SAN MATEO COUNTYWIDE
Water Pollution Prevention Program

Appendix A

SMCWPPP Creek Status Monitoring Report

Water Year 2017 (October 2016 – September 2017)

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

March 31, 2018

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 Flood and Wastewater 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 2017 (October 1, 2016 through September 30, 2017). 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 Project 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) Quality Assurance Program Plan (QAPrP)[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.

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[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 QAPrP 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
C/CAG	City/County Association of Governments
CCCWP	Contra Costa Clean Water Program
CDFW	California Department of Fish and Wildlife
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
IBI	Index of Biological Integrity
IPM	Integrated Pest Management
LID	Low Impact Development
MDL	Method Detection Limit
MIGR	Fish Migration
MPC	Monitoring and Pollutants of Concern Committee
MPN	Most Probable Number
MRP	Municipal Regional Permit
MS4	Municipal Separate Storm Sewer System
MUN	Municipal Beneficial Use
MWAT	Maximum Weekly Average Temperature
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
QAPrP	Quality Assurance Program Plan
QA/QC	Quality Assurance/Quality Control
RARE	Preservation of Rare and Endangered Species
RM	Reporting Module
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
SPWN	Fish Spawning
SRP	Stormwater Resource Plan
SSID	Stressor/Source Identification
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

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1.0 Introduction

This Creek Status Monitoring Report was prepared by the San Mateo Countywide Water Pollution Prevention Program (SMCWPPP or Program). SMCWPPP is a program of the City/County Association of Governments (C/CAG) of San Mateo County. Each incorporated city and town in the county and the County of San Mateo share a common National Pollutant Discharge Elimination System (NPDES) stormwater permit 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 2017) [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?***

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[3] Monitoring data collected pursuant to other C.8 provisions (e.g., Pollutants of Concern Monitoring, Stressor/Source Identification Monitoring Projects) are reported in the SMCWPPP Urban Creeks Monitoring Report (UCMR) for WY 2017 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 2016 were submitted in prior reports (SMCWPPP 2017, 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 Flood and Wastewater 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). The current MRP, updated and reissued in 2015, specifies the probabilistic/targeted approach most of the details of the RMC Creek Status and Long-Term Trends Monitoring Plan. Table 1.2 provides a list of which parameters are included in the probabilistic and targeted programs in the 2015 MRP. 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 Provisions 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. In WY 2017, chlorine was measured at probabilistic sites.

1.3 Monitoring and Data Assessment Methods

1.3.1 Monitoring Methods

Water quality data were collected in accordance with California Surface Water Ambient Monitoring Program (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 SWAMP Quality Assurance Program Plan (QAPrP)[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 QAPrP 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 (except 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
- Alpha Analytical – Pathogen indicators

1.3.3 Data Analysis Methods

Monitoring data generated during WY 2017 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 & 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. Follow-up SSID projects are 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 2017 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 2017 in San Mateo County.

Map ID	Station Number	Bayside or Coastside	Watershed	Creek Name	Land Use	Latitude	Longitude	Probabilistic	Targeted				
								Bioassessment, Nutrients, General WQ	Chlorine	Toxicity, Sediment Chemistry	Temp	Cont. WQ	Pathogen Indicators
550	202R00550	Coastside	Pescadero Creek	Jones Gulch	NU	37.278796	-122.26832	X	X				
552	202R00552	Coastside	San Gregorito Cr	Lawrence Creek	NU	37.388456	-122.31340	X	X				
2472	204R02472	Bayside	Redwood Creek	Redwood Creek	U	37.465155	-122.23462	X	X				
2611	204R02611	Bayside	Atherton Creek	Atherton Creek	U	37.450833	-122.20592	X	X				
3240	204R03240	Bayside	Atherton Creek	Atherton Creek	U	37.427321	-122.22682	X	X				
3252	204R03252	Bayside	San Mateo Creek	San Mateo Creek	U	37.563132	-122.32754	X	X				
3272	204R03272	Bayside	San Mateo Creek	San Mateo Creek	U	37.533846	-122.35018	X	X				
3316	204R03316	Bayside	Redwood Creek	Arroyo Ojo de Agua	U	37.48119	-122.23427	X	X				
3336	204R03336	Bayside	Belmont Creek	Belmont Creek	U	37.516284	-122.27867	X	X				
3496	204R03496	Bayside	Redwood Creek	Redwood Creek	U	37.447749	-122.23470	X	X				
005	202SPE005	Coastside	San Pedro Creek	San Pedro Creek	U	37.59441	-122.50520			X			
17	202DEN017	Coastside	Denniston Creek	NA (MS4)	U	37.50499	-122.48641						X
5	202DEN005	Coastside	Denniston Creek	Denniston Creek	U	37.50465	-122.48697						X
20	202DEN020	Coastside	Denniston Creek	Denniston Creek	U	37.50638	-122.48714						X
1	202CAP001	Coastside	Capistrano Drainage	NA (MS4)	U	37.50377	-122.48568						X
25	202CAP025	Coastside	Capistrano Drainage	NA (MS4)	U	37.50391	-122.48574						X
19	202SPE019	Coastside	San Pedro Creek	San Pedro Creek	U	37.58853	-122.49943				X		
40	202SPE040	Coastside	San Pedro Creek	San Pedro Creek	U	37.58200	-122.48708				X	X	
50	202SPE050	Coastside	San Pedro Creek	San Pedro Creek	U	37.58198	-122.47819				X		
70	202SPE070	Coastside	San Pedro Creek	San Pedro Creek	NU	37.57974	-122.47371				X	X	
85	202SPE085	Coastside	San Pedro Creek	San Pedro Creek	NU	37.57826	-122.47156				X		

U = urban, NU = non-urban, NA = not applicable, MS4 = municipal separate storm sewer system

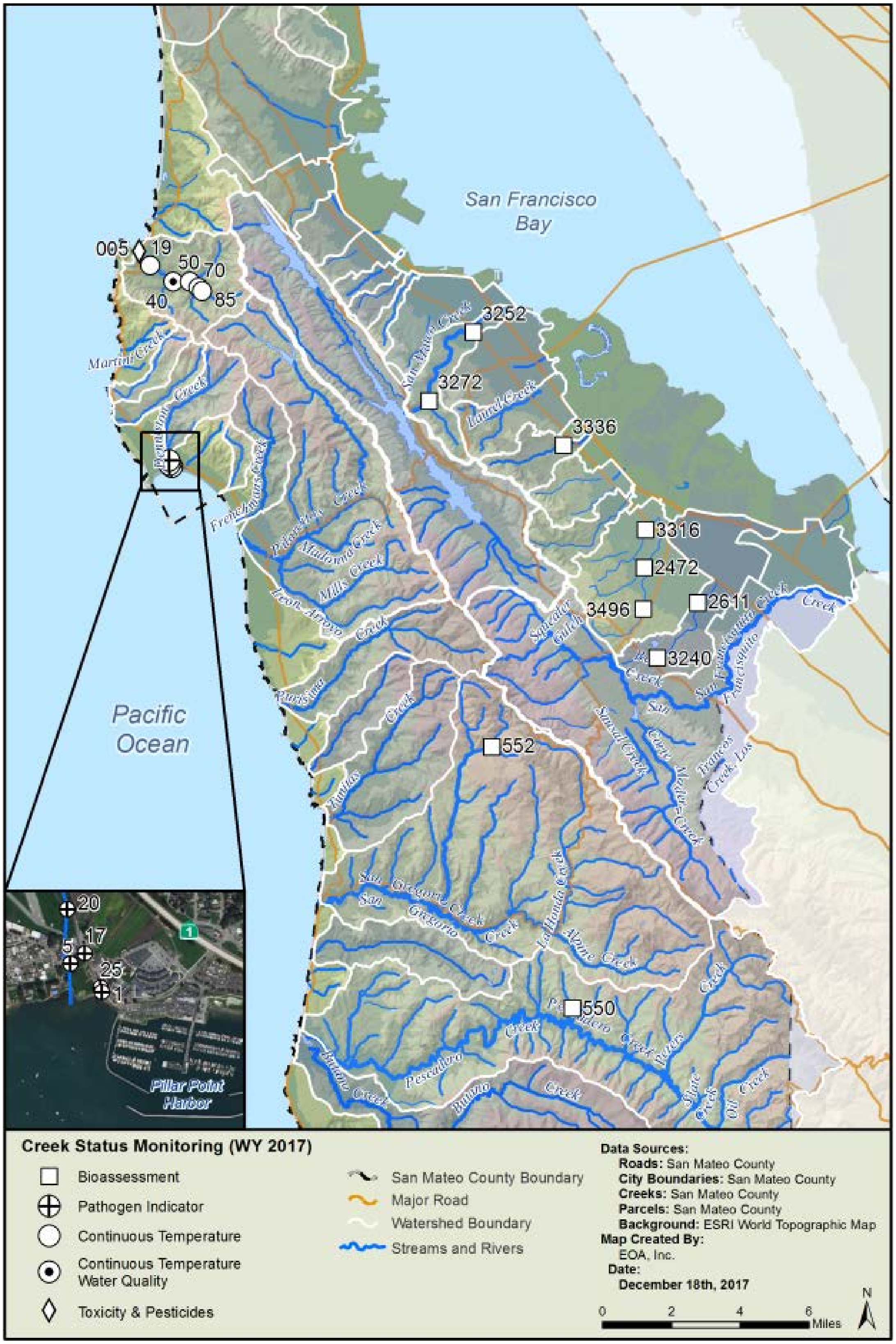

Figure 1.1. Map of SMCWPPP sites monitored in WY 2017.

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 municipal supply. Table 1.4 lists Beneficial Uses designated by the SFRWQCB (2017) for water bodies monitored by SMCWPPP in WY 2017.

Table 1.4. Creeks Monitored by SMCWPPP in WY2017 and their Beneficial Uses (SFRWQCB 2017).

Waterbody	AGR	MUN	FRSH	GWR	IND	PROC	COMM	SHELL	COLD	EST	MAR	MIGR	RARE	SPWN	WARM	WILD	REC-1	REC-2	NAV
Bayside Creeks																			
Arroyo Ojo de Agua															E	E	E	E	
Atherton Creek															E	E	E	E	
Belmont Creek															E	E	E	E	
Redwood Creek															E	E	E	E	
San Mateo Creek			E						E			E	E	E	E	E	E	E	
Coastside Creeks																			
Denniston Creek	E	E							E			E	E	E	E	E	E	E	
Jones Gulch									E						E	E	E	E	
Lawrence Creek[1]	E								E			E	E	E	E	E	E	E	
San Pedro Creek		E							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:

AGR = Agricultural Supply
COLD = Cold Fresh Water Habitat
FRSH = Freshwater Replenishment
GWR - Groundwater Recharge
MIGR = Fish Migration
MUN = Municipal and Domestic Water
SHELL = Shellfish Harvesting
IND = Industrial Service Supply
EST = Estuarine
NAV = Navigation
RARE= Preservation of Rare and Endangered Species
REC-1 = Water Contact Recreation
SPWN = Fish Spawning
COMM = Commercial, and Sport Fishing
REC-2 = Non-contact Recreation
WARM = Warm Freshwater Habitat
WILD = Wildlife Habitat
PROC = Industrial Process Supply
MAR = Marine 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 October through April 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

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

calculated or modeled; actual measured precipitation in a given year rarely equals the statistical average. Figure 1.3 illustrates the temporal variability in annual precipitation measured at the San Francisco International Airport from WY 1946 to WY 2017. This record illustrates that extended periods of drought are common and often punctuated by above average years. Creek Status Monitoring in compliance with the MRP began in WY 2012 which was the first year of a severe statewide drought that persisted through WY 2016. In WY 2017, rainfall was above average but was followed by the hottest recorded summer in California history (California Weather Blog[8]).

Climate patterns (e.g., extended droughts) and individual weather events (e.g., extreme storms, hot summers) influence biological communities (i.e., vegetation, wildlife) and their surrounding physical habitat and should therefore be considered when evaluating the type of data collected by the Creek Status Monitoring Program. For example, periods of drought (rather than individual dry years) can result in changes in riparian and upland vegetation communities. Long 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.

It is uncertain what effect these factors have on indices of biotic integrity (IBIs) based on data collected by the Creek Status Monitoring Program, such as benthic macroinvertebrates or algae. 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, 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 or heat 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.

Extreme heat certainly does affect general water quality such as water temperature and parameters that are influenced by water temperature (e.g., specific conductance, dissolved oxygen). By some measures, WY 2017 was the hottest summer in over 120 years of recorded measurements.[9] The late summer general water quality monitoring results from WY 2017 reflect the high air temperatures during that period.

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[8] http://weatherwest.com/archives/5860

[9] https://www.ncdc.noaa.gov/cag/time-series/us/4/4/tavg/4/9/1895-2017?base_prd=true&firstbaseyear=1901&lastbaseyear=2000

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

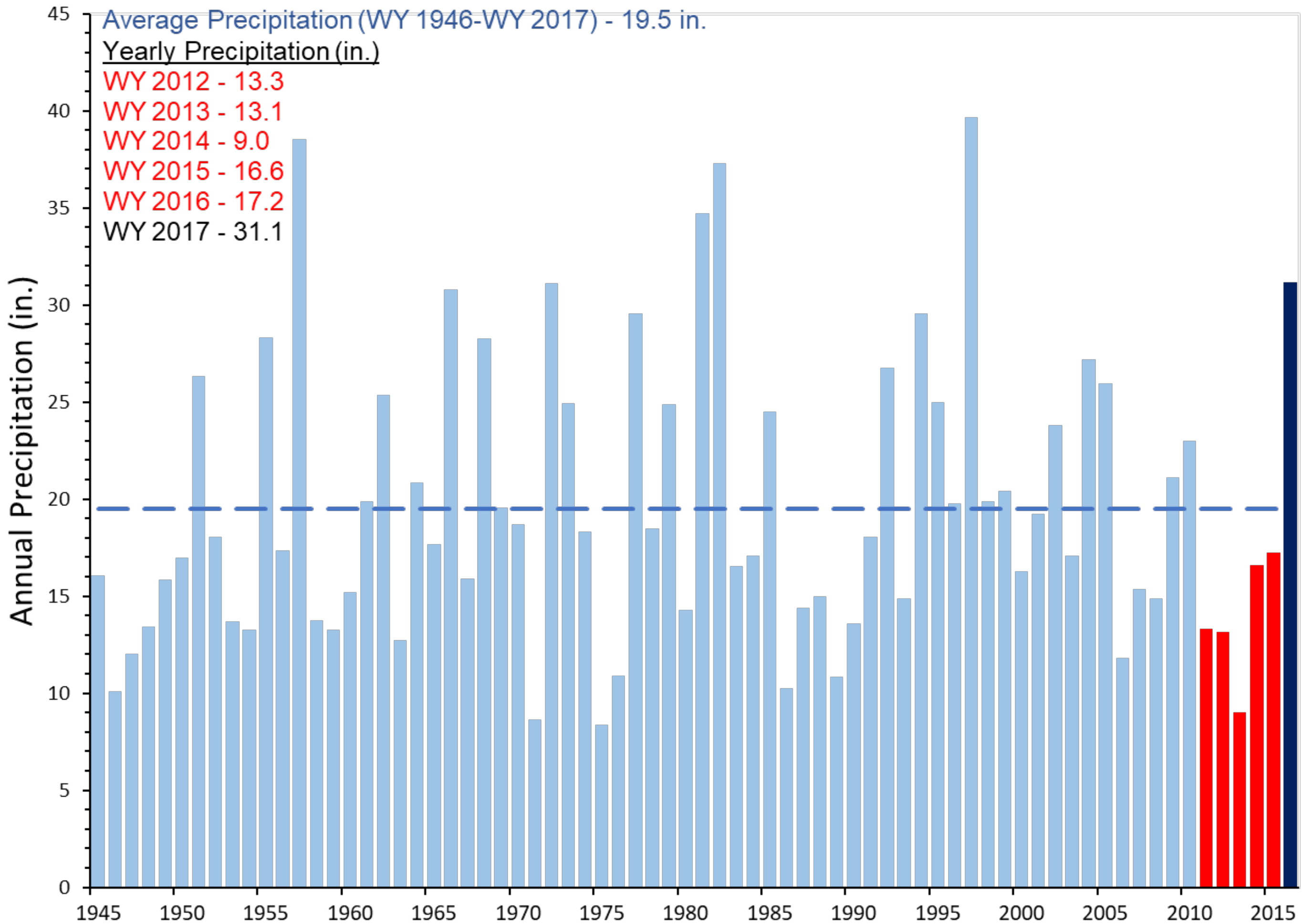

Figure 1.3. Annual rainfall recorded at the San Francisco International Airport, WY 1946 – WY 2017.

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 QAPrP[10]. A detailed QA/QC report is included as Attachment 1.

Based on the QA/QC review, no WY 2017 data were rejected, but some data were flagged. Overall, WY 2017 data met QA/QC objectives.

[10] The current SWAMP QAPrP 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 2017. All bioassessment monitoring was performed at sites selected randomly using the probabilistic monitoring design[11]. 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 six years (WY 2012 through WY 2017), SMCWPPP and the Regional Water Board have sampled 70 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, or of individual watersheds or smaller jurisdictional areas (i.e., cities).[12]

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

[11] The option to conduct 20% of bioassessment surveys at targeted sites was not exercised in WY 2017.

[12] 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).

collected at the probabilistic sites, as potential stressors to biological health. The extent and magnitude of these potential stressors above certain thresholds is also assessed for streams in San Mateo County. In addition, the stressor levels can be compared to biological indicator data through correlation and relative risk analyses. 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. However, trend analysis for the RMC probabilistic survey will require more than six 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 2017. This WY 2017 report presents biological indicator data and potential stressor data. Data are compared to triggers and water quality objectives identified in the MRP; however, statistical analyses evaluating stressor association with biological condition are not presented in this report. Those analyses are being conducted through an ongoing BASMAA RMC regional study.

The BASMAA RMC is currently conducting a *regional* analysis of biological condition using a five-year data set (WY 2012 – WY 2016). The BASMAA regional study will conduct the following analyses:

- Assess the biological condition of streams in the region and each county using IBIs based on benthic macroinvertebrates and algae collected by each countywide program and the SWRCB SWAMP.
- Evaluate IBIs in distinct groupings such as imperviousness categories and type of stream.
- Assess stressors associated with poor stream condition using multivariate modeling analyses.
- Summarize regional data for each year in the five-year dataset.
- Introduce the analyses that will be needed to make recommended changes to the probabilistic monitoring design.

Results of the BASMAA regional study will be available by late 2018. Analytical tools that are found to be useful in evaluating stressor association with biological condition may be implemented in future annual monitoring reports.

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[13].

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[14];
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;

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

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

7. Landowner(s) grant permission to access the site[15].

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 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. During WY 2017, there was a small storm on April 7 (0.56 inches in 24-hour period). Field sampling in San Mateo County began on May 22 and ended on May 31.

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).

[15] 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.

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™ II and DPD Powder Pillows according to SOP FS-3 (BASMAA 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. All taxa identified in samples collected were on the SWAMP Master List and are included in the data submittal for WY 2017.

2.2.4 Data Analysis

BMI and algae data were analyzed to assess the biological condition of the sampled reaches using condition index scores. Physical Habitat Assessment (PHAB) scores, a qualitative tool that assesses the overall habitat condition of the sampling reach during the assessment, were compared to biological condition indictor scores. Additional physical habitat metric scores (see Stressor Variable section below) and water chemistry data were evaluated as potential stressors to biological health using triggers and water quality objectives identified in the MRP. Data analysis methods are described below.

2.2.4.1 Biological Indicators

<u>Benthic Macroinvertebrates</u>

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 (Figure 2.1). 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[16]. 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

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[16] The Biological Integrity Assessment Implementation Plan has been combined with the Biostimulatory Substances Amendment project. The State Water Board is proposing to adopt a statewide water quality objective for biostimulatory substances (e.g., nitrate) along with a program of implementation. A draft policy document for public review is anticipated in late 2018.

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.

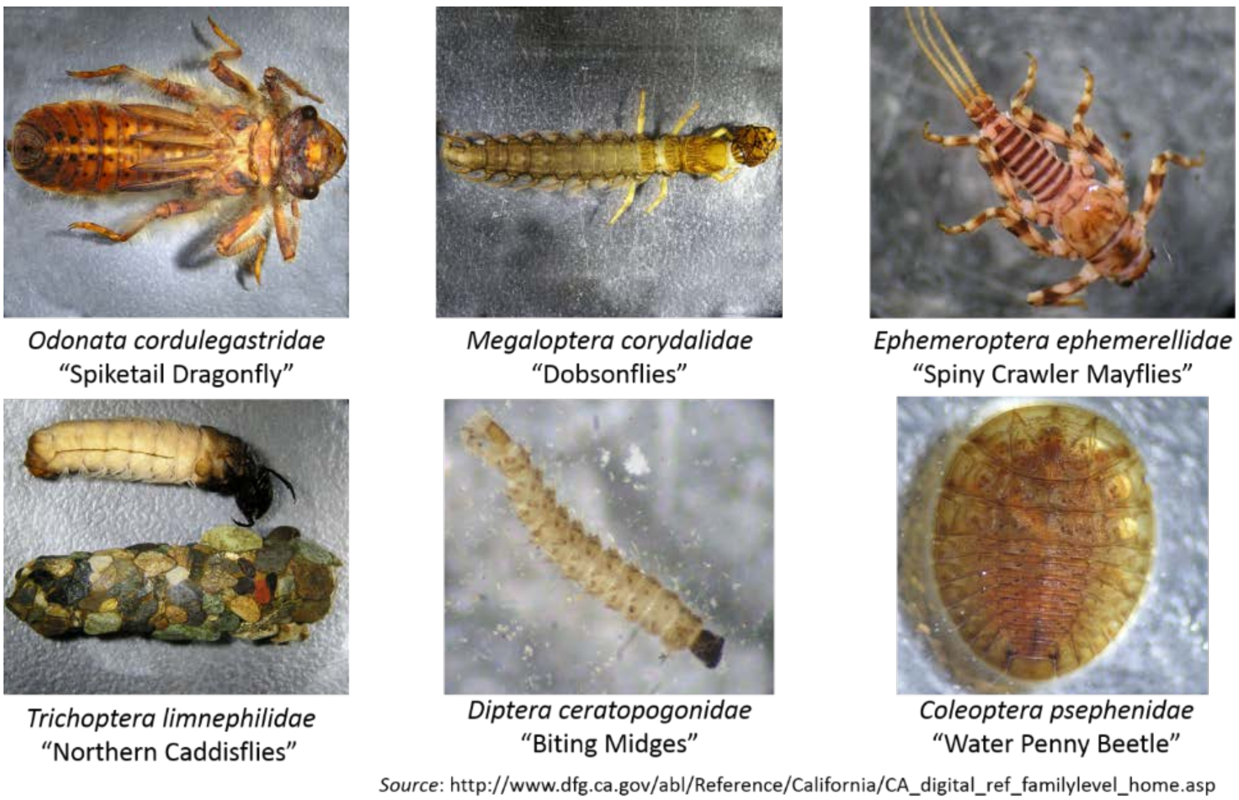


Figure 2.1. Examples of benthic macroinvertebrates.

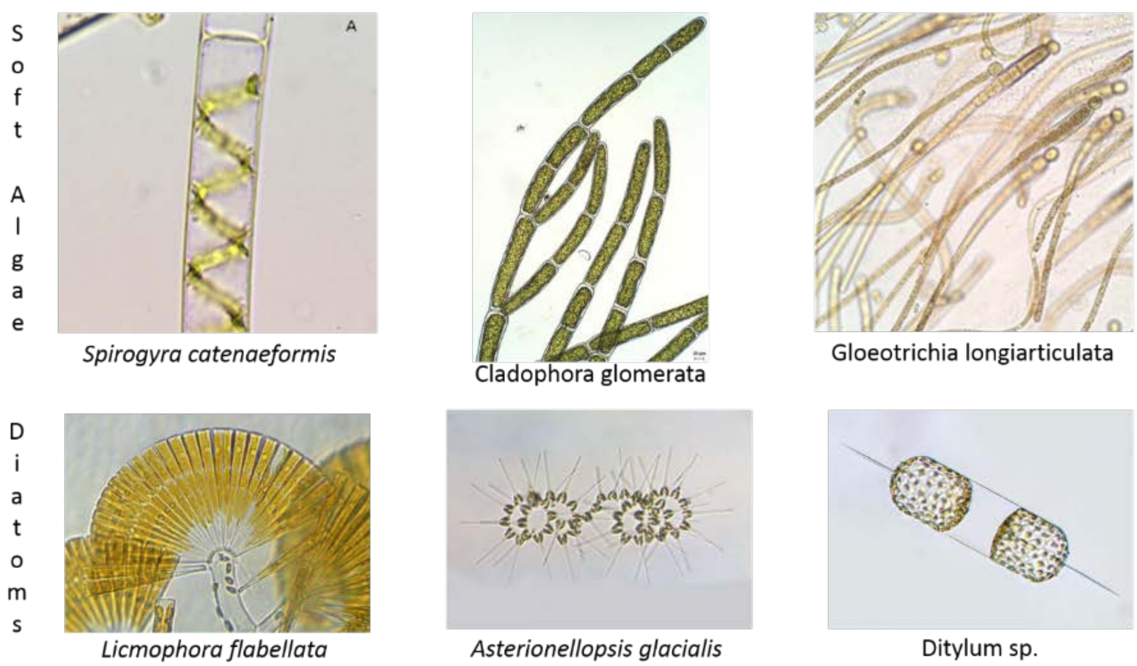
Benthic Algae

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. Figure 2.2 shows examples of benthic algae common in Bay Area streams.

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 Stream Condition Indices (ASCIs) are expected to be available in 2018. The ASCIs will build upon studies by Fetscher et al. (2014) that developed and tested algal IBIs for streams in Southern California (SoCal Algae IBIs). The SoCal Algae IBIs were developed from data comprised of either single-assemblage metrics (i.e., either diatoms or soft algae) or combinations of metrics presenting both assemblages (i.e, "hybrid" IBI).

Algae data collected in San Mateo County were evaluated using the existing SWAMP Algae Reporting Module, (Algae RM) which was developed in 2013 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 initially identified by contracting labs for stormwater projects and, depending on available resources, may be "harmonized" with taxa on the SWAMP Master List. Once harmonized, the new taxa are eventually added to the SWAMP Algae RM. However, autecological information (i.e., traits that associate taxa response to environmental stressors) has not been assigned to the new taxa 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.



Source: http://dbmuseblade.colorado.edu/DiatomTwo/sbsac_site/IDResourceTool.html
http://nathistoc.bio.uci.edu/Diatoms

Figure 2.2. Examples of soft algae and diatoms.

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).

A CSCI score below 0.795 is referenced in the MRP as a threshold indicating 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).

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

Index	Likely Intact	Possibly Intact	Likely Altered	Very Likely Altered
Benthic Macroinvertebrates (BMI)				
CSCI Score	≥ 0.92	≥ 0.795 to < 0.92	≥ 0.63 to < 0.795	< 0.63
Benthic Algae				
S2 Score	≥ 60	≥ 47 to < 60	≥ 29 to < 47	< 29
D18 Score	≥ 72	≥ 62 to < 72	≥ 49 to < 62	< 49
H20 Score	≥ 70	≥ 63 to < 70	≥ 54 to < 63	< 54
Physical Habitat (PHAB)				
PHAB Score	≥ 46	≥ 30 to < 46	≥ 15 to < 30	< 15

Physical Habitat Assessment Scores

The Physical Habitat Assessment score consists of three attributes that are assessed for the entire bioassessment reach. These include channel alteration, epifaunal substrate, and sediment deposition. Each attribute is individually scored on a scale of 0 to 20, with a score of 20 representing good condition. The total PHAB score is the sum of three individual attribute scores with a score of 60 representing the highest possible score. Condition categories for Total PHAB score were created by dividing the highest possible score of 60 into quartiles (Table 2.1).

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 0.025 mg/L annual median standard provided in the San Francisco Basin Water Quality Control Plan (Basin Plan) (SFRWQCB 2017). The conversion was based on a formula provided by the American Fisheries Society (AFS)[17]. The calculation requires total ammonia and field-measured parameters of pH, temperature, and specific conductance.

- 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 metrics were calculated using the SWAMP Bioassessment Reporting Module (RM). The SWAMP RM output includes calculations based on parameters that are measured using EPA's Environmental Monitoring and Assessment Program (EMAP) for freshwater wadeable streams (Kaufmann et al. 1999). The RM also includes additional metrics generated from parameters collected under the SWAMP protocol (Marco Sigala, personal communication, 2017). The RM produces a total of 176 different metrics based on data collected using the SWAMP "Full" habitat protocol.

The California Department of Fish and Wildlife (CDFW) is currently developing a statewide index for physical habitat data collected using the SWAMP bioassesment protocol. The CDFW evaluated a range of physical habitat metrics for their ability to discriminate between reference and stressed sites and provide unbiased representation of waterbodies across the different ecoregions of California. Ten of the top performing metrics (Table 2.2) were selected from the SWAMP RM output to analyze physical habitat data collected from the ten bioassessment sites in San Mateo County during WY 2017.

Table 2.2. Physical habitat metrics used to assess physical habitat data collected at bioassessment sites in WY 2017.

Type	Variable Name	Variable
Channel Morphology	Evenness of Flow Habitat Types	Ev_FlowHab
Channel Morphology	Percent Fast Water of Reach	PCT_FAST
Habitat Complexity and Cover	Mean Filamentous Algae Cover	XFC_ALG
Habitat Complexity and Cover	Natural Shelter cover - SWAMP	XFC_NAT_SWAMP
Habitat Complexity and Cover	Shannon Diversity (H) of Aquatic Habitat Types	H_AqHab
Human Disturbance	Combined Riparian Human Disturbance Index - SWAMP	W1_HALL_SWAMP
Substrate Size and Composition	Evenness of Natural Substrate Types	Ev_SubNat
Substrate Size and Composition	Percent Gravel - coarse	PCT_GC
Substrate Size and Composition	Percent Substrate Smaller than Sand (<2 mm)	PCT_SAFN
Substrate Size and Composition	Shannon Diversity (H) of Natural Substrate Types	H_SubNat

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, total number of road crossings and road density at three different spatial scales (1 km, 5 km, and entire watershed).

Another potential stressor is climate. During the first five years of probabilistic sampling (WY 2012 – WY 2016), average precipitation and dry season base flows were lower than average.

[17] https://fisheries.org/wp-content/uploads/2016/03/Copy-of-pub_ammonia_fwc.xls

Comparison of sampling results from the wetter than average WY 2017 and other future wet 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 2017 were compared to stressor thresholds and applicable water quality standards (Table 2.3). 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 2017). 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 2017. Denniston Creek and San Pedro Creeks are the only creeks sampled in WY 2017 with MUN designated.

Table 2.3. Thresholds for nutrient and general water quality variables.

	Units	Threshold	Direction	Source
Nutrients and Ions				
Nitrate as N [a]	mg/L	10	Increase	Basin Plan
Un-ionized Ammonia [b]	mg/L	0.025	Increase	Basin Plan
Chloride [a]	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

[a] Nitrate and chloride WQOs only apply to waters with MUN designated Beneficial Uses.

[b] This threshold is an annual median value and is not typically applied to individual samples.

2.3 Results and Discussion

A comprehensive analysis of bioassessment data collected by the Program over a five-year period will be presented in the RMC Five-Year Bioassessment Report (5-Year Report). This BASMAA-funded project will evaluate bioassessment data collected at all RMC (n=312) and Water Board (n=45) probabilistic monitoring sites sampled between WY 2012 and WY 2016. The data will be evaluated to assess overall biological condition of streams within the RMC, as well as the extent and influence of stressor data on biological conditions. In addition, the 5-Year Report will evaluate the RMC Sample Frame and provide potential recommendations for revising the monitoring design in the future. The 5-Year Report will be completed by late-2018.

The section below summarizes results from bioassessment sampling conducted during WY 2017.

2.3.1 Site Evaluations

During WY 2017, SMCWPPP conducted site evaluations at a total of 16 potential probabilistic sites in San Mateo County that were drawn from the Sample Frame. Of these sites, a total of ten were sampled in WY 2017 (rejection rate of 38%). Five sites were rejected due to access issues and one site was rejected due to low flow conditions. Two of the sampled sites were classified as non-urban land use and the remaining sites were classified as urban. Land use classification, sampling location, and date for each sampled site are listed are Table 2.4. Sites are mapped in Figure 1.1.

The two non-urban sites were located in coastal watersheds draining into the Pacific Ocean; the remaining eight sites were located in urban watersheds draining into the San Francisco Bay. Three of the urban sites were located in Redwood Creek watershed. Two sites were located on Atherton Creek, two sites were located in San Mateo Creek, and one site was located in Belmont Creek. Two of the lowest elevation sites on Atherton and Redwood Creek, and one location on Arroyo Ojo de Agua, were located in modified (concrete) channels.

Table 2.4. SMCWPPP bioassessment sampling locations and dates in San Mateo County in WY 2017.

Station Code	Creek	Land Use	Modified Channel	Sample Date	Latitude	Longitude
202R00550	Jones Gulch	NU	N	5/30/2017	37.27708	-122.26750
202R00552	Lawrence Creek	NU	N	5/24/2017	37.38802	-122.31349
204R02611	Atherton Creek	U	Y	5/23/2017	37.45228	-122.20451
204R02472	Redwood Creek	U	Y	5/22/2017	37.46660	-122.23534
204R03240	Atherton Creek	U	N	5/23/2017	37.42731	-122.22635
204R03252	San Mateo Creek	U	N	5/31/2017	37.56320	-122.32761
204R03272	San Mateo Creek	U	N	5/31/2017	37.53400	-122.35022
204R03316	Arroyo Ojo de Agua	U	Y	5/24/2017	37.48085	-122.23453
204R03336	Belmont Creek	U	N	5/25/2017	37.51644	-122.27866
204R03496	Redwood Creek	U	N	5/22/2017	37.44764	-122.48500

Since WY 2012, a total of 70 probabilistic sites were sampled by SMCWPPP (n=60) and SWAMP (n=10) in San Mateo County. During the six-year sampling period, SMCWPPP sampled 49 urban sites and 11 non-urban sites; SWAMP sampled 10 non-urban sites. There are sufficient number of samples from probabilistic sites to develop estimates of biological condition and stressor assessment for urban streams in San Mateo County. These analyses are currently being conducted through a BASMAA regional project with results anticipated in late-2018. More samples are needed however, to estimate biological condition for non-urban streams, as well streams at more local scales (e.g., watershed and jurisdictional areas).

2.3.2 Biological Condition Assessment

A total of 103 unique BMI taxa were identified in samples collected at ten bioassessment sites in San Mateo County during WY 2017. A total of 177 benthic algae taxa were identified in samples collected at the same sites, including 138 diatom taxa and 39 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 16 to 50 taxa, and diatoms ranging from 25 to 51 taxa. Soft algae taxa were less common across sites, ranging from 1 to 13 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 2017.

Station ID	Creek	Elevation (m)	Land Use	BMIs	Diatoms	Soft Algae
202R00550	Jones Gulch	88	NU	34	36	1
202R00552	Lawrence Creek	295	NU	50	37	3
204R02472	Atherton Creek	13	U	19	25	9
204R02611	Redwood Creek	21	U	17	25	13
204R03240	Atherton Creek	57	U	18	38	3
204R03252	San Mateo Cr	8	U	19	46	7
204R03272	San Mateo Cr	39	U	21	47	9
204R03316	Ojo de Agua	6	U	16	31	11
204R03336	Belmont Creek	16	U	22	51	3
204R03496	Redwood Creek	31	U	25	43	4

NU = non-urban, U = urban

The total number of BMI taxa was positively correlated with site elevation (r^2=0.88, p value < 0.001) (Figure 2.3). In contrast, total taxa for soft algae generally decreased with increasing site elevation (r^2=0.20, p value = 0.191). Diatoms did not show any association with elevation.

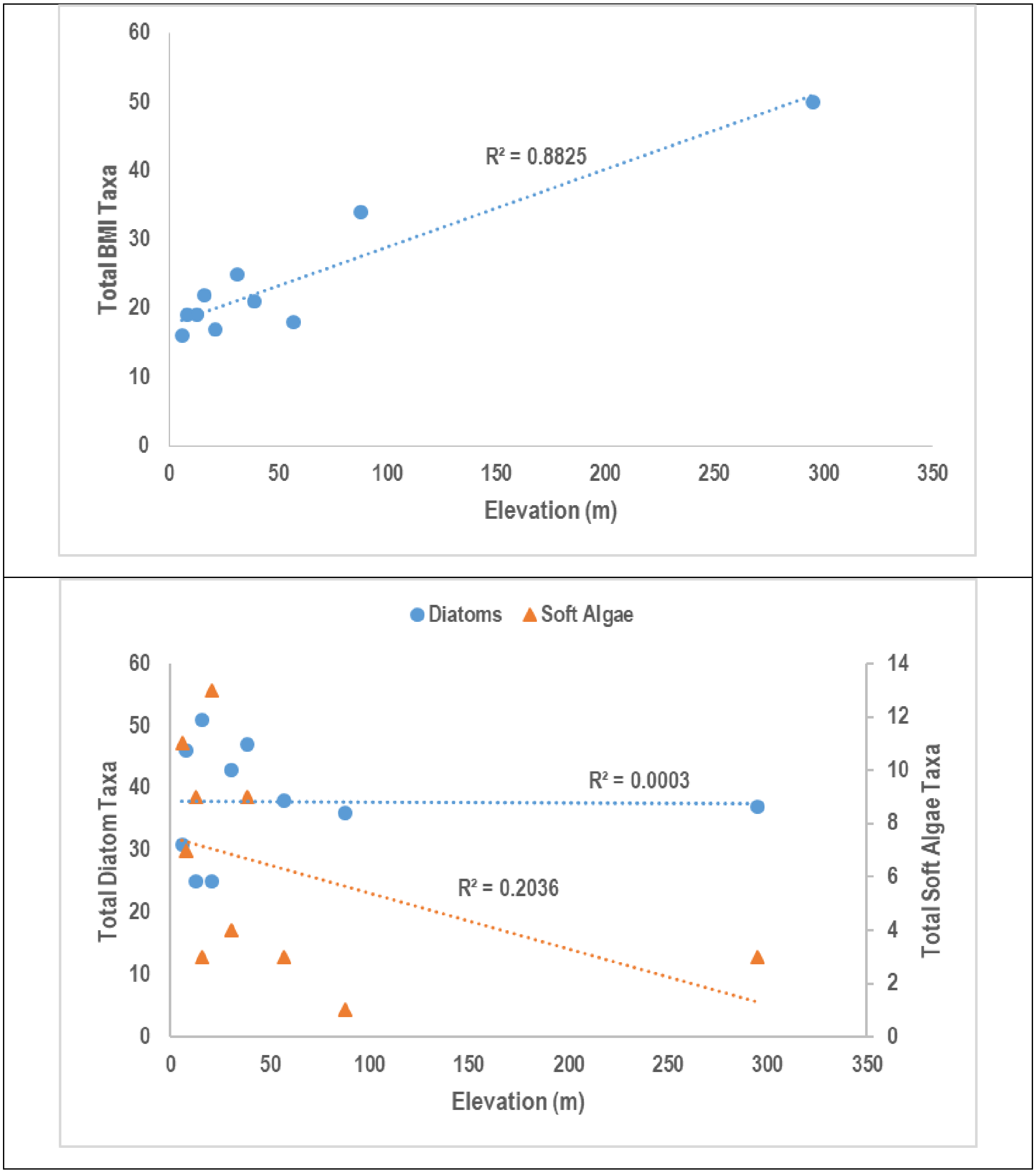


Figure 2.3. Total BMI and soft algae taxa compared to elevation of bioassessment site.

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 2017 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), as defined in Table 2.1, are illustrated for the ten sites in Figure 2.4. Total PHAB scores for each site are also presented in Table 2.6.

Table 2.6. Biological condition scores, presented as CSCI, SoCal Algae IBIs (S2, D18 and H20) for ten probabilistic sites sampled in San Mateo County during WY 2017. PHAB scores are also presented for comparison. 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	Land Use[1]	Impervious Watershed Area (%)	Modified Channel[2]	Flow [3]	CSCI Score	Diatom "D18" IBI Score	Soft Algae "S2" IBI	Hybrid "H20" IBI Score	Total PHAB Score
202R00550	Jones Gulch	NU	1%	N	P	0.87	54	46	67	43
202R00552	Lawrence Creek	NU	2%	N	P	1.16	61	66	77	43
204R02472	Atherton Creek	U	22%	Y	P	0.54	41	64	2	16
204R02611	Redwood Creek	U	24%	Y	P	0.43	40	46	18	18
204R03240	Atherton Creek	U	12%	N	P	0.41	51	42	67	32
204R03252	San Mateo Creek	U	8%	N	P	0.67	60	68	57	21
204R03272	San Mateo Creek	U	7%	N	P	0.63	40	52	15	36
204R03316	Ojo de Aqua	U	45%	Y	P	0.42	38	56	17	18
204R03336	Belmont Creek	U	40%	N	P	0.50	44	30	67	30
204R03496	Redwood Creek	U	19%	N	P	0.60	52	44	67	28

[1] Land Use classification from RMC Sample Frame (NU = Non Urban, U = Urban)
[2] 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.
[3] Flow status (P = perennial, NP = non-perennial) was based on visual observations at each site made during fall or spring seasons.

CSCI Scores

The CSCI scores ranged from 0.41 to 1.16 across the ten bioassessment sites sampled in WY 2017 (Table 2.6). Two of the ten (20%) sites had CSCI scores in the two higher condition categories "possibly intact" and "likely intact", referred to as "good" biological condition in this report. The combined classifications are above the MRP trigger threshold value of 0.795. The good condition sites were classified as non-urban and are located in protected Open Space or County Park land. Site 202R00552, located in El Corte de Madera Creek Preserve, had a CSCI score of 1.16, which is typically a score for reference sites.

The two sites sampled in San Mateo Creek had CSCI scores that ranked as "likely altered" (0.63 to 0.795). The remaining six sites were ranked as "very likely altered" (< 0.63). Three of these sites were located in concrete channel sections of Redwood Creek, Arroyo Ojo de Agua, and Atherton Creek.

Sites with CSCI scores below 0.795 will be considered as candidates for SSID projects.

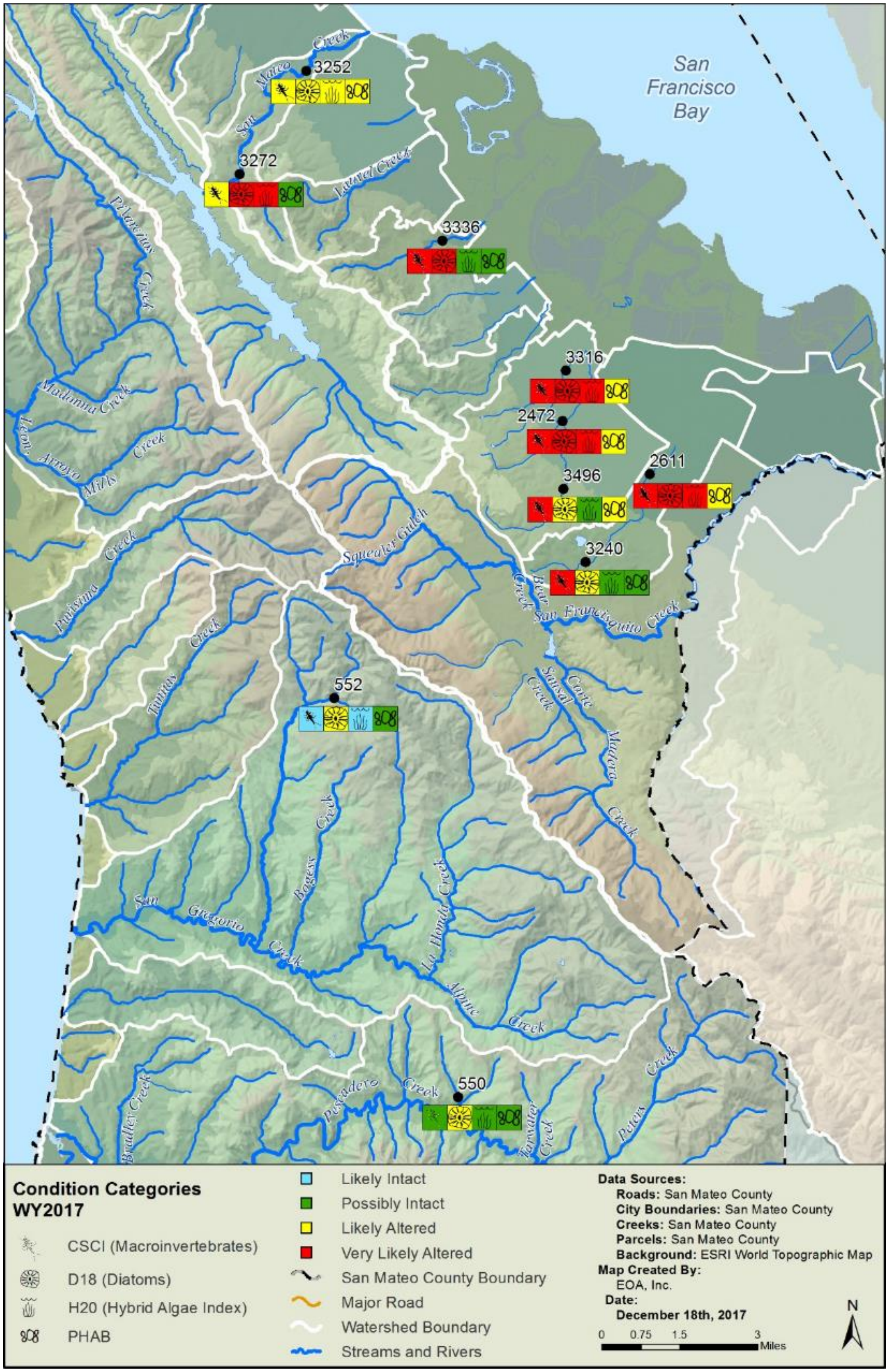


Figure 2.4. Condition category as represented by CSCI, D18, H20 and PHAB for ten probabilistic sites sampled in San Mateo County in WY2017.

Algae IBI Scores

Benthic algae taxa identified in the ten samples collected in San Mateo County were used to calculate scores for three algae IBIs (S2, D18 and H20) (Table 2.6).

- **D18** IBI scores ranged from 38 to 61 across all sites. There were no sites that were ranked in the two higher condition categories (>62). Five sites were ranked as "likely altered" (49 - 62) and five sites were ranked as "very likely altered" (<49) condition categories.
- **S2** IBI scores ranged from 30 to 68 for all sites. There were five sites that ranked in the two higher condition categories for S2 IBI score. One of these sites was non-urban site (also had highest CSCI score 1.16) and the remaining were urban sites. Two of the high ranking urban sites were concrete channels with high impervious watershed area (>22%), suggesting that S2 IBI scores are relatively independent of physical habitat conditions.
- **H20** IBI scores ranged from 17 to 77. There were five sites that were ranked in the two higher condition categories for H20 IBI scores. The lowest four scores ranged from 2 to 18. Three of the low-scoring sites were in concrete channels and had high percent impervious watershed area.

The total number of soft algae taxa identified in samples collected in WY 2017 was much higher (39 taxa) compared to number of taxa identified in samples collected the previous two years (12 taxa in WY 2016 and 3 taxa in WY 2015). The wetter than average winter of WY 2017 may be one reason that higher numbers of soft algae taxa were observed in WY 2017.

Reasons for the lack of soft algae at San Mateo County sites in prior years 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 these factors, however, appear to explain the consistent lack of soft algae in samples across all ten sites.

Currently, some soft algae taxa are not incorporated into the calculation for S2 and H20 IBI scores. The SWAMP Algae Reporting Module requires each taxa to have trait assignments (i.e., fields to indicate if taxa is sensitive or tolerant to a particular stressor). The current version of the RM has not been updated since 2013. As a result, many taxa that have been added to SWAMP Master List in the past five years have not been assigned traits, and thus do not get incorporated into the metric calculations. It is anticipated that the ASCI tool, currently under development, will incorporate the full SWAMP Master List.

Total PHAB Scores

Individual PHAB metrics and total PHAB scores assessed at the ten bioassessment sites in WY 2017 are presented in Table 2.7. The lowest scores for channel alteration and epifaunal substrate attributes (0) were given to sites at concrete channels (i.e., highly modified channel with no quality substrate). High sediment deposition scores were given to sites with little or no fine sediment present. Total PHAB scores were moderately correlated with both CSCI scores (r^2=0.51, p value = 0.020) and H20 IBI scores (r^2=0.42, p value = 0.044) (Figure 2.5). D18 IBI scores had no association with PHAB scores.

Table 2.7. Individual and Total PHAB scores for ten probabilistic sites in San Mateo County sampled in WY 2017. CSCI and D18 IBI scores are shown for comparison.

Station Code	Creek	CSCI Score	Diatom "D18" IBI Score	Channel Alteration	Epifaunal Substrate	Sediment Deposition	Total PHAB Score
202R00550	Jones Gulch	0.87	54	20	15	8	43
202R00552	Lawrence Creek	1.16	61	20	17	6	43
204R02472	Atherton Creek	0.54	41	0	1	15	16
204R02611	Redwood Creek	0.43	40	0	0	18	18
204R03240	Atherton Creek	0.41	51	12	8	12	32
204R03252	San Mateo Creek	0.67	60	11	6	4	21
204R03272	San Mateo Creek	0.63	40	14	13	9	36
204R03316	Ojo de Agua	0.42	38	0	0	18	18
204R03336	Belmont Creek	0.50	44	14	9	7	30
204R03496	Redwood Creek	0.60	52	12	8	8	28

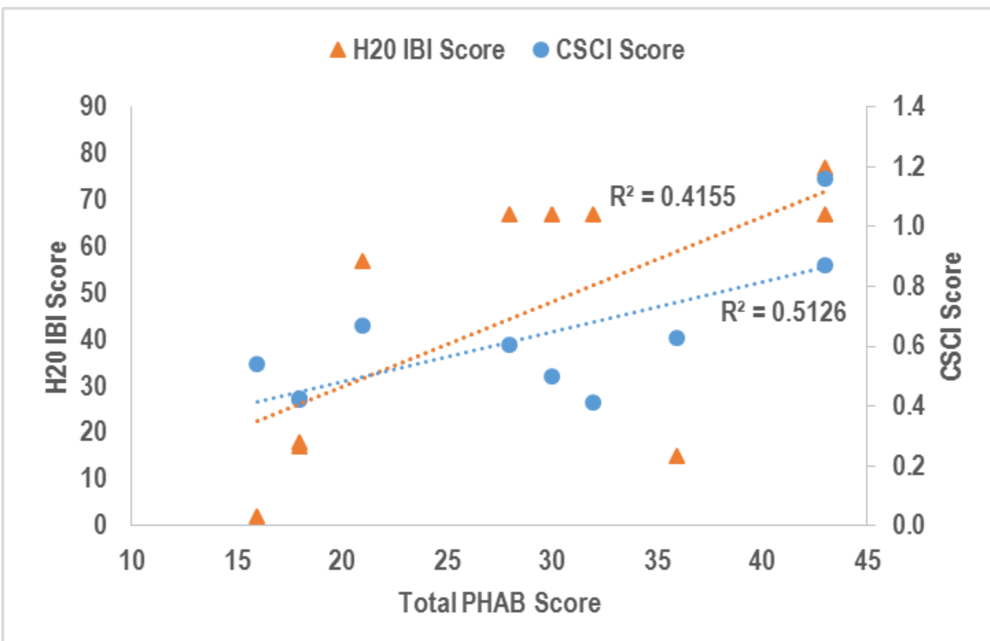


Figure 2.5. CSCI and H20 scores plotted with Total PHAB scores for ten bioassessment sites sampled during WY 2017.

2.3.3 Stressor Assessment

The section below summarizes results for stressor data collected at 10 bioassessment sites during WY 2017. Association between stressor data and biological condition is presented for some of the stressors. However, due to the small number of samples, associations with biological condition are not expected to be very strong. More robust analyses of stressor extent and their association with biological condition will be made in the RMC 5-Year Report.

General Water Chemistry

General water quality measurements sampled at the ten bioassessment sites in WY 2017 are listed in Table 2.8. Sites with general water quality results exceeding water quality objectives or MRP trigger thresholds are indicated in bold. Three measurements exceeded water quality objectives for pH: site 204R02472 (Redwood Creek), site 204R02611 (Atherton Creek) and site 204R03316 (Ojo de Agua) were slightly above the threshold of 8.5. The MRP acute temperature threshold trigger (24°C) for salmonid fish was exceeded at site 205R02472 (Redwood Creek). The MRP trigger for specific conductance was exceeded at both sites on Atherton Creek. All three sites had very low flow conditions in concrete channels with little to no shading. The MRP triggers apply to continuous data and are not considered exceeded unless 20% of the results exceed the trigger. Therefore, these sites with single sample exceedances will not be added to the list of candidate SSID projects

Table 2.8. General water quality measurements for ten probabilistic sites in San Mateo County sampled in WY 2017.

Station Code	Waterbody	Temp (C)	DO (mg/L)	pH	Specific Conductance (uS/cm)
202R00550	Pescadero Creek	11.7	10.1	8.0	519
202R00552	Lawrence Creek	11.9	10.4	8.2	443
204R02472	Redwood Creek	**26.2**	13.1	**8.9**	945
204R02611	Atherton Creek	20.6	13.9	**8.6**	**2626**
204R03240	Atherton Creek	14.4	7.2	7.9	**5322**
204R03252	San Mateo Creek	15.8	10.0	8.1	336
204R03272	San Mateo Creek	14.7	9.6	7.9	249
204R03316	Ojo de Agua	21.8	9.2	**8.6**	778
204R03336	Belmont Creek	14.6	8.2	7.8	1324
204R03496	Redwood Creek	15.6	9.3	8.1	922

Landscape Variables

Landscape variables associated with the drainage area for each bioassessment site sampled in WY 2017 are presented in Table 2.9. Landscape variables include percent urban area, percent impervious area, total number of road crossings, and road density (road length/watershed area). CSCI scores are presented for comparison. CSCI scores were moderately correlated with impervious area (r^2 = 0.46, p value = 0.311) and road density (r^2 = 0.51, p value = 0.022) (Figure 2.6).

Table 2.9. Landscape variables for watershed areas of the 10 bioassessment sites sampled in San Mateo County during WY 2017.

SiteID	CSCI Score	Drainage Area (km2)	Percent Urban	Percent Impervious	Road Crossings Watershed	Road Density Watershed (km/km2)
202R00550	0.87	2	0%	1%	2	2.1
202R00552	1.16	3	1%	2%	0	0.4
204R02472	0.54	7	81%	22%	25	8.0
204R02611	0.43	9	70%	24%	26	7.1
204R03240	0.41	3	30%	12%	3	3.7
204R03252	0.67	85	13%	8%	44	2.7
204R03272	0.63	79	8%	7%	35	2.2
204R03316	0.42	9	93%	45%	75	12.2
204R03336	0.5	7	73%	40%	6	9.1
204R03496	0.6	5	79%	19%	15	7.6

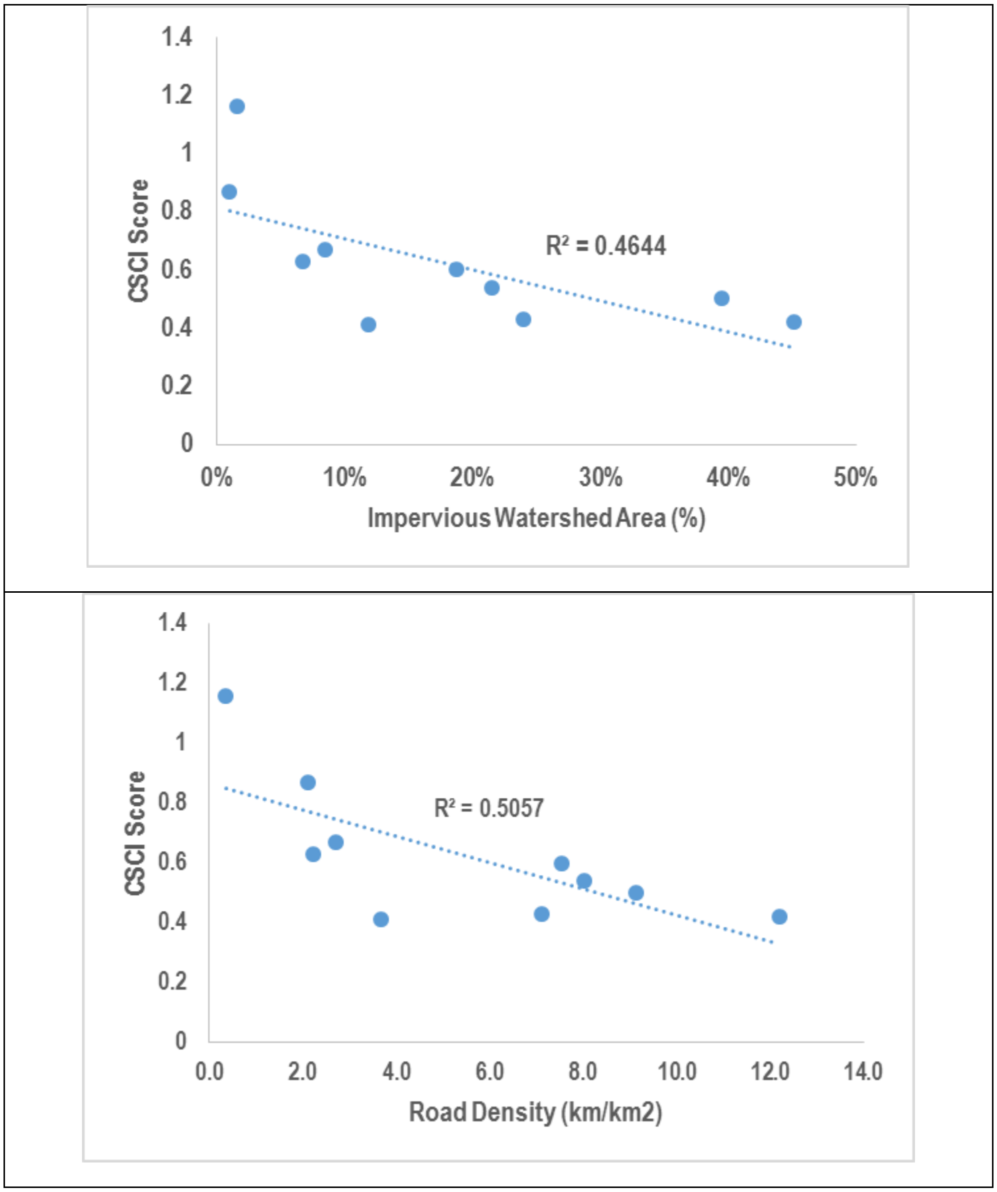
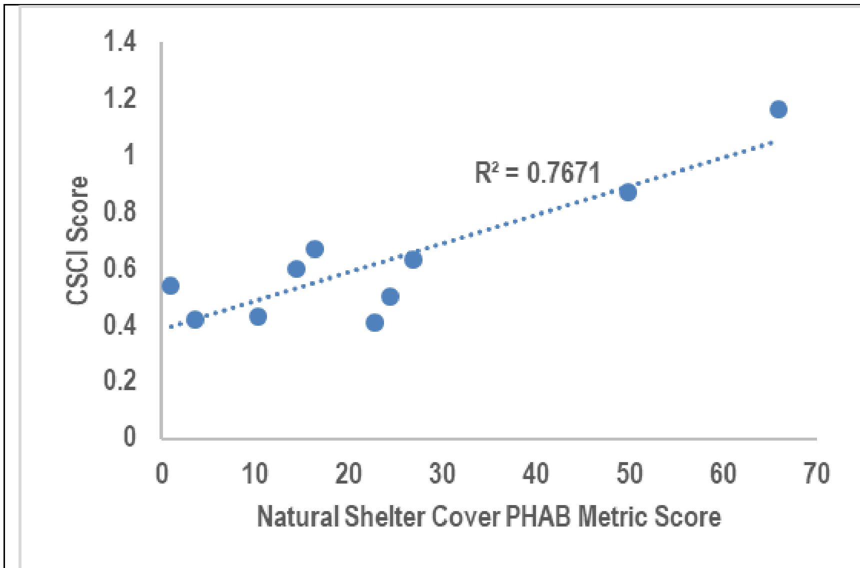


Figure 2.6. CSCI Scores compared to landscape variables (percent impervious and road density) for 10 bioassessment sites sampled in San Mateo County in WY 2017.

Physical Habitat

Scores for ten of PHAB metrics that were generated from the physical habitat data collected at bioassessment sites in WY 2017 are listed in Table 2.109. CSCI scores were positively correlated with *Natural Shelter Cover* ($r^2 = 0.77$, p-value < 0.001) and negatively correlated with *Human Disturbance* ($r^2 = 0.68$, p-value = 0.003) (Figure 2.7). The remaining physical habitat metrics were poorly correlated with CSCI scores.



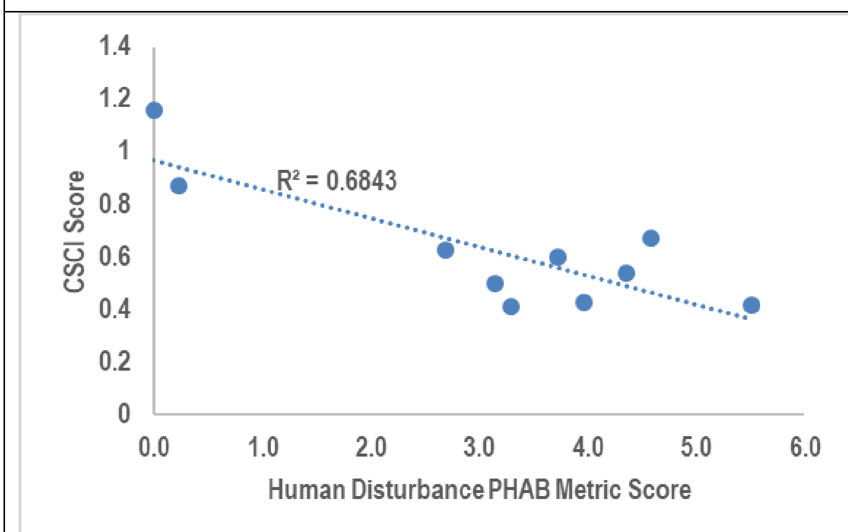


Figure 2.7. CSCI Scores compared to PHAB metric scores Natural Shelter Cover and Human Disturbance Index for 10 bioassessment sites sampled in San Mateo County in WY 2017.

Water Chemistry (nutrients)
Nutrient and conventional analyte concentrations measured in water samples collected at ten bioassessment sites in San Mateo County during WY 2017 are listed in Table 2.11. There were no water quality objective exceedances for water chemistry parameters. Chloride concentrations were above the 250 mg/L at site 204R03240, however Atherton Creek is not designated as Municipal Water Supply Beneficial Use.

Total Nitrogen concentrations ranged from 0.24 to 2.4 mg/L. The two highest concentrations measured for all samples (>2 mg/L) occurred at site 204R02472 in Redwood Creek and site 204R03316 on Arroyo Ojo de Agua (tributary to Redwood Creek). Both sites are located in concrete channels. Total phosphorus concentrations ranged from 0.02 to 0.66 mg/L. The two highest concentrations of total phosphorus (> 0.4 mg/l) occurred at site 204R02472 in Redwood Creek and site 202R00550 (Pescadero Creek).

Table 2.10. Scores for 10 PHAB metrics calculated from physical habitat data collected at ten probabilistic sites in San Mateo County during WY 2017.

Station Code	Creek	Channel Morphology		Habitat Complexity and Cover			Substrate Size and Composition				Human Disturbance
		Evenness of Flow Habitat Types	Percent Fast Water of Reach	Shannon Diversity of Aquatic Habitat Types	Natural Shelter Cover	Mean Filamentous Algae Cover	Evenness of Natural Substrate Types	Shannon Diversity of Natural Substrate Types	Percent Gravel - Coarse	Percent Substrate Smaller than Sand (<2 mm)	Riparian Human Disturbance Index
202R00550	Pescadero Creek	0.6	26.0	1.7	49.9	0.0	0.9	1.8	19.0	40.0	0.2
202R00552	Lawrence Creek	0.7	64.0	1.6	65.9	0.0	0.8	1.7	16.0	50.0	0.0
204R02472	Redwood Creek	0.0	0.0	0.1	1.0	60.5	0.4	0.5	0.0	30.0	4.4
204R02611	Atherton Creek	0.0	0.0	0.6	10.4	57.5	0.7	0.5	0.0	6.0	4.0
204R03240	Atherton Creek	0.3	3.0	1.8	22.8	2.3	0.8	1.2	13.0	78.0	3.3
204R03252	San Mateo Creek	0.9	64.0	1.3	16.4	0.0	1.0	1.3	37.0	33.0	4.6
204R03272	San Mateo Creek	0.8	60.0	1.6	26.9	23.4	0.9	1.6	21.0	46.0	2.7
204R03316	Arroyo Ojo de Agua	0.0	0.0	0.7	3.6	3.6	0.6	0.7	0.0	14.0	5.5
204R03336	Belmont Creek	0.5	18.0	1.5	24.4	0.0	0.9	1.5	30.0	37.0	3.2
204R03496	Redwood Creek	0.6	16.0	1.5	14.5	0.0	0.9	1.5	23.0	59.0	3.7

Table 2.11. Nutrient and conventional constituent concentrations in water samples collected at ten sites in San Mateo County during WY 2017. 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	Total Phosphorus	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	mg/L
	Water Quality Objective:	*NA*	*0.025 [b]*	*250 [a]*	*NA*	*NA*	*10 [a]*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
202R00550	Pescadero Creek	0.1	0.002	46	206	<3.6	0.23	0.006	0.62	0.86	0.32	0.34	0.66	50
202R00552	Lawrence Creek	0.015 J	0.000	32	276	5	<0.02	<0.001	0.22	0.24	0.014	0.02	0.034	20
204R02472	Redwood Creek	0.087	0.025	58	179	292	0.47	0.032	1.9	2.40	0.18	0.23	0.41	30
204R02611	Atherton Creek	0.039	0.004	230	297	203	<0.02	<0.001	1.0	1.02	0.007 J	0.01	0.02	14
204R03240	Atherton Creek	0.034	0.001	440	546	20	<0.02	0.002 J	1.2	1.22	0.05	0.06	0.11	19
204R03252	San Mateo Creek	0.052	0.002	24	163	10	0.046 J	0.004 J	0.4	0.45	0.012	0.03	0.04	11
204R03272	San Mateo Creek	0.079	0.002	18	48	40	0.05	0.003 J	0.26	0.31	0.008 J	0.02	0.03	10
204R03316	Arroyo Ojo de Agua	0.049	0.006	54	158	193	1.80	0.011	0.53	2.34	0.01	0.11	0.12	59
204R03336	Belmont Creek	0.017 J	0.000	160	57	8	0.31	0.001 J	0.66	0.97	0.052	0.048	0.1	22
204R03496	Redwood Creek	0.093	0.003	54	84	24	0.37	0.034	0.83	1.23	0.14	0.15	0.29	33
Number of exceedances		NA	0	0	NA	NA	0	NA	NA	NA	NA	NA	NA	NA

NA = Not Applicable

J = The reported result is an estimate.

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

b. This threshold is an annual median value and is not typically applied to individual samples.

2.4 Conclusions and Recommendations

Bioassessment monitoring in WY 2017 was conducted in compliance with Provision C.8.d.i of the MRP. Ten sites were sampled for BMIs, benthic algae, physical habitat measurements, and nutrients using methods consistent with the BASMAA RMC QAPP (BASMAA 2016a) and SOPs (BASMAA 2016b). Stations were randomly selected using a probabilistic monitoring design. Eight of the ten sites (80%) were classified as urban and two (20%) were classified and non-urban.

The following conclusions and recommendations are made based on the WY 2017 data. An assessment of biological condition is provided and potential stressors are compared to applicable WQOs and triggers identified in the MRP. Sites with monitoring results that exceed WQOs and triggers are considered as candidates for further investigation as SSID projects, consistent with provision C.8.e of the MRP.

A more comprehensive analysis of a five-year dataset (i.e., WY 2012 – WY 2016) is currently being conducted by a BASMAA regional project which is assessing stream conditions and potential stressors on a regional and countywide basis. Tools and approaches developed by the regional project may be applied to the growing SMCWPPP probabilistic dataset in future annual monitoring reports.

Biological Condition Assessment

Stream condition was assessed using three different types of indices/tools: the BMI-based CSCI, the benthic algae-based IBIs developed for Southern California (D18, H2O, and S2), and Physical Habitat Assessment scores.

- **CSCI**. The California Stream Condition Index translates benthic macroinvertebrate data into an overall measure of stream health. Of the ten sites monitored in WY 2017, two sites (20%) were rated in good condition (CSCI scores ≥ 0.795); two sites (20%) rated as likely altered condition (CSCI score 0.635 – 0.795), and six sites (60%) rated as very likely altered condition (≤ 0.635). The two sites in good condition were classified as non-urban and located in protected open space or County Park land. Three of the lowest CSCI scores occurred at sites located in concrete channels.
    - The eight sites with CSCI scores below 0.795 will be considered as candidates for SSID projects.
- **Algae IBIs (D18, H2O, S2)**. Algae IBIs translate benthic algae data (diatoms and soft algae) into overall measures of stream health Three algae IBIs (developed for streams in Southern California) were calculated: D18 (diatoms), S2 (soft algae), and H2O (combination of diatoms and soft algae). Statewide Algae Stream Condition Indices are currently being developed and anticipated to be available in 2018.
    - Based on D18 scores, five sites (50%) were ranked in likely altered condition (D18 score 62-72), and five sites (56%) were ranked in very likely altered condition (< 49). No sites had D18 scores that were ranked in good condition (D18 ≥ 62).
    - Based on S2 scores, five sites (50%) were ranked as possibly intact or likely intact (S2 score > 47). One of these sites was non-urban and also had the highest CSCI score (1.16); the remaining were urban sites. Two of the high

ranking urban sites had a high level of human disturbance (concrete channel and high percent impervious area).

    - Based on H20 scores, five sites (50%) were ranked as possibly intact or likely intact (H20 score >63). The lowest four H20 scores ranged from 2 to 18. Three of these low-scoring sites were in concrete channels and had high percent impervious watershed areas.

- Physical Habitat Assessment (PHAB) scores, a qualitative tool that assesses the overall habitat condition of the sampling reach during the assessment, were compared to biological condition indictor scores. PHAB consists of three attributes that are assessed for the entire bioassessment reach. These include channel alteration, epifaunal substrate and sediment deposition
    - Total PHAB scores were moderately correlated with CSCI scores and H20 scores. No relationship was observed between Total PHAB scores and D18 scores

Stressor Assessment

Relationships between potential stressors (physical habitat and water chemistry) and biological condition were explored using the WY 2017 dataset. Sites with stressor levels exceeding applicable WQOs and triggers identified in the MRP will be considered as candidates for SSID projects.

- **General water quality** (pH, temperature, dissolved oxygen, specific conductance). Water quality objectives for pH were exceeded at three sites. These sites will be considered as candidates for SSID projects. The MRP acute temperature threshold trigger (24°C) for salmonid fish was exceeded at one site, and the MRP trigger for specific conductance (2,000 us/cm) was exceeded at two sites on Atherton Creek. These MRP triggers apply to continuous data and are not considered exceeded unless 20% of the results exceed the trigger. Therefore, these sites with single sample exceedances will not be added to the list of candidate SSID projects.
- **Nutrients and conventional analytes** (ammonia, unionized ammonia, chloride, AFDM, chlorophyll a, nitrate, nitrite, TKN, ortho-phosphate, phosphorus, silica). There were no water quality objective exceedances for water chemistry parameters.
- **PHAB metric scores** were generated from the physical habitat data. CSCI scores were positively correlated with metrics associated with habitat complexity and negatively correlated with human disturbance index.
- **Landscape variables** were calculated for each of the watershed areas draining into the bioassessment sites. CSCI scores were moderately correlated (negatively) with impervious area and road density.

Recommendations

- The BASMAA RMC is currently conducting a regional project to assess stream conditions and potential stressors on a regional and countywide basis using a five-year dataset (WY 2012 – WY 2016). SMCWPPP should consider applying tools and approaches developed by the regional project to the growing San Mateo County probabilistic dataset in future annual monitoring reports.

- Trend analysis for the RMC probabilistic survey will require more than five 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. Recommendations for addressing trends will be forthcoming in the RMC Five-Year Bioassessment Report.

3.0 Targeted Monitoring

3.1 Introduction

During WY 2017 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[18] 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 as candidates for future Stressor Source Identification projects.

3.2 Study Area

In compliance with Provision C.8.d.iii of the MRP, temperature was monitored at 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 and General Water Quality

Continuous (hourly) temperature measurements were recorded at five stations in San Pedro Creek from April 5 through September 26, 2017[19]. Continuous (15-minute) general water quality measurements (temperature, dissolved oxygen, pH, specific conductance) were recorded at two stations in San Pedro Creek during two two-week sampling events. Sample Events 1 and 2 were conducted in May/June and August/September of 2017, respectively. Temperature and general water quality monitoring stations are mapped in Figure 3.1.

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[18] 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."

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

San Pedro Creek, located in the City of Pacifica, was targeted for temperature and general water quality monitoring because it contains the northern-most population of naturally producing steelhead trout (*Oncorhynchus mykiss*) in San Mateo County (Titus et al. 2010 Draft). Although degradation of physical habitat and the presence of fish barriers such as bridge culverts may threaten the steelhead population, restoration efforts are helping to reestablish and enhance habitat. For example, in 2005 the City of Pacifica removed a fish passage and migration barrier at Capistrano Avenue Bridge and restored approximately 1,300 linear feet of channel. The City also implemented the San Pedro Creek Flood Control Project which reconstructed a meandering channel and active floodplain in the lower 3,100-feet of San Pedro Creek. In WY 2015, SMCWPPP conducted bioassessment monitoring at two locations on the Middle Fork of San Pedro Creek. CSCI scores were in the “possibly intact” and “likely intact” stream condition categories.

The San Pedro Creek watershed is approximately 8 square miles and encompasses the urban communities of Linda Mar, Sun Valley and Park Pacifica. The majority of South and Middle Fork subwatersheds are located within the undeveloped and public lands of San Pedro Valley County Park; these sub-watersheds account for approximately 25% of the total watershed area.

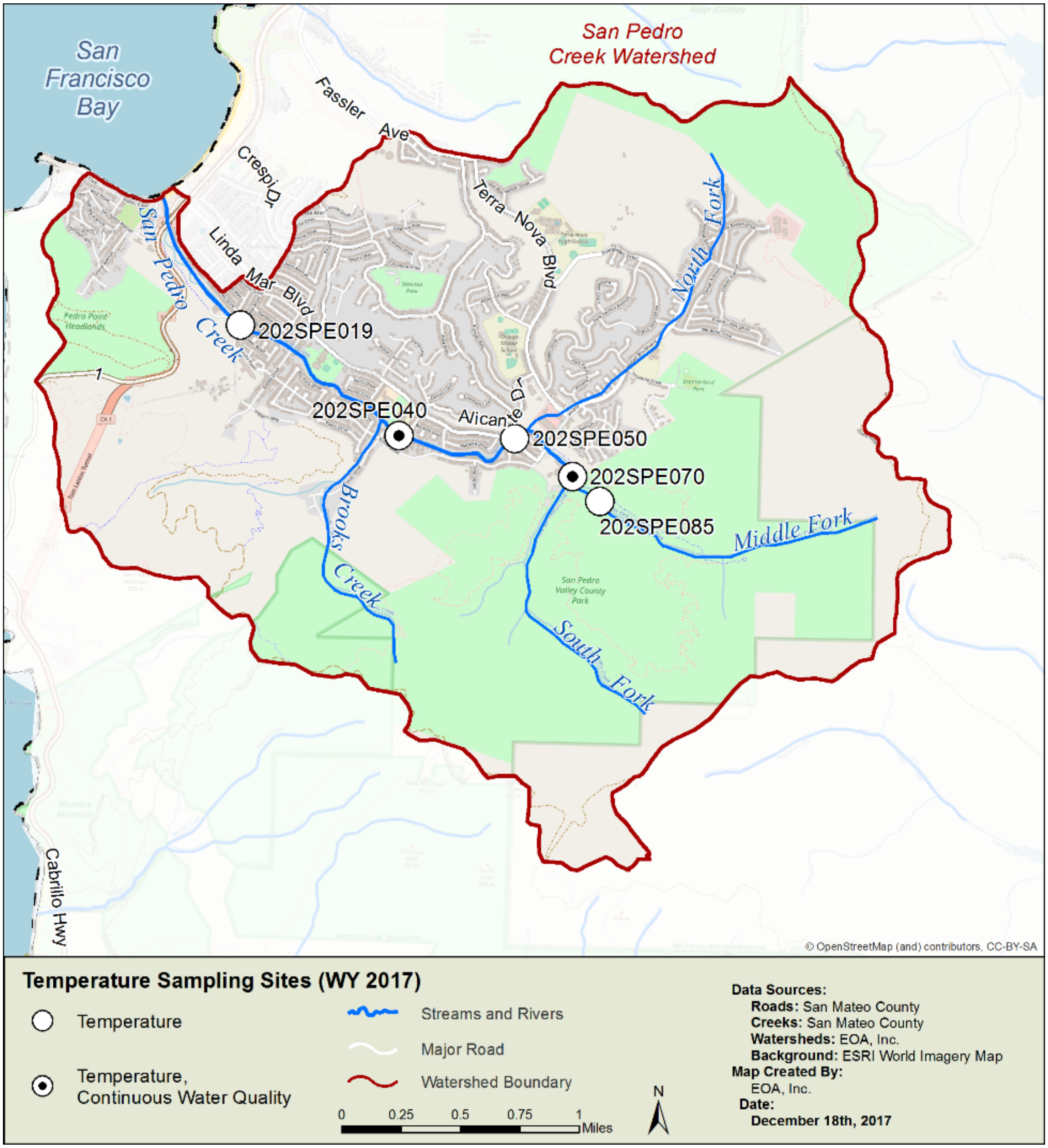

Figure 3.1. Continuous temperature and water quality stations in the San Pedro Creek watershed, San Mateo County, WY 2017.

3.2.2 Pathogen Indicators

Pathogen indicator densities were measured during one sampling event in WY 2017 at two stations on Denniston Creek near Pillar Point Harbor, one storm drain discharging to Denniston Creek, one storm drain discharging to Pillar Point Harbor, and one outfall pipe discharging to Pillar Point Harbor (Figure 3.2). The sites were selected to characterize geographic patterns of pathogen indicator densities within the watershed. Samples collected from these sites were used to gather preliminary information that will support a planned SSID study investigating the extent and source(s) of pathogen indicators near Pillar Point Harbor.

Denniston Creek is a water body designated for REC-1 and REC-2 Beneficial Uses in the Basin Plan, although it is unlikely that the creek supports significant water recreation. Pillar Point Harbor is also designated for REC-1 and REC-2 Beneficial Uses in the Ocean Plan (SWRCB 2015) and contains several popular bathing beaches.

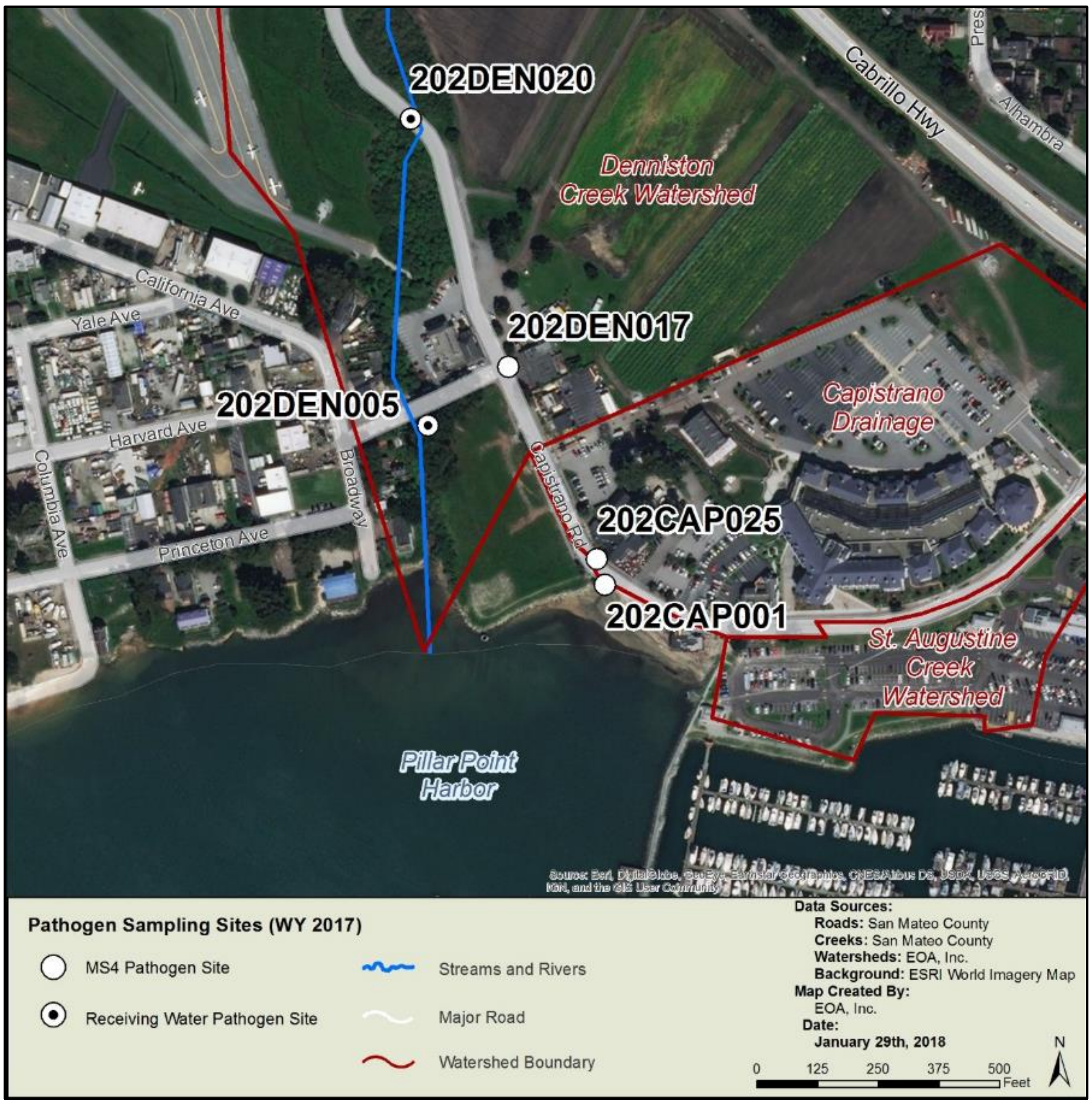

Figure 3.2. Pathogen indicator monitoring sites, Denniston Creek, WY 2017.

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 5 through September 26, 2017. 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 2017. 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 (or use of intermediate sampling containers) 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

Continuous temperature, water quality, and pathogen indicator data generated during WY 2017 were analyzed and evaluated to identify potential stressors that may be contributing to degraded or impacted biological conditions, including exceedances of water quality objectives. Provision C.8.d of the MRP identifies trigger criteria as the principal means of evaluating the creek status monitoring data to identify sites where water quality impacts may have occurred. Sites with targeted monitoring results exceeding the trigger criteria are identified as candidate SSID projects. The relevant trigger criteria for continuous temperature, continuous water quality, and pathogen indicator data are listed in Table 3.1.

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

Monitoring Parameter	Objective/Trigger Threshold	Units	Source
Temperature	Two or more weekly average temperatures exceed the MWAT of 17.0°C for a Steelhead stream, or when 20% of the results at one sampling station exceed the instantaneous maximum of 24°C.	°C	MRP Provision C.8.d.iii.
General Water Quality Parameters	20% of results at each monitoring site exceed one or more established standard or threshold - applies individually to each parameter		
Conductivity	2000	uS/cm	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.

3.4 Results and Discussion

3.4.1 Continuous Temperature

Temperature loggers were deployed at five sites on April 5, 2017, checked on June 12, 2017, and removed on September 30, 2017. All stations 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. The recorded temperatures were relatively consistent between sites, with median values gradually increasing in the downstream direction. Median temperatures ranged from 13.3 °C at the most upstream station, 202SPE085 to 14.7 °C at 202SPE019. All instantaneous temperature data are plotted in Figure 3.3, with the instantaneous maximum temperature threshold (24.0 °C) shown for reference. There were no exceedances of the threshold at any site during WY 2017.

Table 3.2 Descriptive statistics for continuous water temperature measured at five sites in San Mateo County from April 5 through September 26, 2017.

Site ID		202SPE019	202SPE040	202SPE050	202SPE070	202SPE085
Start Date		4/5/2017	4/5/2017	4/5/2017	4/5/2017	4/5/2017
End Date		9/26/2017	9/26/2017	9/26/2017	9/26/2017	9/26/2017
Temperature (ºC)	Minimum	10.9	10.4	10.1	10.1	9.8
	Median	14.7	14.5	13.3	13.3	13.5
	Mean	14.7	14.6	13.3	13.3	13.7
	Maximum	20.4	20.0	17.3	17.3	19.6
	Max 7-day mean	17.6	17.0	16.8	16.8	15.4
	N	4177	4177	4177	4177	4177
MWAT > 17		1	1	0	0	0
MAX > 24		0	0	0	0	0

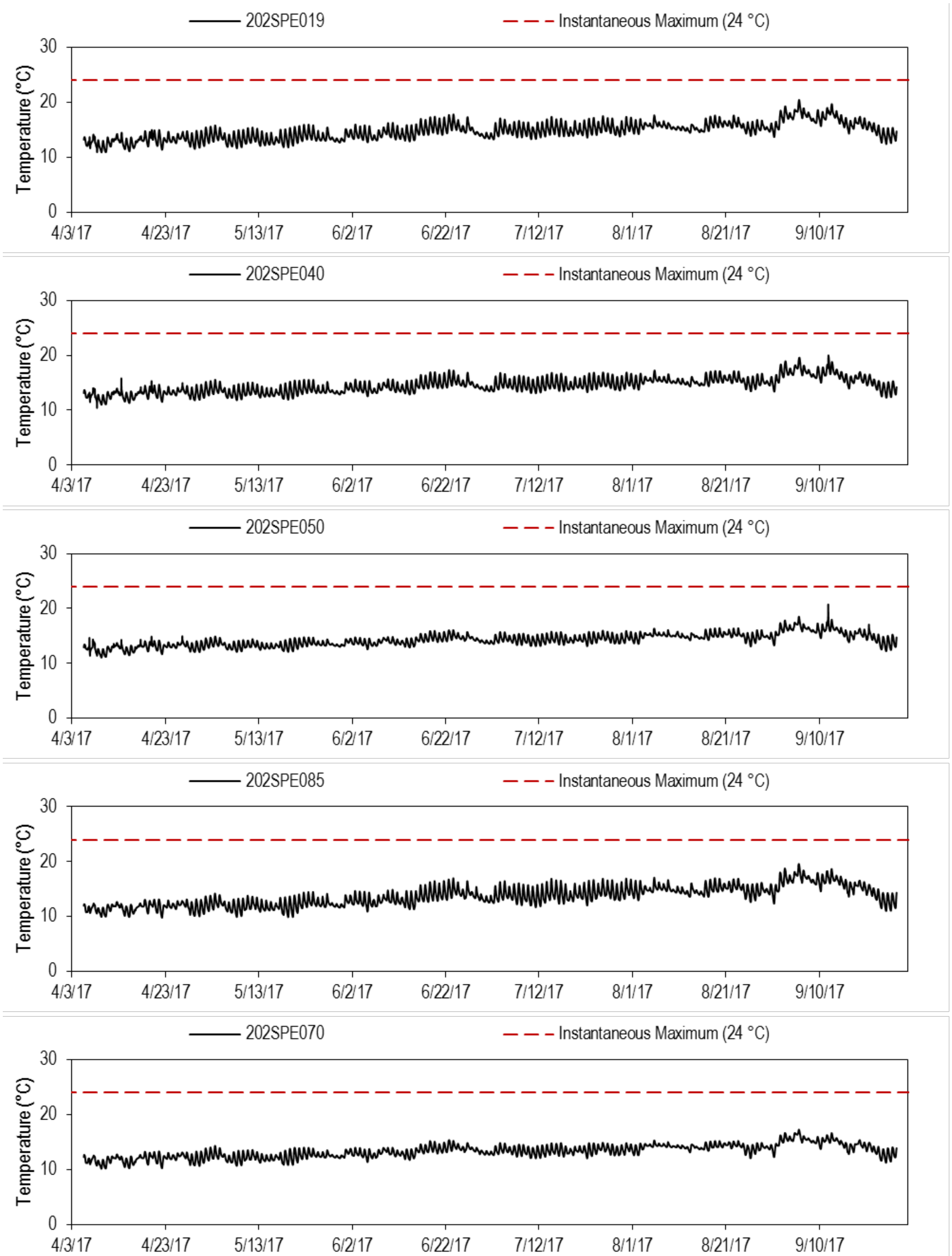

Figure 3.3. Plots of temperature data collected sites in San Pedro Creek, WY 2017.

Consistent with MRP requirements, the Maximum Weekly Average Temperature (MWAT) was calculated for non-overlapping, 7-day periods. Two sites (202SPE019 and 202SPE040) exceeded the MWAT trigger of >17°C during the same week. Of the five sites monitored, these two sites are lowest in the watershed, with the most urban influence and highest percentage of open channel. The exceedances occurred during the week of September 10, during which air temperatures were higher than usual for the time and region. MWAT decreased over the next 10 sampling days and there were no further exceedances. The MRP trigger for MWAT is an exceedance of >17°C for two consecutive weeks; no exceedance of that trigger was observed at any of the sample locations.

The MWAT values calculated from temperatures recorded at five stations are plotted in Figure 3.4. Temperatures only exceeded the MRP threshold for MWAT at sites 202SPE019 and 202SPE040 during the week of September 10.

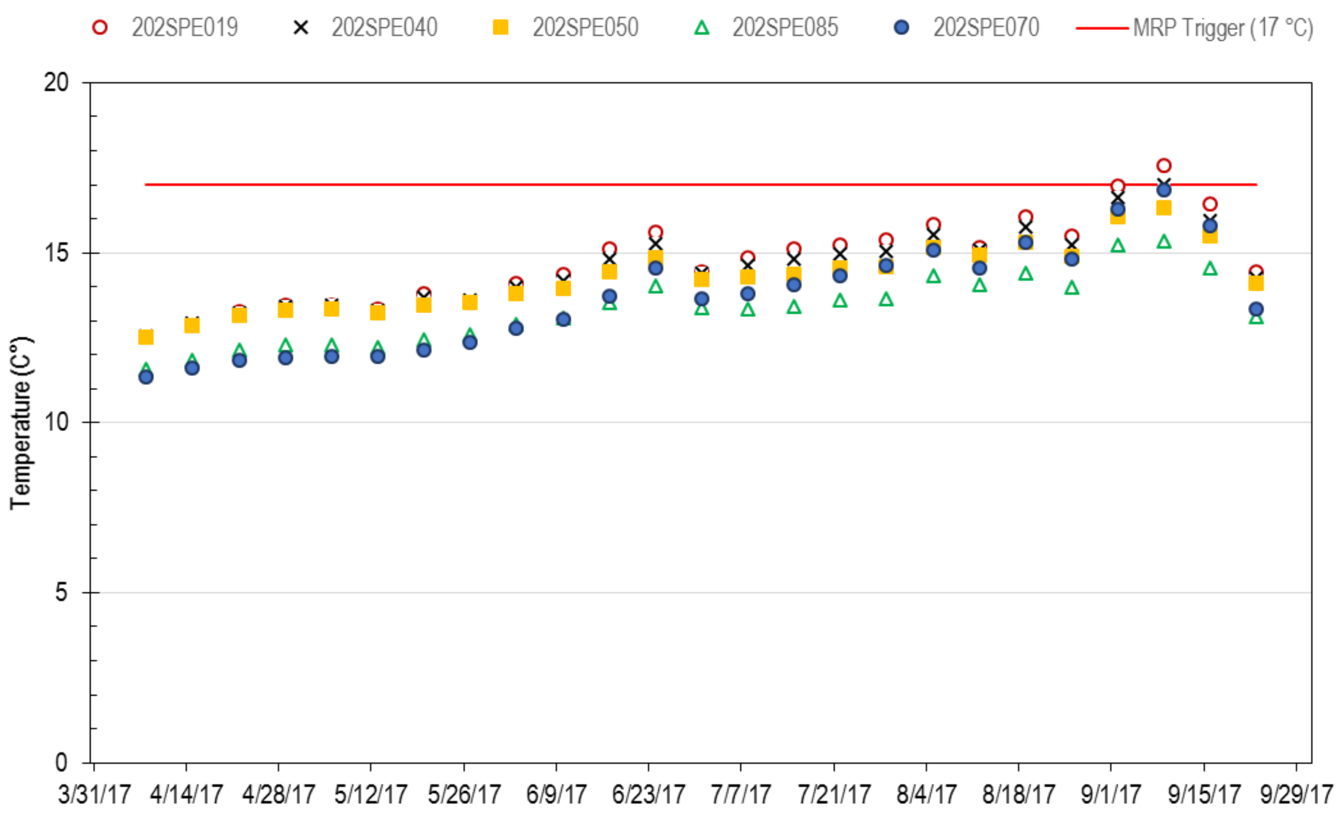

Figure 3.4 Plot showing MWAT values calculated for water temperature collected at five sites in San Pedro Creek in WY 2017.

A summary of the MRP trigger analyses for water temperature collected in WY 2017 is presented in Table 3.3.

Table 3.3. Trigger analysis of WY2017 temperature data, San Pedro Creek. Trigger exceedances are shown in bold.

Site ID	Creek	Number of Weeks MWAT > 17ºC	Trigger Exceeded	% of Results Inst. Max > 24ºC	Trigger Exceeded
202SPE019	San Pedro Creek	1	No	0	No
202SPE040		1	No	0	No
202SPE050		0	No	0	No
202SPE085		0	No	0	No
202SPE070		0	No	0	No

The Basin Plan (SFRWQCB 2017) designates several Beneficial Uses for San Pedro 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 predominantly though the habitat of the protected Middle Fork San Pedro Creek. The restored section of the main stem of the creek is best suited for rearing to smolt size. Measured water quality and temperature are likely not limiting factors for steelhead trout in the creek.

3.4.2 General Water Quality

Summary statistics for general water quality measurements collected at the two stations in San Pedro Creek are listed in Table 3.4. For Event 1, sondes were deployed on May 30 and retrieved on June 12, 2017. For Event 2, sondes were deployed on August 25 and retrieved on September 5, 2017. Time series plots of the data for Event 1 and Event 2 are shown in Figures 3.5 and 3.6, respectively. MRP trigger thresholds are shown for reference. Station locations are mapped in Figure 3.1.

Table 3.4. Descriptive statistics for continuous water temperature, dissolved oxygen, pH, and specific conductance measured at sites in San Mateo County during WY 2017. Data were collected every 15 minutes over a two two-week time periods during May/June (Event 1) and August/September (Event 2).

Parameter	Data Type	202SPE040 San Pedro Creek near the Dog Park		202SPE070 San Pedro Creek Middle Fork	
		May/June WY17	Aug/Sept WY17	May/June WY17	Aug/Sept WY17
Temperature (°C)	Minimum	12.5	13.2	11.5	12.0
	Median	13.9	15.7	13.0	14.4
	Mean	14.0	15.7	13.1	14.6
	Maximum	15.6	18.8	14.1	16.7
	% > 24	0%	0%	0%	0%
Dissolved Oxygen (mg/L)	Minimum	9.9	9.7	10.2	9.8
	Median	10.3	10.7	10.5	10.4
	Mean	10.2	10.6	10.5	10.4
	Maximum	10.6	11.5	10.9	11.1
	% < 7	0%	0%	0%	0%
pH	Minimum	8.13	8.12	7.83	7.81
	Median	8.24	8.22	7.92	7.96
	Mean	8.24	8.24	7.92	7.93
	Maximum	8.32	8.45	7.98	8.02
	% < 6.5 or > 8.5	0%	0%	0%	0%
Specific Conductivity (uS/cm)	Minimum	379	362	255	219
	Median	409	374	260	229
	Mean	409	374	260	229
	Maximum	442	383	264	239
	% > 2000	0%	0%	0%	0%
Total number of data points (N)		1220	1045	1217	1043

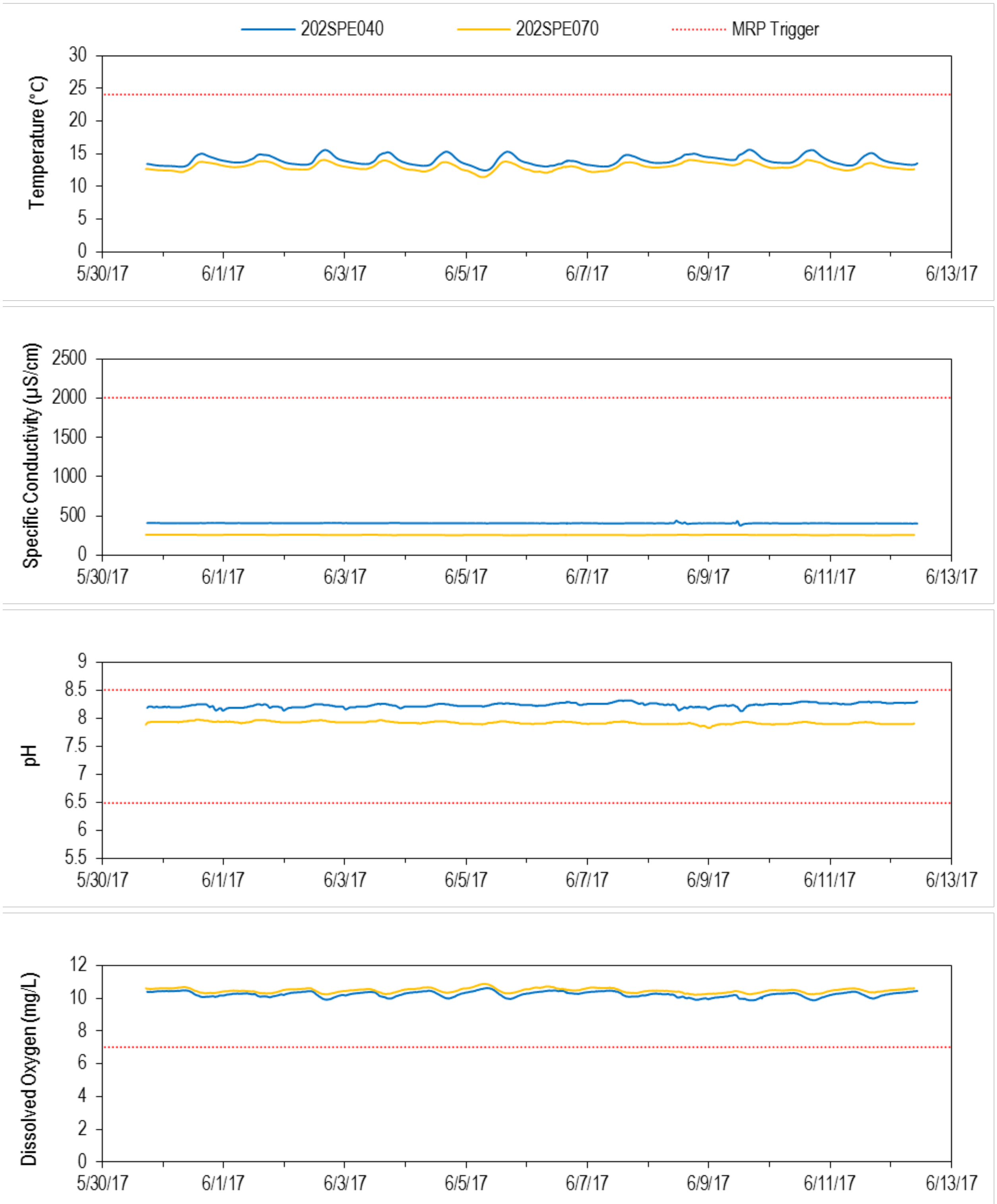

Figure 3.5 Continuous water quality data (temperature, specific conductance, pH, and dissolved oxygen) collected at San Pedro Creek Main Stem (202SPE40) and below the confluence of Middle and South Fork San Pedro Creek (202SPE070) during May 30 – June 12, 2017 (Event 1).

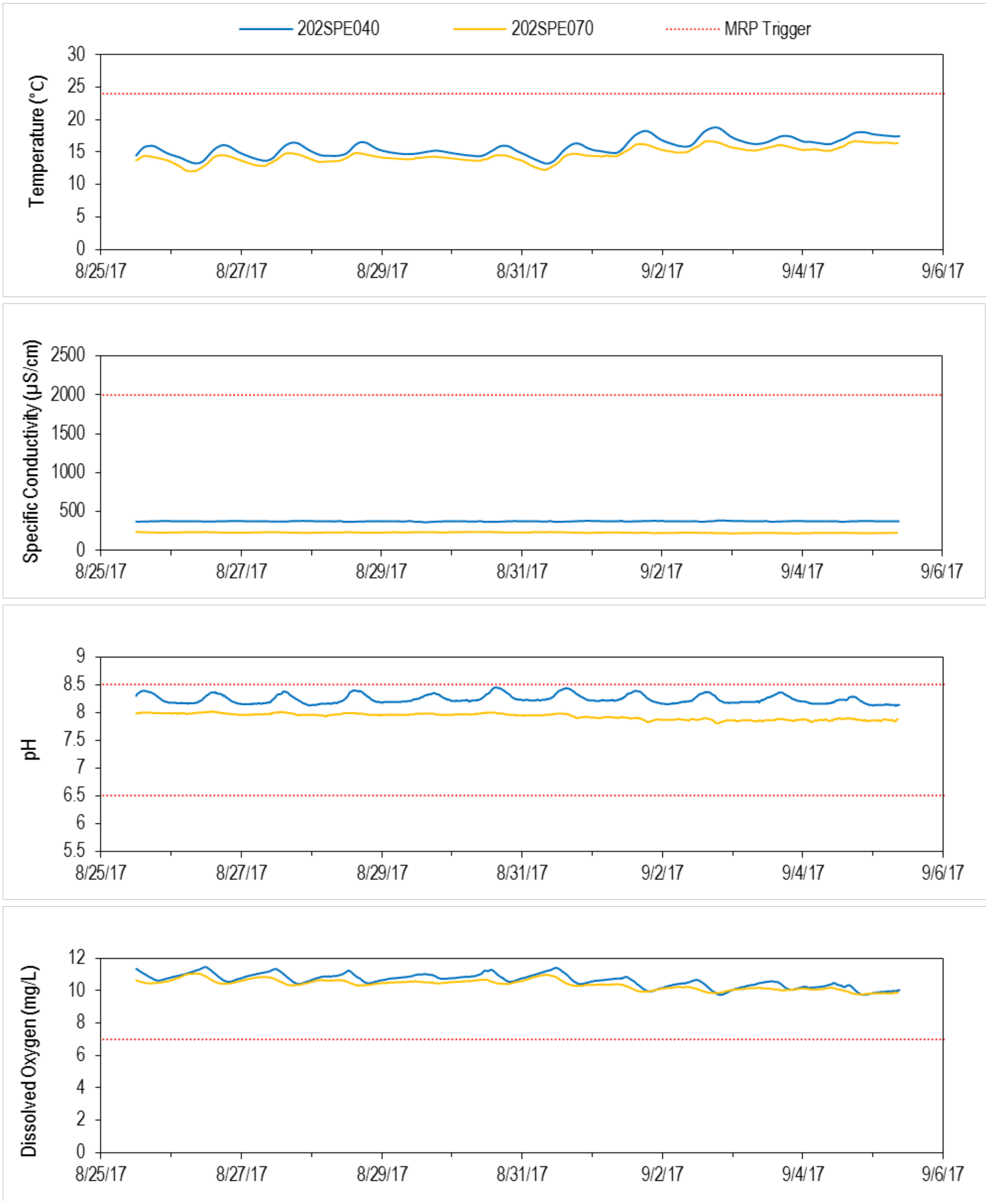

Figure 3.6 Continuous water quality data (temperature, specific conductance, pH, and dissolved oxygen) collected at San Pedro Creek Main Stem (202SPE40) and below the confluence of Middle and South Fork San Pedro Creek (202SPE070) during August 25 – September 6, 2017 (Event 2).

Temperature

Water temperatures never exceeded the 24°C maximum trigger threshold for salmonids at any of the sites for either sampling event (Table 3.4). There were also no exceedances of this trigger during the longer period of record measured with the hobo devices at the same station. MWAT was not calculated for temperature data collected by sondes due to limited number of data points (at least two 7-day periods are required to determine MRP trigger). However, MWAT was calculated for temperature data collected by hobos at both sonde locations. Section 3.4.1 noted that the MWAT threshold of 17°C was exceeded once at the Middle Fork San Pedro Creek station (202SPE040); however, the MRP trigger threshold, which requires that two or more weeks exceed the MWAT was not exceeded.

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 both sampling events. DO concentrations were similar at both locations, ranging between 9.8 mg/L and 11.5 mg/L. The high concentrations are likely a result of the consistent flows observed at both locations during WY 2017, which are supported by several springs in the upper watershed.

pH

During the two sampling events, all pH measurements fell within the Basin Plan WQOs for pH (< 6.5 and/or > 8.5). pH was higher at the downstream site (202SPE040) where it fluctuated between 8.12 and 8.45, with the higher measurements recorded during Event 2 (Figure 3.6). The site is located in a more urbanized part of the creek, and run-off from the surrounding land uses may contribute to the higher pH.

Specific Conductivity

Specific conductance measurements did not exceed the MRP trigger of 2000 µs/cm during either sampling event. Conductivity was slightly higher at the downstream station (202SPE040) compared to the upstream station. Conductivity was also slightly higher during Event 1 compared to Event 2.

3.4.3 Pathogen Indicators

Pathogen indicator (*E. coli* and enterococci) densities measured in grab samples collected on August 28, 2017 are listed in Table 3.5. Stations are mapped in Figure 3.2. Four samples exceeded the MRP trigger for enterococci (202CAP001, 202DEN017, 202CAP025, and 202DEN005). Three samples exceeded the MRP trigger for *E. coli* (202CAP001, 202DEN017, and 202CAP0250). Both of the stations in the Capistrano drainage catchment had pathogen indicator densities exceeding the trigger, with no differences between stations. In the Denniston Creek watershed, the "upstream" station (202DEN020) had relatively low pathogen indicator densities. The "downstream" station (202DEN005) had higher pathogen indicator densities, with enterococci exceeding the trigger. Station 202DEN005 is just downstream of the municipal separate storm sewer system (MS4) outfall that was characterized at station 202DEN017 and which had high levels of both pathogen indicators. Discharges from the MS4 may have contributed to the trigger exceedance at 202DEN005; however, there may also be other sources of bacteria between 202DEN020 and 202DEN005, such as wildlife and homeless encampments.

The pathogen indicator data collected near Pillar Point Harbor in WY 2017 will be used to initiate an SSID study based on pathogen indicators in the area. The purpose of this study is to identify geographic, seasonal, and species-specific sources of bacteria to Pillar Point Harbor from urban areas drained by the MS4 and covered by the MRP. Potential sources of pathogen indicators include, but are not limited to, pet waste, wildlife, bacterial growth within the conveyance system, and leaking public and private sewer lines.

It is important to recognize that a) the REC-1 WQOs for pathogen indicators in the Basin Plan and Ocean 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). It should also be noted that WQOs for pathogen indicators used in this monitoring effort are not applicable to the water that discharges from storm drains or outfall pipes. WQOs represent the maximum level of pollutants that can remain in the water column without adversely affecting the beneficial uses designated for a receiving water body. Since dilution occurs when water from the MS4 mixes with receiving waters, the pollutant concentrations present in the MS4 would not be an accurate representation of the pollutant concentrations present after discharge to a receiving water body.

The State Board is currently in the process of adopting modified WQOs for enterococci and *E. coli* based on USEPA criteria that will serve as new MRP Trigger Thresholds. A statistical threshold value for enterococci of 320 cfu/100mL will likely be used for samples in waters where the salinity is less than 10 parts per thousand 95% of the time, and a statistical threshold value for *E. coli* of 110 cfu/100mL will likely be used for samples in waters where the salinity is equal to or greater than 10 parts per thousand 95% of the time. The new statistical threshold values correspond with an Estimated Illness Rate (NGI) of 32 per 1,000 water contact recreators.[20]

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[20] See http://www.waterboards.ca.gov/bacterialobjectives/ for more information.

Table 3.5. Enterococci and *E. coli* levels measured in San Mateo County during WY 2017.

Site ID	Creek Name	Site Name	*Enterococci (cfu/100ml) (MPN/100ml)*[1]	*E. Coli (cfu/100ml) (MPN/100ml)*[1]	Sample Date
MRP Trigger Threshold (USEPA 2012b)			*130*	*410*	
202CAP025	NA	Capistrano North Drain	>2419.6	>2419.6	8/28/17
202CAP001	NA	Capistrano Outfall	>2419.6	>2419.6 [2]	8/28/17
202DEN020	Denniston Creek	Denniston at Capistrano Road	62	98.5	8/28/17
202DEN017	NA	Denniston Storm Drain	>2419.6	>2419.6	8/28/17
202DEN005	Denniston Creek	Denniston at Prospect Way	435.2	166.4	8/28/17

[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.

[2] The actual concentration of *E. coli* at 202CAP001 was reported as 15,531 MPN/100 mL. This value was obtained using a dilution factor of 10. Other samples were not diluted and did not have quantitative resolution above 2,419.6 MPN/100mL.

3.5 Conclusions and Recommendations

Targeted monitoring in WY 2017 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 Pedro 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 Pedro Creek watershed during two 2-week periods in May/June (Event 1) and August/September (Event 2). Pathogen indicator grab samples were collected at five sites in the Pillar Point Harbor watershed during a sampling event in August. Targeted monitoring stations were deliberatively selected using the Directed Monitoring Design Principle.

Conclusions and recommendations from targeted monitoring in WY 2017 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

- **Spatial**. There was minimal spatial variability in water temperature across the five stations in the San Pedro Creek watershed. Temperature increased slightly at each downstream site but remained 4 to 7 °C below the instantaneous trigger threshold. Likewise, pH and specific conductivity increased slightly in the downstream direction and dissolved oxygen decreased slightly in the downstream direction.
- **Temporal**. Water temperature increased gradually at all five stations between April and early-September, in response to one of the hottest summers on record. In mid-September, water temperatures dropped relatively quickly in response a much cooler air mass. Differences in general water quality measurements (pH, specific conductivity, dissolved oxygen) between the two two-week monitoring periods (May/June and August/September) were less pronounced.

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 in San Pedro Creek. San Pedro Creek, located in the City of Pacifica, was targeted for temperature and general water quality monitoring because it contains the northern-most population of naturally producing steelhead trout (*Oncorhynchus mykiss*) in San Mateo County.
- The two lowermost temperature stations in San Pedro Creek exceeded the maximum weekly average temperature (MWAT) of 17°C once; this is not considered an exceedance of the trigger which requires two consecutive weeks of exceedance. None of the stations exceeded the maximum instantaneous trigger threshold of 24°C.
- None of the general water quality parameters (temperature, pH, dissolved oxygen, and specific conductance) exceeded any of the MRP trigger thresholds.

Potential Impacts to Water Contact Recreation

- In WY 2017, pathogen indicator samples were collected at two stations on Denniston Creek near Pillar Point Harbor and one storm drain discharging to Denniston Creek, one outfall pipe discharging directly to the beach Pillar Point Harbor, and one storm drain upstream of the outfall pipe. Pillar Point Harbor is the site of an SSID project that will examine the extent and sources of pathogen indicators in the area. Pathogen indicator triggers for enterococci were exceeded at four of the five sites. Triggers for *E. coli* were exceeded at three of the five sites.

- 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 or beaches that do not receive wastewater discharges. As a result, the comparison of pathogen indicator results to body contact recreation water quality objectives may not be appropriate and therefore should be interpreted cautiously. Furthermore, the WQOs for pathogens used in this report cannot be applied to waters sampled directly from the MS4, as dilution occurs when water from the MS4 discharges to a receiving water body. It should also be noted that the WQOs for pathogens used in this report are subject to change in the near future upon adoption by the State Board of new statistical threshold values based on USEPA criteria.

- Municipalities near Half Moon Bay are aware of the bacteria exceedances found in Pillar Point Harbor. Results of the coming SSID study will be used to further inform these municipalities about the nature and extent of the bacteria presence and any potential steps they can take to resolve the issue.

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 inadvertently discharged to the MS4 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 Provision C.8.d.ii of the MRP and to assess whether chlorine in receiving waters is potentially toxic to aquatic life, SMCWPPP field staff measured total and free chlorine residual in creeks where bioassessments were conducted. Total chlorine residual is comprised of combined chlorine and free chlorine, and is always greater than or equal to the free chlorine residual. Combined chlorine is chlorine that has reacted with ammonia or organic nitrogen to form chloramines, while free chlorine is chlorine that remains unbound.

4.2 Methods

In accordance with the BASMAA RMC Creek Status and Long-Term Trends Monitoring Plan (BASMAA 2012), WY2017 field testing for free chlorine and total chlorine residual was conducted at all ten probabilistic sites concurrent with spring bioassessment sampling (May-June. 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 (BASMAA 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 so 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 2017, SMCWPPP monitored the ten probabilistic sites 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.

The trigger thresholds for free chlorine and total chlorine residual were exceeded at one of the stations in Redwood Creek on May 22, 2017. In compliance with Provision C.8.d.ii(4), SMCWPPP staff immediately informed City of Redwood City illicit discharge staff of the exceedances. Redwood City staff conducted follow-up investigations on May 23 and June 20, 2017, during which they sampled for chlorine at the original station and four upstream locations. Elevated concentrations of chlorine were detected at all locations, and the City determined that it came from an upstream (but unknown) source in the Town of Woodside. City and SMCWPPP staff contacted the Town of Woodside and will continue to follow up on elevated chlorine levels in Redwood Creek.

Table 4.1. Summary of SMCWPPP chlorine testing results compared to MRP trigger of 0.1 mg/L, WY 2017.

Station Code	Date	Creek	Free Chlorine (mg/L)[1, 2]	Total Chlorine Residual (mg/L)[1, 2]	Exceeds Trigger?[3] (0.1 mg/L)
202R00550	5/30/2017	Jones Gulch	0.02	0.06	No
202R00552	5/24/2017	Lawrence Creek	< 0.02	< 0.02	No
204R02472	5/22/2017	Redwood Creek	0.06 / **0.15**	**0.58 / 0.51**	Yes
204R02611	5/23/2017	Atherton Creek	0.02	0.05	No
204R03240	5/23/2017	Atherton Creek	0.06	0.07	No
204R03252	5/31/2017	San Mateo Creek	< 0.02	< 0.02	No
204R03272	5/31/2017	San Mateo Creek	0.02	0.05	No
204R03316	5/24/2017	Arroyo Ojo de Agua	0.03	0.04	No
204R03336	5/25/2017	Belmont Creek	0.02	0.02	No
204R03496	5/22/2017	Redwood Creek	0.02	0.07	No
Number of sites exceeding 0.1 mg/L:			1	1	1

[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 2017 and prior monitoring results suggest there are occasional trigger exceedances of free chlorine and total chlorine residual 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. SMCWPPP 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 the combined toxic effects (acute and chronic) of all chemicals present in samples of receiving waters or sediments. 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

SMCWPPP is required to conduct water toxicity and sediment chemistry and toxicity monitoring at one location per year during the dry season, for 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 during storm events for toxicity testing and analysis of pyrethroids, fipronil, imidacloprid and indoxacarb. The MRP states that monitoring locations should be representative of urban watersheds (i.e., bottom of watersheds).

The MRP states that if the wet season monitoring is conducted by the RMC on behalf of all Permittees, a total of ten collective 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. SCVURPPP and ACCWP will each collect three samples and SMCWPPP and CCCWP will each collect two samples. The RMC is still in the process of defining the monitoring approach.

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

5.2 Methods

5.2.1 Site Selection

In WY 2017, 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: San Pedro Creek in the City of Pacifica (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. SMCWPPP monitored Laurel Creek in WY 2016 and 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.

Total PAH concentrations were calculated by summing the concentrations of 24 individual PAHs. Concentrations equal to one-half of the respective laboratory method detection limits were substituted for non-detect data so that calculations and statistics could be computed. Therefore, some of the TEC and PEC quotients may be artificially elevated (and contribute to trigger exceedances) due to the method used to account for non-detect data.

The TECs for bedded sediments are very conservative values that do not consider site specific background conditions, and are therefore not very useful in identifying real water quality concerns in receiving waters in the San Mateo County. All sites in the 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 results, based on available literature values for pyrethroids in sediment LC50 values.[21,22] Because organic carbon mitigates the toxicity of pyrethroid 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 2017 dry weather water and sediment samples. Based on the results, it is not necessary to add San Pedro Creek to the list of potential SSID projects.

The water sample was significantly toxic to two of the test organisms (*C. dubia and P. promelas*); however, the Percent Effect did not exceed the 50% threshold for follow-up. The cause of the water toxicity is unknown. The sediment sample was not toxic to either of the test organisms.

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

[22] No LC50 is published for carbaryl.

Table 5.1. Summary of SMCWPPP water toxicity results, San Pedro Creek, WY 2017.

Site	Organism	Test Type	Unit	Results		% Effect	TST Value	Follow up needed (TST "Fail" and **≥50%)**
				Lab Control	Organism Test			
202SPE005 San Pedro Creek	Water							
	Ceriodaphnia dubia	Survival	%	100	100	0%	NA [1]	No
		Reproduction	Num/Rep	30.2	16.2	46.4%	Fail	No
	Pimephales promelas	Survival	%	97.5	80	18.0%	Fail	No
		Growth	mg/ind	0.548	0.497	9.27%	Pass	No
	Chironomus dilutus	Survival	%	95	92.5	3%	Pass	No
	Hyalella azteca	Survival	%	98	97.8	0.23%	Pass	No
	Selenastrum capricornutum	Growth	cells/ml	3000000	5580000	-85.5%	Pass	No
	Sediment							
	Chironomus dilutus	Survival	%	96.2	97.5	-1.30%	Pass	No
	Hyalella azteca	Survival	%	97.5	98.8	-1.28%	Pass	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 concentrations and TEC quotients for sediment chemistry constituents (metals and total PAHs). TEC quotients are calculated as the measured concentration divided by the highly conservative TEC value, per MacDonald et al. (2000)[23]. 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 San Pedro 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 concentrations and PEC quotients for sediment chemistry constituents (metals and total PAHs), calculated as the measured concentration divided by the PEC value,

[23] 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.

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 5.2. Threshold Effect Concentration (TEC) quotients for WY 2017 sediment chemistry constituents. Bolded and shaded values indicate TEC quotient ≥ 1.0.

		202SPE005 San Pedro Creek	
	TEC	Concentration	Quotient
Metals (mg/kg DW)			
Arsenic	9.79	5.2	0.53
Cadmium	0.99	0.09	0.091
Chromium	43.4	48	1.1
Copper	31.6	29	0.92
Lead	35.8	8.9	0.25
Nickel	22.7	61	3
Zinc	121	74	0.61
PAHs (ug/kg DW)			
Total PAHs	1,610	41 [a]	0.025
# Constituents with TEC quotient >= 1.0		2	

[a] Total PAHs calculated using ½ MDLs.

Table 5.3. Probable Effect Concentration (PEC) quotients for WY 2017 sediment chemistry constituents. Bolded and shaded values indicate PEC quotient ≥ 1.0.

		202SPE005 San Pedro Creek	
	PEC	Concentration	Quotient
Metals (mg/kg DW)			
Arsenic	33.0	5.2	0.16
Cadmium	4.98	0.09	0.018
Chromium	111	48	0.43
Copper	149	29	0.19
Lead	128	8.9	0.070
Nickel	48.6	61	**1.3**
Zinc	459	74	0.16
PAHs (ug/kg DW)			
Total PAHs	22,800	41 [a]	0.0018
# Constituents with PEC quotient >= 1.0		**1**	

[a] Total calculated using ½ MDLs.

Table 5.4 lists the concentrations of pesticides measured in sediment samples and calculated TU equivalents for the pesticides for which there are published LC50 values in the literature. 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 in the sample, and the TOC-normalized concentrations were used to compute TU equivalents. Most of the pesticides measured were below method detection limits (MDLs) and are listed as ½ MDLs in Table 5.4. Others were below the reporting limits as noted in Table 5.4. All of the calculated TU equivalents were less than 0.04. The highest TU equivalent was for bifenthrin (0.036) which is considered to be the leading cause of pyrethroid-related toxicity in urban areas (Ruby 2013).

Table 5.4. Pesticide concentrations and calculated toxic unit (TU) equivalents, WY 2017.

			202SPE005 San Pedro Creek		
	Unit	LC50 [d]	Concentration	Normalized to TOC	TU Equivalent
Total Organic Carbon	%		2.1		
Pyrethroids					
Bifenthrin	µg/g dw	0.52	0.00039	0.019	0.036
Cyfluthrin	µg/g dw	1.08	0.00006 [a]	0.0026	0.0024
Cypermethrin	µg/g dw	0.38	0.00005 [a]	0.0024	0.0063
Deltamethrin	µg/g dw	0.79	0.00006 [a]	0.0029	0.0036
Esfenvalerate	µg/g dw	1.54	0.00007 [a]	0.0031	0.0020
Lambda-Cyhalothrin	µg/g dw	0.45	0.00003 [a]	0.0015	0.0032
Permethrin	µg/g dw	10.83	0.00024 [b]	0.011	0.0011
Other Pesticides					
Carbaryl	mg/Kg dw	NA [c]	0.01 [a]	NA	NA
Fipronil	ng/g dw	NA [c]	0.12 [b]	NA	NA
Fipronil Desulfinyl	ng/g dw	NA [c]	0.05 [a]	NA	NA
Fipronil Sulfide	ng/g dw	NA [c]	0.05 [a]	NA	NA
Fipronil Sulfone	ng/g dw	NA [c]	0.27 [b]	NA	NA

a. Concentration was below the method detection limit (MDL). Value listed is 1/2 MDL.
b. Concentration below the reporting limit (J-flagged).
c. No available LC50 value for Carbaryl or Fipronil.
d. Sources: Amweg et al. 2005 and Maund et al. 2002

In compliance with the MRP, a grain size analysis was conducted on the sediment sample (Table 5.5). The San Pedro Creek sample was 18% fines (i.e., 6.5% clay and 11% silt). It unknown whether the relatively high percent fines in the sample influenced the toxicity tests or sediment chemistry analyses.

Table 5.5. Summary of grain size for site 202SPE005 in San Mateo County during WY 2017.

Grain Size (%)		202SPE005
		San Pedro Creek
Clay	<0.0039 mm	6.5%
Silt	0.0039 to <0.0625 mm	11%
Sand	V. Fine 0.0625 to <0.125 mm	5.3%
	Fine 0.125 to <0.25 mm	7.4%
	Medium 0.25 to <0.5 mm	16%
	Coarse 0.5 to <1.0 mm	27%
	V. Coarse 1.0 to <2.0 mm	26%
Granule	2.0 to <4.0 mm	16%
Pebble	Small 4 to <8 mm	26%
	Medium 8 to <16 mm	4.5%
	Large 16 to <32 mm	0%
	V. Large 32 to <64 mm	0%

5.4 Conclusions and Recommendations

Statistically significant toxicity to *C. dubia* and *P. promelas* was observed in water 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. The cause of the observed toxicity is unknown. Pesticide concentrations in the sediment sample were all very low, most below the MDL and TU equivalents did not exceed 0.04.

TEC and PEC quotients were calculated for all metals and total PAHs measured in sediment samples. Two TEC and one PEC quotients exceeded 1.0. In compliance with the MRP, San Pedro 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 2017, 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 2017 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. These analyses were limited to the WY 2017 dataset which does not contain a statistically significant number of records. A more comprehensive analysis of the much larger bioassessment dataset from the previous five years (WY 2012 – WY 2016) is currently being conducted by the BASMAA RMC on a regional and countywide basis. Results of the BASMAA regional study will be available by late 2018. Analytical tools that are found to be useful in evaluating stressor association with biological condition may be implemented in future annual monitoring reports.

6.1 Conclusions

6.1.1 Biological Condition Assessment (WY 2017)

Bioassessment monitoring was conducted at ten sites in WY 2017. The sites were sampled for BMIs, benthic algae, physical habitat, and nutrients using methods consistent with the BASMAA RMC QAPP (BASMAA 2016a) and SOPs (BASMAA 2016b). Stations were randomly selected using a probabilistic monitoring design. Eight of the sites (80%) were classified as urban and two (20%) were classified as non-urban.

The California Stream Condition Index is a statewide tool that translates benthic macroinvertebrate data into an overall measure of stream health. The CSCI is currently the most robust method of assessing aquatic biological health. There are also three benthic algae indices of biological integrity available (D18, H20, S2); however, the applicability of the algae IBIs in San Mateo County streams is uncertain. This is due to several factors including:

- There is an overall dearth of soft algae taxa found in San Mateo streams. This may not reflect stream health, but it significantly lowers the scores of two of the algae IBIs (H20 and S2).
- The algae IBIs were developed for Southern California streams and may not provide adequate interpretations of Northern California algae communities.
- Statewide Algae Stream Condition Indices are currently being developed and are anticipated to be available in 2018.

Of the ten sites monitored in WY 2017, two sites (20%) were rated in good condition (CSCI scores ≥ 0.795); two sites (20%) rated as likely altered condition (CSCI score 0.635 – 0.795), and six sites (60%) rated as very likely altered condition (≤ 0.635). The two sites in good condition were classified as non-urban and located in protected open space or County Park land. Three of the lowest CSCI scores occurred at sites located in concrete channels.

Relationships between potential stressors (physical habitat and water chemistry) and biological condition were explored on a limited basis using the WY 2017 dataset.

- Physical Habitat Assessment (PHAB) scores, a qualitative tool that assesses the overall habitat condition of the sampling reach during the assessment, were compared to biological condition indictor scores. PHAB consists of three attributes that are assessed for the entire bioassessment reach. These include channel alteration, epifaunal substrate and sediment deposition. Total PHAB scores were moderately correlated with CSCI scores (r^2=0.51, p value = 0.02) suggesting that physical habitat (e.g., substrate quality, channel alteration) has an influence on the BMI community. Individual physical habitat metrics associated with substrate size and composition were also correlated with CSCI scores.
- Landscape variables were calculated for each of the watershed areas draining into the bioassessment sites. CSCI scores were moderately correlated (negatively) with impervious area and road density.

Stressor Assessment

Sites with CSCI scores and/or stressor levels exceeding applicable WQOs and triggers identified in the MRP will be considered as candidates for SSID projects.

- The eight sites with CSCI scores below 0.795 will be considered as candidates for SSID projects.
- **General water quality** (pH, temperature, dissolved oxygen, specific conductance). Two measurements exceeded water quality objectives for pH site 204R02472 (Redwood Creek), site 204R02611 (Atherton Creek) and site 204R03316 (Ojo de Agua). These sites will be considered as candidates for SSID projects.
- **Nutrients and conventional analytes** (ammonia, unionized ammonia, chloride, AFDM, chlorophyll a, nitrate, nitrite, TKN, ortho-phosphate, phosphorus, silica). There were no water quality objective exceedances for water chemistry parameters.

6.1.2 Targeted Monitoring for Temperature and General Water Quality

Targeted monitoring in WY 2017 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 Pedro Creek watershed from April through September. Continuous (15-minute) general water quality measurements (pH, DO, specific conductance, temperature) were recorded at two of the sites in the San Pedro Creek subwatershed during two 2-week periods in May/June (Event 1) and August/September (Event 2). Pathogen indicator grab samples were collected at five sites in the Pillar Point Harbor watershed during a sampling event in June.

Continuous temperature, water quality, and pathogen indicator data generated during WY 2017 were analyzed and evaluated to identify potential stressors that may be contributing to degraded or impacted biological conditions. The MRP 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.

Temperature and General Water Quality

San Pedro Creek, located in the City of Pacifica, was targeted for temperature and general water quality monitoring because it contains the northern-most population of naturally producing steelhead trout (*Oncorhynchus mykiss*) in San Mateo County.

- There was minimal spatial variability in water temperature across the five stations in the San Pedro Creek watershed. Temperature increased slightly at each downstream site but remained 4 to 7 °C below the instantaneous trigger threshold. Likewise, pH and specific conductivity increased slightly in the downstream direction and dissolved oxygen decreased slightly in the downstream direction.
- Water temperature increased gradually at all five stations between April and early-September, in response to one of the hottest summers on record. In mid-September, water temperatures dropped relatively quickly in response a much cooler air mass. Differences in general water quality measurements (pH, specific conductivity, dissolved oxygen) between the two two-week monitoring periods (May/June and August/September) were less pronounced.
- None of the temperature or general water quality parameters (temperature, pH, dissolved oxygen, and specific conductance) exceeded any of the MRP trigger thresholds.

Pathogen Indicators

In WY 2017, pathogen indicator samples were collected at two stations on Denniston Creek near Pillar Point Harbor and one storm drain discharging to Denniston Creek, one outfall pipe discharging directly to the beach Pillar Point Harbor, and one storm drain upstream of the outfall pipe. Pillar Point Harbor is the site of an ongoing SSID project that is examining the extent and sources of pathogen indicators in the area. Pathogen indicator triggers for enterococci were exceeded at four of the five sites. Triggers for *E. coli* were exceeded at three of the five sites.

- 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 or beaches that do not receive wastewater discharges. 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. Furthermore, the WQOs for pathogens used in this report cannot be applied to waters sampled directly from the MS4, as dilution occurs when water from the MS4 discharges to a receiving water body. It should also be noted that the WQOs for pathogens used in this report are subject to change in the near future due to adoption by the State Board of new statistical threshold values based on USEPA criteria.

- Municipalities near Half Moon Bay are aware of the bacteria exceedances found in Pillar Point Harbor. Results of the coming SSID study will be used to further inform these municipalities about the nature and extent of the bacteria presence and any potential steps they can take to resolve the issue.

6.1.3 Chlorine Monitoring

Free chlorine and total chlorine residual was measured concurrently with bioassessments at the ten probabilistic sites in compliance with Provision C.8.c.ii. While chlorine residual is generally not a concern in San Mateo County creeks, WY 2017 and prior monitoring results suggest there are occasional free chlorine and total chlorine residual exceedances in the County. In WY 2017, exceedances of the MRP trigger for chlorine (0.1 mg/L) were detected at one station on Redwood Creek. Redwood City illicit discharge staff were notified and conducted an immediate followup investigation. The elevated chlorine measurements were tracked to the upstream edge of the Redwood City jurisdication and subsequently report to the Town of Woodside. Chlorine exceedances are typically 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. SMCWPPP 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 2017, SMCWPPP conducted dry weather pesticides and toxicity monitoring at one station (San Pedro Creek) in compliance with Provision C.8.g of the MRP.

Statistically significant toxicity to *C. dubia* and *P. promelas* was observed in water 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. The cause of the observed toxicity is unknown. Pesticide concentrations in the sediment sample were all very low, most below the MDL and TU equivalents did not exceed 0.04.

TEC and PEC quotients were calculated for all metals and total PAHs (calculated as the sum of 24 individual PAHs) measured in sediment samples. Two TEC and one PEC quotients exceeded 1.0. In compliance with the MRP, San Pedro 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 will work with the BASMAA RMC partners to implement 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 2017). 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 2017 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 2017. "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]
202R00550	Jones Gulch	No	No	No	--	--	--	--	--	--	--	--
202R00552	Lawrence Creek	No	No	No	--	--	--	--	--	--	--	--
204R02472	Redwood Creek	Yes	No	Yes	--	--	--	--	--	Yes	--	--
204R02611	Atherton Creek	Yes	No	No	--	--	--	--	--	Yes	--	--
204R03240	Atherton Creek	Yes	No	No	--	--	--	--	--	--	--	--
204R03252	San Mateo Creek	Yes	No	No	--	--	--	--	--	--	--	--
204R03272	San Mateo Creek	Yes	No	No	--	--	--	--	--	--	--	--
204R03316	Arroyo Ojo de Agua	Yes	No	No	--	--	--	--	--	Yes	--	--
204R03336	Belmont Creek	Yes	No	No	--	--	--	--	--	--	--	--
204R03496	Redwood Creek	Yes	No	No	--	--	--	--	--	--	--	--
202SPE005	San Pedro Creek	--	--	--	No	No	Yes	--	--	--	--	--
202DEN017	NA (MS4)	--	--	--	--	--	--	--	--	--	--	NA
202DEN005	Denniston Creek	--	--	--	--	--	--	--	--	--	--	No
202DEN020	Denniston Creek	--	--	--	--	--	--	--	--	--	--	Yes
202CAP001	NA (MS4)	--	--	--	--	--	--	--	--	--	--	NA
202CAP025	NA (MS4)	--	--	--	--	--	--	--	--	--	--	NA
202SPE019	San Pedro Creek	--	--	--	--	--	--	No	--	--	--	--
202SPE040	San Pedro Creek	--	--	--	--	--	--	No	No	No	No	--
202SPE050	San Pedro Creek	--	--	--	--	--	--	No	--	--	--	--
202SPE070	San Pedro Creek	--	--	--	--	--	--	No	No	No	No	--
202SPE085	San Pedro Creek	--	--	--	--	--	--	No	--	--	--	--

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 San Mateo County and identifying stressors and sources of impacts observed. The sample size from WY 2017 (overall n=10; urban n=8) is not sufficient to develop statistically representative conclusions regarding the overall condition of all creeks. However, it builds on data collected in WY 2012 through WY 2016 which are currently being analyzed by a BASMAA RMC regional project. The BASMAA regional project will assess stream conditions and stressors for the five-year dataset (WY 2012 – WY 2016) on regional and countywide basis. It will review and develop statistical tools that can be utilized in the future to analyze the growing dataset. It will also recommend options for modifying the RMC creek status monitoring program during the next reissue of the MRP, perhaps with a focus on trends monitoring.

Like previous years, WY 2017 data suggest that most urban streams have likely or very likely altered populations of aquatic life indicators (e.g., aquatic macroinvertebrates). These conditions are likely the result of long-term changes in stream hydrology, channel geomorphology, in-stream habitat complexity, and other modifications to the watershed and riparian areas associated with the urban development that has occurred over the past 50 plus years.

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 2017 that specifically target mercury and PCBs are described in the Pollutants of Concern Monitoring Data Report that is included as Appendix D to the WY 2017 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.

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ATTACHMENTS

Attachment 1

QA/QC Report

Quality Assurance/Quality Control Report

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March 31, 2018

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ACRONYMS

BASMAA	Bay Area Stormwater Management Agencies Association
BMI	Benthic Macroinvertebrates
CDFW	California Department of Fish and Wildlife
DQO	Data Quality Objective
EDDs	Electronic data deliverables
EV	Expected Value
KLI	Kinnetic Laboratories, Inc.
LCS	Laboratory Control Sample
LCSD	Laboratory Control Sample Duplicate
MPN	Most Probably Number
MQO	Measurement Quality Objective
MRP	Municipal Regional Permit
MS	Matrix Spike
MSD	Matrix Spike Duplicate
MV	Measured Value
ND	Non-detect
NIST	National Institute of Standards and Technology
NPDES	National Pollution Discharge Elimination System
NV	Native Value
PAH	Polycyclic Aromatic Hydrocarbon
PR	Percent Recovery
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RL	Reporting Limit
RMC	Regional Monitoring Coalition
RPD	Relative Percent Difference
SAFIT	Southwest Association of Freshwater Invertebrate Taxonomists
SCCWRP	Southern California Coastal Water Research Project

SFRWQCB	San Francisco Regional Water Quality Control Board
SMCWPPP	San Mateo County Urban Pollution Prevention Program
SOP	Standard Operating Procedures
STE	Standard Taxonomic Effort
SV	Spike Value
SWAMP	Surface Water Ambient Monitoring Program
TKN	Total Kjeldahl Nitrogen
WY	Water Year

1. INTRODUCTION

In Water Year 2017 (WY 2017; October 1, 2016 through September 30, 2017), the San Mateo County Water 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 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. 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, no WY 2017 data were rejected and some data were flagged. Overall, WY 2017 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)

- Alpha Analytical Laboratories, Inc. (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. 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 exercise, 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.

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[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

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.

2.3.2. 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
NV = 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 °C, it is replaced.

2.6. PRECISION

2.6.1. Field Duplicates

For creek status monitoring, duplicate biological samples were collected at 10% (one) of the 10 probabilistic sites and duplicate water chemistry samples were collected at 10% (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. For WY 2017, one field duplicate was collected in Alameda County 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 2017. 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 (< 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

No field duplicate is required for pathogen indicators.

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. 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

In addition to algae and BMI taxonomic samples, the SMCWPPP field crew collected chlorophyll a and ash free dry mass samples during bioassessments. The taxonomic and analytical laboratories received and reviewed the RMC QAPP, and communicated with the local QA officer. The BMI taxonomic laboratory, BioAssessment Services, 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 10 of 10 planned/required sites for a 100% sampling completion rate. However, physical habitat assessments could not be taken at several transects due to inaccessibility.

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, with the exception of Chironomidae which was analyzed to SAFIT level 1a.

The reporting limit for ash free dry mass analysis (8 mg/L) was 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 that was submitted to an independent QC taxonomic laboratory had one specimen misidentifications and three minor counting errors. The specimen misidentification was speculated to be due to a sorting error. 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 MQOs were met. A comparison of the metrics with the MQOs is shown in Table 1. A copy of the QC laboratory report is available upon request.

There is currently 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 2017 compared to measurement quality objectives.

Quality Control Metric	MQO	Error Rate	Exceeds MQO?
Recount Accuracy	> 95%	99.84%	No
Taxa ID	≤ 10%	4%	No
Individual ID	≤ 10%	0.33%	No
Low Taxonomic Resolution Individual	≤ 10%	0%	No
Low Taxonomic Resolution Count	≤ 10%	0%	No
High Taxonomic Resolution Individual	≤ 10%	0.33%	No
High Taxonomic Resolution Count	≤ 10%	4%	No

3.3.4. Precision

Field blind duplicate chlorophyll a and ash free dry mass samples were collected at one site in WY 2017 and were sent to the laboratory for analysis.

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 RPDs for both parameters are expected to exceed the MQO, and did. 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 sites 205R03272, collected on May 31, 2017

Analyte	Units	205R00609 May 10, 2017			
		Original Result	Duplicate Result	RPD	Exceeds MQO (>25%)[a]
Chlorophyll a	mg/m^2	40.3	115.2	96%	Yes
Ash Free Dry Mass	g/m^2	48.1	223.1	129%	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

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

3.4. Field Measurements

Field measurements of temperature, dissolved oxygen, pH, specific conductivity, and chlorine residual were collected concurrently with bioassessments and water chemistry samples. Chlorine residual was measured using a HACH Pocket Colorimeter™ II, which uses the DPD method. All other parameters were measured with a YSI Professional Plus or YSI 600XLM-V2-S 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 is sent into the manufacturer every other year to be calibrated.

3.4.4. Precision

Precision could not be measured as no duplicate field measurements are required or were 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 field duplicate sample. 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 (0.05 mg/L) and method detection limit (0.02 mg/L) for nitrate samples were higher than the target reporting limit (0.01 mg/L). As a result, one sample was flagged as “detected, not quantified,” but it would have been quantified at the lower reporting limit. Additionally, the nitrate concentrations at three other sites were below the method detection limit. SMCWPPP has discussed the reporting limits with Caltest, and there is the possibility for a lower reporting limit 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. Data in highlighted rows exceed monitoring quality objectives in RMC QAPP.

Analyte	Target RL mg/L	Actual RL mg/L
Ammonia	0.02	0.02
Chloride	0.25	10-100
Total Kjeldahl Nitrogen	0.5	0.1
Nitrate	0.01	0.05
Nitrite	0.01	0.005
Orthophosphate	0.01	0.01
Silica	1	1
Phosphorus	0.01	0.01

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. Two MS/MSD percent recoveries exceeded the MQO range listed in the RMC QAPP for conventional analytes, including ammonia, and total Kjeldahl nitrogen (TKN). The QA samples affected eight sites, whose results have been assigned the appropriate SWAMP flag.

The PR ranges on laboratory reports were 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 the MQO target of < 25%.

Nutrient field duplicates were collected at two sites in San Mateo County and were compared against the original samples. For WY 2017, the total Kjeldahl nitrogen duplicate sample exceeded the RPD MQO. In past years of sampling, total Kjeldahl nitrogen has been common among the analytes that exceed the field duplicate RPD MQOs. Field crews will continue to make an effort in subsequent years to collect the original and duplicate samples in an identical fashion.

The field duplicate water chemistry results and their RPDs are shown in Tables 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 204R03272, collected on May 31, 2017. 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	0.079	0.082	4%	No
Chloride	None	mg/L	18	18	0%	No
Nitrate as N	None	mg/L	0.051	J 0.044	N/A	N/A
Nitrite as N	None	mg/L	J 0.003	J 0.003	N/A	N/A
Nitrogen, Total Kjeldahl	None	mg/L	0.26	0.4	42%	Yes
Orthophosphate as P	Dissolved	mg/L	J 0.008	J 0.008	N/A	N/A
Phosphorus as P	Total	mg/L	0.022	0.021	5%	No
Silica as SiO2	Total	mg/L	9.8	9.6	2%	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. All analytes were non-detect in the laboratory blanks. The RMC QAPP does not require field blanks to be collected, and possible contamination from sample collection could not be assessed. However, the SMCWPPP field crew takes appropriate precautions to avoid contamination, including wearing gloves during sample collection and rinsing sample containers with stream water when preservatives are needed.

3.6. Pathogen Indicators

Pathogen indicator samples were collected by SMCWPPP staff and were analyzed by Alpha Analytical Laboratories, Inc. Samples were collected August 28, 2017, and were received and incubated by the laboratory well within the 8-hour hold time. The laboratory tested the samples for the presence of *E. coli* and enterococcus.

3.6.1. Completeness

All five required/planned pathogen indicator samples were collected for a 100% completeness rate.

3.6.2. Sensitivity

The reporting limits for *E. coli* and enterococcus (1 MPN/100mL and 2 MPN/100m, respectively) met the target RL of 2 MPN/100mL listed in the project QAPP.

3.6.3. Accuracy

Negative and positive laboratory controls were run for microbial media. A negative response was observed in the negative control and a positive response was observed in the positive control required by the project QAPP Table 26-4.

3.6.4. Precision

The RMC QAPP requires one laboratory duplicate to be run per 10 samples or per analytical batch, whichever is more frequent. In WY 2017, five *E.coli* and five enterococcus samples were collected, and one laboratory duplicate was run for each analyte. However, determining precision for pathogen indicators requires 15 duplicates sets. Due to the small number of samples collected for this project, there were not enough laboratory duplicates to determine precision. The RPD for the laboratory duplicates that were run could not be calculated as the original and duplicate samples for both *E. coli* and enterococcus were greater than the method's upper threshold. See Table 5 for the lab duplicate results.

The RMC QAPP does not require a field duplicate to be collected for pathogen indicators. However, one field duplicate was collected in WY 2017 at 202DEN005. The RDP for *E.coli* was 75% and 17% for enterococcus. Since there is no requirement for pathogen field duplicates, there is no corresponding MQO, and the precision could not be assessed. See Table 5 for the field duplicate results.

Table 5. Lab and field duplicate pathogen results collected on August 29, 2017.

Duplicate Type	Analyte	Original Result (MPN/100mL)	Duplicate Result (MPN/100mL)	RPD
Lab Duplicate	E.Coli	> 2419.6	> 2419.6	NA
Lab Duplicate	Enterococcus	> 2419.6	> 2419.6	NA
Field Duplicate	E.Coli	166.4	365.4	75%
Field Duplicate	Enterococcus	435.2	365.4	17%

3.6.5. Contamination

One method blank (sterility check) 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 during the spring (May/June 2017), concurrent with bioassessments, and again in the summer (August/September 2017) in compliance with the MRP. Temperature, pH, dissolved oxygen, and specific conductivity were recorded once every 15 minutes for approximately two-weeks using a multi-parameter water quality sonde (YSI 6600-V2).

3.7.1. Completeness

The MRP requires one to two-week deployments, and both deployments exceeded the one week minimum. The first deployment lasted 14 days while the second deployment lasted 12 days. Sondes collected data for 100% of the planned deployments, and no data were rejected.

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

The SMCWPPP staff conduct pre- and post- deployment sonde calibrations for the two sondes used during monitoring events and calculate the drift during the deployments. A summary of the drift measurements is shown in Table 6. During the second monitoring event, the sonde deployed at 202SPE040 exceeded the drift MQO for dissolved oxygen. Oxygen results at this site were subsequently flagged for this deployment, but not rejected.

Table 6. Drift measurements for two continuous water quality monitoring events in San Mateo County urban creeks during WY 2017. Bold and highlighted values exceeded measurement quality objectives. N/A indicates that a drift check could not be calculated due to missing records.

Parameter	Measurement Quality Objectives	202SPE040		202SPE070	
		Event 1	Event 2	Event 1	Event 2
Dissolved Oxygen (mg/l)	± 0.5 mg/L or 10%	-0.21	-0.86	-0.15	-0.49
pH 7.0	± 0.2	-0.09	-0.09	0.05	0.02
pH 10.0	± 0.2	0.01	-0.04	0.03	-0.03
Specific Conductance (uS/cm)	± 10%	1.7%	-0.6%	2.3%	-0.2%

3.7.4. Precision

There is no protocol listed in the RMC QAPP for measuring the precision of continuous water quality measurements.

3.8. Continuous Temperature Monitoring

Continuous temperature monitoring was conducted from April through September 2016 at nine sites in San Mateo County. 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 the potential for a HOBO temperature logger to be lost during such a long deployment, SMCWPPP deployed one extra temperature logger, for a total of five loggers. In the middle of the deployment, SMCWPPP staff checked the loggers to ensure that they were still in the present and recording. During the field check, staff also downloaded the existing data and redeployed the loggers. Since all nine loggers recorded 100% of the deployment period, SMCWPPP achieved a completion rate of over 100%.

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 2017. Several of the loggers exceeded the 0.2 °C mean difference for the room temperature bath (<0.25 °C), but none exceeded the 0.2 °C mean difference for the ice bath. The deviations were attributed to poor mixing. Consequently, the accuracy check was conducted again for all loggers. During the second accuracy check none of the loggers exceeded the mean difference for either temperature. 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

The dry season sediment chemistry sample was collected by Kinnetic Laboratories, Inc (KLI) concurrently with the dry season toxicity sample on July 13, 2017. Inorganic and synthetic organic compounds were analyzed by Caltest and grain size distribution was analyzed by Soil Control Laboratories, a subcontractor laboratory. The sample was 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. Sediment chemistry data were flagged when necessary, but none were rejected

3.9.1. Completeness

The MRP requires a sediment chemistry sample to be collected at one location each year. In WY 2017, SMCWPPP collected the sediment chemistry sample at 202SPE005. The laboratories analyzed and reported 100% of the required analytes.

3.9.2. Sensitivity

A comparison of target and actual reporting limits for those parameters is shown in Table 7. For sediment chemistry analysis conducted in WY 2017, laboratory reporting limits were higher than RMC QAPP target reporting limits for analytes except for except for bifenthrin. Since reporting limits for a sample are dependent on the percent solids of that sample, it is likely that the amount of solids in the sample resulted in these exceedances.

Table 7. Comparison of target and actual reporting limits for sediment analytes where reporting limits exceeded target limits. Sediment samples were collected in San Mateo County creeks in WY 2017.

Analyte	Target RL mg/kg	Actual RL mg/kg
Arsenic	0.3	0.50
Cadmium	0.01	0.04
Chromium	0.1	0.5
Copper	0.01	0.2
Lead	0.01	0.1
Nickel	0.02	0.1
Zinc	0.1	1.0
Bifenthrin	0.33	0.33
Permethrin	0.03	0.33

3.9.3. Accuracy

Inorganic Analytes

No QA samples exceeded the QAPP MQO for LCS percent recovery (PR) for metals (75-125%), but the MS and/or MSD samples exceeded the PR MQO for chromium, copper, lead, nickel, and zinc. These samples were flagged but not rejected.

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 and were much larger than PR ranges listed in the QAPP. The MQOs ranged from 1 to 275% in certain cases. As a result, 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. However, the MS/MSD percent recoveries exceeded the RMC MQO range for 12 PAHs and one pyrethroid (deltamethrin). The PAHs MS/MSD samples that exceeded the PR MQO include benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(e)pyrene, benzo(k)fluoranthene, dibenz(a,h)anthracene, fluoranthene, 1-methylphenanthrene, naphthalene, perylene, phenanthrene, and pyrene.

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. Nevertheless, all the matrix spike duplicates for metals were well below the RMC RPD MQO of 25%.

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 most synthetic organics, < 35% for pyrethroids and fipronil, and < 40% for carbaryl. Three MS/MSD pairs slightly exceeded the QAPP MQOs for RPD (< 25%), including benz(a)anthracene, benzo(k)fluoranthene, and perylene. These three analytes were flagged by the local QA officer, but not by the laboratory. None of the LCS duplicates exceeded the RPD MQO.

Field Duplicates

A sediment sample field duplicate was collected in Alameda County on July 13, 2017 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 very coarse sand (1 to <2 mm), granules (2 to <4 mm), small pebbles (4 to <8 mm), and benzo(e)pyrene. The three particle size distribution categories that exceeded the MQOs are adjacent in size bins. When the three categories are combined into one larger category (1 to <8 mm), the RPD for the two samples is 25% as compared to 46-87%.

Given the inherent variability associated with field duplicates, the low number of analytes with RPDs outside of the MQO limits is notable. 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 8. Sediment chemistry duplicate field results for site 205R01198, collected on July 13, 2017 in Alameda 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	%	20.48	22.95	11.4%	No
	Silt: 0.0039 to <0.0625 mm	%	45.53	42.26	7%	No
	Sand: V. Fine 0.0625 to <0.125 mm	%	12.71	12.93	2%	No
	Sand: Fine 0.125 to <0.25 mm	%	13.3	13.09	2%	No
	Sand: Medium 0.25 to <0.5 mm	%	5.53	5.91	7%	No
	Sand: Coarse 0.5 to <1.0 mm	%	1.62	1.86	14%	No
	Sand: V. Coarse 1.0 to <2.0 mm	%	1.62	1.01	46%	Yes
	Granule: 2.0 to <4.0 mm	%	0.28	0.71	87%	Yes
	Pebble: Small 4 to <8 mm	%	0.93	0.48	64%	Yes
	Pebble: Medium 8 to <16 mm	%	ND	ND	N/A	N/A
	Pebble: Large 16 to <32 mm	%	ND	ND	N/A	N/A
	Pebble: V. Large 32 to <64 mm	%	ND	ND	N/A	N/A
Metals	Arsenic	mg/Kg dw	4.2	4.7	11%	No
	Cadmium	mg/Kg dw	0.55	0.57	4%	No
	Chromium	mg/Kg dw	45	47	4%	No
	Copper	mg/Kg dw	27	30	11%	No
	Lead	mg/Kg dw	38	37	3%	No
	Nickel	mg/Kg dw	56	57	2%	No
	Zinc	mg/Kg dw	130	140	7%	No
Pyrethroids (MQO <35%)	Bifenthrin	ng/g dw	3.1	3.2	3%	No
	Cyfluthrin, total	ng/g dw	0.49	0.58	17%	No
	Cyhalothrin, Total lambda-	ng/g dw	DNQ	DNQ	N/A	N/A
	Cypermethrin, total	ng/g dw	DNQ	DNQ	N/A	N/A
	Deltamethrin/Tralomethrin	ng/g dw	ND	ND	N/A	N/A
	Esfenvalerate/Fenvalerate, total	ng/g dw	ND	ND	N/A	N/A
	Permethrin, Total	ng/g dw	ND	0.96	N/A	N/A
	Total Organic Carbon	%	7.2	6.2	15%	No
	Carbaryl	mg/Kg dw	ND	ND	N/A	N/A
Fipronil	Fipronil	ng/g dw	ND	ND	N/A	N/A
	Fipronil Desulfinyl	ng/g dw	ND	ND	N/A	N/A
	Fipronil Sulfide	ng/g dw	ND	ND	N/A	N/A
	Fipronil Sulfone	ng/g dw	0.35	0.37	6%	No
Polycyclic Aromatic Hydrocarbons	Acenaphthene	ng/g dw	ND	ND	N/A	N/A
	Acenaphthylene	ng/g dw	ND	ND	N/A	N/A
	Anthracene	ng/g dw	ND	ND	N/A	N/A
	Benz(a)anthracene	ng/g dw	ND	ND	N/A	N/A
	Benzo(a)pyrene	ng/g dw	36	38	5%	No
	Benzo(b)fluoranthene	ng/g dw	60	63	5%	No
	Benzo(e)pyrene	ng/g dw	36	25	36%	Yes
	Benzo(g,h,i)perylene	ng/g dw	ND	ND	N/A	N/A
	Benzo(k)fluoranthene	ng/g dw	ND	ND	N/A	N/A
	Biphenyl	ng/g dw	ND	ND	N/A	N/A
	Chrysene	ng/g dw	120	130	8%	No
	Dibenz(a,h)anthracene	ng/g dw	ND	ND	N/A	N/A

Table 8. Sediment chemistry duplicate field results for site 205R01198, collected on July 13, 2017 in Alameda County. Data in highlighted rows exceed monitoring quality objectives in RMC QAPP.

	Analyte	Unit	Original	Duplicate	RPD	Exceeds MQO? (<25%)[a]
	Dibenzothiophene	ng/g dw	ND	ND	N/A	N/A
	Dimethylnaphthalene, 2,6-	ng/g dw	36	38	5%	No
	Fluoranthene	ng/g dw	240	250	4%	No
	Fluorene	ng/g dw	ND	ND	N/A	N/A
	Indeno(1,2,3-c,d)pyrene	ng/g dw	ND	ND	N/A	N/A
	Methylnaphthalene, 1-	ng/g dw	ND	ND	N/A	N/A
	Methylnaphthalene, 2-	ng/g dw	ND	ND	N/A	N/A
	Methylphenanthrene, 1-	ng/g dw	ND	ND	N/A	N/A
	Naphthalene	ng/g dw	ND	ND	N/A	N/A
	Perylene	ng/g dw	ND	ND	N/A	N/A
	Phenanthrene	ng/g dw	48	51	6%	No
	Pyrene	ng/g dw	120	130	8%	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

Lead was detected in an instrument (lab) blank at a concentration above the reporting limit. As a result, lead samples were flagged. None of the other target analytes were detected in any of the blanks.

3.10. TOXICITY TESTING

Dry season water and sediment toxicity samples were collected by KLI concurrently with dry season sediment chemistry samples at one San Mateo County site on July 13, 2015. 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 dry season water toxicity samples and dry season sediment toxicity samples at one site per year in San Mateo County. SMCWPPP staff collected the planned/required dry season water and sediment toxicity samples for WY 2017. Pacific EcoRisk tested required organisms for toxicity, and 100% of results were reported.

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 Alameda County and tested for toxicity 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 toxicity field duplicates listed in the RMC QAPP, so the recommended MQO listed in the RMC QAPP for the water toxicity field duplicates (< 20%) was used as an MQO for to sediment toxicity field duplicates.

Samples met the MQO for toxicity testing for all species and endpoints with the exception of the *Ceriodaphnia dubia* growth endpoint (see Table 8). This was the same outcome in WY 2016 sampling, suggests that *Ceriodaphnia dubia* growth is highly variable and perhaps is not a good indicator of toxicity in Bay Area creeks.

Table 9. Water and sediment toxicity duplicate results for site 20501198, collected on July 13, 2017 in Alameda County. Data in highlighted rows exceed monitoring quality objectives in RMC QAPP.

Matrix	Organism	Endpoint	Original Sample Mean	Duplicate Sample Mean	RPD	Exceeds Recommended MQO (<20%)?
Water	Pimephales promelas	% Survival	97.5	92.5	5%	No
Water	Pimephales promelas	Biomass (mg/individual)	0.537	0.556	3%	No
Water	Ceriodaphnia dubia	% Survival	100	100	0%	No
Water	Ceriodaphnia dubia	Young per female	18.7	26.3	34%	Yes
Water	Selenastrum capricornutum	Total Cell Count (cells/mL)	4750000	4940000	4%	No
Water	Hyalella azteca	% Survival	98	96	2%	No
Water	Chironomus dilutus	% Survival	93	92.5	0.5%	No
Sediment	Hyalella azteca	% Survival	63.8	60	6%	No
Sediment	Chironomus dilutus	% Survival	46.2	31.2	39%	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 and data that exceeded measurement quality objectives were flagged. However, no data 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 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. 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 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. 192 pp.

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