service 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 beneficial uses (i.e., 7.0 mg/L) was frequently exceeded at both water quality stations during Event 2. The water quality conditions were associated with isolated pools during low or no flow conditions. Both sites will be added to list of potential SSID projects.
- Values for pH measured at one site in WY 2016 (205BCR010 - Bear Creek Sandhill Road) did not meet the lower WQO for pH during Event 2. This site will be added to list of potential SSID projects. The pH excursion was likely related to low/no flow conditions resulting in an isolated pool at the monitoring station.
- Specific conductance concentrations recorded at the two stations in WY 2016 were below the MRP trigger threshold of 2000 us/cm.

Potential Impacts to Water Contact Recreation

- In WY 2016, pathogen indicator sites were located in the San Mateo Creek watershed where a bacteria SSID study was previously conducted. Pathogen indicator triggers for enterococcus were exceeded at two of the five sites. Triggers for *E. coli* were not exceeded.

- 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 (REC-1) WQOs may not be appropriate and should be interpreted cautiously.

- Municipalities in the lower San Mateo Creek watershed are currently implementing prescribed actions to reduce or eliminate conditions in the sanitary sewer collection system that cause or contribute to SSOs. The County of San Mateo also has a public outreach program targeting pet waste and other sources of bacteria. Actions include webpage and Facebook postings and dog bag dispenser giveaways.

6.1.3 Chlorine Monitoring

Free chlorine and total chlorine residual was measured concurrently with bioassessments at the ten probabilistic sites. While chlorine residual is generally not a concern in San Mateo County creeks, WY 2016 and prior monitoring results suggest there are occasional free chlorine and total chlorine exceedances in the County. Free chlorine concentrations at three of the ten sites exceeded the trigger criterion of 0.1 mg/L. The monitoring results were reported to local illicit discharge staff. Exceedances are likely the result of one-time potable water discharges and it is generally very difficult to determine the source of elevated chlorine from such episodic discharges. The Program will continue to monitor chlorine in compliance with the MRP and will follow-up with illicit discharge staff as needed.

6.1.4 Pesticides and Toxicity Monitoring

In WY 2016, SMCWPPP conducted dry weather pesticides and toxicity monitoring at one station in compliance with Provision C.8.g of the MRP.

Statistically significant toxicity to *C. dubia, C. dilutus,* and/or *H. azteca* was observed in both water and sediment samples collected during the dry season. However, the magnitude of the toxic effects in the samples compared to laboratory controls were not great and did not exceed MRP trigger criteria of 50 Percent Effect.

TEC and PEC quotients were calculated for all metals and PAHs measured in sediment samples. Two TEC and one PEC quotients exceeded 1.0. In compliance with the MRP, Laurel Creek will therefore be placed on the list of candidate SSID projects. Decisions about which SSID projects to pursue should be informed by the fact that the TEC and PEC quotient exceedances are related to naturally occurring chromium and nickel due to serpentine soils in local watersheds.

SMCWPPP will continue to sample one station per year for dry weather pesticides and toxicity throughout the permit term. In WY 2018, SMCWPPP anticipates working with the BASMAA RMC partners on a regional approach to wet weather pesticides and toxicity monitoring.

6.2 Trigger Assessment

The MRP requires analysis of the monitoring data to identify candidate sites for SSID projects. Trigger thresholds against which to compare the data are provided for most monitoring parameters in the MRP 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. Nutrient data were evaluated using applicable water quality standards from the Basin Plan (SFRWQCB, 2013). In compliance with Provision C.8.e.i of the MRP, 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 WY 2016 Creek Status and Pesticides/Toxicity 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, WY 2016. "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 [1]	Nutrients [2]	Chlorine [3]	Water Toxicity [4]	Sediment Toxicity [4]	Sediment Chemistry [5]	Continuous Temperature [6]	Dissolved Oxygen [7]	pH [8]	Specific Conductance [9]	Pathogen Indicators [10]
202R00488	Tunitas Creek	Yes	No	Yes	--	--	--	--	--	--	--	--
202R00506	Peters Creek	No	No	No	--	--	--	--	--	--	--	--
202R02332	Pilarcitos Creek	Yes	No	Yes	--	--	--	--	--	--	--	--
204R02228	San Mateo Creek	Yes	No	No	--	--	--	--	--	--	--	--
204R02504	Polhemus Creek	Yes	No	No	--	--	--	--	--	--	--	--
204R02548	Cordilleras Creek	Yes	No	No	--	--	--	--	--	--	--	--
205R02408	Bull Run Creek	Yes	No	Yes	--	--	--	--	--	--	--	--
205R02728	Dry Creek	Yes	No	No	--	--	--	--	--	--	--	--
205R02920	Bear Creek	Yes	No	No	--	--	--	--	--	--	--	--
205R03032	West Union	Yes	No	No	--	--	--	--	--	--	--	--
204LAU010	Laurel Creek	--	--	--	No	No	Yes	--	--	--	--	--
204SMA060	San Mateo Creek	--	--	--	--	--	--	--	--	--	--	Yes
204SMA080	San Mateo Creek	--	--	--	--	--	--	--	--	--	--	Yes
204SMA100	San Mateo Creek	--	--	--	--	--	--	--	--	--	--	No
204SMA119	San Mateo Creek	--	--	--	--	--	--	--	--	--	--	No
204SMA110	Polhemus Creek	--	--	--	--	--	--	--	--	--	--	No
205ALA015	Alambique Creek	--	--	--	--	--	--	No	--	--	--	--
205BCR010	Bear Creek	--	--	--	--	--	--	Yes	Yes	No	No	--
205BCR050	Bear Creek	--	--	--	--	--	--	Yes	--	--	--	--
205BCR060	Bear Creek	--	--	--	--	--	--	No	--	--	--	--
205WUN150	West Union Creek	--	--	--	--	--	--	No	Yes	Yes	No	--

Notes:
1. CSCI score ≤ 0.795.
2. Unionized ammonia (as N) ≥ 0.025 mg/L, nitrate (as N) ≥ 10 mg/L, chloride > 250 mg/L.
3. Free chlorine or total chlorine residual ≥ 0.1 mg/L.
4. Test of Significant Toxicity = Fail and Percent Effect ≥ 50 %.
5. TEC or PEC quotient ≥ 1.0 for any constituent.
6. Two or more MWAT ≥ 17.0°C or 20% of results ≥ 24°C.
7. DO < 7.0 mg/L in COLD streams or DO < 5.0 mg/L in WARM streams.
8. pH < 6.5 or pH > 8.5.
9. Specific conductance > 2000 uS.
10. Enterococcus ≥ 130 cfu/100ml or *E. coli* ≥ 410 cfu/100ml.

6.3 Management Implications

The Program's Creek Status and Pesticides and Toxicity Monitoring programs (consistent with MRP provisions C.8.c and C.8.g, respectively) focus on assessing the water quality condition of urban creeks in the Santa Clara Valley and identifying stressors and sources of impacts observed. Although the sample size from WY 2016 (overall n=10; urban n=8) is not sufficient to develop statistically representative conclusions regarding the overall condition of all creeks, it builds on data collected in WY 2012 through WY 2015 and is analyzed with the full five-year dataset (n=60). 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 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 development (LID) methods, such as rainwater harvesting and use, infiltration and biotreatment are required as part of development and redevelopment projects. In addition, Green Infrastructure planning is now part of all municipal projects. These LID measures are expected to reduce the impacts of urban runoff and associated impervious surfaces on stream health.
- In compliance with MRP 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.
- Trash loadings to local creeks have been reduced through implementation of new control measures in compliance with MRP 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. The MRP 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 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 Best Management Practices 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.

- In compliance with MRP Provision C.13, copper in stormwater runoff is reduced through implementation of controls such as architectural and site design requirements, prohibition of discharges from water features treated with copper, and industrial facility inspections.
- Mercury and polychlorinated biphenyls (PCBs) in stormwater runoff are being reduced through implementation of the respective TMDL water quality restoration plans. In compliance with MRP Provisions C.11 (mercury) and C.12 (PCBs), the Program will continue to identify sources of these pollutants and will implement control actions designed to achieve new minimum load reduction goals. Monitoring activities conducted in WY 2016 that specifically targets mercury and PCBs are described in the Pollutants of Concern Monitoring Data Report that is included as Appendix C to the WY 2016 UCMR.

In addition to the Program and Co-permittee controls implemented in compliance with the MRP, numerous other efforts and programs designed to improve the biological, physical and chemical condition of local creeks are underway. For example, C/CAG recently developed the Draft San Mateo Countywide Stormwater Resource Plan (SRP) to satisfy state requirements and guidelines to ensure C/CAG and SMCWPPP member agencies are eligible to compete for future voter-approved bond funds for stormwater or dry weather capture projects. The SRP identifies and prioritizes opportunities to better utilize stormwater as a resource in San Mateo County through a detailed analysis of watershed processes, surface and groundwater resources, input from stakeholders and the public, and analysis of multiple benefits that can be achieved through strategically planned stormwater management projects. These projects aim to capture and manage stormwater more sustainably, reduce flooding and pollution associated with runoff, improve biological functioning of plants, soils, and other natural infrastructure, and provide many community benefits, including cleaner air and water and enhanced aesthetic value of local streets and neighborhoods.

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.

7.0 References

Atkinson, K. 2011. Evaluating Water Temperature and Turbidity Effects on Steelhead Life History Tactics in Alameda Creek Watershed. Technical Memorandum. Alameda Creek Fisheries Restoration Workgroup.

Bay Area Stormwater Management Agency Association (BASMAA). 2011. Regional Monitoring Coalition Multi-Year Work Plan: FY 2009-10 through FY 2014-15. 26 pp + appendices and attachments.

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

Bay Area Stormwater Management Agency Association (BASMAA) Regional Monitoring Coalition (RMC). 2016a. Creek Status and Pesticides & Toxicity Monitoring Quality Assurance Project Plan, Final Version 3. Prepared for BASMAA by EOA, Inc. on behalf of the Santa Clara Urban Runoff Pollution Prevention Program and the San Mateo Countywide Water Pollution Prevention Program, Applied Marine Sciences on behalf of the Alameda Countywide Clean Water Program, and Armand Ruby Consulting on behalf of the Contra Costa Clean Water Program. 83 pp plus appendices.

Bay Area Stormwater Management Agency Association (BASMAA) Regional Monitoring Coalition (RMC). 2016b. Creek Status and Pesticides & Toxicity Monitoring Standard Operating Procedures, Final Version 3. Prepared for BASMAA by EOA, Inc. on behalf of the Santa Clara Urban Runoff Pollution Prevention Program and the San Mateo Countywide Water Pollution Prevention Program, Applied Marine Sciences on behalf of the Alameda Countywide Clean Water Program, and Armand Ruby Consulting on behalf of the Contra Costa Clean Water Program. 190 pp.

Cutler, D.R., Edwards, T.C., Beard, K.H., Cutler, A., Hess, K.T., Gibson, J.C., and Lawler, J.J. 2007. Random forests for classification in ecology. Ecology 88(11):2783-2792.

Fetscher, A.E, L. Busse, and P.R. Ode. 2009. Standard Operating Procedures for Collecting Stream Algae Samples and Associated Physical Habitat and Chemical Data for Ambient Bioassessments in California. California State Water Resources Control Board Surface Water Ambient Monitoring Program (SWAMP) Bioassessment SOP 002. (Updated May 2010)

Fetscher, A.E., R. Stancheva, J.P. Kociolek, R.G. Sheath, E. Stein, R.D. Mazo and P. Ode. 2013a. Development and comparison of stream indices of biotic integrity using diatoms vs. non-diatom algae vs. a combination. Journal of Applied Phycology. Volume 25 no. 4. August 2013.

Fetscher, A.E., M.A. Sutula, L.B. Busse and E.D. Stein. 2013b. Condition of California Perennial, Wadeable Streams Based on Algal Indicators. Final Technical Report 2007-11. Prepared by Southern California Coastal Water Research Project and San Diego Regional Water Quality Control Board. Prepared for California State Water Board.

Fetscher, A.E., R. Stancheva, J.P. Kociolek, R.G. Sheath, E. Stein, R.D. Mazo and P. Ode. 2014. Development and comparison of stream indices of biotic integrity using diatoms vs. non-diatom algae vs. a combination. Journal of Applied Phycology 26:433-450.

Lawrence, J.E., Lunde, K.B., Mazor, R.D., Beche, L.A., McElravy, E.P., and Resh, V.H. 2010. Long-term macroinvertebrate responses to climate change: implications for biological assessment Mediterranean-climate streams. Journal of the North Americal Benthological Society, 29(4):1424-1440.

Leidy, R.A., G.S. Becker, B.N. Harvey. 2005. Historical distribution and current status of steelhead/rainbow trout *(Oncorhynchus mykiss)* in streams of the San Francisco Estuary, California. Center for Ecosystem Management and Restoration, Oakland, CA.

MacDonald, D.D., C.G. Ingersoll, T.A. Berger. 2000. Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems. Arch. Environ. Contam. Toxicol. 39, 20-31.

Mazor, R.D., Purcell, A.H., and Resh, V.H. 2009. Long-term variability in bioassessments: a twenty-year study from two northern California streams. Environmental Management 43:129-1286.

Mazor, R.D. 2015. Bioassessment of Perennial Streams in Southern California: A Report on the First Five Years of the Stormwater Monitoring Coalition's Regional Stream Survey. Prepared by Raphael D. Mazor, Southern California Coastal water Research Project. Technical Report 844. May 2015.

Mazor, R., Ode, P.R., Rehn, A.C., Engeln, M., Boyle, T., Fintel, E., Verbrugge, S., and Yang, C. 2016. The California Stream Condition Index (CSCI): Interim instructions for calculating scores using GIS and R. SWAMP-SOP-2015-0004. Revision Date: August 5, 2016.

Mazor, R.D., A. Rehn, P.R. Ode, M. Engeln, K. Schiff, E. Stein, D. Gillett, D. Herbst, C.P. Hawkins. In review. Bioassessment in complex environments: Designing an index for consistent meaning in different settings.

Ode, P.R. 2007. Standard Operating Procedures for Collection Macroinvertebrate Samples and Associated Physical and Chemical Data for Ambient Bioassessments in California. California State Water Resources Control Board Surface Water Ambient Monitoring Program (SWAMP) Bioassessment SOP 001.

Ode, P.R., T.M. Kincaid, T. Fleming and A.C. Rehn. 2011. Ecological Condition Assessments of California's Perennial Wadeable Streams: Highlights from the Surface Water Ambient Monitoring Program's Perennial Streams Assessment (PSA) (2000-2007). A Collaboration between the State Water Resources Control Board's Non-Point Source Pollution Control Program (NPS Program), Surface Water Ambient Monitoring Program (SWAMP), California Department of Fish and Game Aquatic Bioassessment Laboratory, and the U.S. Environmental Protection Agency.

Ode, P.R., Fetscher, A.E., and Busse, L.B. 2016. Standard Operating Procedures (SOP) for the Collection of Field Data for Bioassessments of California Wadeable Streams: Benthic Macroinvertebrates, Algae, and Physical Habitat. SWAMP-SOP-SB-2016-0001.

Rehn, A.C., R.D. Mazor, P.R. Ode. 2015. The California Stream Condition Index (CSCI): A New Statewide Biological Scoring Tool for Assessing the Health of Freshwater streams. SWAMP-TM-2015-0002. September 2015.

Ruby, A. 2013. Review of pyrethroid, fipronil and toxicity monitoring data from California urban watersheds. Prepared for the California Stormwater Quality Association (CASQA) by Armand Ruby Consulting. 22 p + appendices.

San Francisco Regional Water Quality Control Board (SFRWQCB). 2009. Municipal Regional Stormwater NPDES Permit. Order R2-2009-0074, NPDES Permit No. CAS612008. 125 pp plus appendices.

San Francisco Regional Water Quality Control Board (SFRWQCB). 2013. Water Quality Control Plan. (Basin Plan). http://www.waterboards.ca.gov/sanfranciscobay/basin_planning.shtml.

San Francisco Regional Water Quality Control Board (SFRWQCB). 2015. Municipal Regional Stormwater NPDES Permit. Order R2-2015-0049, NPDES Permit No. CAS612008. 152 pp plus appendices.

San Mateo Countywide Water Pollution Prevention Program (SMCWPPP). 2014. Part A of the Integrated Monitoring Report.

San Mateo Countywide Water Pollution Prevention Program (SMCWPPP). 2015. San Mateo Creek Pathogen Indicator Stressor/Source Identification Final Project Report. September 28, 2015.

San Mateo Countywide Water Pollution Prevention Program (SMCWPPP). 2016. Urban Creeks Monitoring Report, Water Quality Monitoring Water Year 2015. March 31, 2016.

Smith, J.J. and D.R. Harden. 2001. Adult steelhead passage in the Bear Creek watershed. Prepared for San Francisquito Watershed Council, c/o Acterra. 65 p.

Southern California Coastal Water Research Project (SCCWRP). 2012. Guide to evaluation data management for the SMC bioassessment program. 11 pp.

Stancheva, R., L. Busse, P. Kociolek, and R. Sheath. 2015. Standard Operating Procedures for Laboratory Processing, Identification, and Enumeration of Stream Algae. California State Water Resources Control Board Surface Water Ambient Monitoring Program (SWAMP) Bioassessment SOP 0003.

Stevens, D.L.Jr., and A.R. Olsen. 2004. Spatially Balanced Sampling of Natural Resources. Journal of the American Statistical Association 99(465):262-278.

Sullivan, K., Martin, D.J., Cardwell, R.D., Toll, J.E., and S. Duke. 2000. An analysis of the effects of temperature on salmonids of the Pacific Northwest with implications for selecting temperature criteria. Sustainable Ecosystems Institute, Portland, OR. December 2000.

USEPA. 2012a. Implications of Climate Change for Bioassessment Programs and Approaches to Account for Effects. EPA/600/R-11/036F.

USEPA. 2012b. Recreational Water Quality Criteria. Office of Water 820-F-12-058.

Welsh, H.H., G.R. Hodgson, B.C. Harvey, and M.F. Roche. 2001. Distribution of juvenile coho salmon (Onchorhynchus kisutch) in relation to water temperature in tributaries of the Matole River, California. North American Journal of Fisheries Management. 7 pp.

ATTACHMENTS

Attachment 1
QA/QC Report

Attachment 1

Quality Assurance/Quality Control Report

Prepared by:

EOA, Inc
1410 Jackson Street
Oakland, CA 94612

Prepared for:

San Mateo Countywide Water Pollution Prevention Program

March 31, 2017

TABLE OF CONTENTS

LIST OF TABLES

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
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 2016 (WY 2016; October 1, 2015 through September 30, 2016), the San Mateo Countywide Pollution Prevention Program (SMCWPPP) conducted Creek Status Monitoring in compliance with provision C.8.d and dry weather Pesticide & Toxicity Monitoring in compliance with provision C.8.g.i and C.8.g.ii of the National Pollutant Discharge Elimination System (NPDES) stormwater permit for Bay Area municipalities referred to as the Municipal Regional Permit (MRP). 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 the BASMAA RMC (BASMAA 2016a) and BASMAA RMC Standard Operating Procedures (SOP; BASMAA 2016b), 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 2008).

Based on the QA/QC review, some WY 2016 data were flagged. However, overall, WY 2016 data met QA/QC objectives. Details are provided in the sections below.

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

During pesticide & toxicity monitoring the following data types were collected and evaluated for quality assurance and quality control:

1. Water Toxicity (dry weather; MRP Provision C.8.g.i)
2. Sediment Toxicity (dry weather; MRP Provision C.8.g.ii)
3. Sediment Chemistry (dry weather; MRP Provision C.8.g.ii)

1.2. LABORATORIES

Laboratories that provided 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)

- City of San Jose, Environmental Services Department Laboratory (pathogen indicators)
- BioAsessment Services (benthic macroinvertebrate (BMI) identification)
- Jon Lee Consulting (BMI identification Quality Control)
- 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 5% of all samples for all parameters[1]. The results of the duplicate analyses are reported by the laboratories and evaluated using RMC Database QA/QC Testing Tool. Results of the Tool are confirmed manually. 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 orthophosphate.

[1] The QAPP also requires the collection of field duplicate samples for 10% of biological samples (BMI and algae). However, there are no prescribed methods for determining the precision of these duplicate samples.

2. METHODS

2.1. Representativeness

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

2.2. Comparability

In addition to the bioassessment and field sampling training, SMCWPPP field crew members participated in an inter-calibration exercise with other stormwater programs prior to field assessments at least once during the permit term. During the inter-calibration exercises, the field crews also reviewed water chemistry (nutrient) sample collection and water quality field measurement methods. Close communication throughout the field season with other stormwater program field crews also ensured comparability.

Sub-contractors collecting samples and the laboratories performing analyses received copies of the RMC SOP and QAPP, and have acknowledged reviewing the documents. Data collection and analysis by these parties adhered to the RMC protocols and was 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 checked 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) were 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 followed SWAMP documentation specific to each data type, including the exclusion of qualitative values that do not appear on SWAMP's look up lists[2]. Completed templates were reviewed using SWAMP's online data checker[3], further ensuring SWAMP-comparability.

2.3. Completeness

2.3.1. Data Collection

All efforts were 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 the MRP, 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 was reviewed immediately following deployment, and if data were rejected, samplers were redeployed immediately.

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

---

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

[3] 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

Benthic macroinvertebrates were identified to SAFIT STE Level I.

2.4.2. Chemical Analysis

The reporting limits for analytical results were compared to the target reporting limits in Appendix E (RMC Target Method Reporting Limits) of the RMC QAPP. Results with reporting limits that exceeded 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 a separate taxonomic laboratory, Jon Lee Consulting, for independent assessment of taxonomic accuracy, enumeration of organisms, and conformance to standard taxonomic level. For SMCWPPP, two samples were evaluated for QC purposes. Results were compared to measurement quality objectives (MQOs) in Appendix B (Benthic macroinvertebrate MQOs and Data Production Process).

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 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 was calculated as:

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

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

For matrix spikes, percent recovery was 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 was calculated, and if a logger had a mean difference exceeding 0.2 ^{o}C, it is replaced.

2.6. Precision

2.6.1. Field Duplicates

For creek status monitoring, duplicate biological samples were collected at 10% (two) of the 20 probabilistic sites and duplicate water chemistry samples were collected at 5% (one) of the 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 26-1 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 RMC QAPP requires collection and analysis of duplicate sediment chemistry and toxicity samples at a rate of 5% of total samples collected for the project. The Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP) collected one field duplicate for dry weather sediment chemistry, sediment toxicity, and water toxicity sample to account for the six pesticide & toxicity sites collectively monitored by the RMC in WY 2016. 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. For sediment chemistry field duplicates, the RPD was calculated for each analyte and compared to the MQOs (RPD < 25%) set by Tables 26-7 through 26-11 in Appendix A of the RMC QAPP. For sediment and water toxicity field duplicates, the RPD of the batch mean was calculated and compared to the recommended acceptable RPD (is < 20%) set by Tables 26-12 and 26-13 in Appendix A. If the RPD of the 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 orthophosphate. This equates to a total of one sample for the 10 samples collected in San Mateo County.

For creek status monitoring, the RMC QAPP requires all blanks (laboratory and field) 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 were trained in SWAMP and RMC protocols, and received significant supervision from the local monitoring coordinator and QA officer. As a result, creek status monitoring data was considered to be representative of conditions in San Mateo County Creeks.

3.2. Overall Project Comparability

SMCWPPP creek status monitoring data was 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 communication.

3.3. Bioassessments and Physical Habitat Assessments

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

3.3.1. Completeness

SMCWPPP completed bioassessments and physical habitat assessments for all 11 transects at 10 of 10 planned/required sites and received results for all parameters. SMCWPPP exceeded the QAPP target completion rate of 95% with a 100% completion rate for all parameters.

3.3.2. Sensitivity

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

The reporting limits for ash free dry mass analysis (8 mg/L) were much higher than the RMC QAPP target reporting limits (2 mg/L) due to high concentrations requiring large dilutions. The results were several orders of magnitude higher than the actual and target reporting limit and were not affected by the higher reporting limit. Similarly, the chlorophyll a analytical reporting limits (50 mg/L) were an order of magnitude higher than the QAPP target limits (5 mg/L). Again, reporting limits were elevated due to large dilutions as concentrations were well above the analytical reporting limit and were not impacted by the elevated reporting limit.

Note that the target reporting limits in the RMC QAPP are set by the SWAMP, but there are currently no appropriate SWAMP targets for either ash free dry mass and chlorophyll a. Limits in the RMC QAPP are meant to reflect current laboratory capabilities. At lower analyte concentrations where a dilution would not be necessary, the analytical reporting limits would have met the target reporting limits.

3.3.3. Accuracy

The BMI sample submitted to a separate QC taxonomic laboratory had no major taxonomic discrepancies. The QC laboratory calculated sorting and taxonomic identification metrics, which were compared to the measurement quality objectives in Table 27-1 in Appendix B of the RMC QAPP. All metrics met their respective MQOs. A comparison of the metrics with the MQOs is shown in Table 1. The QC laboratory report is available upon request. There is no protocol for evaluating the accuracy of algae taxonomic identification.

Table 1. Quality control metrics for taxonomic identification of benthic macroinvertebrates collected in San Mateo County in WY 2016 compared to measurement quality objectives.

Quality Control Metric	Error Rate	MQO	Exceeds MQO?
Absolute Recount	0.5%	< 5%[a]	No
Taxa ID	5.0%	≤ 10%	No
Individual ID	0.5%	≤ 10%	No
Lower Taxonomic Resolution Individual	0%	≤ 10%	No
Lower Taxonomic Resolution Count	0%	≤ 10%	No

[a] the RMC QAPP MQO for recount accuracy is ≥ 95%

3.3.4. Precision

Duplicate algae and BMI samples were collected at one site in WY 2016 and were sent to the taxonomic laboratories for identification. Duplicate field samples do not provide a valid estimate of precision in the sampling and are of little use to assessing precision, because there is no reasonable expectation that duplicates will produce identical data. Nonetheless, the RPD of the cholorophyll a and ash free dry mass duplicate results were calculated and compared to the MQO (< 25%) for conventional analytes in water (Table 26-1 in Appendix B of the RMC QAPP). Due to the nature of chlorophyll a and ash free dry mass collection, the RPD for both parameters are not expected to meet the MQO. Surprisingly, only ash free dry mass exceeded the MQO. The field duplicate results and their RPDs are shown in Table 2.

Again, discrepancies were 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). As a result, both parameters have frequently exceeded the field duplicate RPD MQOs during past years' monitoring efforts.

Table 2. Field duplicate water chemistry results for site 205R03032, collected on May 16, 2016.

Analyte Name	Fraction Name	Unit	Original Result	Duplicate Result	RPD	Exceeds MQO (>25%)[a]
Chlorophyll a	Particulate	mg/m^2	3.33	3.02	10%	Yes
Ash Free Dry Mass	Fixed	g/m^2	43.3	64.3	39%	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

3.3.5. Contamination

The benthic macroinvertebrate taxonomic laboratory identified New Zealand mudsnails in three of the San Mateo County biological samples collected at site 202R02332 in Pilarcitos Creek, site 204R02228 in San Mateo Creek, and site 204R02504 Polhemus Creek, a San Mateo Creek tributary. All field collection equipment was decontaminated between sites in accordance with the RMC SOP FS-8 and CDFW protocols and it is believed equipment was free of biological contamination prior to sampling. Creek status monitoring in past years has also identified New Zealand mudsnails in other stream reaches in the San Mateo Creek Watershed, and as a result, decontamination is taken very seriously by SMCWPPP staff.

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 were 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) was 0.02 mg/L. There is, however, no established method 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 required or collected.

3.5. Water Chemistry

Water chemistry samples were collected by SMCWPPP staff concurrently with bioassessment samples, and analyzed 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 Table 26-2.

3.5.1. Completeness

SMCWPPP collected 100% of planned/required water chemistry samples at the 10 bioassessment sites including one duplicate sample (5% of total project sample count). 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 chloride and nitrate. The reporting limit for all chloride samples exceeded the target reporting limit, but concentrations were much higher than reporting limits, and the elevated reporting limits do not decrease confidence in the measurements.

The reporting limit and method detection limit for all nitrate samples were higher than the target reporting limit, but two samples, collected at 202R02332 and 204R02228, were affected and flagged as “detected, not quantified” when they would have been quantified at the lower reporting limit.   SMCWPPP will discuss the nitrate reporting limit with Caltest for future analysis. Target and actual reporting limits are shown in Table 3.

Table 3. Target and actual reporting limits for nutrients analyzed in SMCWPPP creek status monitoring. Analytes that did not meet the target RL are highlighted.

Analyte	Target RL mg/L	Actual RL mg/L
Ammonia	0.02	0.02
Chloride	0.25	1-10
Nitrate	0.01	0.05
Nitrite	0.01	0.005
Total Kjeldahl Nitrogen	0.5	0.1
Orthophosphate	0.01	0.01
Phosphorus	0.01	0.01
Silica	1	1

3.5.3. Accuracy

Recoveries on all laboratory control samples (LCS) were within the MQO target range of 80-120% recovery, and most matrix spikes (MS) and matrix spike duplicates (MSD) percent recoveries (PR) were within the target range. Three MS/MSD percent recoveries exceeded the MQO range listed in the RMC QAPP for phosphorus, and 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 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 laboratory control sample and matrix spike duplicate pairs were consistently below 11%, well below the MQO target of < 25%.

The field duplicate samples exceeded the RPD MQO for ammonia. Discrepancies between other duplicates is attributed to timing, i.e., not collecting the duplicate at the exact moment the original sample is collected. The field crew will continue to make an effort in subsequent years to collect the original and duplicate samples in an identical fashion and at the same time.

The field duplicate water chemistry results and their 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. For those analytes whose RPDs could be calculated and did not meet the RMC MQO, they were assigned the appropriate SWAMP flag.

Table 4. Field duplicate water chemistry results for site 205R03032, collected on May 20, 2016. Data in highlighted rows exceed monitoring quality objectives in RMC QAPP.

Analyte Name	Fraction Name	Unit	Original Result	Duplicate Result	RPD	Exceeds MQO (>25%)[a]
Ammonia as N	Total	mg/L	0.028	0.053	62%	Yes
Chloride	None	mg/L	44	44	0%	No
Nitrate as N	None	mg/L	< 0.02	< 0.02	NA	No
Nitrite as N	None	mg/L	< 0.001	< 0.001	NA	No
Nitrogen, Total Kjeldahl	None	mg/L	0.44	0.48	9%	No
Orthophosphate as P	Dissolved	mg/L	< 0.006	0.007	NA	No
Phosphorus as P	Total	mg/L	< 0.007	< 0.007	NA	No
Silica as SiO2	Total	mg/L	15	14	7%	No

[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 at levels above their reporting limit. Phosphorus was detected but not quantified in one laboratory blank, but since the concentration were below the reporting limit, no data were flagged.

SMCWPPP collected an orthophosphate field blank sample (5% of total project samples) as required by the RMC QAPP for the 10 samples collected in San Mateo County in WY 2016. Caltest ran the field blank which was non-detect.

The field crew took precautions to prevent contamination during sample collection by following RMC SOP protocols, including but not limited to wearing gloves during sample collection and rinsing bottles with stream water prior to collection.

3.6. Pathogen Indicators

Pathogen indicator samples were collected by SMCWPPP staff at WY 2016 bioassessment sites and were analyzed by the City of San Jose's Environmental Services Department Laboratory. Samples were collected on the morning of June 22, 2016 and were analyzed later that day for *E. coli* and enterococcus.

3.6.1. Completeness

All five required/planned pathogen indicator samples were collected and analyzed within the 8-hour holding time, for a 100% completeness rate. No data were flagged or rejected.

3.6.2. Sensitivity

The reporting limits for *E. coli* and enterococcus (1 MPN/100mL for both indicators) were below the target RL of 2 MPN/100mL listed in the project QAPP.

3.6.3. Accuracy

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

3.6.4. Precision

Due to the number of samples collected and the laboratory methodology, it was not possible to run a laboratory duplicate and evaluate the pathogen samples could not be evaluated for precision

3.6.5. Contamination

One method blank was run in the batch for *E. coli* and enterococcus. No growth was observed in the blank.

3.7. CONTINUOUS WATER QUALITY

Continuous water quality measurements were recorded at two sites in San Mateo County during the spring (May 2016), concurrent with bioassessment sampling, and at the same two sites in the summer (August 2016), in accordance with the MRP. 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).

3.7.1. Completeness

There were no issues for either deployment and both sondes recorded all four parameters for the entire length of each deployment period. The sondes were deployed for 2.5 weeks during the summer deployment for a completion rate of over 100%. No data were rejected from either deployment.

3.7.2. Sensitivity

There are 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.

3.7.3. Accuracy

All drift measurements meet the RMC QAPP MQOs and are summarized in Table 5. No data were flagged or rejected for accuracy.

Table 5. Drift measurements for two continuous water quality monitoring events in San Mateo County urban creeks during WY 2016.

Parameter	Measurement Quality Objectives	205BRC10		205WUN150	
		Event 1	Event 2	Event 1	Event 2
Dissolved Oxygen (mg/l)	± 0.5 mg/L or 10%	-0.2	-0.08	-0.02	-0.02
pH 7.0	± 0.2	-0.06	0.06	0	-0.05
pH 10.0	± 0.2	0.06	-0.1	-0.07	-0.1
Specific Conductance (uS/cm)	± 10%	0.3%	0.3%	-0.3%	0.3%

3.7.4. Precision

There is no protocol listed in the RMC QAPP for measuring the precision of continuous water quality measurements, but during the summer deployment, two sondes were deployed at the same location to test the precision of the measurements. The RPD of each measurement and the median for the deployment was calculated for each parameter. The median RPD for temperature and pH was 1%, the median for specific conductivity was 2%, and the median RPD for dissolved oxygen was 5%. While there is no RPD MQO in the RMC QAPP, these low RPDs were deemed acceptable.

3.8. CONTINUOUS TEMPERATURE MONITORING

Continuous temperature monitoring was conducted from April 1 through September 20, 2016 at five sites in San Mateo. Onset HOBO Water Temperature Data loggers recorded one measurement per hour.

3.8.1. Completeness

The MRP requires SMCWPPP to monitor four stream reaches for temperature each year, but anticipating a lost HOBO temperature logger, SMCWPPP deployed one extra temperature loggers, for a total of five temperature loggers. Additionally, SMCWPPP staff checked the loggers in June to ensure that they were still recording and to download the data that were already recorded. While no temperature loggers were lost, the reach in Alambique Creek at Portola Road (205ALA015) went dry in late August. For that stream reach, temperature data were collected for 82% of the deployment period, while the other four sites collected data for 100% of the deployment period. The overall completion exceeded 100% for continuous temperature monitoring.

3.8.2. Sensitivity

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

3.8.3. Accuracy

A pre-deployment accuracy check was run on the temperature loggers in March 2016. None of the loggers exceeded the 0.2 ºC mean difference for the room temperature bath (<0.25 ºC) or for the ice bath (0.27 ºC). All tested loggers were deployed and no data were flagged.

3.8.4. Precision

There are no precision protocols for continuous temperature monitoring.

3.9. Sediment Chemistry

Dry season sediment chemistry samples were collected by Kinnetic Laboratories, Inc (KLI) concurrently with dry season toxicity samples on July 11, 2016. 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 26-9 through 26-11.

3.9.1. Completeness

One sediment chemistry sample was planned/required and collected in San Mateo County. The sample was analyzed for all requested analytes, and 100% of results were reported.

3.9.2. Sensitivity

Laboratory reporting limits generally met or were lower than RMC QAPP target reporting limits, except for metals. A comparison of target and actual reporting limits for metals is shown in Table 6. For all metal samples, concentrations were measured at concentrations above the RLs; therefore, the method provided adequate sensitivity.

Table 6. Comparison of target and actual reporting limits for metals in sediment samples collected in San Mateo County creeks in WY 2016.

Analyte	Target RL mg/kg	Actual RL mg/kg
Arsenic	0.3	1
Cadmium	0.01	0.08
Chromium	0.1	0.2
Copper	0.01	0.4
Lead	0.01	0.2
Nickel	0.02	0.2
Zinc	0.1	4.1

3.9.3. Accuracy

Inorganic Analytes

No QA samples exceeded the QAPPP MQO for LCS or MS percent recovery (PR) for metals (75-125%).

Synthetic Organic Compounds

The percent recovery MQO for pyrethroids and other synthetic organic compounds in sediment is 50-150% in the RMC QAPP. However, the PR MQOs listed in the laboratory reports for synthetic organic compounds varied by analyte 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.

None of the laboratory control sample (LCS) percent recoveries exceeded the RMC MQO range. The MS/MSD percent recoveries exceeded the RMC MQO range for carbaryl, 12 PAHs, and three surrogates. The PAHs MS/MSD samples that exceeded the PR MQO include benzo(a)pyrene, benzo(b)fluoranthene, benzo(e)pyrene, benzo(g,h,i)perylene, benzo(k)fluoranthene. biphenyl, dibenz(a,h)anthracene, dimethylnaphthalene, 2,6-indeno(1,2,3-c,d)pyrene, methylnaphthalene, 2-perylene. Sediment chemistry data were flagged when necessary, but none were rejected.

3.9.4. 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. However, the RMC QAPP lists the MQO as < 25% RPD for all synthetic organics excepting pyrethroids, and as <35% for pyrethroids. The RPD for duplicates was evaluated using the RMC MQOs, and as a result, three analytes that were not flagged by the laboratory were flagged by the local QA officer; the MS/MSD RPDs for benz(a)anthracene, phenanthrene, and 2-methylnaphthalene were all slightly over the MQO of < 25%.

Field Duplicates

A sediment sample field duplicate was collected in Santa Clara County on July 11, 2016, and was evaluated for precision. The field duplicate sample and corresponding RPDs are shown in Table 7. 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 small pebbles (4 to <8 mm), benz(a)anthracene, 2-methylnaphthalene, and phenanthrene. Given the inherent variability associated with field duplicates, the low number of analytes with RPDs outside of the MQO limits is remarkable. The method used to collect sediment field duplicates provides more insight to laboratory precision than precision of field methods; however, the results do suggest that field methods are very precise.

Table 7. Sediment chemistry duplicate field results for site 205STE021, collected on July 11, 2016 in Santa Clara County. Data in highlighted rows exceed monitoring quality objectives in RMC QAPP.

Analyte		Unit	Original	Duplicate	RPD	Exceeds MQO? (<25%)[a]
Grain Size Distribution	Clay: <0.0039 mm	%	4.44	4.51	2%	No
	Silt: 0.0039 to <0.0625 mm	%	4.49	4.42	2%	No
	Sand: V. Fine 0.0625 to <0.125 mm	%	5.77	5.69	1%	No
	Sand: Fine 0.125 to <0.25 mm	%	10.61	11	4%	No
	Sand: Medium 0.25 to <0.5 mm	%	18.59	19.24	3%	No
	Sand: Coarse 0.5 to <1.0 mm	%	28.68	28.88	1%	No
	Sand: V. Coarse 1.0 to <2.0 mm	%	27.42	26.25	4%	No
	Granule: 2.0 to <4.0 mm	%	12.85	10.83	17%	No
	Pebble: Small 4 to <8 mm	%	2.05	2.93	35%	Yes
	Pebble: Medium 8 to <16 mm	%	-0.01	2.64	N/A	N/A
	Pebble: Large 16 to <32 mm	%	-0.01	-0.01	N/A	N/A
	Pebble: V. Large 32 to <64 mm	%	-0.01	-0.01	N/A	N/A
Metals	Arsenic	mg/Kg dw	2.9	3	3%	No
	Cadmium	mg/Kg dw	0.21	0.21	0%	No
	Chromium	mg/Kg dw	72	65	10%	No
	Copper	mg/Kg dw	39	32	20%	No
	Lead	mg/Kg dw	14	14	0%	No
	Nickel	mg/Kg dw	63	63	0%	No
	Zinc	mg/Kg dw	98	93	5%	No
Pyrethroids (MQO <35%)	Bifenthrin	ng/g dw	1.1	0.8	32%	No
	Cyfluthrin, total	ng/g dw	0.39	0.32	20%	No
	Cyhalothrin, Total lambda-	ng/g dw	-0.06	0.072	N/A	N/A
	Cypermethrin, total	ng/g dw	0.14	0.14	0%	No
	Deltamethrin/Tralomethrin	ng/g dw	0.41	0.17	83%	Yes
	Esfenvalerate/Fenvalerate, total	ng/g dw	-0.13	-0.13	N/A	N/A
	Permethrin, Total	ng/g dw	0.92	0.88	4%	No
	Total Organic Carbon	%	0.27	0.26	4%	No
	Carbaryl	mg/Kg dw	-0.021	-0.021	N/A	N/A
	Fipronil	ng/g dw	-0.1	-0.1	N/A	N/A
Polycyclic Aromatic Hydrocarbons	Acenaphthene	ng/g dw	-3.1	-3.1	N/A	N/A
	Acenaphthylene	ng/g dw	-3.1	-3.1	N/A	N/A
	Anthracene	ng/g dw	5.1	4.1	22%	No
	Benz(a)anthracene	ng/g dw	10	21	71%	Yes
	Benzo(a)pyrene	ng/g dw	8.2	9.2	11%	No
	Benzo(b)fluoranthene	ng/g dw	21	21	0%	No
	Benzo(e)pyrene	ng/g dw	8.2	8.2	0%	No
	Benzo(g,h,i)perylene	ng/g dw	-3.1	10	N/A	N/A
	Benzo(k)fluoranthene	ng/g dw	7.2	7.2	0%	No
	Biphenyl	ng/g dw	-3.4	-3.4	N/A	N/A
	Chrysene	ng/g dw	51	51	0%	No
	Dibenz(a,h)anthracene	ng/g dw	-3.1	-3.1	N/A	N/A
	Dibenzothiophene	ng/g dw	-3.4	-3.4	N/A	N/A
	Dimethylnaphthalene, 2,6-	ng/g dw	6.2	5.1	19%	No
	Fluoranthene	ng/g dw	82	72	13%	No
	Fluorene	ng/g dw	3.1	-3.1	N/A	N/A

Table 7. Sediment chemistry duplicate field results for site 205STE021, collected on July 11, 2016 in Santa Clara County. Data in highlighted rows exceed monitoring quality objectives in RMC QAPP.

Analyte		Unit	Original	Duplicate	RPD	Exceeds MQO? (<25%)[a]
	Indeno(1,2,3-c,d)pyrene	ng/g dw	-3.1	8.2	N/A	N/A
	Methylnaphthalene, 1-	ng/g dw	-3.1	-3.1	N/A	N/A
	Methylnaphthalene, 2-	ng/g dw	4.1	3.1	28%	Yes
	Methylphenanthrene, 1-	ng/g dw	-3.1	-3.1	N/A	N/A
	Naphthalene	ng/g dw	-3.1	-3.1	N/A	N/A
	Perylene	ng/g dw	-3.1	-3.1	N/A	N/A
	Phenanthrene	ng/g dw	41	31	28%	Yes
	Pyrene	ng/g dw	72	72	0%	No
Surrogates	Chloroxuron(Surrogate)	%	101	96	5%	No
	Esfenvalerate-d6-1(Surrogate)	%	78	74	5%	No
	Esfenvalerate-d6-2(Surrogate)	%	88	84	5%	No
	Fluorobiphenyl, 2-(Surrogate)	%	60	50	18%	No
	Nitrobenzene-d5(Surrogate)	%	57	45	24%	No
	Tebuthiuron(Surrogate)	%	104	100	4%	No
	Terphenyl-d14(Surrogate)	%	94	91	3%	No

[a] MQO for pyrethroids is <35%. In accordance with the RMC QAPP, if the native concentration of either sample is less than the reporting limit, the RPD is not applicable

3.9.5. Contamination

Copper was detected in one blank at a concentration above the method detection limit, but not above the reporting limit. The RMC QAPP for blank samples is < RL, so the same was not flagged. None of the other target analytes were detected in any of the blanks.

3.10. Toxicity Testing

The dry season water and sediment toxicity sample was collected by KLI staff concurrently with the dry season sediment chemistry sample at one San Mateo County site on July 11, 2016. All toxicity tests were performed by Pacific EcoRisk. 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* and *Chironomus dilutus.*

3.10.1. Completeness

The MRP requires the collection of one dry season water toxicity sample and one dry season sediment toxicity sample per year in San Mateo County. Both samples were collected and tested for toxicity for a 100% completion rate in WY 2016.

3.10.2. Sensitivity and Accuracy

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. A copy of the laboratory QC report is available upon request.

3.10.3. Precision

One field duplicate was collected in Santa Clara County and tested by Pacific EcoRisk. The mean toxicity endpoints of test organisms (mean survival, mean cell count, mean biomass, and mean young per female) for the field duplicates were compared, and the RPD for each for toxicity test was calculated. These RPDs are compared to the RMC QAPP MQO of <20% for acute and chronic freshwater toxicity testing (Appendix A, Table 26-12 and 26-13) in Table 8. There is no MQO for sediment duplicates listed in the RMC QAPP, but sediment duplicates met the MQO for water toxicity testing with the exception of the *Ceriodaphnia dubia* growth endpoint (see Table 8).

Table 8. Water and sediment toxicity duplicate results for site 205STE021, collected on July 11, 2016 in Santa Clara County. Data in highlighted rows exceed monitoring quality objectives in RMC QAPP.

Matrix	Organism	Endpoint	Original Sample Mean	Duplicate Sample Mean	RPD	Exceeds MQO (<20%)?
Water	Pimephales promelas	% Survival	67.5	72.5	7%	No
Water	Pimephales promelas	Biomass (mg/individual)	0.605	0.612	1%	No
Water	Ceriodaphnia dubia	% Survival	100	100	0%	No
Water	Ceriodaphnia dubia	Young per female	32.4	24.9	26%	Yes
Water	Selenastrum capricornutum	Total Cell Count (cells/mL)	3120000	3340000	7%	No
Water	Hyalella azteca	% Survival	100	100	0%	No
Water	Chironomus dilutus	% Survival	70	80	13%	No
Sediment	Hyalella azteca	% Survival	98.8	98.8	0%	No
Sediment	Chironomus dilutus	% Survival	76.3	72.5	5%	No

3.10.4. Contamination

There are no QA/QC procedures for contamination of toxicity samples, but staff followed applicable RMC SOPs to limit possible contamination of samples.

4. CONCLUSIONS

Sample collection and analysis followed MRP and RMC QAPP requirements. There were no major exceedances of measurement quality objectives and data that did exceeded measurement quality objectives were flagged. No data collected in San Mateo County in WY 2016 were rejected.

5. REFERENCES

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

Bay Area Stormwater Management Agency Association (BASMAA) Regional Monitoring Coalition. 2016a. Creek Status Monitoring Program Quality Assurance Project Plan, Final Draft Version 3. Prepared for BASMAA by EOA, Inc. on behalf of the San Mateo Urban Runoff Pollution Prevention Program and the San Mateo Countywide Water Pollution Prevention Program, Applied Marine Sciences on behalf of the Alameda Countywide Clean Water Program, and Armand Ruby Consulting on behalf of the Contra Costa Clean Water Program. 128 pp.

Bay Area Stormwater Management Agency Association (BASMAA) Regional Monitoring Coalition. 2016b. Creek Status Monitoring Program Standard Operating Procedures Version 3. Prepared for BASMAA by EOA, Inc. on behalf of the San Mateo Urban Runoff Pollution Prevention Program and the San Mateo Countywide Water Pollution Prevention Program, Applied Marine Sciences on behalf of the Alameda Countywide Clean Water Program, and Armand Ruby Consulting on behalf of the Contra Costa Clean Water Program. 192 pp.

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

Attachment 2
Biological Indicator Metric Scores

Table A-1. Output for calculation of CSCI score, including O/E and MMI components of CSCI, for 20 bioassessment sites sampled in WY2016 in Santa Clara County.

Station Code	E	Mean_O	O/E	MMI	CSCI
205R00213	12.9	9.0	0.7	0.62	0.66
205R00305	11.8	11.0	0.9	0.85	0.89
205R00578	10.1	8.7	0.9	0.64	0.74
205R01114	9.4	5.8	0.6	0.17	0.39
205R01731	10.0	7.3	0.7	0.53	0.63
205R02330	9.4	6.6	0.7	0.28	0.49
205R02422	10.2	9.3	0.9	0.53	0.72
205R02458	10.2	7.7	0.8	0.46	0.61
205R02474	14.6	14.5	1.0	0.65	0.82
205R02538	11.6	7.5	0.6	0.50	0.57
205R02547	15.3	15.2	1.0	0.93	0.96
205R02563	9.4	6.7	0.7	0.34	0.52
205R02602	10.5	11.9	1.1	0.73	0.93
205R02618	16.0	15.6	1.0	0.69	0.83
205R02650	10.2	10.0	1.0	0.48	0.73
205R02659	10.1	8.9	0.9	0.35	0.62
205R02730	11.1	4.4	0.4	0.19	0.29
205R02762	10.5	4.6	0.4	0.16	0.30
205R02771	10.1	7.0	0.7	0.29	0.49
205R02835	12.7	10.4	0.8	0.76	0.79

Table A-2. SoCal "D18" (diatom only) IBI scores for 10 bioassessment sites sampled in WY2016 in San Mateo County. Individual metric values and scores are also shown. Each IBI score is scaled to 100 based on the number of metrics involved. For D18, the total sum of scores is multiplied by 100/50 to obtain the total score.

Station Code	Proportion halobiontic	Proportion low TP indicators	Proportion N heterotrophs	Proportion requiring >50% DO saturation	Proportion sediment tolerant (highly motile)	Proportion halobiontic Score	Proportion low TP indicators Score	Proportion N heterotrophs Score	Proportion requiring >50% DO saturation Score	Proportion sediment tolerant (highly motile) Score	Total MMI Score
202R00488	0.33	0.002	0.312	0.989	0.254	4	0	4	9	5	44
202R00506	0.267	0.026	0.197	0.924	0.211	5	1	6	8	6	52
202R02332	0.238	0.068	0.108	0.843	0.179	6	1	8	6	6	54
204R02228	0.169	0.058	0.081	0.905	0.128	7	1	8	7	7	60
204R02504	0.36	0.076	0.192	0.952	0.152	3	1	6	8	7	50
204R02548	0.093	0.02	0.108	0.949	0.067	8	1	8	8	9	68
205R02408	0.445	0.049	0.297	0.803	0.162	2	1	4	5	7	38
205R02728	0.088	0.002	0.073	0.975	0.063	8	0	8	9	9	68
205R02920	0.429	0.009	0.445	0.955	0.308	2	0	1	8	4	30
205R03032	0.302	0.115	0.286	0.983	0.173	4	2	4	9	7	52

Table A-3. SoCal "S2" (soft algae only) IBI scores for 10 bioassessment sites sampled in WY2016 in San Mateo County. Individual metric values and scores are also shown. Each IBI score is scaled to 100 based on the number of metrics involved. For S2, the total sum of scores is multiplied by 100/60 to obtain the total score.

Station Code	Prop high Cu (s, sp)	Prop high DOC (s, sp)	Prop low TP (s, sp)	Prop non-ref (s, sp)	Prop green algae in CRUS (s, b)	Prop ZHR (s, m)	Prop high Cu (s, sp) Score	Prop high DOC (s, sp) Score	Prop low TP (s, sp) Score	Prop non-ref (s, sp) Score	Prop green algae in CRUS (s, b) Score	Prop ZHR (s, m) Score	S2 Score
202R00488	1	0.5	0	0.5	1	0	0	4	0	0	0	0	7
202R00506	0	0	0	0	0	0	10	10	0	10	10	0	67
204R02228	1	1	0	1	1	0	0	0	0	0	0	0	0
204R02504	1	1	0	1	1	0	0	0	0	0	0	0	0
204R02548	0.25	0.6	0	0.5	1	0	3	2	0	0	0	0	8
205R02408	0	0	0	0	0	0	10	10	0	10	10	0	67
205R02728	1	1	0	1	1	0	0	0	0	0	0	0	0
205R02920	1	1	0	1	1	0	0	0	0	0	0	0	0
205R03032	1	1	0	1	0	0	0	0	0	0	10	0	17
202R00488	1	0.5	0	0.5	1	0	0	4	0	0	0	0	7

Table A-4. SoCal "H20" (hybrid) IBI scores for 10 bioassessment sites sampled in WY2016 in San Mateo County. Individual metric values and scores are also shown. Each IBI score is scaled to 100 based on the number of metrics involved. For H20, the total sum of scores is multiplied by 100/80 to obtain the total score. "d' represents metrics based on diatoms, "s" represents metrics based on soft algae, "sp" is species richness metric. "NR" refers to values and scores that were not reported due to insufficient data.

Station Code	Prop halo-biontic (d)	Prop high Cu (s, sp)	Prop high DOC (s, sp)	Prop low TN (d)	Prop low TP (s, sp)	Prop N hetero-trophs (d)	Prop require >50% DO sat (d)	Prop sed tol (highly motile) (d)	Prop halo-biontic Score	Prop high Cu Score	Prop high DOC Score	Prop low TN Score	Prop low TP Score	Prop N hetero-trophs Score	Prop require >50% DO sat Score	Prop sed tol (highly motile) Score	Total MMI Score
202R00488	0.33	1	0.5	0.002	0	0.312	0.989	0.254	4	0	4	0	0	4	9	5	32
202R00506	0.267	0	0	0.026	0	0.197	0.924	0.211	5	10	10	1	0	6	8	6	58
202R02332	0.238	NR	NR	0.022	NR	0.108	0.843	0.179	6	NR	NR	1	NR	8	6	6	NR
204R02228	0.169	1	1	0.057	0	0.081	0.905	0.128	7	0	0	1	0	8	7	7	38
204R02504	0.36	1	1	0.065	0	0.192	0.952	0.152	3	0	0	1	0	6	8	7	31
204R02548	0.093	0.25	0.6	0.02	0	0.108	0.949	0.067	8	3	2	1	0	8	8	9	49
205R02408	0.445	0	0	0.05	0	0.297	0.803	0.162	2	10	10	1	0	4	5	7	49
205R02728	0.088	1	1	0.002	0	0.073	0.975	0.063	8	0	0	0	0	8	9	9	42
205R02920	0.429	1	1	0.009	0	0.445	0.955	0.308	2	0	0	0	0	1	8	4	19
205R03032	0.302	1	1	0.116	0	0.286	0.983	0.173	4	0	0	2	0	4	9	7	32