Santa Clara Valley
Urban Runoff
Pollution Prevention Program

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March 31, 2018

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

Subject: SCVURPPP Urban Creeks Monitoring Report and Electronic Monitoring Data submittal for Water Year 2017

Dear Bruce:

On behalf of the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP), I am pleased to submit SCVURPPP's Urban Creeks Monitoring Report (UCMR) and Electronic Monitoring Data for water quality monitoring conducted in Water Year (WY) 2017 (October 1, 2016 through September 30, 2017).

The UCMR is submitted in compliance with provision C.8.h.iii of the 2015 Municipal Regional Stormwater Permit (MRP, NPDES # CAS612008, Order R2-2015-0049) and pursuant to provision C.8 of the MRP, including: Creek Status Monitoring (Provision C.8.d), Stressor/Source Identification Projects (Provision C.8.e), Pollutants of Concern Monitoring (Provision C.8.f), and Pesticides and Toxicity Monitoring (C.8.g). The UCMR consists of a main report and several appendices.

Electronic Monitoring Data are submitted in compliance with provision C.8.h.ii of the MRP. Whereas, the UCMR summarizes data collected by SCVURPPP and third-party organizations[1], the electronic data files include only those data collected by SCVURPPP pursuant to the MRP provisions listed in Table 1.

Table 1. Project, date range, and applicable MRP provision for data included in the Electronic Status Monitoring Data Report.

Project	Date Range	MRP Provision
Creek Status Monitoring	April - September 2017	C.8.d
Stressor/Source Identification Study	April – September 2017	C.8.e
Pollutants of Concern Monitoring	December 2016 – June 2017	C.8.f
Pesticides and Toxicity Monitoring	July 2017	C.8.g

The quality of all Creek Status Monitoring (MRP provision C.8.d), Stressor/Source Investigation (MRP provision C.8.e), and Pesticides and Toxicity Monitoring (MRP provision C.8.g) data and the Pollutants of Concern (MRP provision C.8.f) nutrient data was evaluated consistent with the Bay Area Stormwater

[1] See Third-Party Monitoring Statement at end of this letter.

Management Agencies Association (BASMAA) Regional Monitoring Coalition's *Creek Status Monitoring Program Quality Assurance Project Plan* (QAPP), which is comparable with the latest version of the State of California's Surface Water Ambient Monitoring Program (SWAMP) Quality Assurance Program Plan (QAPrP). The quality of all data from the Pollutants of Concern Monitoring (MRP provision C.8.f) PCBs and mercury data was consistent with the Clean Watersheds for Clean Bay (CW4CB) QAPP.

In compliance with provision C.8.h.ii (Electronic Reporting) of the MRP, all CEDEN-acceptable data (i.e., data collected from receiving waters) were also provided to the Regional Data Center for the California Environmental Data Exchange Network (CEDEN), located at the San Francisco Estuary Institute (SFEI), via upload to their FTP site. These data are submitted in a format comparable with the SWAMP database. Pollutants of Concern Monitoring data collected in non-receiving waters are included in the attached electronic files but were not submitted to the Regional Data Center. For more details regarding the data types associated with CEDEN, see the BASMAA letter to the CEDEN Data Manager (dated March 20, 2017) which was cc'd to several of your staff.

Monitoring data included in this submittal suggest that ambient biological conditions in Santa Clara Basin creeks vary substantially among sites and between monitoring events. Temporal and spatial variability adds to the challenge of interpreting and evaluating the data and using it to help identify potential persistent water quality issues warranting a programmatic response from stormwater agencies. A detailed analysis of the data is included in the UCMR.

We look forward to discussing the findings, conclusions and recommended next steps included in the UCMR and to continuing to work with you and your staff to successfully address new challenges regarding water quality monitoring. Please contact me or Chris Sommers (csommers@eoainc.com) if you have any comments or questions.

Certification Regarding SCVURPPP Program Urban Creeks Monitoring Report

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

Very truly yours,

Original signed by

Adam W. Olivieri, Dr. P.H., P.E.
Program Manager

CC: SCVURPPP Management Committee Members
Tom Mumley, Assistant Executive Officer, SF Bay Water Board
Chris Sommers, SCVURPPP Project Manager

Attachments: SCVURPPP UCMR Water 2017
Electronic Data Report (i.e., one compact disc) for Water Year 2017 Creek Status and Pesticides & Toxicity Monitoring Data, Stressor/Source Identification Data, and Pollutants of Concern Monitoring Data
Third Party Monitoring Statement

Third Party Monitoring Statement

Please note that consistent with provision C.8.a.iii of the MRP, one water quality monitoring requirement was partially fulfilled by third party monitoring in Water Year 2017:

- The Regional Monitoring Program for Water Quality in the San Francisco Estuary (RMP) conducted a portion of the data collection in Water Year 2017 on behalf of Permittees, pursuant to MRP provision C.8.f – Pollutants of Concern Loads Monitoring. The results of that monitoring are summarized in Section 5 of the attached UCMR. Data collected from stations monitored by the RMP will be submitted to the California Environmental Data Exchange Network directly by the RMP following completion of their quality assurance review.

- Data collected by the State of California's Surface Water Ambient Monitoring Program (SWAMP) through its Stream Pollutant Trend (SPoT) Monitoring Program at the San Mateo location is used to partially fulfill MRP Provision C.8.f - Pollutants of Concern Monitoring requirements addressing trends evaluation. Data collected from stations monitored by the SPoT Program will be submitted directly to the California Environmental Data Exchange Network according to the SWAMP schedule for review and reporting of data, which may not occur for several years.

Santa Clara Valley
Urban Runoff
Pollution Prevention Program

Watershed Monitoring and Assessment Program

Urban Creeks Monitoring Report

Water Quality Monitoring

Water Year 2017 (October 2016 – September 2017)

Submitted in compliance with Provision C.8.h.iii of NPDES Permit # 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 the MRP).[1] The RMC includes the following participants:

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

This Urban Creeks Monitoring Report complies with MRP provision C.8.h.iii for reporting of all data in Water Year 2016 (October 1, 2015 through September 30, 2016). Data were collected pursuant to provision C.8 of the MRP. Data presented in this report were produced under the direction of the RMC and the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP) using probabilistic and targeted monitoring designs as described herein.

Consistent with the BASMAA RMC Multi-Year Work Plan (Work Plan; BASMAA 2011) and the 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 the 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 SCVURPPP to the Regional Water Board on behalf of SCVURPPP Co-permittees and pursuant to provision C.8.h.ii of the MRP.

[1] The San Francisco Bay Regional Water Quality Control Board (SFRWQCB or Regional Water Board) issued the MRP to 76 cities, counties and flood control districts (i.e., Permittees) in the Bay Area on October 14, 2009 (SFRWQCB 2009). On November 19, 2015, the Regional Water Board updated and reissued the MRP (SFRWQCB 2015). The BASMAA programs supporting MRP Regional Projects include all MRP Permittees as well as the cities of Antioch, Brentwood, and Oakley, which are not named as Permittees under the MRP but have voluntarily elected to participate in MRP-related regional activities.

[2] The current SWAMP 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
BASMAA	Bay Area Stormwater Management Agency Association
BASMAA BOD	BASMAA Board of Directors
BMI	Benthic Macroinvertebrate
BMP	Best Management Practice
CADDIS	Causal Analysis/Diagnosis Decision Information System
CCCWP	Contra Costa Clean Water Program
CEC	Chemicals of Emerging Concern
CEDEN	California Environmental Data Exchange Network
COLD	Cold Freshwater Habitat
CSCI	California Stream Condition Index
ECWG	Emerging Contaminant Workgroup
FSURMP	Fairfield Suisun Urban Runoff Management Program
FY	Fiscal Year
GIS	Geographic Information Systems
HDS	Hydrodynamic Separator
IBI	Index of Biological Integrity
IPM	Integrated Pest Management
IWRMP	Integrated Water Resources Master Plan
LID	Low Impact Development
MPC	Monitoring and Pollutants of Concern Committee
MRP	Municipal Regional Permit
MWAT	Maximum Weekly Average Temperature
NMFS	National Marine Fisheries Service
NMS	Nutrient Management Strategy
NPDES	National Pollution Discharge Elimination System
PAHs	Polycyclic Aromatic Hydrocarbons
PBDEs	Polybrominated Diphenyl Ethers
PCBs	Polychlorinated Biphenyls
PEC	Probable Effect Concentration
PFAS	Perfluoroalkyl and Polyfluoroalkyl Substances
PFOS	Perfluorooctane Sulfonate
PHAB	Physical Habitat Assessment
POC	Pollutant of Concern
POTW	Publicly Owned Treatment Works
QAPP	Quality Assurance Project Plan
QAPrP	Quality Assurance Program Plan
RAA	Reasonable Assurance Analysis
RMC	Regional Monitoring Coalition
RMP	Regional Monitoring Program
RWSM	Regional Watershed Spreadsheet Model
SCVURPPP	Santa Clara Valley Urban Runoff Pollution Prevention Program
SCVWD	Santa Clara Valley Water District
SFEI	San Francisco Estuary Institute
SMCWPPP	San Mateo County Water Pollution Prevention Program
SOP	Standard Operating Procedures
SPLWG	Sources, Pathways, and Loadings Workgroup
SPoT	Statewide Stream Pollutant Trend Monitoring
SSC	Suspended Sediment Concentration
SSID	Stressor/Source Identification

S&T	Status and Trends Monitoring Program
STLS	Small Tributary Loading Strategy
SWAMP	Surface Water Ambient Monitoring Program
TEC	Threshold Effect Concentration
TIE	Toxicity Identification Evaluations
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TRC	Technical Review Committee
TRE	Toxicity Reduction Evaluations
TU	Toxic Unit
UCMR	Urban Creeks Monitoring Report
USEPA	US Environmental Protection Agency
USGS	US Geological Survey
WARM	Warm Freshwater Habitat
WMA	Watershed Management Area
WQ	Water Quality
WQO	Water Quality Objective
WY	Water Year

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Appendix E. SCVURPPP POC Data Report, Water Year 2017

Appendix F. RMP’s POC Reconnaissance Monitoring Final Progress Report, Water Years 2015, 2016, and 2017

TABLE E.1. WATER YEAR 2017 CREEK STATUS MONITORING STATIONS

In compliance with provision C.8.h.iii.(1), this table of all Creek Status Monitoring stations sampled by SCVURPPP in Water Year 2017 is provided immediately following the Table of Contents. See Section 3.0 for additional information on Creek Status Monitoring.

Table E.1. Water Year 2017 Creek Status Monitoring Stations.

Map ID *	Station ID	Watershed	Creek Name	Land Use	Latitude	Longitude	Probabilistic	Targeted				
							Bioassessment, Nutrients, General WQ	Chlorine	Toxicity, Sediment Chemistry	Temp	Cont WQ	Pathogen Indicators
570	205R00570	Guadalupe River	Aldercroft Trib	NU	37.181464	-122.002165	X	X				
609	205R00609	Coyote Creek	Hunting Hollow	NU	37.073721	-121.460268	X	X				
645	205R00645	Coyote Creek	Packwood Creek	NU	37.170717	-121.613387	X	X				
2693	205R02693	Coyote Creek	Packwood Creek	U	37.174793	-121.616695	X	X				
2755	205R02755	Lower Penitencia Cr	Berryessa Creek	U	37.420931	-121.840146	X	X				
2787	205R02787	Matadero Creek	Matadero Creek	U	37.432204	-122.124836	X	X				
2915	205R02915	Stevens Creek	Stevens Creek	U	37.306931	-122.069249	X	X				
2947	205R02947	Lower Penitencia Cr	Lower Penitencia	U	37.429177	-121.90895	X	X				
3011	205R03011	Lower Penitencia Cr	Berryessa Creek	U	37.41123	-121.858567	X	X				
3091	205R03091	Coyote Creek	Arroyo Aguague	U	37.399248	-121.785626	X	X				
3098	205R03098	Guadalupe River	Guadalupe Creek	U	37.243658	-121.874066	X	X				
3235	205R03235	Stevens Creek	Stevens Creek	U	37.334668	-122.064327	X	X				
3306	205R03306	San Tomas Aquino	Saratoga Creek	U	37.277387	-122.011719	X	X				
3331	205R03331	Guadalupe River	Los Gatos Creek	U	37.300891	-121.919698	X	X				
3354	205R03354	Guadalupe River	Guadalupe Creek	U	37.212368	-121.908596	X	X				
3386	205R03386	Guadalupe River	Aldercroft Creek	U	37.176762	-121.995876	X	X				
3418	205R03418	Guadalupe River	Alamitos Creek	U	37.22855	-121.861762	X	X				
3443	205R03443	Coyote Creek	Calabazas Creek	U	37.388639	-121.986842	X	X				
3523	205R03523	Coyote Creek	Upper Penitencia Creek	U	37.393389	-121.83237	X	X				
3530	205R03530	Guadalupe River	Los Gatos Creek	U	37.25194	-121.963874	X	X				
400	205LGA400	Guadalupe River	Los Gatos Creek	U	37.2389	-121.97054						X
30	205MAT030	Matadero Creek	Matadero Creek	U	37.4099	-122.13831						X
64	205STE064	Stevens Creek	Stevens Creek	U	37.3174	-122.06182						X
225	205GUA225	Guadalupe River	Arroyo Calero	U	37.214116	-121.83444						X
75	205SAR075	San Tomas Aquino	Saratoga Creek	U	37.25826	-122.03445						X
210	205GUA210	Guadalupe River	Guadalupe Creek	U	37.21746	-121.91039				X		
202	205GUA202	Guadalupe River	Guadalupe Creek	U	37.23291	-121.89795				X		
190	205GUA190	Guadalupe River	Guadalupe Creek	U	37.24373	-121.87561				X		
270	205GUA270	Guadalupe River	Alamitos Creek	U	37.20129	-121.82891				X		
340	205GUA340	Guadalupe River	Arroyo Calero	U	37.20706	-121.82362				X		

Map ID *	Station ID	Watershed	Creek Name	Land Use	Latitude	Longitude	Probabilistic	Targeted				
							Bioassessment, Nutrients, General WQ	Chlorine	Toxicity, Sediment Chemistry	Temp	Cont WQ	Pathogen Indicators
225	205GUA225	Guadalupe River	Arroyo Calero	U	37.21403	-121.83442				X		
262	205GUA262	Guadalupe River	Alamitos Creek	U	37.220409	-121.845155				X		
255	205GUA255	Guadalupe River	Alamitos Creek	U	37.22607	-121.85842				X		
250	205GUA250	Guadalupe River	Alamitos Creek	U	37.23363	-121.87058				X		
235	205COY235	Coyote Creek	Coyote Creek	U	37.3536	-121.87417					X	
236	205COY236	Coyote Creek	Coyote Creek	U	37.35098	-121.87378					X	
239	205COY239	Coyote Creek	Coyote Creek	U	37.33722	-121.86953					X	
21	205STE021	Stevens Creek	Stevens Creek	U	37.40985	-122.06906			X			
10	205STQ010	San Tomas Aquino	San Tomas Aquino	U	37.38843	-121.96865			X			

U = urban, NU = non-urban
* Map ID applies to Figure 3.1.

1.0 INTRODUCTION

This Urban Creeks Monitoring Report (UCMR) was prepared by the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP or Program), on behalf of its 15 member agencies (13 cities/towns, the County of Santa Clara, and the Santa Clara Valley Water District) subject to the National Pollutant Discharge Elimination System (NPDES) stormwater permit for Bay Area municipalities referred to as the Municipal Regional Permit (MRP).

The MRP was first adopted by the San Francisco Regional Water Quality Control Board (SFRWQCB or Regional Water Board) on October 14, 2009 as Order R2-2009-0074 (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 monitoring data collected during the foregoing October 1 – September 30 period (i.e., Water Year 2017). Data were collected pursuant to water quality monitoring requirements in provision C.8 of the MRP. Monitoring data presented in this report were submitted electronically to the Regional Water Board by SCVURPPP and, if collected from a receiving water, may be obtained via the San Francisco Bay Area Regional Data Center of the California Environmental Data Exchange Network (CEDEN) (http://www.ceden.org).

Chapters in this report are organized according to the following topics and MRP sub-provisions. Several of the topics are summarized in this report but described fully in appendices.

1.0 Introduction

2.0 San Francisco Estuary Receiving Water Monitoring (MRP provision C.8.c)

3.0 Creek Status Monitoring (MRP provision C.8.d) and Pesticides and Toxicity Monitoring (MRP provision C.8.g) (**Appendix A**)

4.0 Stressor/Source Identification (SSID) Projects (MRP provision C.8.e) (**Appendices B, C, and D**)

5.0 Pollutants of Concern (POC) Monitoring (MRP provision C.8.f) (**Appendices E and F**)

6.0 Recommendations and Next Steps

Figure 1.1 maps locations of monitoring stations associated with provision C.8 compliance in Water Year 2017 (WY 2017), including Creek Status Monitoring, the SSID project, Pesticides and Toxicity Monitoring, and POC Monitoring conducted by SCVURPPP and the Small Tributaries Loading Strategy (STLS). This figure illustrates the geographic extent of monitoring conducted in Santa Clara County in WY 2017.

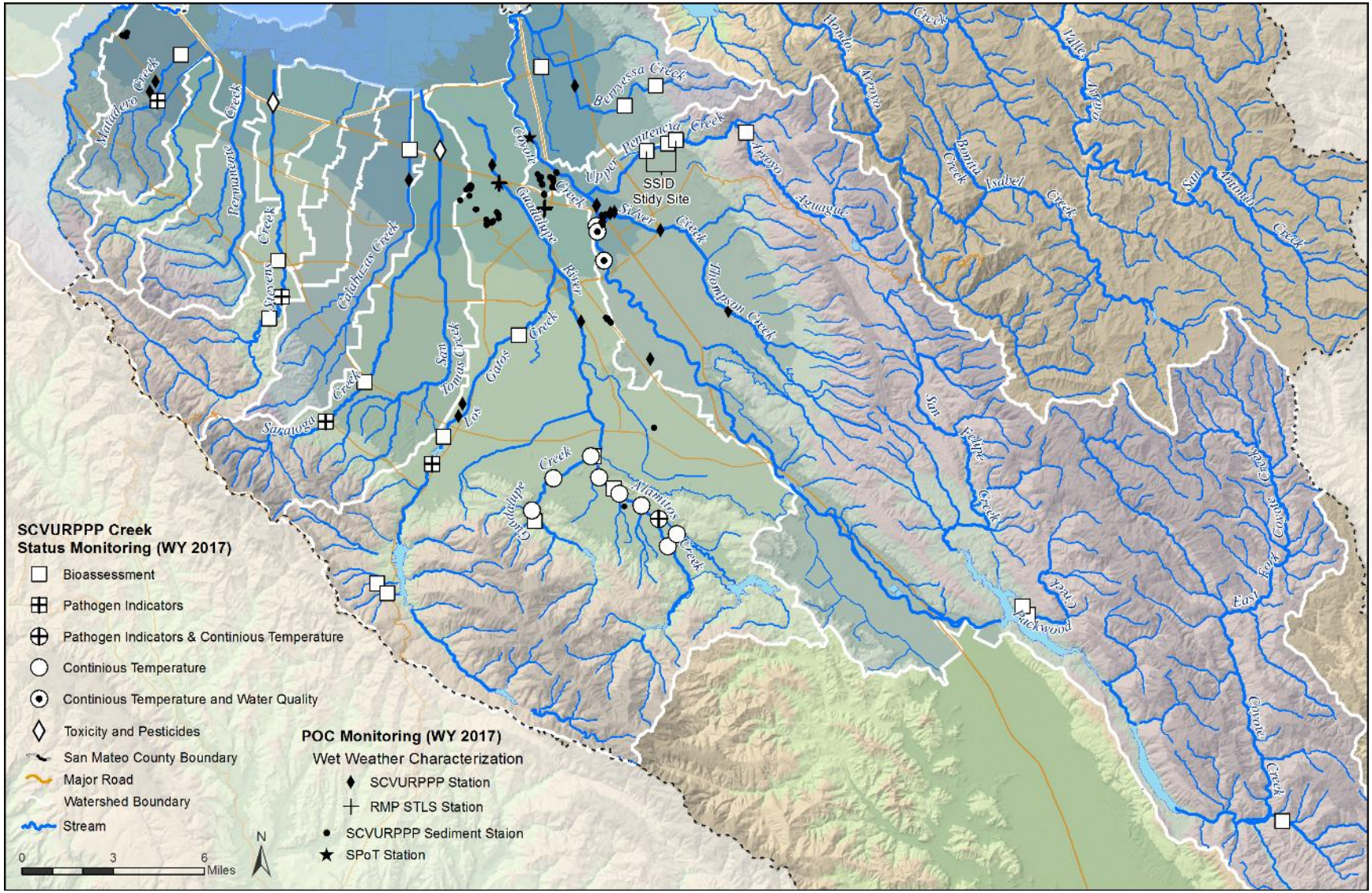

Figure 1.1. SCVURPPP Creek Status, Pollutants of Concern (POC), Pesticides and Toxicity, and Stressor/Source Identification (SSID) monitoring stations in WY 2017.

1.1 RMC Overview

Provision C.8.a (Compliance Options) of the MRP allows Permittees to address monitoring requirements through a "regional collaborative effort," their Stormwater Program, and/or individually. In June 2010, Permittees notified the Water Board in writing of their agreement to participate in a regional monitoring collaborative to address requirements in provision C.8. The regional monitoring collaborative is referred to as the Bay Area Stormwater Management Agencies Association (BASMAA) Regional Monitoring Coalition (RMC). In a November 2, 2010 letter to the Permittees, the Water Board's Assistant Executive Officer (Dr. Thomas Mumley) acknowledged that all Permittees have opted to conduct monitoring required by the MRP through a regional monitoring collaborative, the BASMAA RMC. Participants in the RMC are listed in Table 1.1.

In February 2011, the RMC developed a Multi-Year Work Plan (RMC Work Plan; BASMAA 2011) to provide a framework for implementing regional monitoring and assessment activities required under provision C.8 of the 2009 MRP. The RMC Work Plan summarizes RMC projects planned for implementation between Fiscal Years 2009-10 and 2014-15. Projects were collectively developed by RMC representatives to the BASMAA Monitoring and Pollutants of Concern Committee (MPC), and were conceptually agreed to by the BASMAA Board of Directors (BASMAA BOD). Although there are no plans to update the Multi-Year Work Plan, several regional projects have already been identified and will be conducted in compliance with the 2015 MRP. Current regional projects relevant to provision C.8 compliance include (but may not be limited to) projects to maintain and update the regional database, coordinate the RMC Workgroup meetings, and conduct POC monitoring.

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

Table 1.1 Regional Monitoring Coalition (RMC) participants.

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

1.2 Coordination with Third-party Monitoring Programs

SCVURPPP strives to work collaboratively with our water quality monitoring partners to find mutually beneficial monitoring approaches. Provision C.8.a.iii of the MRP allows Permittees to use data collected by third-party organizations to fulfill monitoring requirements, provided the data are demonstrated to meet the required data quality objectives.

In WY 2017, SCVURPPP continued to coordinate with water quality monitoring programs conducted by third parties. These programs include the Regional Monitoring Program for Water Quality in San Francisco Bay's (RMP) Small Tributaries Loading Strategy (STLS) and the Stream Pollutant Trends (SPoT) monitoring conducted by the State of California's Surface Water Ambient Monitoring Program (SWAMP). Water quality data from these programs are reported in this document and were utilized to supplement SCVURPPP compliance with provision C.8 of the MRP, consistent with sub-provision C.8.a.iii.[3,4] Data are specifically referenced in section 5.0 (POC Monitoring) of this report.

[3] Data reported by the RMP STLS are summarized in this report but were not included in the SCVURPPP electronic data submittal.

[4] In most years, including WY 2017, the SPoT Program monitors two stations in Santa Clara County for a subset of the constituents required by provision C.8.f of the MRP.

2.0 SAN FRANCISCO ESTUARY RECEIVING WATER MONITORING (C.8.C)

As described in provision C.8.c of the MRP, Permittees are required to provide financial contributions towards implementing an Estuary receiving water monitoring program on an annual basis that at a minimum is equivalent to the Regional Monitoring Program for Water Quality in the San Francisco Estuary (RMP). Since the adoption of the 2009 MRP, SCVURPPP has complied with this provision by making financial contributions to the RMP. Additionally, SCVURPPP staff actively participates in RMP committees, workgroups, and strategy teams as described in the following sections, which also provide a brief description of the RMP and associated monitoring activities conducted during WY 2017.

Now in its 25th year, the RMP is a long-term monitoring program that is discharger-funded and shares direction and participation by regulatory agencies and the regulated community with the goal of assessing water quality in the San Francisco Bay. The regulated community includes municipal stormwater (MS4s), publicly owned treatment works (POTWs), dredger, and industrial dischargers. The San Francisco Estuary Institute (SFEI) is the implementing entity for the RMP and the fiduciary agent for RMP stakeholder funds. SFEI does not provide direct oversight of the RMP but does help identify stakeholder information needs, develop workplans that address these needs, and implement the workplans.

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

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

The RMP budget is generally broken into two major program elements: Status and Trends and Pilot/Special Studies. The following sections provide a brief overview of these programs. The *RMP 2017 Detailed Workplan and Budget*[5] provides more details and establishes deliverables for each component of the RMP budget. The RMP publishes annual summary reports. In odd years, the *Pulse of the Estuary Report* focuses on Bay water quality and summarizes information from all sources. In even years, the *RMP Update Report* has a narrower and specific focus. The *2017 Pulse of the Estuary*[6] celebrates the 25th anniversary of the RMP with a look back at the history of the program, along with articles on emerging contaminants, nutrients, and the Bay margins.

2.1 RMP Status and Trends Monitoring Program

The Status and Trends Monitoring Program (S&T Program) is the long-term contaminant-monitoring component of the RMP. The S&T Program was initiated as a pilot study in 1989, implemented thereafter, and was redesigned in 2007 based on a more rigorous statistical design that enables the detection of trends. The Technical Review Committee (TRC), in which SCVURPPP participates, continues to assess the efficacy and value of the various elements of the S&T Program and to recommend modifications to S&T Program activities based on ongoing findings. The current S&T sampling schedule, established in 2014, is listed in Table 2.1 with 2017 accomplishments and 2018 goals.

[5] http://www.sfei.org/documents/2017-rmp-detailed-workplan-and-budget

[6] http://www.sfei.org/documents/pulse-bay-25th-anniversary-rmp

Table 2.1. RMP Status and Trends Monitoring Schedule.

Program Element	Schedule	2017 Sampling	2018 Sampling
Water	Every two years	Yes	No
Bird Eggs	Every three years	No	Yes
Sediment	Every four years	Yes (Bay margins only)	Yes
Sport Fish	Every five years	No	No
Bivalves	Every two years	No	Yes
Support to the USGS for suspended sediment and nutrient monitoring	Every year	Yes	Yes

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

2.2 RMP Pilot and Special Studies

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

In 2017, Pilot and Special Studies focused on the following topics:

- Nutrients Management Strategy
    - Continuous monitoring of nutrients, phytoplankton biomass, and dissolved oxygen at moored sensors
    - Continuous monitoring of dissolved oxygen in shallow margin habitats
    - Ship-based nutrient sampling
    - Data analysis and quantitative mechanistic interpretations to identify factors contributing to observed conditions
- Small Tributary Loadings Strategy (see below and Section 5.0 for more details)
- Chemicals of emerging concern (CEC) monitoring (imidacloprid, perfluorochemicals, phosphate flame retardants, bisphenol compounds, triclosan, and update of CEC Strategy)
- Development of conceptual PCB models for prioritized Bay margin units
- Dioxin data synthesis report
- Selenium in fish tissue monitoring
- Evaluation of toxicity testing protocols for marine sediments
- Implementation of a Sediment Monitoring Strategy

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

In WY 2017, a considerable amount of RMP and Stormwater Program staff time was spent overseeing and implementing Special Studies associated with the RMP's Small Tributary Loading Strategy (STLS). Pilot and Special Studies associated with the STLS are intended to fill data gaps associated with loadings of Pollutants of Concern (POC) from relatively small tributaries to the San Francisco Bay. Additional information on STLS-related studies is included in Section 5.0 (POC Loads Monitoring) of this report.

2.3 Participation in Committees, Workgroups and Strategy Teams

In WY 2017, SCVURPPP actively participated in the following RMP committees, workgroups, and strategy teams:

- Steering Committee (SC)
- Technical Review Committee (TRC)
- Sources, Pathways and Loadings Workgroup (SPLWG)
- Emerging Contaminant Workgroup (ECWG)
- Nutrient Technical Workgroup
- Strategy Teams (e.g., Small Tributaries, PCBs, and Selenium)

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

3.0 CREEK STATUS (C.8.D) AND PESTICIDES/TOXICITY MONITORING (C.8.G)

This section summarizes the results of creek status monitoring and pesticides and toxicity monitoring required by provisions C.8.d and C.8.g of the MRP, respectively. Creek Status and Pesticides and Toxicity monitoring stations are listed in Table E-1 and mapped in Figure 3.1. Detailed methods and results are provided in **Appendix A.** Consistent with provision C.8.h.ii of the MRP, creek status and pesticides and toxicity monitoring data were submitted to the Regional Water Board by SCVURPPP in electronic SWAMP-comparable formats. These data were also provided to the Regional Data Center (i.e., SFEI) for upload to CEDEN.

Creek Status Monitoring (C.8.d)

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 waters supportive of or likely supportive of beneficial uses?*

Creek status monitoring parameters, methods, occurrences, durations and minimum number of sampling sites for each stormwater program are described in provision C.8.d of the MRP. The RMC's regional monitoring strategy for complying with creek status monitoring requirements is described in the RMC Creek Status and Long-Term Trends Monitoring Plan (BASMAA 2012). The strategy includes a regional ambient/probabilistic monitoring component and a component based on local "targeted" monitoring. The combination of these monitoring designs allows each individual RMC participating program to assess the status of beneficial uses in local creeks within its Program (jurisdictional) area, while also contributing data to answer management questions at the regional scale (e.g., differences between aquatic life condition in urban and non-urban creeks). Implementation began in WY 2012.

The probabilistic monitoring design was developed to remove bias from site selection such that ecosystem conditions can be objectively assessed on local (i.e., SCVURPPP) and regional (i.e., RMC) scales. Probabilistic parameters consist of bioassessments, nutrients, and conventional analytes conducted according to methods described in the SWAMP SOP (Ode et al. 2016). Free chlorine and total chlorine residual were also measured at probabilistic sites. Twenty probabilistic sites were sampled by SCVURPPP in WY 2017.

The targeted monitoring design focuses on sites selected based on the presence of significant fish and wildlife resources as well as historical and/or recent indications of water quality concerns. Targeted monitoring parameters consist of water temperature, general water quality, and pathogen indicators using methods, sampling frequencies, and number of stations required in provision C.8.d of the MRP. Hourly water temperature measurements were recorded during the dry season at eight sites using HOBO® temperature data loggers in the Guadalupe River watershed. General water quality monitoring (temperature, dissolved oxygen, pH and specific conductivity) was conducted using YSI continuous water quality equipment (sondes) for two 2-week periods (spring and late summer) at three sites in the Coyote Creek watershed. Water samples for analysis of pathogen indicators (*E. coli* and enterococcus) were collected at five sites located in parks.

Pesticides and Toxicity Monitoring (C.8.g)

Provision C.8.g of the MRP requires Permittees to conduct wet weather and dry weather pesticides and toxicity monitoring. Test methods, sampling frequencies, and number of stations required are described in the MPR. In WY 2017, SCVURPPP conducted dry weather pesticides and toxicity monitoring at two bottom-of-the-watershed stations. Consistent with provision C.8.g.iii, wet weather pesticides and toxicity monitoring will be conducted on a regional basis in WY 2018.

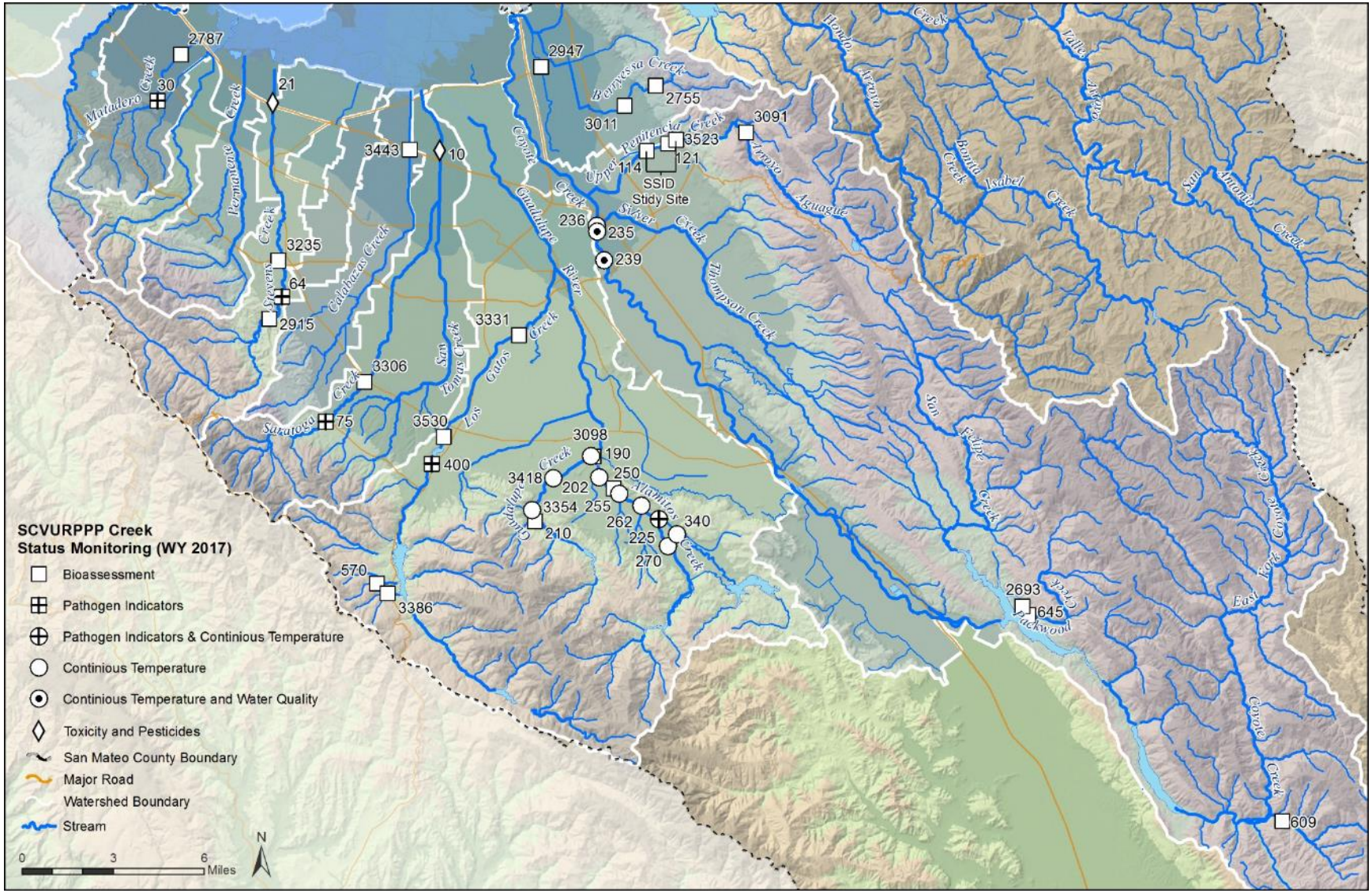

Figure 3.1. SCVURPPP Creek Status and Pesticides and Toxicity monitoring stations, WY 2017.

3.1 Approach to Management Questions

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

The second MRP creek status management question (*Are conditions in local receiving waters supportive of or likely supportive of beneficial uses?*) is addressed primarily by assessing indicators of aquatic biological health using benthic macroinvertebrate and algae data collected at probabilistic sites. Although the total number of probabilistic sites in Santa Clara Valley that have been sampled since WY 2012 (i.e., 132) is sufficient to evaluate the condition of aquatic life within known estimates of precision, the analysis presented in Appendix A is limited to the 20 sites monitored in WY 2017.

A more comprehensive analysis of a five-year dataset (WY 2012 – WY 2016) is currently being conducted by a BASMAA regional project. The BASMAA regional study will include the following analyses:

- Assess the biological condition of streams in the region and each county using indices of biological integrity (IBIs) based on benthic macroinvertebrate and algae data collected by each countywide program and 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.

3.2 Monitoring Results and Conclusions

3.2.1 Bioassessment Monitoring

Twenty sites were sampled for benthic macro-invertebrates (BMIs), benthic algae, physical habitat observations, 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. Seventeen of the sites were classified as urban and three were classified as non-urban. The following conclusions are made based on the WY 2017 data. An assessment of biological condition is provided and potential stressors are compared to applicable water quality objectives (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. See **Appendix A** for detailed explanations of the findings.

Biological Condition Assessment

The California Stream Condition Index (CSCI) 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 Santa Clara Valley streams is uncertain. This is due to several factors including:

- There is an overall dearth of soft algae taxa found in Santa Clara Valley streams. This may not reflect stream health, but it can significantly lower 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 20 sites monitored in WY 2017, nine sites (45%) were rated in good condition (CSCI scores ≥ 0.795); four sites (20%) rated as likely altered condition (CSCI score 0.635 – 0.795), and seven sites (35%) rated as very likely altered condition (≤ 0.635). The three sites with the lowest CSCI scores had a high proportion of impervious watershed area (> 30%) and were characterized as modified 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=0.30, p = 0.012) 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 slightly 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 eleven 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 205R03011 (Berryessa Creek) and site 205R03443 (Calabazas Creek). The acute temperature threshold trigger (24°C) for salmonid fish was also exceeded at site 205R03443 (Calabazas Creek). 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, except for unionized ammonia (.025 mg/L) at site 205R03011 (Berryessa Creek), and site 205R03011 (Calabazas Creek). Both sites are at the bottom of highly urbanized watersheds and will be considered as candidates for SSID projects.

3.2.2 Targeted Monitoring Results/Conclusions

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 nine sites in the Guadalupe River Watershed from April through September. Continuous (15-minute) general water quality measurements (pH, DO, specific conductance, temperature) were recorded at three sites in the Coyote Creek watershed during two 2-week periods in June (Event 1) and September (Event 2). Pathogen indicator grab samples were collected during a sampling event in July at five sites throughout Santa Clara County that coincide with public parks. 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 based on three management questions. See **Appendix A** for detailed explanations of the findings.

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 in Water Quality

- **Spatial**. Water temperatures measured in three tributaries to Guadalupe River generally increased within decreasing site elevation due their distance from upstream reservoirs, which are the source of cooler water. General water quality parameters measured at three stations in Coyote Creek were similar across the stations except for dissolved oxygen which displayed different patterns at the sites. The findings were consistent with the Coyote Creek Dissolved Oxygen SSID Project which concluded that low channel gradients and high amounts of accumulated organic material in the studied reach cause low dissolved oxygen (DO) concentrations.
- **Temporal**. Temperatures increased at all nine sites in the Guadalupe River watershed from June to August 2017 and started to decline towards the end of September. In Coyote Creek, decreases in dissolved oxygen concentrations occurred following a period of hot weather during week of June 18, 2017. Following the heat wave, the DO levels increased, with pronounced diurnal variability observed at all three sites.

Potential Impacts to Aquatic Life

- Potential impacts to aquatic life were assessed through analysis of continuous temperature data collected at nine targeted stations in the Guadalupe River watershed from April through September and analysis of continuous general water quality data (pH, dissolved oxygen, specific conductance, and temperature) collected at three targeted stations in Coyote Creek during two two-week periods (June and September).
- All nine temperature stations in the Guadalupe River Watershed exceeded the MRP trigger threshold of having two or more weeks where the Maximum Weekly Average Temperature exceeded 17°C. None of the stations exceeded the maximum instantaneous trigger threshold of 24°C for more than 1% of total recorded samples.
    - All stations with Maximum Weekly Average Temperature (MWAT) trigger exceedances will be added to the list of candidate SSID projects; however, review of the monitoring data in the context of locally-derived temperature thresholds developed by National Marine Fisheries Services (NMFS) suggests that temperature may not be a limiting factor for salmonid habitat (i.e., summer rearing juveniles) in the study reaches, as long as

sufficient dam releases maintain longitudinal connectivity and provide cooler water temperatures and potential refugia for juvenile steelhead during the summer.

- Sites on Coyote Creek had no exceedances of the maximum temperature trigger threshold of 24°C but did exceed the MWAT trigger of 17.0 °C for two consecutive weeks during both events and will therefore be added to the list of candidate SSID projects.
- The WQO for DO in waters designated as having cold freshwater habitat (COLD) Beneficial Uses (i.e., 7.0 mg/L) was not met in over 20% of the measurements recorded at all three water quality stations in Coyote Creek. The results were similar to the findings from the WY 2013 SSID study carried out at the same locations. The Coyote Creek DO SSID Study concluded that low DO concentrations are caused by low gradient channels with high amounts of accumulated organic matter. Furthermore, this reach Coyote Creek currently supports habitat and water quality that may be suitable for a warm water fishery and not for cold water fishery.
- Values for pH and specific conductivity measured at the three sites in Coyote Creek during WY 2017 did not exceed their respective triggers during either event.

Potential Impacts to Water Contact Recreation

- Pathogen indicator densities were measured at five targeted sites during WY 2017. Although none of the stations could be considered “bathing beaches,” monitoring locations were selected at city parks or trails that were considered to have a relatively high potential for public access. The MRP trigger threshold for *E. coli* (410 cfu/100 ml) was exceeded at two sites: Arroyo Calero at Singer Park and Saratoga Creek at Wildwood Park. The MRP trigger threshold for enterococcus (130 cfu/100 ml) was exceeded at four sites: Arroyo Calero at Singer Park, Saratoga Creek at Wildwood Park, Stevens Creek at Blackberry Farm, and Matadero Creek at Bol Park. These sites will be added to the list of candidate SSID projects.
- 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. Pathogen indicators observed at the WY 2017 stations may not be associated with human sources and therefore may not pose a threat to human health. As a result, the comparison of pathogen indicator results to water quality objectives and criteria for full body contact recreation may not be appropriate and should be interpreted cautiously.
- The State Water Resources Control 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 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 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.[7]

3.2.3 Chlorine Monitoring Results/Conclusions

Free chlorine and total chlorine residual were measured concurrently with bioassessments at the twenty probabilistic sites (and two additional SSID sites) in compliance with provision C.8.c.ii. While chlorine residual is generally not a concern in Santa Clara Valley urban 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 (Lower Penitencia Creek). City of Milpitas illicit discharge staff were notified of the exceedance but did not observe exceedances during follow-up monitoring. The exceedance was likely the result of a one-time

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

potable water discharge and it is generally very difficult to determine the source of elevated chlorine from such episodic discharges. The Program will continue to monitor chlorine in compliance with the MRP and will follow-up with illicit discharge staff as needed.

3.2.4 Pesticides and Toxicity Monitoring Results/Conclusions

In WY 2017, SCVURPPP conducted dry weather pesticides and toxicity monitoring at two stations (Stevens Creek and San Tomas Aquino) in compliance with provision C.8.g of the MRP.

Statistically significant toxicity to *C. dubia* (reproduction) was observed in water samples collected from both sites in July 2017. Although toxicity was observed in the sample from San Tomas Aquino, the magnitude of toxicity was not great enough to exceed the MRP trigger threshold. The magnitude of the toxic effects in the Stevens Creek sample did exceed the MRP threshold for re-sampling (i.e., 50 Percent Effect). Statistically significant toxicity to *C. dubia* was not observed in the second sample collected from Stevens Creek in August 2017. The cause of the toxicity observations is unknown. Pesticide concentrations in the sediment samples were all very low, most below MDLs and calculated TU equivalents did not exceed 0.09 in either sample from the Stevens Creek site.

TEC and PEC quotients were calculated for all metals and total PAHs (calculated as the sum of 24 individual PAHs) measured in sediment samples. Both sites had at least one TEC or PEC quotient exceeding 1.0. In compliance with the MRP, both stations 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 most of the TEC and PEC quotient exceedances are related to naturally occurring chromium and nickel.

SCVURPPP will continue to sample the same two stations for dry weather pesticides and toxicity throughout the permit term. In WY 2018, SCVURPPP will work with the BASMAA RMC partners to implement a regional approach to wet weather pesticides and toxicity monitoring.

3.3 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 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. 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 will be selected from this list. Table 3.1 lists candidate SSID projects based on WY 2017 Creek Status and Pesticides/Toxicity monitoring data.

Additional analysis of the data is provided in **Appendix A** and should be considered prior to selecting and defining SSID projects. The analyses include review of physical habitat (including channel type and location with respect to reservoirs) and water chemistry data to identify potential stressors that may be contributing to degraded or diminished biological conditions. Analyses in Appendix A also include historical and spatial perspectives that help provide context and deeper understanding of the trigger exceedances.

Table 3.1. Summary of SCVURPPP trigger threshold exceedance analysis in WY 2017. "No" indicates samples were collected, but did not exceed the MRP trigger threshold. "Yes" and shading indicates an exceedance of the MRP trigger threshold.

Station ID	Creek	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]
205R00570	Trib to Aldercroft Cr	No	No	No	--	--	--	--	--	--	--	--
205R00609	Hunting Hollow	Yes	No	No	--	--	--	--	--	--	--	--
205R00645	Packwood Creek	Yes	No	No	--	--	--	--	--	--	--	--
205R02693	Packwood Creek	Yes	No	No	--	--	--	--	--	--	--	--
205R02755	Berryessa Creek	Yes	No	No	--	--	--	--	--	--	--	--
205R02787	Matadero Creek	Yes	No	No	--	--	--	--	--	--	--	--
205R02915	Stevens Creek	Yes	No	No	--	--	--	--	--	--	--	--
205R02947	Lower Penitencia	Yes	No	Yes	--	--	--	--	--	--	--	--
205R03011	Berryessa Creek	No	Yes	No	--	--	--	--	--	--	--	--
205R03091	Arroyo Aguague	No	No	No	--	--	--	--	--	--	--	--
205R03098	Guadalupe Creek	Yes	No	No	--	--	--	--	--	--	--	--
205R03235	Stevens Creek	No	No	No	--	--	--	--	--	--	--	--
205R03306	Saratoga Creek	No	No	No	--	--	--	--	--	--	--	--
205R03331	Los Gatos Creek	Yes	No	No	--	--	--	--	--	--	--	--
205R03354	Guadalupe Creek	No	No	No	--	--	--	--	--	--	--	--
205R03386	Aldercroft Creek	No	No	No	--	--	--	--	--	--	--	--
205R03418	Alamitos Creek	Yes	No	No	--	--	--	--	--	--	--	--
205R03443	Calabazas Creek	Yes	Yes	No	--	--	--	--	--	--	--	--
205R03523	Upper Penitencia Creek	No	No	No	--	--	--	--	--	--	--	--
205R03530	Los Gatos Creek	Yes	No	No	--	--	--	--	--	--	--	--
205LGA400	Los Gatos Creek	--	--	--	--	--	--	--	--	--	--	No
205MAT030	Matadero Creek	--	--	--	--	--	--	--	--	--	--	Yes
205STE064	Stevens Creek	--	--	--	--	--	--	--	--	--	--	Yes
205GUA225	Arroyo Calero	--	--	--	--	--	--	--	--	--	--	Yes
205SAR075	Saratoga Creek	--	--	--	--	--	--	--	--	--	--	Yes
205GUA210	Guadalupe Creek	--	--	--	--	--	--	Yes	--	--	--	--
205GUA202	Guadalupe Creek	--	--	--	--	--	--	Yes	--	--	--	--
205GUA190	Guadalupe Creek	--	--	--	--	--	--	Yes	--	--	--	--
205GUA270	Alamitos Creek	--	--	--	--	--	--	Yes	--	--	--	--
205GUA340	Arroyo Calero	--	--	--	--	--	--	Yes	--	--	--	--
205GUA225	Arroyo Calero	--	--	--	--	--	--	Yes	--	--	--	--
205GUA262	Alamitos Creek	--	--	--	--	--	--	Yes	--	--	--	--
205GUA255	Alamitos Creek	--	--	--	--	--	--	Yes	--	--	--	--
205GUA250	Alamitos Creek	--	--	--	--	--	--	Yes	--	--	--	--
205COY235	Coyote Creek	--	--	--	--	--	--	Yes	Yes	No	No	--
205COY236	Coyote Creek	--	--	--	--	--	--	Yes	Yes	No	No	--
205COY239	Coyote Creek	--	--	--	--	--	--	Yes	Yes	No	No	--
205STE021	Stevens Creek	--	--	--	No	No	Yes	--	--	--	--	--
205STQ010	San Tomas Aquino	--	--	--	No	No	Yes	--	--	--	--	--

Notes:

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

3.4 Management Implications

The Program's Creek Status and Pesticides and Toxicity Monitoring programs (consistent with MRP provisions C.8.c and C.8.g, respectively) focus on assessing the water quality condition of urban creeks in the Santa Clara Valley and identifying stressors and sources of impacts observed. The sample size from WY 2017 (overall n=20; urban n=17) 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. Additionally, episodic or site-specific increases in temperature (particularly in lower creek reaches) may not be optimal for aquatic life in local creeks.

The Program and its Co-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, the Program and Co-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 Co-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) Co-permittees continue to implement programs that are designed to prevent non-stormwater discharges during dry weather and reduce the exposure of contaminants to stormwater and sediment in runoff during rainfall events.

- 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 Section 5.0 of this report.

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, the Santa Clara Valley Water District's "One Water Plan" is an ongoing, multi-year process to develop a framework and watershed-specific plans for long-term management of Santa Clara county water resources. The One Water Plan will identify, prioritize and implement activities at a watershed scale to meet flood protection, water supply, water quality and environmental stewardship goals and objectives. The Santa Clara Valley Water District is also using Proposition 1 grant funds to develop a Storm Water Resource Plan for the Santa Clara Basin that will support the development and implementation of MRP-required Green Infrastructure Plans and produce a list of prioritized runoff capture and use projects eligible for future State implementation grant funds. Through the continued implementation of MRP-associated and other watershed stewardship programs, SCVURPPP 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 from creeks those 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. Where possible, creek status monitoring should support and/or compliment metrics and targets of long-term and/or watershed plans such as the One Water Plan.

4.0 STRESSOR/SOURCE IDENTIFICATION (C.8.E)

Provision C.8.e of the MRP requires that Permittees evaluate creek status (provision C.8.d) and pesticides and toxicity (provision C.8.g) monitoring data with respect to triggers defined in the MRP, and maintain a list of all results exceeding trigger thresholds. Table 3.1 lists the results of the trigger evaluation for WY 2017 data. Sites where triggers are exceeded may indicate potential impacts to aquatic life or other beneficial uses and are therefore considered as candidates for future Stressor/Source Identification (SSID) projects. SSID projects are selected from the list of trigger exceedances based on criteria such as magnitude of threshold exceedance, parameter, and likelihood that stormwater management action(s) could address the exceedance. The MRP requires that Permittees initiate a minimum number of SSID projects during the permit term, with a minimum of one for toxicity. Four of the SSID projects must be initiated with a work plan by the third year of the permit term (i.e., 2018). All SSID project reports must be summarized in a unified, regional-level report. In 2017, SCVURPPP, SMCWPPP, ACCWP, and CCCWP each developed an SSID project work plan in compliance with the 2015 MRP. These new SSID projects are summarized in the regional SSID report (**Appendix B**) along with all SSID projects initiated under the 2009 MRP. All SSID projects initiated in compliance with the 2009 MRP are now complete including the three projects initiated by SCVURPPP.

SSID projects must identify and isolate potential sources and/or stressors associated with observed water quality impacts. They are intended to be oriented to taking action(s) to alleviate stressors and reduce sources of pollutants. The 2015 MRP describes the stepwise process for conducting SSID projects initiated under the current permit:

- Step 1: Develop a work plan for each SSID project that defines the problem to the extent known, describes the SSID project objectives, considers the problem within a watershed context, lists candidate causes of the problem, and establishes a schedule for investigating the cause(s) of the trigger. The MRP recommends study approaches for specific triggers. For example, toxicity studies should follow guidance for Toxicity Reduction Evaluations (TRE) or Toxicity Identification Evaluations (TIE), physical habitat and conventional parameter (e.g., dissolved oxygen, temperature) studies should generally follow Step 5 (Identify Probable Causes) of the Causal Analysis/Diagnosis Decision Information System (CADDIS), and pathogen indicator studies should generally follow the California Microbial Source Identification Manual (SCCWRP 2013).

- Step 2: Conduct SSID investigation according to the schedule in the SSID work plan and report on the status of SSID investigations annually in the UCMR.

- Step 3: Conduct follow-up actions based on SSID investigation findings. These may include development of an implementation schedule for new or improved best management practices (BMPs). If a Permittee determines that MS4 discharges are not contributing to an exceedance of a water quality standard, the Permittee may end the SSID project upon written concurrence of the Executive Officer. If the SSID investigation is inconclusive, the Permittee may request that the Executive Officer consider the SSID project complete.

In 2017, SCVURPPP followed-up the Upper Penitencia Creek SSID Project that was initiated in compliance with the 2009 MRP (**Appendix C**). SCVURPPP also developed a work plan for the Coyote Creek Toxicity SSID Project (**Appendix D**), which will fulfil the regional requirement of one toxicity project. Both projects are summarized in the sections below. SCVURPPP will continue to collaborate with RMC partners on additional SSID projects.

4.1 Upper Penitencia Creek SSID Project

In WY 2016, the Program conducted the Upper Penitencia Creek SSID Project (Project). Project results were presented in a Final Report that was submitted to the Water Board on March 31, 2017 (SCVURPPP 2017). The Project was the third and final SSID project the Program was required to complete during the term of MRP 1.0.

Based on findings from the Project, the reduced biological integrity observed in Upper Penitencia Creek is believed to be associated with intermittent stream flow in the segment associated with the case site, that has been exacerbated by preceding two years of dry conditions associated with the drought. The source of stressors that may reduce the biological condition in the study area do not appear to be linked to stormwater impacts. As a result, the Upper Penitencia Creek SSID Project was considered complete. However, in effort to assist in future management of natural resources in Upper Penitencia Creek watershed, the Program identified additional follow-up actions. These actions include:

- Conduct biological assessments at Project study sites for a second year (WY 2017) to evaluate potential variability in biological conditions during years with different hydrological conditions.

- Conduct a brief evaluation of current management practices associated with water quality and water flows in Upper Penitencia Creek, and provide recommendations on how biological conditions may be improved in the water body.
- .

The monitoring results showed biological conditions, based on CSCI scores, at the case site were much higher in 2017 compared to 2016 (0.84 and 0.65, respectively). The increase in CSCI scores were likely associated with longer periods of wetted channel during the spring season of WY 2017 due to wet winter season and higher groundwater levels.

The management practices assessment (included as **Appendix C**) evaluated three types of practices in Upper Penitencia Creek that may impact the Project reach, including: 1) water operations; 2) channel maintenance, and 3) sediment controls in upper watershed. Recommended management/monitoring actions were as follows:

- Evaluate management scenarios to release water from Robert Gross Percolation Ponds that would enhance aquatic life uses in Upper Penitencia Creek. Management scenarios may include operations to enhance the timing, duration and magnitude of water releases to potentially benefit downstream migration of juvenile steelhead.
- Consider removal of non-native plant species (e.g., ivy) and encourage natural recruitment of native riparian vegetation at the case site to improve aquatic conditions as part of actions taken by the District's Safe Clean Water and Natural Flood Protection Program, Priority D[8]. Priority D focuses on Restoring Wildlife Habitat and Providing Open Space in Santa Clara County. Funding for this priority pays for control of non-native, invasive plants, revegetation of native species, and maintenance of previously revegetated areas. Other projects include removal of fish barriers, improvement of steelhead habitat and stabilization of eroded creek banks.
- Consider the installation of large woody debris to increase habitat type diversity (e.g., scour pools) to increase the diversity of aquatic biota, leveraging the District's Safe Clean Water and Natural Flood Protection Program, Priority D opportunities when possible. Large woody debris placement should consider habitat benefit versus flood risk. Consider use of SCVWD's gravel placement and large-wood placement site prioritization criteria which aims to integrate geomorphic analysis and aquatic ecology principles to increase in-stream complexity in select urbanized waterways throughout the county[9]. Other sources of information may include SCVWD's Stream Maintenance Program large woody debris guidelines.

To support these and future restoration projects the District will create a comprehensive, updated database on stream conditions countywide. The District and other agencies can then use the new

[8] https://www.valleywater.org/project-updates/safe-clean-water-and-natural-flood-protection-program/priority-d-restore-wildlife-habitat-and-provide-open-space

[9] Countywide Gravel and Large Wood Augmentation Program (Draft)

information to make informed decisions on where and how to use restoration dollars so they have the greatest value for wildlife.

Monitoring results and management practices assessment are summarized in the Upper Penitencia Creek SSID Project Follow-up Monitoring and Management Assessment Report which is included as **Appendix C**.

4.2 Coyote Toxicity

Consistent with MRP provision C.18.e, SCVURPPP has initiated an SSID project in Coyote Creek to investigate sources of sediment toxicity observed over the past decade. The Regional Water Board recently recommended listing of Coyote Creek for toxicity in sediment in the 2016 Integrated Report (303(d) List/305(b) Report) for the San Francisco Bay Region. The SSID project design is described in the Coyote Creek SSID Work Plan (see Appendix D) and is designed to:

1. Identify the magnitude and extent of toxicity in a reach of the Coyote Creek mainstem where previous data were collected; and
2. Identify potential causes of sediment toxicity (if observed).

Depending on results of the investigation, management actions to control toxicity in Coyote Creek will be identified in the project report. Although several potential stressors will be evaluated, it is likely that the cause of sediment toxicity in Coyote Creek will be pesticides. This hypothesis is based on previous monitoring throughout California that has concluded that urban applications of pyrethroid pesticides are causing toxicity to the amphipod *Hyalella azteca* in water and sediment from urban creeks. Fipronil, a common pyrethroid replacement pesticide, is also found in substantial numbers of water and sediment samples and the concentrations of this pesticide and its degradates are typically well above published toxicity (LC50) values.

The Coyote Toxicity SSID project will focus on evaluating if sediment toxicity is present in Coyote Creek and if so, evaluate pesticides as the stressor that may be causing the toxicity. The Program will implement an adaptive monitoring approach to further investigate potential sources and causes of sediment toxicity in Coyote Creek. The approach includes an initial evaluation of sediment chemistry and toxicity testing during the dry season of WY 2018. If results indicate the following, the described next steps will be implemented:

- If toxicity tests exhibit significant toxicity and percent effect is greater than 20% reduction in survival (compared to the Lab Control) AND sediment chemistry results indicate the presence of pyrethroid or fipronil pesticide at adverse effects levels (i.e., greater than LC50 threshold), then the SSID project will be considered complete.

- If toxicity tests exhibit significant toxicity, BUT the sediment chemistry results are inconclusive, the Program will implement a Toxicity Identification Evaluation (TIE) consistent with guidance provided in the EPA sediment TIE manual (EPA/600/R-08/080). The TIE will consist of a series of treatments designed to identify the type of chemicals that may be causing toxicity (Anderson 2009). The Program will implement a TIE that includes three targeted tests: 1) Baseline sample (i.e., re-test of sample); 2) Activated Carbon (i.e., general organic contaminants); and 3) Cationic Resin (metals). The TIE will confirm toxicity is present (or not), and the type of contaminant (i.e., metal and/or organic) that may be causing the toxicity. TIEs are more effective when there is sufficient toxicity in the sample. Thus, a TIE will only be conducted for samples that exhibit toxicity with percent effect that is greater than 50% reduction in survival (compared to Lab Control). A maximum of one TIE will be conducted at two sites (total of two TIEs) for the SSID Project, providing all sites meet the 50% reduction in survival criterion. The TIE(s) will be conducted immediately following receipt of the sediment chemistry laboratory.

All toxicity testing, sediment chemistry results and TIE results from WY 2018 will be evaluated prior to any additional monitoring being considered for WY 2019. Should additional monitoring be planned for WY 2019, the evaluation of WY 2018 and description of planned WY 2019 monitoring will be included in a revised Work Plan that will be submitted with the Program's WY 2018 UCMR. If monitoring results suggest that Coyote Toxicity SSID project is complete (i.e., toxicity observed is associated with pesticides), the Program will prepare a Final Report with data results and interpretation, and submit the report with the Program's WY 2018 UCMR.

5.0 POLLUTANTS OF CONCERN MONITORING

Pollutants of Concern (POC) monitoring is required by provision C.8.f of the MRP. POC monitoring is intended to assess inputs of POCs to the Bay from local tributaries and urban runoff, provide information to support implementation of total maximum daily load action plans (TMDLs) and other pollutant control strategies, assess progress toward achieving wasteload allocations (WLAs) for TMDLs, and help resolve uncertainties associated with loading estimates for these pollutants. The MRP identifies five priority POC management information needs that need to be addressed though POC monitoring:

1. **Source Identification** – identifying which sources or watershed source areas provide the greatest opportunities for reductions of POCs in urban stormwater runoff;
2. **Contributions to Bay Impairment** – identifying which watershed source areas contribute most to the impairment of San Francisco Bay beneficial uses (due to source intensity and sensitivity of discharge location);
3. **Management Action Effectiveness** – providing support for planning future management actions or evaluating the effectiveness or impacts of existing management actions;
4. **Loads and Status** – providing information on POC loads, concentrations, and presence in local tributaries or urban stormwater discharges; and
5. **Trends** – evaluating trends in POC loading to the Bay and POC concentrations in urban stormwater discharges or local tributaries over time.

Provision C.8.f of the MRP requires POC monitoring of polychlorinated biphenyls (PCBs), mercury, copper, emerging contaminants, and nutrients.[10] The MRP defines yearly and total (i.e., permit term) minimum number of samples for each POC and specifies the minimum number of samples for each POC that must address each information need. Progress toward POC monitoring requirements accomplished in WY 2017 and the planned allocation of effort for WY 2018 are described in the SCVURPPP POC Monitoring Report (SCVURPPP 2017) that was submitted to the Regional Water Board on October 15, 2017 in compliance with provision C.8.h.iv of the MRP.

In WY 2017, SCVURPPP complied with Provision C.8.f of the MRP through the following activities:

- Implementation of a catchment-scale storm sampling program for PCBs and mercury (n=17), and copper analysis (n=2);
- Collection of upland sediment samples for PCBs and mercury analysis (n=76);
- Collection of wet weather samples for nutrients and copper analysis (n=3) and dry weather samples for nutrients analysis (n=1);
- Participation in SWAMP's Stream Pollutant Trends monitoring program; and
- Participation in the RMP Small Tributaries Loading Strategy Team (STLS).[11]

POC monitoring in WY 2017 continued to focus primarily on identification of source areas of PCBs and mercury to the MS4 and San Francisco Bay. WY 2017 data are being used by SCVURPPP to implement a process to identify and prioritize watershed management areas (WMAs) and identify specific source properties in the Santa Clara Valley. This process is generally consistent with the approaches currently being implemented by other RMC partners. WMAs are priority watersheds or catchments in the urban landscape where control measures for PCBs and mercury are currently being implemented or will be

[10] Emerging contaminant monitoring requirements will be met through participation in RMP special studies and will address at least PFOS, PFAS, and alternative flame retardants being used to replace PBDEs.

[11] SCVURPPP strives to work collaboratively with our water quality monitoring partners to find mutually beneficial monitoring approaches. Provision C.8.a.iii of the MRP allows Permittees to use data collected by third-party organizations to fulfill monitoring requirements, provided the data are demonstrated to meet the required data quality objectives. Samples collected in Santa Clara County through the RMP are used to supplement the Program's efforts towards achieving provision C.8.f monitoring requirements.

implemented during the MRP permit term, to the extent that feasible and cost-effective controls can be identified.

A report describing the results of all POC monitoring conducted by SCVURPPP is included as **Appendix E** to this report and a report describing the results of POC monitoring conducted by the STLS is included as **Appendix F**. Appendices E and F are summarized in the sections below.

5.1 SCVURPPP POC Monitoring (C.8.f)

In compliance with provision C.8.f of the MRP, the Program conducted POC monitoring in WY 2017 for PCBs, mercury, copper, and nutrients. The MRP-required yearly minimum number of samples was exceeded for all POCs. Results are summarized in the sections below and described in more detail in **Appendix E**.

5.1.1 PCBs and Mercury

PCBs and mercury monitoring by the Program in WY 2017 served two related purposes: WMA prioritization and source property identification.

WMA Prioritization

Wet weather samples were collected from MS4 outfalls or manholes to provide information to identify WMAs where control measures could be implemented to comply with MRP requirements for load reductions of PCBs and mercury. This is the same approach that was implemented in WY 2016 and monitoring was conducted in accordance with the Water Year 2016 Pollutant of Concern Monitoring - Sampling and Analysis Plan (SCVURPPP 2015). The sampling was focused on collection of storm composite samples from high interest WMAs that may contain PCB and/or mercury source properties. High interest WMAs were identified and prioritized for sampling by evaluating several types of data, including: PCBs and mercury concentrations from prior sediment and water sampling efforts, land use data showing old industrial parcels, municipal storm drain data showing pipelines and access points (e.g., manholes, outfalls, pump stations), catchment areas delineated from municipal storm drain data, and logistical/safety considerations (SCVURPPP 2015).

During WY 2017, the Program collected seventeen samples for PCBs and mercury analysis. Each sample was a composite consisting of four to eight aliquots collected during the rising limb and peak of the storm hydrograph (as determined through field observations). Samples were analyzed for the “RMP 40” PCB congeners (method EPA 1668C), total mercury (method EPA 1631E), and suspended sediment concentration (SSC; method ASTM D3977-97).

In summary, WY 2017 results included:

- Total PCB concentrations, calculated as the sum of the “RMP 40” congeners, ranged from 0.884 ng/L to 57.6 ng/L; and PCB particle ratios, calculated by dividing total PCB concentrations by SSC, ranged from 47.1 ng/g to 1,070 ng/g.
- Mercury concentrations ranged from ND to 3.01 ng/L. Although the data appeared to be of sufficient quality for comparison of stations sampled in WY 2017, the mercury concentrations reported in WY 2017 were significantly lower than prior years. Therefore, all mercury data were rejected by the Program Quality Assurance Officer (QAO) due to potential QA concerns.

When compared to the growing dataset of wet weather characterization monitoring conducted in the Bay Area over the past 12 years (i.e., n=118), three of the PCBs samples that were collected in WY 2017 ranked in the top quartile of PCB particle ratios. The WMAs associated with these samples have been flagged for follow-up monitoring to investigate specific source properties. Figure 5.1 illustrates those WMAs (i.e., catchments) that have been identified as high interest source areas (11) or are confirmed to contain source properties (2).

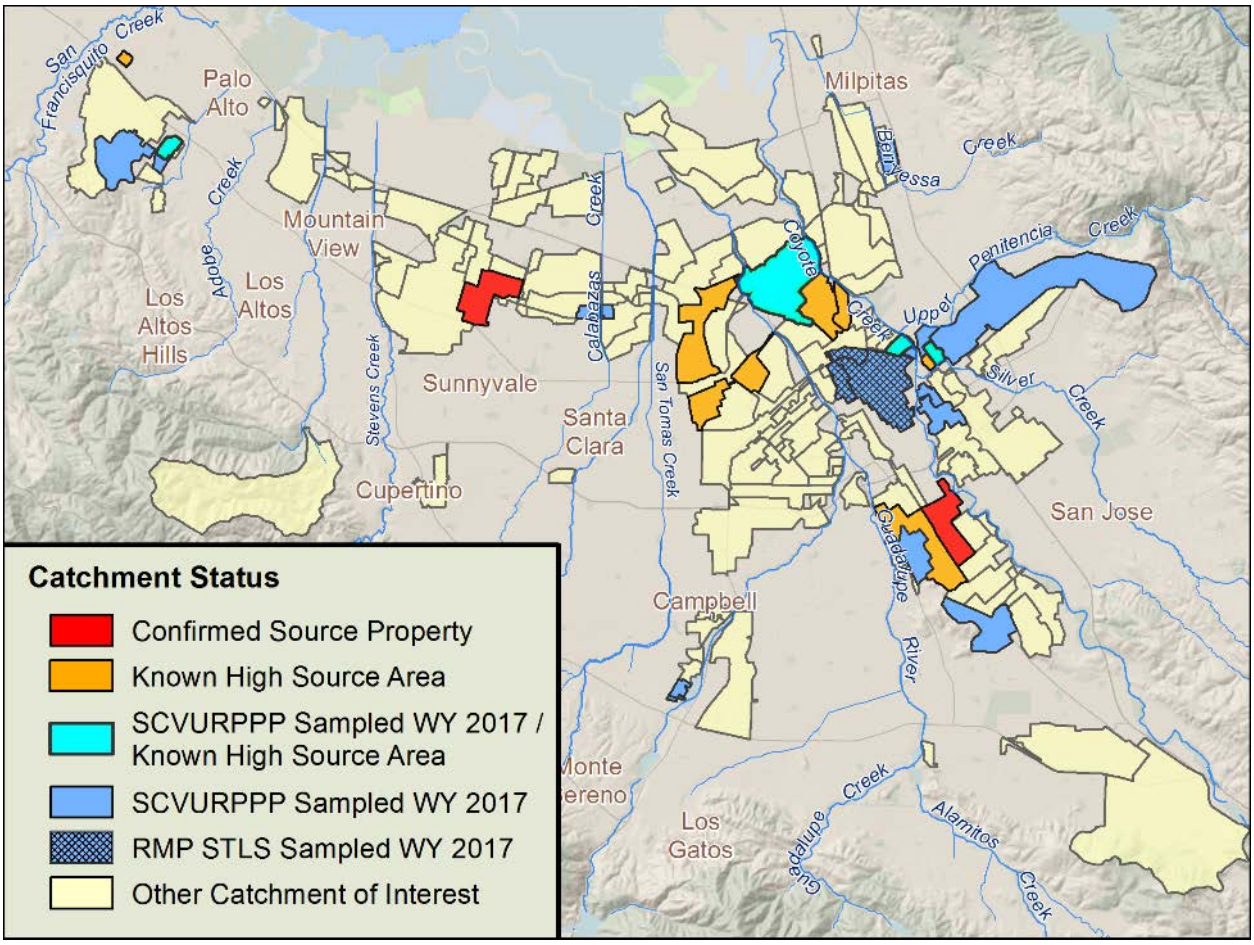

Figure 5.1. WMA map of Santa Clara County, showing catchments sampled in WY 2017.

Source Property Identification

One strategy to reduce PCBs and mercury loadings to the Bay is to identify properties that disproportionately contribute these pollutants to the MS4 and abate these properties via referrals to appropriate agencies. In this effort, the Program collected 76 PCBs and mercury samples in WY 2017 from seven prioritized WMAs. Total PCB concentrations in the samples, calculated as the sum of the "RMP 40" congeners, ranged from 0.004 mg/kg to 11.9 mg/kg. Mercury concentrations ranged from 0.03 mg/kg to 4.29 mg/kg. The data are being evaluated in concert with other source property investigation approaches such as property record and aerial photography reviews, public right-of-way surveys, and facility site visits to identify specific properties for referrals. A report describing the investigations and results is currently under development and will be included with the Program's FY 17-18 Annual Report (September 2018). It is anticipated that up to six properties will be referred as a result of the WY 2017 investigations.

SCVURPPP plans to continue working with other Bay Area countywide stormwater programs (through the BASMAA MPC Committee) and the RMP STLS to evaluate the results of the ongoing efforts in the Bay Area to identify PCBs and mercury source areas and plan next steps in Santa Clara County.

5.1.2 Copper

In WY 2017, the Program collected a total of five samples for copper analysis (i.e., total and dissolved copper, and hardness). Two samples from storm drain outfalls (067CTC350A and 067CTC351A) concurrently with PCBs and mercury storm composite samples. The goal of these samples is to address

Management Question #4 (Loads and Status) by characterizing copper concentrations in stormwater runoff from highly urban catchments. Three samples were collected during a large storm event at upstream and downstream locations in the Silver Creek watershed to address Management Question #4 (Loads and Status) by characterizing copper concentrations in stormwater runoff from upstream and downstream locations in mixed land-use catchments.

Based on the laboratory results, the following findings are noted:

- As expected, dissolved copper concentrations are lower than total copper concentrations.
- Copper concentrations reported for the stormwater outfalls were comparable to concentrations measured in creeks. However, the hardness of the outfall water was less than the creek water.
- Copper concentrations increased in the downstream direction in the Silver Creek watershed.
- All dissolved copper concentrations were below the hardness-dependent acute and chronic WQOs.

5.1.3 Nutrients

In WY 2017, the Program collected samples for nutrients analysis (i.e., ammonium[12], nitrate, nitrite, total Kjeldahl nitrogen (TKN), dissolved orthophosphate, and total phosphorus) from three locations along Silver Creek (upstream, middle, and downstream) to address Management Question #4 (loads and status). Samples were collected during a large storm event on January 9, 2017 and during dry season baseflows on June 1, 2017. The upstream location was dry during the June sampling event.

Based on the laboratory results, the following findings are noted:

- During the January storm event, total nitrogen concentrations were lower at the downstream station (205COY180) compared to the upstream (205COY205) and middle (205C07185) stations. In June, this trend was reversed with higher total nitrogen concentrations at the downstream station compared to the middle station.
- In contrast to total nitrogen, phosphorus concentrations increased in the downstream direction during the January storm event and decreased in the downstream direction in June.
- Inorganic nitrogen (nitrate and nitrite) concentrations were higher in June compared to the January storm event and organic nitrogen (i.e., TKN) concentrations were lower in June compared to the January storm event.
- Organic nitrogen (i.e., TKN) made up a greater proportion of the total nitrogen concentration during the January storm event compared to the June event. It is likely that organically-bound nitrogen washed off surfaces during the January storm had not yet had time to cycle through the ammonification and nitrification processes before samples were collected. In June, TKN made up just a small percent of the total nitrogen.
- Phosphorus concentrations were higher during the January storm runoff sampling event compared to the June baseflow event. This finding is consistent with the draft conceptual model developed by the “San Francisco Bay Nutrient Management Strategy” (NMS) which suggests that nutrient loads to San Francisco Bay from creeks are highest during the wet season, although considerably less than loads from publicly owned wastewater treatment works (POTWs) (Senn and Novick 2014). However, nutrient concentrations (primarily nitrate) were higher during the

[12] Ammonium was calculated as the difference between ammonia and un-ionized ammonia. Un-ionized ammonia was calculated using the formula provided by the American Fisheries Society Online Resources (http://fishculture.fisheries.org/resources/fish-hatchery-management-calculators/).

baseflow event. It unknown why nitrate patterns in Silver Creek were not consistent with the NMS model.

- No applicable WQOs were exceeded.

5.1.4 Recommendations for WY 2018 POC Monitoring

As described in **Appendix E**, the Program identified the following recommendations for POC monitoring in WY 2018 and beyond:

- SCVURPPP and the RMP's STLS will continue to conduct PCB and mercury monitoring with the goal of identifying WMAs and specific source properties where new PCB and mercury control measures can be implemented during the permit term.

- At least eight PCBs and mercury samples that address Management Question #3 (Management Action Effectiveness) must be collected by the end of year four of the permit (i.e., 2020). BASMAA is currently implementing a regional project that addresses POC Management Action Effectiveness. The Study Design, approved by the Project Management Team in August 2017, addresses the effectiveness of hydrodynamic separator (HDS) units and various types of biochar-amended bioretention soil media (BSM) at removing PCBs and mercury from stormwater. Findings from the regional project will be reported in the WY 2018 UCMR which will be submitted by March 31, 2019. Findings will also be used to support development of the Reasonable Assurance Analysis (RAA) that is required by provision C.12.c.iii.(3) of the MRP and which must be submitted with the 2020 Annual Report (September 30, 2020).

- At least eight samples that address Management Question #5 (Trends) must be collected by the end of year four of the permit (i.e., 2020). SCVURPPP will continue to participate in the STLS Trends Strategy Team to meet this requirement. The STLS Trends Strategy Team, initiated in WY 2015, is currently developing a regional monitoring strategy to assess trends in POC loading to San Francisco Bay from small tributaries (see Section 5.2.3). The STLS Trends Strategy will initially focus on PCBs and mercury, but will not be limited to those POCs. Analysis of recent and historical data collected at region-wide loadings stations suggests that PCB concentrations are highly variable. Therefore, a monitoring design to detect trends with statistical confidence may require more samples than is feasible with current financial resources. The STLS Trends Strategy Team is continuing to evaluate available data from the Guadalupe River watershed to explore more economical monitoring opportunities. The Team is also considering modeling options that could be used in concert with monitoring to detect and predict trends in POC loadings. A Trends Strategy Road Map is currently being developed via the STLS.

- SCVURPPP will continue to work with the SPoT Program to address Management Question #5 (Trends). The *SPoT Monitoring Program* conducts annual dry season monitoring (subject to funding constraints) of sediments collected from a statewide network of large rivers. The goal of the SPoT Program is to investigate long-term trends in water quality (Management Question #5 – Trends). Sites are targeted in bottom-of-the-watershed locations with slow water flow and appropriate micromorphology to allow deposition and accumulation of sediments, including two stations in Santa Clara County (Coyote Creek and Guadalupe River). In most years, sediments are analyzed for PCBs, mercury, other metals, toxicity, pesticides, and organic pollutants (Phillips et al. 2014).

- Copper and nutrient samples will be collected from mixed land use watersheds during storm events.

- SCVURPPP will continue to participate in the RMP's STLS and the RMP's CEC Strategy.

5.2 Small Tributaries Loading Strategy

The RMP Small Tributaries Loading Strategy was developed in 2009 by the STLS Team, which includes representatives from BASMAA, Regional Water Board staff, RMP staff, and technical advisors and is overseen by the Sources, Pathways, and Loadings Workgroup (SPLWG). The objective of the STLS is to develop a comprehensive planning framework to coordinate POC monitoring/modeling between the RMP and RMC participants. In 2017, the following management policies and decisions were identified:

- Refining pollutant loading estimates for future TMDL updates,
- Informing provisions of the current and future versions of the MRP,
- Identifying small tributaries to prioritize for management actions, and
- Informing decisions on the best management practices for reducing concentrations and loads.

The sections below describe the tasks implemented by the RMP STLS in WY 2017 to address the relevant management policies.

5.2.1 Wet Weather Characterization

With a goal of identifying watershed sources of PCBs and mercury, STLS field monitoring in WY 2017 continued to focus on collection of storm composite samples in the downstream reaches of catchments located throughout the region. In WY 2017, 17 catchments ranging in size from 0.09 km^2 to 36.57 km^2 and representing engineered MS4 drainage areas throughout the Bay Area were sampled during storm events. Storm composite water samples were analyzed for concentrations of PCBs, total mercury, and suspended sediment concentration. In addition, a pilot study was continued at a subset of locations to collect fine sediments using specialized settling chambers. A full description of the methods and results from WY 2015, WY 2016, and WY 2017 monitoring is included in **Appendix F** (Pollutants of Concern Reconnaissance Monitoring Final Progress Report, Water Years 2015, 2016, and 2017).

In WY 2017 two catchments were targeted in Santa Clara County based on recommendations by Program staff evaluating land uses in the County that have the highest likelihood of generating PCBs in stormwater runoff. Both of the Santa Clara County sampling stations were located at manholes accessing the MS4. Results of these STLS stations are summarized with SCVURPPP monitoring results in **Appendix E**. Wet weather characterization monitoring by the RMP STLS is planned to continue in WY 2018.

Findings

The RMP STLS has a growing database of nearly 75 stations that have been sampled at least once during wet weather events for PCBs, mercury, and SSC since 2003. (Some stations have also been sampled for a larger suite of constituents.) Prior to WY 2015, most of the stations were located in natural creeks, whereas the 55 stations sampled in WY 2015 through WY 2017 were primarily located in small catchments draining primarily old industrial land uses. At 16 of the stations, a second sample was collected with either a Hamlin or Walling tube remote sediment sampler.

Acknowledging that dynamic climatic conditions and individual storm characteristics may affect data interpretation, the following conclusions have been identified:

- PCBs positively correlate with impervious cover, old industrial land use, and mercury. They inversely correlate with watershed area. Although mercury and PCBs positively correlate, the relationship is relatively weak, probably due to the larger role of atmospheric recirculation in the mercury cycle and the differences in use history of each POC.

- Neither PCBs nor mercury have strong correlations with other trace metals (As, Cu, Cd, Pb, and Zn). Therefore, there is no support for the use of trace metals as surrogate investigative tools for either PCBs or mercury sources.

- The testing of the remote samplers showed mixed results and further testing is needed to determine their utility in investigating PCB and mercury sources.

- Resampling of some stations (i.e., those that return lower than expected concentrations) is recommended to test for false negatives.

5.2.2 Regional Watershed Spreadsheet Model

The Regional Watershed Spreadsheet Model (RWSM) is a land use based planning tool for estimation of annual POC loads from small tributaries to San Francisco Bay at a regional scale. Development of the RWSM began in 2010 and, in WY 2017, the STLS Team (with support and input from BASMAA representatives) published a beta version of the RWSM tool-kit.

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

The RWSM is based on the assumption that an estimate of mean annual **volume** for each land use type within a watershed can be combined with an estimate of mean annual **concentration** for that same land use type to derive a **load** which can be aggregated for a watershed or many watersheds within a region of interest. It may be used to provide hypotheses about which sub-regions or watersheds export relatively higher or lower loads to the Bay relative to area. It can also serve as a baseline for analyzing changes in loadings due to large scale changes in land use (e.g., associated with redevelopment and new development) and runoff (e.g., associated with climate change and changes in impoundment). However, the RWSM is less reliable for predicting real loadings for individual watersheds and for estimating load changes in relation to implementation of treatment BMPs.

The RWSM beta tool-kit published in June 2017 includes:

- Hydrology Model coded using ArcPy and drawing on a user interface accessible through ArcGIS;
- Pollutant Model Spreadsheet for taking the outputs from the Hydrology Model and inputting land use coefficients to estimate pollutant loads;
- Two optional calibration tools – a spreadsheet for manual calibration, and an R script for an optimized automated calibration; and
- User Manual

5.2.3 STLS Trends Strategy

In WY 2017, the STLS Trends Strategy team continued to meet. The STLS Trends Strategy was initiated in 2015 by recommendation of from the SPLWG which advised the STLS to define where and how trends may be most effectively measured in relation to management effort so that data collection methods deployed over the next several years will support this management information need. The STLS Trends Strategy team is comprised of SFEI staff, RMC participants, and Regional Water Board staff. Invitations to key meetings are expanded to additional interested parties (e.g., EPA) and technical advisors (e.g., USGS) are consulted to review specific technical work products.

The Trends Strategy document and Technical Appendix, drafted in WY 2016, serves as a foundation for this team. The main document summarizes the background, management questions, and guiding principles of the Trends Strategy. It also describes coordination between the RMP and BASMAA within the context of the MRP, proposed tasks to answer the management questions, anticipated deliverables, and the overall timeline. The current priority POCs are PCBs and mercury and trend indicators under consideration (i.e., PCB concentrations and particle-ratios) were identified within the context of existing datasets (e.g., POC loading stations) and TMDL timelines. However, the Strategy recognizes that priorities can change in the future. The Technical Appendix (Melwani et al. 2016) presents an evaluation of variability and statistical power for detecting trends based on POC loading station PCBs data. It presents sample size and revisit frequency scenarios needed to detect declining trends in PCBs in 25 years with > 80% statistical power. Due to high variability in baseline PCB concentrations, the modeled sampling scenarios would likely be too expensive and unrealistic to implement. Therefore, the Technical Appendix recommends additional analyses and monitoring that should be considered prior to developing a trends monitoring design.

In WY 2017, the STLS Trends Strategy team followed up on some of the recommendations from the Technical Appendix. A statistical model for trends in PCB loads in the Guadalupe River (as a case study) was developed. The model incorporates the significant turbidity-PCB relationships that exist and evaluates climatic, seasonal, and inter-annual factors as potential drivers of PCB loads. More intensive review of the Guadalupe River dataset resulted in two main findings: 1) No trends in PCB loads were apparent for the period of 2003 through 2014: 2) A monitoring design that includes sampling at least two storms in 13 out of 20 years (with 4 to 6 grab samples per storm) would detect inter-annual trends of 25% or more over 20 years with > 80% power[13] (Melwani et al. 2018). Results of the statistical analyses were presented at key stages in the analysis to USGS technical advisors with expertise in trends analysis of water data. It is uncertain how the Guadalupe River model and analysis could be applied to other watersheds which have distinct characteristics.

In WY 2018, the Trends Strategy team is updating the Trends Strategy document to include an evaluation of how various tasks to date have and could be used to address the five POC information needs from the MRP (see list at the beginning of Section 5.0. This review will focus on the Guadalupe River statistical analysis, RWSM, BASMAA source identification and BMP effectiveness monitoring, and POC loads monitoring (loading stations and wet weather characterization). The updated document will also propose conceptual ideas for a regional load model that may be supplemented, optimized, and/or calibrated with data from field monitoring. A five-year workplan with estimates of annual budget allocations will be presented.

5.2.4 Guadalupe River Loading Station Contingency Monitoring

POC loads monitoring activities were conducted from 2003 through 2014 in the Guadalupe River near the Highway 101 overpass. These efforts occurred via a combination of RMP, SCVURPPP and Santa Clara Valley Water District (SCVWD) funding and were generally aimed at developing robust estimates of annual mercury and other POC loading to the Bay from the watershed (see Section 5.2.3 for more information). One key information gap that remains is the concentrations and loading associated with high intensity storm events that necessitate the release of water from reservoirs located in the upper watershed. These events rarely occur and, for the past few years, the Program has been prepared to institute contingency monitoring to sample water at the Highway 101 station in the event of a qualifying storm. In WY 2017, a qualifying event occurred and was successfully sampled.

McKee et al. (2018) describes monitoring methods and results from the five-day sampling event that occurred in January 2017. SFEI staff implemented an adaptive sampling strategy and captured a total of 14 samples over five days. During that time, flow peaked three times in response to heavy and prolonged

[13] Power is defined as the probability of detecting a trend of a certain magnitude during a specified monitoring period (years), where a Type I error rate is set at 5%.

rainfall. **Figure 5.2** (i.e., Figure 4 from McKee et al. 2018) illustrates how mercury concentrations varied throughout the storm hydrograph.

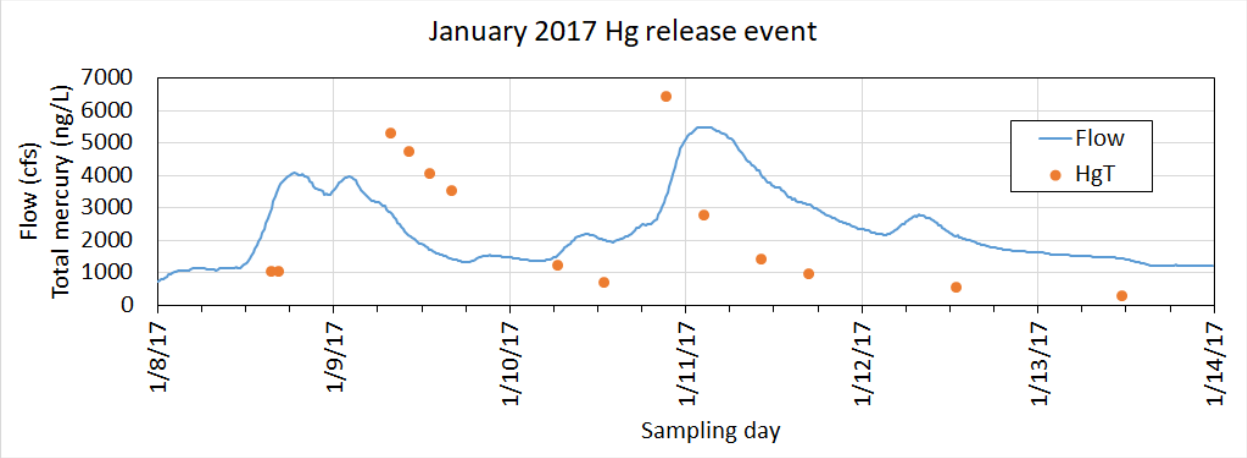

Figure 5.2. January 2017 storm hydrograph and total mercury concentrations in Guadalupe River at Highway 101 (Figure 4 from McKee et al. 2017; flow data are provisional and subject to change).

Two methods were applied to estimate mercury loads during the event. The first method was used to generate a load estimate for every 15-minute interval during the sampling period (using linear interpolation between grab samples) and resulted in a total event load of 70 kg. The second method combined a flow-weighted average concentration with total event flow for a load estimate of 82 kg. Approximately 86% of the load is assumed to emanate from the historic mining district in the upper watershed, rather than the urbanized areas in the lower watershed. Regardless of which method is used, a load equivalent of more than half of the previously estimated average annual baseline load for the Guadalupe River was transported during this one storm. The loads during this one storm exceeded the TMDL wasteload allocation of 9.4 kg/year by a factor of over 7. These findings illustrate the very episodic nature of loads in this system.

Comparison to Applicable Water Quality Standards

MRP provision C.8.g.iii requires RMC participants to assess all data collected pursuant to provision C.8 for compliance with applicable water quality standards. In compliance with this requirement, comparisons of data collected in the Guadalupe River in WY 2017 to applicable numeric WQO is provided below.

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

Discharge vs. Receiving Water – WQOs apply to receiving waters, not discharges. WQOs are designed to represent the maximum amount of pollutants that can remain in the water column without causing any adverse effect on organisms using the aquatic system as habitat, on people consuming those organisms or water, and on other current or potential beneficial uses. POC monitoring data collected as part of the wet weather characterization effort (Section 5.2.1) were not collected in receiving waters; instead, they were collected within the engineered storm drain network where WQOs do not apply.

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

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

Acute vs. Chronic Objectives/Criteria - Monitoring was conducted during episodic storm events and results do not likely represent long-term (chronic) concentrations of monitored constituents. POC monitoring data were therefore compared to "acute" WQOs/criteria for aquatic life that represent the highest concentrations of an analyte to which an aquatic community can be exposed briefly (e.g., 1-hour) without resulting in an unacceptable effect. Of the analytes monitored in Guadalupe River in WY 2017, WQOs or criteria have only been promulgated for total mercury. Therefore, the comparison of data collected in WY 2017 to applicable numeric WQOs or criteria adopted by the Regional Water Board is limited to total mercury.

Six of the 14 samples collected in the Guadalupe River in WY 2017 were above the freshwater acute objective for mercury of 2.4 µg/L. Total mercury concentrations ranged from 0.28 µg/L to 6.45 µg/L with the highest concentrations occurring during storm peak flows. Mercury discharges from urban areas that drain through the MS4 are being addressed through provision C.11 of the MRP which implements the San Francisco Bay and Guadalupe River Watershed mercury TMDLs.

6.0 NEXT STEPS

Water quality monitoring required by provision C.8 of the MRP is intended to assess the condition of water quality in the Bay area receiving waters (creeks and the Bay); identify and prioritize stormwater associated impacts, stressors, sources, and loads; identify appropriate management actions; and detect trends in water quality over time and the effects of stormwater control measure implementation. On behalf of Co-permittees, SCVURPPP conducts creek water quality monitoring and monitoring projects in the Santa Clara Valley (Lower South Bay) in collaboration with the Regional Monitoring Coalition (RMC), and actively participates in the San Francisco Bay Regional Monitoring Program, which focuses on assessing Bay water quality and associated impacts.

In WY 2018, SCVURPPP will continue to comply with water quality monitoring requirements of the MRP. The following list of next steps will be implemented in WY 2018:

- SCVURPPP will continue to collaborate with the RMC (MRP provision C.8.a).
- Where applicable, monitoring data collected and reported by SCVURPPP will continue to be SWAMP comparable (MRP provision C.8.b).
- SCVURPPP will continue to provide financial contributions towards the RMP and to actively participate in the RMP committees and work groups described in Sections 2.0 and 5.0 (MRP provision C.8.c).
- SCVURPPP will continue to conduct probabilistic and targeted Creek Status Monitoring consistent with the specific requirements in the MRP (MRP provision C.8.d).
- SCVURPPP will continue to implement dry weather Pesticides and Toxicity Monitoring and will work with RMC partners to develop and implement a wet weather Pesticides and Toxicity Monitoring program consistent with MRP provision C.8.g.
- SCVURPPP will continue to review monitoring results and maintain a list of all results exceeding trigger thresholds (MRP provision C.8.e.i). SCVURPPP will coordinate with the RMC to initiate a region wide goal of eight new SSID projects by the end of the permit term including four new SSID projects by the third year of the permit (MRP provision C.8.e.iii). This will include implementation of the Coyote Creek Toxicity SSID Project.
- SCVURPPP will continue to participate in the STLS and SPLWG which address MRP provision C.8.f POC management information needs and monitoring requirements through wet weather characterization monitoring, refinement of the RWSM, and advancement of the STLS Trends Strategy.
- SCVURPPP will continue to support mercury monitoring at the Guadalupe River loading stations which is now conducted through the Coordinated Monitoring Program for the Guadalupe River watershed, a collaboration of entities subject to the Guadalupe River Mercury TMDL.
- SCVURPPP will implement a POC monitoring framework to comply with provision C.8.f of the MRP. The monitoring framework will address the annual and total minimum number of samples required for each POC (i.e., PCBs, mercury, copper, emerging contaminants, nutrients) and each management information need (i.e., Source Identification, Contributions to Bay Impairment, Management Action Effectiveness, Loads and Status, Trends). WY 2018 monitoring will include collection of wet weather composite water samples from catchments and collection of dry weather sediment samples from the public right-of-way to identify areas where PCB and mercury control measures may be implemented. WY 2018 monitoring will also include sampling for nutrients and copper.
- WY 2018 POC monitoring accomplishments and allocation of sampling efforts for POC monitoring in WY 2098 will be submitted in the Pollutants of Concern Monitoring Report that is due to the Water Board by October 15, 2018 (MRP provision C.8.h.iv).

- Results of WY 2018 monitoring will be described in the Programs WY 2018 Urban Creeks Monitoring Report that is due to the Water Board by March 31, 2019 (MRP provision C.8.h.iii).

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Appendix A

SCVURPPP Creek Status Monitoring Report, Water Year 2017

Santa Clara Valley
Urban Runoff
Pollution Prevention Program

Watershed Monitoring and Assessment Program

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. R2-2015-049

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 the 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 Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP or Program) using probabilistic and targeted monitoring designs as described herein.

Consistent with the Creek Status and Long-Term Trends Monitoring Plan (BASMAA 2012), monitoring data were collected in accordance with the most recent versions of the BASMAA RMC Quality Assurance Project Plan (QAPP; BASMAA, 2016a) and the 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 submitted in electronic SWAMP-comparable formats by SCVURPPP to the San Francisco Bay Regional Water Quality Control Board on behalf of SCVURPPP Co-permittees and pursuant to provision C.8.h.ii of the MRP.

[1] The San Francisco Bay Regional Water Quality Control Board (SFRWQCB or Regional Water Board) issued the MRP to 76 cities, counties and flood control districts (i.e., Permittees) in the Bay Area on October 14, 2009 (SFRWQCB 2009). On November 19, 2015, the Regional Water Board updated and reissued the MRP (SFRWQCB 2015). The BASMAA programs supporting MRP Regional Projects include all MRP Permittees as well as the cities of Antioch, Brentwood, and Oakley, which are not named as Permittees under the MRP but have voluntarily elected to participate in MRP-related regional activities.

[2] The current SWAMP 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
CAP	Conservation Action Planning
CCCWP	Contra Costa Clean Water Program
CDFW	California Department of Fish and Wildlife
CEDEN	California Environmental Data Exchange Network
COLD	Cold Freshwater Habitat
CSCI	California Stream Condition Index
DO	Dissolved Oxygen
DPR	Department of Pesticide Regulation
DPS	Distinct Population Segment
EPA	Environmental Protection Agency
FSURMP	Fairfield Suisun Urban Runoff Management Program
GIS	Geographic Information Systems
GRTS	Generalized Random Tessellation Stratified
IBI	Indices of Biotic Integrity
IWRMP	Integrated Water Resources Management Plan
LID	Low Impact Development
MIGR	Fish Migration
MPC	Monitoring and Pollutants of Concern Committee
MRP	Municipal Regional Permit
MUN	Municipal and Domestic Water Supply
MWAT	Maximum Weekly Average Temperature
NMFS	National Marine and Fisheries Services
NPDES	National Pollution Discharge Elimination System
O/E	Observed to Expected
PAH	Polycyclic Aromatic Hydrocarbons
PEC	Probable Effects Concentrations
PHAB	Physical Habitat Assessment
pMMI	Predictive Multi-Metric Inde
xPSA	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
RMP	Regional Monitoring Program
RWB	Reachwide Benthos
SAFIT	Southwest Association of Freshwater Invertebrate Taxonomists
SCCWRP	Southern California Coastal Water Research Project
SCVURPPP	Santa Clara Valley Urban Runoff Pollution Prevention Program
SCVWD	Santa Clara Valley Water District

SFRWQCB	San Francisco Bay Regional Water Quality Control Board
SMCWPPP	San Mateo County Water Pollution Prevention Program
SPoT	Stream Pollution Trends
SPWN	Fish Spawning
SOP	Standard Operating Protocol
SSID	Stressor/Source Identification
SWAMP	Surface Water Ambient Monitoring Program
SWPP	Surface Water Protection Program
TEC	Threshold Effects Concentrations
TMDL	Total Maximum Daily Load
TNS	Target Non-Sampleable
TOC	Total Organic Carbon
TS	Target Sampleable
TST	Test of Significant Toxicity
TU	Toxicity Unit
UCMR	Urban Creeks Monitoring Report
WARM	Warm Freshwater Habitat
USEPA	Environmental Protection Agency
WQ	Water Quality
WQO	Water Quality Objective
WY	Water Year

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LIST OF ATTACHMENTS

Attachment 1. QA/QC Report

1.0 INTRODUCTION

This Creek Status Monitoring Report was prepared by the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP or Program), on behalf of its 15 member agencies (13 cities/towns, the County of Santa Clara, and the Santa Clara Valley Water District), which are subject to the National Pollutant Discharge Elimination System (NPDES) stormwater permit for Bay Area municipalities referred to as the Municipal Regional Permit (MRP). The MRP was first adopted by the San Francisco Regional Water Quality Control Board (SFRWQCB or Regional Water Board) on October 14, 2009 as Order R2-2009-0074 (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 SCVURPPP and may be obtained via the San Francisco Bay Area Regional Data Center of the California Environmental Data Exchange Network (CEDEN) (http://water100.waterboards.ca.gov/ceden/sfei.shtml).

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

- **Section 1.0** – Introduction including overview of the Program goals, background, monitoring approach, and statement of data quality
- **Section 2.0** – 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?*

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 SCVURPPP between 2002 and 2009. 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 (SCVURPPP 2017, SCVURPPP 2016, SCVURPPP 2015, SCVURPPP 2014, SCVURPPP 2013).

[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 SCVURPPP Urban Creeks Monitoring Report (UCMR) for WY 2017 to which this Creek Status Monitoring Report is appended.

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.[4] 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.

Table 1.1. Regional Monitoring Coalition (RMC) 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 provision C.8 (Water Quality Monitoring) of the MRP;
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., Regional 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

[4] 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.

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 Santa Clara 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)[5], 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.

[5] 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 SCVURPPP, 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 project. SSID projects are intended to be oriented toward taking action(s) to alleviate stressors and reduce sources of pollutants. A stepwise process for conducting SSID projects is described in provision C.8.e.iii.

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

1.4 Setting

1.4.1 Watersheds Monitored by SCVURPPP

There are 13 major watersheds within the SCVURPPP jurisdictional boundaries and these watersheds comprise most of the Santa Clara Basin. The watersheds are mapped in Figure 1.1 and their major characteristics are listed in Table 1.3. The Santa Clara Basin, San Francisco Bay south of the Dumbarton Bridge, and the 840 square miles that drain to it, are bounded by the Diablo Mountains on the east and the Santa Cruz Mountains on the west and south. Elevations range from sea level at the Bay to almost 4,000 feet in the Santa Cruz Mountains. There is a distinct transition in geography and land use at elevations of 600 to 800 feet. Areas above this elevation generally have steeper slopes and are largely forest, rangeland, or open space; below this threshold, an urbanized landscape dominates. Most watersheds have their headwaters in the undeveloped mountains and drain north through urbanized areas to the Bay. Flows in the lower reaches of most watersheds are controlled by the presence of water supply reservoirs that are managed by the Santa Clara Valley Water District (SCVWD) and other agencies. Many of the reservoirs are constructed at the transition between the Santa Clara Valley and the surrounding foothills. Water is captured during the winter rainy season and released in the spring at managed rates to allow for percolation through the stream bed and to protect fish habitat downstream of the reservoirs. To varying degrees, portions of all watersheds within the urban zone have been engineered or placed within underground culverts. The Sunnyvale East and West Channel watersheds contain no natural creek bed at all; they were constructed in the 1960s to manage flooding.

Table 1.3. Characteristics of major watersheds within SCVURPPP boundary.

Watershed	Area (square miles)	Number of Tributary Creeks	Natural Creek Bed (Miles)	Engineered Channel (Miles)	Underground Culvert or Stormdrain (Miles)	Impervious Area	Land Use				
							Residential	Industrial/ Commercial	Forest	Rangeland	Other
Adobe	11.0	7	18.8	2.3	12.0	44.7%	46.5%	11.8%	36.3%	2.7%	2.7%
Barron	15.6	5	15.1	7.9	28.6	60.3%	60.5%	20.1%	7.3%	7.0%	5.1%
Calabazas	20.3	6	12.9	14.1	55.5	NA	54.5%	29.4%	8.8%	5.2%	2.1%
Coyote	321	53	670	36.4	146	11.1%	8.6%	3.7%	49.9%	29.6%	8.2%
Guadalupe	171	50	207	45.5	265	37.1%	29.6%	13.6%	34.7%	15.5%	6.6%
Lower Penitencia	28.6	13	29.2	20.8	61.6	42.9%	30.7%	19.0%	1.1%	38.7%	10.5%
Matadero	14.0	3	18	NA	NA	60.3%	57.1%	5.8%	8.9%	8.2%	20%
Permanente	17.3	7	NA	NA	NA	43.9%	46.3%	13.1%	35.0%	2.8%	2.8%
San Francisquito	42.8	25	90.6	4.8	15.3	20.8%	29.6%	5.2%	44.7%	15.0%	5.5%
San Tomas Aquino	44.8	15	50.5	15.5	79.3	60.1%	53.9%	18.8%	23.7%	0.8%	2.8%
Stevens	29.2	12	54.2	1.1	30.0	28.6%	24.5%	9.0%	49.2%	12.5%	4.8%
Sunnyvale East	7.1	0	0	6.2	26.6	82.2%	65.3%	31.8%	0%	0%	2.9%
Sunnyvale West	7.6	0	0	6.7	18.7	72.4%	20.9%	65.2%	0%	0%	13.9%

Source: http://www.scvurppp-w2k.com/watersheds.shtml
NA – not available

WY 2017 Creek Status and Pesticides and Toxicity Monitoring Stations

The complete list of probabilistic and targeted monitoring sites samples by SCVURPPP in WY 2017 in compliance with provisions C.8.d (Creek Status Monitoring) and C.8.g (Pesticides and Toxicity Monitoring) is presented in Table 1.4. Monitoring locations with monitoring parameter(s) are mapped in Figure 1.2. Probabilistic station numbers, generated from the RMC Sample Frame, are provided for all bioassessment locations. Targeted stations numbers, based on SWAMP station numbering methods (BASMAA 2016b), are provided for all targeted monitoring sites.

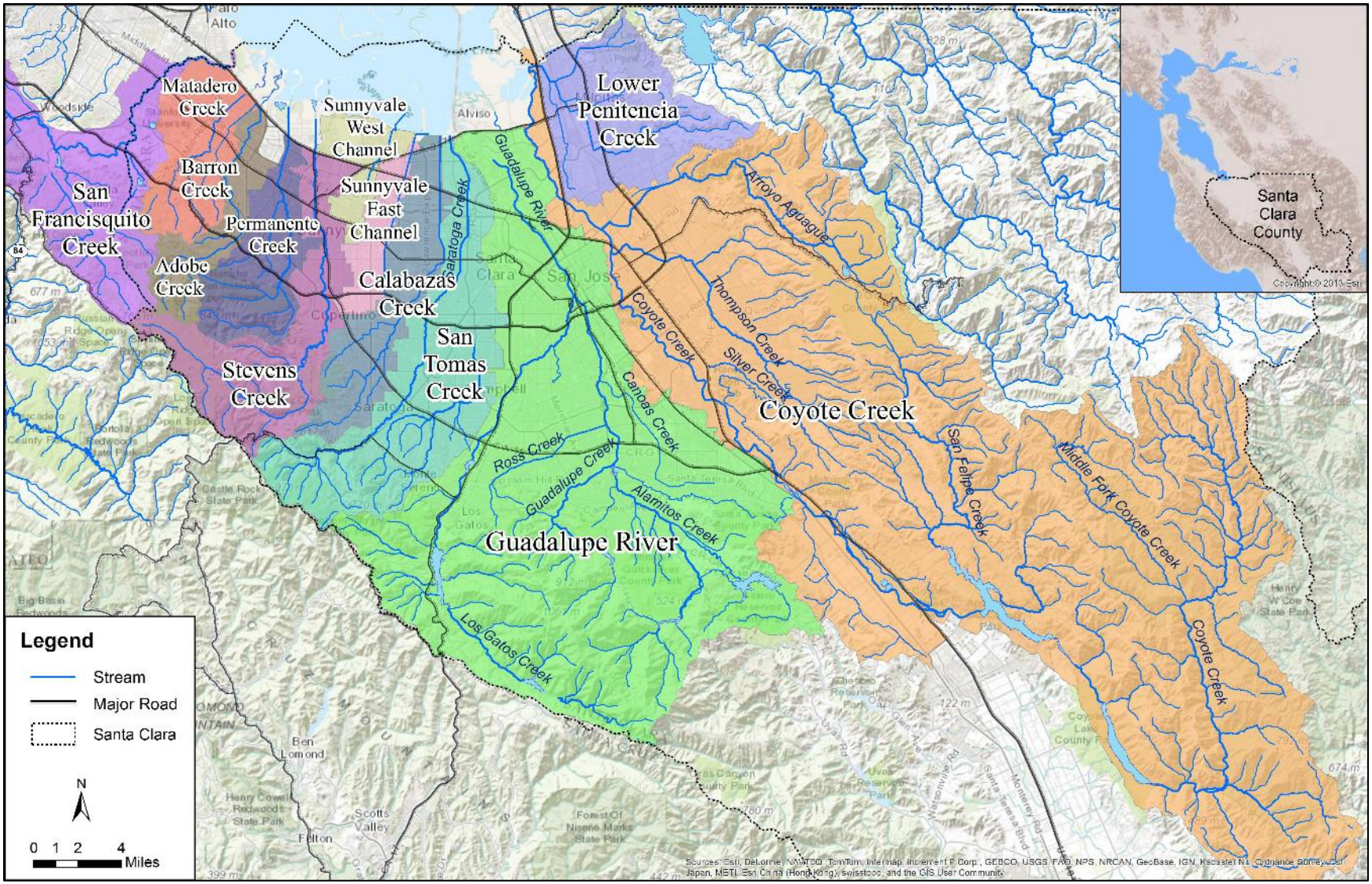

Figure 1.1. Watersheds within SCVURPPP jurisdictional boundaries.

Table 1.4. Sites and parameters monitored in WY 2017 in Santa Clara County.

Map ID	Station ID	Watershed	Creek Name	Land Use	Latitude	Longitude	Probabilistic	Targeted				
							Bioassessment, Nutrients, General WQ	Chlorine	Toxicity, Sediment Chemistry	Temp	Cont WQ	Pathogen Indicators
570	205R00570	Guadalupe River	Trib to Aldercroft Cr	NU	37.181464	-122.002165	X	X				
609	205R00609	Coyote Creek	Hunting Hollow	NU	37.073721	-121.460268	X	X				
645	205R00645	Coyote Creek	Packwood Creek	NU	37.170717	-121.613387	X	X				
2693	205R02693	Coyote Creek	Packwood Creek	U	37.174793	-121.616695	X	X				
2755	205R02755	Lower Penitencia Cr	Berryessa Creek	U	37.420931	-121.840146	X	X				
2787	205R02787	Matadero Creek	Matadero Creek	U	37.432204	-122.124836	X	X				
2915	205R02915	Stevens Creek	Stevens Creek	U	37.306931	-122.069249	X	X				
2947	205R02947	Lower Penitencia Cr	Lower Penitencia	U	37.429177	-121.90895	X	X				
3011	205R03011	Lower Penitencia Cr	Berryessa Creek	U	37.41123	-121.858567	X	X				
3091	205R03091	Coyote Creek	Arroyo Aguague	U	37.399248	-121.785626	X	X				
3098	205R03098	Guadalupe River	Guadalupe Creek	U	37.243658	-121.874066	X	X				
3235	205R03235	Stevens Creek	Stevens Creek	U	37.334668	-122.064327	X	X				
3306	205R03306	San Tomas Aquino	Saratoga Creek	U	37.277387	-122.011719	X	X				
3331	205R03331	Guadalupe River	Los Gatos Creek	U	37.300891	-121.919698	X	X				
3354	205R03354	Guadalupe River	Guadalupe Creek	U	37.212368	-121.908596	X	X				
3386	205R03386	Guadalupe River	Aldercroft Creek	U	37.176762	-121.995876	X	X				
3418	205R03418	Guadalupe River	Alamitos Creek	U	37.22855	-121.861762	X	X				
3443	205R03443	Coyote Creek	Calabazas Creek	U	37.388639	-121.986842	X	X				
3523	205R03523	Coyote Creek	Upper Penitencia Creek	U	37.393389	-121.83237	X	X				
3530	205R03530	Guadalupe River	Los Gatos Creek	U	37.25194	-121.963874	X	X				
400	205LGA400	Guadalupe River	Los Gatos Creek	U	37.2389	-121.97054						X
30	205MAT030	Matadero Creek	Matadero Creek	U	37.4099	-122.13831						X
64	205STE064	Stevens Creek	Stevens Creek	U	37.3174	-122.06182						X
225	205GUA225	Guadalupe River	Arroyo Calero	U	37.214116	-121.83444						X
75	205SAR075	San Tomas Aquino	Saratoga Creek	U	37.25826	-122.03445						X
210	205GUA210	Guadalupe River	Guadalupe Creek	U	37.21746	-121.91039				X		
202	205GUA202	Guadalupe River	Guadalupe Creek	U	37.23291	-121.89795				X		
190	205GUA190	Guadalupe River	Guadalupe Creek	U	37.24373	-121.87561				X		
270	205GUA270	Guadalupe River	Alamitos Creek	U	37.20129	-121.82891				X		
340	205GUA340	Guadalupe River	Arroyo Calero	U	37.20706	-121.82362				X		
225	205GUA225	Guadalupe River	Arroyo Calero	U	37.21403	-121.83442				X		
262	205GUA262	Guadalupe River	Alamitos Creek	U	37.220409	-121.845155				X		
255	205GUA255	Guadalupe River	Alamitos Creek	U	37.22607	-121.85842				X		

Map ID	Station ID	Watershed	Creek Name	Land Use	Latitude	Longitude	Probabilistic	Targeted				
							Bioassessment, Nutrients, General WQ	Chlorine	Toxicity, Sediment Chemistry	Temp	Cont WQ	Pathogen Indicators
250	205GUA250	Guadalupe River	Alamitos Creek	U	37.23363	-121.87058				X		
235	205COY235	Coyote Creek	Coyote Creek	U	37.3536	-121.87417					X	
236	205COY236	Coyote Creek	Coyote Creek	U	37.35098	-121.87378					X	
239	205COY239	Coyote Creek	Coyote Creek	U	37.33722	-121.86953					X	
21	205STE021	Stevens Creek	Stevens Creek	U	37.40985	-122.06906			X			
10	205STQ010	San Tomas Aquino	San Tomas Aquino	U	37.38843	-121.96865			X			

U = urban, NU = non-urban

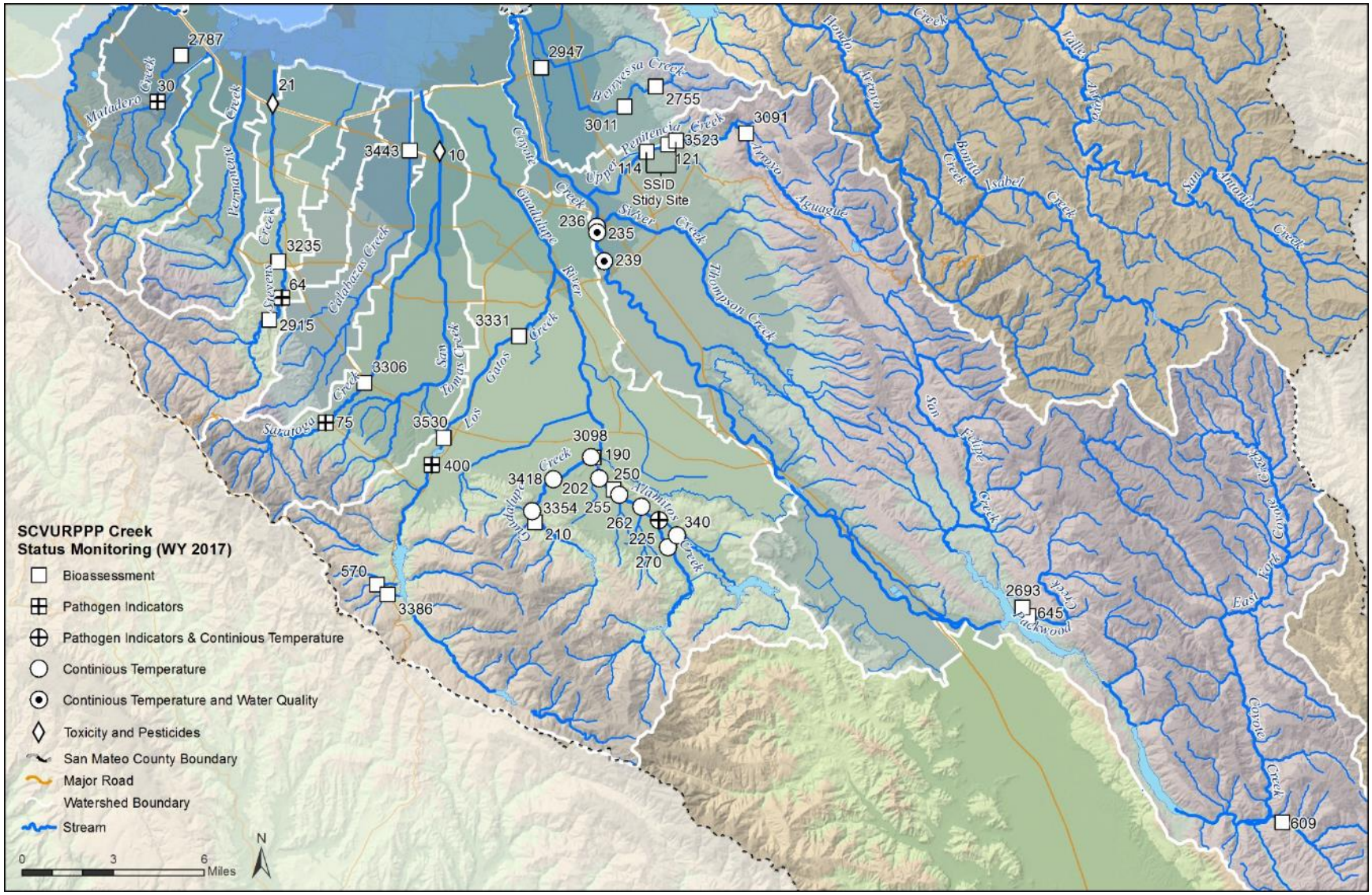

Figure 1.2. Map of SCVURPPP Program Area, major creeks, and sites monitored in WY 2017.

1.4.2 Designated Beneficial Uses

Beneficial Uses in Santa Clara Valley creeks are designated by the SFRWQCB for specific water bodies. Uses include aquatic life, recreation, consumption by humans, and habitat. Table 1.5 lists Beneficial Uses designated by the SFRWQCB (2017) for water bodies monitored by SCVURPPP in WY 2017.

Table 1.5. Creeks monitored by SCVURPPP in WY 2017 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
Alamitos Creek			E	E					E			E	E	E	E	E	E	E	
Aldercroft Creek[1]		E	E	E					E			E	E	E	E	E	E	E	
Arroyo Aguague									E			E	E	E	E	E	E	E	
Arroyo Calero			E						E			E	E	E	E	E	E	E	
Berryessa Creek															E	E	E	E	
Calabazas Creek	E			E					E						E	E	E	E	
Coyote Creek				E			E		E			E	E	E	E	E	E	E	
Guadalupe Creek			E	E					E			E	E	E	E	E	E	E	
Hunting Hollow[1]				E			E		E			E	E	E	E	E	E	E	
Los Gatos Creek		E	E	E					E			P	E	P	E	E	E	P	
Lower Penitencia Creek															E	E	E	E	
Matadero Creek									E			E	E	E	E	E	E	E	
Packwood Creek			E						E					E	E	E	E	E	
San Tomas Aquino									E				E		E	E	E	E	
Saratoga Creek	E		E	E					E						E	E	E	E	
Stevens Creek			E	E					E			E	E	E	E	E	E	E	
Tributary to Aldercroft Creek[1]		E	E	E					E			E	E	E	E	E	E	E	
Upper Penitencia Creek			E	E					E			E	E	E	E	E	E	E	

[1] No Beneficial Uses listed specifically for waterbody.

Notes:

COLD = Cold Fresh Water Habitat
FRSH = Freshwater Replenishment
GWR = Groundwater Recharge
MIGR = Fish Migration
MUN = Municipal and Domestic Water
EST = Estuarine (the Basin Plan assigns this beneficial use to slough portions of Plummer Creek; for this evaluation WARM is presumed applicable to freshwater portions)

NAV = Navigation
RARE= Preservation of Rare and Endangered Species
REC-1 = Water Contact Recreation
REC-2 = Non-contact Recreation

WARM = Warm Freshwater Habitat
WILD = Wildlife Habitat
P = Potential Use
E = Existing Use
L = Limited Use.
* = "Water quality objectives apply; water contact recreation is prohibited or limited to protect public health" (SFRWQCB 2013).

1.4.3 Climate

The Santa Clara Valley 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 15 inches near the Bay to over 55 inches along the highest ridges in the Santa Cruz Mountains (PRISM Climate Group 30-year normals, 1981-2010[6]). Figure 1.3 illustrates the geographic variability of mean annual precipitation in the area. It is important to understand that mean annual precipitation depths are statistically calculated or modeled; actual measured precipitation in a given year rarely equals the statistical average. Figure 1.4 illustrates the temporal variability in annual precipitation measured at the Mineta San Jose International Airport from WY 1946 to WY 2017. 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[7]).

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. In addition, during severe droughts, water management agencies (such as the Santa Clara Valley Water District) may also decrease the magnitude and duration of reservoir releases.

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 can affect water temperature and other general water quality 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.[8] The late summer general water quality monitoring results from WY 2017 reflect the high air temperatures during that period.

[6] http://www.prism.oregonstate.edu/normals/
[7] http://weatherwest.com/archives/5860
[8] https://www.ncdc.noaa.gov/cag/time-series/us/4/4/tavg/4/9/1895-2017?base_prd=true&firstbaseyear=1901&lastbaseyear=2000

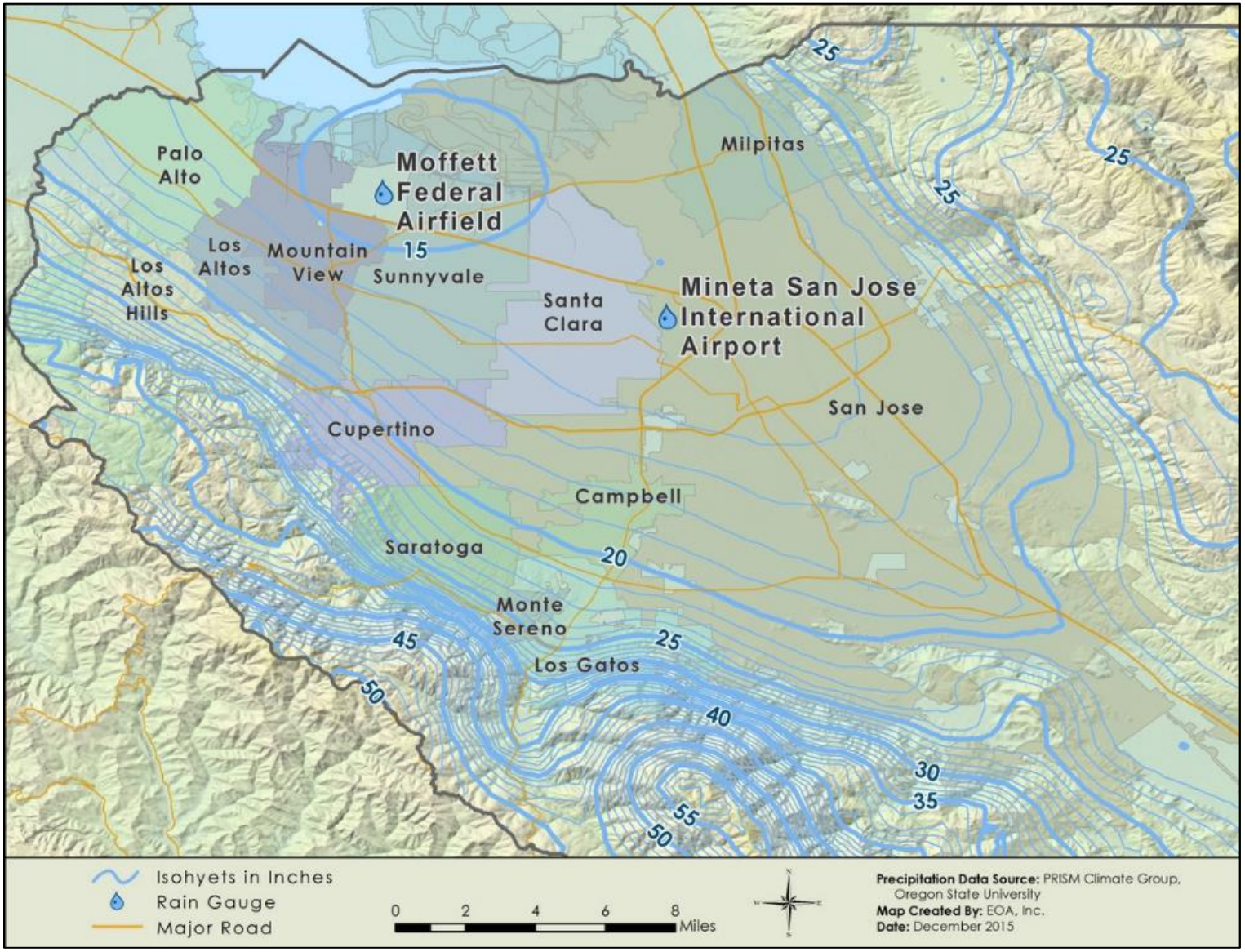

Figure 1.3. Average annual precipitation in Santa Clara Valley, as modeled by the PRISM Climate Group for the period of 1981-2010.

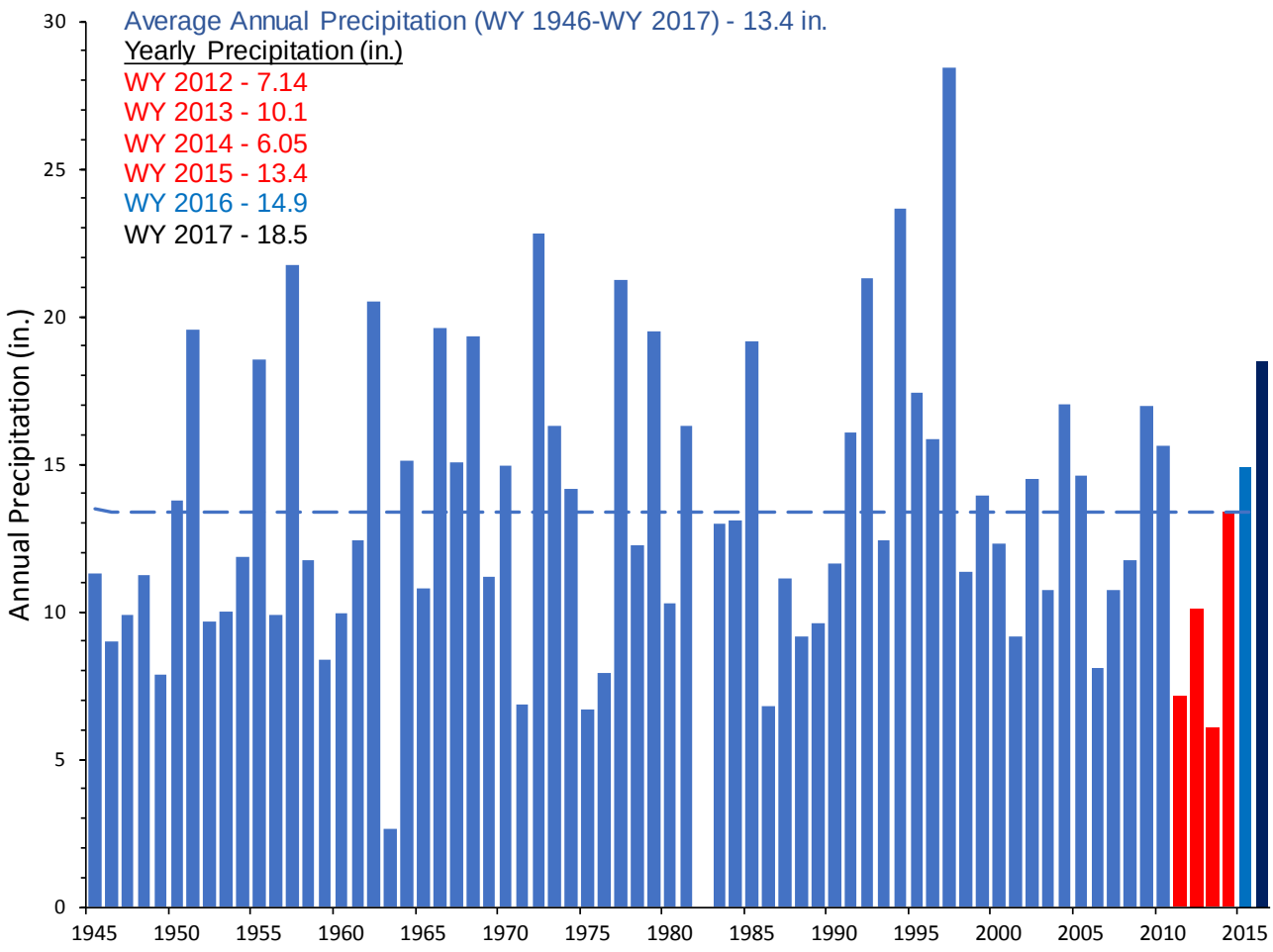

Figure 1.4. Annual rainfall recorded at the San Jose Airport, WY 1946 – WY 2017.

1.5 Statement of Data Quality

A comprehensive Quality Assurance/Quality Control (QA/QC) program was implemented by SCVURPPP 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[9]. 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.

[9] 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, SCVURPPP conducted bioassessment monitoring in WY 2017. All bioassessment monitoring was performed at sites selected randomly using the probabilistic monitoring design[10]. The probabilistic monitoring design allows each individual RMC participating program to objectively assess stream ecosystem conditions within its program area (e.g., 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 area?*) 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), the SCVURPPP and Regional Water Board have sampled 132 probabilistic sites in Santa Clara 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).[11]

The second question (i.e., *What are major stressors to aquatic life in the RMC area?*) is addressed by the collection and evaluation of physical habitat and water chemistry data collected at the probabilistic sites, as potential stressors to biological health. The extent and magnitude of these potential stressors above certain thresholds is also assessed for streams in Santa Clara 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. Although, long-term trend analysis for

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

[11] 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).

the RMC probabilistic survey will require more than six years of data collection, preliminary trend analysis of biological condition may be possible for some stream reaches using a combination of historical targeted data with the probabilistic data.

The sections below present bioassessment data collected at twenty sites 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 dataset (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 macroinvertebrate and algae data 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 (SCCWRP 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 (listed in Table 1.1). 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 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.

Most 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 12 sites in Santa Clara County.[12]

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;[13]
2. Site is not tidally influenced;
3. Site is wadeable during the sampling index period;
4. Site has sufficient flow during the sampling index period to support standard operation procedures for biological and nutrient sampling.
5. Site is physically accessible and can be entered safely at the time of sampling;
6. Site may be physically accessed and sampled within a single day;
7. Landowner(s) grant permission to access the site.[14]

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.

[12] As of WY 2016, the SFRWQCB SWAMP is no longer conducting RMC-related bioassessment monitoring at probabilistic sites.
[13] The evaluation procedure permits certain adjustments of actual site coordinates within a maximum of 300 meters.
[14] 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.

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 were a couple of small storms in April, including a storm on April 8 (0.55 inches in 24-hour period) and a smaller storm on April 14 (0.35 inches in 24-hour period). Field sampling was conducted over a period of one month, between May 8 and June 8, 2017.

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 et al. 2009), provides additional guidance, and adds two new physical habitat analytes (assess scour and engineered channels). The full suite of physical habitat data were collected within the sample reach using methods described in Ode et al. (2016). The presence of micro- and macroalgae was assessed during the pebble counts following methods described in Ode et al. (2016).

Immediately prior to biological and physical habitat data collection, water samples were collected at 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 conductance 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. There were five soft algae taxa that were not on the SWAMP list and were subsequently harmonized and 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.

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 a biological index that was developed by the State Water Resources Control Board (State Board) and is used to score the condition of BMI communities in perennial wadeable rivers and streams. The CSCI translates benthic macroinvertebrate data into an overall measure of stream health. The CSCI was developed using a large reference data set that is intended to represent the full range of natural conditions in California (Rehn et al. 2015). It combines two types of indices: 1) taxonomic completeness, as measured by the ratio of observed-to-expected taxa (O/E); and 2) ecological structure and function, measured as a predictive multi-metric index (pMMI) that is based on reference conditions. The CSCI score is computed as the average of the sum of O/E and pMMI.

The CSCI is calculated using a combination of biological and environmental data following methods described in Rehn et al. (2015). Biological data include benthic macroinvertebrate data collected and analyzed using protocols described in the previous section. The environmental predictor data are generated in GIS using drainage areas upstream of each BMI sampling location. The environmental predictors and BMI data were formatted into comma delimited files and used as input for the RStudio statistical package and the necessary CSCI program scripts, developed by Southern California Coastal Water Research Project (SCCWRP) staff (Mazor et al. 2016).

The State Board is continuing to evaluate the performance of CSCI in a regulatory context. In the current MRP, the Regional Water Board defined a CSCI score of 0.795 as a threshold for identifying sites with degraded biological condition that may be considered as candidates for a Stressor Source Identification project.

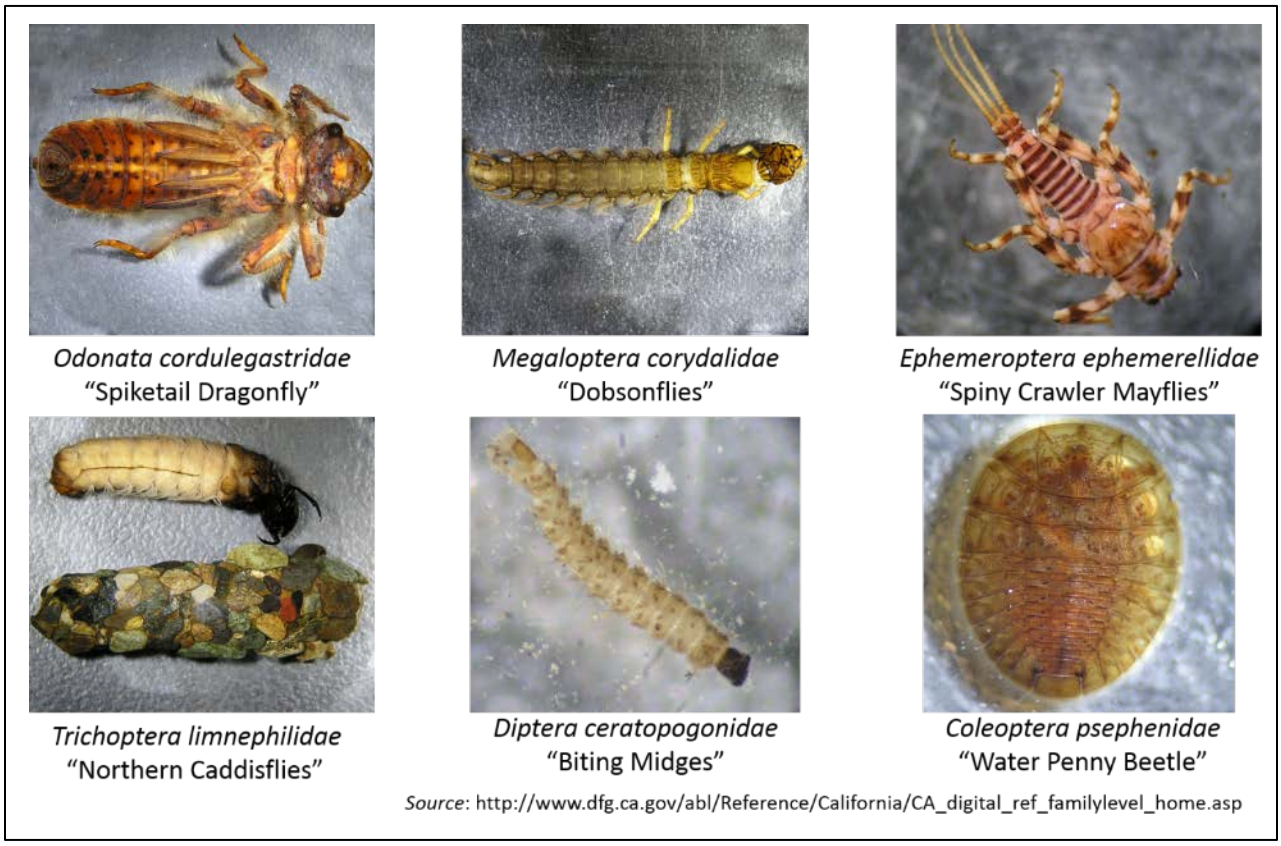

Figure 2.1. Examples of benthic macroinvertebrates.

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 several 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 Santa Clara County were evaluated using the existing SWAMP Algae Reporting Module, (Algae RM) which was developed in 2012 using the SoCal Algae IBIs 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 Santa Clara 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 Santa Clara 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 the 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.

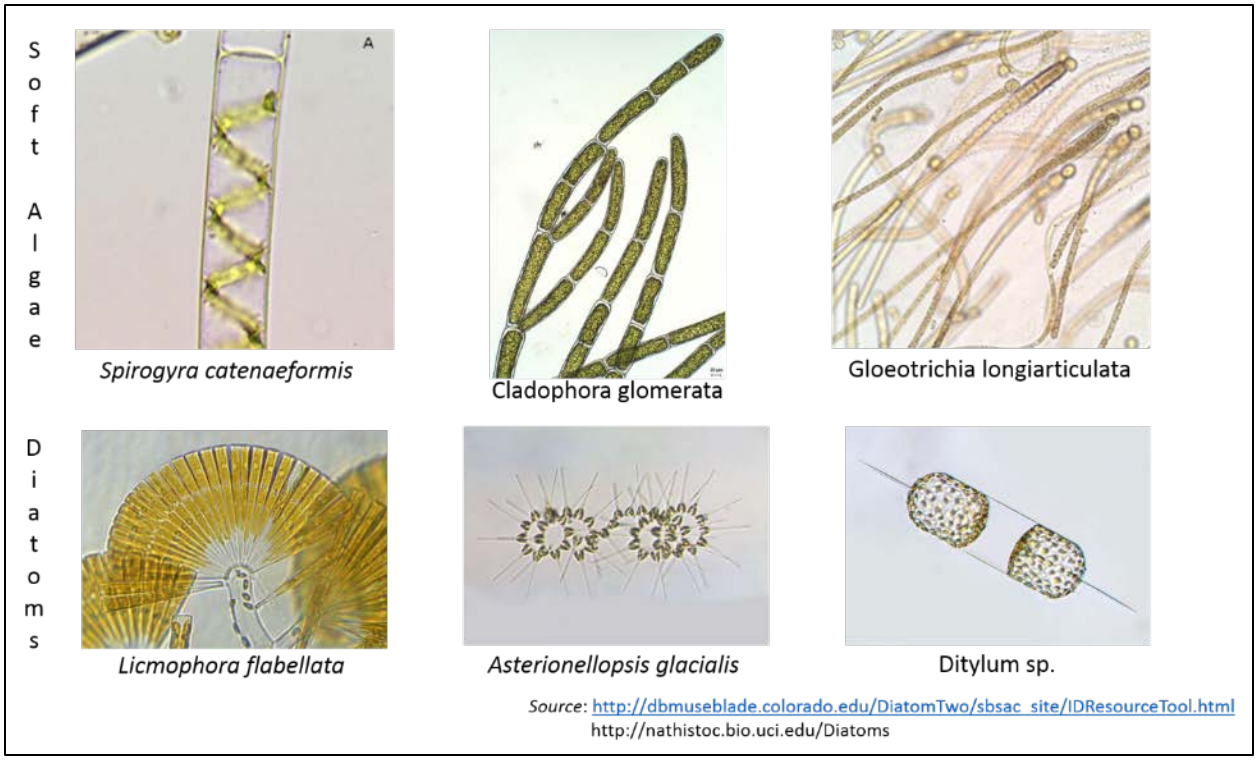

Figure 2.2. Examples of soft algae and diatoms.

Biological Condition Thresholds

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

Table 2.1. Condition categories used to evaluate CSCI, 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

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). Further investigation is needed to evaluate the applicability of this threshold to sites in highly urban watersheds and/or modified channels.

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).

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, internet source). 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 (SWAMP 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 20 bioassessment sites in Santa Clara 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 was lower than average. During the drought, low base flow conditions were further impacted by minimal or complete absence of water releases from upstream reservoirs and diversion pipes bringing imported water from other parts of the State. 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.

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 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). Los Gatos Creek is the only creek sampled in WY 2016 with MUN designated (see Table 1.4). The MUN designation may also apply to Los Gatos Creek tributaries (i.e., Aldercroft Creek).

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 to 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 Use
[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, SCVURPPP conducted site evaluations at a total of 93 potential probabilistic sites in Santa Clara County drawn from the Sample Frame. Of these sites, a total of twenty were sampled in WY 2017 (rejection rate of 78%). Approximately 60% of the sites evaluated were rejected due to low or no flow conditions. Three of the twenty sampled sites (15%) were classified as non-urban land use. Land use classification, sampling location, and date for each site sampled during WY 2017 are listed in Table 2.4. Sites are mapped in Figure 1.2.

Table 2.4. Bioassessment sampling date and locations in Santa Clara County in WY 2017.

Station Code	Creek	Land Use	Sample Date	Latitude	Longitude
205R00570	Trib to Aldercroft Cr	NU	5/16/2017	37.18121	-122.00152
205R00609	Hunting Hollow	NU	5/10/2017	37.07420	-121.46120
205R00645	Packwood Creek	NU	5/15/2017	37.17820	-121.61414
205R02693	Packwood Creek	U	5/15/2017	37.17472	-121.61719
205R02755	Berryessa Creek	U	5/8/2017	37.42100	-121.84169
205R02787	Matadero Creek	U	6/1/2017	37.25500	-122.73100
205R02915	Stevens Creek	U	6/5/2017	37.30691	-122.07005
205R02947	Lower Penitencia Cr	U	5/11/2017	37.42968	-121.90913
205R03011	Berryessa Creek	U	5/8/2017	37.41155	-121.85889
205R03091	Arroyo Aguague	U	5/18/2017	37.39935	-121.78585
205R03098	Guadalupe Creek	U	6/6/2017	37.24370	-121.87554
205R03235	Stevens Creek	U	6/5/2017	37.33500	-122.06470
205R03306	Saratoga Creek	U	5/9/2019	37.27756	-122.01164
205R03331	Los Gatos Creek	U	6/7/2017	37.30144	-121.91892
205R03354	Guadalupe Creek	U	6/6/2017	37.21212	-121.90870
205R03386	Aldercroft Creek	U	5/16/2017	37.17738	-121.99789
205R03418	Alamitos Creek	U	6/8/2017	37.22874	-121.86173
205R03443	Calabazas Creek	U	6/1/2017	37.38864	-121.98684
205R03523	Upper Penitencia Cr	U	5/11/2017	37.39356	-121.83262
205R03530	Aldercroft Trib	U	6/7/2017	37.25122	-121.96510

NU = non-urban, U = urban

Since WY 2012, a total of 132 probabilistic sites were sampled by SCVURPPP (n=120) and SWAMP (n=12) in Santa Clara County. During the six-year sampling period, SCVURPPP sampled 104 urban and 16 non-urban sites and SWAMP sampled 12 non-urban sites. There are sufficient number of samples from probabilistic sites to develop estimates of biological condition and stressor assessment for both urban and non-urban streams in Santa Clara 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 at more local scales (e.g., watershed and jurisdictional areas).

2.3.2 Biological Condition Assessment

A total of 141 unique BMI taxa were identified in samples collected at 20 bioassessment sites in Santa Clara County during WY 2017. A total of 124 benthic algae taxa were identified in samples collected at all sites, including 85 diatom taxa and 39 soft algae taxa. The total number of BMI, diatom, and soft algae taxa identified at each bioassessment location is presented in Table 2.5. BMIs and diatoms were relatively well represented across all sites, with BMIs ranging from 14 to 43 taxa, and diatoms ranging from 10 to 46 taxa. Soft algae taxa were less common across sites, ranging from 0 to 11 taxa. Nine of the sites (45%) had three or less soft algae taxa.

Table 2.5. The total number of unique BMI, diatom and soft algae taxa identified in samples collected at 20 bioassessment sites in Santa Clara County during WY 2017.

Station Code	Creek	Elevation (m)	Land Use	BMI	Diatoms	Soft Algae
205R00570	Tributary to Aldercroft Cr	282	NU	35	27	1
205R00609	Hunting Hollow	266	NU	34	15	8
205R00645	Packwood Creek	202	NU	25	24	3
205R02693	Packwood Creek	192	U	21	17	4
205R02755	Berryessa Creek	177	U	24	18	1
205R02787	Matadero Creek	4	U	20	26	11
205R02915	Stevens Creek	119	U	25	22	7
205R02947	Lower Penitencia	4	U	14	30	8
205R03011	Berryessa Creek	49	U	14	18	1
205R03091	Arroyo Aguague	247	U	36	10	2
205R03098	Guadalupe Creek	60	U	28	36	4
205R03235	Stevens Creek	80	U	28	24	3
205R03306	Saratoga Creek	98	U	24	20	0
205R03331	Los Gatos Creek	41	U	18	30	6
205R03354	Guadalupe Creek	114	U	34	17	3
205R03386	Aldercroft Creek	246	U	43	13	0
205R03418	Alamitos Creek	70	U	28	27	7
205R03443	Calabazas Creek	7	U	16	11	10
205R03523	Upper Penitencia Cr	78	U	40	24	5
205R03530	Los Gatos Creek	82	U	16	46	4

NU = non-urban, U = urban

The total number of BMI taxa was moderately correlated with site elevation (r^2=0.41, p=0.002) (Figure 2.3). In contrast, total taxa for both diatom and soft algae generally decreased with increasing site elevation (r^2=0.15, p=0.088 and r^2=0.26, p=0.021, respectively). Total BMI taxa did not appear to be correlated with diatom or soft algae richness across the 20 bioassesment sites. Similarly, diatom richness did not appear to have any correlation with soft algae richness.

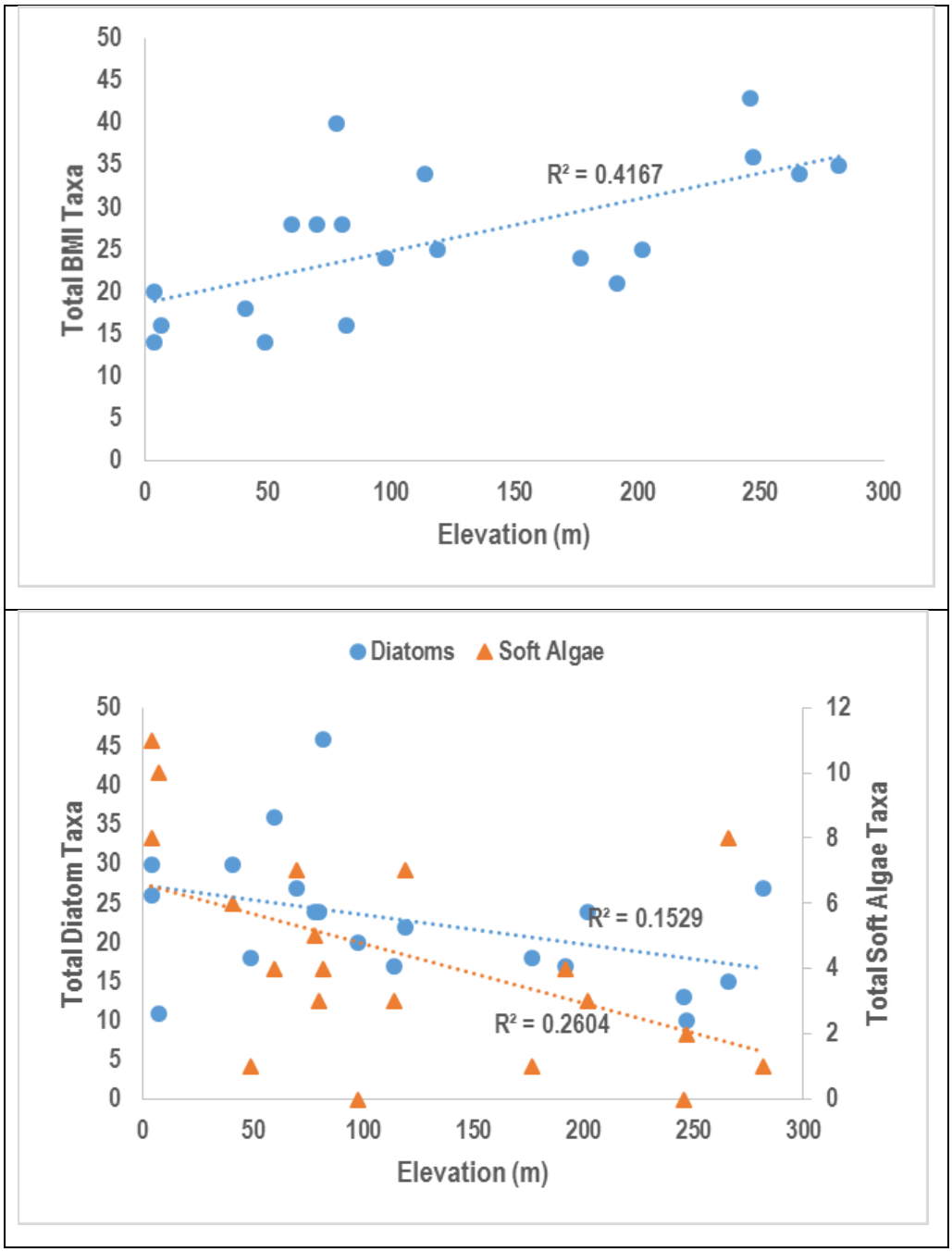

Figure 2.3. Total BMI (top), diatom and soft algae (bottom) taxa compared to elevation of the bioassessment site.

Biological conditions, as represented by CSCI scores and algae IBI scores (S2, D18 and H20), for the 20 probabilistic sites sampled by SCVURPPP during WY 2017 are presented in Table 2.6. Biological condition scores within the two higher condition categories for each indicator are show in bold. The condition categories for three of the biological indicator scores (CSCI, D18 and H20), as defined in Table 2.1, are illustrated in Figure 2.5 for the 20 sites.

Table 2.6. Biological condition scores, presented as CSCI and SoCal Algae IBIs (S2, D18 and H20) for 20 probabilistic sites sampled in WY 2017. PHAB scores are also presented for comparison. Site characteristics related to percent impervious watershed area, channel modification and flow condition are also presented. Bold values indicate "good" condition. Scores that could not be calculated are indicated as "NR".

Station Code	Creek	Land Use[1]	Impervious Area (%)	Modified Channel[2]	Flow[3]	CSCI Score	Soft Algae "S2" IBI Score	Diatom "D18" IBI Score	Hybrid "H20" IBI Score	Total PHAB Score
205R00570	Trib to Aldercroft Cr	NU	1%	N	P	0.95	67	66	66	31
205R00609	Hunting Hollow	NU	2%	N	NP	0.66	83	72	70	45
205R00645	Packwood Creek	NU	1%	N	P	0.75	2	38	24	49
205R02693	Packwood Creek	U	1%	N	P	0.62	7	36	28	33
205R02755	Berryessa Creek	U	1%	N	P	0.93	NR	50	NR	45
205R02787	Matadero Creek	U	30%	Y	P	0.49	0	20	12	16
205R02915	Stevens Creek	U	2%	N	P	0.58	0	20	12	51
205R02947	Lower Penitencia	U	69%	Y	P	0.27	0	10	6	9
205R03011	Berryessa Creek	U	4%	N	NP	0.8	NR	56	NR	29
205R03091	Arroyo Aguague	U	1%	N	P	1.01	NR	62	NR	50
205R03098	Guadalupe Creek	U	6%	N	P	0.7	0	60	38	42
205R03235	Stevens Creek	U	4%	N	P	0.86	0	40	25	24
205R03306	Saratoga Creek	U	8%	N	NP	0.87	NR	20	NR	38
205R03331	Los Gatos Creek	U	14%	N	P	0.59	8	32	22	45
205R03354	Guadalupe Creek	U	1%	N	P	1.03	50	78	61	47
205R03386	Aldercroft Creek	U	4%	N	P	1.0	NR	50	NR	43
205R03418	Alamitos Creek	U	7%	N	P	0.7	0	68	42	34
205R03443	Calabazas Creek	U	49%	Y	P	0.45	2	76	48	16
205R03523	Upper Penitencia Cr	U	3%	N	NP	0.91	0	28	19	41
205R03530	Los Gatos Creek	U	8%	N	P	0.56	0	54	34	42

[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 0.27 to 1.03 across the 20 bioassessment sites sampled in WY 2017 (Table 2.6). Nine of the 20 bioassessment sites (45%) had CSCI scores in the two higher condition categories - "possibly intact" and "likely intact" condition. The combined classifications are above the MRP trigger threshold value of 0.795. All but one of these sites were classified as urban; however, seven of these urban sites had relatively low impervious area (<4%) (Table 2.6).

Four sites (20%) had CSCI scores that ranked as "likely altered"; two of these sites were classified as non-urban land use. Seven sites (35%) were ranked as "very likely altered" (CSCI < 0.63), indicating

highly degraded condition. The three sites with the lowest CSCI scores had a high proportion of impervious watershed area (> 30%) and were characterized as modified channels.

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

Algae IBI Scores

The benthic algae taxa identified in the twenty samples collected in Santa Clara County were used to calculate scores for three SoCal Algae IBIs (S2, D18 and H20) (Table 2.6). Three of the 124 total algal taxa identified in samples collected in WY 2017 were not on the SWAMP Master Taxa list, but were subsequently harmonized, and added to the SWAMP list.

- **D18.** Six of the twenty bioassessment sites had D18 scores (> 62) that were classified as "possibly intact" or "likely intact" condition. Three of these sites had low impervious area (<1%) and also received high CSCI scores (Table 2.6). In contrast, one of the sites with high D18 scores (205R03343) had high impervious area (49%), was categorized as having a modified channel, and received a low CSCI score (0.45). Five sites received D18 scores that ranked in the "likely altered" condition category (62-72). The remaining nine sites had D18 scores that ranked in "very likely altered" condition (<49). Six of the sites in these two categories had CSCI scores that were ranked in good condition, indicating that BMIs and diatoms had very different responses to stressors at these sites.

- **S2**. Soft algae were absent from samples collected at five bioassessment sites[15]. As a result, no S2 IBI scores could be calculated for these sites. Of the remaining 15 sites, three had scores that were classified as "possibly intact" or "likely intact" condition (> 47). The remaining 12 sites had very low S2 IBI scores, ranging from 0 to 8, ranking in the "very likely altered" condition.

  Two factors may explain the low S2 score at these sites: 1) overall low diversity or abundance of soft algal taxa present in the samples; and/or 2) low proportion of soft algal taxa that could be used to calculate a metric score. 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.

- **H2O**. The H20 IBI includes three soft algae and five diatom metrics. Therefore, for the reasons discussed above, the H20 IBI was not calculated at the same five sites that received no S2 IBI score (i.e., soft algae metric score(s) could not be calculated). Of the remaining 15 sites, two had scores that were classified as "possibly intact" or "likely intact" condition (> 63). The remaining thirteen sites had scores that ranged from 6 to 61. The higher scores are likely associated with diatom metrics, since many of the soft algae metrics were zero or very low.

Total PHAB Scores

Individual PHAB attribute scores and total PHAB scores assessed at the twenty bioassessment sites are presented in Table 2.7. The lowest scores for channel alteration and epifaunal substrate attributes (0-2) 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 better correlated with CSCI scores (r^2=0.30, p = 0.012) compared to D18 scores (r^2=0.04, p= 0.373), suggesting that physical habitat (e.g., substrate quality, channel alteration) has a greater influence on the BMI community compared to the diatoms assemblage (Figure 2.4). These results are consistent with

[15] IBI metrics only use taxa that are identified in the composite quantitative samples. Thus, soft algae that are only found in the qualitative samples are not incorporated into the metric calculations.

bioassessment data collected in Southern California, which found high CSCI scores were rarely found in engineered channels, but high algae IBI scores (particularly D18) frequently occurred in highly modified channels (Rafael Mazor, SCCWRP, personal communication). These results suggest that algae indices have some ability to respond to water quality gradients in highly modified channels.

Table 2.7. Individual and Total PHAB scores for twenty probabilistic sites in Santa Clara County sampled in WY 2017. CSCI and D18 IBI scores are shown for comparison.

Station Code	Waterbody	CSCI Score	Diatom "D18" IBI Score	Channel Alteration	Epifaunal Substrate	Sediment Deposition	Total PHAB Score
205R00570	Trib to Aldercroft Cr	0.95	66	14	13	4	31
205R00609	Hunting Hollow	0.66	72	20	16	9	45
205R00645	Packwood Creek	0.75	38	20	16	13	49
205R02693	Packwood Creek	0.62	36	20	9	4	33
205R02755	Berryessa Creek	0.93	50	20	12	13	45
205R02787	Matadero Creek	0.49	20	0	2	14	16
205R02915	Stevens Creek	0.58	20	20	17	14	51
205R02947	Lower Penitencia Cr	0.27	10	4	3	2	9
205R03011	Berryessa Creek	0.8	56	11	8	10	29
205R03091	Arroyo Aguague	1.01	62	19	17	14	50
205R03098	Guadalupe Creek	0.7	60	16	15	11	42
205R03235	Stevens Creek	0.86	40	4	6	14	24
205R03306	Saratoga Creek	0.87	20	14	14	10	38
205R03331	Los Gatos Creek	0.59	32	14	15	16	45
205R03354	Guadalupe Creek	1.03	78	14	17	16	47
205R03386	Aldercroft Creek	1.0	50	19	14	10	43
205R03418	Alamitos Creek	0.7	68	11	14	9	34
205R03443	Calabazas Creek	0.45	76	0	2	14	16
205R03523	Upper Penitencia Cr	0.91	28	12	14	15	41
205R03530	Los Gatos Creek	0.56	54	16	15	11	42

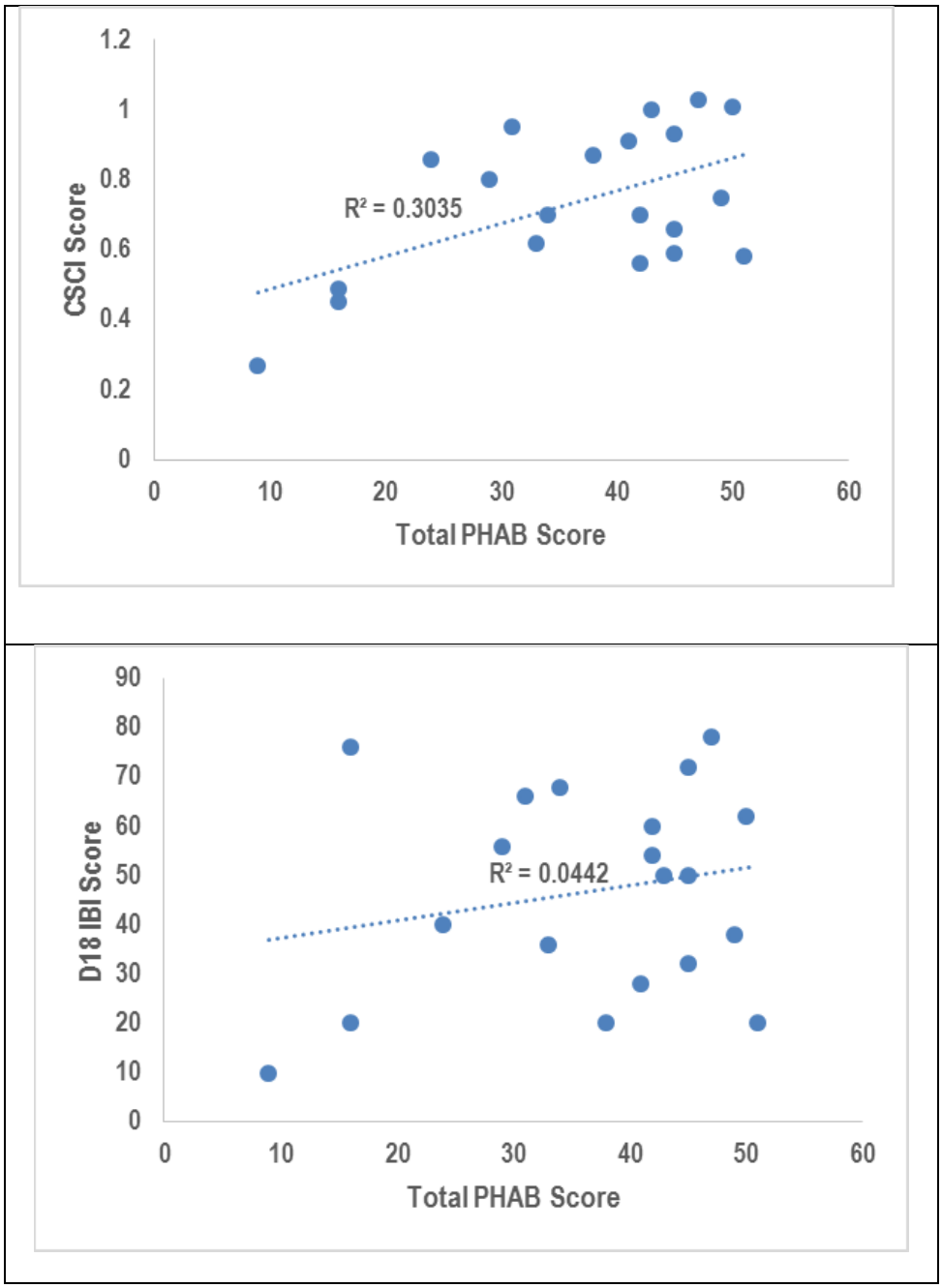

Figure 2.4. CSCI and D18 IBI Scores compared to Total PHAB Scores for 20 bioassessment sites sampled in Santa Clara County in WY 2017.

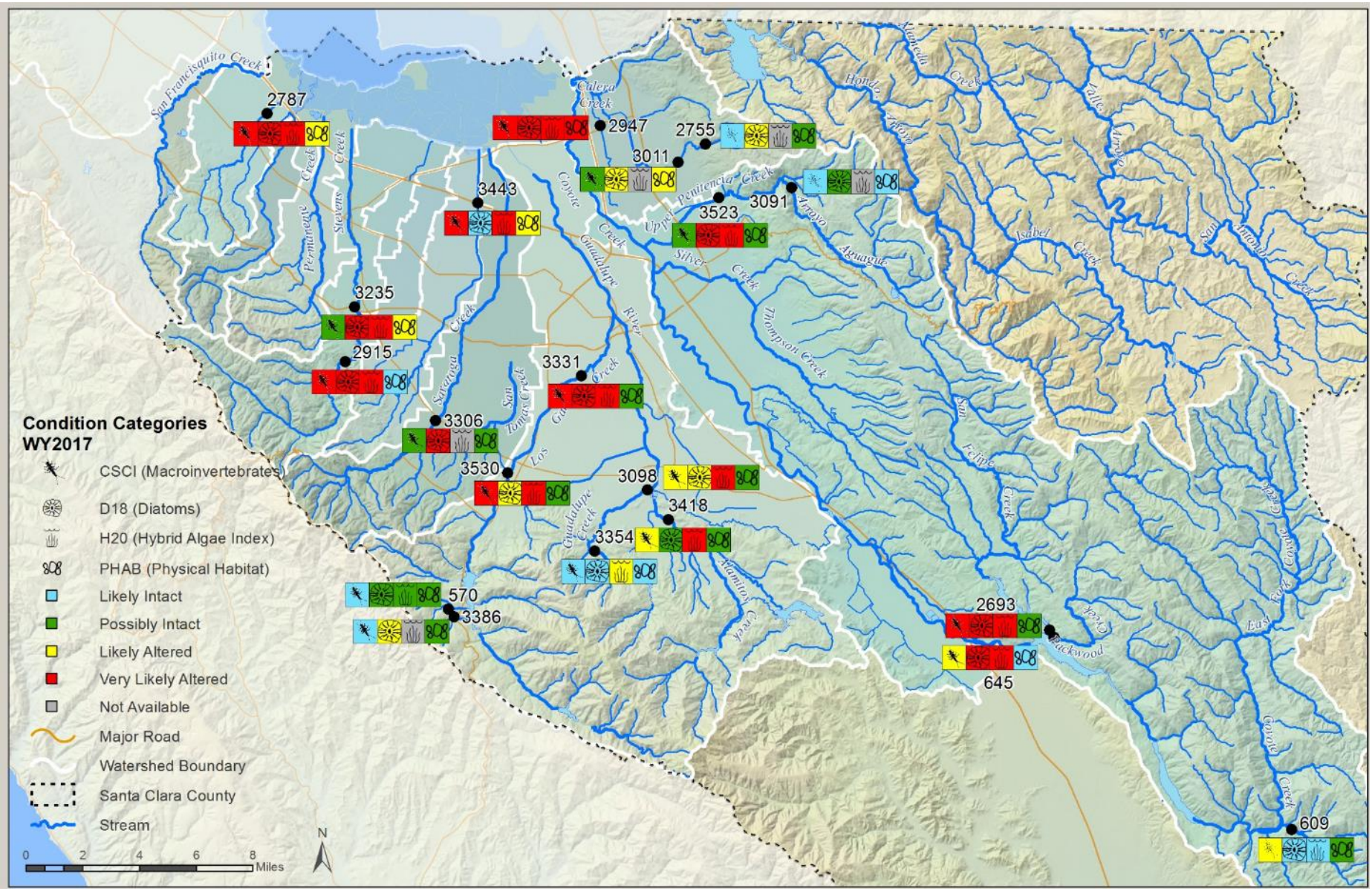

Figure 2.5. Condition category as represented by CSCI, D18, H20 and PHAB scores for 20 probabilistic sites sampled in Santa Clara County during WY 2017.

2.3.3 Stressor Assessment

The section below summarizes results for stressor data collected at 20 bioassessment sites during WY 2017. Association between stressor data and biological condition is presented for some of the stressors. However, due to small number of samples (n=20), 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 BASMAA RMC 5-Year Report.

General Water Chemistry

General water quality measurements sampled at the twenty 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. Two measurements exceeded water quality objectives for pH: site 205R03011 (Berryessa Creek) and site 205R03443 (Calabazas Creek). The acute temperature threshold (24°C) for salmonid fish was also exceeded at site 205R03443 (Calabazas Creek). The site on Calabazas Creek is a concrete channel near the bottom of the watershed. The sampling event at Calabazas Creek site occurred during an extremely hot day and the channel bottom was mostly stagnant water covered in filamentous algae.

The dissolved oxygen sensor for the multiparameter sonde malfunctioned on May 11, 2017. The device was used for approximately one week to measure other parameters until a replacement unit was obtained on May 18, 2017. All DO measurements made and recorded at six sites between May 11-16 did not meet data quality objectives (e.g., unable to calibrate within acceptable range) and thus, were rejected. These data are indicated as “NA” in Table 2.8.

Table 2.8. General water quality measurements for twenty probabilistic sites in Santa Clara County sampled in WY 2017.

Station Code	Waterbody	Sample Date	Temp (C)	DO (mg/L)	pH	Specific Conduct (uS/cm)
205R00570	Trib to Aldercroft Cr	5/16/2017	10.6	NA	8.0	738
205R00609	Hunting Hollow	5/10/2017	15.1	9.1	8.0	618
205R00645	Packwood Creek	5/15/2017	11.7	NA	8.4	576
205R02693	Packwood Creek	5/15/2017	15.6	NA	8.5	579
205R02755	Berryessa Creek	5/8/2017	10.9	11.1	8.5	590
205R02787	Matadero Creek	6/1/2017	19.9	12.9	8.5	1218
205R02915	Stevens Creek	6/5/2017	15.3	9.7	8.0	504
205R02947	Lower Penitencia Cr	5/11/2017	23.3	NA	8.4	1386
205R03011	Berryessa Creek	5/8/2017	20.4	8.1	**8.7**	614
205R03091	Arroyo Aguague	5/18/2017	10.5	10.7	8.5	670
205R03098	Guadalupe Creek	6/6/2017	17.8	10.5	8.3	393
205R03235	Stevens Creek	6/5/2017	16.6	11.5	8.5	519
205R03306	Saratoga Creek	5/9/2019	12.6	11.5	8.3	458
205R03331	Los Gatos Creek	6/7/2017	21.0	9.9	8.4	332
205R03354	Guadalupe Creek	6/6/2017	13.7	10.1	8.2	346
205R03386	Aldercroft Creek	5/16/2017	11.4	NA	8.1	320
205R03418	Alamitos Creek	6/8/2017	16.5	10.2	8.3	461
205R03443	Calabazas Creek	6/1/2017	**30.4**	19.6	**9.0**	703
205R03523	Upper Penitencia Cr	5/11/2017	13.8	NA	8.5	788
205R03530	Los Gatos Creek	6/7/2017	18.5	9.4	8.2	331

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 ($r^2 = 0.55$, $p < 0.001$) and road density ($r^2 = 0.54$, $p < 0.001$) (Figure 2.6).

Table 2.9. Landscape variables for watershed areas of the 20 bioassessment sites sampling in WY 2017.

Station Code	CSCI Score	Drainage Area (km2)	Percent Urban Watershed	Percent Impervious Watershed	Road Crossings Watershed	Road Density Watershed (km/km^2)
205R00570	0.95	2	0%	1%	3	3.3
205R00609	0.66	28	0%	2%	3	0.3
205R00645	0.75	27	0%	1%	1	0.4
205R02693	0.62	27	0%	1%	1	0.4
205R02755	0.93	10	3%	1%	0	0.7
205R02787	0.49	27	65%	30%	63	7.0
205R02915	0.58	47	2%	2%	25	1.2
205R02947	0.27	12	96%	69%	24	12.3
205R03011	0.8	13	8%	4%	4	1.5
205R03091	1.01	34	1%	1%	2	0.3
205R03098	0.7	38	11%	6%	19	2.7
205R03235	0.86	51	7%	4%	31	1.7
205R03306	0.87	27	17%	8%	29	2.7
205R03331	0.59	129	23%	14%	99	4.4
205R03354	1.03	24	0%	1%	6	1.3
205R03386	1.0	3	5%	4%	0	0.8
205R03418	0.7	89	14%	7%	121	2.6
205R03443	0.45	49	84%	49%	111	10.4
205R03523	0.91	57	6%	3%	12	0.8
205R03530	0.56	115	14%	8%	78	3.2

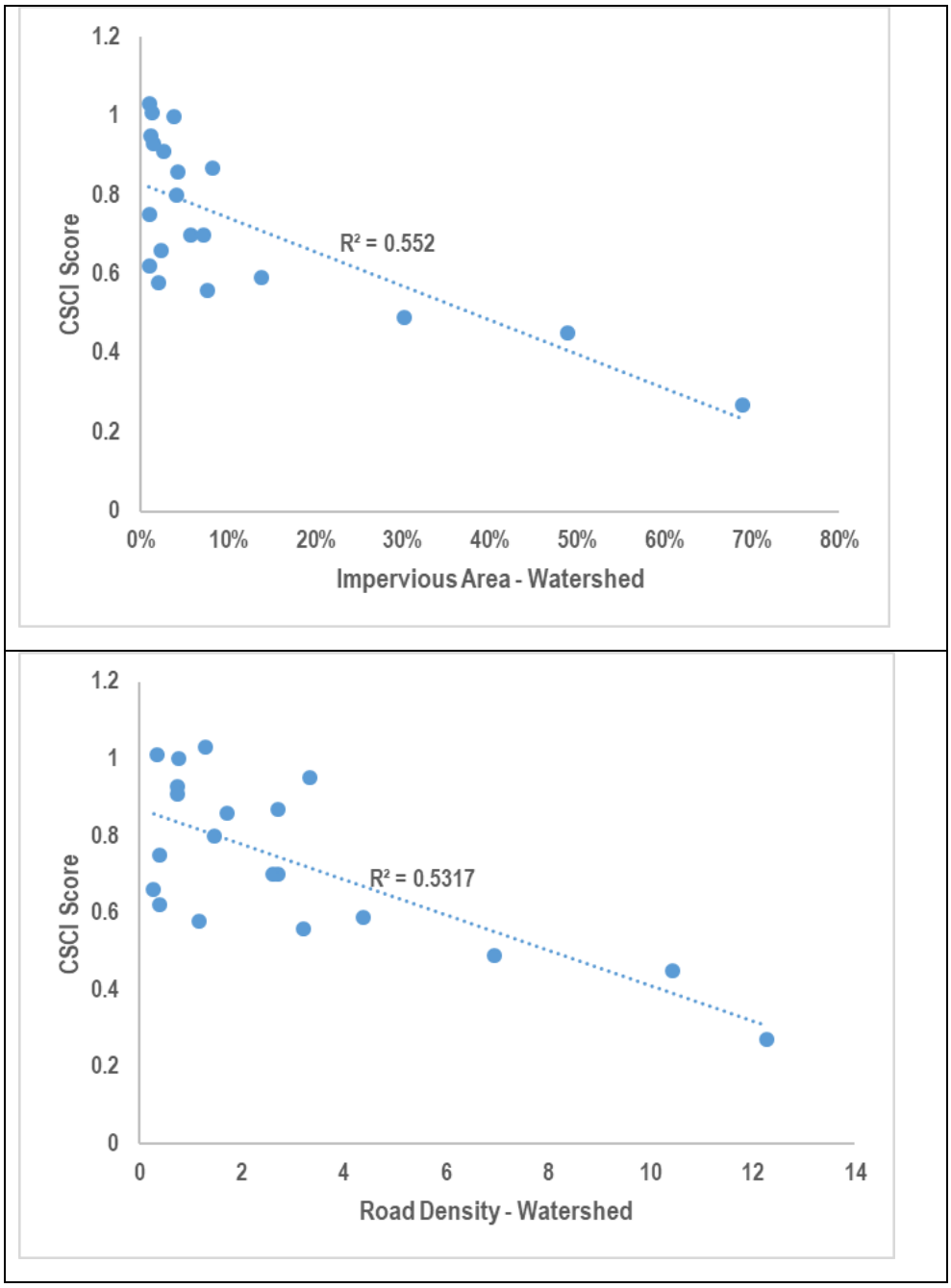

Figure 2.6. CSCI Scores compared to landscape variables (percent impervious and road density) for 20 bioassessment sites sampled in Santa Clara County in WY 2017.

Physical Habitat

Scores for ten physical habitat metrics that were generated from the physical habitat data collected at bioassessment sites in WY 2017 are listed in Table 2.10. CSCI scores were slightly correlated with metrics associated with substrate size and composition, including *Diversity of Natural Substrate Types* metric ($r^2 = 0.38$, $p = 0.002$) and *Substrate Smaller than Sand* metric ($r^2 = 0.22$, $p = 0.037$) (Figure 2.7). The remaining physical habitat metrics were poorly correlated with CSCI scores. D18 IBI scores were poorly correlated with all physical habitat metrics.

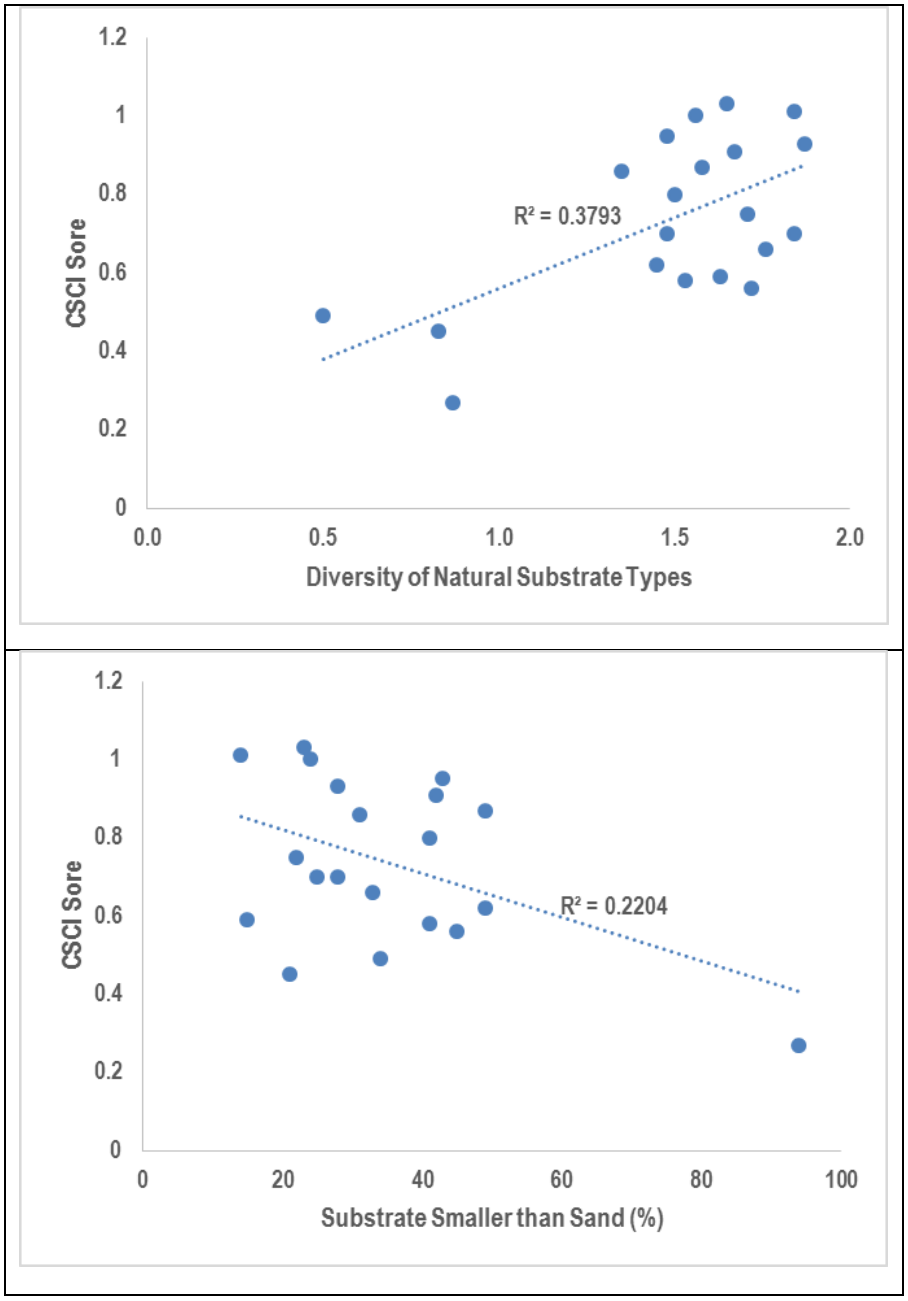

Figure 2.7. CSCI Scores compared to physical habitat metrics associated with substrate size and composition (i.e., diversity of natural substrate types and substrate smaller than sand) for 20 bioassessment sites sampled in Santa Clara County in WY 2017.

Water Chemistry (nutrients)

Nutrient and conventional analyte concentrations measured in water samples collected at twenty bioassessment sites in Santa Clara County during WY 2017 are listed in Table 2.11. There were no water quality objective exceedances for water chemistry parameters, except for unionized ammonia (.025 mg/L) at site 205R03011 (Berryessa Creek), and site 205R03011 (Calabazas Creek). Both sites are at the bottom of highly urbanized watersheds.

Total Nitrogen concentrations ranged from 0.19 to 3.12 mg/L. The two highest concentrations measured for all samples (>3 mg/L) occurred at site 205R03443 in Calabazas Creek and site 205R02787 on Matadero Creek. Both sites are located in concrete channels near the bottom of each watershed. Total phosphorus concentrations ranged from 0.2 to 0.39 mg/L. The two highest concentrations of total phosphorus (> 0.3 mg/l) occurred at the two sites in Berryessa Creek. The upper site in Berryessa Creek is in open space land, indicating a potential natural source of phosphorus in this watershed.

In an effort to assess whether total nitrogen concentrations (measured during bioassessments) are affecting indicators of biomass (i.e., chlorophyll a, ash free dry mass, percent algae cover), simple regression models were run. There was no correlation between total nitrogen concentration and chlorophyll a, ash free dry mass, or algae cover for 20 sites sampled in WY 2017. However, chlorophyll a and algae cover were moderately correlated ($r^2 = 0.57$, $p < 0.001$) indicating that estimating algae cover during pebble counts may provide a reasonable estimate for algae biomass at bioassessment sites.

Table 2.10. Scores for 10 PHAB metrics calculated from physical habitat data collected at twenty probabilistic sites in Santa Clara County during WY 2017.

Station Code	Channel Morphology		Habitat Complexity and Cover			Substrate Size and Composition				Human Disturbance
	Evenness of Flow Habitat Types	% 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	% Gravel - Coarse	% Substrate Smaller than Sand (<2 mm)	Riparian Human Disturbance Index
205R00570	0.7	64	1.9	39	0.0	0.8	1.5	30	43	2.7
205R00609	0.5	11	1.2	51	3.2	0.9	1.8	21	33	0.8
205R00645	1.0	52	1.4	39	26.8	0.9	1.7	29	22	0.1
205R02693	0.8	75	1.3	12	10.7	0.8	1.5	24	49	1.3
205R02755	1.0	39	1.4	32	0.9	1.0	1.9	17	28	0.5
205R02787	1.0	52	0.2	2	30.9	0.7	0.5	0	34	5.2
205R02915	0.8	37	2.0	33	3.6	1.0	1.5	21	41	0.9
205R02947	0.0	0	0.8	22	20.7	0.8	0.9	0	94	3.5
205R03011	1.0	51	1.7	22	0.0	0.8	1.5	36	41	3.0
205R03091	0.6	40	0.8	50	1.4	1.0	1.8	21	14	0.1
205R03098	1.0	27	1.5	43	46.4	0.8	1.5	40	25	1.9
205R03235	0.9	69	1.5	29	15.9	0.8	1.4	30	31	3.0
205R03306	1.0	52	1.7	13	5.9	0.9	1.6	22	49	3.1
205R03331	0.7	65	1.4	31	29.1	0.9	1.6	31	15	3.3
205R03354	0.6	20	1.7	22	16.1	0.9	1.7	36	23	2.8
205R03386	0.9	62	1.7	21	0.0	0.9	1.6	36	24	1.4
205R03418	0.8	40	1.0	18	51.1	0.9	1.8	30	28	3.8
205R03443	1.0	52	0.2	2	62.3	0.8	0.8	4	21	6.0
205R03523	1.0	28	1.9	34	9.5	0.9	1.7	22	42	2.5
205R03530	1.0	43	1.8	34	17.0	0.8	1.7	26	45	2.5

Table 2.11. Nutrient and conventional constituent concentrations in water samples collected at 20 sites in Santa Clara County during WY 2016. Analyte concentrations that exceed water quality objectives are indicated in bold.

Station Code	Creek	Ammonia as N	Unionized Ammonia (as N)	Chloride	AFDM	Chlorophyll a	Nitrate as N	Nitrite as N	Total Kjeldahl 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
205R00570	Trib to Aldercroft Cr	0.054	0.001	14	277.84	8.68	0.063	0.003 J	0.13	0.20	0.12	0.14	0.26	27
205R00609	Hunting Hollow	0.058	0.001	28	21.48	12.00	<0.02	<0.001	0.97	0.98	0.01	0.015	0.025	17
205R00645	Packwood Creek	< 0.015	< 0.0004	19	172.74	21.05	1.8	0.002 J	0.44	2.24	0.015	0.019	0.034	17
205R02693	Packwood Creek	< 0.015	< 0.0005	19	61.82	11.52	1.7	0.003 J	0.31	2.01	0.015	0.024	0.039	17
205R02755	Berryessa Creek	0.22	0.012	25	289.58	16.30	0.71	0.007	0.62	1.34	0.18	0.21	0.39	31
205R02787	Matadero Creek	0.082	0.007	110	253.40	139.86	2.1	0.025	0.92	3.05	0.064	0.07	0.134	31
205R02915	Stevens Creek	0.081	0.002	22	46.98	79.00	0.032 J	<0.001	0.57	0.60	0.024	0.066	0.09	18
205R02947	Lower Penitencia	0.047	0.004	120	218.41	52.06	0.22	0.013	0.66	0.89	0.013	0.012	0.025	16
205R03011	Berryessa Creek	0.27	**0.043**	27	260.46	5.41	0.43	0.005	0.62	1.06	0.13	0.18	0.31	30
205R03091	Arroyo Aguague	0.017 J	0.001	22	1.51	5.11	< 0.02	0.001 J	0.31	0.32	0.033	0.033	0.066	16
205R03098	Guadalupe Creek	0.073	0.004	17	370.98	54.26	0.092	0.002 J	0.53	0.62	0.011	0.025	0.036	16
205R03235	Stevens Creek	0.061	0.004	24	42.42	117.42	0.078	0.01	0.44	0.53	0.022	0.052	0.074	17
205R03306	Saratoga Creek	0.049	0.002	21	90.32	17.35	0.18	0.001 J	0.48	0.66	0.047	0.065	0.112	24
205R03331	Los Gatos Creek	0.12	0.011	11	40.55	163.14	< 0.02	0.003 J	0.18	0.19	0.016	0.029	0.045	14
205R03354	Guadalupe Creek	0.056	0.002	7.3	30.40	18.71	0.036 J	0.003 J	0.88	0.92	0.007 J	0.015	0.022	16
205R03386	Aldercroft Creek	0.068	0.001	16	49.01	4.36	0.099	0.003 J	0.22	0.32	0.11	0.14	0.25	26
205R03418	Alamitos Creek	0.11	0.005	19	73.81	219.19	0.088	0.002 J	0.57	0.66	0.022	0.033	0.055	20
205R03443	Calabazas Creek	0.11	0.046	83	136.41	196.21	1.4	0.035	1.7	3.14	<0.006	0.014	0.02	20
205R03523	Upper Penitencia Cr	0.038	0.002	41	44.14	41.52	0.19	0.007	0.66	0.86	0.036	0.043	0.079	17
205R03530	Los Gatos Creek	0.14	0.007	9.4	208.61	152.48	0.03 J	0.006	0.18	0.22	0.012	0.027	0.039	17

NA = Not Applicable
J = The reported result is an estimate.
[a] Nitrate and chloride WQOs only apply to waters with MUN designated Beneficial Use
[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. Twenty 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. Seventeen of the sites were classified as urban and three were classified as 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 Santa Clara Valley 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).

- **CSCI**. The California Stream Condition Index translates benthic macroinvertebrate data into an overall measure of stream health. Of the 20 sites monitored in WY 2017, nine sites (45%) were rated in good condition (CSCI scores ≥ 0.795); four sites (20%) rated as likely altered condition (CSCI score 0.635 – 0.795), and seven sites (35%) rated as very likely altered condition (≤ 0.635). Each of the three sites with the lowest CSCI scores had a high proportion of impervious watershed area (> 30%) and were characterized as modified channels.
    - The eleven 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, six sites (30%) were ranked in good condition (D18 score ≥ 62), five sites (25%) were ranked in likely altered condition (62-72), and nine sites (45%) were ranked in very likely altered condition (< 49).
    - Soft algae were absent from samples collected at five sites. As a result, no S2 or H20 scores could be calculated for these sites. Based on S2 scores, three of the remaining 15 sites (20%) were ranked as possibly intact or likely intact (S2 score > 47) and twelve sites (80%) were ranked in very likely altered condition. Based on H20 scores, two of the remaining 15 sites (13%) were ranked as possibly intact or likely intact (H20 score > 63) and 13 sites (87%) were ranked in very likely altered condition (< 54).
- 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 better correlated with CSCI scores than they were with D18 scores, suggesting that physical habitat (e.g., substrate quality, channel alteration) has a greater influence on the BMI community compared to the diatoms assemblage. In contrast, algae indices appear to have some ability to respond to water quality gradients

in highly modified channels. This was apparent at site 205R03443 on Calabazas Creek, which had poor habitat quality (i.e., concrete channel) but received one of the highest 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). Two measurements exceeded water quality objectives for pH: site 205R03011 (Berryessa Creek) and site 205R03443 (Calabazas Creek). The acute temperature threshold trigger (24°C) for salmonid fish was also exceeded at site 205R03443 (Calabazas Creek). 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, except for unionized ammonia (0.025 mg/L) at site 205R03011 (Berryessa Creek), and site 205R03011 (Calabazas Creek). Both sites are at the bottom of highly urbanized watersheds and will be considered as candidates for SSID projects.
- **Physical habitat metric scores** were generated from the physical habitat data. CSCI scores were slightly correlated with metrics associated with substrate size and composition. D18 scores were poorly correlated with all ten physical habitat metrics.
- **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). SCVURPPP should consider applying tools and approaches developed by the regional project to the growing Santa Clara Valley 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[16] 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 MRP, temperature was monitored at a minimum of eight sites, general water quality was monitored at three sites, and pathogen indicator samples were collected at five sites. The targeted monitoring design focuses on sites selected based on the presence of significant fish and wildlife resources as well as historical and/or recent indications of water quality concerns.

3.2.1 Temperature

Continuous (hourly) water temperature measurements were collected from April through September 2017, at nine locations[17] in three creeks of the Guadalupe River watershed: Alamitos Creek, Arroyo Calero and Guadalupe Creek (Figure 3.1). All three creeks are impounded by large dams located at the base of the Santa Cruz Mountains. The temperature monitoring locations were approximately 3-5 miles downstream of the reservoirs in reaches flowing through the Santa Clara Valley. The upper watershed areas for these creeks include rangeland and forested land uses within Almaden Quicksilver County Park and the Sierra Azul Open Space Preserve. The lower watershed areas are primarily residential land uses within the City of San Jose.

Guadalupe Creek and Alamitos Creeks support spawning and rearing habitat for steelhead, although fish are less abundant in the unshaded, warm section of Guadalupe Creek downstream of Camden Avenue. Arroyo Calero is generally too silty and does not provide good habitat for steelhead (Smith 2013).

[16] 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."

[17] SCVURPPP typically monitors water temperature at more stations than the MRP required minimum to mitigate for potential equipment loss.

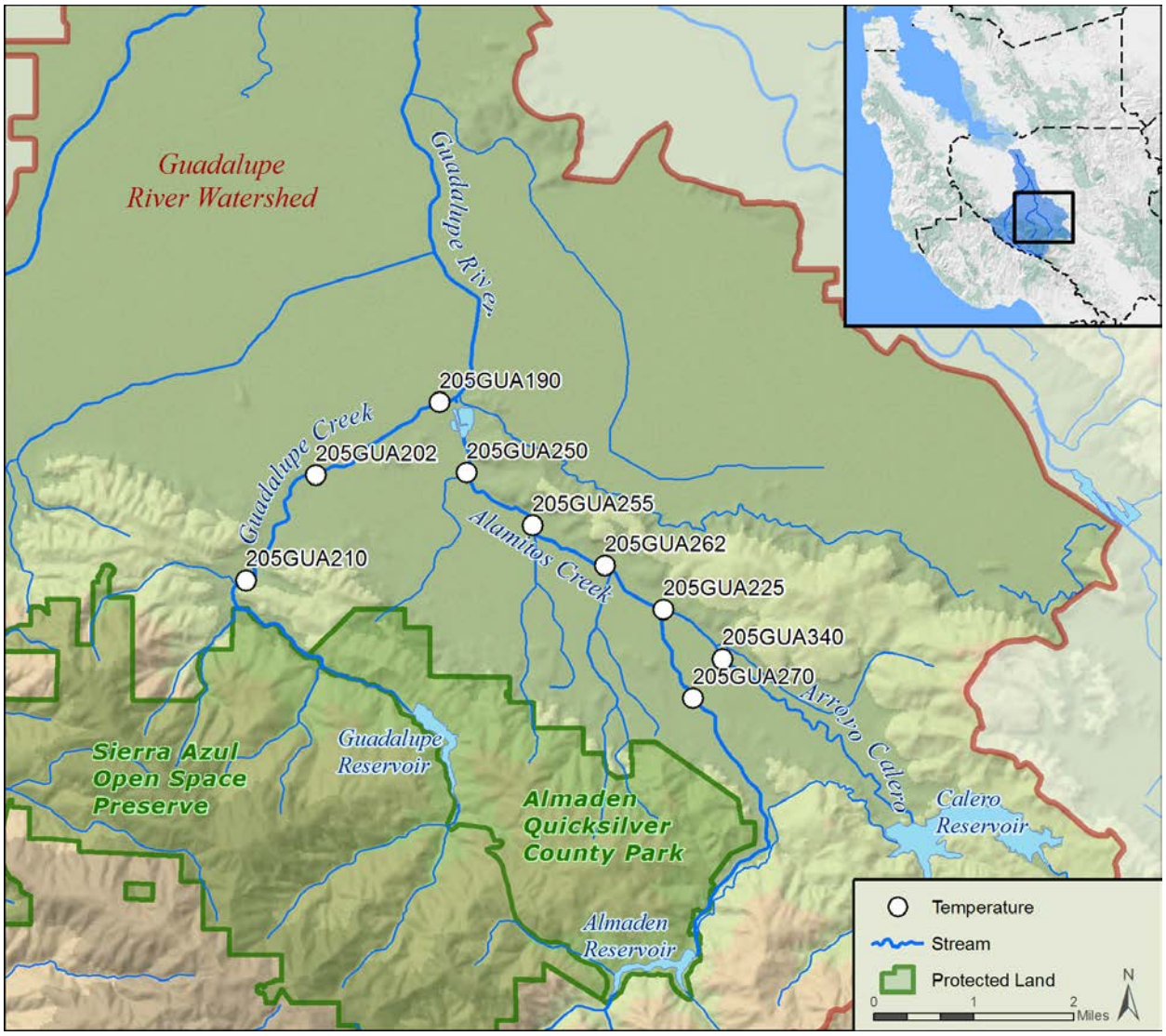

Figure 3.1. Continuous temperature stations in the Guadalupe River watershed, WY 2017.

3.2.2 General Water Quality

Continuous (15-minute) general water quality measurements (dissolved oxygen, specific conductance, pH, and temperature) were recorded at three locations on the mainstem of Coyote Creek during two two-week sampling events in WY 2017 (Figure 3.2). The first event was in June and the second event was in September.

The monitoring stations were previously sampled for continuous water quality in WY 2013 as part of the Coyote Creek Dissolved Oxygen Stressor Source Identification (Coyote Creek SSID) Project (SCVURPPP 2014). The Coyote Creek SSID Project evaluated a range of potential stressors and sources that may cause low dissolved oxygen in the section of Coyote Creek between Watson Park and Williams Park. The Coyote Creek SSID Project measured continuous water quality at six locations between June and September 2013. Three of the six locations were selected for Creek Status Monitoring in WY 2017. These stations include site 205COY235 (Watson Park), site 205COY236 (Julian Street) and site 205COY239 (Williams). These sites were selected to evaluate potential changes in water quality conditions following high flow conditions in Coyote Creek during the wet season of WY 2017.

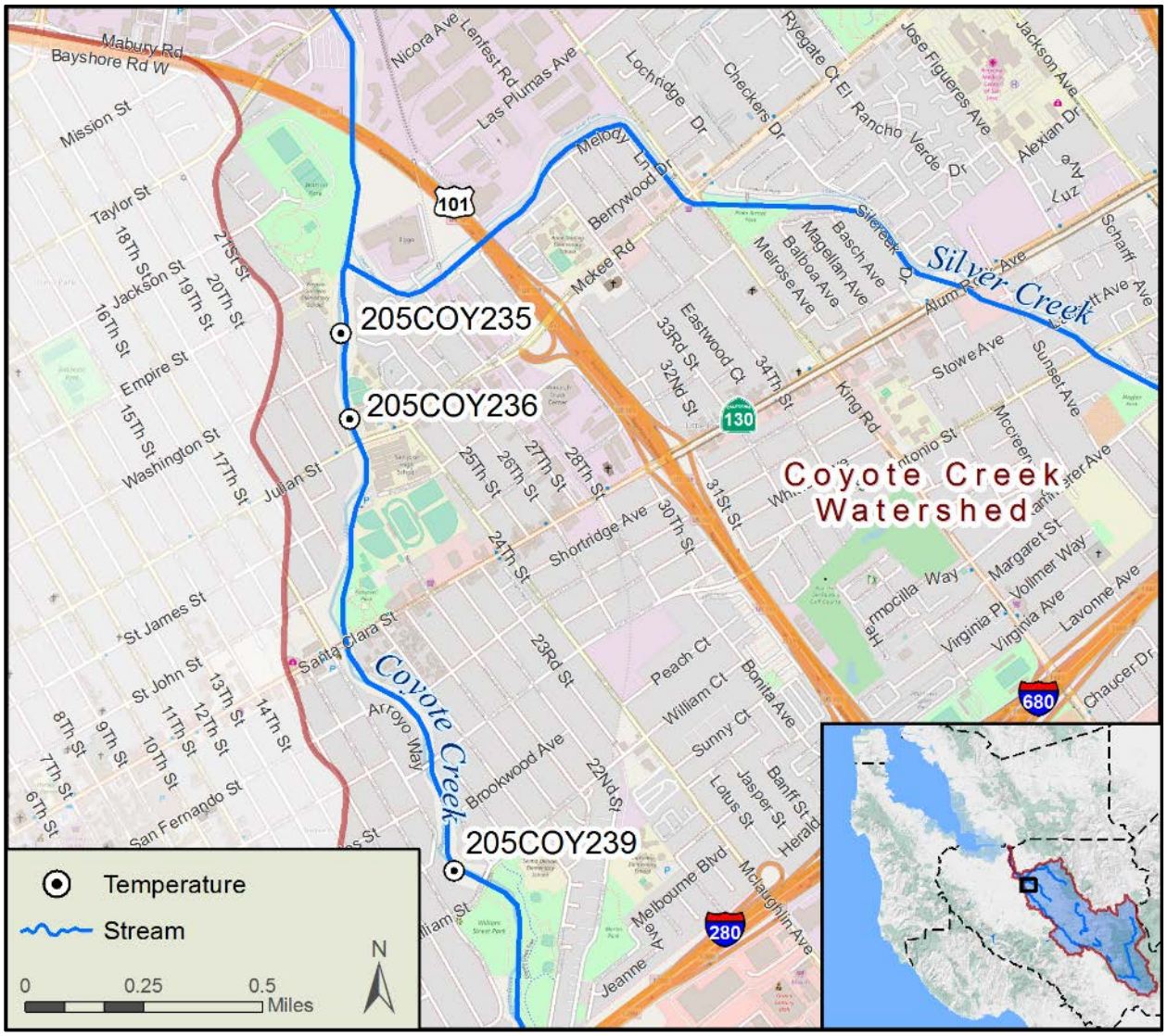

Figure 3.2. Continuous water quality stations in Coyote Creek during WY 2017.

3.2.3 Pathogen Indicators

Pathogen indicator samples were collected at five sites located in municipal parks in areas with good public access to creeks and potential for recreational water contact (Figure 3.3). One site was located on Arroyo Calero at Singer Park (205GUA225), one was located on Los Gatos Creek at Vasona Park (205LGA400), one was located on Saratoga Creek at Wildwood Park (205SAR075), one was located on Stevens Creek at Blackberry Farm (205(STE064), and the final site was located on Matadero Creek at Cornelis Bol Park (205MAT030).

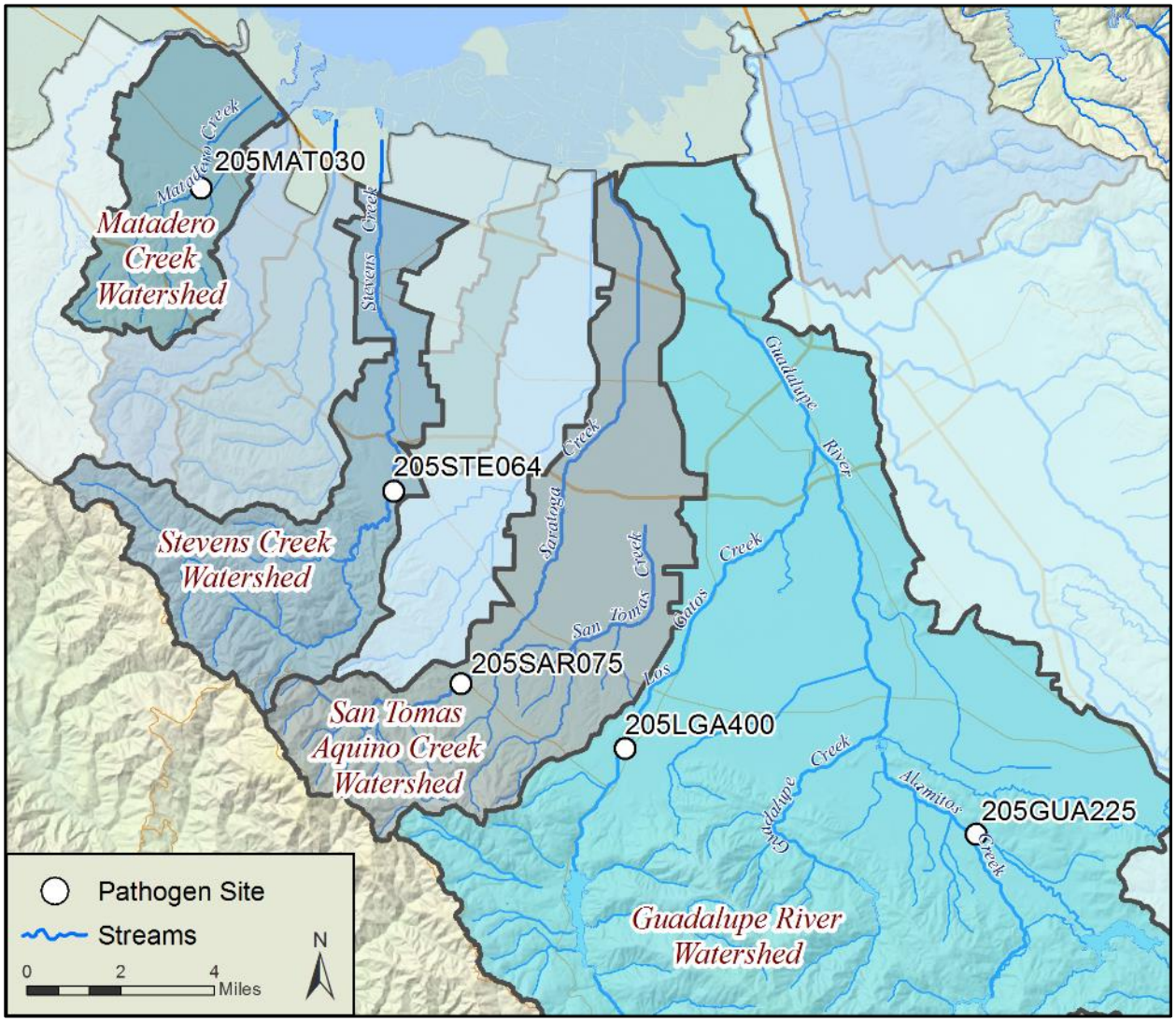

Figure 3.3. Pathogen indicator monitoring sites sampled in Santa Clara County during WY 2017.

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) were programmed to record data at 60-minute intervals and were deployed at targeted sites from April through September 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 Measurements

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 (June) and once during summer season (September) in 2017. Procedures for calibrating, deploying, programming and downloading data are described in RMC SOP FS-4 (BASMAA 2016b).

3.3.3 Pathogen Indicators Sampling

Water samples were collected during the dry season. Sampling techniques for pathogen indicators (enterococcus and *E. coli*) include direct filling of sterile containers at targeted sites and transfer of samples to the analytical laboratory within specified holding time requirements. Procedures 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.	^{0}C	MRP provision C.8.d.iii.
General Water Quality Parameters	20% of results at each monitoring site exceed one or more established standard or threshold - applies individually to each parameter		
Conductivity	2000	µS/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			
Enteroccocus	≥ 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

Hourly temperature data were collected at nine sites in the Guadalupe River watershed from April 3 through September 26, 2017 (26 weeks). All stations had continuous flow during the sampling season and all HOBO devices were successfully recovered at the end of the season. Summary statistics for continuous water temperature data collected at the nine sites are listed in Table 3.2. Table 3.2 includes the number of weeks in the record that exceed the Maximum Weekly Average Temperature (MWAT) trigger of 17°C. Consistent with MRP requirements, the MWAT was calculated for non-overlapping, seven-day periods. Table 3.2 also lists the number and percent of records from each site that exceed the instantaneous maximum temperature trigger of 24°C.

Time series plots of the instantaneous data are shown in Figures 3.4 and 3.5. The instantaneous maximum temperature trigger is shown for reference. Temperatures generally followed the same pattern at all nine sites, with a gradual increase throughout the summer months of June through August followed by a slow decline by mid/late September. For each creek, sites at lower elevations generally had higher temperatures. The higher elevation sites are likely colder due to releases from upstream reservoirs that release cool water from low in the water column. Temperatures at several of the sites exceeded the instantaneous maximum of 24°C on several occasions. These exceedances typically occurred on days with high air temperatures (>90° F). The exceedances did not exceed 1% of the dataset at any station and therefore the MRP trigger (20%) was not exceeded.

Time series plots of the MWAT values are shown in Figure 3.6 (Guadalupe Creek) and Figure 3.7 (Alamitos Creek and Arroyo Calero). The MWAT trigger of 17°C is shown for reference. The MWAT data used to populate these figures is listed in Table 3.3. MWAT values ranged from 11.9 °C to 14.5 °C in beginning of April to 17.2 °C to 19.8 °C in late September. The MWAT trigger was exceeded on two or more consecutive weeks at all stations. Therefore, they will be added to the list of candidate SSID sites. Air temperatures during summer months of 2017 were some of the hottest on record (see discussion on climate in Section 1.4.3). It is likely that these conditions increased water temperatures in Guadalupe Creek, Alamitos Creek, and Arroyo Calero during Event 2.

Table 3.2. Descriptive statistics for continuous water temperature measured in Guadalupe River watershed at nine sites during WY 2017.

		Guadalupe Creek			Alamitos Creek/Arroyo Calero					
Site		205GUA190	205GUA202	205GUA210	205GUA250	205GUA255	205GUA262	205GUA225	205GUA270	205GUA340
Start Date		4/3/2017	4/3/2017	4/3/2017	4/3/2017	4/3/2017	4/3/2017	4/3/2017	4/3/2017	4/3/2017
End Date		9/26/2017	9/26/2017	9/26/2017	9/26/2017	9/26/2017	9/26/2017	9/26/2017	9/26/2017	9/26/2017
Temperature (ºC)	Minimum	10.6	10.2	10.2	12.0	11.6	12.4	11.6	11.5	11.6
	Median	18.8	17.7	17.0	19.2	19.1	18.5	18.9	18.9	19.2
	Mean	18.0	17.2	16.7	18.8	18.6	18.4	18.3	18.3	18.5
	Maximum	26.2	23.8	24.1	24.8	24.6	23.7	23.4	24.3	23.2
	Max 7-day mean	21.1	21.3	21.1	21.2	21.4	21.2	21.1	21.9	21.4
	N	4220	4220	4220	4220	4220	4220	4220	4220	4220
MWAT > 17°C		17	15	15	20	19	19	18	18	18
# Measurements > 24°C		36	0	2	18	6	0	0	13	0
		1%	0%	0%	0%	0%	0%	0%	0%	0%

MWAT = Maximum Weekly Average Temperature; N = number of records in dataset

Table 3.3. MWAT values for water temperature data collected at nine stations monitored in Guadalupe River watershed, WY 2017. MWAT values that exceed MRP trigger (17°C) are indicated in bold.

Station Date	Guadalupe Creek			Alamitos Creek/Arroyo Calero					
	205GUA190	205GUA202	205GUA210	205GUA225	205GUA250	205GUA255	205GUA262	205GUA270	205GUA340
	Maximum Weekly Average Temperature								
4/3/2017	12.8	12.3	11.9	14.5	14.4	14.0	13.9	13.4	14.1
4/10/2017	12.9	12.3	11.9	14.6	14.2	13.9	13.8	13.2	14.2
4/17/2017	13.5	12.9	12.5	15.0	14.8	14.4	14.3	13.7	14.8
4/24/2017	14.0	13.3	12.8	15.5	15.5	15.1	14.9	14.1	15.3
5/1/2017	15.5	14.7	14.0	16.8	16.9	16.4	16.1	15.1	16.7
5/8/2017	14.8	13.9	13.3	16.3	16.5	16.2	15.9	15.4	16.2
5/15/2017	15.4	14.5	13.8	16.6	17.1	16.7	16.5	16.2	16.7
5/22/2017	16.6	15.7	14.9	17.2	18.1	17.7	17.4	17.0	17.4
5/29/2017	17.0	16.1	15.2	17.2	18.3	18.0	17.6	17.6	17.4
6/5/2017	16.5	15.5	14.9	16.9	17.8	17.4	17.2	17.5	16.7
6/12/2017	18.3	16.9	16.0	18.0	19.2	18.8	18.3	18.6	18.1
6/19/2017	21.1	19.4	18.1	19.6	21.0	20.7	19.9	20.5	19.6
6/26/2017	19.2	17.8	17.0	18.4	20.0	19.3	18.8	19.2	18.5
7/3/2017	20.0	18.6	17.7	19.1	20.5	19.9	19.4	20.0	19.2
7/10/2017	19.9	18.8	18.1	19.4	20.7	20.2	19.7	20.5	19.6
7/17/2017	19.6	18.8	18.2	19.4	18.5	19.9	19.5	20.2	19.5
7/24/2017	19.8	19.4	18.6	19.9	19.5	20.2	19.9	20.5	20.0
7/31/2017	21.0	20.4	19.7	20.6	20.7	20.8	20.6	21.4	20.7
8/7/2017	19.8	19.7	19.3	20.5	20.7	20.6	20.4	20.5	20.9
8/14/2017	19.9	19.6	19.4	20.5	20.7	20.5	20.4	20.3	20.9
8/21/2017	20.1	20.2	20.0	20.7	20.9	20.8	20.6	20.8	20.9
8/28/2017	20.4	21.1	20.8	21.2	21.2	21.3	21.1	21.8	21.3
9/4/2017	20.7	21.3	21.1	21.2	21.2	21.4	21.1	21.9	21.4
9/11/2017	20.5	20.1	20.1	20.8	20.8	20.8	20.6	20.9	21.3
9/18/2017	19.9	17.5	18.2	19.3	19.5	19.0	19.2	18.1	20.2
9/25/2017	19.8	17.2	17.3	18.5	18.8	18.6	18.7	17.5	19.5
Total Weeks	26	26	26	26	26	26	26	26	26
MWAT >17	17	15	15	18	20	19	19	18	18
> MRP Trigger	Y	Y	Y	Y	Y	Y	Y	Y	Y

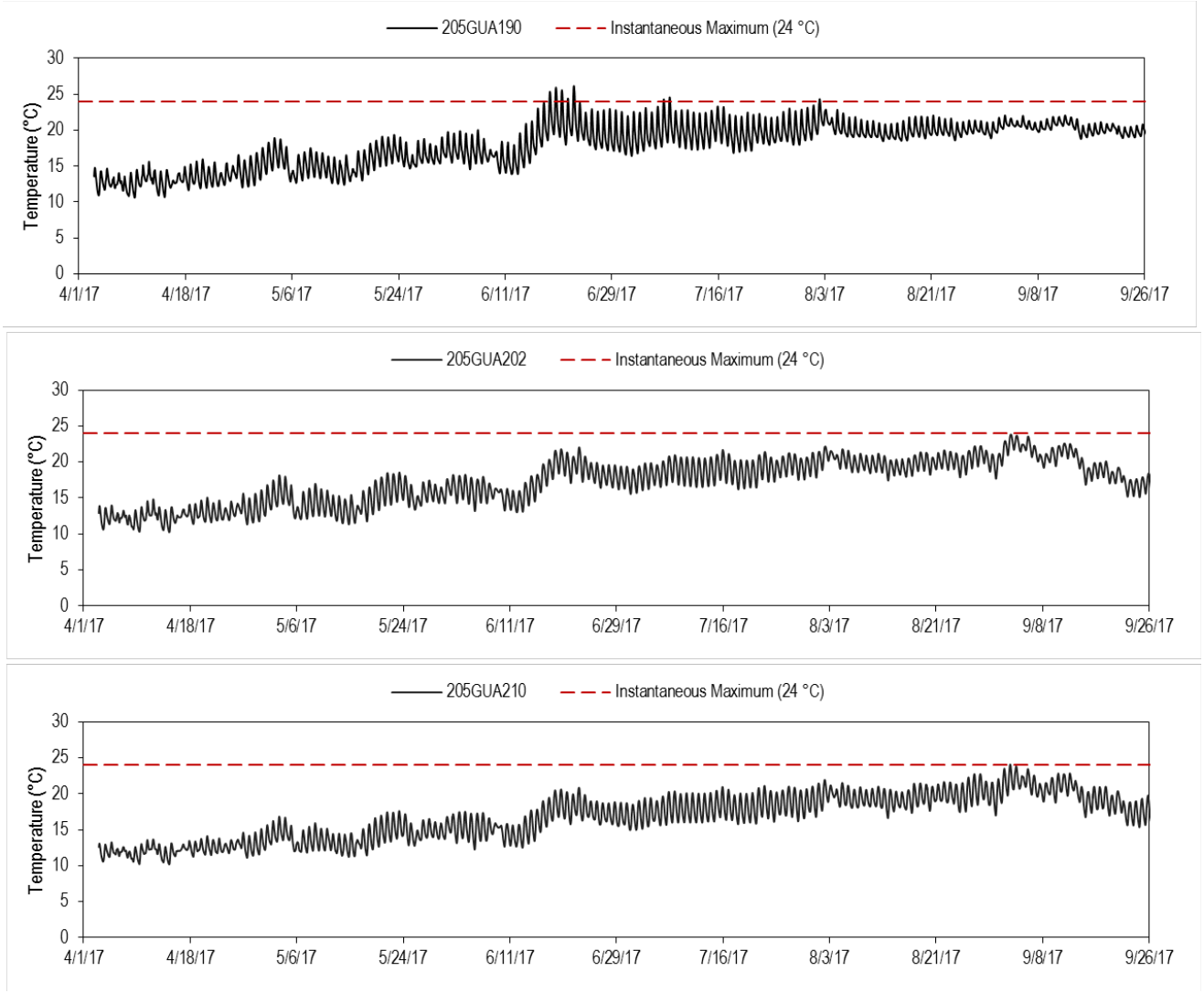

Figure 3.4. Plots of water temperature data collected at three stations in Guadalupe Creek, April through September 2017.

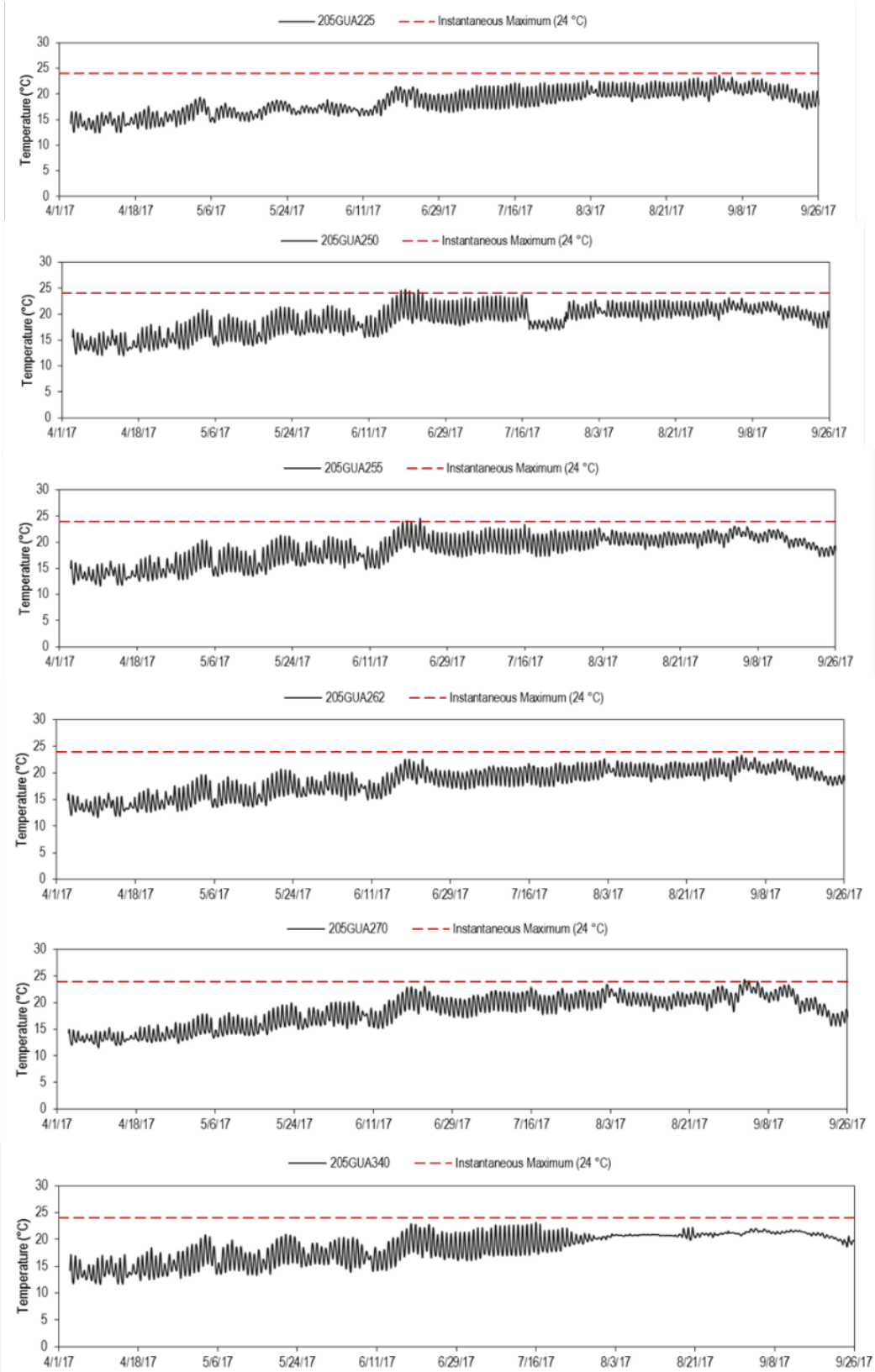

Figure 3.5. Plots of water temperature data collected at six stations in Alamitos Creek and Arroyo Calero, April through September 2017.

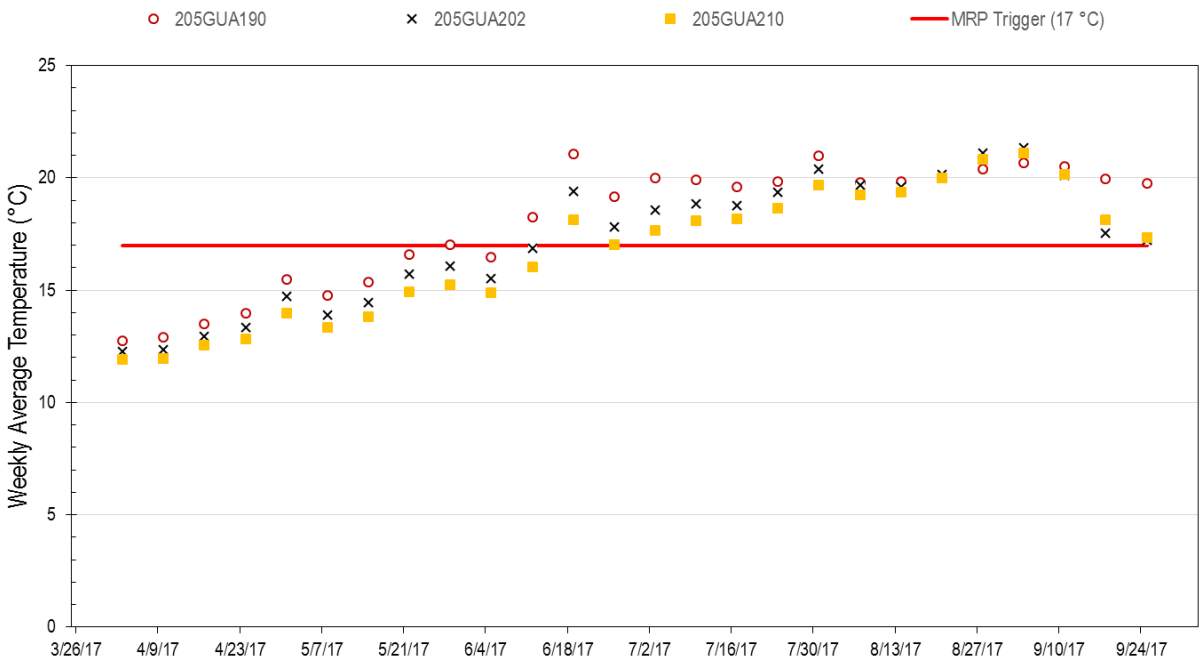

Figure 3.6. Plot of MWAT values calculated from temperatures collected at three stations in Guadalupe Creek over 26 weeks of temperature monitoring, WY 2017. The MRP trigger (17°C) is shown for comparison.

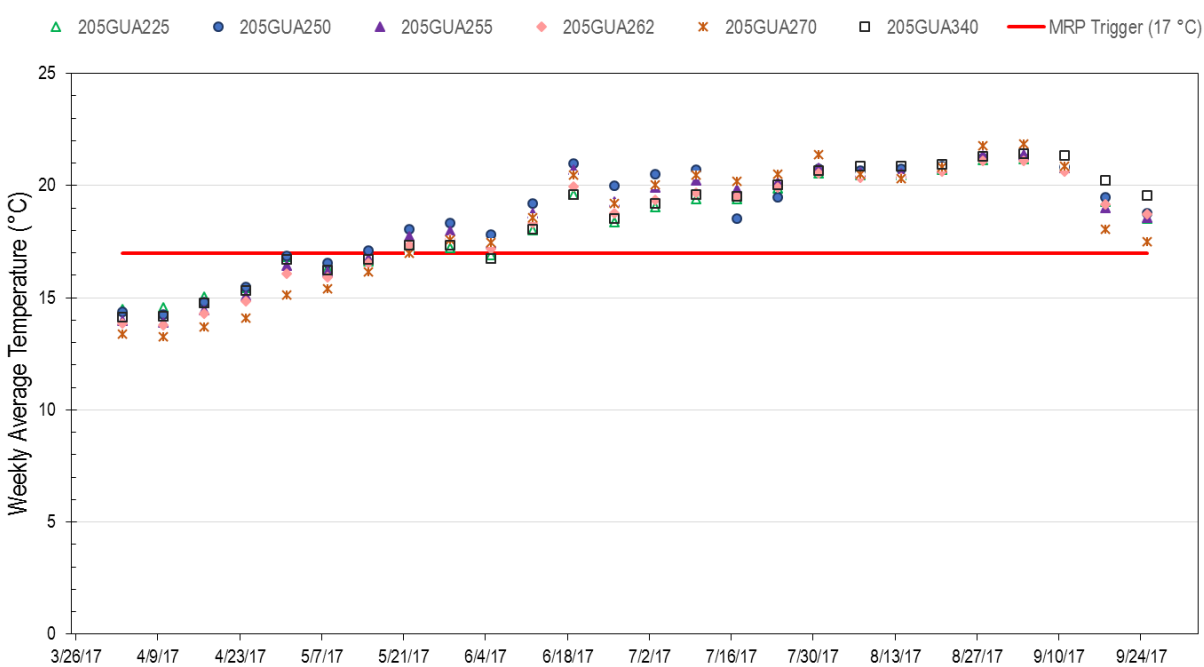

Figure 3.7. Plot of MWAT values calculated from temperatures collected at six stations in Alamitos Creek and its tributary Arroyo Calero over 26 weeks of temperature monitoring, WY 2017. The MRP trigger (17°C) is shown for comparison.

Temperature Trigger Considerations

The Basin Plan (SFRWQCB 2017) designates several Beneficial Uses associated with aquatic life uses, including COLD, WARM, MIGR, SPWN and RARE, for Guadalupe Creek, Alamitos Creek and Arroyo Calero (Table 1.5). Important spawning and rearing habitat for juvenile steelhead is present in the reaches of Guadalupe Creek and Alamitos Creek below the reservoirs (Becker et al. 2007). The extent and quality of steelhead rearing habitat is dependent on the amount and timing of releases from the reservoirs. Additional limiting factors to the steelhead population in these creeks include passage barriers, water temperature, riparian cover, sediment, mercury contamination, and predatory warm water fish species (FAHCE 2003).

Since WY 2004, the SCVWD conducted temperature and fisheries monitoring in Guadalupe Creek to meet mitigation monitoring requirements for the Downtown-Guadalupe River Flood Control Project. Most of the temperature monitoring was conducted at stations in the Guadalupe River. Limited data available for Guadalupe Creek showed cooler temperatures further upstream at stations closest to the dam, which is consistent with monitoring results presented in this report. Portions of Guadalupe and Alamitos creeks presently support reasonably good populations of steelhead/resident rainbow trout, although fish are generally less abundant in the unshaded, warm section of Guadalupe Creek downstream of Camden Avenue (Smith 2013).

Over the 12 years of monitoring by SCVWD, juvenile steelhead were typically present during the annual fall monitoring conducted in Guadalupe Creek (SCVWD et al. 2016). Steelhead numbers have dropped in 2015 due to low flow conditions caused by the recent drought. In 2016, only two steelhead individuals were documented at one site, which was the lowest count on record. However, a separate study in 2016~~,~~ documented a total of twenty-six juvenile and adult steelhead further upstream below the dam for Guadalupe Reservoir (Leicester and Smith 2016). Additional monitoring in 2017 recorded thirty steelhead in 2.5 mile reach downstream of dam for Guadalupe Reservoir (SCVWD, personal communication, Clayton Leal). In general, the upper reaches of Guadalupe Creek provide summer refugia for steelhead.

Steelhead were historically found in Alamitos Creek (Leidy et al. 2005); however, no records were available to confirm current day presence of steelhead population in the creek. Smith (2013) reports portions of Alamitos Creek support populations of steelhead. Low numbers of steelhead were documented in Arroyo Calero in 1980s; however, these fish may have been primarily fish moving upstream from Alamitos Creek (Smith 2013).

Although the MRP trigger for temperature (i.e., MWAT exceeding 17°C for two or more weeks) occurred at all nine stations, it is important to keep in mind that some of the highest air temperatures on record occurred during the summer of 2017. Water temperature was not monitored in reaches below the reservoirs. Due to continuous flow during dry season, the steelhead presumably could migrate further upstream to more optimal habitat conditions. In addition, longitudinal connectivity to areas where food is available can allow juvenile steelhead to increase feeding behavior and maintain optimal body weight to survive periods of warmer temperatures (Smith 2013). Thus, flow in the lower reaches is critically important for sustaining steelhead population, as well as other Aquatic Life Uses.

3.4.2 General Water Quality

Summary statistics for general water quality measurements collected at the three sites in Coyote Creek during two sampling events in WY 2017 are listed in Table 3.4. Sample Events 1 and 2 were conducted in June and September, respectively. Sampling locations are mapped in Figure 3.2. Plots for all water quality parameters collected during Event 1 are shown in Figure 3.8 and for Event 2 in Figure 3.9.

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

Parameter	Data Type	205COY235	205COY236	205COY239	205COY235	205COY236	205COY239
		June WY 2017			September WY 2017		
Temperature (°C)	Minimum	18.6	18.5	18.4	19.6	19.3	19.1
	Median	21.9	21.6	21.3	22.0	21.7	21.7
	Mean	21.7	21.4	21.2	21.6	21.4	21.4
	Maximum	23.7	23.3	24.1	23.3	22.8	23.6
	% > 24	0%	0%	0%	0%	0%	0%
Dissolved Oxygen (mg/L)	Minimum	3.1	2.4	1.4	2.6	2.8	5.0
	Median	5.3	4.1	4.0	3.5	3.5	5.8
	Mean	5.6	4.1	4.3	3.6	3.6	5.8
	Maximum	10.4	6.2	7.8	5.4	5.0	6.9
	% < 7	81%	100%	95%	100%	100%	100%
pH	Minimum	7.66	7.53	7.63	7.62	7.59	7.54
	Median	7.74	7.60	7.78	7.67	7.65	7.64
	Mean	7.74	7.61	7.76	7.67	7.65	7.67
	Maximum	7.87	7.79	7.88	7.74	7.70	7.88
	% < 6.5 or > 8.5	0%	0%	0%	0%	0%	0%
Specific Conductance (µ S/cm)	Minimum	943	949	883	843	833	786
	Median	1154	1174	1140	922	915	859
	Mean	1156	1183	1144	914	906	846
	Maximum	1427	1489	1416	945	936	886
	% > 2000	0%	0%	0%	0%	0%	0%
Total number of data points (N)		1435	1434	1436	955	953	952

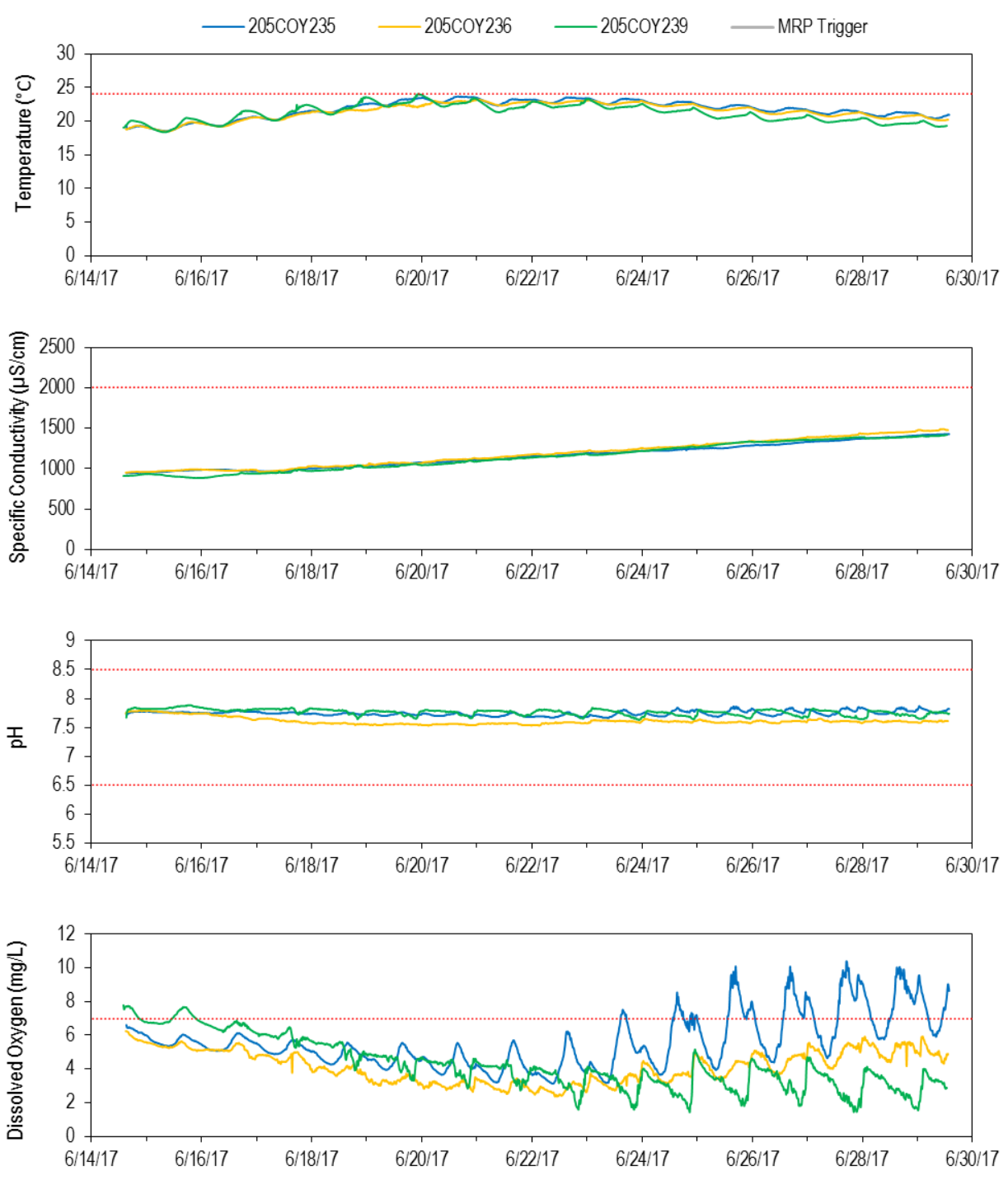

Figure 3.8 Continuous water quality data (temperature, specific conductance, pH, and dissolved oxygen) collected at three sites in Coyote Creek in June 2017.

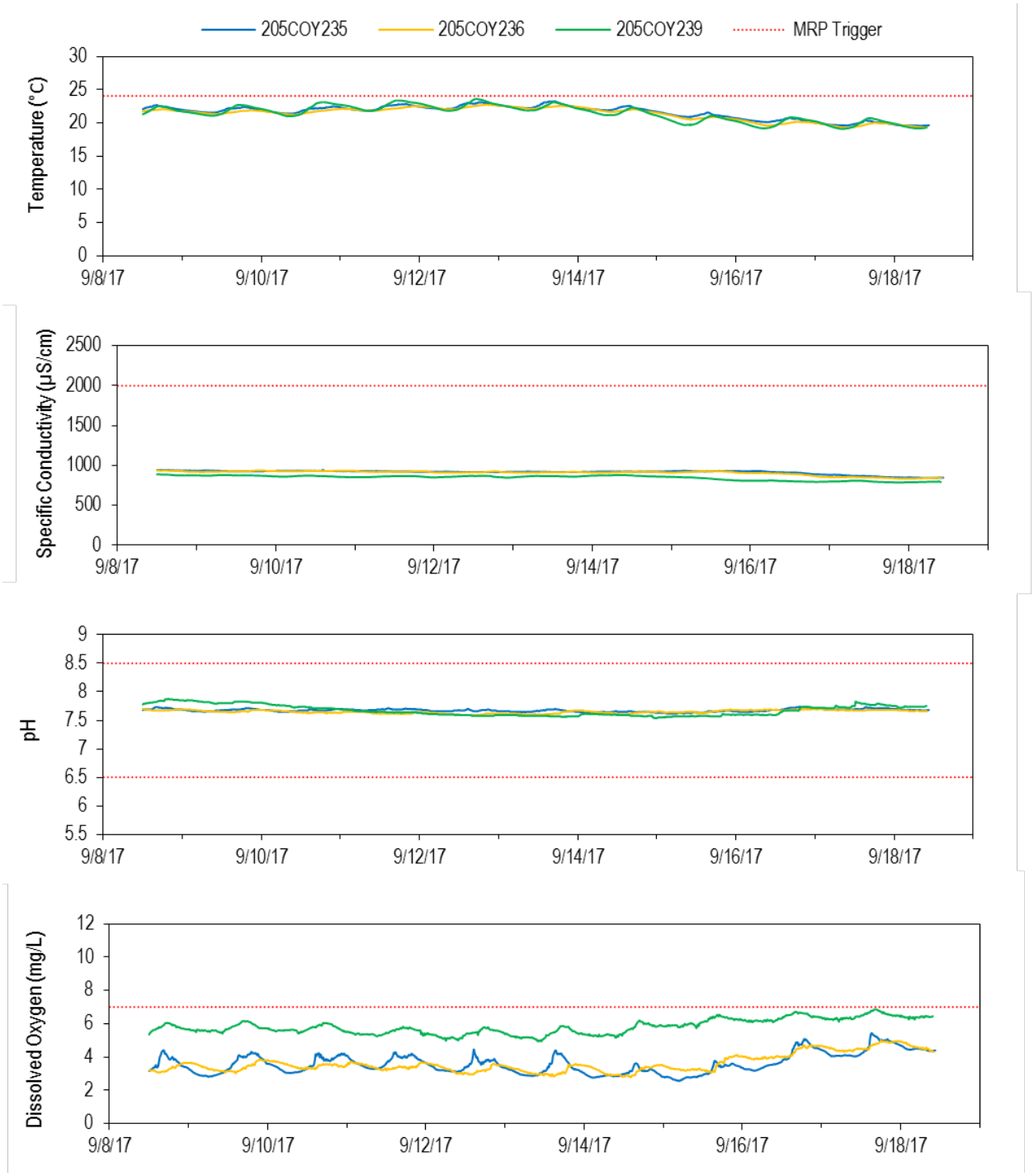

Figure 3.9 Continuous water quality data (temperature, specific conductance, pH, and dissolved oxygen) collected at three sites in Coyote Creek in September 2017.

Temperature

The water temperature data show a similar pattern for all three sites during both events. During the June sampling event (Event 1), water temperatures steadily increased during the first week of deployment and gradually declined during the following week (Figure 3.8). During Event 1 deployment, air temperatures exceeded 90°C for several of the days, with the highest temperature of 103°C recorded at San Jose airport on June 18, 2017. In general, water temperatures showed little variability between sites during each event.

Water temperature never exceeded 24°C, so the MRP trigger for maximum temperature was never exceeded at any of the sites for either sampling event (Table 3.4). MWAT was calculated for both two-week events (Table 3.5). The MWAT threshold (17 °C) was exceeded at all three stations during both weeks of both events.

Table 3.5. MWAT values for water temperature data collected at three stations monitored in Coyote Creek, WY 2017.

Station		205COY235	205COY236	205COY239
Month	Week	Maximum Weekly Average Temperature		
June	Week 1	20.98	20.73	21.17
	Week 2	22.45	22.15	21.41
September	Week 1	22.27	22.00	22.18
	Week 2 (4 Days)	20.28	20.03	19.94

pH

The pH data was generally consistent between sites (ranging between 7.5 and 8.0) for both sampling events. The pH at all three sonde locations remained above the WQO minimum of 6.5 and below the maximum of 8.5 for both events.

Specific Conductance

The specific conductance data followed a similar pattern at all three sites during both events. During the June sampling event, specific conductance steadily increased from 900 to 1400 µS /cm at all three sites. This increase may have been associated with increased air and water temperatures causing a concentration in dissolved solids due to evaporation and/or a greater influence of higher conductivity groundwater in the creek. During Event 2, specific conductance remained relatively steady around 900 µS/cm at all three sites. The specific conductance never exceeded the MRP trigger threshold (2000 µS/cm) at the three sonde locations for either event.

Dissolved Oxygen

The dissolved oxygen concentrations decreased across all the sites during first week of the June sampling event. The decrease is likely associated with the increase in water temperatures that occurred during the same period. During the second week of the June deployment, several patterns emerged. Dissolved oxygen levels dramatically increased at site 205COY235 in Watson Park. Following the heat wave on June 18th, the diurnal pattern at the Watson Park site starts to get more pronounced, exhibiting a small peak occurring a few hours after the large peak. The smaller peak may be associated with thermal stratification, followed by mixing of water layers when temperatures begin to drop. A similar diurnal pattern is observed at site 205COY239 (Williams Park), however dissolved oxygen levels are much lower compared to the site at Watson Park. The diurnal pattern is barely noticeable at site 205COY236 (Julian).

The dissolved oxygen data for the September sampling event show a consistent pattern for all three sites, with lower DO levels occurring at the Watson and Julian sites, and higher DO levels at the Williams site.

The diurnal pattern is less pronounced at the sites compared to the June sampling event. The Williams site shows the least amount of daily variation in DO levels compared to the other sites, which is consistent with pattern observed during the June event.

Dissolved oxygen data collected during the September 2017 sampling event was compared to data collected at the same sites during the same time period in September 2013. The dissolved oxygen data from 2013 was collected as part of the Coyote Creek Dissolved Oxygen Stressor Source Identification Project (Coyote Creek SSID). Distribution of the data from both years, presented as box plots, are shown in Figure 3.10. The mean DO levels at all three sites were about 1.0 mg/L higher in 2017 compared to 2013. One hypothesis for the observed increase in DO levels in 2017 may be associated with high stream flows that occurred in Coyote Creek during winter season 2016-2017. These high flows may have caused an overall reduction in the amount of organic material and sediment at the sites. One of the conclusions of the Coyote Creek SSID project was that accumulated organic material and sediment coupled with slow velocity and low gradient of the channel are likely important factors in the low DO concentrations and the low potential for re-aeriation of the water column.

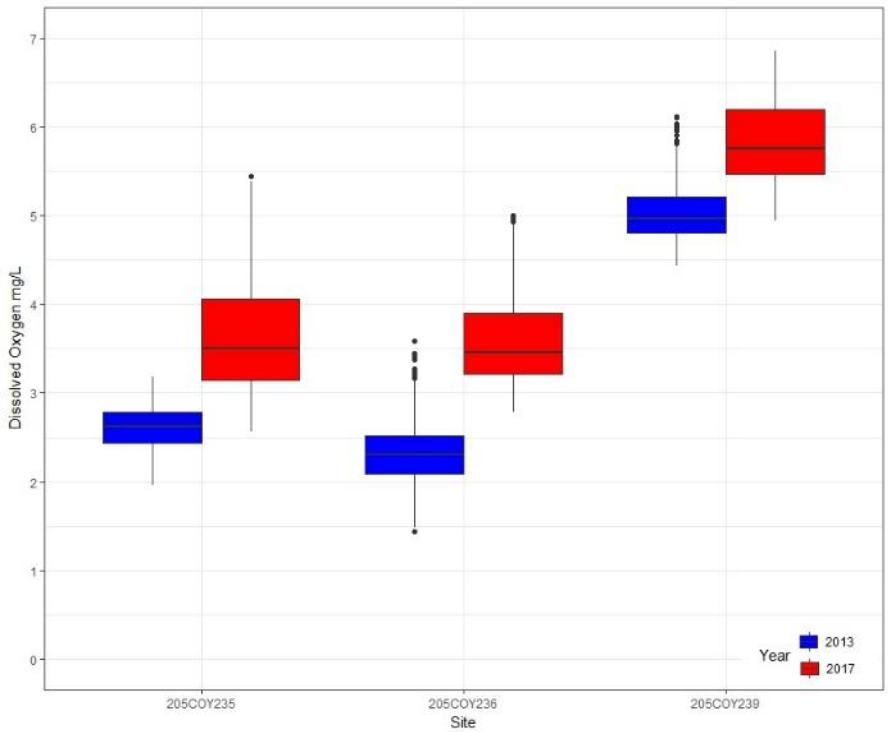

Figure 3.10 Comparison of dissolved oxygen data collected in September 2017 for the Creek Status Monitoring Project (WY 2017) with data collected in September 2013 for the Coyote Creek SSID Project.

The dissolved oxygen concentrations were below 7.0 mg\L (MRP trigger for cold water fishery stream) at all three sites (Table 3.4). These data results should be interpreted cautiously. Although Coyote Creek is designated as COLD Habitat, Aquatic Life Uses associated with cold water fishery, with the exception of migration, are generally not supported in the reach where water quality sampling was conducted. The sampling reach of Coyote Creek mainstem may support WARM water fishery; however, existing habitat and water quality conditions currently do not support a cold water fishery.

The MRP trigger summary for the continuous water quality data is shown in table 3.6. All three sites exceeded triggers for MWAT and dissolved oxygen and will therefore we included in the trigger exceedance table; however, decisions to initiate SSID studies will consider the discussions above.

Table 3.6. Exceedances of MRP triggers at three sites in Coyote Creek, Santa Clara County, WY 2017.

Data Type	MRP Trigger	205COY235	205COY236	205COY239	205COY235	205COY236	205COY239
		June WY 2017			September WY 2017		
Instantaneous Temperature	> 20% results are > 24°C	No	No	No	No	No	No
MWAT	2 Weeks > 17°C	Yes	Yes	Yes	Yes	Yes	Yes
Instantaneous Dissolved Oxygen	> 20% results are < 7 mg/L	Yes	Yes	Yes	Yes	Yes	Yes

3.4.3 Pathogen Indicators

Pathogen indicator (*E. coli* and enterococci) densities measured in water samples collected on July 27, 2017 are listed in Table 3.7. Stations are mapped in Figure 3.3.

Table 3.7. Enterococcus and *E. coli* levels measured in Santa Clara County during WY 2017.

Site ID	Creek Name	Site Name	*Enterococcus (cfu/100ml) (MPN/100ml)*[1]	*E. Coli (cfu/100ml) (MPN/100ml)*[1]	Sample Date
MRP Trigger Threshold (USEPA 2012b)			*130*	*410*	
205GUA225	Arroyo Calero	Singer Park	1986	687	7/27/2017
205SAR075	Saratoga Creek	Wildwood Park	218	517	7/27/2017
205LGA400	Los Gatos Creek	Vasona Park	29	55	7/27/2017
205STE064	Stevens Creek	Blackberry Farm	345	70	7/27/2017
205MAT030	Matadero Creek	Bol Park	816	248	7/27/2017

[1] USEPA 2012b 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.

All five creeks monitored for pathogen indicators are designated for both contact (REC-1) and non-contact (REC-2) recreation Beneficial Uses.[18] Although none of the stations could be considered "bathing beaches," monitoring locations at each creek were selected at city parks or trails that were considered to exhibit high potential for public access. The MRP threshold for *E. coli* was exceeded at two sites. The MRP threshold for enterococcus was exceeded at four sites. These will be added to the list of candidate SSID projects.

[18] The REC2 Beneficial Use for Los Gatos Creek is designated as Potential, whereas the four other creeks have Existing REC1 and REC2 Beneficial Uses.

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 nine sites in the Guadalupe River Watershed from April through September. Continuous (15-minute) general water quality measurements (pH, DO, specific conductance, temperature) were recorded at three sites in the Coyote Creek watershed during two 2-week periods in June (Event 1) and September (Event 2). Pathogen indicator grab samples were collected during a sampling event in July at five sites throughout Santa Clara County that coincide with public parks. 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 in Water Quality

- **Spatial**. Water temperatures measured in three tributaries to Guadalupe River generally increased within decreasing site elevation due their distance from upstream reservoirs, which are the source of cooler water. General water quality parameters measured at three stations in Coyote Creek were similar across the stations with the exception of dissolved oxygen which displayed different patterns at the sites. The findings were consistent with the Coyote Creek Dissolved Oxygen SSID Project which concluded that low channel gradients and high amounts of accumulated organic material in the studied reach cause low DO concentrations.
- **Temporal**. Temperatures became elevated at all nine sites in the Guadalupe River watershed from June to August 2017 and started to decline towards the end of September. In Coyote Creek, decreases in dissolved oxygen concentrations occurred following a period of hot weather during week of June 18, 2017. Following the heat wave, the DO levels increased, with pronounced diurnal variability observed at all three sites.

Potential Impacts to Aquatic Life

- Potential impacts to aquatic life were assessed through analysis of continuous temperature data collected at nine targeted stations in the Guadalupe River watershed from April through September and analysis of continuous general water quality data (pH, dissolved oxygen, specific conductance, and temperature) collected at three targeted stations in Coyote Creek during two two-week periods (June and September).
- All nine temperature stations in the Guadalupe River Watershed exceeded the MRP trigger threshold of having two or more weeks where the Maximum Weekly Average Temperature exceeded 17°C. None of the stations exceeded the maximum instantaneous trigger threshold of 24°C for more than 1% of total recorded samples.
    - All stations with MWAT trigger exceedances will be added to the list of candidate SSID projects; however, review of the monitoring data in the context of locally-derived temperature thresholds developed by NMFS (NMFS 2016) suggests that temperature may not be a limiting factor for salmonid habitat (i.e., summer rearing juveniles) in the study reaches, as long as sufficient dam releases maintain longitudinal connectivity and

provide cooler water temperatures and potential refugia for juvenile steelhead during the summer.

- Sites on Coyote Creek had no exceedances of the maximum temperature trigger threshold of 24°C but did exceed the MWAT trigger of 17.0 °C for two consecutive weeks during both events and will therefore be added to the list of candidate SSID projects.
- The WQO for DO in waters designated as having cold freshwater habitat (COLD) Beneficial Uses (i.e., 7.0 mg/L) was not met in over 20% of the measurements recorded at all three water quality stations in Coyote Creek. The results were similar to the findings from the WY 2013 SSID study carried out at the same locations. The Coyote Creek DO SSID Study concluded that low DO concentrations are caused by low gradient channels with high amounts of accumulated organic matter. Furthermore, this reach Coyote Creek currently supports habitat and water quality that may be suitable for a warm water fishery and not for cold water fishery.
- Values for pH and specific conductance measured at the three sites in Coyote Creek during WY 2017 did not exceed their respective triggers during either event.

Potential Impacts to Water Contact Recreation

- Pathogen indicator densities were measured at five targeted sites during WY 2017. Although none of the stations could be considered “bathing beaches,” monitoring locations were selected at city parks or trails that were considered to have a relatively high potential for public access. The MRP trigger threshold for *E. coli* (410 cfu/100 ml) was exceeded at two sites: Arroyo Calero at Singer Park and Saratoga Creek at Wildwood Park. The MRP trigger threshold for enterococcus (130 cfu/100 ml) was exceeded at four sites: Arroyo Calero at Singer Park, Saratoga Creek at Wildwood Park, Stevens Creek at Blackberry Farm, and Matadero Creek at Bol Park. These sites will be added to the list of candidate SSID projects.
- 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. Pathogen indicators observed at the WY 2017 stations may not be associated with human sources and therefore may not pose a threat to human health. As a result, the comparison of pathogen indicator results to water quality objectives and criteria for full body contact recreation may not be appropriate and should be interpreted cautiously.
- The State Water Resources Control 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 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 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.[19]

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

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 MS4s and/or urban creeks from residential activities, such as pool dewatering or over-watering landscaping, or from municipal activities, such as hydrant flushing or water main breaks.

In compliance with provision C.8.d.ii of the MRP and to assess whether the chlorine in receiving waters is potentially toxic to the aquatic life living there, SCVURPPP field staff measured free chlorine and total 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 the chlorine that has reacted with ammonia or organic nitrogen to form chloramines, while free chlorine is the chlorine that remains unbound.

4.2 Methods

In accordance with the BASMAA RMC Creek Status and Long-Term Trends Monitoring Plan (BASMAA 2012), WY 2017 field testing for free chlorine and total chlorine residual was conducted at all 20 probabilistic sites (and two SSID sites: 205COY114 and 205COY121) 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 (BASMAAS 2016b), water samples were collected and analyzed for free and total chlorine using a Pocket Colorimeter™ II and DPD Powder Pillows, which has a method detection limit of 0.02 mg/L. If concentrations exceed the trigger criteria of 0.1 mg/L, the site was immediately resampled. Per provision C.8.d.ii(4) of the MRP, “if the resample is still greater than 0.1 mg/L, then Permittees report the observation to the appropriate Permittee central contact point for illicit discharges to that the illicit discharge staff can investigate and abate the associated discharge in accordance with its provision C.5.e – Spill and Dumping Complaint Response Program.”

4.3 Results

In WY 2017, SCVURPPP monitored the 20 probabilistic sties and 2 SSID sites for free chlorine and total chlorine residual. These measurements were compared to the MRP trigger threshold of 0.1 mg/L.[20] Results are listed in Table 4.1.

The trigger thresholds for free chlorine and total chlorine residual were exceeded at one of the stations on Lower Penitencia Creek (205R02947) on May 11, 2017. In compliance with Provision C.8.d.ii(4), SCVURPPP staff immediately informed City of Milpitas illicit discharge staff of the exceedances. City staff reported that follow-up measurements were at or below the MRP trigger and determined that either the source of the higher readings had stopped, or that the original results were in error.

[20] For reference, 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 residual chlorine.

Table 4.1. Summary of SCVURPPP 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 Threshold? [3] (0.1 mg/L)
205R00570	5/17/2017	Trib to Aldercroft Cr	0.04	< 0.02	No
205R00609	5/17/2017	Hunting Hollow	0.04	0.04	No
205R00645	5/16/2017	Packwood Creek	0.02	< 0.02	No
205R02693	5/10/2017	Packwood Creek	0.03	0.03	No
205R02755	5/15/2017	Berryessa Creek	< 0.02	0.04	No
205R02787	5/15/2017	Matadero Creek	0.02	0.03	No
205R02915	5/8/2017	Stevens Creek	0.05	0.06	No
205R02947	6/1/2017	Lower Penitencia	0.16 / 0.16	0.2 / 0.2	Yes
205R03011	6/5/2017	Berryessa Creek	0.02	0.04	No
205R03091	5/11/2017	Arroyo Aguague	< 0.02	0.03	No
205R03098	5/8/2017	Guadalupe Creek	0.02	0.02	No
205R03235	5/18/2017	Stevens Creek	0.04	0.04	No
205R03306	6/6/2017	Saratoga Creek	0.04	0.03	No
205R03331	6/5/2017	Los Gatos Creek	0.04	0.03	No
205R03354	5/9/2017	Guadalupe Creek	0.08	0.02	No
205R03386	6/7/2017	Aldercroft Creek	0.03	0.03	No
205R03418	6/6/2017	Alamitos Creek	< 0.02	< 0.02	No
205R03443	5/16/2017	Calabazas Creek	0.06	0.08	No
205R03523	6/8/2017	Upper Penitencia Creek	0.04	0.03	No
205R03530	6/1/2017	Los Gatos Creek	0.03	0.03	No

[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.q 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 Santa Clara Valley 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. The Program will continue to monitor chlorine in compliance with the MRP and will follow-up with illicit discharge staff as needed.

5.0 TOXICITY AND SEDIMENT CHEMISTRY MONITORING

5.1 Introduction

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

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

Dry Weather

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

- Toxicity testing in water is required using five species: *Ceriodaphnia* dubia (chronic survival and reproduction), *Pimephales promelas* (larval survival and growth), *Selenastrum capricornutum* (growth), *Hyalella azteca* (survival) and *Chironomus dilutus* (survival).
- Toxicity testing in sediment is required using two species: *Hyella azteca* (survival) and *Chironomus dilutus* (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 two sites during dry weather: Stevens Creek and San Tomas Aquino Creek (see Figure 1.2). Sites were selected to represent urban watersheds that are not already being monitored for toxicity or pesticides by other programs, such as the SWAMP Stream Pollution

Trends (SPoT) program or the California Department of Pesticide Regulation (DPR) Surface Water Protection Program Monitoring (SWPP). Specific stations within the watersheds were identified based on the likelihood that they would contain fine depositional sediments during dry season sampling and would be safe to access during future wet weather sampling. SCVURPPP sampled these two stations in WY 2016 and it is anticipated that SCVURPPP will continue to sample the same two stations throughout the permit term with the goal of building a long-term dataset that complements data being gathered through SWAMP SPoT and DPR SWPP.

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 filling in non-detect data.

The TECs for bedded sediments are very conservative values that do not consider site specific background conditions, and are therefore not very useful in identifying real water quality concerns in receiving waters in the Santa Clara Valley. All sites in Santa Clara 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, SCVURPPP 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 the sites to the list of potential SSID projects.

- **San Tomas Aquino Creek (205STQ010).** The water sample collected from San Tomas Aquino Creek was found to be significantly toxic to *C. dubia* (reproduction); however, the Percent Effect did not exceed the 50% threshold for follow-up. The sediment sample was not significantly toxic to either of the two test organisms.
- **Stevens Creek (205STE021).** The sediment sample collected from Stevens Creek in July 2017 was not significantly toxic to any of the test organisms; however, the water sample was found to be significantly toxic to *C. dubia* (reproduction). The Percent Effect was greater than 50%; therefore, a second sample was collected in August 2017 and tested for *C. dubia* toxicity. The August 2017 water sample was not significantly toxic.

The cause of the water and water toxicity in San Tomas Aquino Creek and the sediment toxicity in Stevens Creek is unknown.

[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 fipronil or carbaryl in sediment.

Table 5.1. Summary of SCVURPPP toxicity results for WY 2017.

Site	Organism	Test Type	Unit	Results		TST Result	% Effect	Follow up needed (TST "Fail" and **≥50%)**
				Lab Control	Organism Test			
205STQ010 San Tomas Aquino Creek	Water							
	Ceriodaphnia dubia	Survival	%	100	90	NA [1]	10%	No
		Reproduction	Num/Rep	30.2	21.2	Fail	29.7%	No
	Pimephales promelas	Survival	%	97.5	92.5	Pass	5.1%	No
		Growth	mg/ind	0.548	0.557	Pass	-1.69%	No
	Chironomus dilutus	Survival	%	95	85	Pass	11%	No
	Hyalella azteca	Survival	%	98	100	Pass	-2.04%	No
	Selenastrum capricornutum	Growth	cells/ml	3000000	4610000	Pass	-53.3%	No
	Sediment							
	Chironomus dilutus	Survival	%	96.2	96.2	Pass	0.00%	No
	Hyalella azteca	Survival	%	97.5	98.8	Pass	-1.28%	No
205STE021 Stevens Creek	Water							
	Ceriodaphnia dubia	Survival	%	100	100	NA [1]	0%	No
		Reproduction	Num/Rep	30.2	6	Fail	80.1%	Yes
	Ceriodaphnia dubia (followup sample Aug 2017)	Survival	%	100	100	NA [1]	0%	No
		Reproduction	Num/Rep	26.3	15.5	Pass	41.1%	No
	Pimephales promelas	Survival	%	97.5	95	Pass	2.56%	No
		Growth	mg/ind	0.548	0.674	Pass	-23.0%	No
	Chironomus dilutus	Survival	%	95	87.5	Pass	7.89%	No
	Hyalella azteca	Survival	%	98	96	Pass	2.04%	No
	Selenastrum capricornutum	Growth	cells/ml	3000000	4960000	Pass	-65.1%	No
	Sediment							
	Chironomus dilutus	Survival	%	96.2	95	Pass	1.30%	No
	Hyalella azteca	Survival	%	97.5	100	Pass	-2.56%	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. SCVURPPP 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. Both sites 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. There were TEC exceedances of nickel in both creeks and of chromium in Stevens Creek as expected in watersheds draining hillsides underlain by serpentinite formations. In Stevens Creek (205STE021), the TEC for total PAHs was also exceeded.

Table 5.3 provides PEC quotients for sediment chemistry constituents (metals and total PAHs) and calculated mean values of the PEC quotients for each site. PECs are intended to identify concentrations above which toxicity to benthic-dwelling organisms are predicted to be probable. The PEC quotient for nickel was greater than 1.0 in both creeks.

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 at each site, 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 are J-flagged, meaning that the measured concentration was above the MDL but below the reporting limit. No TU equivalents exceeded 1.0. The highest TU equivalents in both samples were for bifenthrin and cypermethrin. Bifenthrin is considered to be the leading cause of pyrethroid-related toxicity in urban areas (Ruby 2013).

In compliance with the MRP, a grain size analysis was conducted on both of the sediment samples (Table 5.5). The Stevens Creek (205STE021) sample was 14% fines (i.e., 6.1% clay and 7.7% silt); whereas the San Tomas Aquino Creek (205STQ010) sample was 4.7% fines (i.e., 2.6% clay and 2.1% silt). It unknown whether these differences in percent fines influenced the toxicity tests or sediment chemistry analysis and evaluation.

[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.

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

	TEC	205STE021 Stevens Creek		205STQ010 San Tomas Aquino Creek	
		Concentration	Quotient	Concentration	Quotient
Metals (mg/kg DW)					
Arsenic	9.79	3.3	0.34	3.3	0.34
Cadmium	0.99	0.2	0.20	0.07	0.071
Chromium	43.4	68	1.6	41	0.94
Copper	31.6	30	0.95	27	0.85
Lead	35.8	10	0.28	5.7	0.16
Nickel	22.7	64	3	53	2.33
Zinc	121	78	0.64	62	0.51
PAHs (ug/kg DW)					
Total PAHs	1,610	4478.2 [a]	2.78	38.9 [a]	0.024
# Constituents with TEC quotient >= 1.0		3		1	

[a] Total 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.

	PEC	205STE021 Stevens Creek		205STQ010 San Tomas Aquino Creek	
Metals (mg/kg DW)		Concentration	Quotient	Concentration	Quotient
Arsenic	33	3.3	0.10	3.3	0.10
Cadmium	4.98	0.2	0.04	0.07	0.014
Chromium	111	68	0.6	41	0.37
Copper	149	30	0.20	27	0.18
Lead	128	10	0.08	5.7	0.04
Nickel	48.6	64	1.3	53	1.09
Zinc	459	78	0.17	62	0.14
PAHs (ug/kg DW)					
Total PAHs	22,800	4478.2 [a]	0.20	38.9 [a]	0.002
# Constituents with PEC quotient >= 1.0		1		1	

[a] Total calculated using ½ MDLs.

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

			205STE021 Stevens Creek			205STQ010 San Tomas Aquino Creek		
	Unit	LC50 [d]	Concentration	Normalized to TOC	TU Equivalent	Concentration	Normalized to TOC	TU Equivalent
Total Organic Carbon	%		1.8			0.48		
Pyrethroids								
Bifenthrin	µg/g dw	0.52	0.00063	0.035	0.067	0.00018 [b]	0.038	0.072
Cyfluthrin	µg/g dw	1.08	0.00006 [a]	0.003	0.0031	0.00006 [a]	0.013	0.012
Cypermethrin	µg/g dw	0.38	0.00015 [b]	0.008	0.022	0.00015 [a]	0.031	0.082
Deltamethrin	µg/g dw	0.79	0.00007 [a]	0.004	0.0046	0.00007 [a]	0.014	0.017
Esfenvalerate	µg/g dw	1.54	0.00007 [a]	0.004	0.0025	0.00007 [a]	0.015	0.009
Lambda-Cyhalothrin	µg/g dw	0.45	0.00003 [a]	0.002	0.0040	0.00003 [a]	0.007	0.015
Permethrin	µg/g dw	10.83	0.00045	0.025	0.0023	0.00045 [a]	0.094	0.009
Other Pesticides								
Carbaryl	mg/Kg dw	NA [c]	0.011 [a]	NA	NA	0.011 [a]	NA	NA
Fipronil	ng/g dw	NA [c]	0.055 [a]	NA	NA	0.055 [a]	NA	NA
Fipronil Desulfinyl	ng/g dw	NA [c]	0.055 [a]	NA	NA	0.055 [a]	NA	NA
Fipronil Sulfide	ng/g dw	NA [c]	0.055 [a]	NA	NA	0.055 [a]	NA	NA
Fipronil Sulfone	ng/g dw	NA [c]	0.055 [a]	NA	NA	0.055 [a]	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

Table 5.5. Summary of grain size for the two locations sampled in Santa Clara during WY 2017.

Grain Size (%)		205STE021 Stevens Creek	205STQ010 San Tomas Aquino Creek
Clay	<0.0039 mm	6.1%	2.6%
Silt	0.0039 to <0.0625 mm	7.7%	2.1%
Sand	V. Fine 0.0625 to <0.125 mm	8.6%	1.1%
	Fine 0.125 to <0.25 mm	28%	2.6%
	Medium 0.25 to <0.5 mm	30%	19%
	Coarse 0.5 to <1.0 mm	13%	25%
	V. Coarse 1.0 to <2.0 mm	6.4%	48%
Granule	2.0 to <4.0 mm	2.0%	30%
Pebble	Small 4 to <8 mm	1.7%	19%
	Medium 8 to <16 mm	0%	0%
	Large 16 to <32 mm	0%	0%
	V. Large 32 to <64 mm	0%	0%

5.4 Conclusions and Recommendations

Statistically significant toxicity to *C. dubia* (reproduction) was observed in water samples collected from both sites in July 2017. The magnitude of the toxic effects in the San Tomas Aquino Creek sample was not great and did not exceed MRP trigger criteria. However, the magnitude of the toxic effects in the Stevens Creek sample did exceed the MRP threshold for re-sampling. Statistically significant toxicity to *C. dubia* was not observed in the second sample collected from Stevens Creek in August 2017. The cause of the toxicity observations is unknown. Pesticide concentrations in the sediment samples were all very low, most below MDLs and calculated TU equivalents did not exceed 0.09 in either sample.

TEC and PEC quotients were calculated for all metals and total PAHs measured in sediment samples. Both sites had at least one TEC or PEC quotient exceeding 1.0. In compliance with the MRP, both stations 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 most of the TEC and PEC quotient exceedances are related to naturally occurring chromium and nickel due to serpentine soils in the 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), SCVURPPP 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 Santa Clara 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 twenty 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. Seventeen of the sites were classified as urban and three 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 Santa Clara Valley streams is uncertain. This is due to several factors including:

- There is an overall dearth of soft algae taxa found in Santa Clara Valley streams. This may not reflect stream health, but it can significantly lower 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 20 sites monitored in WY 2017, nine sites (45%) were rated in good condition (CSCI scores ≥ 0.795); four sites (20%) rated as likely altered condition (CSCI score 0.635 – 0.795), and seven sites (35%) rated as very likely altered condition (≤ 0.635). The three sites with the lowest CSCI scores had a high proportion of impervious watershed area (> 30%) and were characterized as modified 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=0.30, p value = 0.012) 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 slightly 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 eleven 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 205R03011 (Berryessa Creek) and site 205R03443 (Calabazas Creek). The acute temperature threshold trigger (24°C) for salmonid fish was also exceeded at site 205R03443 (Calabazas Creek). 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, except for unionized ammonia (.025 mg/L) at site 205R03011 (Berryessa Creek), and site 205R03011 (Calabazas Creek). Both sites are at the bottom of highly urbanized watersheds and will be considered as candidates for SSID projects.

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 nine sites in the Guadalupe River Watershed from April through September. Continuous (15-minute) general water quality measurements (pH, DO, specific

conductance, temperature) were recorded at three sites in the Coyote Creek watershed during two 2-week periods in June (Event 1) and September (Event 2). Pathogen indicator grab samples were collected during a sampling event in July at five sites throughout Santa Clara County that coincide with public parks.

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

All nine temperature stations in the Guadalupe River Watershed exceeded the MRP trigger threshold of having two or more weeks where the Maximum Weekly Average Temperature exceeded 17°C. None of the stations exceeded the maximum instantaneous trigger threshold of 24°C for more than 1% of total recorded samples. Based on the MWAT exceedances, the sites will be added to the list of candidate SSID projects. However, review of the monitoring data in the context of locally-derived temperature thresholds developed by NMFS (NMFS 2016) suggests that temperature may not be a limiting factor for salmonid habitat (i.e., summer rearing juveniles) in the study reaches, as long as sufficient dam releases maintain longitudinal connectivity and provide cooler water temperatures and potential refugia for juvenile steelhead during the summer.

General Water Quality

- Sites on Coyote Creek had no exceedances of the maximum temperature trigger threshold of 24°C but did exceed the MWAT trigger of 17°C for two consecutive weeks during both events and will therefore be added to the list of candidate SSID projects.
- The WQO for DO in waters designated as having cold freshwater habitat (COLD) Beneficial Uses (i.e., 7.0 mg/L) was not met in over 20% of the measurements recorded at all three water quality stations in Coyote Creek. The results were similar to the findings from the WY 2013 SSID study carried out at the same locations. The Coyote Creek DO SSID Study concluded that low DO concentrations are caused by low gradient channels with high amounts of accumulated organic matter. Furthermore, this reach Coyote Creek currently supports habitat and water quality that may be suitable for a warm water fishery and not for cold water fishery.
- Values for pH and specific conductance measured at the three sites in Coyote Creek during WY 2017 did not exceed their respective triggers during either event.

Pathogen Indicators

- Pathogen indicator densities were measured at five targeted sites during WY 2017. Although none of the stations could be considered “bathing beaches,” monitoring locations were selected at city parks or trails that were considered to have a relatively high potential for public access. The MRP trigger threshold for *E. coli* (410 cfu/100 ml) was exceeded at two sites: Arroyo Calero at Singer Park and Saratoga Creek at Wildwood Park. The MRP trigger threshold for enterococcus (130 cfu/100 ml) was exceeded at four sites: Arroyo Calero at Singer Park, Saratoga Creek at Wildwood Park, Stevens Creek at Blackberry Farm, and Matadero Creek at BOL Park. These sites will be added to the list of candidate SSID projects.
- 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. Pathogen indicators observed at the WY 2017 stations may not be associated with human sources and therefore may not pose a threat to human health. As a result, the comparison of pathogen indicator results to water quality

objectives and criteria for full body contact recreation may not be appropriate and should be interpreted cautiously.

- The State Water Resources Control 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 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 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.[24]

6.1.3 Chlorine Monitoring

Free chlorine and total chlorine residual were measured concurrently with bioassessments at the twenty probabilistic sites (and two additional SSID sites) in compliance with provision C.8.c.ii. While chlorine residual is generally not a concern in Santa Clara Valley urban 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 (Arroyo Aguague). City of Milpitas illicit discharge staff were notified of the exceedance but did not observe exceedances during followup monitoring. The exceedance was likely the result of a one-time potable water discharge and it is generally very difficult to determine the source of elevated chlorine from such episodic discharges. The Program will continue to monitor chlorine in compliance with the MRP and will follow-up with illicit discharge staff as needed.

6.1.4 Pesticides and Toxicity Monitoring

In WY 2017, SCVURPPP conducted dry weather pesticides and toxicity monitoring at two stations (Stevens Creek and San Tomas Aquino Creek) in compliance with provision C.8.g of the MRP.

Statistically significant toxicity to *C. dubia* (reproduction) was observed in water samples collected from both sites in July 2017. The magnitude of the toxic effects in the San Tomas Aquino Creek sample was not great and did not exceed MRP trigger criteria. However, the magnitude of the toxic effects in the Stevens Creek sample did exceed the MRP threshold for re-sampling (i.e., 50 Percent Effect). Statistically significant toxicity to *C. dubia* was not observed in the second sample collected from Stevens Creek in August 2017. The cause of the toxicity observations is unknown. Pesticide concentrations in the sediment samples were all very low, most below MDLs and calculated TU equivalents did not exceed 0.09 in either sample.

TEC and PEC quotients were calculated for all metals and total PAHs (calculated as the sum of 24 individual PAHs) measured in sediment samples. Both sites had at least one TEC or PEC quotient exceeding 1.0. In compliance with the MRP, both stations 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 most of the TEC and PEC quotient exceedances are related to naturally occurring chromium and nickel.

SCVURPPP will continue to sample the same two stations for dry weather pesticides and toxicity throughout the permit term. In WY 2018, SCVURPPP 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

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

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. 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 will be selected from this list. Table 6.1 lists 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 SCVURPPP 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 ID	Creek	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]
205R00570	Trib to Aldercroft Cr	No	No	No	--	--	--	--	--	--	--	--
205R00609	Hunting Hollow	Yes	No	No	--	--	--	--	--	--	--	--
205R00645	Packwood Creek	Yes	No	No	--	--	--	--	--	--	--	--
205R02693	Packwood Creek	Yes	No	No	--	--	--	--	--	--	--	--
205R02755	Berryessa Creek	Yes	No	No	--	--	--	--	--	--	--	--
205R02787	Matadero Creek	Yes	No	No	--	--	--	--	--	--	--	--
205R02915	Stevens Creek	Yes	No	No	--	--	--	--	--	--	--	--
205R02947	Lower Penitencia	Yes	No	Yes	--	--	--	--	--	--	--	--
205R03011	Berryessa Creek	No	Yes	No	--	--	--	--	--	--	--	--
205R03091	Arroyo Aguague	No	No	No	--	--	--	--	--	--	--	--
205R03098	Guadalupe Creek	Yes	No	No	--	--	--	--	--	--	--	--
205R03235	Stevens Creek	No	No	No	--	--	--	--	--	--	--	--
205R03306	Saratoga Creek	No	No	No	--	--	--	--	--	--	--	--
205R03331	Los Gatos Creek	Yes	No	No	--	--	--	--	--	--	--	--
205R03354	Guadalupe Creek	No	No	No	--	--	--	--	--	--	--	--
205R03386	Aldercroft Creek	No	No	No	--	--	--	--	--	--	--	--
205R03418	Alamitos Creek	Yes	No	No	--	--	--	--	--	--	--	--
205R03443	Calabazas Creek	Yes	Yes	No	--	--	--	--	--	--	--	--
205R03523	Upper Penitencia Creek	No	No	No	--	--	--	--	--	--	--	--
205R03530	Los Gatos Creek	Yes	No	No	--	--	--	--	--	--	--	--
205LGA400	Los Gatos Creek	--	--	--	--	--	--	--	--	--	--	No
205MAT030	Matadero Creek	--	--	--	--	--	--	--	--	--	--	Yes
205STE064	Stevens Creek	--	--	--	--	--	--	--	--	--	--	Yes
205GUA225	Arroyo Calero	--	--	--	--	--	--	--	--	--	--	Yes
205SAR075	Saratoga Creek	--	--	--	--	--	--	--	--	--	--	Yes
205GUA210	Guadalupe Creek	--	--	--	--	--	--	Yes	--	--	--	--
205GUA202	Guadalupe Creek	--	--	--	--	--	--	Yes	--	--	--	--
205GUA190	Guadalupe Creek	--	--	--	--	--	--	Yes	--	--	--	--
205GUA270	Alamitos Creek	--	--	--	--	--	--	Yes	--	--	--	--
205GUA340	Arroyo Calero	--	--	--	--	--	--	Yes	--	--	--	--
205GUA225	Arroyo Calero	--	--	--	--	--	--	Yes	--	--	--	--
205GUA262	Alamitos Creek	--	--	--	--	--	--	Yes	--	--	--	--
205GUA255	Alamitos Creek	--	--	--	--	--	--	Yes	--	--	--	--
205GUA250	Alamitos Creek	--	--	--	--	--	--	Yes	--	--	--	--
205COY235	Coyote Creek	--	--	--	--	--	--	Yes	Yes	No	No	--
205COY236	Coyote Creek	--	--	--	--	--	--	Yes	Yes	No	No	--
205COY239	Coyote Creek	--	--	--	--	--	--	Yes	Yes	No	No	--
205STE021	Stevens Creek	--	--	--	No	No	Yes	--	--	--	--	--
205STQ010	San Tomas Aquino	--	--	--	No	No	Yes	--	--	--	--	--

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

6.3 Management Implications

The Program's Creek Status and Pesticides and Toxicity Monitoring programs (consistent with MRP provisions C.8.c and C.8.g, respectively) focus on assessing the water quality condition of urban creeks in the Santa Clara Valley and identifying stressors and sources of impacts observed. The sample size from WY 2017 (overall n=20; urban n=17) 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. Additionally, episodic or site-specific increases in temperature (particularly in lower creek reaches) may not be optimal for aquatic life in local creeks.

The Program and its Co-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, the Program and Co-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 Co-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 trash full 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) Co-permittees continue to implement programs that are designed to prevent non-stormwater discharges during dry weather and reduce the exposure of contaminants to stormwater and sediment in runoff during rainfall events.

- 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 2076 that specifically target mercury and PCBs are described in the Pollutants of Concern Monitoring Data Report that is included as Appendix E 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, the Santa Clara Valley Water District's "One Water Plan" is an ongoing, multi-year process to develop a framework and watershed-specific plans for long-term management of Santa Clara County water resources. The One Water Plan will identify, prioritize and implement activities at a watershed scale to meet flood protection, water supply, water quality and environmental stewardship goals and objectives. The Santa Clara Valley Water District is also using Proposition 1 grant funds to develop a Storm Water Resource Plan for the Santa Clara Basin that will support the development and implementation of MRP-required Green Infrastructure Plans and produce a list of prioritized runoff capture and use projects eligible for future State implementation grant funds. Through the continued implementation of MRP-associated and other watershed stewardship programs, SCVURPPP 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 "gray" infrastructure and disconnect from creeks those 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

SCVURPPP	Santa Clara Valley Urban Pollution Prevention Program
SFRWQCB	San Francisco Regional Water Quality Control Board
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 Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP) 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). SCVURPPP 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 SCVURPPP 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 SCVURPPP 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 Santa Clara Valley urban creeks.

2.2. COMPARABILITY

In addition to the bioassessment and field sampling training, SCVURPPP 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 SCVURPPP 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, SCVURPPP 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 SCVURPPP 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 SCVURPPP staff member reviewed the field sheets again, and noted any missing data.

2.3.3. Laboratory Results

SCVURPPP 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 SCVURPPP, 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 ^{o}C, it is replaced.

2.6. PRECISION

2.6.1. Field Duplicates

For creek status monitoring, duplicate biological samples were collected at 10% (two) of the 20 probabilistic sites and duplicate water chemistry samples were collected at 10% (two) 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:

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

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 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 SCVURPPP 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 Santa Clara Valley Creeks.

3.2. OVERALL PROJECT COMPARABILITY

SCVURPPP 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 SCVURPPP 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

SCVURPPP completed bioassessments and physical habitat assessments for 20 of 20 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 two BMI samples that were submitted to a separate QC taxonomic laboratory had a total of eight specimen misidentifications and two minor counting errors. 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 except for the Taxa ID Error Rate for one of the samples. 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 Santa Clara County in WY 2017 compared to measurement quality objectives.

Quality Control Metric	MQO	Sample 1		Sample 2	
		Error Rate	Exceeds MQO?	Error Rate	Exceeds MQO?
Recount Accuracy	> 95%	99.34%	No	100%	No
Taxa ID	≤ 10%	11.43%	Yes	6.67%	No
Individual ID	≤ 10%	1.81%	No	0.33%	No
Low Taxonomic Resolution Individual	≤ 10%	0%	No	0%	No
Low Taxonomic Resolution Count	≤ 10%	0%	No	0%	No
High Taxonomic Resolution Individual	≤ 10%	0%	No	0%	No
High Taxonomic Resolution Count	≤ 10%	0%	No	0%	No

3.3.4. Precision

Field blind duplicate chlorophyll a and ash free dry mass samples were collected at two sites 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. However, the RPD for the two analytes for the first sample exceeded the MQO, but the RPD for the second duplicate sample did not. 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 205R00609, collected on May 10, 2017 and 205R03418, collected June 8, 2017.

Analyte	Units	205R00609 May 10, 2017				205R03418 June 8, 2017			
		Original Result	Duplicate Result	RPD	Exceeds MQO (>25%)[a]	Original Result	Duplicate Result	RPD	Exceeds MQO (>25%)[a]
Chlorophyll a	mg/m^2	12.0	8.4	35%	Yes	219.2	192.5	13%	No
Ash Free Dry Mass	g/m^2	21.5	44.3	69%	Yes	73.8	84.9	14%	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

3.3.5. 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 20 bioassessment sites, but the oxygen sensor malfunctioned at five sites, and was subsequently replaced with the other multi-parameter instrument. Consequently, oxygen results at those sites were flagged and rejected. The overall completeness rate was 75% for oxygen, but 100% for all other measurements.

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 SCVURPPP 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

SCVURPPP collected 100% of planned/required water chemistry samples at the 20 bioassessment sites including field duplicate samples. The RMC QAPP requires duplicates to be collected at a frequency of 5% of the total project sample count. For 20 sites, SCVURPPP is required to collect one duplicate. In WY 2017, staff collected duplicate water chemistry samples at two sites, exceeding the 5% requirement. 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, three samples were flagged as "detected, not quantified," but they all would have been quantified at the lower reporting limit. Additionally, the nitrate concentrations at three other sites were below the method detection limit. SCVURPPP 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 SCVURPPP 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	1-10
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. Several MS/MSD percent recoveries exceeded the MQO range listed in the RMC QAPP for various conventional analytes, including ammonia, nitrate, nitrite, total Kjeldahl nitrogen (TKN), chloride, and silica. These QA samples affected 12 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 Santa Clara County and were compared against the original samples. The ammonia field duplicate sample collected at site 205R00609 exceeded the RPD MQO and the total Kjeldahl nitrogen duplicate sample collected at site 205R03418 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 and 5. 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 205R00609, collected on May 10, 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	0.058	0.034	52%	Yes
Chloride	None	mg/L	28	28	0%	No
Nitrate as N	None	mg/L	< 0.02	< 0.02	N/A	N/A
Nitrite as N	None	mg/L	< 0.001	< 0.001	N/A	N/A
Nitrogen, Total Kjeldahl	None	mg/L	0.97	0.88	10%	No
Orthophosphate as P	Dissolved	mg/L	0.01	J 0.007	N/A	N/A
Phosphorus as P	Total	mg/L	0.015	J 0.007	N/A	N/A
Silica as SiO2	Total	mg/L	17	17	0%	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

Table 5. Field duplicate water chemistry results for site 205R03418, collected on June 8, 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	0.11	0.12	9%	No
Chloride	None	mg/L	19	19	0%	No
Nitrate as N	None	mg/L	0.088	0.095	8%	No
Nitrite as N	None	mg/L	J 0.002	J 0.002	N/A	N/A
Nitrogen, Total Kjeldahl	None	mg/L	0.57	0.35	48%	Yes
Orthophosphate as P	Dissolved	mg/L	0.022	0.024	9%	No
Phosphorus as P	Total	mg/L	0.088	0.095	8%	No
Silica as SiO2	Total	mg/L	20	20	0%	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 SCVURPPP 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 SCVURPPP staff and were analyzed by Alpha Analytical Laboratories, Inc. Samples were collected July 27, 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 does not require a field duplicate to be collected for pathogen indicators, but it does require 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 were 35.2% for E. coli and 13.6% for enterococcus. These values have no significance without an pathogen indicator MQO for RPD.

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 three sites during the spring (June 2017), concurrent with bioassessments, and again in the summer (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 15 days while the second deployment lasted 10 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

Internal SCVURPPP staff calibrate sondes before deployment and upon retrieval, but the calibration records for the post-deployment calibration could not be found for all three sites during the first event and for the sonde deployed at 205COY239 during the second event. As a result, drift could only be calculated for two sites during the second deployment. A summary of the drift measurements is shown in Table 6. These sondes have been used in other non-SCVURPPP projects, concurrent with SCVURPPP creek status monitoring, and during past years. Rarely were data rejected because of excessive drift, and thus none of the continuous monitoring data were rejected for missing drift calculations. It is assumed the drift during these deployments was within the allowable range. The sonde deployed at 205COY235 during the second event had no drift issues, but the sonde deployed at 205COY236 exceeded the dissolved oxygen measurement quality objective. Oxygen results at this site were subsequently flagged for this deployment.

Table 6. Drift measurements for two continuous water quality monitoring events in Santa Clara Valley 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	205COY235		205COY236		205COY239	
		Event 1	Event 2	Event 1	Event 2	Event 1	Event 2
Dissolved Oxygen (mg/l)	± 0.5 mg/L or 10%	N/A	0.1	N/A	**0.82**	N/A	N/A
pH 7.0	± 0.2	N/A	0.02	N/A	-0.06	N/A	N/A
pH 10.0	± 0.2	N/A	-0.03	N/A	0	N/A	N/A
Specific Conductance (uS/cm)	± 10%	N/A	-0.2%	N/A	-0.4%	N/A	N/A

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 Santa Clara. Onset HOBO Water Temperature Data loggers recorded one measurement per hour.

3.8.1. Completeness

The MRP requires SCVURPPP to monitor eight stream reaches for temperature each year, but in past years one to two loggers have been lost during the deployment. Anticipating a lost HOBO temperature logger, SCVURPPP deployed one extra temperature logger, for a total of nine loggers. In the middle of the deployment, SCVURPPP 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, SCVURPPP 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

Dry season sediment chemistry samples were collected by Kinnetic Laboratories, Inc (KLI) concurrently with dry season toxicity samples 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. All samples were analyzed within the one year holding time for analytes in sediment, set by the RMC SOP. Caltest conducted all QA/QC requirements as specified in the RMC QAPP and reported their findings to the RMC. Key sediment chemistry MQOs are listed in RMC QAPP Tables 26-9 through 26-11. Sediment chemistry data were flagged when necessary, but none were rejected

3.9.1. Completeness

Both planned/required samples were collected and analyzed for all requested analytes, and 100% of results were reported.

3.9.2. Sensitivity

A comparison of target and actual reporting limits for those parameters is shown in Table 7. Note that reporting limits for a particular analyte may vary within the same batch due a difference in percent solids for each sample. Similarly, reporting limits may exceed target reporting limits due to the percent solids of a particular sample. 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.

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

Analyte	Target RL mg/kg	Actual RL mg/kg
Arsenic	0.3	0.50-0.53
Cadmium	0.01	0.04
Chromium	0.1	0.5-0.53
Copper	0.01	0.2-0.21
Lead	0.01	0.1-0.11
Nickel	0.02	0.1-0.11
Zinc	0.1	1.0-1.1
Bifenthrin	0.33	0.33
Permethrin	0.03	0.33

3.9.3. Accuracy

Inorganic Analytes

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

Synthetic Organic Compounds
The percent recovery MQO for pyrethroids and other synthetic organic compounds in sediment is 50-150% in the RMC QAPP. However, the PR MQOs listed in the laboratory reports for synthetic organic compounds varied by analyte 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 8. 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 two Santa Clara County sites on July 11, 2016. All toxicity tests were performed by Pacific EcoRisk. The water samples were analyzed for toxicity to four organisms (*Selenastrum capricornutum, Ceriodaphnia dubia, Pimephales promelas, and Hyalella azteca*) and the sediment samples were analyzed for toxicity to *Hyalella azteca* and *Chironomus dilutus.*

3.10.1. Completeness

The MRP requires the collection of dry season water toxicity samples and dry season sediment toxicity samples at two sites per year in Santa Clara County. All planned/required dry season water and sediment toxicity samples were collected in WY 2016. 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 SCVURPPP. 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 9. 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 9). 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 generally followed MRP and RMC QAPP requirements, with the following exception:

- No post-deployment calibration records for the first continuous water quality monitoring event or the second event at 205COY239.

Data that exceeded measurement quality objectives were flagged, and no data were rejected with the following exception:

- 5 out of 20 dissolved oxygen field measurements were rejected due to sensor malfunction.

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.

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

Appendix B

Regional Stressor/Source Identification (SSID) Report

BASMAA Regional Monitoring Coalition
Regional Stressor/Source Identification (SSID) Report, prepared in compliance with Municipal Regional Stormwater NPDES Permit (MRP; Order No. R2-2015-0049) Provision C.8.e.ii(1)
MRP 2.0 SSID Project Locations, Rationales, Status
Updated March 2018

SSID Project ID	Date Updated	County/ Program	Creek/ Channel Name	Site Code(s) or Other Site ID	Project Title	Primary Indicator(s) Triggering Stressor/Source ID Project									Indicator Result Summary	Rationale for Proposing/Selecting Project	Current Status of SSID Project or Date Completed	EO Concurrence of project completion (per C.8.e.iii.(b))
						Bioassess	General WQ	Chlorine	Temp	Water Tox	Sed Tox	Sed Chem	Pathogen Indicators	Other				
AL-1	2/23/18	ACCWP	Palo Seco Creek		Exploring Unexpected CSCI Results and the Impacts of Restoration Activities	X									Sites where there is a substantial difference in CSCI score observed at a location relative to upstream or downstream sites, including sites on Palo Seco Creek upstream of the Sausal Creek restoration-related sites, that had substantial and unexpected differences in CSCI scores.	The project will provide additional data to aid consideration of unexpected and unexplained CSCI results from previous water year sampling on Palo Seco Creek, enable a more focused study of monitoring data collected over many years in a single watershed, and allow analysis of before and after data at sites upstream and downstream of previously completed restoration activities.	The work plan is under development. Completion planned June 2018.	
AL-2		ACCWP																
CC-1	2/1/18	CCCWP	Lower Marsh Creek		Stressor Source Identification Study of Marsh Creek Fish Kills					X					9 fish kills have been documented in Marsh Creek between September 2005 and October 2017. A conclusive cause has not been identified.	Fish kills are clear indicators that aquatic habitat beneficial uses are not attained in this reach of Marsh Creek. These events are of interest to the public as well as regulatory and resource agencies in SF Bay and Central Valley regions. Past monitoring data from CCCWP and other parties are being used to develop a phased work plan investigating multiple potential causes, including low dissolved oxygen, warm temperatures, daily pH swings, fluctuating flows, physical stranding, and pesticide exposure.	The work plan is under development. Completion planned June 2018.	
SC-1	1/22/18	SCVURPPP	Coyote Creek		Coyote Creek Toxicity SSID Project						X				The SWRCB recently added Coyote Creek to the 303(d) list for toxicity.	This SSID study will investigate sources of toxicity to Coyote Creek.	The work plan will be submitted with SCVURPPP's WY 2017 UCMR.	
SC-2		SCVURPPP																
SM-1	1/31/18	SMCWPPP	Pillar Point / Deer Creek / Denniston Creek		Pillar Point Harbor Bacteria SSID Project								X		FIB samples from 2008, 2011-2012 exceeded WQOs.	The Pillar Point Harbor MST study conducted in 2008, 2011-2012 pointed to urban runoff as a primary contributor to bacteria at Capistrano Beach and Pillar Point Harbor. However, the specific urban locations were not identified nor were the contributing organisms established. This SSID project will investigate bacteria contributions from the urban areas within the watershed.	The work plan will be submitted with SMCWPPP's WY 2017 UCMR.	

DISCUSSION DRAFT

SSID Project ID	Date Updated	County/ Program	Creek/ Channel Name	Site Code(s) or Other Site ID	Project Title	Primary Indicator(s) Triggering Stressor/Source ID Project									Indicator Result Summary	Rationale for Proposing/Selecting Project	Current Status of SSID Project or Date Completed	EO Concurrence of project completion (per C.8.e.iii.(b))
						Bioassess	General WQ	Chlorine	Temp	Water Tox	Sed Tox	Sed Chem	Pathogen Indicators	Other				
FS-1		FSURMP																
TBD		RMC/TBD																

DISCUSSION DRAFT

Appendix C

SCVURPPP Upper Penitencia Creek Stressor/Source Identification Project,
Follow-up Monitoring and Management Practice Assessment

Santa Clara Valley
Urban Runoff
Pollution Prevention Program

Watershed Monitoring and Assessment Program

Upper Penitencia Creek Stressor/Source Identification Project

Monitoring and Management Practice Assessment

March 31, 2018

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1.0 INTRODUCTION

The Santa Clara Valley Urban Runoff Pollution Prevention Program (Program) conducted the Upper Penitencia Creek SSID Project (Project) during Water Year (WY) 2016 to meet the requirements of Provision C.8.d.i of the San Francisco Bay Region Municipal Regional Stormwater NPDES Permit ("MRP 1.0"; Order No. R2-2009-0074). This MRP 1.0 provision requires Permittees to conduct monitoring projects to identify and isolate potential stressors and/or sources associated with observed potential water quality impacts. The Project was the third and final SSID project the Program was required to complete during the term of MRP 1.0.

The *Upper Penitencia Creek SSID Project Workplan* (SCVURPPP 2015) was developed in January 2015, but field monitoring for the project was delayed due to dry channel conditions caused by extended period of drought. Subsequent rainfall during the following wet weather season provided wet channel conditions for field monitoring during the spring/summer season 2016. Monitoring data results and interpretation were presented in the *Final Project Report*, which was submitted to the Water Board on March 31, 2017 (SCVURPPP 2017).

Based on findings described in the Final Project Report, the reduced biological integrity in Upper Penitencia Creek that was observed in WY 2016 at the "case site" (COY114), located within the segment of interest, is likely due to the reduction in surface flows from the natural percolation of water through the stream bed into the hyporheic zone. Furthermore, the low biological condition scores at the case site observed during WY 2016, are likely due to the lack of natural and augmented surface water flows caused by the drought that occurred during the preceding four years. These natural seasonal changes in habitat and water flows are likely magnified by anthropogenic activities associated with water operations directly upstream of the case site. The sources of stressors that may reduce the biological condition in the study area, however, do not appear to be linked to stormwater discharges from the municipal separate storm sewer system (MS4).

Although no enhanced or improved municipal stormwater management actions are warranted, SCVURPPP recommended follow-up actions in WY 2017 in an effort to evaluate and inform future monitoring and management actions that may improve biological conditions in Upper Penitencia. These actions include:

- Conduct biological assessments at Project study sites for a second year (WY 2017) to evaluate potential variability in biological conditions during years with different hydrological conditions.

- Conduct a brief evaluation of current management practices associated with water quality and water flows in Upper Penitencia Creek, and provide recommendations on how biological conditions may be improved in the water body.

This report provides summary results for the follow-up actions described above and represents the final report for the Upper Penitencia Creek SSID Project.

2.0 BACKGROUND

The Causal Analysis/Diagnosis Decision Information System (CADDIS) approach was applied to assess potential biological impacts observed in Upper Penitencia Creek. The study approach focused on evaluating the differences in biological, physical, chemical and toxicological indicators between the "case site" (COY114) located within the segment of interest and a "comparator site" (COY121) located directly upstream of the segment. Historical data showed that biological condition, as measured by California Stream Condition Index (CSCI) scores, at the case site was consistently lower than the comparator site. The CADDIS process was focused on identifying indicators of biological condition stress that may indicate the cause of decreased CSCI scores.

Biological assessments and water and sediment sampling was conducted between April and June 2016. An evaluation of the stressor (physical, chemical and toxicological) data did not show a clear linkage to the biological condition observed at the case site. In general, the physical habitat at the case and comparator sites were very similar and not likely the cause of reduced biological condition at the case site. Similarly, water and sediment chemistry at the two sites are very similar, with the exception of temperature and nutrient concentrations, which increased with the increase in water diverted from the percolation ponds into the stream channel during the summer months.

Based on findings from the Project, the reduced biological integrity observed in Upper Penitencia Creek is believed to be associated with intermittent stream flow in the segment associated with the case site. This segment has historically lacked surface water flow during the spring/summer season due to the percolation of surface flow into the underlying groundwater basin. The aquatic biota present at the case site are typically associated with habitat that experiences abrupt, seasonal changes in flow and water quality conditions. The natural seasonal changes in habitat are likely magnified by anthropogenic activities associated with water operations occurring directly upstream of the case site. However, the sources of stressors that may reduce the biological condition in the study area do not appear to be linked to stormwater discharges from the MS4. As a result, the Upper Penitencia Creek SSID Project is considered complete, with the exception of some additional follow-up actions that were identified in the Final Project Report (SCVURPPP 2017) and are summarized below.

3.0 FOLLOW-UP ACTIONS TO SSID PROJECT

3.1 Biological Assessments (WY 2017)

To evaluate the inter-annual variability in biological condition scores, the Program conducted biological assessments at the Project case site (COY114) and control site (COY121) using methods described in SCVURPPP (2017) (Figure 1). Bioassessments were conducted in May 2017 during natural flow conditions at both sites. A second sampling event (during the water releases from percolation ponds) was not conducted in 2017 due to late onset of percolation pond operations (i.e., mid-July), which is well after the sampling index period for bioassessments (i.e., April – June). Biological condition, presented as CSCI and Algae H20 IBI metric scores, at both sites for the three sampling events over the two years of bioassessments are presented in Table 1.

Table 1. CSCI and Algae H20 IBI scores at case and control sites in Upper Penitencia Creek during WYs 2016 and 2017.

Station Code	Station Type	Sampling Date	CSCI Score	Algae "H20" IBI Score
COY114	Case	4/28/2016	0.65	11
		6/9/2016[1]	0.66	19
		5/17/2017	0.84	26
COY121	Control	4/28/2016	0.78	20
		6/9/2016	0.97	32
		5/17/2017	0.73	15

[1] Augmented water from percolation pond influenced habitat conditions prior to and during sampling event.

Figure 1. Bioassessment locations sampled in Upper Penitencia Creek during May 2017.

The CSCI scores were higher at the case site (0.84) compared to control site (0.73) in 2017, which is the opposite trend observed during the previous year. A similar pattern was observed for algae H20 IBI scores. CSCI scores were also higher at the case site for the May 2017 sampling event (0.84) compared to both April and June sampling events in 2016 (0.65 and 0.66, respectively). The CSCI scores at the case site were slightly lower in May 2017 (0.73) compared to April event in 2017 (0.78). A second sampling event was not conducted in 2017, so it is unknown if biological conditions improved a month later at the control site, which was the pattern that was observed in 2016.

The BMI assemblage at the case site during the April 2016 sampling event consisted of primarily short-lived and tolerant taxa that are typically associated with unstable habitat and flow conditions (SCVURPPP 2017). In contrast, the BMI community at the same site in 2017 had a more diverse assemblage, with a greater number of Ephemera/Plecoptera/Tricoptera (EPT) and predator taxa, both indicators of stable habitat and good water quality conditions (Attachment 1).

Water chemistry results were similar at both Project sites during the April 2016 and May 2017 sampling events (Attachment 2). The major differences were higher concentrations of chlorophyll a and AFDM, both indicators of algal biomass, at the case site in 2017. Water temperatures were consistently higher at case site in 2017, which may be associated with combination of groundwater mixing with the surface flows, as well as influences from increased solar radiation and air temperature.

Bioassessment results indicate that habitat and water quality conditions were more supportive of biological indicators at the case site in 2017. The differences in biological conditions at the site across the two years may be associated with differences in precipitation and stream flow patterns. In 2016, the flow conditions were highly variable, with large fluctuation in baseflows occurring during month of February, followed by a series of late spring storms in April, which may have produced scouring flows impacting aquatic biota (Figure 2). In 2017, the stream flows were more consistent during the winter season with smaller magnitude storms in the spring. A plot of the daily surface water flow measured at the nearby

stream gage (Piedmont) for WY 2016 and WY 2017 are shown in Figure 2. Also shown in the figure is the timing and duration of flow augmentation from percolation ponds over the two years. Flow augmentation occurred much earlier in 2016 due to an earlier decline in natural hydrograph.

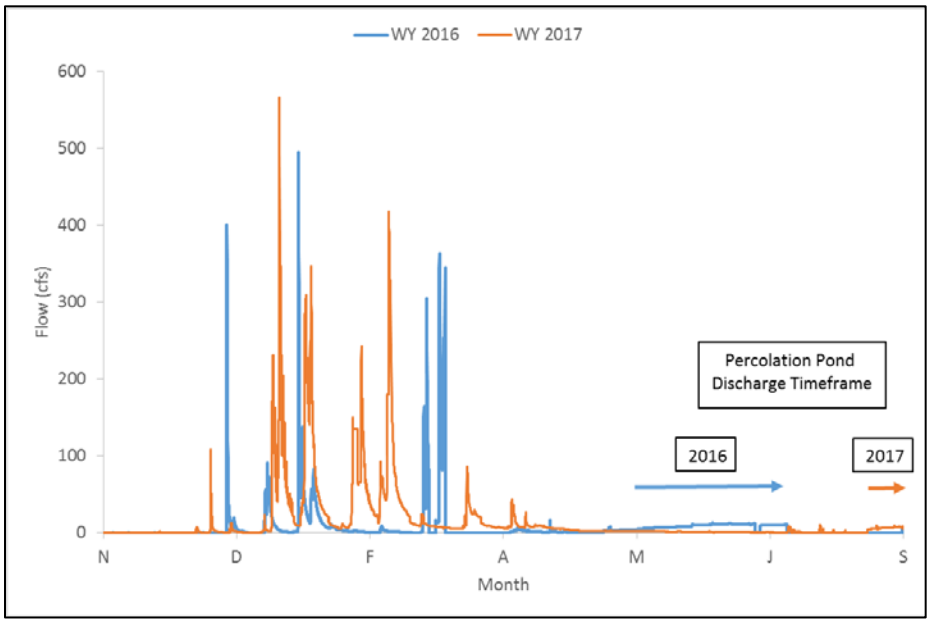

Figure 2. Daily stream flow discharge measured at Piedmont stream gage during WY 2016 and WY 2017.

Monthly average discharges at the Piedmont stream gage for WY 2014 through WY 2017 are shown in Table 2. The spring season of WY 2014 and WY 2015 were extremely dry, with average monthly flows well below 1 cfs. Flows increased during spring WY 2016 following a wetter January, dropped dramatically during the month of February (channel was completely dry for part of the month), increased in March, and then dropped again in April. Starting in May 2016, the stream discharge was entirely derived from percolation pond releases. In contrast, flows in 2017 were more consistent during the winter season and gradually decreased during spring and summer seasons. Percolation pond operations did not begin until late July.

It is not clear why biological condition scores in 2017 were higher at the case site, compared to the comparison site. Water chemistry and physical habitat data collected at both sites in 2017 were very similar and do not appear to be adversely impacting biological conditions at either of the sites.

Table 2. Monthly average stream flow (cfs) measured at Piedmont stream gage over the past four years (WY 2014 through WY 2017). Shaded cells indicate month that stream flow was augmented by percolation pond releases. CSCI scores for the past two years is also shown.

WY Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	CSCI Score
2014	3.6	3.3	2.9	2.6	1.4	.05	.05	0	0	0	0	0	NA
2015	0	.04	10.2	0	0.3	0	< .01	< .01	0	0	0	0	NA
2016	0.0	0.0	5.2	21.4	1.9	21.6	1.5	2.9	9.3	6.1	0.0	7.5	0.65
2017	0.8	0.0	2.0	64.7	62.2	13.0	8.2	2.1	1.3	0.7	2.7	3.3	0.84

Conclusions based on results from bioassessment monitoring in 2017 are provided below:

- Reduced biological conditions observed at the case site in 2016 were likely associated with intermittent flow conditions that occurred prior to sampling events, as well as preceding two years of dry conditions associated with the drought.

- Higher biological conditions observed at the case site in 2017 appear to be associated with consistent storm patterns during the winter season and less variable baseflow conditions during the spring season. In addition, higher groundwater levels likely helped maintain surface flows during the spring and summer seasons in 2017.

3.2 Management Practices Assessment

The Project findings suggest that MS4 discharges are not the probable cause of reduced biological conditions observed at the case site on Upper Penitencia Creek. However, the Program recognizes the importance of freshwater habitat in this creek that currently supports freshwater organisms, including a viable steelhead trout population. To assist in the continued management of this important natural resource, the Program summarized management practices and/or projects that may affect biological conditions within the Project reach. These management practices fall into four categories:

- Water Operations;
- Channel Maintenance; and
- Sediment Control in Upper Watershed, including rural roads, trails and grazing.

For each management practice/project, the following are provided:

- Summary of watershed management activities in the watershed;
- Evaluation of potential impacts that existing and/or planned management practices may have on biological conditions; and
- Recommendations of actions (monitoring or management) that would support the management of the freshwater habitat beneficial use in Upper Penitencia Creek.

3.3.1 Water Operations

The SCVWD conducts water operations in Upper Penitencia Creek to recharge the underlying groundwater basin by diverting water from the South Bay Aqueduct into the Robert Gross percolation ponds, located just upstream of Piedmont Avenue. Water imports are typically initiated when creek flow ceases upstream of the pond turnout. Historically, Upper Penitencia Creek loses surface flow over a segment that spans the groundwater recharge zone, between Dorel Avenue and just downstream of Interstate 680. Imported water is transported to off-channel ponds for percolation. The pond water may then be released to the creek at three potential locations: 1) Pond 1a via pipeline near Toyon Avenue; and 2) Pond 3 via overflow structure, approximately 400 meters upstream of Piedmont Road and 3) overflow structure immediately upstream Piedmont Road (Figure 3). In 2012, a fish screen was installed at the outlet pipe from Pond 1a to prevent fish passage into the ponds during water releases.

The SCVWD water operations for groundwater percolation is dependent on the availability of imported water from the State. During WY 2014 and WY 2015, the State did not allocate imported water to the SCVWD due to an extended period of drought. As a result, both ponds and the reach of Upper Penitencia Creek below Dorel Drive were dry throughout the spring and summer seasons for both years. Although water imports were reinitiated in WY 2016, the augmented water only extended a short distance below the ponds (i.e., down to about Capitol Expressway), presumably due to high percolation rates caused by lower than normal elevation of the groundwater basin following the drought.

Pond water is discharged into the creek for two reasons: 1) groundwater percolation, and 2) to satisfy downstream well users/water rights. Typically, the augmented water extends from the Robert Gross Percolation Ponds downstream to a diversion structure at Jackson Road that conveys water to another off-channel percolation pond at Mabury Road. Approximately 75% of the total volume of imported water that is percolated occurs at the ponds and the remaining 25% occurs in the channel (Aaron Baker, personal communication, SCVWD).

Figure 3. Robert Gross Percolation Ponds in Upper Penitencia Creek, San Jose Ca.

During wetter years, the timing and volume of water that is released from the percolation ponds can be variable. During WY 2016, the natural flows in the creek ceased in early May and water was released from the ponds between May and July 2016 (Table 3). Approximately 90% of these discharges occurred at Pond 1 via pipeline at Toyon Avenue. Pond discharge was stopped for approximately 40 days and reinitiated in September 2016 for about one month. In 2017, natural stream flow continued late into the summer season and water releases did not begin until late July 2017. As a result, the volume of water discharged from the pond during WY 2017 was significantly less, compared to WY 2016 (note period of record for 2017 only extend into early August).

Table 3. Timing and estimated volume of water released from Robert Gross percolation ponds in 2016 and 2017.

Calendar Year	Pond 1 Discharge via Pipeline			Pond 3 Discharge via Overflow		
	Total Volume (Annual)		Timeframe	Total Volume (Annual)		Timeframe
	cfs	Acre-ft		cfs	Acre-ft	
2016	774.6	1536	May 12-July 19; Sept 1-Oct 6 (with some days off)	78.4	156	June 15-July 20; Sept 12-Oct 5 (with some days not overflowing)
2017*	0	0	No discharge between Jan 1 and Aug 5.	6.3	12	July 21-Aug 2 (with some days not overflowing)

*Data only available through August 5, 2017

Percolation pond releases can dramatically effect stream flow discharge in Upper Penitencia Creek. On May 12, 2016, the initial release of water from the percolation ponds increased flow at the Piedmont gage from 0.25 cfs to 2.5 cfs in the span of one hour. Continued releases over the period of one month (May-June 2016) increased stream flow from 2.5 cfs to 12 cfs. In July, the releases were shut off and flows dropped from 11 cfs to 1 cfs in one hour. The channel remained dry for approximately one month, and water releases began again in September 2016 until October 6th.

The City of San Jose owns and operates Cherry Flat Reservoir, which is located about one mile upstream of Alum Rock Park. The reservoir has a capacity of 500 acre-feet and was originally built for flood control and water use in the park. Dam releases are typically made when the reservoir is in danger of exceeding capacity or additional flows are needed to maintain perennial flow in Upper Penitencia Creek mainstem (SCVURPPP 2003). Regular releases are typically not needed during most years due to contribution of natural springs near the dam and perennial flow from Arroyo Aguague.

Evaluation

Based on the Project results, the effects of percolation pond releases to biological conditions, as measured by CSCI and algae IBI scores, were inconclusive. Biological condition scores at the case site were essentially no different between the 2016 sampling events that occurred before and after percolation pond releases. It is unclear to what extent the biological conditions observed at the case site for both sampling events in 2016 were influenced by persistent dry channel conditions caused by the drought (and absence of augmented flow from ponds) during the previous two years.

The percolation pond releases in 2016 resulted in an increase in stream discharge, elevated water temperatures and higher nutrient concentrations at the case site, compared to the upstream comparator site. It is not clear to what degree these stressors may have affected the aquatic biota at the case site, considering the channel at the case site was dry prior to the percolation pond releases and therefore the releases provide a wetted channel where none existed prior to. It is assumed that BMIs and algae present during the June 2016 bioassessment event either recently colonized the stream or were dispersed from the ponds during the releases. The augmented flow may provide connectivity to existing habitat further downstream during wet years (e.g., confluence of Coyote Creek), however in 2016 the augmented flow only extended a short distance downstream before it percolated below the surface at Capitol Expressway.

In general, the additional volume of water from the ponds appears to increase the spatial and temporal extent of water flows in the “dry back” zone downstream of the ponds, which increases the availability of habitat for native warm water fish community and other aquatic organisms (e.g., benthic macroinvertbrates) during spring/summer months. Native fish community of California roach, Sacramento suckers, prickly sculpin and Pacific lamprey larvae are typically found in the reach downstream of the Percolation Ponds (Smith 2013). In addition, the water releases from percolation ponds may benefit juvenile steelhead during their downstream migration (Leicester and Smith, 2013). During dry years, intermittent flows in the percolation zone may result in the stranding of juvenile steelhead during spring migration.

Recommendations

The following recommended management/monitoring actions associated with water operations are provided below.

- Evaluate management scenarios to release water from Robert Gross Percolation Ponds that would enhance aquatic life uses in Upper Penitencia Creek. Management scenarios may include operations to enhance the timing, duration and magnitude of water releases to potentially benefit downstream migration of juvenile steelhead.

3.3.2 Channel Maintenance

The SCVWD performs routine stream and channel maintenance on streams and channels under their jurisdiction as part of the SCVWD Stream Maintenance Program (SMP) (SCVWD 2013). The activities addressed in the SMP include sediment removal projects, vegetation management and bank protection. The SCVWD has flood control jurisdiction for 52% of the Upper Penitencia Creek downstream of Alum Rock Park, including the Project reach.

Sediment removal activities conducted under the SMP typically occur in areas where sediment deposition has reduced flood conveyance capacity, impeded function of facilities and impeded fish passage. Vegetation management activities include removal of vegetation within the riparian zone to maintain flood conveyance capacity, maintain water conveyance for supply purposes, reduce fuel loads on stream banks for fire protection, and control invasive nonnative vegetation (e.g., mowing, hand clearing or herbicide application).

Bank protection activities performed by the SCVWD, where SCVWD has right of way, fee title or easement, include repair of eroding stream banks in areas where erosion could cause property damage, create a public safety concern, and/or negatively affect transportation, beneficial uses, or riparian habitat. Bank protection measures used by the SCVWD may include hard structures (e.g., rock), as well as soft structures (e.g., brush mattresses, root wads, or crib walls).

Evaluation

One of the most pressing issues in Upper Penitencia Creek is the accumulation of sediment at several locations where the channel is constricted, including the Interstate 680 crossing and the confluence of Coyote Creek. In the past four years, the SMP has performed very limited activities in Upper Penitencia Creek (Carole Foster, SCVWD, personal communication, 2017), due to the lack of project approvals by the National Marine Fisheries Service. The District has focused solely on vegetation management, including aquatic herbicide application, vegetation removal and tree pruning, and has not performed sediment removal in Upper Penitencia in over a decade. All vegetation management activities currently occur above and below Noble Avenue road crossing and have very limited effects to biological conditions to the Project reach. The last sediment removal project was proposed in 2015 along a reach at Mabury Road, however it was not approved by the National Marine Fisheries Service. Historically, sediment removal activities are primarily conducted downstream of the Project reach, and thus would not likely impact biological conditions at the Project reach.

The riparian vegetation at the case site contains several mature sycamore trees mixed with younger willows and alders at various locations. A majority of the banks, however, are covered with non-native vegetation, including ivy, blackberries and vinca. The non-native plant species provide little bank protection or stream side shading, which would be beneficial for benthic organisms and native fishes. Qualitative physical habitat (PHAB) assessments conducted as part of the bioassessments support this observation, as the case site had moderately low scores for epifaunal substrate, a measure for potential diversity of habitat available for aquatic organisms. The absence of large woody debris in the channel is one factor contributing to the lower epifaunal substrate score. In general, large woody debris in the channel increases overall habitat diversity for aquatic organisms, and could improve habitat at the case site.

Recommendations

The following recommended management/monitoring actions associated with channel maintenance are provided below.

- Consider removal of non-native plant species (e.g., ivy) and encourage natural recruitment of native riparian vegetation as appropriate at the case site to improve aquatic conditions as part of actions taken by the District's Safe Clean Water and Natural Flood Protection Program, Priority D[1]. Priority D focuses on Restoring Wildlife Habitat and Providing Open Space in Santa Clara County. Funding for this priority pays for control of non-native, invasive plants, revegetation of native species, and maintenance of previously revegetated areas. Other projects include removal of fish barriers, improvement of steelhead habitat and stabilization of eroded creek banks.
- Consider the installation of large woody debris to increase habitat type diversity (e.g., scour pools) to increase the diversity of aquatic biota, leveraging the District's Safe Clean Water and Natural Flood Protection Program, Priority D opportunities when possible. Large woody debris placement should consider habitat benefit versus flood risk. Consider use of SCVWD's gravel placement and large-wood placement site prioritization criteria which aims to integrate geomorphic analysis and aquatic ecology principles to increase in-stream complexity in select urbanized waterways throughout the county[2]. Other sources of information may include SCVWD's Stream Maintenance Program large woody debris guidelines

3.2.3 Sediment Control in Upper Watershed

The Program previously documented management practices associated with controlling anthropogenic sources of sediment in Upper Penitencia Creek (SCVURPPP 2008). A sediment source assessment (Stillwater 2007) determined that active and frequent landslides are common in Upper Penitencia Creek, especially in sensitive geological-land cover areas. The study identified road-related landslide features are a chronic source of sediment and grazing and feral animal as potential sediment source. However, existing information was not sufficient to differentiate the anthropogenic sediment inputs from what is likely a naturally high sediment yield from the watershed (Stillwater 2008).

Although sediment was not identified as an important stressor to the biological condition observed at the case site, compared to control site, sediment impacts from both natural and anthropogenic sources can potentially impact biological conditions in the Upper Penitencia Creek watershed. A summary of sediment management practices potentially impacting Project reach are provided below.

<u>Rural Roads and Trails</u>

The City of San Jose Department of Transportation is primarily responsible for maintaining roads within Alum Rock Park. The City follows standard operating procedures for the maintenance and repair of unpaved roads and trails that are described in the Rural Public Works Maintenance and Support Activities Performance Standards. The goal of these procedures is to ensure that maintenance and/or repairs of unpaved roads and trails/embankments are conducted in a manner that minimizes, to the maximum extent practicable, the impacts on water quality. The City of San Jose Parks and Recreation Department is also responsible for maintaining and protecting facilities in Alum Rock Park. These activities include monthly inspections of Cherry Flat Reservoir and road and trail inspections and maintenance.

Santa Clara County has two departments that are responsible for maintenance of roads within unincorporated areas of Upper Penitencia Creek watershed. The County Roads and Airports Department maintains the majority of Alum Rock Falls Road (i.e., roadway outside of Alum Rock Park boundary). The

[1] https://www.valleywater.org/project-updates/safe-clean-water-and-natural-flood-protection-program/priority-d-restore-wildlife-habitat-and-provide-open-space
[2] Countywide Gravel and Large Wood Augmentation Program (Draft)

Santa Clara County Parks and Recreation Department manages roads, as well as recreational trails, within Joseph D. Grant County Park. Joseph Grant Park covers approximately 24% of the total watershed area of Upper Penitencia Creek, all within the Arroyo Aguague subwatershed.

The Santa Clara Open Space Authority (SCCOSA) manages nearly 10% of the total watershed area in Upper Penitencia Creek watershed above Alum Rock Park. Approximately 70% of total length of roads in land owned or managed by OSA has a dirt surface (i.e., 7.7 miles). Sediment management practices generally consist of repairing roads and culverts that are failing or not functioning properly. The OSA follows guidelines described in “Handbook for Forest and Ranch Roads” and “Road building guide for private roads”, developed by the Mendocino Resource.

Grazing

In December 2012, the Santa Clara County Open Space Authority (OSA) purchased three parcels (Kammerer property) surrounding the upper end of Cherry Flat Reservoir in the Upper Penitencia Creek watershed with the intention of partnering with the Santa Clara Valley Water District (SCVWD). Ownership of this property (now referred to as the Upper Penitencia Creek Property) was transferred to SCVWD for the purpose of providing mitigation in perpetuity for impacts associated with the SCVWD's 2002 Multi-Year Stream Maintenance Program (SMP). In December 2015, the SCVWD also purchased the Rancho Cañada de Pala Preserve (Preserve) from The Nature Conservancy (TNC), also for providing mitigation for impacts associated with the SMP.

The Open Space management approach is provided below.

Upper Penitencia Creek Property (Property)

The approach to protecting, managing, and enhancing stream and pond conditions on the Property is to:

1. Monitor and maintain residual dry matter (RDM) at levels sufficient to protect the soils. Ensure sufficient vegetative cover, thus reducing the potential for watershed lands erosion and for increased runoff into streams.

2. Implement a grazing strategy to reduce cattle presence during the hot/dry summer season (once grass forage is dried) when cattle tend to congregate near streams and ponds. This will minimize routine cattle intrusion into the vicinity of ponds and streams. In addition, retain any existing functional watering troughs and install new troughs if they are determined to be needed in the future. Ensure troughs are placed in the Property in sufficient numbers and locations to provide an adequate and preferred water source for cattle, thus deterring cattle utilization of the natural water sources on the Property. Similarly, salt/mineral blocks for cattle will be located well away from sensitive aquatic resources.

3. After implementation of the grazing regime has commenced, conduct annual monitoring of sensitive areas (streams and ponds) that are accessible to cattle to determine that the Property’s identified conservation values are being met.

4. Take additional measures (e.g., installation of additional troughs, salt licks, molasses, and temporary or permanent fencing) that may be needed to adapt the grazing plan in a manner that better supports the Property’s conservation values.

5. Rehabilitate existing degraded road areas, particularly stream crossings that are currently contributing to minor erosion, and institute an annual road maintenance program to properly configure roads to minimize erosion potential.

Rancho Canada de Pala Preserve (Preserve)

The approach to protecting, managing, and enhancing stream and pond conditions on the Preserve is to:

1. Monitor and maintain residual dry matter (RDM) at levels sufficient to protect the soils. Ensure sufficient vegetative cover, thus reducing the potential for watershed lands erosion and for increased runoff into streams.

2. Implement a grazing strategy to provide relatively low grassland vegetation with appropriate conditions for burrowing mammals and the species that utilize their burrows while minimizing the potentially adverse effects of livestock grazing during the hot/dry summer season (once grass forage is dried) when livestock tend to congregate near water sources. This will minimize routine cattle intrusion into the vicinity of ponds and streams on the Preserve. In addition, maintain the existing watering troughs and install new troughs if they are determined to be needed in the future. Ensure troughs are present in sufficient numbers and locations to provide an adequate and preferred water source for cattle, thus deterring cattle utilization of the natural water sources on the Preserve. Similarly, mineral and protein supplements for cattle will be located well away from sensitive aquatic resources.

3. Conduct annual monitoring of sensitive areas (i.e., streams and ponds) that are accessible to cattle to determine that the identified conservation values of the Preserve are being met.

4. Take additional measures (e.g., installation of additional troughs and mineral and protein supplements) that may be needed to adapt the grazing plan in a manner that better supports the conservation values of the Preserve.

5. Rehabilitate existing degraded road areas and institute a regular road maintenance program to properly configure roads to minimize erosion potential.

Evaluation

The upper basin of Upper Penitencia creek contains highly erosive geology and steep topography, local seismic activity and the intense, episodic winter rainfall, which combine to produce a naturally high sediment load (Stillwater 2007). An extended dry period between WY 2014 and WY 2016, followed by wet winter during WY 2017, resulted in several landslides in Alum Rock Park, causing damages to several buildings in the park (Alex Pearson, City of San Jose, personal communication, 2017). Alum Rock Falls Road (i.e., roadway outside of Alum Rock Park boundary) was shut down due to rockslides and road failures.

City of San Jose and County agency staff are currently addressing these sediment issues with management actions in Alum Rock Park, primarily focused on intercepting erosive soils at roadways to prevent them from entering the creek (Jordan Ciprian, City of San Jose, personal communication, 2017). A subsequent dry winter in WY 2018 has reduced the potential for sediment to get transported to the creek.

Sediment was not identified as an important stressor at the case site during bioassessments conducted in WY 2016 or WY 2017. The case site is located at the downstream end of historical zone for sediment transport (Figure 4). As a result, sediment that is being transported from upstream sources will likely get deposited further downstream of the case site.

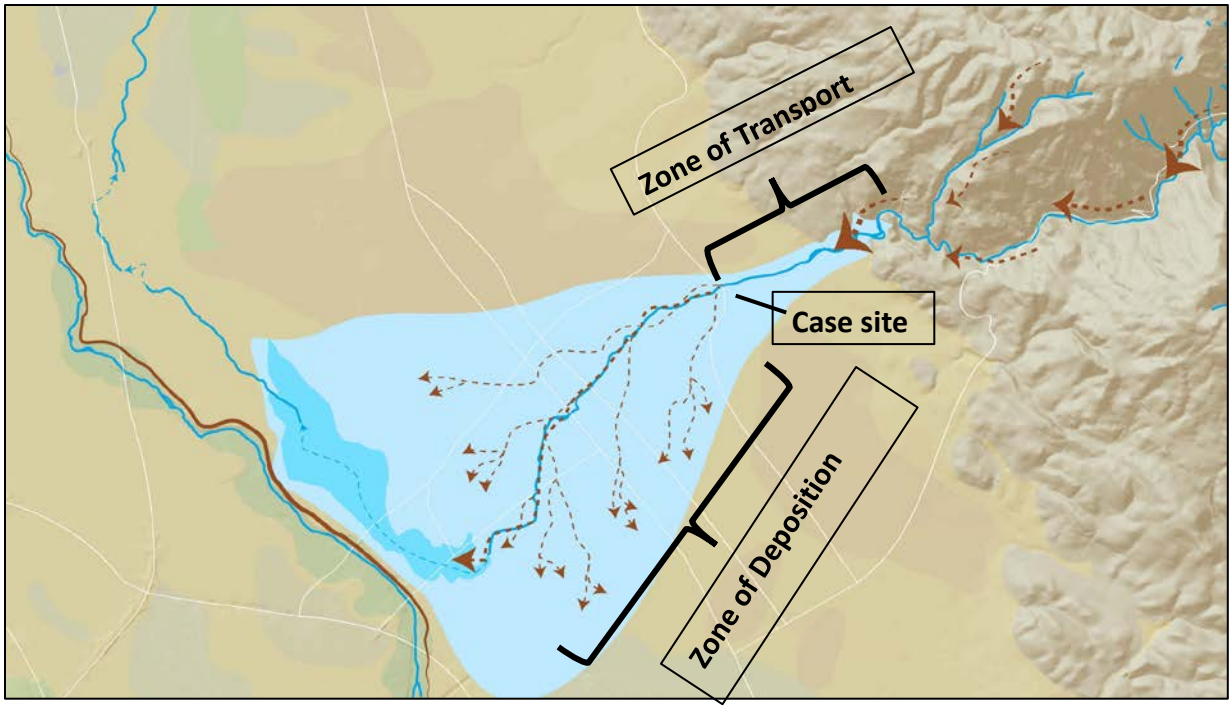

Figure 4. Historical map showing zones of sediment transport and deposition in Upper Penitencia Creek.

Recommendation

There are no recommended management/monitoring action associated sediment control practices.

4.0 CONCLUSIONS AND RECOMMENDATIONS

Conclusions based on results from bioassessment monitoring in WY 2017 are provided below:

- Reduced biological conditions observed at the case site in 2016 were likely associated with intermittent flow conditions that occurred prior to sampling events, as well as preceding two years of dry conditions associated with the drought.

- Higher biological conditions observed at case site in 2017 appear to be associated with consistent storm patterns during the winter season and less variable baseflows during spring season. In addition, higher groundwater levels likely helped to maintain surface flows during the spring and summer season of 2017.

The following recommended management/monitoring actions are provided below.

- Evaluate management scenarios to release water from Robert Gross Percolation Ponds that would enhance aquatic life uses in Upper Penitencia Creek. Management scenarios may include operations to enhance the timing, duration and magnitude of water releases to potentially benefit downstream migration of juvenile steelhead.
- Consider removal of non-native plant species (e.g., ivy) and encourage natural recruitment of native riparian vegetation as appropriate at the case site to improve aquatic conditions as part of actions taken by the District's Safe Clean Water and Natural Flood Protection Program, Priority

D[3]. Priority D focuses on Restoring Wildlife Habitat and Providing Open Space in Santa Clara County. Funding for this priority pays for control of non-native, invasive plants, revegetation of native species, and maintenance of previously revegetated areas. Other projects include removal of fish barriers, improvement of steelhead habitat and stabilization of eroded creek banks.

- Consider the installation of large woody debris to increase habitat type diversity (e.g., scour pools) to increase the diversity of aquatic biota, leveraging the District's Safe Clean Water and Natural Flood Protection Program, Priority D opportunities when possible. Large woody debris placement should consider habitat benefit versus flood risk. Consider use of SCVWD's gravel placement and large-wood placement site prioritization criteria which aims to integrate geomorphic analysis and aquatic ecology principles to increase in-stream complexity in select urbanized waterways throughout the county[4]. Other sources of information may include SCVWD's Stream Maintenance Program large woody debris guidelines.

To support these and future restoration projects the District will create a comprehensive, updated database on stream conditions countywide. The District and other agencies can then use the new information to make informed decisions on where and how to use restoration dollars so they have the greatest value for wildlife.

5.0 REFERENCES

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Stillwater Sciences Inc. 2007. Upper Penitencia Creek Sediment Source Assessment Technical Memorandum. Prepared for the Santa Clara Valley Urban Runoff Pollution Prevention Program. June, 2007.

[3] https://www.valleywater.org/project-updates/safe-clean-water-and-natural-flood-protection-program/priority-d-restore-wildlife-habitat-and-provide-open-space

[4] Countywide Gravel and Large Wood Augmentation Program (Draft)

ATTACHMENTS

Attachment 1. Metric scores for BMI taxa in samples collected at two Project sites in April 2016 and May 2017.

Metrics	4/28/2016		5/7/2017	
	205COY114	205COY121	205COY114	205COY121
Richness:				
Taxonomic	19	27	31	32
EPT*	6	12	13	11
Ephemeroptera	3	4	7	6
Plecoptera	0	3	2	1
Trichoptera	3	5	4	4
Coleoptera*	0	1	4	0
Predator*	5	9	10	13
Diptera	7	7	7	15
Composition:				
EPT Index (%)	2.8	5.8	24	17
Sensitive EPT Index (%)	0.5	2.6	3.5	3.0
Shannon Diversity	1.33	1.56	2.16	1.91
Dominant Taxon (%)	54	39	23	33
Non-insect Taxa (%)*	26	22	23	19
Tolerance:				
Tolerance Value	5.4	5.5	5.4	5.5
Intolerant Organisms (%)*	0.3	2.3	3.5	2.1
Intolerant Taxa (%)	5.3	22	13	16
Tolerant Organisms (%)	0.6	1.6	3.3	5.7
Tolerant Taxa (%)*	11	22	19	16
Functional Feeding Groups:				
Collector-Gatherers (%)	68	55	70	56
Collector-Filterers (%)	29	40	22	34
Collectors (%)*	98	95	92	90
Scrapers (%)	0.3	1.4	1.3	0.8
Predators (%)	1.6	3.4	6.3	8.2
Shredders (%)	0.3	0.5	0.3	0.9
Other (%)	0.0	0.0	0.3	0.0

Attachment 2. Water chemistry (nutrients) and sonde grab samples collected at two Project sites in April 2016 and May 2017.

Parameter	COY114		COY121	
	4/28/2016	5/17/2017	4/28/2016	5/17/2017
Water Quality				
Temperature	16.2	16.9	11.4	12.3
Dissolved Oxygen	NR	11.15	10.82	8.26
pH	8.62	8.77	8.45	8.39
Specific Conductance	NR	798	757	773
Nutrients and Anions				
Ammonia as N	0.025	0.05	0.043	0.05
Unionized Ammonia (as N)	NR	0.007	0.002	0.002
Chloride	43	38	42	40
AFDM	52	162	61	46
Chlorophyll a	23	150	31	54
Nitrate as N	0.13	0.08	0.24	0.16
Nitrite as N	0.008	0.005	0.011	0.007
Total Kjeldahl	0.57	0.53	0.48	0.57
Total Nitrogen	0.71	0.61	0.73	0.74
Ortho-Phosphate as P	0.02	0.02	0.02	0.03
Phosphorus as P	0.03	0.04	0.03	0.04
Total Phosphorus	0.06	0.06	0.06	0.07
Silica as SiO2	12	15	12	16

NR = Not recorded/measured

Appendix D

SCVURPPP Coyote Creek Toxicity Stressor/Source Identification Work Plan

Santa Clara Valley
Urban Runoff
Pollution Prevention Program

Watershed Monitoring and Assessment Program

Coyote Creek Toxicity Stressor Source Identification Project

Work Plan - Water Year 2018

March 31, 2017

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1.0 INTRODUCTION

The purpose of this work plan is to describe the design of and tasks that will be completed for a Stressor/Source Identification (SSID) project, which is required by Provision C.8.e.iii of the San Francisco Bay Region Municipal Regional Stormwater National Pollutant Discharge Elimination System (NPDES) Stormwater Permit (MRP) (Order No. R2-2015-0049). The Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP or Program) is working with the Bay Area Stormwater Management Agencies Association (BASMAA) Regional Monitoring Coalition (RMC) to collectively initiate eight new SSID projects during the five-year term of the MRP (i.e., 2016 – 2020). SSID projects typically follow-up on monitoring conducted in compliance with MRP Provision C.8 (or monitoring conducted through other programs) with results that exceed trigger thresholds identified in the MRP. Trigger thresholds are not necessarily equivalent to Water Quality Objectives (WQOs) established in the San Francisco Bay Basin (Region 2) Water Quality Control Plan (Basin Plan, SFRWQCB 2017) by the San Francisco Bay Regional Water Quality Control Board (Regional Water Board); however, sites where triggers are exceeded may indicate potential impacts to aquatic life or other Beneficial Uses.

This SSID work plan describes the steps that will be taken during WY 2018 to investigate sources of toxicity in **Coyote Creek, San Jose, California**. The Regional Water Board recently recommended listing Coyote Creek for toxicity in sediment in the 2016 Integrated Report (303(d) List/305(b) Report) for the San Francisco Bay Region. The recommendation has been submitted to the State Water Resources Control Board (State Board) and will be compiled into a statewide 303(d) list, which is subject to the approval of both the State Water Board and the USEPA.

1.1 SSID Regulatory Background

SSID projects are intended to be oriented toward taking action(s) to alleviate stressors and reduce sources of pollutants. MRP Provision C.8.e.iii requires that SSID projects are conducted in a stepwise process:

Step 1: Develop a work plan. The work plan must:

- Define the problem (e.g., magnitude and temporal and geographic extent) to the extent known;
- Describe the SSID project objectives, including the management context within which the results of the investigation will be used;
- Consider the problem within a watershed context and look at multiple types of related indicators, where possible (e.g., basic water quality data and biological assessment results);
- List candidate causes of the problem (e.g., biological stressors, pollutant sources, and physical stressors);
- Establish a schedule for investigating the cause(s) of the trigger stressor/source to begin upon completion of the work plan. Investigations may include evaluation of existing data and/or collection of new data.
- Conduct a site specific study (or non-site specific if the problem is wide-spread) in a stepwise process to identify and isolate the cause(s) of the trigger stressor/source. Study approaches are listed depending on the stressor being investigated.
    - For toxicity studies, a Toxicity Identification Evaluation (TIE) should be conducted when no chemical pollutant is present in the sample that exhibited toxicity. In the case where samples exhibiting toxicity contain pollutant at concentrations that might produce adverse effects, it is not necessary to conduct a TIE, and the SSID project would be considered complete.

Step 2: Conduct SSID investigations according to the schedule in the work plan and report on the status of the SSID investigation annually in the Urban Creeks Monitoring Report (UCMR) that is submitted to the Regional Water Board on March 31 of each year.

Step 3: Follow-up actions:

- If it is determined that discharges to the municipal separate storm sewer system (MS4) contribute to an exceedance of a water quality standard (WQS) or an exceedance of a trigger threshold such that the water body's beneficial uses are not supported, submit a report in the UCMR that describes Best Management Practices (BMPs) that are currently being implemented and additional BMPs that will be implemented to prevent or reduce the discharge of pollutants that are causing or contributing to the exceedance of WQS. The report must include an implementation schedule.
- If it is determined that MS4 discharges are not contributing to an exceedance of a WQS, the SSID project may end. The Executive Officer must concur in writing before an SSID project is determined to be completed.
- If the SSID investigation is inconclusive (e.g. the trigger threshold exceedance is episodic or reasonable methods do not reveal a stressor/source), the Permittee may request that the Executive Officer consider the SSID project complete.

1.2 SSID Work Plan Organization

This work plan fulfills **Step 1** of the SSID process described above in Section 1.1. It describes the steps that will be conducted to investigate sources of toxicity observed in Coyote Creek. The work plan is organized according to the required work plan elements described in Step 1.

Section 2.0 Problem Definition and Study Objectives

Section 3.0 Study Area, Existing Data, and Candidate Causes

Section 4.0 Monitoring Approach and Schedule

Section 5.0 References

2.0 PROBLEM DEFINITION AND STUDY OBJECTIVES

2.1 Problem Definition

This Coyote Creek Sediment Toxicity SSID Project (Project) was triggered by the recommended listing of Coyote Creek for toxicity in sediment in the 2016 Integrated Report (303(d) List/305(b) Report) for the San Francisco Bay Region (Integrated Report). The revised Integrated Report (dated April 2017) was approved by the Regional Water Board on April 12, 2017. The Regional Water Board identified Coyote Creek for toxicity as a Category 5 listing group; which is defined as listing "when at least one beneficial use is not supported and a TMDL is needed." The recommendation has been submitted to the State Water Resources Control Board (State Board) and will be compiled into a statewide 303(d) list subject to the approval of the State Water Board and the USEPA.

The Water Board evaluated toxicity data that were collected prior to 2010 for determination of the recommended listing. Four lines of evidence were evaluated showing significant toxicity from sediment and/or water samples collected in 2007 and 2008 at two locations in the lower reaches of the Coyote Creek mainstem and one location in Coyote Slough. The locations, sampling date, monitoring program and number of samples used as evidence are shown in Table 1. Only the sediment toxicity data collected from two sites in Coyote Creek were determined to exceed the 303(d) listing evaluation guidelines. The sediment toxicity test included survival and growth of *Hyalella azteca*. Toxicity was defined as a statistically significant effect in the sample exposure compared to the control using EPA-recommended hypothesis testing.

Table 1. The sampling locations, date, monitoring program and number of samples used as evidence for listing sediment toxicity in Coyote Creek.

Station ID	Location	Sample Date	Program	Sample Type	Number of Samples	Number of Exceedences of WQOs[1]	Exceeded Evaluation Guidelines[2]
205COY240 (205SUP022)	Coyote Creek at Williams Park	January 2007	Urban Pyrethroid Status Monitoring	Sediment	1	1	Yes
205COY060	Coyote Creek at Montague Exp	June 2008	Stream Pollution Trends Study	Sediment	2	1	Yes
C-3-0	Coyote Slough	1997 - 2002	Regional Monitoring Program (RMP)	Sediment	7	2	No
C-3-0[1]	Coyote Slough	1997 - 2001	Regional Monitoring Program (RMP)	Water	16	1	No

[1] WQO for Toxicity: All waters shall be maintained free of toxic substances in concentrations that are toxic to, or that produce detrimental physiological responses in, human, plant, animal, or aquatic life. (Region 2 Basin Plan 2007).
[2] Toxicity is defined as a significant reduction of test organism relative to the control (alpha < 0.05) and test organism survival is 80% or less than the control survival (at least 20% effect).

In response to the proposed 303(d) listing, the Program developed a comment letter to the Regional Water Board, dated March 13, 2017. The comments were primarily associated with the data evaluation process used by the Water Board to derive the proposed listing. The Program's comments are summarized below:

- The water quality data used by the Water Board to evaluate potential exceedences of water quality objectives were collected 10 – 20 years prior to the data evaluation. With regards to water and sediment toxicity, these data were collected prior to initiation of the pesticide control program mandated by the San Francisco Bay Regional Water Board's Water Quality Attainment Strategy for Pesticide-related Toxicity for Urban Creeks and implemented under the MRP, and thus should not be considered representative of current water quality conditions in Coyote Creek or the San Francisco Bay. Recent sediment toxicity data collected in Coyote Creek since 2010 show a decline in incidences of toxicity.

- Receiving water monitoring data collected through 2010 under NPDES permits were not used for the 303(d) listing process. The Program collected water quality data from 2002 – 2008 in Santa Clara Valley Creeks during implementation of the SCVURPPP Multi-Year Receiving Waters Monitoring Plan. These data include total and dissolved metal concentrations and aquatic and sediment toxicity results from hundreds of samples collected at roughly 70 sites in Santa Clara Valley. Specifically, the Program conducted a sediment toxicity study in the Coyote Creek watershed in 2007-2008 (see Section 3.2.1 below). Not including data collected via NPDES permits potentially contributes to the mischaracterization of water quality conditions in local receiving water bodies. Without conducting such an evaluation and review as part of the 303(d) list data analysis process, a scientifically defensible conclusion regarding water quality conditions and the need for additional control measures should not be made.

- Instead of using a robust data analysis process, it appears that data evaluations to support listing recommendations in 2016 have been reduced to simplistic "black box" approaches where all data (in addition to incomplete datasets noted above) that are housed in the California Environmental Data Exchange Network (CEDEN) for a specific analyte are considered equal, regardless of the context of when, where, how and for what reason they were collected. Data are run through binomial tests with no interpretation in the context of the receiving water bodies or monitoring program goals and objectives.

2.2 Study Objectives

The objective of this Project is to focus on potential causes and sources of toxicity in Coyote Creek. The study is designed to:

1. Identify the magnitude and extent of toxicity in a reach of the Coyote Creek mainstem where previous data were collected; and
2. Identify potential causes of sediment toxicity (if observed).

Depending on results of the investigation, management actions to control toxicity in Coyote Creek will be identified in the project report.

3.0 STUDY AREA, EXISTING DATA, PROBABLE CAUSES

3.1 Study Area

The Coyote Creek watershed covers approximately 320 square miles and drains most of the west-facing slope of the Diablo Range (SCVURPPP 2003). The watershed extends 45 miles from the creek's headwaters (approximately 3,000-foot elevation) to the tidal sloughs entering San Francisco Bay. Coyote Creek has two reservoirs in the middle reaches, Coyote and Anderson Reservoirs. The creek flows for approximately 22 miles between the lowermost reservoir (i.e., Anderson Reservoir) and its confluence with San Francisco South Bay at Alviso Slough.

Coyote Creek flows through unincorporated land with predominantly agricultural land and recent urbanization in the reach between the Cities of Morgan Hill and San Jose. The upper section of Coyote Creek is buffered by Santa Clara County Park land, with densely vegetated flood prone areas. The middle reaches of Coyote Creek are a relatively incised channel that flow through dense urban areas of San Jose. The lower reaches of Coyote have been partially modified for flood protection with setback levees and high-flow bypass channels.

Stream flow in Coyote Creek is extensively regulated by Anderson Dam. The creek also has a small dam that creates Metcalf Percolation Pond. Downstream of the ponds, the stream channel often runs dry, or flows intermittently during the dry season (SCVURPPP 2003). The lower reaches of Coyote Creek are fed by groundwater and urban runoff, as well as tributary flow. Upper Penitencia Creek, Lower Silver - Thompson Creek, and Upper Silver Creek are the largest tributaries that empty into the lower reaches of Coyote Creek below Anderson Dam.

3.2 Existing Sediment Toxicity Data

3.2.1 Sediment Quality Triad Pilot Study (WY 2007 – WY 2008)

During Water Year (WY) 2007 and WY 2008, the Program conducted the Sediment Quality Triad (SQT) Pilot Study as part of the Program's Multi-Year Receiving Waters Monitoring Plan (SCVURPPP 2008). The SQT Study used a weight of evidence (WOE) approach to evaluate bedded sediment chemistry, sediment toxicity, benthic macroinvertebrate (BMI) community and physical habitat data. The SQT approach was implemented to better evaluate relationships between BMIs and stressor variables, and to identify potential causes of aquatic life use impacts in creeks within the Santa Clara Valley.

In WY 2007, the Program collected bedded sediments for toxicity testing at six locations along the mainstem of Coyote Creek during two sampling events: September 2006 and May 2007. In WY 2008, sediment samples were collected for toxicity testing at four locations on Coyote Creek mainstem during two sampling events: October 2007 and April 2008. During the April 2008 sampling event, sediment samples were also collected for toxicity testing from two major tributaries to Coyote Creek, with two sites in Upper Penitencia Creek and two sites in Lower Silver-Thompson Creek. Station locations (latitude and longitude) and sample periods are listed in Table 2. Stations are mapped in Figure 2.

The toxicity of sediments collected over the two years from the ten monitoring locations were evaluated by exposing the amphipod, *Hyalella azteca,* to the collected sediments in a standard ten-day survival test (EPA method 600-R-99/064). In WY 2007, significant toxicity was observed in sediments collected at 5 of the 6 sites during the fall 2006 sampling event. Toxicity was not observed at any of the sites during the spring 2007 sampling event (Figure 1). In WY 2008, significant toxicity was observed in sediments collected at 4 of 8 sites during the fall 2007 and/or spring 2008 sampling events. Sediment samples from the two lowest elevation sites on the Coyote Creek mainstem (COY080 and COY240) had significant toxicity during both water years (Figure 1).

Sediment samples were also analyzed for total recoverable metals and a suite of pyrethroid pesticides. The PECs[1] for metals and LC50s[2] for pyrethroids were used to assess sediment contamination. Metal concentrations were consistently below PECs for all samples, with the exception of nickel, which occurs naturally in Bay Area soils. The co-occurrence of pyrethroid concentrations above LC50s and sediment toxicity in samples collected during spring 2008 sampling event suggests that pyrethroids may have caused (at least partially) the toxicity at those sites. In particular, either Bifenthrin or Cypermethrin concentrations were above levels that one would expect to observe a significant toxic response (i.e., LC50s) at three sites (Table 3).

Table 2. Sampling locations and date of sediment collected for toxicity testing for SCVURPPP Sediment Quality Triad Study.

Station ID	Sampling Location	Latitude	Longitude	Sediment Toxicity Sampling Event			
				9/2006	5/2007	10/2007	4/2008
205COY060	Coyote Creek at Montague Exp	37.39540	-121.91485	x	x		
205COY080	Coyote Creek at Oakland Ave	37.37778	121.89455	x	x	x	x
205COY240	Coyote Creek at Williams Park	37.33575	121.86707	x	x	x	x
205COY330	Coyote Creek at Hellyer Park	37.29000	121.81801	x	x	x	x
205COY400	Coyote Creek at Metcalf Rd	37.22429	121.74741	x	x	x	x
205COY460	Coyote Creek at Osier Ponds	37.17705	121.68516	x	x		
205COY090	Upper Penitencia Cr at Flea Market	37.37080	121.87660				x
205COY130	Upper Penitencia Cr at Quail Hollow	37.39420	121.81250				x
205COY180	Lower Silver Cr at Wooster Ave.	37.35548	121.87052				x
205COY200	Thompson Cr at Quimby Road	37.32423	121.80757				x

[1] The Probable Effects Concentrations (PEC) represent concentrations of metals above which one would expect to observe some degree of toxic response (MacDonald et al. 2000)

[2] A concentration of a chemical that is lethal to 50% of test organisms exposed

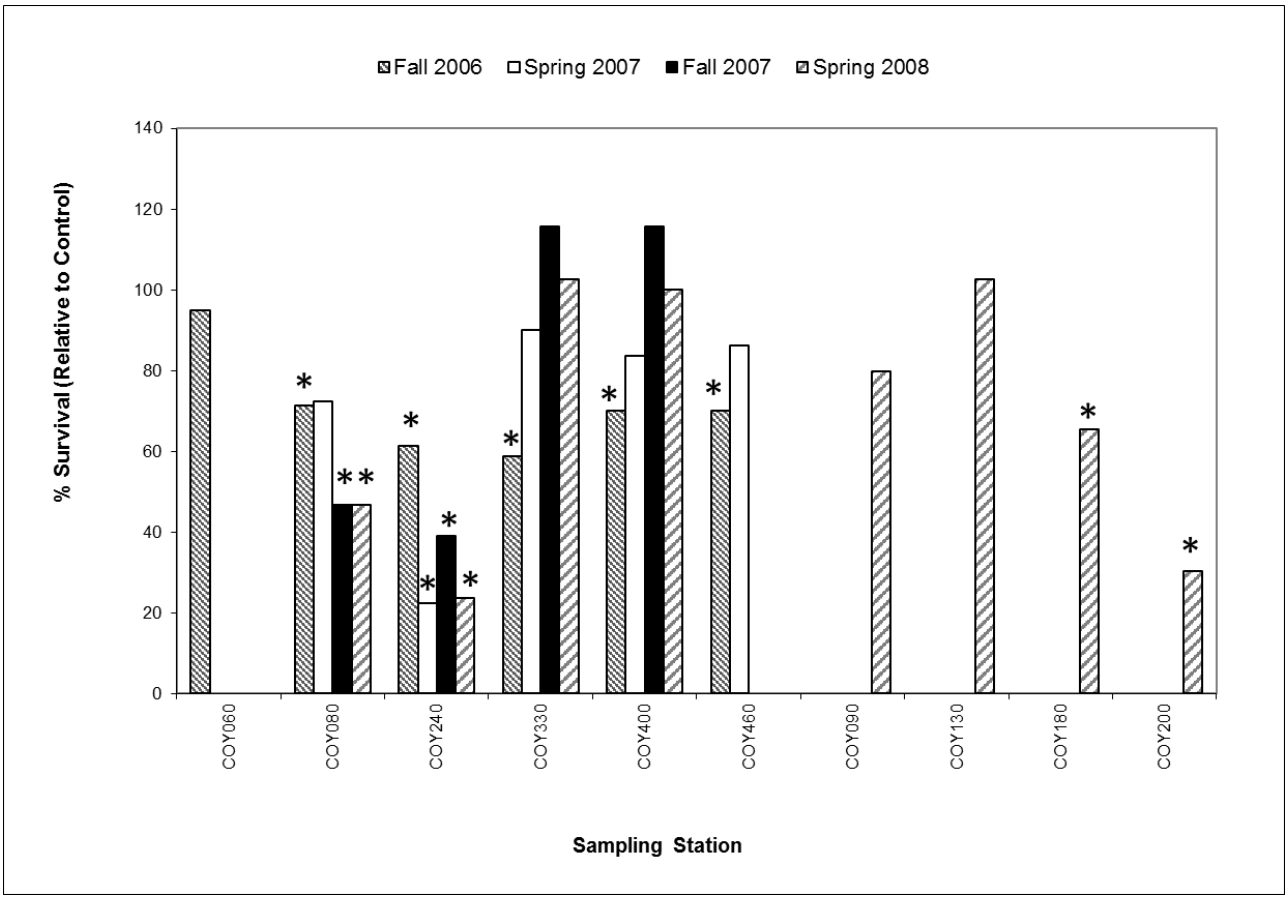

Figure 1. *Hyalella azteca* 10 day survival bioassay results. Star indicates significantly reduced survival compared to lab control.

Table 3. A comparison of sediment toxicity occurrences and pyrethroid pesticide detections in bedded sediment samples collected in Coyote Creek and Lower Penitencia Creek watersheds in spring 2008.

Sampling Site	Sediment Toxicity (% Survival Relative to Control)	Pyrethroid Concentration Greater than LC50[1]			
		Bifenthrin	Cyfluthrin	Cypermethrin	L-Cyhalothrin
Coyote Creek					
COY080	Yes (47%)	Yes (1.22)	-	-	-
COY240	Yes (24%)	Yes (1.25)	No (0.29)	Yes (1.21)	No (0.03)
COY330	No	-	-	-	-
COY400	No	-	-	-	-
Coyote Creek Tributaries					
COY090	Yes (80%)	No (0.61)	-	-	-
COY130	No	-	-	-	-
COY180	Yes (65%)	-	-	Yes (1.25)	-
COY200	Yes (30%)	No (0.96)	-	No (0.33)	-

[1]Dash (-) = pyrethroid not detected.

3.2.2 Stream Pollution Trends Monitoring (SPoT) (WY 2008 - WY 2015)

The Stream Pollution Trends Program (SPoT) is a core component of the Surface Water Ambient Monitoring Program (SWAMP) that conducts statewide monitoring to provide information on the health of California waterways with respect to sediment toxicity and contamination (Phillips et al. 2015). SPoT data is used by the California Water Boards to assess the levels to which aquatic life beneficial uses are supported in California streams and rivers.

The SPoT Program has annually conducted monitoring of sediment chemistry and toxicity testing at site 205COY060 (Coyote Creek at Montague Expressway) since 2008. The toxicity of sediments are evaluated by exposing the amphipod, *Hyalella azteca,* to the collected sediments in a standard ten-day survival test (EPA method 600-R-99/064). Between 2011 and 2013, SPoT conducted two sampling events each year, typically during the month of July and again during September/October. Only ten percent (one of ten) of the sediment samples collected since 2010 were significantly toxic AND the percent effect was greater than 20% reduction in *Hyalella azteca* growth compared to the Lab Control (Table 4). None of the sediment samples collected since 2010 met this criteria for *Hyalella azteca* survival.

Between 2011 and 2013, SPoT conducted sediment toxicity tests using two different temperature treatments. For five sampling events, toxicity tests were conducted at the standard temperature defined in the EPA protocol (23°C) and at a lower temperature (15°C) to better evaluate potential toxic effects on *Hyalella azteca* from pyrethroids. Sediment toxicity tests run at the lower temperature exhibited significant toxicity and exceeded the percent effect threshold (< 20% relative to control sample) for all five sampling events conducted at 205COY060.

Over the past eight years (2008-2014), there has been a significant trend of increasing amphipod (*H. azteca*) survival in toxicity tests at site 205COY060 (Phillips et al 2016). In addition, there was no significant increase in pyrethroid concentrations over the eight-year review period. It is not clear if the overall decline in toxicity at the Coyote site (using the EPA method) reflects a decrease in pyrethroid concentrations in the sediment over time. Recent monitoring results in SPoT monitoring stations in California (including Coyote Creek) have detected other contaminants of emerging concern (i.e., fipronil). In 2015, SPoT initiated use of a new test organism (i.e., *Chironomus dilutus*) to assess potential toxic effects associated with fipronil.

Table 4. Toxicity testing results for 12 sediment samples collected between 2008 and 2016 by the SPoT Program at Coyote Creek site 205COY060.

Year	Date	Significant Toxicity and > 20% Effect Threshold	
		Growth	Survival
2008	6/17/2008	X	
2009	6/16/2009	X	X
2010	6/30/2010		
2011	7/21/11		
2011	10/21/11		
2012	7/5/2012		
2012	9/19/2012		
2013	1/3/2013		
2013	7/2/2013		
2014	6/25/2014		
2015	7/1/2015	X	
2016	7/19/2016		

3.2.3 Creek Status Monitoring for MRP (WY 2012 – WY 2014)

The Program conducted sediment sampling and toxicity testing as part of the Creek Status Monitoring project in compliance with the MRP (1.0) requirements. Sampling was conducted at three sites on the Coyote Creek mainstem, one site in Upper Penitencia Creek, and one site in Lower Silver-Thompson Creek (Table 4). Sites are mapped in Figure 2. Significant toxicity combined with percent effect that was greater than 20% reduction in survival (compared to Lab Control) was reported for sediment samples collected at two sites on Coyote Creek during WY 2013 (SCVURPPP 2014).

The PECs for metals and LC50s for pyrethroids were used to assess sediment contamination. Metal concentrations were consistently below PECs for all samples, with the exception of nickel and cadmium, both of which occur naturally in Bay Area soils. None of the pyrethroid concentrations were above the LC50 threshold for toxic effects.

Table 5. Toxicity testing results for 5 sediment samples collected in Coyote Creek Watershed between 2012 and 2014 by SCVURPPP as part of the Creek Status Monitoring Program. Two of the five samples exhibited significant toxicity and were more than 20% less than control sample.

Station Code	Creek	Date	Significant Toxicity and > 20% Effect Threshold	
			Growth	Survival
205R00035	Upper Penitencia Cr	7/25/2012		
205R00042	Coyote Creek	7/25/2012		
205R00451	Coyote Creek	7/9/2013		X
205R00474	Coyote Creek	7/9/2013		X
205R00979	Lower Silver Cr	6/4/2014		

3.2.4 Upper Penitencia Creek SSID Project (WY 2016)

The Program collected sediment samples on May 2016 at two locations (205COY114 and 205COY121) in Upper Penitencia Creek as part of the Upper Penitencia Creek SSID Project. Samples were tested for sediment toxicity and analyzed for pyrethroid pesticides. Sediment toxicity testing was performed on two species, *Hyalella azteca* and *Chironomus dilutus* using acute endpoints (i.e., survival). No significant toxicity was observed from samples collected at either site. All pyrethroid pesticides detected in the sediment samples were well below the LC50 threshold concentrations (SCVURPPP 2017).

The location of all sediment toxicity monitoring stations in the Coyote Creek watershed that have been sampled by SPoT and SCVURPPP between 2008 and 2016 are shown in Figure 2.

3.3 Probable Cause

Over the past ten years, pyrethroid pesticides have become the predominant group of chemicals deployed for insect control in urban areas in California, and are the primary cause of toxicity in urban water bodies in the state. Ruby (2013) compiled and summarized chemistry data from monitoring performed in urban areas of California for pyrethroid and fipronil pesticides, as well as related toxicity testing results, covering the ten year period from 2003-2012. These studies showed that pyrethroids are linked to toxicity to the amphipod *Hyalella azteca* in water and sediment samples from urban creeks in all of California's major urban areas. Bifenthrin was the most frequently detected pyrethroid (64% of water samples, 69% of sediment samples) and the greatest contributor to toxic potency in both water and sediment samples collected from urban creeks (Ruby 2013). Average concentrations for seven pyrethroids that were reported in the study were substantially greater than the published LC50 values.

The study also showed that Fipronil, a common pyrethroid replacement pesticide, is also found in substantial numbers of water and sediment samples (Ruby 2013). The maximum reported concentrations for fipronil and its degradates in water samples are well above the USEPA benchmarks. Similarly, the maximum reported concentrations of fipronil and its degradates in sediment samples are well above published toxicity (LC50) values.

Linkage between toxicity and pyrethroids have also been observed in studies conducted in San Francisco Bay urban streams. Toxicity was observed to the test species Hyalella azteca synoptically with adverse effects levels of pyrethroids in both water and sediment samples collected in two urban streams in Contra Costa County (CCCWP 2014). Similar association between sediment toxicity and pyrethroids was observed in a toxicity study conducted by SCVURPPP in Stevens Creek, Santa Clara County (SCVURPPP 2008). Summary results from toxicity data in Coyote Creek (presented in Section 3.2) also indicate pesticide related toxicity.

The Coyote Toxicity SSID Project will focus on evaluating if sediment toxicity is present in Coyote Creek and if so, evaluate pesticides as the stressor that may be causing the toxicity.

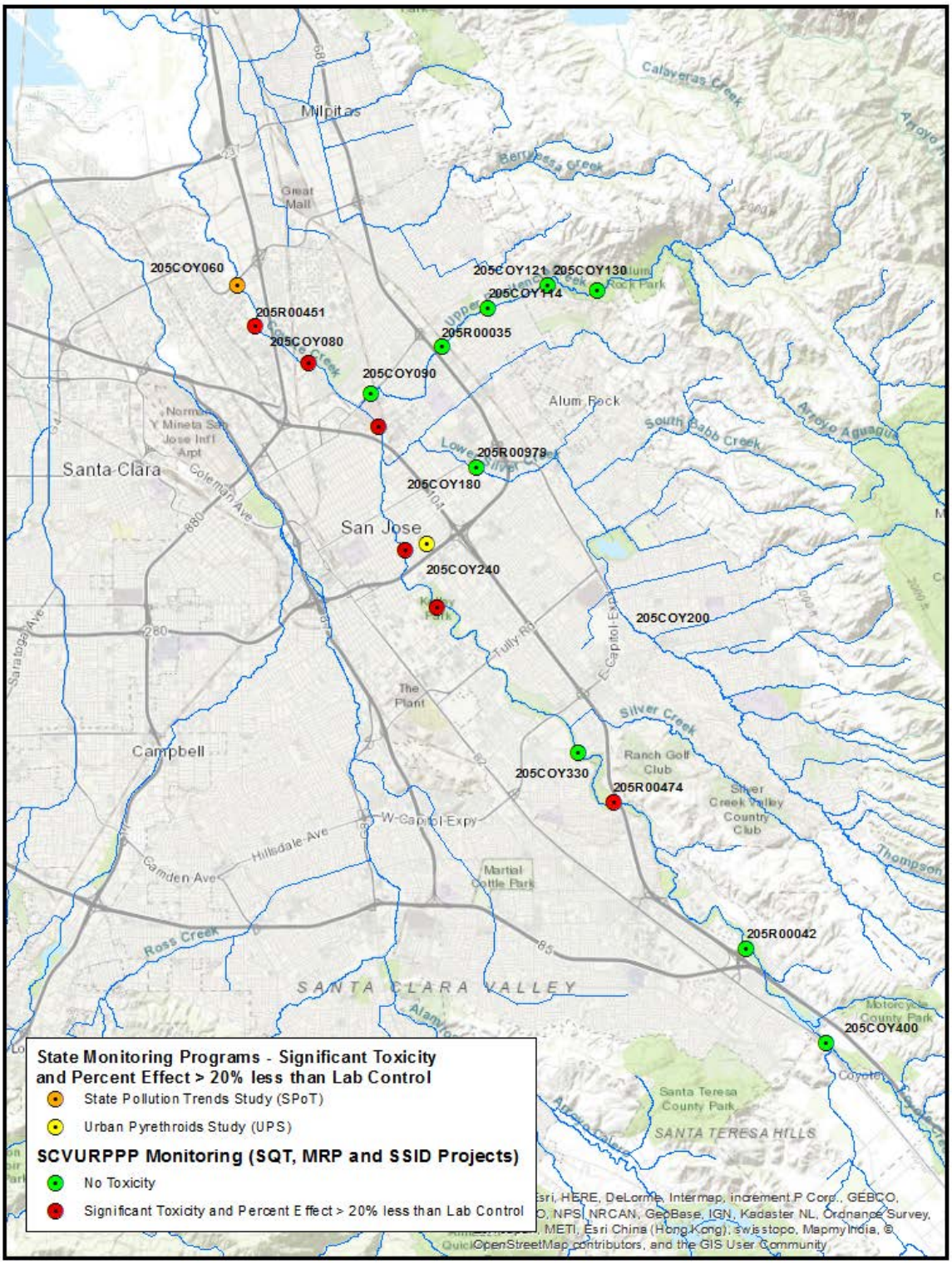

Figure 2. Monitoring locations for sediment toxicity data collected by SWAMP and SCVURPPP between 2008 and 2015.

4.0 SSID MONITORING APPROACH AND SCHEDULE

The Program will implement an adaptive monitoring approach to further investigate potential sources and causes of sediment toxicity in Coyote Creek. The approach is described below and illustrated as a flow diagram in Figure 3 . The approach is consistent with Section C.8.e.iii.(1)(f) of the MRP, which states:

"*Conduct a site specific study (or non-site specific if the problem is wide-spread) in a stepwise process to identify and isolate the cause(s) of the trigger stressor/source…..for toxicity studies where there is no chemical pollutant associated with the creek status monitoring sample exhibiting toxicity, a TIE should be conducted. Where chemical data indicate a pollutant, such as fipronil or a pyrethroid, is present at adverse effects levels in the sample location, it is not necessary to conduct a TIE, and the SSID project would be considered complete*."

The Coyote Toxicity SSID monitoring design includes an initial evaluation of sediment chemistry and toxicity testing during the dry season of WY 2018. Toxicity testing will be conducted using *Hyallela azteca* and *Chironomus dilutes* for acute toxicity. Sediment chemistry will be analyzed for metals and pesticides, including fipronil and pyrethroids. The Program will evaluate sediment chemistry results for adverse effects using analytical methods described in Section 4.4 below. In summary, if results indicate the following, the described next steps will be implemented.

- If toxicity tests exhibit **significant toxicity** and percent effect is greater than 20% reduction in survival (compared to the Lab Control) **AND** sediment chemistry results indicate the presence of pyrethroid or fipronil **pesticide at adverse effects levels** (i.e., greater than LC50 threshold), then the **SSID project will be considered complete**.

- If toxicity tests exhibit **significant toxicity**, **BUT the sediment chemistry results are inconclusive**, the Program will implement a **Toxicity Identification Evaluation** (TIE) consistent with guidance provided in the EPA sediment TIE manual (EPA/600/R-08/080). The TIE will consist of a series of treatments designed to identify the type of chemicals that may be causing toxicity (Anderson 2009). The Program will implement a TIE that includes three targeted tests: 1) Baseline sample (i.e., re-test of sample); 2) Activated Carbon (i.e., general organic contaminants); and 3) Cationic Resin (metals). The TIE will confirm toxicity is present (or not), and the type of contaminant (i.e., metal and/or organic) that may be causing the toxicity. TIEs are more effective when there is sufficient toxicity in the sample. Thus, a TIE will only be conducted for samples that exhibit toxicity with percent effect that is greater than 50% reduction in survival (compared to Lab Control). A maximum of one TIE will be conducted at two sites (total of two TIEs) for the SSID Project, providing all sites meet the 50% reduction in survival criterion. The TIE(s) will be conducted immediately following receipt of the sediment chemistry laboratory.

All toxicity testing, sediment chemistry results and TIE results from WY 2018 will be evaluated prior to any additional monitoring is considered for WY 2019.

Potential for Near-term Delisting

The potential for delisting Coyote Creek for toxicity even if no toxicity were observed during the study, appears to be challenging. Using the Water Board's 303(d) listing policy binomial distribution, a large number of samples with no toxicity would be required to effectively de-list Coyote Creek for sediment toxicity, considering the number of toxicity observations that have been documented over the course of the last decade. The Water Board 303(d) listing policy identifies 28-36 samples with no toxicity would be needed to de-list a waterbody that has two observations of toxicity (SWQCB 2015). This number would be larger due to additional exceedences that have occurred in Coyote Creek since the listing was made in 2008.

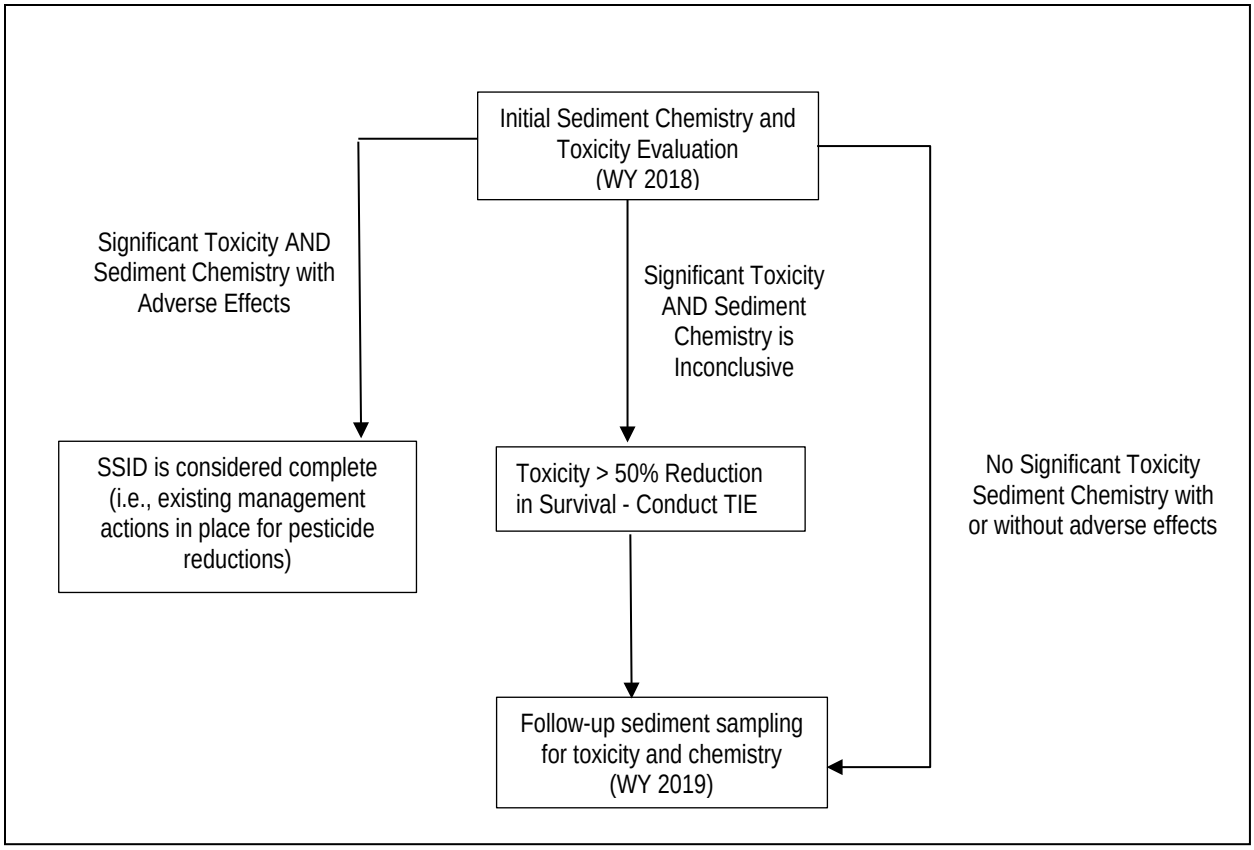

Figure 3. Adaptive monitoring approach used for the Coyote Toxicity SSID Project.

4.1 Sampling Locations

In WY 2018, bedded sediments will be collected at **five stations** that are located within the reach of the Coyote Creek mainstem that extends from Montague Expressway upstream to Kelley Park (south of Story Road). Samples will be collected at three stations that previously exhibited sediment toxicity in 2008. Sediment toxicity data that were used to determine the recommended 303(d) listing were collected at two of these stations. Sediment samples will also be collected at two stations with no previous toxicity data, but are within the reach of interest. Sampling location information is provided in Table 6 and illustrated in Figure 4.

Table 6. Sampling locations in WY 2018 for sediment chemistry and toxicity testing in Coyote Creek mainstem as part of the Coyote Toxicity SSID Project.

Station ID	Sampling Location	Lat	Long	Sampling History
205COY060	Coyote Creek at Montague Exp	37.39540	121.91485	SPoT monitoring site (2008 to present); tox data from 2008 used for 303(d) listing
205COY080	Coyote Creek at Oakland Ave	37.37778	121.89455	SCVURPPP SQT Study monitoring site; tox data collected in 2007 and 2008
205COY165	Coyote Creek at Maybury	37.36341	121.87445	New site located below confluence of Lower Silver Creek; (note:two sites on Lower Silver were toxic in SQT Study)
205COY240	Coyote Creek at Williams Park	37.33575	121.86707	Urban Pyrethroid Study monitoring site; tox data from 2007 used for 303(d) listing; SCVURPPP SQT Study monitoring site; tox data collected in 2007 and 2008
205COY250	Coyote Creek at Kelley Park	37.32444	-121.85983	New site; upstream extent of SSID Study Reach

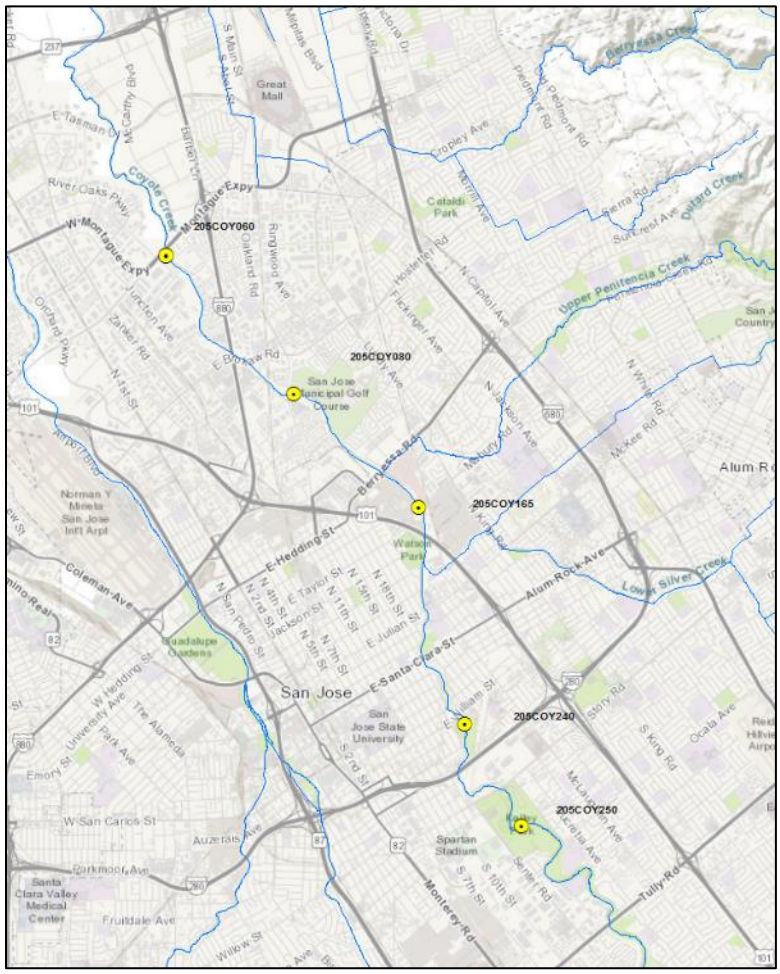

Figure 4. Sampling locations in WY 2018 for sediment chemistry and toxicity testing in Coyote Creek mainstem as part of the Coyote Toxicity SSID Project.

4.2 Schedule

One sampling event will occur during the dry season of WY 2018 (May-September 2018). The sampling event will be coordinated with a sediment sampling event that is planned for SCVURPPP's Pesticide and Toxicity Monitoring Project for WY 2018. The need for additional sampling events will be assessed following analyses of data collected in WY 2018. Additional monitoring activities, if deemed necessary, will be described in a revised Coyote Toxicity SSID Work Plan.

4.3 Field Monitoring Methods

Field sampling procedures will be conducted by Kinnetic Laboratories Inc. from Santa Cruz. Bedded sediment samples will be collected at each of the five sites for sediment chemistry and toxicity testing during the dry season of WY 2018. Sample collection will follow protocols described in RMC Quality Assurance Project Plan (QAPP; BASMAA 2016a) and RMC Standard Operating Procedures (BASMAA 2016b). A summary of the field methods is described below.

Water quality measurements will be collected at each site using a multi-parameter probe to measure temperature, pH, dissolved oxygen (DO) and specific conductance. Water quality measurements, field observations of water quality (e.g., odor, clarity, color, etc.), and site information (e.g., GPS coordinates, stream width and depth) will be recorded on a SWAMP field data sheet for each sampling event.

Prior to sediment sampling, field personnel will survey the proposed sampling area for appropriate fine-sediment depositional areas. Personnel will carefully enter the stream to avoid disturbing sediment at collection sub-sites. Sediment samples are collected from the top 2 cm at each sub-site beginning at the downstream-most location and continuing upstream. Sediment samples will be placed in a compositing container, thoroughly homogenized, and then aliquoted into separate jars for chemical or toxicological analysis using standard clean sampling techniques.

The sediment sample volumes and containers required for each analyte and/or test are listed in Table 7. All samples will be placed on ice, and delivery of samples to the analytical laboratory will be under chain-of-custody (COC) within specified hold time requirements. Sediment samples will be submitted to Caltest Analytical Laboratory in Napa for chemical analyses and to Pacific EcoRisk in Fairfield for toxicity testing.

Table 7. Containers and handling requirements for bedded sediment samples.

Analyte	Container	Hold Times	Handling Requirements
Sediment Toxicity	4L wide mouth glass	14 days	Preserved with ice, stored at 4°C
Pyrethroids and Fipronil	8 oz. amber glass jar	14 days	
Metals			
% Solids			
Total Organic Carbon	8 oz. amber glass jar	28 days	
Sediment Grain size			

4.4 Testing and Analytical Methods

Sediment samples will be analyzed using methods and reporting limits shown in Table 8. Sediment will be analyzed for pyrethroid and fipronil pesticides and metals. Sediment toxicity testing will be performed on *Hyalella azteca* and *Chironomus dilutus* using 10-Day acute endpoints (i.e., survival).

Data evaluation 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) to the laboratory control endpoints. A Percent Effect that is > 20 % survival (compared to Lab Control) is the threshold used to determine adverse effects. Both the TST result and the Percent Effect are determined by the laboratory.

Table 8. Analytical constituents, methods and reporting limits used for sediment samples collected for the Coyote Toxicity SSID Project.

Analyte	Analytical Method	Reporting Limit	Contracting Lab
TOTAL RECOVERABLE METALS (µg/kg)			
Arsenic	EPA 6020	500	*Caltest*
Cadmium		40	
Chromium		100	
Copper		200	
Lead		100	
Nickel		100	
Zinc		1000	
Total Organic Carbon* (%)	EPA 9060	0.1	
Sediment Grain Analysis* (%)	ASTM D422M/PSEP	1	
Percent Solids	EPA 160.3	NA	
Pyrethroid Pesticides, including fipronil (ug/kg)	SW846 8270 Mod (GCMS-NCI-SIM)	0.33	
TOXICITY TESTING			
10-Day *Hyalella azteca* acute	EPA-600-R-99-064 2nd Edition	NA	*Pacific EcoRisk*
10-day *Chrironomus dilutus* acute	EPA-600-R-99-064 2nd Edition	NA	

** Analysis done by subcontracting lab*

Consistent with MRP Provision C.8.g.iv, sediment sample results will be 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 is equal to or greater than 1.0 will be identified.

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 Santa Clara Valley. All sites in Santa Clara 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 should be considered when interpreting the data.

Toxicity unit (TU) equivalents for individual pyrethroid and fipronil results are based on available literature values for the LC50 values for these pesticides.[3] Because organic carbon mitigates the toxicity of pyrethroid pesticides in sediments, the LC50 values were derived on the basis of total organic carbon (TOC)-normalized concentrations. Therefore, the pesticide concentrations as reported by the lab will be divided by the measured TOC concentration at each site, and the TOC-normalized concentrations will be used to compute TU equivalents for each constituent.

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

4.5 Quality Assurance

Quality Assurance/Quality Control (QA/QC) analyses include levels of precision and accuracy, and tolerable levels of error as presented in detail in the RMC QAPP (BASMAA et al., 2016a). Caltest Laboratories will perform all chemical analyses and Pacific EcoRisk (PER) will perform all toxicology analyses in accordance with the RMC QAPP and their respective quality assurance programs.

The sediment toxicity sampling event for the Coyote Toxicity SSID Project will be coordinated with sediment sampling associated with the Pesticide and Toxicity Monitoring (PTM) Project. As a result, the Coyote Toxicity SSID Project will not require the collection of field QA/QC samples. Since the samples collected for the Coyote Toxicity SSID Project will be in the same batch as the PTM Project, the same Reference Toxicant Test will be used.

4.6 Reporting

If the monitoring results from WY 2018 suggest further sampling and investigation is warranted, the Program will develop a revised Work Plan that will summarize results from WY 2018 and describe additional monitoring work to be conducted. If monitoring results suggest that Coyote Toxicity SSID project is complete, the Program will prepare a Final Report with data results and interpretation and will submit the Final Report to the Water Board on March 31, 2019 with the WY 2019 Urban Creeks Monitoring Report.

5.0 REFERENCES

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

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Appendix E

SCVURPPP Pollutants of Concern Data Report, Water Year 2017

Santa Clara Valley
Urban Runoff
Pollution Prevention Program

Pollutants of Concern Monitoring - Data Report

Water Year 2017

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

March 31, 2018

This report is submitted by the agencies participating in the

Santa Clara Valley
Urban Runoff
Pollution Prevention Program

City of Campbell	City of Milpitas	City of Santa Clara
City of Cupertino	City of Monte Sereno	City of Saratoga
City of Los Altos	City of Mountain View	City of Sunnyvale
Town of Los Altos Hills	City of Palo Alto	County of Santa Clara
Town of Los Gatos	City of San Jose	Santa Clara Valley Water District

Prepared for:

Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP)

Prepared by:

EOA, Inc.
1410 Jackson St., Oakland, CA 94612

LIST OF ACRONYMS

BASMAA	Bay Area Stormwater Management Agency Association
BMP	Best Management Practice
CADDIS	Causal Analysis/Diagnosis Decision Information System
CEC	Contaminants of Emerging Concern
CEDEN	California Environmental Data Exchange Network
MRP	Municipal Regional Permit
NPDES	National Pollution Discharge Elimination System
PBDEs	Polybrominated Diphenyl Ethers
PCBs	Polychlorinated Biphenyls
PFAS	Perfluoroalkyl Sulfonates
PFOS	Perfluorooctane Sulfonates
POC	Pollutant of Concern
RMP	Regional Monitoring Program
RWSM	Regional Watershed Spreadsheet Model
SAP	Sampling and Analysis Plan
SCVURPPP	Santa Clara Valley Urban Runoff Pollution Prevention Program
SFEI	San Francisco Estuary Institute
SPoT	Statewide Stream Pollutant Trend Monitoring
SSC	Suspended Sediment Concentration
SSID	Stressor/Source Identification
STLS	Small Tributary Loading Strategy
SWAMP	Surface Water Ambient Monitoring Program
TOC	Total Organic Carbon
USEPA	US Environmental Protection Agency
WY	Water Year

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1.0 INTRODUCTION

This Pollutants of Concern Monitoring - Data Report (POC Data Report) was prepared by the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP or Program) on behalf of its 15 member agencies (13 cities/towns, the County of Santa Clara, and the Santa Clara Valley Water District) subject to the National Pollutant Discharge Elimination System (NPDES) stormwater permit for Bay Area municipalities, referred to as the Municipal Regional Permit (MRP). The MRP was issued by the San Francisco Regional Water Quality Control Board (Regional Water Board) on November 19, 2015 as Order R2-2015-0049. This report fulfills the requirements of Provision C.8.h.iii of the MRP for reporting a summary of MRP provision C.8.f POC Monitoring conducted during Water Year (WY) 2017.[1]

This POC Data Report builds on the POC Monitoring Reports that were submitted to the Regional Water Board on October 15, 2017 (SCVURPPP 2017a). In accordance with Provision C.8.h.iv, the POC Monitoring Report included POC monitoring locations, number and types of samples collected, purpose of sampling (i.e., Management Questions addressed), and analytes measured (SCVURPPP 2017a). The October 15, 2017 POC Monitoring Report also described the allocation of sampling effort for POC monitoring planned for WY 2018.

This POC Data Report is included as an appendix to the WY 2017 Urban Creeks Monitoring Report (UCMR) which was submitted to the Regional Water Board on March 31, 2018. Consistent with MRP Provision C.8.h.ii, POC monitoring data generated from sampling of receiving waters (e.g., creeks) were submitted to the San Francisco Bay Area Regional Data Center for upload to the California Environmental Data Exchange Network (CEDEN).[2]

1.1 POC Monitoring Requirements

Provision C.8.f of the MRP requires monitoring of several POCs including polychlorinated biphenyls (PCBs), mercury, copper, emerging contaminants[3], and nutrients. POC monitoring is conducted on a Water Year (WY) basis. Provision C.8.f specifies yearly (i.e., WY) and total (i.e., permit term) minimum numbers of samples for each POC. In addition, POC monitoring must address the five priority management information needs (i.e., Management Questions) identified in C.8.f:

1. **Source Identification** – identifying which sources or watershed source areas provide the greatest opportunities for reductions of POCs in urban stormwater runoff;
2. **Contributions to Bay Impairment** – identifying which watershed source areas contribute most to the impairment of San Francisco Bay beneficial uses (due to source intensity and sensitivity of discharge location);
3. **Management Action Effectiveness** – providing support for planning future management actions or evaluating the effectiveness or impacts of existing management actions;
4. **Loads and Status** – providing information on POC loads, concentrations or presence in local tributaries or urban stormwater discharges; and

[1] Most hydrologic monitoring occurs for a period defined as a water year, which begins on October 1 and ends on September 30 of the named year. For example, water year 2017 (WY 2017) began on October 1, 2016 and concluded on September 30, 2017.

[2] CEDEN has historically only accepted and shared data collected in streams, lakes, rivers, and the ocean (i.e., receiving waters). In late-2016, we were notified that there were changes to the types of data that CEDEN would accept and share. However, there is still some uncertainty and until the changes are clarified, SCVURPPP will continue to submit only receiving water data to CEDEN.

[3] Emerging contaminant monitoring requirements will be met through participation in the Regional Monitoring Program for Water Quality in the San Francisco Estuary (RMP) special studies. The special studies will account for relevant Contaminants of Emerging Concern (CECs) in stormwater and will address at least PFOS, PFAS, and alternative flame retardants being used to replace PBDEs.

5. **Trends** – providing information on trends in POC loading to the Bay and POC concentrations in urban stormwater discharges or local tributaries over time.

The MRP specifies the minimum number of samples that must be collected and analyzed for each POC. For example, over the first five years of the permit, a minimum total of 80 PCBs samples must be collected and analyzed. On average 16 PCBs samples should be collected per year to meet the total requirement of 80 samples; however, the Permit requires a minimum of at least 8 PCB samples per year which gives flexibility to collect more samples some years and less other years. The MRP also specifies the minimum number of samples for each POC that must address each Management Question. For example, by the end of Year Four[4] of the permit term, each of the five Management Questions must be addressed with at least 8 PCB samples. It is possible that a single sample can address more than one Management Question. POC Monitoring requirements are summarized in Table 1. In addition to the required yearly and cumulative total number of samples, Table 1 lists the yearly average number of samples that would need to be analyzed to meet the total sample goal, a good benchmark to consider when planning annual sampling goals.

Other MRP provisions require studies or have information needs that could be addressed through Provision C.8.f (POC Monitoring) and for which related samples will count towards POC monitoring requirements. These other Permit provisions and their associated timelines are listed below.

- Provisions C.11.a.iii and C.12.a.iii require that Permittees provide a list of management areas (referred to in this report as Watershed Management Areas, or WMAs) in which new mercury and PCB control measures will be implemented during the permit term. The most recent POC Control Measures Plan (Version 2.0) (SCVURPPP 2017b) was submitted with the 2017 Annual Report on September 30, 2017 and will be updated with each subsequent Annual Report per Provision C.11.a.iii(3). Provision C.8.f (POCs Monitoring) supports C.11.a/12.a requirements by requiring monitoring directed toward source identification (i.e., identifying which WMAs provide the greatest opportunities for implementing controls to reduce loads of POCs in urban stormwater runoff and source areas within the WMAs).

- Provision C.12.e requires that Permittees collect at least 20 composite samples (region-wide) of the caulks and sealants used in storm drains or roadway infrastructure in public rights-of-way. Results of the investigation must be reported with the 2018 Annual Report, due by September 30, 2018. SCVURPPP is participating in a Bay Area Stormwater Management Agencies Association (BASMAA) regional project to address this requirement. The Final Study Design was approved by the BASMAA Project Management Team (PMT) in June 2017, sample collection was conducted in November and December 2017, and a report summarizing results of the study is anticipated for submittal with the 2018 Annual Report on September 30, 2018.

[4] Note that the minimum sampling requirements addressing information needs must be completed by the end of year four of the permit; whereas, the minimum number of total samples does not need to be met until the end of year five of the permit.

Table 1. MRP Provision C.8.f Pollutants of Concern monitoring requirements.

Pollutant of Concern	Media	Total Samples[d]	Yearly Minimum	Yearly Average	Minimum # of Samples that Must be Collected for Each Information Need by the End of Year Four				
					Source Identification	Contributions to Bay Impairment	Management Action Effectiveness	Loads and Status	Trends
PCBs	Water or sediment	80	8	16	8	8	8	8	8
Total Mercury	Water or sediment	80	8	16	8	8	8	8	8
Total & Dissolved Copper	Water	20	2	4	--	--	--	4	4
Nutrients[a]	Water	20	2	4	--	--	--	20	--
Emerging Contaminants[b]	--	--	--	--	--	--	--	--	--
Ancillary Parameters[c]	--	--	--	--	--	--	--	--	--

a. Ammonium[5], nitrate, nitrite, total Kjeldahl nitrogen, orthophosphate, total phosphorus (analyzed concurrently in each nutrient sample).

b. Must include perfluorooctane sulfonates (PFOS, in sediment), perfluoroalkyl sulfonates (PFAS, in sediment), alternative flame retardants. The Permittee shall conduct or cause to be conducted a special study that addresses relevant management information needs for emerging contaminants. The special study must account for relevant Contaminants of Emerging Concern (CECs) in stormwater and would address at least PFOS, PFAS, and alternative flame retardants being used to replace PBDEs.

c. Total Organic Carbon (TOC) should be collected concurrently with PCBs data when normalization to TOC is deemed appropriate. Suspended sediment concentration (SSC) should be collected in water samples used to assess loads, loading trends, or Best Management Practice (BMP) effectiveness. Hardness data are used in conjunction with copper concentrations collected in fresh water.

d. Total samples that must be collected over the five-year Permit term.

[5] There are several challenges to collecting samples for "ammonium" analysis. Therefore, samples are analyzed for total ammonia which is the sum of un-ionized ammonia (NH3) and ionized ammonia (ammonium, NH4+). Ammonium concentrations are calculated by subtracting the calculated concentration of un-ionized ammonia from the measured concentration of total ammonia. Un-ionized ammonia concentrations are calculated using a formula provided by the American Fisheries Society that includes field pH, field temperature, and specific conductance. This approach was approved by Regional Water Board staff in an email dated June 21, 2016.

1.2 Third-Party Data

SCVURPPP strives to work collaboratively with our water quality monitoring partners to find mutually beneficial monitoring approaches. Provision C.8.a.iii of the MRP allows Permittees to use data collected by third-party organizations to fulfill monitoring requirements, provided the data are demonstrated to meet the required data quality objectives. For example, samples collected in Santa Clara County through the Regional Monitoring Program for Water Quality in the San Francisco Estuary (RMP) and the State's Stream Pollution Trends (SPoT) Monitoring Program may supplement the Program's efforts towards achieving Provision C.8.f monitoring requirements. Third party monitoring conducted by the RMP and SPoT also provide context for reviewing and interpreting SCVURPPP monitoring results.

The RMP's Small Tributary Loading Strategy (STLS) Team typically conducts annual monitoring for POCs on a region-wide basis. SCVURPPP is an active participant in the STLS and works with other Bay Area municipal stormwater programs to identify opportunities to direct RMP funds and monitoring activities towards meeting both short- and long-term municipal stormwater permit requirements. During WY 2013 – WY 2014 POC monitoring activities by the STLS focused on pollutant loading monitoring at six region-wide stations including two stations in Santa Clara County. In WY 2015, the loading stations were discontinued and STLS monitoring shifted to wet weather characterization in catchments of interest. In WY 2017, the STLS Team continued wet weather characterization sampling using a similar approach to the PCBs and mercury sampling that was implemented by the Program. In Santa Clara County, the STLS sampled two catchments for PCBs and mercury in WY 2017, six catchments in WY 2016, and eight catchments in WY 2015. STLS wet weather characterization data are described in Gilbreath et al. (2018, in preparation).

In WY 2017, the STLS Team also mobilized for a five-day high flow event at the bottom of the Guadalupe River watershed. McKee et al. (2018) describes monitoring methods and results from the five-day sampling event that occurred in January 2017. SFEI staff implemented an adaptive sampling strategy and captured a total of 14 mercury samples over five days. During that time, flow peaked three times in response to heavy and prolonged rainfall. One composite sample from the event was analyzed for PCBs.

The goal of the SPoT program is to monitor trends in sediment toxicity and sediment contaminant concentrations in selected large rivers throughout California, and relate contaminant concentrations and toxicity to watershed land uses. SPoT monitoring staff reported that both Coyote Creek (205COY060) and Guadalupe River (205GUA020) were monitored in June 2017. Sediment samples from both stations were analyzed for PCBs. The Guadalupe River sample was also analyzed for mercury and copper. Results of the WY 2017 SPoT monitoring are not yet available. The most recent report from this program describes 2008 – 2014 trends (Phillips et al. 2016). Results from these large catchment stations provide context for the monitoring conducted by the Program.

2.0 POC MONITORING RESULTS

In compliance with Provision C.8.f of the MRP, the Program conducted POC monitoring in WY 2017 for PCBs, mercury, copper, and nutrients. The MRP-required yearly minimum number of samples was met or exceeded for all POCs. The total number of samples collected for each POC, the agency conducting the monitoring, and the Management Questions addressed are listed in Table 2. Specific monitoring stations are listed in Table 3 (and Attachment 1 for sediment stations) and illustrated in Figure 1. The sections below describe the results of the monitoring accomplished in WY 2017. Compliance with applicable water quality standards is described in Section 3.0.

2.1 Statement of Data Quality

A comprehensive Quality Assurance/Quality Control (QA/QC) program was implemented by SCVURPPP covering all aspects of POC monitoring.

Monitoring for PCBs, mercury, and copper in water was performed according to protocols specified or referenced in the WY 2016 POC Sampling and Analysis Plan (SAP) (SCVURPPP 2015). Monitoring for PCBs and mercury in sediment was performed using methods similar to those implemented in WY 2015 for the reconnaissance sediment sampling program summarized in SCVURPPP (2016b). Both documents reference the Clean Watersheds for a Clean Bay (CW4CB) Quality Assurance Project Plan (QAPP; BASMAA 2013) as the basis for (QA/QC) procedures. Monitoring for nutrients in water was performed according to protocols specified in the BASMAA Standard Operating Procedures (SOPs) (BASMAA 2016a) and QAPP (BASMAA 2016b).

Data were assessed for seven data quality attributes, which include (1) Representativeness, (2) Comparability, (3) Completeness, (4) Sensitivity, (5) Contamination, (6) Accuracy, and (7) Precision. 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. Overall, the results of the QA/QC review suggest that most of the POC monitoring data generated during WY 2017 were of sufficient quality. Although, some data were flagged in the project database, none were rejected according to DOQs. However, most of the concentrations of mercury in water reported in WY 2017 were significantly lower than prior years (i.e., approximately ten-fold). There is no reason to expect lower mercury concentrations. The population monitored was similar to prior years (e.g., geographic, storm size, land use). Therefore, all mercury in water data were rejected by the Program Quality Assurance Officer (QAO). Details of the QA/QC review are provided in Attachment 2.

Table 2. SCVURPPP and Third-Party POC Monitoring Accomplishments in WY 2017.

Pollutant of Concern/ Agency	Number of Samples (WY2017)	Management Question Addressed [a]					Sample Type and Comments
		1. Source Identification	2. Contributions to Bay Impairment	3. Management Action Effectiveness	4. Loads and Status	5. Trends	
PCBs & Mercury							
SCVURPPP	17 [b]	17	17	--	17	--	Stormwater runoff samples to characterize high interest catchments
SCVURPPP	76	76	--	--	--	--	Upland sediment samples to identify source properties
RMP STLS	2	2	2	--	2	--	Stormwater runoff samples to characterize high interest catchments
RMP STLS (PCBs only)	1	--	1	--	1	1	Composite sample collected during a high flow event in Guadalupe River
RMP STLS (Mercury only)	14	--	14	14	14	14	Series of samples collected during a high flow event in Guadalupe River
SPoT	2	--	--	--	--	2	Sediment samples to assess trends (only 1 analyzed for mercury)
Copper							
SCVURPPP	2	--	--	--	2	2	Copper analyzed on a subset of PCBs/Hg stormwater runoff samples
SCVURPPP	3	--	--	--	3	3	Creek water samples collected during storm event
SPoT	1	--	--	--	--	1	Sediment sample to assess trends at long-term monitoring station
Nutrients							
SCVURPPP	5 [c]	--	--	--	5	--	Samples collected during storm event and following dry weather event

a. Individual samples can address more than one Management Question simultaneously.
b. SCVURPPP (2017a) incorrectly reported that 16 water samples were analyzed for PCBs and mercury.
c. SCVURPPP (2017a) incorrectly reported that 4 samples were analyzed for nutrients.

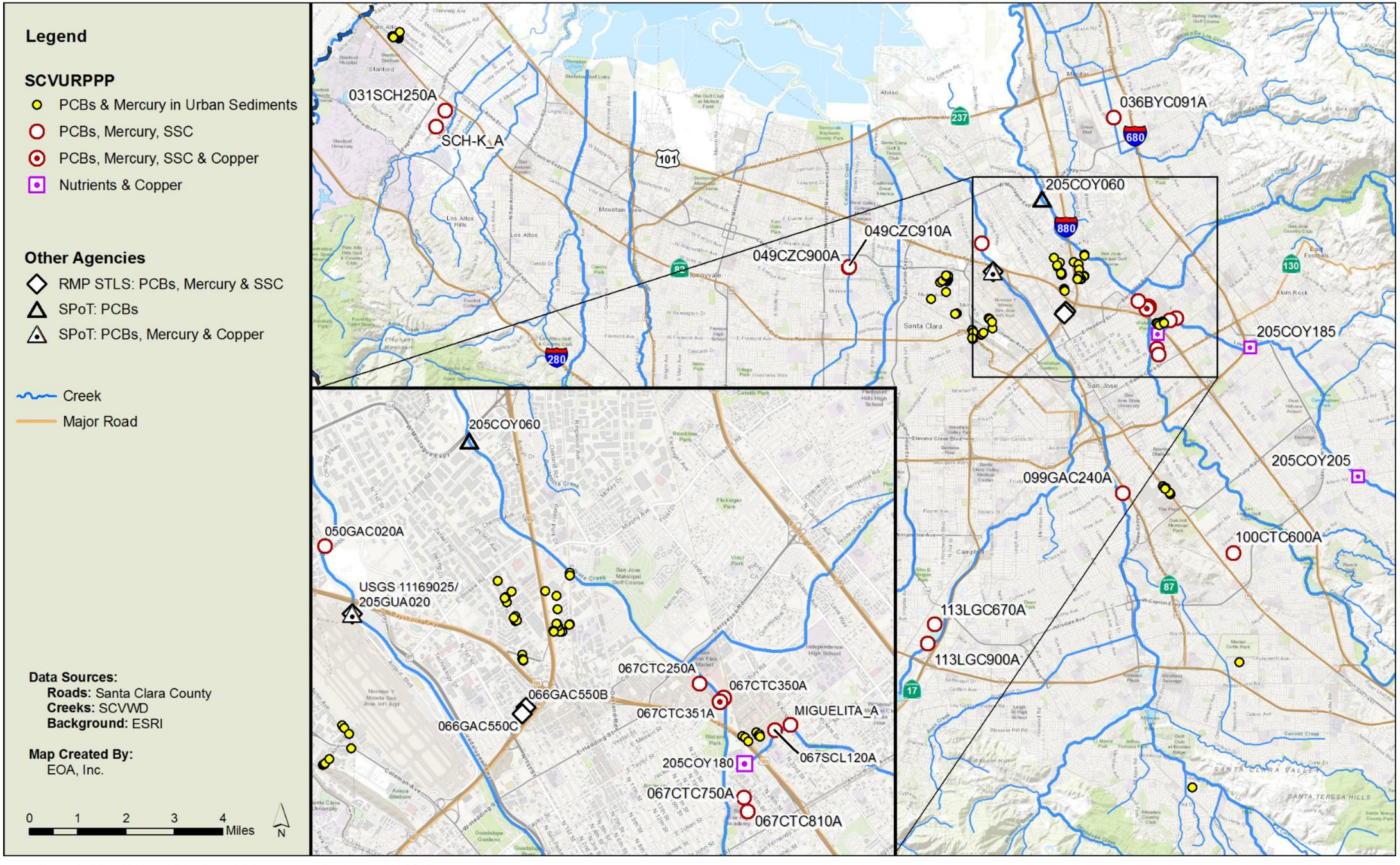

Figure 1. SCVURPPP and Third-Party POC Monitoring Stations in WY 2017.

Table 3. POC monitoring stations in Santa Clara County, WY 2017.

Agency	Station Code	Sample Date	Latitude	Longitude	Matrix	PCBs	Mercury	Suspended Sediment Concentration	Total Copper	Dissolved Copper	Hardness as CaCO3	Nutrients [b]
SCVURPPP												
SCVURPPP	MIGUELITA_A	12/15/2016	37.3604	-121.8637	water	x	x	x				
SCVURPPP	067SCL120A	12/15/2016	37.3597	-121.8661	water	x	x	x				
SCVURPPP	SCH-K_A	12/15/2016	37.4141	-122.1429	water	x	x	x				
SCVURPPP	031SCH250A	12/15/2016	37.4190	-122.1396	water	x	x	x				
SCVURPPP	036BYC091A	12/23/2016	37.4202	-121.8884	water	x	x	x				
SCVURPPP	099GAC240A	1/7/2017	37.3078	-121.8828	water	x	x	x				
SCVURPPP	050GAC020A	1/7/2017	37.3819	-121.9373	water	x	x	x				
SCVURPPP	049CZC900A	1/7/2017	37.3741	-121.9870	water	x	x	x				
SCVURPPP	049CZC910A	1/7/2017	37.3742	-121.9868	water	x	x	x				
SCVURPPP	067CTC350A	1/10/2017	37.3636	-121.8742	water	x	x	x	x	x	x	
SCVURPPP	067CTC351A	1/10/2017	37.3631	-121.8748	water	x	x	x	x	x	x	
SCVURPPP	100CTC600A	2/7/2017	37.2903	-121.8410	water	x	x	x				
SCVURPPP	067CTC750A	2/7/2017	37.3512	-121.8709	water	x	x	x				
SCVURPPP	067CTC810A	2/7/2017	37.3494	-121.8402	water	x	x	x				
SCVURPPP	113LGC670A	2/9/2017	37.2676	-121.9528	water	x	x	x				
SCVURPPP	113LGC900A	2/9/2017	37.2618	-121.9551	water	x	x	x				
SCVURPPP	067CTC250A [a]	2/9/2017	37.3654	-121.8781	water	x	x	x				
SCVURPPP	See Attachment 1 [c]				sediment	x	x					
SCVURPPP	205COY180	1/9/2017	37.3554	-121.8708	water				x	x	x	x
SCVURPPP	205COY180	6/1/2017	37.3554	-121.8708	water							x
SCVURPPP	205COY185	1/9/2017	37.3519	-121.8360	water				x	x	x	x
SCVURPPP	205COY185	6/1/2017	37.3519	-121.8360	water							x
SCVURPPP	205COY205	1/9/2017	37.3138	-121.7947	water				x	x	x	x
Third Party Organizations												
RMP STLS	066GAC550B	1/8/2017	37.3620	-121.9053	water	x	x	x				
RMP STLS	066GAC550C	1/8/2017	37.3612	-121.9059	water	x	x	x				
RMP STLS	USGS 11169025	1/8/2017	37.3734	-121.9328	water	x	x	x				
SPoT	205GUA020	June 2017	37.3734	-121.9328	sediment	x	x		x			
SPoT	205COY060	June 2017	37.3954	-121.9148	sediment	x						

a. This station (067CTC250A) was not included in the October 2017 report (SCVURPPP 2017a).
b. Ammonia (for ammonium), nitrate, nitrite, total Kjeldahl nitrogen, orthophosphate, and total phosphorus are analyzed concurrently in each nutrient sample.
c. SCVURPPP collected 76 sediment samples for PCBs and mercury analysis during the spring and summer of 2017. See Attachment 1 for station codes, sample dates, and latitude/longitude.
d. 205COY205 was not sampled in June due to dry creek conditions.

2.2 PCBs and Mercury

PCBs and mercury monitoring conducted by the Program in WY 2017 served two related purposes: WMA prioritization and source property identification. Monitoring results for WMA prioritization are described in detail in the section below. Monitoring results for source property identification are briefly summarized in this report and will be described in more detail in a separate report scheduled for completion in September 2018.

2.2.1 WMA Prioritization

During WY 2017, the Program collected 17 wet weather water samples from municipal separate storm sewer system (MS4) outfalls for PCBs and mercury analysis. An additional two samples were collected in Santa Clara County by the RMP's Small Tributary Loading Strategy (STLS) at similar types of stations using similar methods. These combined 19 samples address POC Management Questions #1 (Source Identification) and #2 (Contributions to Bay Impairment). Data may also be used to improve calibration of the Regional Watershed Spreadsheet Model (RWSM) which is a land use based planning tool for estimation of overall POC loads from small tributaries to San Francisco Bay at a regional scale (i.e., Management Question #4 – Loads and Status).

WMAs are land areas where PCBs and mercury control measures are or will be implemented. They have been delineated mostly at the catchment level using topographic and storm drain maps. To help identify where the most PCBs/mercury load reduction benefit can be achieved, the Program has focused efforts on identifying WMAs where we may find elevated PCBs and mercury concentrations.

WMA prioritization monitoring conducted by the Program was performed in accordance with the *Water Year 2016 Pollutant of Concern Monitoring - Sampling and Analysis Plan* (SCVURPPP 2015). The primary goal of the monitoring, as described in the SAP, is to provide information to identify Watershed Management Areas that disproportionately contribute PCBs and mercury to stormwater. Monitoring is focused on collection of storm composite samples from high interest WMAs that may contain PCB and/or mercury source properties. High interest WMAs were identified and prioritized for sampling by evaluating several types of data, including: PCBs and mercury concentrations from prior sediment and water sampling efforts, land use data showing old industrial parcels, municipal storm drain data showing pipelines and access points (e.g., manholes, outfalls, pump stations), catchment areas delineated from municipal storm drain data, and logistical/safety considerations (SCVURPPP 2015).

The current WMA map is illustrated in Figure 2. This map shows the 19 catchments that were sampled in WY 2017 by the Program and RMP STLS, as well as the status of all other WMAs. Some WMAs contain confirmed source properties that have already been referred to agency staff for follow-up abatement. Some WMAs are identified as having "known high source areas." These are WMAs with water and/or sediment sampling results showing elevated concentrations of PCBs. These are currently under source property investigation or an investigation is planned for the near future. The remainder of the WMAs/catchments are of interest and may have been sampled but do not have elevated concentrations in those samples. All other land areas within a city that don't fit into one of the "high interest catchments" are lumped into a single city-wide WMA (that is not necessarily spatially contiguous). These city-wide WMAs are not shown in Figure 2.

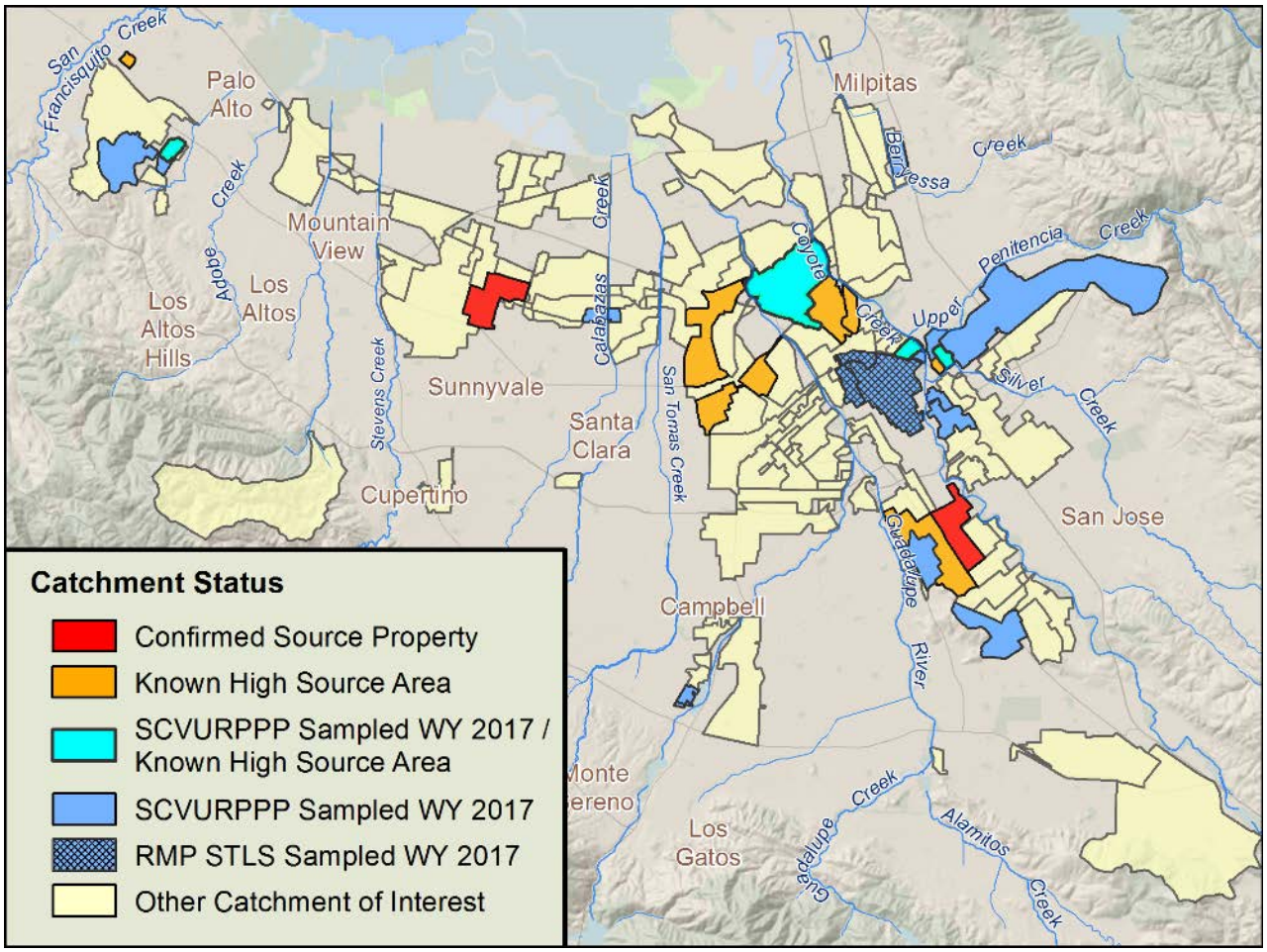

Figure 2. SCVURPPP current Watershed Management Area (WMA) map showing catchments sampled in WY 2017.

Composite samples consisting of four to eight aliquots collected during the rising limb and peak of the storm hydrograph (as determined through field observations) were analyzed for the "RMP 40" PCB congeners (method EPA 1668C), total mercury (method EPA 1631E), and SSC (method ASTM D3977-97). Two of the samples were also analyzed for total and dissolved copper (method EPA 200.8) and hardness (method SM 2340C). See Section 2.3 for a discussion of copper results.

Table 4 lists WMA prioritization monitoring results collected by SCVURPPP and the RMP STLS in WY 2017[6]. "Total PCBs" were calculated as the sum of the RMP 40 congeners. The "PCB Particle Ratio" and "Hg Particle Ratio" is calculated by dividing Total PCBs and Total Mercury by SSC. The PCB Particle Ratio and Hg Particle Ratio address the fact that PCBs are generally bound to sediment. Water concentrations and particle ratios are compared to countywide and regional datasets in order to "rank" monitoring stations and the WMAs they characterize. High ranking WMAs are flagged for future source property investigations which typically include property records review, aerial photography interpretation, public right-of-way surveys, facility site visits, and sediment sampling.

For the 17 samples that were collected by SCVURPPPP in WY 2017, total PCB concentrations ranged from 0.884 ng/L to 57.6 ng/L and PCB particle ratios ranged from 47.1 ng/g to 1,070 ng/g. Due to the data quality issues noted above in Section 2.1, mercury concentrations are only reported for the two urban catchments sampled by the RMP STLS. The concentrations of these two were 22.9 ng/L and 27.2 ng/L with Hg particle ratios of 477 ng/g and 591 ng/g. PCB monitoring results within the context of other water samples analyzed for PCBs in Santa Clara County and region-wide are described below.

[6] RMP STLS results are also reported separately by the San Francisco Estuary Institute (SFEI).

Table 4. PCB, mercury, and suspended sediment concentrations in water samples collected by SCVURPPP and STLS, WY 2017.

Station Code	Sample Date	SSC (mg/L)	Total PCBs (ng/L) [a]	PCB Particle Ratio (ng/g) [b]	Hg (ng/L)	Hg Particle Ratio (ng/g) [b]
SCVURPPP Samples						
031SCH250A	12/15/2016	12.2	13.0	1066	(c)	(c)
036BYC091A	12/23/2016	66	8.74	132	(c)	(c)
049CZC900A	1/7/2017	18.6	2.76	148	(c)	(c)
049CZC910A	1/7/2017	10.3	2.03	197	(c)	(c)
050GAC020A	1/7/2017	13.2	7.00	530	(c)	(c)
067CTC250A	2/9/2017	518	57.6	111	(c)	(c)
067CTC350A	1/10/2017	55	9.75	177	(c)	(c)
067CTC351A	1/10/2017	168	9.32	55.5	(c)	(c)
067CTC750A	2/7/2017	27.9	2.84	102	(c)	(c)
067CTC810A	2/7/2017	37.4	2.85	76.2	(c)	(c)
067SCL120A	12/15/2016	55.9	27.1	485	(c)	(c)
076CTC503A	1/10/2017	61.2	11.2	183	(c)	(c)
099GAC240A	1/7/2017	43.2	6.42	149	(c)	(c)
100CTC600A	2/7/2017	98.6	14.5	147	(c)	(c)
113LGC670A	2/9/2017	31.2	3.20	103	(c)	(c)
113LGC900A	2/9/2017	16	0.884	55.3	(c)	(c)
MIGUELITA_A	12/15/2016	84.7	3.99	47.1	(c)	(c)
SCH-K_A	12/15/2016	51.6	10.1	196	(c)	(c)
RMP STLS Samples						
066GAC550B	1/8/2017	48	4.17	86.9	22.9	477
066GAC550C	1/8/2017	46	4.11	89.3	27.2	591
Guadalupe River	1/8/2017	560	32.7	58.5	1,053 [d]	1,880 [d]

[a] Total PCBs calculated as sum of RMP 40 congeners.
[b] PCB and Hg Particle Ratios calculated by dividing Total PCBs and Hg concentrations by SSC.
[c] SCVURPPP mercury data was rejected.
[d] Guadalupe River mercury values are average of 14 individual samples.

Comparison with Region-wide Storm Sampling Results

The current storm sample dataset includes samples collected from 107 MS4 catchments and 20 natural waterways throughout the Bay Area.[7] The MS4 catchment sites include storm drain manholes, outfalls, pump stations, and artificial channels.[8] The 20 sites in natural waterways have watersheds ranging in size from less than 3,000 acres (i.e., Lower Penitencia Creek) to the entire Sacramento–San Joaquin River Delta watershed (i.e., Mallard Island). Many of the sites have been sampled more than once and/or have multiple sample results reported for individual storm events. Nine of the 107 MS4 sites also have multiple sample results (2 to 80). Five of the 20 natural waterway sites have multiple sample results (3 to 126). For sites with more than

[7] This dataset includes samples collected by SCVURPPP, the San Mateo Countywide Water Pollution Prevention Program (SMCWPPP), and the RMP's STLS.
[8] Stormwater samples have also been collected from inlets and/or LID systems as part of special studies. However, those were not included in this analysis.

one sample, the particle ratio is calculated by dividing the sum of PCB concentrations by the sum of suspended sediment concentrations. Performing the calculation in this way is effectively the equivalent of compositing all the individual samples that have been collected at a site. This is consistent with the RMP STLS approach to data evaluation (Gilbreath et al. 2017).

Table 5 lists descriptive statistics on PCB (n=127) and mercury concentrations (n=71) for the Bay Area stormwater dataset. The median concentration of PCBs in water is 7.89 ng/L, and the mean is 20.5 ng/L. The median PCB particle ratio is 113 ng/g, and the mean is 350 ng/g. As can be seen in Figures 3 and 4, there are a few catchments with highly elevated samples that increase the average concentration statistic over the median (i.e., 50th percentile). Both SCVURPPP and the RMP are collecting additional stormwater composite samples in WY 2018 in an effort to grow this dataset. In future years, it may be informative to correlate measured concentrations to various factors such as storm size, rainfall intensity, antecedent dry weather, land use characteristics, and age of development.

Table 5. Descriptive statistics of PCB and mercury concentrations in water and particle ratios.

	PCBs (ng/L) [a]	Hg (ng/L)	SSC (mg/L)	PCB Particle Ratio (ng/g) [b]	Hg Particle Ratio (ng/mg) [b]
N	127	71	127	127	71
Min	ND	3.90	5.80	ND	0.045
10th Percentile	1.71	6.65	19.2	16.0	0.155
25th Percentile	2.84	11.5	35.0	45.6	0.215
50th Percentile	7.89	22.9	58.0	113	0.346
75th Percentile	18.4	42.5	131	221	0.557
90th Percentile	46.8	85.7	296	784	0.896
Max	448	1,050	2,630	8,220	5.29
Mean	20.5	54.7	146	350	0.505

[a] Total PCBs calculated as sum of RMP 40 congeners.
[b] PCB and Hg Particle Ratios calculated by dividing Total PCBs and Hg concentrations by SSC.

PCB concentrations in water samples for the Bay Area dataset (n=127) are plotted in Figure 3. PCB particle ratios are plotted in Figure 4. Figures 3 and 4 identify sites by location (i.e., County) and sample type (i.e., MS4 or natural waterway/creek). There are 50 sites in Santa Clara County of which 17 were sampled by SCVURPPP in WY 2017 and nine in WY 2016. Two sites were sampled by RMP STLS in WY 2017, nine in WY 2016, and thirteen in WY 2015. Eight sites were sampled multiple times by the RMP in prior water years.

Overall, Santa Clara County has relatively low PCB concentrations and PCB particle ratios compared to the other three counties in the region (Alameda, Contra Costa, and San Mateo). However, some of the highest water concentrations and particle ratios measured in the Bay Area to-date have been observed in Santa Clara County. The highest PCB concentrations in Santa Clara County have been measured at:

- Sunnyvale East Channel (96.6 ng/L),
- 067CTC250A (Yard Court San Jose) (57.6 ng/L),
- 051CTC400A (Ridder Park Dr Storm Drain) (55.5 ng/L),
- 067SCL080A (Outfall to Lower Silver Creek) (44.6 ng/L), and
- 067SCL120A (Las Plumas Ave San Jose) (27.1 ng/L).

The sites with the highest PCB particle ratios are:

- 031SCH250A (Hansen Way Palo Alto) (1,070 ng/g),
- 067SCL080A (Outfall to Lower Silver Creek) (783 ng/g),
- 050GAC020A (Rincon 2 PS San Jose) (530 ng/g),
- 051CTC400A (Ridder Park Dr Storm Drain) (488 ng/g), and
- 067SCL120A (Las Plumas Ave San Jose) (485 ng/g).

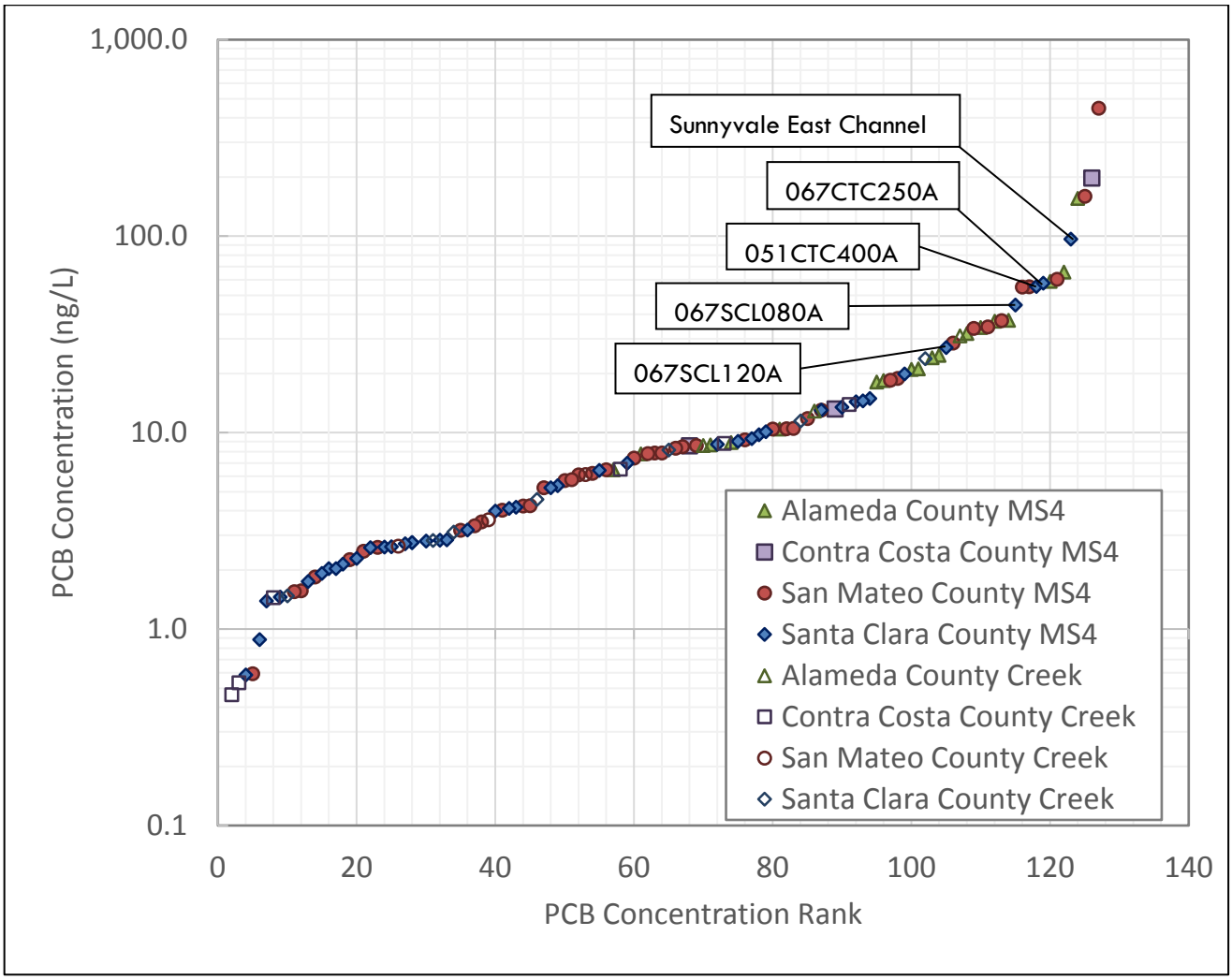

Figure 3. PCB concentrations for water samples collected in large MS4s in the Bay Area

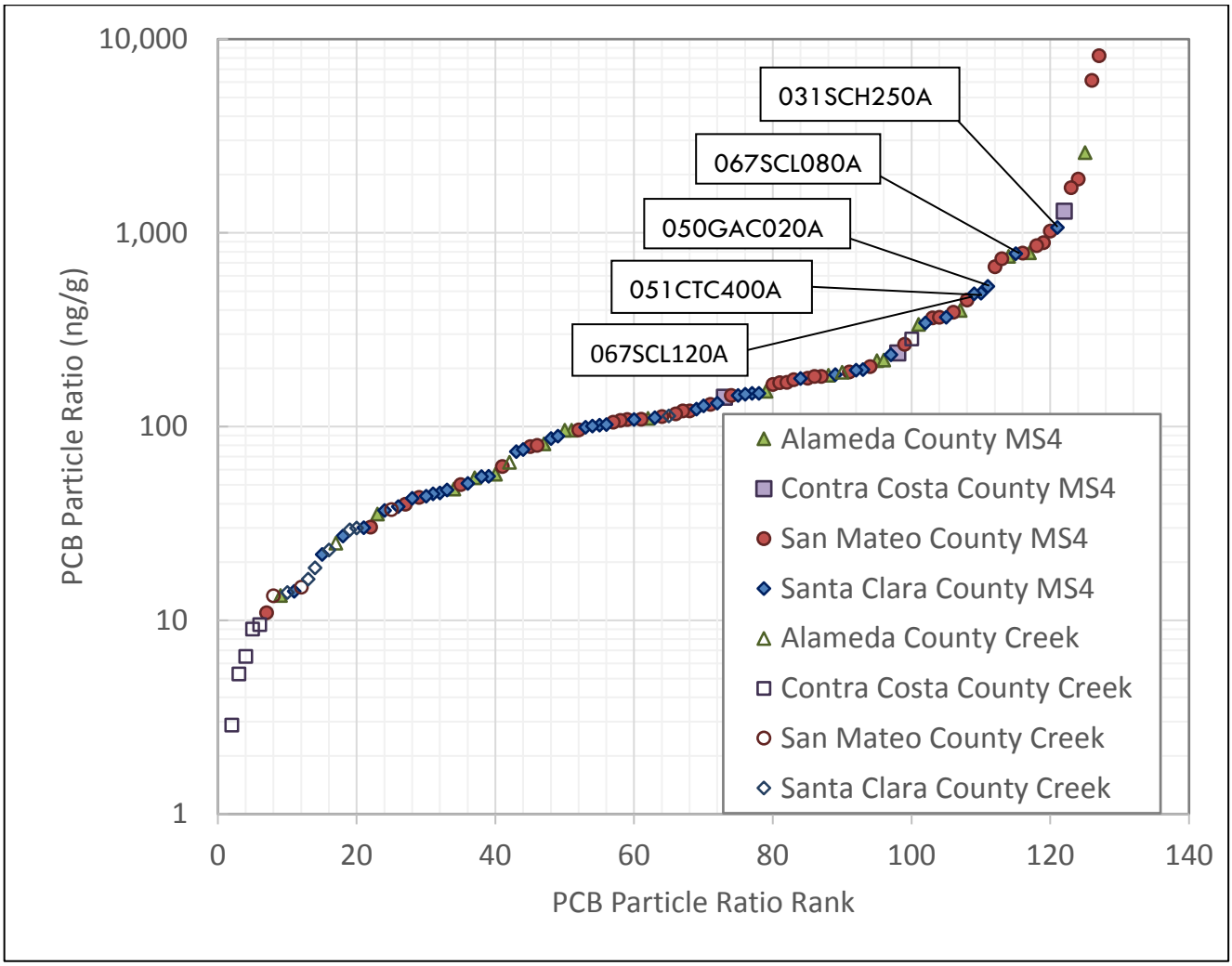

Figure 4. PCB particle ratios for water samples collected in MS4s and small tributaries (i.e., creeks/rivers) draining to the Bay.

WMA Update

PCB and mercury sampling data are used to identify specific source properties and/or WMAs where control measures will be implemented. There are currently no thresholds established for classifying or prioritizing PCB or mercury concentrations in stormwater. Therefore, the Program is currently focusing on PCBs and applying the BASMAA RMC sediment concentration thresholds to PCB particle ratio data which can be expressed in the same units (mg/kg). A PCB particle ratio greater than 0.5 mg/kg (or 500 ng/g) is used as a preliminary threshold for classifying water samples as high, 0.2 – 0.5 mg/kg (200 – 500 ng/g) is moderate, and less than 0.2 mg/kg (200 ng/g) is low.

Sites are also ranked within the regional dataset (n=127) based on concentrations in water and particle ratios and these rankings differ. Rankings of the sites monitored in WY 2017 are listed in Table 4. A sample that has a relatively low concentration in water but a high particle ratio may suggest that the storm that was sampled was relatively small, and the rainfall was not enough to mobilize much sediment. A larger storm may mobilize more sediment and PCBs, so catchments with an elevated concentration or particle ratio may be considered for a source investigation.

Based on WY 2017 sampling, four WMAs were identified as high priority catchments where source investigations should be considered.

- **WMA 031SCH250.** This 42-acre catchment located in the City of Palo Alto was characterized in WY 2017 with sample 031SCH250A which had a total PCBs concentration of 13 ng/L and a PCB particle ratio of 1.07 mg/kg. The catchment area contains primarily old industrial (38%) and new urban (48%) land uses, many of which house technology companies. This catchment drains to Matadero Creek via the Stanford Channel.

- **WMA 050GAC020.** This 843-acre catchment located in the City of San Jose was characterized in WY 2017 with sample 050GAC020A which had a total PCBs concentration of 7.0 ng/L and a PCB particle ratio of 0.53 mg/kg. The catchment area contains old industrial (36%), old urban (10%), new urban (45%), and open space (9%) land uses and is crossed by several rail lines. This catchment drains directly to the Guadalupe River via a large pump station (Rincon 2) that was constructed in 2004.

- **WMA 067SCL120.** This 40-acre catchment located in the City of San Jose was characterized in WY 2017 with sample 067SCL120 which had a total PCBs concentration of 27.1 ng/L and a PCB particle ratio of 0.48 mg/kg. The catchment area is almost entirely light industrial with a mixture of older and new construction dates. There is also an old railroad right-of-way that passes through the catchment. This catchment drains directly to Lower Silver Creek. WMA 067SCL120 borders another small catchment (WMA 067SCL080) that was targeted for a source investigation in WY 2017. Results of the WMA 067SCL080 source investigation will be reported under separate cover.

- **WMA 067CTC250.** This 41-acre catchment located in the City of San Jose was characterized in WY 2017 with sample 067CTC250A which had a total PCBs concentration of 57.6 ng/L and a PCB particle ratio of 0.11 mg/kg. Although the particle ratio is relatively low, the PCBs concentration was one of the highest measured in Santa Clara County. Furthermore, a sediment sample collected in WY 2015 in the WMA had a PCBs concentration of 0.24 mg/kg. The catchment area is primarily old industrial land uses (61%) and includes multiple large recycling facilities. Several industrial properties in the catchment are unpaved, including a pallet company, and these properties may contribute sediment to stormwater. This catchment drains directly to Coyote Creek.

WY 2018 POC sampling will include the collection of sediment samples within several WMAs to investigate suspected PCBs and mercury source properties. It is likely that the four WMAs described above will be targeted. If WY 2018 sediment sampling results in the identification of source properties, the Program will work with local municipalities to cleanup and abate the properties, and/or refer these properties to Regional Water Board for follow up action.

2.2.2 Source Property Identification

One strategy to reduce PCBs and mercury loadings to the Bay is to identify properties that disproportionately contribute these pollutants to the MS4 and abate these properties via referrals to appropriate agencies. In this effort, the Program collected 76 PCBs and mercury samples in WY 2017 from soil or sediment samples in seven prioritized WMAs. Station IDs, locations, and analytical results (total PCBs and mercury) are listed in Attachment 1. Total PCB concentrations in the samples, calculated as the sum of the "RMP 40" congeners, ranged from 0.004mg/kg to 11.9 mg/kg[9]. Mercury concentrations ranged from 0.03 mg/kg to 4.29 mg/kg. The data are being evaluated in concert with other source property investigation approaches such as property record and aerial photography reviews, public right-of-way surveys, and facility site visits to identify specific properties for referrals. A report describing the investigations and results is currently under development and will be submitted with the Program's FY 2017-18 Annual Report. At least six PCB or mercury source properties and seven potential PCB or mercury source properties have been identified to-date in priority WMAs. It is anticipated that up to six of these properties may be referred to the Water Board as a result of the WY 2017 investigations. Should they occur, referrals will be presented under separate cover.

[9] Results of individual PCB congeners can be made available upon request.

2.3 Copper

In WY 2017, SCVURPPP collected a total of five samples for copper analysis:

- Two copper samples were collected from storm drain outfalls (067CTC350A and 067CTC351A) concurrently with PCBs and mercury storm composite samples. The goal of these samples is to address Management Question #4 (Loads and Status) by characterizing copper concentrations in stormwater runoff from highly urban catchments.

- Three copper samples were collected during a large storm event on January 9, 2017 at upstream and downstream locations in the Silver Creek watershed which is tributary to Coyote Creek (upstream [205COY205], middle [205COY185], downstream [205COY180]). The goal of this approach is to address Management Question #4 (Loads and Status) by characterizing copper concentrations in stormwater runoff from upstream and downstream locations in mixed land-use catchments.

All samples were analyzed for total copper, dissolved copper[10], and hardness. Results are listed in Table 6. Comparisons to freshwater water quality objectives are described in Section 3.0.

Table 6. Total and dissolved copper concentrations in water samples collected by SCVURPPP, WY 2017.

Station Code	Sample Date	Total Copper (µg/L)	Dissolved Copper (µg/L)	Hardness as $CaCO_3$ (mg/L)
067CTC750A	2/7/2017	8.8	3.0	146
067CTC810A	2/7/2017	28	7.2	58.4
205COY180 (downstream)	1/9/2017	31	9.6	160
205COY185 (middle)	1/9/2017	29	8.7	170
205COY205 (upstream)	1/9/2017	14	7.5	200

Based on the laboratory results, the following findings are noted:

- As expected, dissolved copper concentrations are lower than total copper concentrations.

- Copper concentrations reported for the stormwater outfalls were comparable to concentrations measured in creeks. However, the hardness of the outfall water was less than the creek water.

- Copper concentrations increased in the downstream direction in the Silver Creek watershed.

2.4 Nutrients

Nutrients were included in the POC monitoring requirements to support Regional Water Board efforts to develop nutrient numeric endpoints (NNE) for the San Francisco Bay Estuary. The "San Francisco Bay Nutrient Management Strategy" (NMS) is part of a statewide initiative to address nutrient over-enrichment in State waters (Regional Water Board 2012). Its goal is to lay out a well-reasoned and cost-effective program to generate the scientific understanding needed to fully support major management decisions such as establishing/revising objectives for nutrients and dissolved oxygen, developing/implementing a nutrient monitoring program, and specifying nutrient limits in NPDES permits. The NMS monitoring program currently focuses on stations located within San Francisco Bay rather than freshwater tributaries.

The suite of nutrients required in MRP Provision C.8.f (i.e., ammonium, nitrate, nitrite, total Kjeldahl nitrogen

[10] In order to simplify the field effort and reduce the risk of sample contamination, the analytical laboratory was asked to conduct the sample filtration required for dissolved copper analysis.

(TKN), orthophosphate, and total phosphorus) closely reflects the list of analytes measured by the RMP and BASMAA partners at the six regional loading stations (including Santa Clara County stations in Guadalupe River and the Sunnyvale East Channel) monitored in WY 2012 - WY 2014. The prior data collected in freshwater tributaries to San Francisco Bay were used by the Nutrient Strategy Technical Team to develop and calibrate nutrient loading models.

In WY 2017, POC monitoring for nutrients in Santa Clara County was conducted at three stations along Silver Creek (upstream, middle, and downstream) during a large storm event. Follow-up monitoring at all three stations was attempted during the dry season; however, one of the stations (205COY205) was dry. Nutrient POC monitoring addresses Management Question #4 (Loads and Status). Results are listed in Table 7. Comparisons to applicable freshwater water quality objectives are described in Section 3.0.

Table 7. Nutrient concentrations (mg/L) in water samples collected by SCVURPPP, WY 2017.

Date/Station	Nitrate as N	Nitrite as N	Total Kjeldahl Nitrogen (TKN)	Ammonia as N	Un-ionized Ammonia as N [1]	Ammonium [2]	Total Nitrogen [3]	Dissolved Orthophosphate as P	Phosphorus as P
January 9, 2017 (storm event)									
205COY205 (upstream)	2.7	0.014	1.9	0.069	0.0022	0.067	4.6	0.18	0.43
205COY185 (middle)	1.4	0.012	2.0	0.095	0.0016	0.093	3.4	0.20	0.87
205COY180 (downstream)	1.2	0.011	2.1	0.073	0.0016	0.071	3.3	0.18	0.88
June 1, 2017 (spring baseflow)									
205COY205 (upstream)	no samples collected – creek bed dry								
205COY185 (middle)	4.2	0.044	0.62	0.11	0.0073	0.10	4.9	0.046	0.10
205COY180 (downstream)	5.3	0.031	0.22	0.082	0.0067	0.075	5.6	0.024	0.051

Notes:

All constituents reported as mg/L..

[1] Un-ionized ammonia calculated using formula provided by the American Fisheries Society Online Resources.

[2] Ammonium = ammonia – un-ionized ammonia.

[3] Total nitrogen = TKN + nitrate + nitrite. Non-detects valued at ½ method detection limit in calculation.

Based on the laboratory results, the following findings are noted:

- During the January storm event, total nitrogen concentrations were lower at the downstream station (205COY180) compared to the upstream (205COY205) and middle (205C07185) stations. In June, this trend was reversed with higher total nitrogen concentrations at the downstream station compared to the middle station.

- In contrast to total nitrogen, phosphorus concentrations increased in the downstream direction during the January storm event and decreased in the downstream direction in June.

- Inorganic nitrogen (nitrate and nitrite) concentrations were higher in June compared to the January storm event and organic nitrogen (TKN) concentrations were lower in June compared to the January storm event.

- Organic nitrogen (TKN) made up a greater proportion of the total nitrogen concentration during the January storm event compared to the June event. It is likely that organically-bound nitrogen washed off surfaces during the January storm had not yet had time to cycle through the ammonification and nitrification processes before samples were collected. In June, TKN made up just a small percent of the total nitrogen.

- Phosphorus concentrations were higher during the January storm runoff sampling event compared to the June baseflow event. This finding is consistent with the draft conceptual model developed by the NMS which suggests that nutrient loads to San Francisco Bay from creeks are highest during the wet season, although considerably less than loads from publicly owned wastewater treatment works (POTWs) (Senn and Novick 2014). However, nutrient concentrations (primarily nitrate) were higher during the baseflow event. It unknown why nitrate patterns were not consistent with the NMS model.

2.5 Emerging Contaminants

Emerging contaminant monitoring is being addressed through Program participation in the RMP. The RMP has been investigating Chemicals of Emerging Concern (CECs) since 2001 and established the RMP Emerging Contaminants Work Group (ECWG) in 2006. The goal of the ECWG is to identify CECs that have the potential to impact beneficial uses in the Bay and to develop cost-effective strategies to identify, monitor, and minimize impacts. The RMP published a CEC Strategy "living" document in 2013 and completed a full revision in 2017 (Sutton et al. 2013; Sutton and Sedlak 2015; Sutton et al. 2017). The CEC Strategy document guides RMP special studies on CECs using a tiered risk and management action framework. PFOS compounds are identified in the CEC Strategy as "moderate" concern due to Bay occurrence data suggesting a high probability of a low-level effect on Bay wildlife. PFAS compounds and alternative flame retardants (AFRs) are identified as "possible" concern due to uncertainties in measured or predicted Bay concentrations or in toxicity thresholds. RMP staff recently published reports summarizing PFOS and PFAS monitoring results (Houtz et al. 2016; Sedlak et al. 2017). The RMP is currently reviewing data available on AFRs to help inform a conceptual model that is currently under development.

3.0 COMPARISON TO APPLICABLE WATER QUALITY STANDARDS

MRP provision C.8.h.i requires RMC participants to assess all data collected pursuant to Provision C.8 for compliance with applicable water quality standards. In compliance with this requirement POC data collected in WY 2017 by SCVURPPP were compared to applicable numeric water quality objectives (WQOs) included in the SF Bay Water Quality Control Plan.

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

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

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

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

Acute vs. Chronic Objectives/Criteria – All monitoring (in water) for PCBs, mercury, and copper was conducted during episodic storm events and results do not likely represent long-term (chronic) concentrations of monitored constituents. The same is true for three out of five nutrient samples. Storm monitoring data were therefore compared to "acute" WQOs/criteria for aquatic life that represent the highest concentrations of an analyte to which an aquatic community can be exposed briefly (e.g., 1-hour) without resulting in an unacceptable effect. Spring baseflow monitoring data were also compared to "chronic" WQOs/criteria.

Of the analytes monitored by SCVURPPP at POC stations in WY 2017, WQOs or criteria for the protection of aquatic life have only been promulgated for total mercury, dissolved copper, and un-ionized ammonia. In WY 2017, there were no exceedances of applicable water quality standards for these analytes in samples collected in receiving waters. Details of the analyses are provided below.

- **Total Mercury**. All mercury concentrations measured in SCVURPPP samples in WY 2017 were well below the freshwater acute objective for mercury of 2.4 ug/L (see Table 4).
- **Nutrients**. All un-ionized ammonia concentrations measured in SCVURPPP samples were below the annual median objective for un-ionized ammonia of 0.025 mg/L (see Table 7).
- **Dissolved Copper.** Acute (1-hour average) WQOs for copper are expressed in terms of the dissolved fraction of the metal in the water column and are hardness dependent[11]. The acute copper WQO was calculated using the online spreadsheet posted by the State Water Resources Control Board (http://www.waterboards.ca.gov:8080/WaterQualityGoal/wq_docs/23.xls) which applies hardness values measured at the sample station. Dissolved copper concentrations measured at those

[11] The current copper standards for freshwater in California do not account for the effects of pH or natural organic matter and can be overly stringent or underprotective (or both, at different times). Therefore, the California Stormwater Quality Association (CASQA) has asked the USEPA to considering updating the California Toxics Rule for copper using the Biotic Ligand Model (BLM) which accounts for the effect of water chemistry in addition to hardness (i.e., temperature, pH, dissolved organic carbon, major cations and anions).

stations were compared to the calculated WQO. None of the MS4 or receiving water stations exceeded the calculated WQO for dissolved copper (Table 8).

Table 8. Comparison of WY 2017 Monitoring Data to the Copper WQO.

Station Code	Sample Date	Dissolved Copper (µg/L)	Hardness as $CaCO_3$ (mg/L)	Acute WQO for Dissolved Copper at Measured Hardness (µg/L)
067CTC750A	2/7/2017	3.0	146	19.2
067CTC810A	2/7/2017	7.2	58.4	8.1
205COY180 (downstream)	1/9/2017	9.6	160	20.9
205COY185 (middle)	1/9/2017	8.7	170	22.2
205COY205 (upstream)	1/9/2017	7.5	200	25.8

4.0 CONCLUSIONS AND RECOMMENDATIONS

In WY 2017, SCVURPPP collected and analyzed POC samples in compliance with Provision C.8.f of the MRP. Yearly minimum requirements were met for all monitoring parameters. In addition, SCVURPPP continued to work with the RMP's STLS to supplement WY 2017 monitoring accomplishments.

Conclusions from WY 2017 POC monitoring include the following:

- SCVURPPP collected 17 wet weather samples from high interest catchments for PCBs and mercury analysis. Results from SCVURPPP monitoring were compiled with results from RMP STLS monitoring (2 samples) to potentially identify new high interest WMAs in which new PCB or mercury source investigations should be considered. Based on the monitoring results, four new WMAs were added to the list of catchments warranting source property investigations.

- SCVURPPP collected 76 sediment samples from seven prioritized WMAs in an effort to identify specific PCB source properties. Based on the combined results of this monitoring effort and other aspects of the source property investigations, SCVURPPP has preliminarily identified six PCB or mercury source properties and one additional property for PCBs. These properties My warrant follow up action, which may include referral to the Regional Water Board or further investigation.

- Two of the wet weather catchment samples were analyzed for total and dissolved copper. An additional three samples were collected along a creek gradient during a storm event. None of the samples exceeded applicable water quality standards which generally apply to receiving waters rather than pipelines within the MS4.

- Three nutrient samples were collected along a gradient in the Silver Creek watershed during a storm event. Two of these stations were re-sampled for nutrients during spring baseflow conditions. None of the samples exceeded applicable water quality standards.

Recommendations for WY 2018 POC monitoring include the following:

- SCVURPPP and the RMP's STLS will continue to conduct PCB and mercury monitoring with the goal of identifying WMAs and specific source properties where new PCB and mercury control measures can be implemented during the permit term.

- At least eight PCBs and mercury samples that address Management Question #3 (Management Action Effectiveness) must be collected by the end of year four of the permit (i.e., 2020). BASMAA is currently implementing a regional project that addresses POC Management Action Effectiveness. The Study Design, approved by the Project Management Team in August 2017, addresses the effectiveness of hydrodynamic separator (HDS) units and various types of biochar-amended bioretention soil media (BSM) at removing PCBs and mercury from stormwater. Findings from the regional project will be reported in the WY 2018 UCMR which will be submitted by March 31, 2019. Findings will also be used to support development of the Reasonable Assurance Analysis (RAA) that is required by provision C.12.c.iii.(3) of the MRP and which must be submitted with the 2020 Annual Report (September 30, 2020).

- At least eight samples that address Management Question #5 (Trends) must be collected by the end of year four of the permit (i.e., 2020). SCVURPPP will continue to participate in the STLS Trends Strategy Team to meet this requirement. The STLS Trends Strategy Team, initiated in WY 2015, is currently developing a regional monitoring strategy to assess trends in POC loading to San Francisco Bay from small tributaries (see Section 5.2.3). The STLS Trends Strategy will initially focus on PCBs and mercury, but will not be limited to those POCs. Analysis of recent and historical data collected at region-wide loadings stations suggests that PCB concentrations are highly variable. Therefore, a monitoring design to detect trends with statistical confidence may require more samples than is feasible with current financial resources. The STLS Trends Strategy Team is continuing to evaluate available data from the Guadalupe River watershed to explore more economical monitoring

opportunities. The Team is also considering modeling options that could be used in concert with monitoring to detect and predict trends in POC loadings. A Trends Strategy Road Map is currently being developed.

- SCVURPPP will continue to work with the SPoT Program to address Management Question #5 (Trends). The SPoT Monitoring Program conducts annual dry season monitoring (subject to funding constraints) of sediments collected from a statewide network of large rivers. The goal of the SPoT Program is to investigate long-term trends in water quality (Management Question #5 – Trends). Sites are targeted in bottom-of-the-watershed locations with slow water flow and appropriate micromorphology to allow deposition and accumulation of sediments, including two stations in Santa Clara County (Coyote Creek and Guadalupe River). In most years, sediments are analyzed for PCBs, mercury, other metals, toxicity, pesticides, and organic pollutants (Phillips et al. 2014).

- Copper and nutrient samples will be collected from mixed land use watersheds during storm events to address Management Question # 4 (Loads and Status). Stations should be resampled for copper during summer baseflow conditions to address Management Question #5 (Trends).

- SCVURPPP will continue to participate in the RMP's STLS and the RMP's CEC Strategy.

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Attachment 1

Sediment Monitoring Stations and Analytical Results

San
Jose

Permittee	WMA	Sample	Sample Source	Latitude	Longitude	Total PCBs (ug/kg)	Mercury (mg/kg)
Palo Alto	001SFC100A	SC-PAO-18-C	Street Dirt	37.44105	-122.16002	0.02	0.07
		SC-PAO-18-D	Street Dirt	37.44094	-122.15985	0.03	0.08
		SC-PAO-18-G	Street Dirt	37.44036	-122.15763	0.17	0.12
		SC-PAO-18-H	Street Dirt	37.44072	-122.15790	0.06	0.04
		SC-PAO-18-N (Dup of SC-PAO-18-H)				0.05	0.04
		SC-PAO-18-I	Street Dirt	37.44086	-122.15814	0.02	0.15
		SC-PAO-18-J	Street Dirt	37.44117	-122.15810	0.01	0.05
		SC-PAO-18-K	Street Dirt	37.44128	-122.15756	0.01	0.05
		SC-PAO-18-L	Manhole	37.44184	-122.15749	0.01	0.08
		SC-PAO-18-M	Manhole	37.44219	-122.15168	0.02	0.11
Santa Clara	066GAC150	SC-SCL-01-C	Manhole	37.35447	-121.93710	3.81	0.48
		SC-SCL-01-E	Street Dirt	37.35445	-121.93688	0.04	0.06
		SC-SCL-01-F	Street Dirt	37.35466	-121.93670	0.02	0.08
		SC-SCL-01-G	Street Dirt	37.35519	-121.93608	0.19	0.07
		SC-SCL-01-I (Dup of SC-SCL-01-G)				0.20	0.07
		SC-SCL-01-H	Street Dirt	37.35656	-121.93269	0.09	0.14
		SC-SCL-23-B	Inlet	37.35593	-121.94040	0.02	0.12
		SC-SCL-23-C	Street Dirt	37.35529	-121.93995	0.02	0.11
		SC-SCL-23-D	Street Dirt	37.35946	-121.93418	0.64	0.07
		SC-SCL-23-E	Manhole	37.35917	-121.93379	0.11	0.09
		SC-SCL-23-F	Street Dirt	37.35843	-121.93300	0.13	0.14
		SC-SCL-26-A	Street Dirt	37.35327	-121.94012	0.01	0.12
	050GAC400	SC-SCL-02-F	Manhole	37.37103	-121.94970	0.05	0.26
		SC-SCL-02-G	Street Dirt	37.37042	-121.95014	0.05	0.81
		SC-SCL-02-H	Street Dirt	37.37078	-121.95011	0.02	0.10
		SC-SCL-02-I	Street Dirt	37.37124	-121.95012	0.07	0.18
		SC-SCL-02-J	Street Dirt	37.37144	-121.95007	0.02	0.20
		SC-SCL-02-K	Street Dirt	37.37150	-121.95005	0.02	0.23
		SC-SCL-02-L	Street Dirt	37.36068	-121.94839	0.01	0.05
		SC-SCL-03-E	Street Dirt	37.36497	-121.95602	0.02	0.09
		SC-SCL-04-D	Inlet	37.36717	-121.95043	0.07	0.21
		SC-SCL-04-G (Dup of SC-SCL-04-D)				0.06	0.13
		SC-SCL-04-E	Manhole	37.37205	-121.94967	0.00	0.09

Permittee	WMA	Sample	Sample Source	Latitude	Longitude	Total PCBs (ug/kg)	Mercury (mg/kg)
		SC-SCL-04-F	Manhole	37.37250	-121.94967	0.01	0.50
		SC-SCL-05-C	Manhole	37.36996	-121.95262	0.29	0.24
		SC-SCL-05-D	Inlet	37.37176	-121.95042	0.20	0.17
		SC-SCL-05-E	Street Dirt	37.37215	-121.95045	0.15	0.09
San Jose	051CTC400	SC-SJY-07-A	Street Dirt	37.37903	-121.89875	2.80	0.38
		SC-SJY-08-H	Street Dirt	37.37844	-121.89870	0.18	0.17
		SC-SJY-08-I	Street Dirt	37.37668	-121.90253	0.00	0.06
		SC-SJY-08-J	Street Dirt	37.37612	-121.90079	0.00	0.23
		SC-SJY-08-K	Manhole	37.37444	-121.90063	0.07	0.10
		SC-SJY-08-L		37.37255	-121.89857	0.05	0.09
		SC-SJY-08-M	Street Dirt	37.37243	-121.89868	0.21	0.14
		SC-SJY-08-N	Street Dirt	37.37160	-121.89980	0.02	0.09
		SC-SJY-08-O	Street Dirt	37.37185	-121.90025	0.05	0.12
		SC-SJY-08-S (Dup of SC-SJY-08-O)				0.06	0.08
		SC-SJY-08-P	Manhole	37.37222	-121.90040	0.02	0.06
		SC-SJY-08-Q	Street Dirt	37.37231	-121.90045	0.03	0.13
		SC-SJY-08-R	Inlet	37.37258	-121.90076	0.03	0.07
		SC-SJY-08-T	Street Dirt	37.37176	-121.90114	0.28	0.06
		SC-SJY-08-U	Manhole	37.37176	-121.90114	0.05	0.06
		SC-SJY-08-V	Manhole	37.37175	-121.90110	0.03	0.20
		SC-SJY-08-W	Street Dirt	37.37160	-121.90106	0.02	0.11
		SC-SJY-08-X (Dup of SC-SJY-08-W)				0.01	0.13
	051CTC275	SC-SJY-10-G	Street Dirt	37.36864	-121.90599	0.03	0.22
		SC-SJY-10-H	Street Dirt	37.36798	-121.90583	2.04	0.25
		SC-SJY-10-I	Inlet	37.36800	-121.90584	11.91	1.32
		SC-SJY-10-M (Dup of SC-SJY-10-I)				17.11	1.22
		SC-SJY-10-J	Street Dirt	37.37349	-121.90716	0.03	0.09
		SC-SJY-10-K	Inlet	37.37325	-121.90746	0.03	0.15
		SC-SJY-10-L	Inlet	37.37292	-121.90695	0.01	0.04
		SC-SJY-10-N	Street Dirt	37.37521	-121.90857	0.57	3.01
		SC-SJY-10-O	Street Dirt	37.37657	-121.90778	0.28	0.12
		SC-SJY-10-P	Street Dirt	37.37783	-121.91004	0.24	1.57
		SC-SJY-10-Q	Street Dirt	37.37569	-121.90890	0.04	0.15
	067SCL080	SC-SJY-17-B	Street Dirt	37.35887	-121.87121	0.01	0.14

Permittee	WMA	Sample	Sample Source	Latitude	Longitude	Total PCBs (ug/kg)	Mercury (mg/kg)
San Jose		SC-SJY-17-C	Inlet	37.35936	-121.86900	0.12	0.03
		SC-SJY-17-D	Street Dirt	37.35900	-121.86863	0.05	0.11
		SC-SJY-17-E	Street Dirt	37.35909	-121.86850	0.03	0.12
		SC-SJY-17-F	Street Dirt	37.35869	-121.87077	0.03	0.12
		SC-SJY-17-G	Street Dirt	37.35821	-121.87025	0.04	0.26
		SC-SJY-17-H	Manhole	37.35885	-121.86840	0.09	0.09
		SC-SJY-47-E	Street Dirt	37.30763	-121.86494	0.12	0.32
		SC-SJY-47-F	Street Dirt	37.30802	-121.86531	0.23	0.95
		SC-SJY-47-G	Street Dirt	37.30817	-121.86549	0.25	0.77
		SC-SJY-47-I (Dup of SC-SJY-47-G)				0.22	2.58
		SC-SJY-47-H	Street Dirt	37.30962	-121.86691	0.30	1.95
		SC-SJY-47-J	Manhole	37.30996	-121.86778	7.06	1.88
		SC-SJY-47-K	Street Dirt	37.30948	-121.86730	0.07	0.42
		SC-SJY-47-L	Street Dirt	37.30918	-121.86699	0.08	0.42
	Other - San Jose	SC-SJY-90-A	Street Dirt	37.25767	-121.83825	0.00	0.09
		SC-SJY-91-A	Street Dirt	37.22004	-121.85523	0.08	4.29

Attachment 2

Quality Assurance/Quality Control Report

Pollutants of Concern Monitoring - Quality Assurance/Quality Control Report, WY 2017

1.0 INTRODUCTION

The Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP) conducted Pollutants of Concern (POC) Monitoring in Water Year (WY) 2017 to comply with Provision C.8.f (Pollutants of Concern Monitoring) of the National Pollutant Discharge Elimination Program (NPDES) Municipal Regional Permit for the San Francisco Bay Area (i.e., MRP). Monitoring included analysis for polychlorinated biphenyls (PCBs), total mercury, total and dissolved copper, suspended sediment concentration (SSC), and nutrients (i.e., ammonia, nitrate, nitrite, total Kjeldahl nitrogen, orthophosphate, and total phosphorus).

This project utilized the Clean Watersheds for Clean Bay Project (CW4CB) Quality Assurance Project Plan (QAPP; BASMAA2013) as a basis for Quality Assurance and Quality Control (QA/QC) procedures. Missing components were supplemented by the Bay Area Stormwater Management Agencies Association (BASMAA) Regional Monitoring Coalition (RMC) QAPP (BASMAA 2016) and the QAPP for the California Surface Water Ambient Monitoring Program (SWAMP), specifically for nutrient and copper samples, respectively. Data were assessed for seven data quality attributes, which include (1) Representativeness, (2) Comparability, (3) Completeness, (4) Sensitivity, (5) Contamination, (6) Accuracy, and (7) Precision. 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.

The MQOs for each of the POC analytes are summarized in Table 1 for water and Table 2 for sediment. As there was no reporting limit listed in the QAPP for copper, results were compared the SWAMP recommended reporting limits for inorganic analytes in freshwater. Overall, the results of the QA/QC review suggest that the data generated during this study were of sufficient quality for the purposes of the project. Further details regarding the QA/QC review are provided in the sections below. While some data were flagged in the project database, none of the data were rejected based on the MQOs or DQOs identified in the QAPPs. However, mercury data collected in water were later rejected by the project QA/QC officer based on comparison of results to similar data collected in recent years by SCVURPPP and other programs from the same population of urban catchments.

Table 1. Measurement quality objectives for analytes in water from the Clean Watersheds for a Clean Bay (CW4CB) Quality Assurance Project Plan (BASMAA 2013) and BASMAA RMC Quality Assurance Project Plan (BASMAA 2016)

Sample	Nutrients[1]	Hardness[1]	SSC[2]	Copper[2]	Mercury[2]	PCBs[2]
Laboratory Blank	< RL	<RL	< RL	< RL	< RL	< RL
Reference Material (Laboratory Control Sample) Recovery	90-110%	80-120%	NA	75-125%	75-125%	50-150%
Matrix Spike Recovery	80-120%	80-120%	NA	75-125%	75-125%	50-150%
Duplicates (Matrix Spike, Field, and Laboratory)[3]	RPD < 25%	RPD < 25%	RPD < 25%	RPD < 25%	RPD < 25%	RPD < 25%
Reporting Limit	0.01mg/L for all except: Ammonia (0.02mg/L) TKN[4] (0.5mg/L)	1 mg/L[5]	0.5 mg/L	0.10 µg/L[6]	0.0002 µg/L (0.2 ng/L)	0.002 µg/L (2000 pg/L)

RL = Reporting Limit; RPD = Relative Percent Difference

[1] From the BASMAA QAPP

[2] From the CW4CB QAPP

[3] NA if native concentration for either sample is less than the reporting limit

[4] TKN = Total Kjeldahl Nitrogen

[5] No hardness RL listed in either QAPP. Value is from SWAMP-recommended reporting limits for conventional analytes in freshwater. (https://www.waterboards.ca.gov/water_issues/programs/swamp/docs/tools/19_tables_fr_water/1_conv_fr_water.pdf)

[6] No copper RL listed in either QAPP. Value is from SWAMP-recommended reporting limits for inorganic analytes in freshwater. (http://www.waterboards.ca.gov/water_issues/programs/swamp/docs/tools/19_tables_fr_water/4_inorg_fr_water.pdf)

Table 2. Measurement quality objectives for analytes in sediment from the Clean Watersheds for a Clean Bay (CW4CB) Quality Assurance Project Plan (BASMAA 2013).

Sample	Total Solids	Mercury	PCBs
Laboratory Blank	< RL	< RL	< RL
Reference Material (Laboratory Control Sample) Recovery	N/A	75-125%	50-150%
Matrix Spike Recovery	N/A	75-125%	50-150%
Duplicates [1] (Matrix Spike, Field, and Laboratory)	RPD < 25%	RPD < 25%	RPD < 25%[2]
Reporting Limit	0.1%[3]	30 µg/kg 0.03 mg/kg 30,000 ng/kg	0.2 µg/kg 0.0002 mg/kg 200 ng/kg

RL = Reporting Limit; RPD = Relative Percent Difference

[1] NA if native concentration for either sample is less than the reporting limit

[2] Only applicable for matrix spike duplicates. Method specific for field and laboratory duplicates

[3] RL for total solids in water

2.0 REPRESENTATIVENESS

Data representativeness assesses whether the data were collected so as to represent actual conditions at each monitoring location. For this project, all samples are assumed to be representative if they are collected and analyzed according to protocols specified in the CW4CB QAPP and RMC QAPP. All field and laboratory personnel received and reviewed the QAPPs, and followed prescribed protocols including laboratory methods.

3.0 COMPARABILITY

The QA/QC officer ensures that the data may be reasonably compared to data from other programs producing similar types of data. For POC 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.

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

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

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

4.0 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.

During WY 2017, SCVURPPP collected over 100% of planned samples. Nutrients were collected during two events – three samples were collected in January and two were collected in June 2017. Three copper and hardness samples were also collected concurrently with nutrients during the January event. A total of 17 aqueous samples were collected in WY 2017 and analyzed for PCBs, mercury, and SSC. Three additional aqueous hardness samples and six aqueous copper samples were collected concurrently with PCBs and mercury. Seventy-six (76) sediment samples were also collected in WY 2017 and analyzed for PCBs and mercury. A comparison of the total and actual samples collected for POC monitoring in WY 2017 is shown in Table 2.

Table 2. Comparison of the targeted number of samples with the actual number of samples collected during POC monitoring in WY 2017

Analyte	Matrix	Target	Actual
Nutrients[1]	Water	4	5
Suspended Sediment Concentration	Water	10-20	17
Hardness	Water	4	6
Copper	Water	4	9
Mercury	Water	10-20	17
PCBs	Water	10-20	17
Mercury	Sediment	40-60	76
PCBs	Sediment	40-60	76
Total Solids	Sediment	40-60	83

[1] Nutrients include ammonia, nitrate, nitrite, total Kjeldahl nitrogen, phosphorus, orthophosphate.

5.0 SENSITIVITY

5.1. Water

Sensitivity analysis determines whether the methods can identify and/or quantify results at low enough levels. For the aqueous 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) and the CW4CB QAPP Appendix B (CW4CB Target Method Reporting Limits).

A summary of the target and actual reporting limits for each analyte is shown in Table 3. Nutrient analysis, except for nitrate, and PCB analysis met their respective target reporting limits listed in the RMC QAPP and CW4CB QAPP. However, the reporting limits for all nitrate, suspended sediment concentration (SSC), hardness, and mercury samples exceeded their respective target reporting limits. Additionally, all but two copper samples exceeded the target reporting limit for copper.

Table 3. Target and actual reporting limits for SCVURPPP pollutants of concern monitoring in water in WY 2017.

Analyte	Unit	Target	Actual	Exceeds Target?
Ammonia	mg/L	0.02	0.02	No
Nitrate	mg/L	0.01	0.05	Yes
Nitrite	mg/L	0.01	0.005	No
Total Kjeldahl Nitrogen	mg/L	0.5	0.1	No
Phosphorus	mg/L	0.01	0.01	No
Orthophosphate	mg/L	0.01	0.01	No
Suspended Sediment Concentration	mg/L	0.5	1.0-1.1	Yes
Hardness	mg/L	1	2-20	Yes
Copper	µg/L	0.1	0.1-0.5	Yes
Mercury	ng/L	0.2	0.5	Yes
PCBs	pg/L	2000	19.9-383	No

5.2. Sediment Analysis

The project manager identified 0.5 mg/kg as an elevated/high total PCBs concentration threshold for sites to be considered for additional investigation. Because a different analytical method was used in this project for PCBs congeners (i.e., 8082M) compared to the CW4CB project (i.e., 1668A), a reporting limit requirement had to be developed. To maintain a conservative approach, QA/QC goals for this project focused on concentrations greater than 1/5 of the high concentration threshold (i.e., 0.1 mg/kg), and applied a reporting limit requirement of 10 µg/kg (i.e., 0.01 mg/kg), or 1/10 of this new lower threshold, for each of the forty PCB congeners analyzed.

Approximately 4% of congener samples (146 of 3320) did not meet the reporting limit requirement of 10 µg/kg. However, the majority of these exceedances are explained by dilutions, necessary to conduct the analysis, resulting in elevated reporting limits. Only a small minority (32; 1%) of the samples that did not meet the reporting limit requirements were not diluted, and therefore, did not have a justification for the elevated reporting limits. Slightly more than one-quarter (13) of the 40 congeners were affected.

The target method reporting limits for mercury (0.30 mg/kg) and total solids (0.1%) were met for all mercury and total solids samples.

6.0 CONTAMINATION

For chemical data, contamination is assessed as the presence of analytical constituents in blank samples.

6.1. Water Analysis

Laboratory blanks that were run during the nutrient and copper analyses were all non-detect and met the measurement quality objectives for nutrients (< reporting limit). Two laboratory blanks analyzed for hardness were above the method detection limit, but below reporting limit. Similarly, analytes were detected in laboratory blanks for mercury and several PCBs above the method detection limit, but below the reporting limit. The PCBs that were detected in laboratory blanks include PCB 8, PCB 11, PCB 52, PCB 44/47/65, PCB 153/168, and PCB129/138/163.

6.2. Sediment Analysis

Laboratory blanks that were run during sediment analysis, and several PCBs were detected in the blanks above the method detection limits. However, concentrations were below the reporting limit and therefore met the MQO. PCBs that were detected above the method detection limit, but below the reporting limit include the following:

- PCB 153
- PCB 158
- PCB 018
- PCB 028
- PCB 033
- PCB 044
- PCB 052
- PCB 138
- PCB 180
- PCB 008

7.0 ACCURACY

Accuracy is assessed as the percent recovery of samples spiked with a known amount of a specific chemical constituent. The analytical laboratory evaluated and reported the Percent Recovery (PR) of Laboratory Control Samples (LCS; in lieu of reference materials) and Matrix Spikes (MS)/Matrix Spike Duplicates (MSD), which were recalculated and compared to the target ranges in the RMC and CW4CB QAPPs . If a QA sample did not meet MQOs, all samples in that batch for that analyte were flagged.

7.1. Water Analysis

All nutrient LCS and MS/MSD samples were within the MQO specified by the BASMAA QAPP for both the January and June analysis. All of the copper laboratory control samples met the MQOs. However, one copper MS sample did not meet the MQO, and the associated copper samples were flagged. All of the hardness LCS and MS/MSD samples met the MQO. All SSC laboratory control samples met the MQO. No SSC MS/MSD samples were run. Laboratory control samples exceeded the MQOs for 19 PCBs, and three MS/MSD samples exceeded the MQO for PCBs. No MS/MSD samples were run for mercury and accuracy could not be assessed.

7.2. Sediment Analysis

All laboratory control samples met the MQOs during the sediment analysis, but three MS/MSD samples exceeded the MQOs, including PCB 18 and PCB 56.

8.0 PRECISION

Precision is the repeatability of a measurement and is quantified by the Relative Percent Difference (RPD) of two duplicates samples. Three measures of precision were used for this project – matrix spikes duplicates , laboratory duplicates, and field duplicates. The MQO for RPD specified by both the CW4CB QAPP and the BASMAA QAPP is <25%.

8.1. Water Analysis

8.1.1. Laboratory Duplicates

Matrix spike duplicates and laboratory control sample duplicates for nutrients, copper, and hardness were well below the targeted range of < 25%. One MS/MSD pair for PCB 144 did not meet the MQO. Laboratory duplicates were analyzed for PCBs, and most of the duplicates were less than 25% and met the MQO except for the following:

- PCB 017
- PCB 018/030
- PCB 031
- PCB 041/071/040
- PCB 128/166
- PCB 135/151/154
- PCB 144
- PCB 176
- PCB 201
- PCB 209

The PCB samples associated with these QA samples were flagged.

The laboratory did not analyze matrix spikes or laboratory duplicates for mercury, and precision could not be assessed.

8.1.2. Field Duplicates

One nutrient field duplicate was collected during WY 2017 POC monitoring at site 205COY185. The field duplicate sample met the MQO for RPD for all analytes.

One field duplicate was collected during this project at site 067CTC350A for hardness, copper, mercury, and PCBs. The duplicate sample was run as a blind duplicate by the laboratory. The duplicatesample met the MQO for RPD for all analytes except for hardness (55%) and PCB 144 (31%). If either measurement was less than the reporting limit, the RPD was not calculated, in accordance with both the CW4CB and BASMAA QAPPs.

8.2. Sediment Analysis

8.2.1. Laboratory Duplicates

Matrix spike duplicates for 31 PCBs exceeded MQO (<25%). One out of four laboratory duplicates for mercury exceeded the MQO. Nine laboratory duplicates were run for total solids, and their RPDs were all well below the MQOs. Samples associated with laboratory duplicates that exceeded MQOs were flagged.

8.2.2. Field Duplicates

Five sediment field blind duplicates were collected in WY 2017. The field duplicates exceed the RPD MQO for mercury and 28 PCBs. Most duplicates exceeded the MQO for very few analytes, but the sample at SC-SJY-10-M exceeded the MQO for 27 analytes. The following analytes exceeded the MQO for field duplicates (the number of samples that exceeded the MQO for that analyte are included in parentheses):

- Mercury (2)

- PCB 28 (1)
- PCB 44 (1)
- PCB 49 (1)
- PCB 52 (1)
- PCB 70 (1)
- PCB 87 (1)
- PCB 95 (2)
- PCB 97 (1)
- PCB 99 (2)
- PCB 101 (1)
- PCB 110 (2)
- PCB 118 (1)
- PCB 128 (1)
- PCB 138 (1)
- PCB 141 (2)
- PCB 149 (2)
- PCB 151 (1)
- PCB 153 (2)
- PCB 156 (1)
- PCB 158 (1)
- PCB 170 (1)
- PCB 174 (1)
- PCB 177 (1)
- PCB 180 (1)
- PCB 183 (1)
- PCB 187 (1)
- PCB 195 (1)
- PCB 203 (2)

9.0 REFERENCES

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Surface Water Ambient Monitoring Program (SWAMP). 2017. Quality Assurance Program Plan. May 2017. 140 pp.

Appendix F

Regional Monitoring Program for the SF Bay
Pollutants of Concern (POC) Reconnaissance Monitoring Final Progress Report
Water Years 2015, 2016, and 2017

RMP
REGIONAL MONITORING PROGRAM FOR WATER QUALITY IN SAN FRANCISCO BAY

sfei.org/rmp

Pollutants of Concern Reconnaissance Monitoring Water Years 2015, 2016, and 2017

Draft Progress Report

Prepared by

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SFEI

CONTRIBUTION NO. 840 / JANUARY 2018

Preface

Reconnaissance monitoring for water years 2015, 2016, and 2017 was completed with funding provided by the Regional Monitoring Program for Water Quality in San Francisco Bay (RMP). This report is designed to be updated each year until completion of the study. At least one additional water year (2018) is planned for this study. This initial full draft report was prepared for BASMAA in support of materials submitted on or before March 31st 2018 in compliance with the Municipal Regional Stormwater Permit (MRP) Order No. R2-2015-0049. Changes are likely after further RMP review and prior to the final report being made available on the RMP website in early summer 2018.

Acknowledgements

We appreciate the support and guidance from members of the Sources, Pathways, and Loadings Workgroup of the RMP. The detailed work plan behind this study was developed by the Small Tributaries Loading Strategy (STLS) Team during a series of meetings in the summer of 2014, with slight modifications made during the summers of 2015, 2016, and 2017. Local members on the STLS Team at that time were Arleen Feng (Alameda Countywide Clean Water Program), Bonnie de Berry (San Mateo Countywide Water Pollution Prevention Program), Lucile Paquette (Contra Costa Clean Water Program), Chris Sommers and Lisa Sabin (Santa Clara Valley Urban Runoff Pollution Prevention Program), and Richard Looker and Jan O'Hara (Regional Water Board). San Francisco Estuary Institute (SFEI) field and logistical support over the first year of the project was provided by Patrick Kim, Carolyn Doehring, and Phil Trowbridge, in the second year of the project by Patrick Kim, Amy Richey, and Jennifer Sun, and in the winter of WY 2017 by Ila Shimabuku, Amy Richey, Steven Hagerty, Diana Lin, Margaret Sedlak, Jennifer Sun, Katie McKnight, Emily Clark, Don Yee, and Jennifer Hunt. SFEI's data management team is acknowledged for their diligent delivery of quality-assured well-managed data. This team was comprised of Amy Franz, Adam Wong, Michael Weaver, John Ross, and Don Yee in WYs 2015, 2016, and 2017. Helpful written reviews of this report were provided by members of BASMAA (Bonnie DeBerry, EOA Inc.; Lucile Paquette, Contra Costa Clean Water Program; Jim Scanlin, Alameda Countywide Clean Water Program).

Suggested citation:

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Executive Summary

The San Francisco Bay polychlorinated biphenyl (PCB) and mercury (Hg) total maximum daily loads (TMDLs) called for implementation of control measures to reduce PCB and Hg loads entering the Bay via stormwater. Subsequently, in 2009, the San Francisco Bay Regional Water Quality Control Board (Regional Water Board) issued the first combined Municipal Regional Stormwater Permit (MRP). This first MRP contained provisions aimed at improving information on stormwater pollutant loads in selected watersheds (Provision C.8.) and piloted a number of management techniques to reduce PCB and Hg loading to the Bay from smaller urbanized tributaries (Provisions C.11. and C.12.). In 2015, the Regional Water Board issued the second iteration of the MRP. "MRP 2.0" placed an increased focus on identifying those watersheds, source areas, and source properties that are potentially most polluted and are therefore most likely to be cost-effective areas for addressing load reduction requirements through implementation of control measures.

To support this increased focus, a stormwater screening monitoring program was developed and implemented in water years (WYs) 2015, 2016, and 2017. Most of the sites monitored were in Alameda, Santa Clara, and San Mateo Counties, with a few sites in Contra Costa County. At the 55 sampling sites, time-weighted composite water samples collected during individual storm events were analyzed for 40 PCB congeners, total Hg (HgT), suspended sediment concentration (SSC), selected trace metals, organic carbon (OC), and grain size. Where possible, sampling efficiency was increased by sampling two sites during a single storm that were near enough to one another that alternating between the two sites was safe and rapid. This same design is being implemented in the winter of WY 2018 by the RMP. The San Mateo Countywide Water Pollution Prevention Program and the Santa Clara Valley Urban Runoff Pollution Prevention Program are also implementing the design with their own funding.

During this study, the RMP began piloting the use of un-manned "remote" suspended sediment samplers (i.e., Hamlin samplers and Walling tube samplers). These remote samplers are designed to enhance settling and capture of suspended sediment from the water column. At nine of the manual sampling sites, a sample was collected in parallel using a Hamlin remote suspended sediment sampler, and at seven sites a sample was collected in parallel using a Walling tube suspended sediment sampler.

Key Findings

Based on this monitoring, a number of sites with elevated PCB and Hg concentrations in stormwater and estimated particle concentrations were identified. Total PCB concentrations measured in the composite water samples collected from the 55 sites ranged 300-fold, from 533 to 160,000 pg/L (excluding one sample where PCBs were below the detection level). The three highest ranking sites for PCB whole water concentrations from WYs 2015-2017 were Industrial Rd Ditch in San Carlos (160,000 pg/L), Line 12H at Coliseum Way in Oakland (156,000 pg/L), and the Outfall at Gilman St. in Berkeley (65,700 pg/L). When normalized by SSC to generate estimated particle concentrations, the three sites with highest estimated particle concentrations were slightly different: Industrial Rd Ditch in San Carlos (6,139 ng/g), Line 12H at Coliseum Way in Oakland (2,601 ng/g), and Gull Dr. SD in South San Francisco (859 ng/g). Estimated particle concentrations of this magnitude are among the highest observed in the Bay Area. Prior to this reconnaissance study, maximum concentrations were measured at Pulgas Pump Station-

South (8,222 ng/g), Santa Fe Channel (1,295 ng/g), Pulgas Pump Station-North (893 ng/g) and Ettie St. Pump Station (759 ng/g).[1]

Total Hg concentrations in composite water samples collected during WYs 2015-2017 ranged over 78-fold, from 5.6 to 439 ng/L. The lower variation in HgT concentrations as compared to PCBs is consistent with conceptual models for these substances (McKee et al., 2015). HgT is expected to be more uniformly distributed than PCBs because it has more widespread sources in the urban environment and a larger influence of atmospheric redistribution in the global mercury cycle. The greatest HgT concentrations were measured at the Outfall at Gilman St. in Berkeley (439 ng/L), Line 12K at the Coliseum Entrance in Oakland (288 ng/L), and Rodeo Creek at Seacliff Ct. Pedestrian Bridge in Rodeo (119 ng/L). For the estimated particle concentrations, the highest ranked site was the same, Outfall at Gilman St. in Berkeley (5.3 µg/g), but the second and third ranked sites were different, Meeker Slough in Richmond (1.3 µg/g), and Line 3A-M at 3A-D in Union City (1.2 µg/g). Estimated particle concentrations of this magnitude are similar to the upper range of those observed previously (mainly in WY 2011).

The sites with the highest particle concentrations for PCBs were typically not the sites with the highest concentrations for HgT. The ten highest ranking sites for PCBs based on estimated particle concentrations only ranked 18th, 12th, 15th, 1st, 48th, 26th, 6th, 10th, 37th, and 52nd, respectively, in relation to estimated HgT particle concentrations.

Remote Suspended Sediment Samplers

Results from the two remote suspended sediment sampler types used (Walling tube sampler and Hamlin sampler) generally characterized sites similarly to the composite stormwater sampling methods. Sites with higher concentrations with the remote samplers lined up with sites with higher concentrations in the composite samples and vice versa. The match appears to be better for PCBs (R^2 = 0.69) than for HgT (R^2 = -0.22), and the results suggest that the Walling tube sampler (R^2 = 0.84 for PCBs) performs better than the Hamlin (R^2 = 0.64 for PCBs). These results indicate that one option to consider is using Walling tube samplers to do preliminary screening of sites before doing a more thorough sampling of the water column during multiple storms at selected higher priority sites. However, further testing is needed to determine the overall reliability and practicality of deploying these remote instruments instead of, or to augment, manual composite stormwater sampling.

Further Data Interpretations

Relationships between the PCB and HgT estimated particle concentrations, watershed characteristics, and other water quality measurements were evaluated using Spearman Rank correlation analysis. Based on data collected by SFEI since WY 2003, PCB particle concentrations positively correlate with

[1]Note, these estimated particle concentrations do not all match those reported in McKee et al. (2012) because of the slightly different method of computing the central tendency of the data (see the Methods section of this report above) and, in the case of Pulgas Pump Station – South, because of the extensive additional sampling that has occurred since McKee et al. (2012) reported the reconnaissance results from the WY 2011 field season.

impervious cover (r_s = 0.56), old industrial land use (r_s = 0.58), and HgT particle concentrations (r_s = 0.43). PCB particle concentrations inversely correlate with watershed area and trace metal particle concentrations (other than Hg, i.e., As, Cu, Cd, Pb, and Zn). HgT particle concentrations do not correlate with any of the other trace metals and showed similar but weaker relationships to impervious cover, old industrial land use, and watershed area than did PCBs. In contrast, the trace metals other than HgT (i.e., As, Cd, Cu, Pb, and Zn) all correlate with one another more generally. Overall, the data collected to date do not support the use of any of the trace metals analyzed as a tracer for either PCB or HgT pollution sources.

Old industrial land use is believed to yield the greatest mass of PCB loads in the region. The watersheds for the 79 sites that have been sampled by SFEI since WY 2003 cover about 34% of the old industrial land use in the region. The largest proportion of old industrial area sampled so far in each county has occurred in Santa Clara (96% of old industrial area in this county is in the watershed of a sampling site), followed by San Mateo (51%), Alameda (41%), and Contra Costa (11%). The higher coverage in Santa Clara County is due to sampling of a number of large watersheds and the prevalence of older industrial areas upstream in the Coyote Creek and Guadalupe River watersheds. Of the remaining areas in the region with older industrial land use yet to be sampled in the region (~100 km^2), 46% of it lies within 1 km of the Bay and 67% of it is within 2 km of the Bay. These areas are more likely to be tidal, include heavy industrial areas that were historically serviced by rail and ship based transport, and are often very difficult to sample due to a lack of public rights of way. A different sampling strategy may be needed to effectively determine what pollution levels might be associated with these areas. In the short term, this study will continue into WY 2018 and possibly beyond in the attempt to continue to identify areas for follow up investigation and possible management action. The focus will continue to be on finding new areas of concern, although follow up sampling may occur at some sites in order to verify initial sampling results, and there will also be effort towards continuing the remote sampler pilot study.

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Introduction

The San Francisco Bay polychlorinated biphenyl (PCB) and mercury total maximum daily loads (TMDLs) (SFBRWQCB, 2006; 2007) called for implementation of control measures to reduce stormwater polychlorinated biphenyl (PCB) loads from an estimated annual baseline load of 20 kg to 2 kg by 2030 and total mercury (HgT) loads from about 160 kg to 80 kg by 2028. Shortly after adoption of the TMDLs, in 2009, the San Francisco Bay Regional Water Quality Control Board (Regional Water Board) issued the first combined Municipal Regional Stormwater Permit (MRP) for MS4 phase I stormwater agencies (SFBRWQCB, 2009; 2011). In support of the TMDLs, MRP 1.0, as it came to be known, contained a provision for improved information on stormwater loads for pollutants of concern (POCs) in selected watersheds (Provision C.8.) as well as specific provisions for Hg, methylmercury and PCBs (Provisions C.11 and C.12) that called for reducing Hg and PCB loads from smaller urbanized tributaries. To help address these permit requirements, a Small Tributaries Loading Strategy (STLS) was developed that outlined four key management questions (MQs) as well as a general plan to address these questions (SFEI, 2009).

MQ1. Which Bay tributaries (including stormwater conveyances) contribute most to Bay impairment from POCs?

MQ2. What are the annual loads or concentrations of POCs from tributaries to the Bay?

MQ3. What are the decadal-scale loading or concentration trends of POCs from small tributaries to the Bay?

MQ4. What are the projected impacts of management actions (including control measures) on tributaries and where should these management actions be implemented to have the greatest beneficial impact?

During the first MRP term (2009-15), the majority of STLS effort was focused on refining pollutant loading estimates and finding and prioritizing potential “high leverage” watersheds and subwatersheds which contribute disproportionately high concentrations or loads to sensitive Bay margins, through the funding from both RMP and Bay Area Stormwater Management Agencies Association (BASMAA)[2]. As a result of these efforts, sufficient pollutant data were collected at 11 urban sites, making it possible to estimate pollutant loads from these sites with varying degrees of certainty (McKee et al. 2015, Gilbreath et al. 2015a). During the first MRP term, a Regional Watershed Spreadsheet Model (RWSM) was also developed as a regional-scale planning tool primarily to estimate long-term pollutant loads from the small tributaries, and secondarily to provide supporting information for prioritizing watersheds or sub-watershed areas for management (Wu et al., 2016; Wu et al., 2017).

In November 2015, the Regional Water Board issued the second iteration of the MRP (SFBRWQCB, 2015). MRP “2.0” places an increased focus on finding high leverage watersheds, source areas, and

[2] BASMAA is made up of a number of programs which represent Permittees and other local agencies

source properties that are more polluted, and that are located upstream of sensitive Bay margin areas. Specifically, the permit adds a new stipulation that calls for the identification of sources or watershed source areas that provide the greatest opportunities for reductions of PCBs and Hg in urban stormwater runoff. To help support this focus and also refine information to address Management Questions, the Sources, Pathways and Loadings Work Group (SPLWG) and the Small Tributaries Loading Strategy (STLS) Team developed and implemented a stormwater reconnaissance screening monitoring program in WYs 2015, 2016, and 2017 to provide data, as part of multiple lines of evidence, for the identification of potential high leverage areas. The monitoring program was adapted from the one first implemented in WY 2011 (McKee et al., 2012) and benefited from lessons learned from that effort. This same design was also implemented in WYs 2016 and 2017 by the San Mateo Countywide Water Pollution Prevention Program and the Santa Clara Valley Urban Runoff Pollution Prevention Program (EOA, 2017a and 2017b).

This report summarizes and provides a preliminary interpretation of data collected during WYs 2015, 2016, and 2017. The data collected and presented here are contributing to a broad effort of identifying potential management areas for pollutant reduction. During Calendar Year (CY) 2018, the RMP is funding a data analysis project that aims to mine and analyze all the existing stormwater data. The primary goals of that analysis are to develop an improved method for identifying and ranking watersheds of management interest for further screening or investigation, and to guide future sampling design. In addition, the STLS team is evaluating sampling programs for monitoring stormwater loading trends in response to management efforts (Melwani et al., 2017 in preparation). Reconnaissance data collected in WYs 2011, 2015, 2016, and 2017 may provide baseline data for identifying concentration or particle concentration trends over time.

The report is designed to be updated annually and will be updated again in approximately 12 months to include the WY 2018 sampling data that is currently being collected.

Sampling Methods

Sampling locations

Four objectives were used as bases for site selection.

1. Identifying potential high leverage watersheds and subwatersheds
    a. Watersheds with suspected high pollution
    b. Sites with ongoing or planned management actions
    c. Source identification within a larger watershed of known concern (nested sampling design)
2. Sampling strategic large watersheds with USGS gauges to provide first-order loading estimates and to support calibration of the Regional Watershed Spreadsheet Model (RWSM)
3. Validating unexpected low (potential false negative) concentrations (to address the possibility of a single storm composite poorly characterizing a sampling location)
4. Filling gaps along environmental gradients or source areas (to support the RWSM)

The majority of samples each year (60-70% of the effort) were dedicated to identifying potential high leverage watersheds and subwatersheds. The remaining resources were allocated to address the other three objectives. SFEI worked with the respective Countywide Clean Water Programs to identify priority drainages for monitoring including storm drains, ditches/culverts, tidally influenced areas, and natural areas. During the summers of 2014, 2015, and 2016, a large number of sites were visited, and each of them was surveyed for safety, logistical constraints, and feasible drainage-line entry points. From this larger set, a final set of about 25 sites was selected each year to form the pool from which field staff would select sampling locations for each storm depending on logistics.

Watershed sites with a wide variety of characteristics were sampled in WYs 2015, 2016, and 2017 (Figure 1 and Table 1). Of these sites, 17 were in Santa Clara County, 17 in San Mateo County, 15 in Alameda County, five in Contra Costa County[3] and one site in Solano County. The drainage area for each sampling location ranged from 0.09 km^2 to 233 km^2 and typically was characterized by a high degree of imperviousness (2%-88%: mean = 64%; dataset used is the National Land Cover Database). The percentage of the watersheds designated as old industrial[4] ranged from 0% to 87% (mean 24%) (dataset used included the land use dataset input to the Regional Watershed Spreadsheet Model (in prep; estimated 2018 release to public)). While the majority of sampling sites were selected to primarily identify potential high leverage watersheds and subwatersheds, Lower Penitencia Creek was resampled to verify whether the first sample collected there (WY 2011) was a false negative (unexpectedly low concentration). Guadalupe River at Hwy 101 was also resampled in WY 2017 during a large and rare storm to assess trends for mercury (McKee et al., in prep). A matrix of site characteristics for sampling strategic larger watersheds was also developed (Table 2), but none of them were sampled in WYs 2015 or 2016 because the sampling trigger criteria for rainfall and flow were not met and only one (Colma Creek) was sampled in WY 2017. Trigger criteria were met in January and February 2017 for other strategic larger watersheds under consideration (Alameda Creek, Dry Creek at Arizona Street, San Francisquito Creek at University Avenue, Matadero Creek at Waverly Street, and Colma Creek at West Orange Avenue), but none were sampled because staff and budgetary resources were allocated elsewhere.

[3] Given the long history of industrial zoning along much of the Contra Costa County waterfront relative to other counties, still more sampling is needed to characterize these areas.

[4] Note the definition of "old Industrial" land use used here is based on definitions developed by the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP) building on GIS development work completed during the development of the RWSM (Wu et al., 2016; 2017).

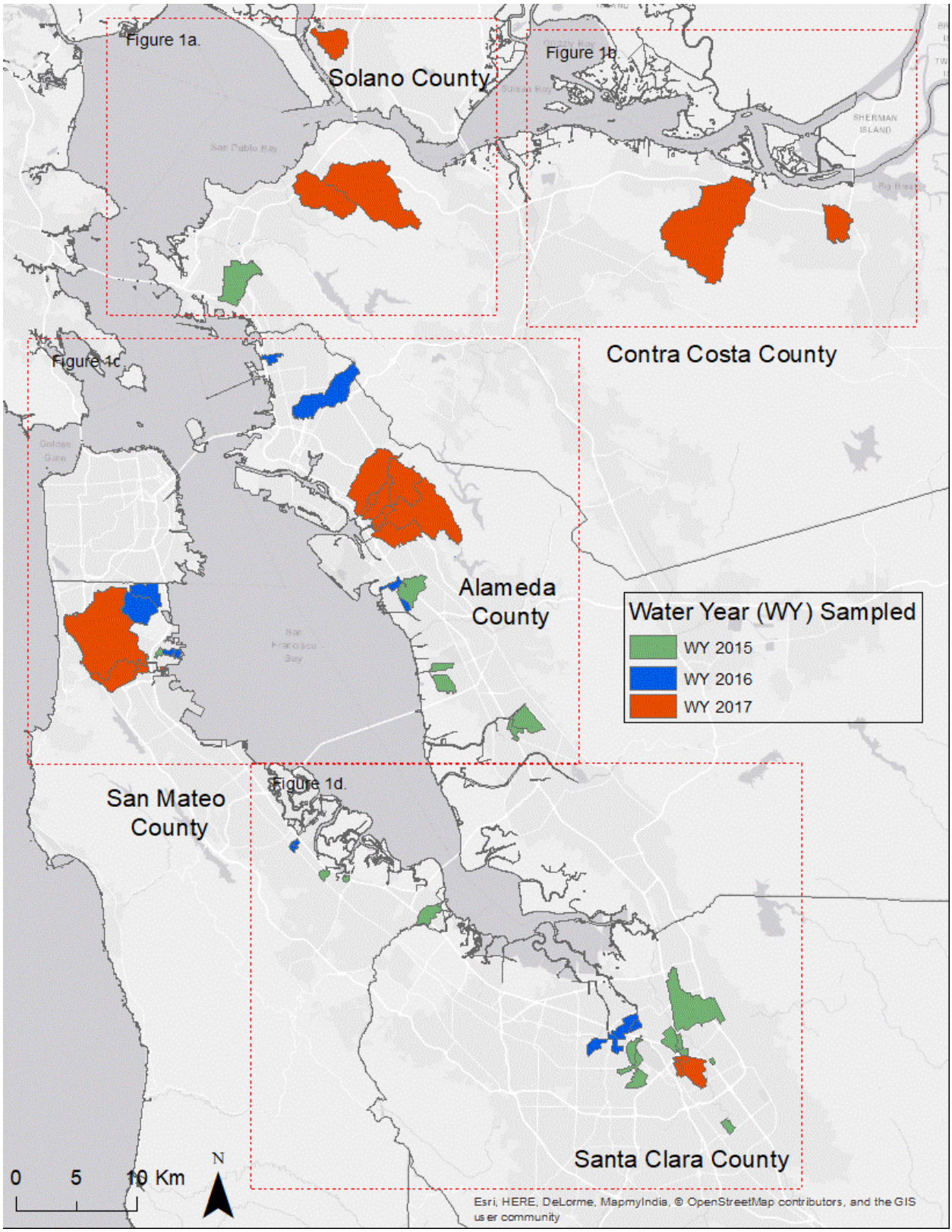

Figure 1. Watersheds sampled in water years 2015, 2016, and 2017.

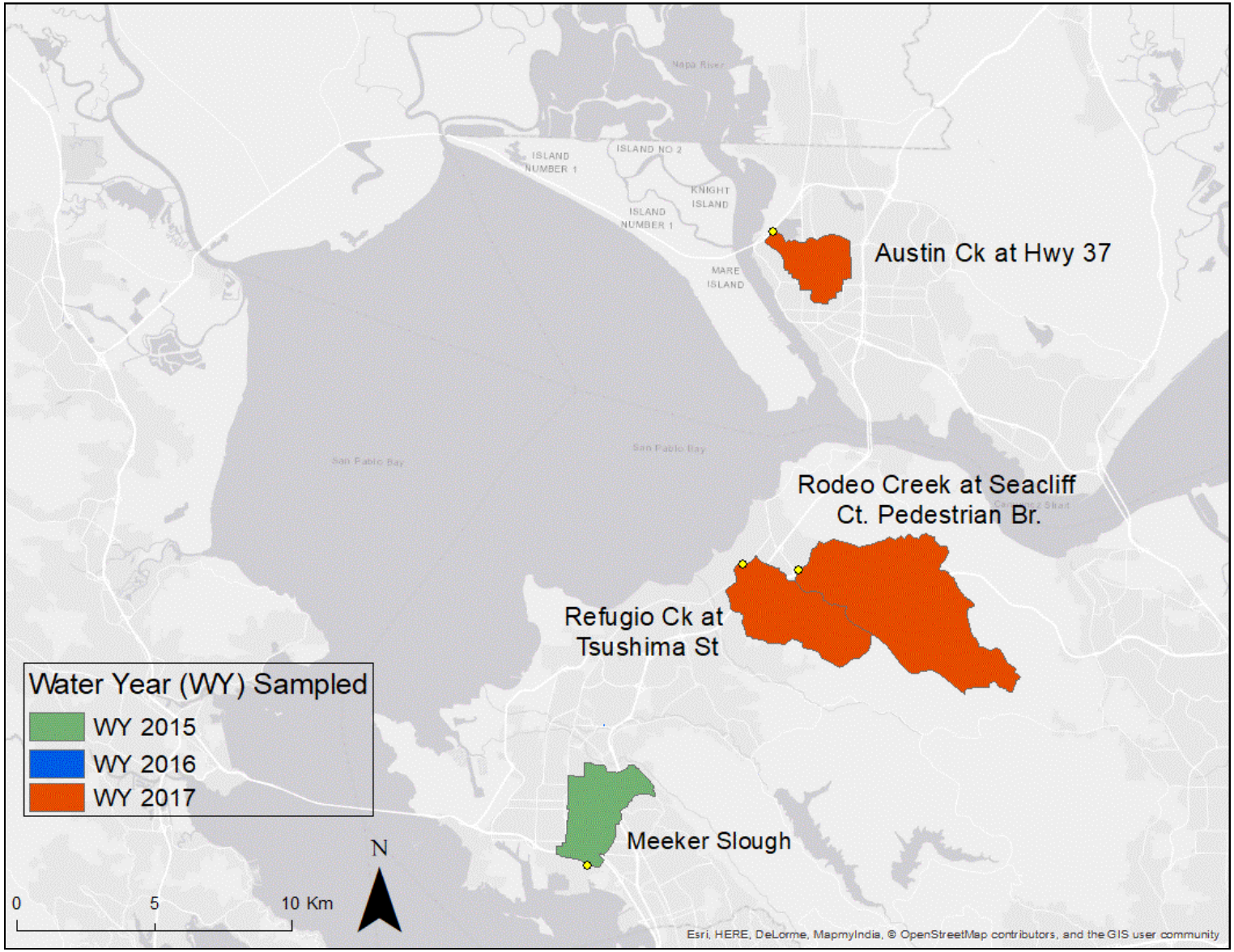

Figure 1a. Sampling locations (marked by yellow dots) and watershed boundaries in western Contra Costa County and Solano County.

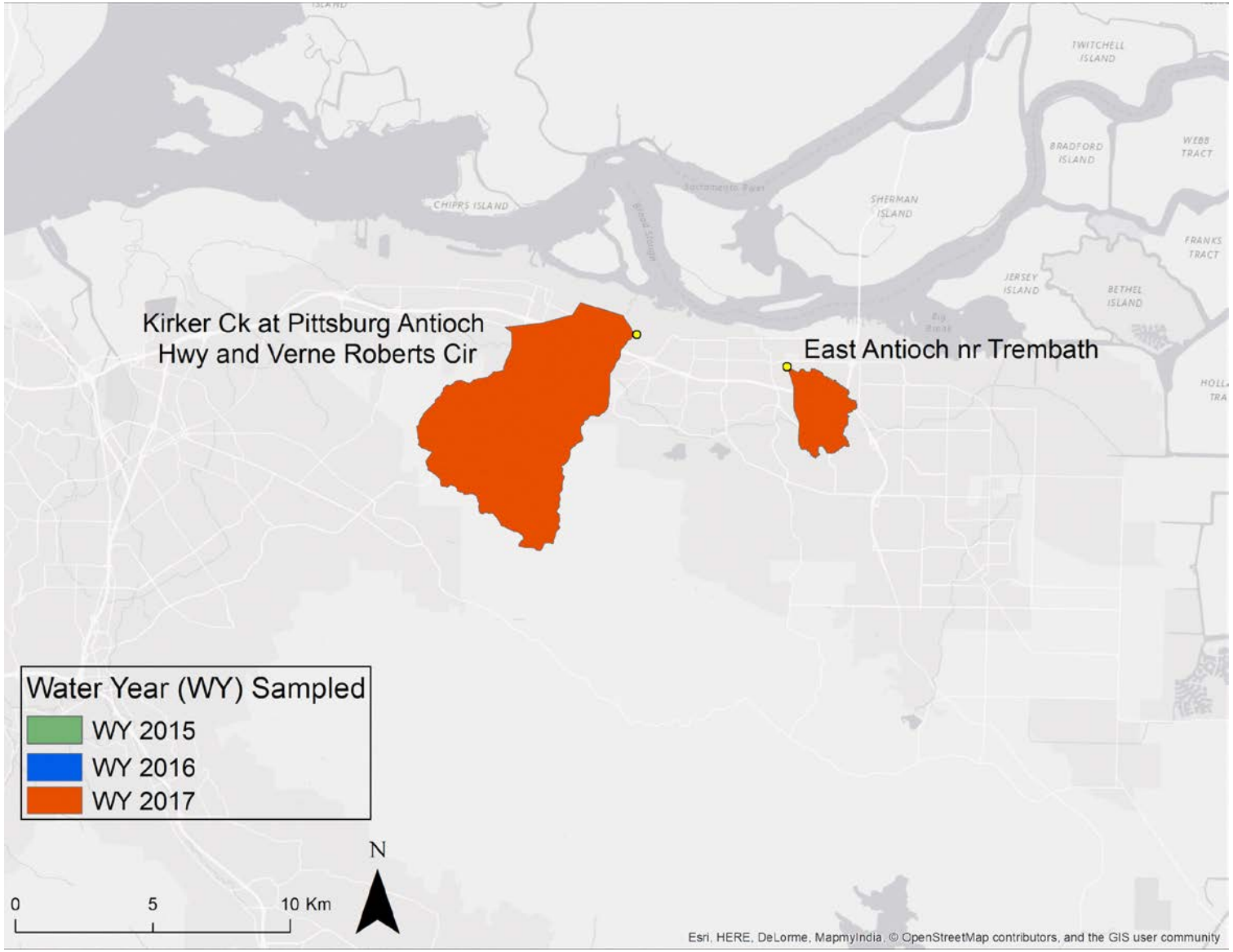

Figure 1b. Sampling locations (marked by yellow dots) and watershed boundaries in eastern Contra Costa County.

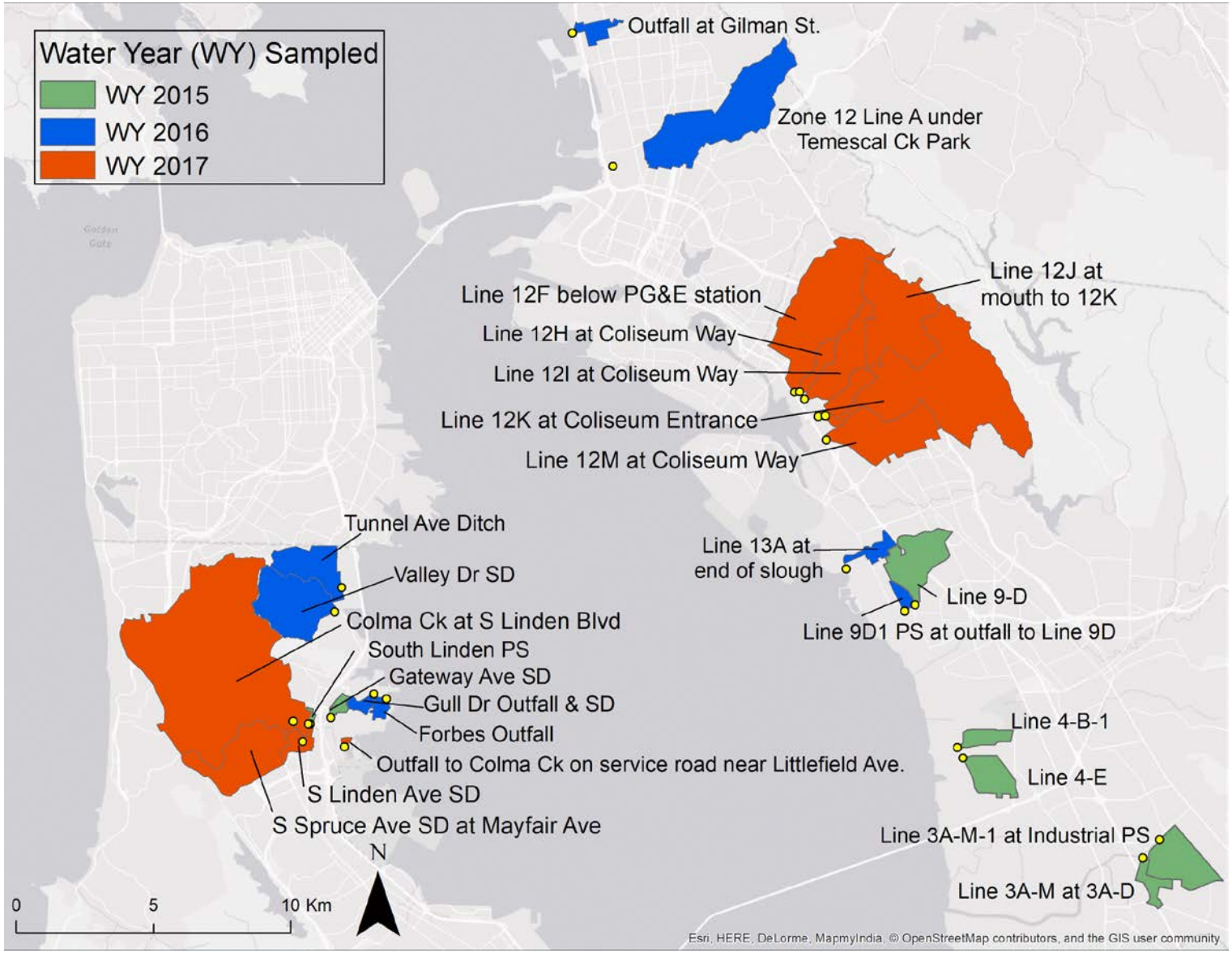

Figure 1c. Sampling locations (marked by yellow dots) and watershed boundaries in Alameda County and northern San Mateo County.

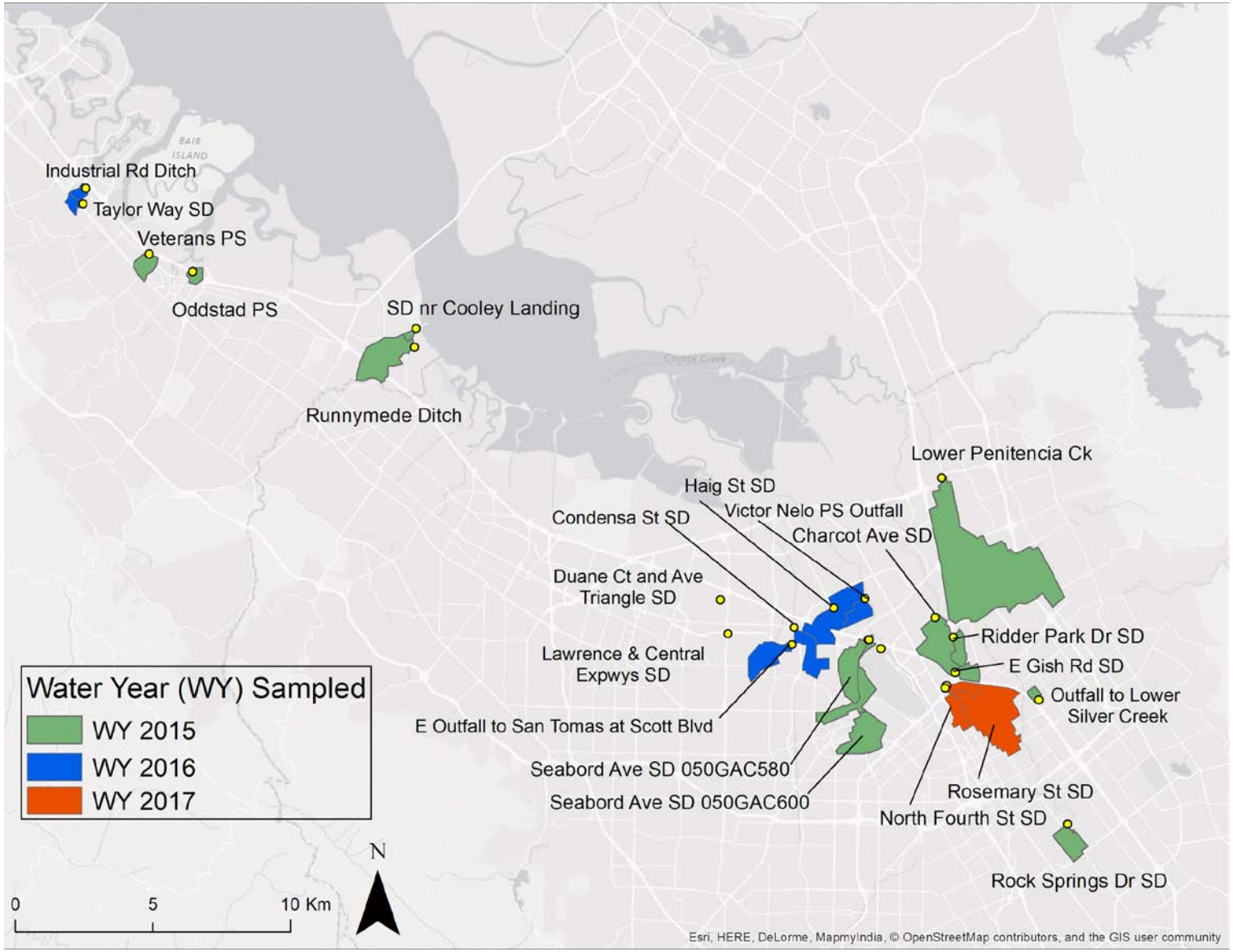

Figure 1d. Sampling locations (marked by yellow dots) and watershed boundaries in northern San Mateo County and Santa Clara County.

Table 1. Key characteristics of water years 2015, 2016, and 2017 sampling locations.

County	City	Watershed Name	Catchment Code	MS4 or Receiving Water	Latitude	Longitude	Sample Date	Area (sq km)	Impervious Cover (%)	Old Industrial (%)
Alameda	Union City	Line 3A-M-1 at Industrial PS	AC-Line 3A-M-1	MS4	37.61893	-122.05949	12/11/14	3.44	78%	26%
Alameda	Union City	Line 3A-M at 3A-D	AC-Line 3A-M	MS4	37.61285	-122.06629	12/11/14	0.88	73%	12%
Alameda	Hayward	Line 4-B-1	AC-Line 4-B-1	MS4	37.64752	-122.14362	12/16/14	0.96	85%	28%
Alameda	Hayward	Line 4-E	AC-Line 4-E	MS4	37.64415	-122.14127	12/16/14	2.00	81%	27%
Alameda	San Leandro	Line 9-D	AC-Line 9-D	MS4	37.69383	-122.16248	4/7/15	3.59	78%	46%
Alameda	Berkeley	Outfall at Gilman St.	AC-2016-1	MS4	37.87761	-122.30984	12/21/15	0.84	76%	32%
Alameda	San Leandro	Line 9-D-1 PS at outfall to Line 9-D	AC-2016-15	MS4	37.69168	-122.16679	1/5/16	0.48	88%	62%
Alameda	Emeryville	Zone 12 Line A under Temescal Ck Park	AC-2016-3	MS4	37.83450	-122.29159	1/6/16	17.47	30%	4%
Alameda	San Leandro	Line 13-A at end of slough	AC-2016-14	MS4	37.70497	-122.19137	3/10/16	0.83	84%	68%
Alameda	Oakland	Line 12F below PG&E station	Line12F	MS4	37.76218	-122.21431	12/15/16	10.18	56%	3%
Alameda	Oakland	Line 12H at Coliseum Way	Line12H	MS4	37.76238	-122.21217	12/15/16	0.97	71%	10%
Alameda	Oakland	Line 12I at Coliseum Way	Line12I	MS4	37.75998	-122.21020	12/15/16	3.41	63%	9%
Alameda	Oakland	Line 12J at mouth to 12K	Line12J	MS4	37.75474	-122.20136	12/15/16	8.81	30%	2%
Alameda	Oakland	Line 12K at Coliseum Entrance	Line12KEntrance	MS4	37.75446	-122.20431	2/9/17	16.40	31%	1%
Alameda	Oakland	Line 12M at Coliseum Way	Line12MColWay	MS4	37.74689	-122.20069	2/9/17	5.30	69%	22%
Contra Costa	Richmond	Meeker Slough	Meeker Slough	Receiving Water	37.91786	-122.33838	12/3/14	7.34	64%	6%
Contra Costa	Pittsburg	Kirker Ck at Pittsburg Antioch Hwy and Verne Roberts Cir	KirkerCk	Receiving Water	38.01275	-121.84345	1/8/17	36.67	18%	5%
Contra Costa	Antioch	East Antioch nr Trembath	EAntioch	Receiving Water	38.00333	-121.78106	1/8/17	5.26	26%	3%
Contra Costa	Hercules	Refugio Ck at Tsushima St	RefugioCk	Receiving Water	38.01775	-122.27710	1/18/17	10.73	23%	0%
Contra Costa	Rodeo	Rodeo Creek at Seacliff Ct. Pedestrian Br.	RodeoCk	Receiving Water	38.01604	-122.25381	1/18/17	23.41	2%	3%
San Mateo	Redwood City	Oddstad PS	SM-267	MS4	37.49172	-122.21886	12/2/14	0.28	74%	11%
San Mateo	Redwood City	Veterans PS	SM-337	MS4	37.49723	-122.23693	12/15/14	0.52	67%	7%
San Mateo	South San Francisco	Gateway Ave SD	SM-293	MS4	37.65244	-122.40257	2/6/15	0.36	69%	52%
San Mateo	South San Francisco	South Linden PS	SM-306	MS4	37.65018	-122.41127	2/6/15	0.14	83%	22%

San Mateo	East Palo Alto	Runnymede Ditch	SM-70	MS4	37.46883	-122.12701	2/6/15	2.05	53%	2%
San Mateo	East Palo Alto	SD near Cooley Landing	SM-72	MS4	37.47492	-122.12640	2/6/15	0.11	73%	39%
San Mateo	South San Francisco	Forbes Blvd Outfall	SM-319	MS4	37.65889	-122.37996	3/5/16	0.40	79%	0%
San Mateo	South San Francisco	Gull Dr Outfall	SM-315	MS4	37.66033	-122.38502	3/5/16	0.43	75%	42%
San Mateo	South San Francisco	Gull Dr SD	SM-314	MS4	37.66033	-122.38510	3/5/16	0.30	78%	54%
San Mateo	Brisbane	Tunnel Ave Ditch	SM-350/368/more	Receiving Water	37.69490	-122.39946	3/5/16	3.02	47%	8%
San Mateo	Brisbane	Valley Dr SD	SM-17	MS4	37.68694	-122.40215	3/5/16	5.22	21%	7%
San Mateo	San Carlos	Industrial Rd Ditch	SM-75	MS4	37.51831	-122.26371	3/11/16	0.23	85%	79%
San Mateo	San Carlos	Taylor Way SD	SM-32	MS4	37.51320	-122.26466	3/11/16	0.27	67%	11%
San Mateo	South San Francisco	S Linden Ave SD (291)	SLinden	MS4	37.64420	-122.41390	1/8/17	0.78	88%	57%
San Mateo	South San Francisco	S Spruce Ave SD at Mayfair Ave (296)	SSpruce	MS4	37.65084	-122.41811	1/8/17	5.15	39%	1%
San Mateo	South San Francisco	Colma Ck at S. Linden Blvd	ColmaCk	MS4	37.65017	-122.41189	2/7/17	35.07	41%	3%
San Mateo	South San Francisco	Outfall to Colma Ck on service rd nr Littlefield Ave. (359)	ColmaCkOut	MS4	37.64290	-122.39677	2/7/17	0.09	88%	87%
Santa Clara	Milpitas	Lower Penitencia Ck	Lower Penitencia	Receiving Water	37.42985	-121.90913	12/11/14	11.50	65%	2%
Santa Clara	Santa Clara	Seabord Ave SD SC-050GAC580	SC-050GAC580	MS4	37.37637	-121.93793	12/11/14	1.35	81%	68%
Santa Clara	Santa Clara	Seabord Ave SD SC-050GAC600	SC-050GAC600	MS4	37.37636	-121.93767	12/11/14	2.80	62%	18%
Santa Clara	San Jose	E. Gish Rd SD	SC-066GAC550	MS4	37.36632	-121.90203	12/11/14	0.44	84%	71%
Santa Clara	San Jose	Ridder Park Dr SD	SC-051CTC400	MS4	37.37784	-121.90302	12/15/14	0.50	72%	57%
Santa Clara	San Jose	Outfall to Lower Silver Ck	SC-067SCL080	MS4	37.35789	-121.86741	2/6/15	0.17	79%	78%
Santa Clara	San Jose	Rock Springs Dr SD	SC-084CTC625	MS4	37.31751	-121.85459	2/6/15	0.83	80%	10%
Santa Clara	San Jose	Charcot Ave SD	SC-051CTC275	MS4	37.38413	-121.91076	4/7/15	1.79	79%	25%
Santa Clara	Santa Clara	Lawrence & Central Expwys SD	SC-049CZC800	MS4	37.37742	-121.99566	1/6/16	1.20	66%	1%
Santa Clara	Santa Clara	Condensa St SD	SC-049STA710	MS4	37.37426	-121.96918	1/19/16	0.24	70%	32%
Santa Clara	San Jose	Victor Nelo PS Outfall	SC-050GAC190	MS4	37.38991	-121.93952	1/19/16	0.58	87%	4%
Santa Clara	Santa Clara	E Outfall to San Tomas at Scott Blvd	SC-049STA550	MS4	37.37991	-121.96842	3/6/16	0.67	66%	31%
Santa Clara	San Jose	Haig St SD	SC-050GAC030	MS4	37.38664	-121.95223	3/6/16	2.12	72%	10%

Santa Clara	San Jose	North Fourth St SD 066GAC550B	NFourth	MS4	37.36196	-121.90535	1/8/17	1.01	68%	27%
Santa Clara	San Jose	Rosemary St SD 066GAC550C	Rosemary	MS4	37.36118	-121.90594	1/8/17	3.67	64%	11%
Santa Clara	San Jose	Guadalupe River at Hwy 101	Guad 101	Receiving Water	37.37355	-121.93269	1/8/17	233.00	39%	3%
Santa Clara	Santa Clara	Duane Ct and Ave Triangle SD	SC-049CZC200	MS4	37.38852	-121.99901	12/13/15 and 1/6/2016	1.00	79%	23%
Solano	Vallejo	Austin Ck at Hwy 37	AustinCk	Receiving Water	38.12670	-122.26791	3/24/17	4.88	61%	2%

Table 2. Characteristics of larger watersheds to be monitored, proposed sampling location, and proposed sampling trigger criteria. None of these watersheds were sampled during water years 2015 or 2016 because sampling trigger criteria for flow and rainfall were not met, and in WY 2017 large watershed sampling was focused on the Guadalupe River rather than the watersheds in this list.

Proposed sampling location							Relevant USGS gauge fo 1st order loads computations	
Watershed system	**Watershed Area (km²)**	**Impervious Surface (%)**	**Industrial (%)**	**Sampling Objective**	**Commentary**	**Proposed Sampling Triggers**	**Gauge number**	**Area at USGS Gauge (sq²)**
Alameda Creek at EBRPD Bridge at Quarry Lakes	913	8.5	2.3	2, 4	Operating flow and sediment gauge at Niles just upstream will allow the computation of 1st order loads to support the calibration of the RWSM for a large, urbanizing type watershed.	7" of antecedent rainfall in Livermore (reliable web published rain gauge), after at least an annual storm has already occurred (~2000 cfs at the Niles gauge), and a forecast for the East Bay interior valleys of 2-3" over 12 hrs.	11179000	906
Dry Creek at Arizona Street (purposely downstream from historic industrial influences)	25.3	3.5	0.3	2, 4	Operating flow gauge at Union City just upstream will allow the computation of 1st order loads to support the calibration of the RWSM for mostly undeveloped land use type watersheds.	7" of antecedent rainfall in Union City, after at least a common annual storm has already occurred (~200 cfs at the Union City gauge), and a forecast for the East Bay Hills of 2-3" over 12 hrs.	11180500	24.3
San Francisquito Creek at University Avenue (as far down as possible to capture urban influence upstream from tide)	81.8	11.9	0.5	2, 4	Operating flow gauge at Stanford upstream will allow the computation of 1st order loads to support the calibration of the RWSM for larger mixed land use type watersheds. Sample pair with Matadero Ck.	7" of antecedent rainfall in Palo Alto, after at least a common annual storm has already occurred (~1000 cfs at the Stanford gauge), and a forecast for the Peninsula Hills of 3-4" over 12 hrs.	11164500	61.1
Matadero Creek at Waverly Street (purposely downstream from the railroad)	25.3	22.4	3.7	2, 4	Operating flow gauge at Palo Alto upstream will allow the computation of 1st order loads to support the calibration of the RWSM for mixed land use type watersheds. Sample pair with San Francisquito Ck.	7" of antecedent rainfall in Palo Alto, after at least a common annual storm has already occurred (~200 cfs at the Palo Alto gauge), and a forecast for the Peninsula Hills of 3-4" over 12 hrs.	11166000	18.8
Colma Creek at West Orange Avenue or further downstream (as far down as possible to capture urban and historic influence upstream from tide)	27.5	38	0.8	2, 4 (possibly 1)	Historic flow gauge (ending 1996) in the park a few hundred feet upstream will allow the computation of 1st order loads estimates to support the calibration of the RWSM for mixed land use type watersheds.	Since this is a very urban watershed, precursor conditions are more relaxed: 4" of antecedent rainfall, and a forecast for South San Francisco of 2-3" over 12 hrs. Measurement of discharge and manual staff plate readings during sampling will verify the historic rating.	11162720	27.5

Field methods

Mobilization and preparing to sample

The mobilization for sampling was typically triggered by storm forecast. When a minimum rainfall of at least one-quarter inch[5] over 6 hours was forecasted, sampling teams were deployed, ideally reaching the sampling site about 1 hour before the onset of rainfall[6]. When possible, one team sampled two sites close to one another to increase efficiency and reduce staffing costs. Upon arrival, the team assembled equipment and carried out final safety checks. Sampling equipment used at a site depended on the accessibility of drainage lines. Some sites were sampled by attaching laboratory-prepared trace-metal-clean Teflon sampling tubing to a painter's pole and a peristaltic pump with laboratory-cleaned silicone pump-roller tubing (Figure 2a). During sampling, the tube was dipped into the channel or drainage line at mid-channel mid-depth (if shallow) or depth integrating if the depth was more than 0.5 m. In other cases, a DH 84 (Teflon) sampler was used without a pump.

Manual time-paced composite stormwater sampling procedures

At each site, a time-paced composite sample was collected with a variable number of sub-samples, or aliquots. Based on the weather forecast, prevailing on-site conditions, and radar imagery, field staff estimated the duration of the storm and selected an aliquot size for each analyte (0.1-0.5 L) and number of aliquots (minimum=2; mode=5) to ensure the minimum volume requirements for each analyte (Hg, 0.25L; SSC, 0.3L; PCBs, 1L; Grain Size, 1L; TOC, 0.25L) would be reached before the storm's end. Because the minimum volume requirements were less than the size of sample bottles, there was flexibility to add aliquots in the event when a storm continued longer than predicted. The final volume of the aliquots was determined just before the first aliquot was taken and remained fixed for the sampling event. All aliquots for a storm were collected into the same bottle, which was kept in a cooler on ice and/or refrigerated at 4 °C before transport to a lab (see Yee et al. (2017)) for information about bottles, preservatives and hold times).

Remote suspended sediment sampling procedures

Two remote samplers, the Hamlin (Lubliner, 2012) and the Walling tube (Phillips et al., 2000), were deployed approximately at mid-channel/ storm drain to collect suspended sediment samples. To date, 9 locations have been sampled with the Hamlin and 7 locations with the Walling tube sampler (Table 3). During each deployment, the Hamlin sampler[7] was stabilized on the bed of stormdrain or concrete channel either by its own weight (approximately 25 lbs) or additionally by attaching barbell weight plates to the bottom of the sampler (Figure 2b). The Walling tube could not be deployed in storm drains due to its size and the need for staying horizontal, and therefore was secured in open channels either by barbell weights secured with hose clamps to a concrete bed, or to a natural bed with hose clamps

[5] Note, this was relaxed due to a lack of larger storms. Ideally, mobilization would only proceed with a minimum forecast of at least 0.5".

[6] Antecedent dry-weather was not considered prior to deployment. Antecedent conditions can have impacts on the concentration of certain build-up/wash-off pollutants like metals. For PCBs, however, antecedent dry-weather may be less important than the mobilization of in-situ legacy sources.

[7] In future years, if the Hamlin is deployed within a natural bed channel, elevating the sampler more off the bed may be considered but was not done in WYs 2015 or 2016.

attached to temporarily installed rebar (Figure 2c). To minimize the chances of sampler loss, both samplers were secured by a stainless steel cable to a temporary rebar anchor or another object such as a tree or fencepost.

The remote samplers were deployed for the duration of the manual sampling, and removed from the channel bed/storm drain bottom shortly after the last water quality sample aliquot was collected. Water and sediment collected in the samplers were decanted into one or two large glass bottles. When additional water was needed to flush the settled sediments from the remote samplers into the collecting bottles, site water from the sampled channel was used. The collected samples were split and placed into laboratory containers and then shipped to the laboratory for analysis. Most samples were analyzed as whole water samples (due to insufficient solid mass to analyze as a sediment sample), and only one location was analyzed as a sediment sample. Between sampling sites, the remote samplers were thoroughly cleaned using a brush and Alconox detergent, followed by a DI rinse.

(a)

(b)

(c)

(d)

Figure 2. Sampling equipment used in the field. (a) Painter's pole, Teflon tubing and an ISCO used as a slave pump; (b) Teflon bottle attached to the end of a DH81 sampling pole; (c) a Hamlin suspended sediment sampler secured atop a 45 lb plate; and (d) a Walling tube suspended sediment sampler secured by 5 lb weights along the body of the tube (because it is sitting atop a concrete bed) and rebar driven into the natural bed at the back of the sampler.

Table 3. Locations where remote sediment samplers were pilot tested.

Site	Date	Sampler(s) deployed	Comments
Meeker Slough	11/2015	Hamlin and Walling	Sampling effort was unsuccessful due to very high velocities. Both samplers washed downstream because they were not weighted down enough and debris caught on the securing lines.
Outfall to Lower Silver Creek	2/06/15	Hamlin and Walling	Sampling effort was successful. This sample was analyzed as a water sample.
Charcot Ave Storm Drain	4/07/15	Hamlin	Sampling effort was successful. This sample was analyzed as a sediment sample.
Cooley Landing Storm Drain	2/06/15	Hamlin	Sampling effort was successful. This sample was analyzed as a water sample.
Duane Ct and Ave Triangle SD	1/6/2016	Hamlin	Sampling effort was successful. This sample was analyzed as a water sample.
Victor Nelo PS Outfall	1/19/2016	Hamlin and Walling	Sampling effort was successful. This sample was analyzed as a water sample.
Forbes Blvd Outfall	3/5/2016	Hamlin	Sampling effort was successful. This sample was analyzed as a water sample.
Tunnel Ave Ditch	3/5/2016	Hamlin and Walling	Sampling effort was successful. This sample was analyzed as a water sample.
Taylor Way SD	3/11/2016	Hamlin	Sampling effort was successful. This sample was analyzed as a water sample.
Colma Creek Outfall	2/7/2017	Walling	Sampling effort was successful; however, sampler became submerged for several hours during a high tide cycle and was retrieved afterwards. We hypothesize that this may have had the effect of adding cleaner sediment into the sampler and therefore the result may be biased low. This sample was analyzed as a water sample.
Austin Creek	3/24/2017	Hamlin and Walling	Sampling effort was successful. This sample was analyzed as a water sample.
Refugio Creek	1/18/2017	Walling	Sampling effort was successful. This sample was analyzed as a water sample.
Rodeo Creek	1/18/2017	Walling	Sampling effort was successful. This sample was analyzed as a water sample.

Laboratory analytical methods

The target analytes for this study are listed in Table 4. The analytical methods and quality control tests are further described in the RMP Quality Assurance Program Plan (Yee et al., 2017). Laboratory methods were chosen based on a combination of factors of method detection limits, accuracy and precision, and costs (BASMAA, 2011; 2012) (Table 4). For some sites where the remote samplers were deployed, Hg, PCBs and organic carbon (OC) were analyzed for both particulate and dissolved phases to be compared with total water concentrations and particulate-only concentrations from manually collected water samples.

Table 4. Laboratory analysis methods.

Analysis	Matrix	Analytical Method	Lab	Filtered	Field Preservation	Contract Lab / Preservation Hold Time
PCBs (40)[8]-Dissolved	Water	EPA 1668	AXYS	Yes	NA	NA
PCBs (40)[8]-Total	Water	EPA 1668	AXYS	No	NA	NA
SSC	Water	ASTM D3977	USGS	No	NA	NA
Grain size	Water	USGS GS method	USGS	No	NA	NA
Mercury-Total	Water	EPA 1631E	BRL	No	BrCl	BRL preservation within 28 days
Metals-Total (As, Cd, Pb, Cu, Zn)	Water	EPA 1638 mod	BRL	No	HNO_3	BRL preservation with Nitric acid within 14 days
Mercury-Dissolved	Water	EPA 1631E	BRL	Yes	BrCl	BRL preservation within 28 days
Organic carbon-Total (WY 2015)	Water	5310 C	EBMUD	No	HCL	NA
Organic carbon-Dissolved (WY 2015)	Water	5310 C	EBMUD	Yes	HCL	NA
Organic carbon-Total (WY 2016, 2017)	Water	EPA 9060A	ALS	No	HCL	NA
Organic carbon-Dissolved (WY 2016, 2017)	Water	EPA 9060A	ALS	Yes	HCL	NA
Mercury	Particulate	EPA 1631E, Appendix	BRL	NA	NA	
PCBs (40)[8]	Particulate	EPA 1668	AXYS	NA	NA	NA
Organic carbon (WY 2016, 2017)	Particulate	EPA 440.0	ALS	NA	NA	NA

[8] Samples were analyzed for 40 PCB congeners (PCB-8, PCB-18, PCB-28, PCB-31, PCB-33, PCB-44, PCB-49, PCB-52, PCB-56, PCB-60, PCB-66, PCB-70, PCB-74, PCB-87, PCB-95, PCB-97, PCB-99, PCB-101, PCB-105, PCB-110, PCB-118, PCB-128, PCB-132, PCB-138, PCB-141, PCB-149, PCB-151, PCB-153, PCB-156, PCB-158, PCB-170, PCB-174, PCB-177, PCB-180, PCB-183, PCB-187, PCB-194, PCB-195, PCB-201, PCB-203).

Interpretive methods

Estimated particle concentrations

The reconnaissance monitoring is designed to collect only one composite sample during a single storm at each site to provide "screening level" information. Measured PCB and Hg concentrations from this single sample could exhibit large inter-storm variability associated with storm size and intensity, as observed from previous studies when a large number of storms were sampled (Gilbreath et al., 2015a). However, this variability can be reduced when the concentrations are normalized to SSC, which produces an estimate of the pollutant concentration on particles in the sample. It was therefore reasoned that the estimated particle concentration (EPC) is likely a better characterization of water quality for a site, and therefore a better metric for comparison between sites (McKee et al., 2012; Rügner et al., 2013; McKee et al., 2015). For each analyte the estimated particle concentration (mass of a given pollutant of concern in relation to mass of suspended sediment) was computed for each composite water sample (Equation 1) at each site:

$$EPC\ (ng/mg) = (pollutant\ concentration\ (ng/L))/(SSC\ (mg/L)\ ) \qquad (1)$$

where SSC is the suspended sediment concentration in the sample in units of mg/L. These EPCs were used as the primary index to compare sites without regard to climate or rainfall intensity.

While normalizing PCB and Hg concentrations with SSC provides an improved metric to compare sites, climatic conditions can influence relative ranking based on EPCs. The absolute nature of that influence may differ between watershed locations depending on source characteristics. For example, dry years or lower storm intensity might result in a greater estimated particle concentration for some watersheds if transport of the polluted sediment is triggered but the sediment is less diluted by erosion of less contaminated particles from other parts of the watershed. This is most likely to occur in mixed land use watersheds with large amounts of pervious area. For other watersheds, the source may be a patch of polluted soil that can only be eroded and transported when antecedent conditions and/or rainfall intensity reach some threshold. In this instance, a false negative could occur during a dry year. Only with many years of data during many types of storms can such processes be teased out.

Therefore, relative ranking of sites based on EPC data from one or two storms should be interpreted with caution. Such comparisons may be sufficient for providing evidence to differentiate a group of sites with higher pollutant concentrations from a contrasting group with lower pollutant concentrations (acknowledging the risk that some data for watersheds in this group will be false negatives). However, to generate information on the absolute relative ranking between individual sites, a much more rigorous sampling campaign targeting many storms over many years would be required (c.f. the Guadalupe River study: McKee et al., 2006, or the Zone 4 Line A study: Gilbreath et al., 2012a), or a more advanced data analysis would need to be performed that that takes into account a variety of parameters (PCB and suspended sediment sources and mobilization processes, PCB congeners, rainfall intensity, rainfall antecedence, flow production and volume) in the normalization and ranking procedure. As mentioned above, the RMP has funded in project in CY 2018 to complete this type of investigation.

Derivations of central tendency for comparisons with past data

Mean, median, geometric mean, time-weighted mean, or flow-weighted mean can be used as measures of a dataset's central tendency. Most of these measures have been used to summarize data from RMP studies with discrete stormwater samples. To best compare composite data from WY 2015, 2016, and 2017 monitoring with previously collected discrete sample data, a slightly different approach was used to re-compute the central tendency of the discrete stormwater samples. For older data which were collected as multiple discrete samples within a storm, it was reasoned that a water composite collected over a single storm with timed intervals is equivalent to mixing all discrete samples collected during a storm into a single bottle. Mathematically, this is done by taking the sum of all PCB or HgT concentrations in discrete samples and dividing that by the sum of SSCs from the same samples collected within the same storm event (Equation 2):

$$EPCd\ (ng/mg) = (\Sigma POCd\ (ng/L))/(\Sigma SSCd\ (mg/L)) \qquad (2)$$

where *EPCd* is the estimated particle concentration for a site with discrete sampling, *POCd* is the pollutant concentration of the discrete sample at a site, and *SSCd* is suspended sediment concentration of a discrete sample at a site.

Note that this method is mathematically not equivalent to averaging together the EPCs of each discrete PCB:SSC or HgT:SSC pair. Because of the use of this alternative method, EPCs reported here differ slightly from those reported previously for some sites (McKee et al., 2012; McKee et al., 2014; Wu et al., 2016).

Results and Discussion

The data collected in WYs 2015, 2016 and 2017 were presented in the context of two key questions.

a) What are the concentrations and EPCs observed at each of the sites based on the composite water samples?
b) How do the EPCs measured at each of the sites from the composite water samples compare to EPCs derived from the remote suspended-sediment samplers?

These data contribute to a broad effort to identify potential management areas, and the rankings based on either stormwater concentration or EPCs are part of a weight-of-evidence approach for locating and prioritizing areas that may be disproportionately impacting downstream water quality. As the number of sample sites has increased over time, the relative rankings of particular sites have been changing, but the highest-ranking sites have generally remained in the top quarter of sites.

PCBs stormwater concentrations and estimated particle concentrations

Total PCB concentrations from composite water samples across the 55 sampling sites ranged from 533 to 159,606 pg/L excluding one <MDL (Table 5). The highest concentration was measured at Industrial Rd Ditch in San Carlos, located downstream of a known PCB contamination site (Delta Star) with 85% of impervious cover and 79% of old industrial within its drainage area. The second highest concentration (156,060 pg/L) was measured at Line 12H at Coliseum Way in Oakland, with 71% of its watershed

impervious but only 10% classified as old industrial. Sediment and soil samples upstream from this sampling location indicated the existence of some localized sources (Geosyntec, 2011). We often associate high PCB concentrations with old industrial land use, but these results suggest there is not a perfect correlation. Rather, localized sources are likely the most important factor, and these sources tend to be located within old industrial areas. These two highest concentrations are 3 times higher than the concentrations measured at the third and fourth highest sites: Outfall at Gilman Street (65,370 pg/L) and Ridder Park Dr SD location (55,503 pg/L), as well as measurements of PCBs in Bay Area stormwater taken prior to this study[9] (Gilbreath et al., 2012a; McKee et al., 2012).

There was good correspondence between the highest-ranking sites based on stormwater concentrations and those based on EPCs. The four highest ranking sites based on EPCs (Table 5) were the Industrial Rd Ditch in San Carlos (6,140 ng/g), Line 12H at Coliseum Way (2,601 ng/g), Gull Dr Storm Drain in South San Francisco (859 ng/g), and the Outfall at Gilman St. in Berkeley (794 ng/g). These EPCs are of similar magnitude to high values from previous studies in the Bay Area (McKee et al., 2012; Gilbreath et al., 2016)[10]. The repeat sample collected at Lower Penitencia Creek in WY 2015 was consistent with a previous measurement in WY 2011 (McKee et al., 2012). Similarly, two samples taken at the Duane Ct and Ave Triangle SD site during separate storm events on December 2015 and January 2016 showed relatively consistent and low EPCs (24.6 ng/g and 17.3 ng/g, respectively). Overall, the EPCs from WY 2015, 2016, and 2017 sampling were higher than those from WY 2011 (McKee et al., 2012), probably because the sites selected in the more recent study have a much greater proportion of old industrial in their drainage areas, and thereby a higher likelihood of PCB discharge to stormwater.

[9] E.g. Zone 4 Line A FWMC = 14,500 pg/L: Gilbreath et al., 2012a; Ettie Street Pump Station mean = 59,000 pg/L; Pulgas Pump Station-North: 60,300 pg/L: McKee et al., 2012.

[10] Note, Pulgas Pump Station-South (8,222 ng/g), Santa Fe Channel (1,295 ng/g), Pulgas Pump Station-North (893 ng/g), Ettie St. Pump Station (759 ng/g). Inconsistencies between the EPCs reported herein and those reported in McKee et al. (2012) stem from the slightly different method of computing the central tendency of the data (see the methods section of this report above) and, in the case of Pulgas Pump Station – South, because of the extensive additional sampling that has occurred since McKee et al. (2012) reported the reconnaissance results from the WY 2011 field season.

Table 5. Concentrations of total mercury, sum of PCBs and ancillary constituents measured at each of the sites during winter storms of water years 2015, 2016, and 2017. The sum of PCBs and total mercury are also expressed as an estimated particle concentration (mass of pollutant divided by mass of suspended sediment). The table is sorted from high to low PCB estimated particle concentrations.

Watershed/Catchment	County	City	Sample Date	Number of Aliquots Collected	SSC	DOC	TOC	PCBs				Total Hg			
					(mg/L)	(mg/L)	(mg/L)	(pg/L)	Rank	(ng/g)	Rank	(ng/L)	Rank	(µg/g)	Rank
Industrial Rd Ditch	San Mateo	San Carlos	3/11/16	4	26			160,000	1	6,140	1	13.9	40	0.535	18
Line 12H at Coliseum Way	Alameda	Oakland	12/15/16	3	60			156,000	2	2601	2	36.1	24	0.602	12
Gull Dr SD	San Mateo	South San Francisco	3/5/16	5	10			8,590	30	859	3	5.62	55	0.562	15
Outfall at Gilman St.	Alameda	Berkeley	12/21/15	9	83			65,700	3	794	4	439	1	5.31	1
Outfall to Colma Ck on service rd nr Littlefield Ave. (359)	San Mateo	South San Francisco	2/7/17	2	43	1.7	1.4	33,900	9	788	5	9.05	51	0.210	48
Outfall to Lower Silver Ck	Santa Clara	San Jose	2/6/15	5	57	8.6	8.3	44,600	5	783	6	24.1	33	0.423	26
S Linden Ave SD (291)	San Mateo	South San Francisco	1/8/17	7	16			11,800	22	736	7	12.4	46	0.775	6
Austin Ck at Hwy 37	Solano	Vallejo	3/24/17	6	20		6.3	11,500	23	573	8	12.8	45	0.640	10
Ridder Park Dr SD	Santa Clara	San Jose	12/15/14	5	114	7.7	8.8	55,500	4	488	9	37.1	23	0.326	37
Line 12I at Coliseum Way	Alameda	Oakland	12/15/16	3	93			37,000	7	398	10	12.0	48	0.129	52
Line 3A-M at 3A-D	Alameda	Union City	12/11/14	5	74	9.5	7.3	24,800	13	337	11	85.9	6	1.17	3
Kirker Ck at Pittsburg Antioch Hwy and Verne Roberts Cir	Contra Costa	Pittsburg	1/8/17	4	23			6,530	34	284	12	5.98	53	0.260	44

Watershed/Catchment	County	City	Sample Date	Number of Aliquots Collected	SSC	DOC	TOC	PCBs				Total Hg			
					(mg/L)	(mg/L)	(mg/L)	(pg/L)	Rank	(ng/g)	Rank	(ng/L)	Rank	(µg/g)	Rank
Seabord Ave SD SC-050GAC580	Santa Clara	Santa Clara	12/11/14	5	85	9.5	10	19,900	16	236	13	46.7	15	0.553	17
Line 12M at Coliseum Way	Alameda	Oakland	2/9/17	4	109			24,100	14	222	14	39.6	19	0.365	30
Line 4-E	Alameda	Hayward	12/16/14	6	170	2.8	3.6	37,400	6	219	15	59.0	12	0.346	33
Seabord Ave SD SC-050GAC600	Santa Clara	Santa Clara	12/11/14	5	73	7.9	8.6	13,472	21	186	16	38.3	21	0.528	19
Line 12F below PG&E station	Alameda	Oakland	12/15/16	3	114			21,000	15	184	17	42.5	17	0.373	28
South Linden PS	San Mateo	South San Francisco	2/6/15	5	43	7.4	7.4	7,810	32	182	18	29.2	28	0.679	9
Gull Dr Outfall	San Mateo	South San Francisco	3/5/16	5	33			5,760	37	174	19	10.4	50	0.315	38
Taylor Way SD	San Mateo	San Carlos	3/11/16	5	25	4.5	9.1	4,230	41	169	20	28.9	30	1.16	4
Line 9-D	Alameda	San Leandro	4/7/15	8	69	5	4.6	10,500	25	153	21	16.6	36	0.242	45
Meeker Slough	Contra Costa	Richmond	12/3/14	6	60	4.4	5.3	8,560	31	142	22	76.4	8	1.27	2
Rock Springs Dr SD	Santa Clara	San Jose	2/6/15	5	41	11	11	5,250	38	128	23	38	22	0.927	5
Charcot Ave SD	Santa Clara	San Jose	4/7/15	6	121	20	20	14,900	18	123	24	67.4	11	0.557	16
Veterans PS	San Mateo	Redwood City	12/15/14	5	29	5.9	6.3	3,520	44	121	25	13.7	41	0.469	22
Gateway Ave SD	San Mateo	South San Francisco	2/6/15	6	45	9.9	10	5,240	39	117	26	19.6	35	0.436	23

Watershed/Catchment	County	City	Sample Date	Number of Aliquots Collected	SSC	DOC	TOC	PCBs				Total Hg			
					(mg/L)	(mg/L)	(mg/L)	(pg/L)	Rank	(ng/g)	Rank	(ng/L)	Rank	(µg/g)	Rank
Line 9-D-1 PS at outfall to Line 9-D	Alameda	San Leandro	1/5/16	8	164			18,100	17	110	27	118	4.5	0.720	8
Tunnel Ave Ditch	San Mateo	Brisbane	3/5/16	6	96	5.8	11.3	10,500	24	109	28	73.0	10	0.760	7
Valley Dr SD	San Mateo	Brisbane	3/5/16	6	96			10,400	26	109	29	26.5	32	0.276	42
Runnymede Ditch	San Mateo	East Palo Alto	2/6/15	6	265	16	16	28,500	12	108	30	51.5	14	0.194	51
E. Gish Rd SD	Santa Clara	San Jose	12/11/14	5	145	12	13	14,400	19	99.2	31	84.7	7	0.585	14
Line 13-A at end of slough	Alameda	San Leandro	3/10/16	7	357			34,300	8	96.0	32	118	4.5	0.331	35
Line 3A-M-1 at Industrial PS	Alameda	Union City	12/11/14	6	93	4.2	4.5	8,920	28	95.8	33	31.2	26	0.335	34
Rosemary St SD 066GAC550C	Santa Clara	San Jose	1/8/17	5	46			4,110	43	89.4	34	27.2	31	0.591	13
North Fourth St SD 066GAC550B	Santa Clara	San Jose	1/8/17	5	48			4,170	42	87.0	35	22.9	34	0.477	21
Forbes Blvd Outfall	San Mateo	South San Francisco	3/5/16	5	23	3.4	7.9	1,840	52	80.0	36	14.7	39	0.637	11
SD near Cooley Landing	San Mateo	East Palo Alto	2/6/15	6	82	13	13	6,470	36	78.9	37	35.0	25	0.427	25
Lawrence & Central Expwys SD	Santa Clara	Santa Clara	1/6/16	3	58			4,510	40	77.7	38	13.1	42.5	0.226	46
Condensa St SD	Santa Clara	Santa Clara	1/19/16	6	35			2,600	48	74.4	39	11.5	49	0.329	36
Oddstad PS	San Mateo	Redwood City	12/2/14	6	148	8	7.5	9,200	27	62.4	40	54.8	13	0.372	29

Watershed/Catchment	County	City	Sample Date	Number of Aliquots Collected	SSC	DOC	TOC	PCBs				Total Hg			
					(mg/L)	(mg/L)	(mg/L)	(pg/L)	Rank	(ng/g)	Rank	(ng/L)	Rank	(µg/g)	Rank
Guadalupe River at Hwy 101	Santa Clara	San Jose	1/8/17	7	560			32,700	10	58.4	41	NR		NR	
Line 4-B-1	Alameda	Hayward	12/16/14	5	152	2.8	3.1	8,670	29	57	42	43.0	16	0.282	41
Zone 12 Line A under Temescal Ck Park	Alameda	Emeryville	1/6/16	8	143			7,800	33	54.4	43	41.5	18	0.290	40
Victor Nelo PS Outfall	Santa Clara	San Jose	1/19/16	9	45	4.0	11	2,290	49	50.9	44	15.8	37	0.351	31
Line 12K at Coliseum Entrance	Alameda	Oakland	2/9/17	4	671			32,000	11	47.6	45	288	2	0.429	24
Haig St SD	Santa Clara	San Jose	3/6/16	6	34			1,450	53	42.8	46	6.61	52	0.194	50
Colma Ck at S. Linden Blvd	San Mateo	South San Francisco	2/7/17	5	71			2,650	47	37.3	47	15.3	38	0.215	47
Line 12J at mouth to 12K	Alameda	Oakland	12/15/16	3	183			6,480	35	35.4	48	73.4	9	0.401	27
S Spruce Ave SD at Mayfair Ave (296)	San Mateo	South San Francisco	1/8/17	8	111			3,360	45	30.3	49	38.9	20	0.350	32
E Outfall to San Tomas at Scott Blvd	Santa Clara	Santa Clara	3/6/16	6	103			2,800	46	27.2	50	13.1	42.5	0.127	53
Duane Ct and Ave Triangle SD	Santa Clara	Santa Clara	12/13/15 and 1/6/2016	5	79			1,950	51	24.6	51	5.91	54	0.0748	54
Duane Ct and Ave Triangle SD	Santa Clara	Santa Clara	12/13/15 and 1/6/2016	3	48	4.2	12	832	54	17.3	52	12.9	44	0.268	43
Lower Penitencia Ck	Santa Clara	Milpitas	12/11/14	7	144	5.9	6.1	2,030	50	14.1	53	29.0	29	0.202	49
Refugio Ck at Tsushima St	Contra Costa	Hercules	1/18/17	6	59	5.5		533	55	9.04	54	30.0	27	0.509	20

Watershed/Catchment	County	City	Sample Date	Number of Aliquots Collected	SSC	DOC	TOC	PCBs				Total Hg			
					(mg/L)	(mg/L)	(mg/L)	(pg/L)	Rank	(ng/g)	Rank	(ng/L)	Rank	(µg/g)	Rank
Rodeo Creek at Seacliff Ct. Pedestrian Br.	Contra Costa	Rodeo	1/18/17	7	2630		11	13,900	20	5.28	55	119	3	0.0453	55
East Antioch nr Trembath	Contra Costa	Antioch	1/8/17	6	39			<MDL		NA		12.2	47	0.313	39
Minimum				2	10	1.7	1.4	533		5.28		5.62		0.0453	
Median				5	73.1	5.90	8.45	8923		109		29.2		0.373	
Maximum				9	2630	20	20	160,000		6140		439		5.31	

Mercury stormwater concentrations and estimated particle concentrations

Total mercury concentrations in composite water samples ranged from 5.62 to 439 ng/L, a variation of 78-fold, among the 55 catchment sampling sites sampled so far (Table 5). This relatively large range among sites is similar to that from a previous reconnaissance effort in WY 2011, when mean HgT concentrations ranged from 13.9 to 503 ng/L among sites (McKee et al., 2012). The highest HgT concentration measured was at the Outfall at Gilman Street (439 ng/L), which has 32% old industrial upstream from the sampling point. Other sites with high HgT concentrations were Line 12K at the Coliseum Entrance in Oakland (0.9% old industrial), Rodeo Creek at Seacliff Ct. Pedestrian Br. in Rodeo (2.6% old industrial), Line 9-D-1 PS at outfall to Line 9-D, and Line 13-A at end of the slough, both in San Leandro (62% and 68% old industrial respectively). These results suggest that there is no direct or strong relationship between mercury concentrations and old industrial land use, in contrast to the weak and positive relationship between concentrations measured in water and industrial land use for PCBs, after the addition of WY 2017 data to the dataset.

Based on estimated particle concentrations, the highest site was the same but the rest of the high-ranking sites were different than the ranking based on water concentration. The five most highly ranked sites were Outfall at Gilman Street (32% old industrial), Meeker Slough in Richmond (6% old industrial), Line-3A-M at 3A-D in Hayward (12% old industrial), Taylor Way Storm Drain in San Carlos (11% Old Industrial), and Rock Springs Dr. Storm Drain in San Jose (10% old industrial). Estimated particle concentrations at these sites were 5.3, 1.3, 1.2, 1.2, and 1.0 µg/g, respectively, exceeding the upper range of those measured during the WY 2011 sampling campaign[11] (McKee et al., 2012). On a regional basis, there is no discernible relationship between old industrial land use and HgT EPCs.

Co-occurrence of elevated PCBs and total mercury at the same locations

Another important issue during the ranking process is to consider the combined ranks of PCBs and HgT to determine whether management effort might address both pollutants together. There are few areas where both pollutants are elevated, notably the Gilman Street site in Berkeley and the area around the Coliseum in Oakland. However, in general, only a weak positive relationship exists between PCB and HgT concentrations. The six highest ranking sites for PCBs based on EPCs ranked 14th, 11th, 1st, 19th, 26th, and 3rd for HgT. There is one obvious location where both HgT and PCBs are high: Gilman Street. It shows up in the top five for both pollutants in stormwater and EPCs. The other area (not a site) that shows up high for both is around the Coliseum in Oakland. Line 12H is high for PCBs EPC. Line 12K is high for HgT in stormwater. They are not the same site but they are the same area. This observation contrasts with the conclusions drawn from the WY 2011 dataset, where there appeared to be more of a general correlation between the two contaminants (McKee et al., 2012). This difference might reflect a stronger focus on PCBs during the WY 2015-2017 sampling drainage-line outfalls to creeks with higher imperviousness and old industrial land use, or perhaps it might still be an artifact of small datasets without sample representation along all environmental gradients. This observation is explored further in later sections.

[11] Pulgas Pump Station-South: 0.83 µg/g, San Leandro Creek: 0.80 µg/g, Ettie Street Pump Station: 0.78 µg/g, and Santa Fe Channel: 0.68 µg/g (McKee et al., 2012).

Trace metal (As, Cd, Cu, Mg, Pb, Se and Zn) concentrations

Trace metal concentrations (for As, Cd, Cu, Pb and Zn) measured in select watersheds during WYs 2015, 2016, and 2017 were all similar in range to those previously measured in the Bay Area.

- Arsenic (As): Measured As concentrations ranged from less than the reporting limit (RL)-2.66 µg/L (Table 6). Total As concentrations of this magnitude have been measured in the Bay Area before (Guadalupe River at Hwy 101: mean=1.9 µg/L; Zone 4 Line A: mean=1.6 µg/L) but are much lower than what was measured at the North Richmond Pump Station (mean=11 µg/L) (Appendix A3 in McKee et al., 2015).
- Cadmium (Cd): Cadmium concentrations were 0.023-0.55 µg/L (Table 6). These Cd concentrations are similar to mean concentrations measured at Guadalupe River at Hwy 101 (0.23 µg/L), North Richmond Pump Station (0.32 µg/L), and Zone 4 Line A (0.25 µg/L) (Appendix A3 in McKee et al., 2015).
- Copper (Cu): Concentrations for Cu ranged from 3.63-52.7 µg/L (Table 6). These concentrations are typical of those measured in other Bay Area watersheds (Guadalupe River at Hwy 101: 19 µg/L; Lower Marsh Creek: 14 µg/L; North Richmond Pump Station: Cu 16 µg/L; Pulgas Pump Station-South: Cu 44 µg/L; San Leandro Creek: Cu 16 µg/L; Sunnyvale East Channel: Cu 18 µg/L; and Zone 4 Line A: Cu 16 µg/L) (Appendix A3 in McKee et al., 2015).
- Lead (Pb): Measured Pb concentrations ranged from 0.910-21.3 µg/L (Table 6). Total Pb concentrations of this magnitude have been measured in the Bay Area before (Guadalupe River at Hwy 101: 14 µg/L; North Richmond Pump Station: Pb 1.8 µg/L; and Zone 4 Line A: 12 µg/L) (Appendix A3 in McKee et al., 2015).
- Zinc (Zn): Zinc concentrations measured 39.4-337 µg/L (Table 6). Zinc measurements at 26 of the sites sampled during WYs 2015, 2016, and 2017 were comparable to the mean concentrations measured in the Bay Area previously (Zone 4 Line A: 105 µg/L; Guadalupe River at Hwy 101: 72 µg/L) (see Appendix A3 in McKee et al., 2015).

In WY 2016, measurements of Mg (528-7350 µg/L) and Se (<RL-0.39 µg/L) were added to the analytical list. Both of these analytes largely reflect geologic sources in watersheds. No measurements of Mg have been previously reported in the Bay Area. The measured concentrations of Se are on the lower side of previously reported values (North Richmond Pump Station: 2.7 µg/L; Walnut Creek: 2.7 µg/L; Lower Marsh Creek: 1.5 µg/L; Guadalupe River at Hwy 101: 1.3 µg/L; Pulgas Creek Pump Station - South: 0.93 µg/L; Sunnyvale East Channel: 0.62 µg/L; Zone 4 Line A: 0.48 µg/L; Mallard Island: 0.46 µg/L; Santa Fe Channel - Richmond: 0.28 µg/L; San Leandro Creek: 0.22 µg/L) (Table A3: McKee et al., 2015). Given the high proportion of Se transported in the dissolved phase and inversely correlated with flow (David et al., 2012; Gilbreath et al., 2012a), it is reasonable that the current sampling design, with a focus on high flow, most likely measured lower concentrations than those measured with sampling designs that included low flow and baseflow samples (North Richmond Pump Station: 2.7 µg/L; Guadalupe River at Hwy 101: 1.3 µg/L; Zone 4 Line A: 0.48 µg/L; Mallard Island: 0.46 µg/). Therefore, Se concentrations reported from this study should not be used to estimate regional loads due to this sampling bias.

Table 6. Concentrations of selected trace elements measured during winter storms of water years 2015, 2016, and 2017. The highest and lowest concentration for each trace element is bolded.

Watershed/Catchment	Sample Date	As (µg/L)	Cd (µg/L)	Cu (µg/L)	Pb (µg/L)	Mg (µg/L)	Se (µg/L)	Zn (µg/L)
Charcot Ave SD	4/7/2015	0.623	0.0825	16.1	2.02			115
Condensa St SD	1/19/2016	1.07	0.055	6.66	3.37	3,650	0.39	54.3
E. Gish Rd SD	12/11/2014	1.52	**0.552**	23.3	19.4			152
East Antioch nr Trembath	1/8/2017	1.57	0.119	**3.53**	1.68	5,363	0.53	**36.3**
Forbes Blvd Outfall	3/5/2016	1.5	0.093	31.7	3.22	7,350	**0**	246
Gateway Ave SD	2/6/2015	1.18	0.053	24.3	1.04			78.8
Gull Dr SD	3/5/2016	**0**	**0.023**	3.63	1.18	**528**	**0**	39.4
Line 9-D-1 PS at outfall to Line 9-D	1/5/2016	1.07	0.524	22.5	20.9	2,822	0.2	217
Line 3A-M at 3A-D	12/11/2014	2.08	0.423	19.9	17.3			118
Line 3A-M-1 at Industrial PS	12/11/2014	1.07	0.176	14.8	7.78			105
Line 4-B-1	12/16/2014	1.46	0.225	17.7	8.95			108
Line 4-E	12/16/2014	2.12	0.246	20.6	13.3			144
Line 9-D	4/7/2015	0.47	0.053	6.24	**0.91**			67
Lower Penitencia Ck	12/11/2014	2.39	0.113	16.4	4.71			64.6
Meeker Slough	12/3/2014	1.75	0.152	13.6	14.0			85.1
North Fourth St SD 066GAC550B	1/8/2017	1.15	0.125	14.0	5.70	**11,100**	**0.67**	75.7
Oddstad PS	12/2/2014	2.45	0.205	23.8	5.65			117
Outfall to Lower Silver Ck	2/6/2015	2.11	0.267	21.8	5.43			**337**
Ridder Park Dr SD	12/15/2014	**2.66**	0.335	19.6	11.0			116
Rock Springs Dr SD	2/6/2015	0.749	0.096	20.4	2.14			99.2
Runnymede Ditch	2/6/2015	1.84	0.202	**52.7**	**21.3**			128
S Spruce Ave SD at Mayfair Ave (296)	1/8/2017	2.2	0.079	9.87	5.31	3,850	0.13	54.8
SD near Cooley Landing	2/6/2015	1.74	0.100	9.66	1.94			48.4
Seabord Ave SD SC-050GAC580	12/11/2014	1.29	0.295	27.6	10.2			168
Seabord Ave SD SC-050GAC600	12/11/2014	1.11	0.187	21	8.76			132
South Linden PS	2/6/2015	0.792	0.145	16.7	3.98			141
Taylor Way SD	3/11/2016	1.47	0.0955	10.0	4.19	5,482	**0**	61.6
Veterans PS	12/15/2014	1.32	0.093	8.83	3.86			41.7
Victor Nelo PS Outfall	1/19/2016	0.83	0.140	16.3	3.63	1,110	0.04	118
Minimum		0	0.0233	3.53	0.91	528	0	36.3
Maximum		2.66	0.552	52.7	21.3	11,100	0.67	337

Comparison between composite and remote sampling methods

The results from remote suspended-sediment samplers were compared to those from the water composite samples collected in parallel (Table 7a and Table 7b).

Grain sizes were analyzed for a select number of sites and the results show that the grain size distribution for the Hamlin samplers was typically coarser than for the Walling tube samples, and the grain size distribution for the Walling tube samples better approximated the grain size distribution for the manual water composite samples (Figure 3).

The EPCs for the samples from the remote samplers and manual water composites were evaluated to compare the measurement techniques. Following the Bland-Altman approach (Bland and Altman, 1986; and explained in Dallal, 2012), results were first plotted against one another for a basic visual inspection of scatter about the 1:1 line, and then the differences between the methods were plotted against the mean of the two measurements to evaluate symmetric grouping around zero and systematic variation of the differences with the mean.

Results for Hg showed that much of the remote sampler data had lower EPCs than those obtained from the composited stormwater samples (Figure 4A, B). However, the Walling tube samples are much closer to the 1:1 line than the Hamlin samples, and have no obvious bias (four samples are lower than the 1:1 line and two are higher). The mean and standard deviation of the paired sample differences (remote samples minus the water composite samples) for the Hamlin sampler were -240 ng/g (mean) and 292 (standard deviation), whereas the mean for the Walling tube sampler was -77 ng/g with a standard deviation of 148. The smallest difference in Hg EPCs between the remote samplers and the composite water samples was at Rodeo Creek at Seacliff Ct. Pedestrian Br (RPD 10%), which could be a result of subsampling and analytical variation. However, at other sites the differences could be up to 5-fold and cannot be easily explained by subsampling or analytical variation, as both the composite sample (time paced with just 2 to 9 sub-samples) and remote sampler methods collect time-integrated samples which reduce the influence of momentary spikes in concentrations. That the Hg EPCs from the remote sampler are typically lower than those from the manual composites is conceptually in concordance with the findings in Yee and McKee (2010). This study found that composited samples often have lower sediment content and thus a greater proportion of Hg in the dissolved phase or on fine particles and, hence, a higher EPC.

For PCBs, there is better agreement between the remote and manual sampling methods (Figure 4C,D). For sites with high EPCs from composite samples, consistently high EPCs were measured from remote samples. The EPCs from remote samples were higher than those from the manual samples, a result that is conceptually reasonable but somewhat surprising, since the manual composite EPCs also included a dissolved proportion (mean 15%, median 12%; Table 7) that would elevate the manual composite EPC versus a remote sample that has an insignificant dissolved phase contribution. Additional sampling in future years is expected to allow for more definitive interpretation. There was one interesting outlier from the Hamlin remote sampler with EPC (1767 ng/g) elevated well above the manual water composite EPC (783 ng/g). A Walling tube was also deployed at this location during the same storm and resulted with an EPC (956 ng/g) much closer to the manual water composite EPC (783 ng/g). One hypothesis is

Table 7a. Remote suspended-sediment sampler PCB data and comparison with manually collected composite water data. Note: EPC = estimated particle concentration.

Site	Remote Sampler Used	Manual Water Composite Data								Remote Sampler Data	
		SSC (manual composite) (mg/L)	PCBs Total (pg/L)	PCBs Particulate (pg/L)	PCBs Dissolved (pg/L)	% Dissolved	PCB particle concentration (lab measured on filter) (ng/g)	PCB EPC (ng/g)	Bias (EPC: lab measured)	PCB EPC (remote) (ng/g)	Comparative Ratio between Remote Sampler and Manual Water Composites
Duane Ct and Ave Triangle SD (Jan 6)	Hamlin	48	832	550	282	34%	11	17	151%	43	246%
Victor Nelo PS Outfall	Hamlin	45	2,289	2,007	283	12%	45	51	114%	70	137%
Taylor Way SD	Hamlin	25	4,227	3,463	764	18%	139	169	122%	237	140%
Tunnel Ave Ditch	Hamlin	96	10,491	9,889	602	6%	103	109	106%	150	137%
Forbes Blvd Outfall	Hamlin	23	1,840	1,794	47	3%	78	80	103%	42	53%
Charcot Ave SD	Hamlin	121	14,927	No data				123	No data	142	115%
Outfall to Lower Silver Ck	Hamlin	57	44,643					783		1767	226%
SD near Cooley Landing	Hamlin	82	6,473					79		68	87%
Austin Ck at Hwy 37	Hamlin	20	11,450					573		700	122%
Outfall to Lower Silver Ck	Walling	57	44,643					783		956	122%
Austin Ck at Hwy 37	Walling	20	11,450					573		362	63%
Rodeo Creek at Seacliff Ct. Pedestrian Br.	Walling	2626	13,863					5		10	195%
Victor Nelo PS Outfall	Walling	45	2,289	2,007	283	12%	45	50.9	114%	100	197%
Tunnel Ave Ditch	Walling	96	10,491	9,889	602	6%	103	109	106%	96	88%
Refugio Ck at Tsushima St	Walling	59	533	533	<MDL	0%	9	9	100%	8	86%
Outfall to Colma Ck on service rd nr Littlefield Ave. (359)	Walling	43	33,875	37,461	1045	3%	871	788	90%	1172	149%
Median						6%			106%		130%
Mean						11%			112%		135%

Table 7b. Remote suspended-sediment sampler Hg data and comparison with manually collected composite water data. Note: EPC = estimated particle concentration.

Site	Remote Sampler Used	Manual Water Composite Data								Remote Sampler Data	
		SSC (manual composite)	Hg Total (ng/L)	Hg Particulate (ng/L)	Hg Dissolved (ng/L)	% Dissolved	Hg particle concentration (lab measured on filter) (ng/g)	Hg EPC (ng/g)	Bias (EPC: lab measured)	Hg EPC (remote) (ng/g)	Comparative Ratio between Remote Sampler and Manual Water Composites
Duane Ct and Ave Triangle SD (Jan 6)	Hamlin	48	13	11	1.88	15%	229	268	117%	99	37%
Victor Nelo PS Outfall	Hamlin	45	16	12.1	3.71	23%	269	351	131%	447	127%
Taylor Way SD	Hamlin	25	29	17.9	11	38%	716	1156	161%	386	33%
Tunnel Ave Ditch	Hamlin	96	73	65.8	7.23	10%	685	760	111%	530	70%
Forbes Blvd Outfall	Hamlin	23	15	12.2	2.45	17%	530	637	120%	125	20%
Charcot Ave SD	Hamlin	121	67	No data				557	No data	761	137%
Outfall to Lower Silver Ck	Hamlin	57	24					423		150	36%
SD near Cooley Landing	Hamlin	82	35					427		101	24%
Austin Ck at Hwy 37	Hamlin	20	13					640		459	72%
Outfall to Lower Silver Ck	Walling	57	24					423		255	60%
Austin Ck at Hwy 37	Walling	20	13					640		548	86%
Rodeo Creek at Seacliff Ct. Pedestrian	Walling	2626	119					45		50	110%
Victor Nelo PS Outfall	Walling	45	16	12.1	3.71	23%	269	351	131%	483	138%
Tunnel Ave Ditch	Walling	96	73	65.8	7.23	10%	685	760	111%	577	76%
Refugio Ck at Tsushima St	Walling	59	30	21.6	8.44	28%	366	509	139%	223	44%
Outfall to Colma Ck on service rd nr Littlefield Ave. (359)	Walling	43	9	9.7	4.9	54%	225	210	93%	264	125%
Median						23%			120%		71%
Mean						26%			125%		75%

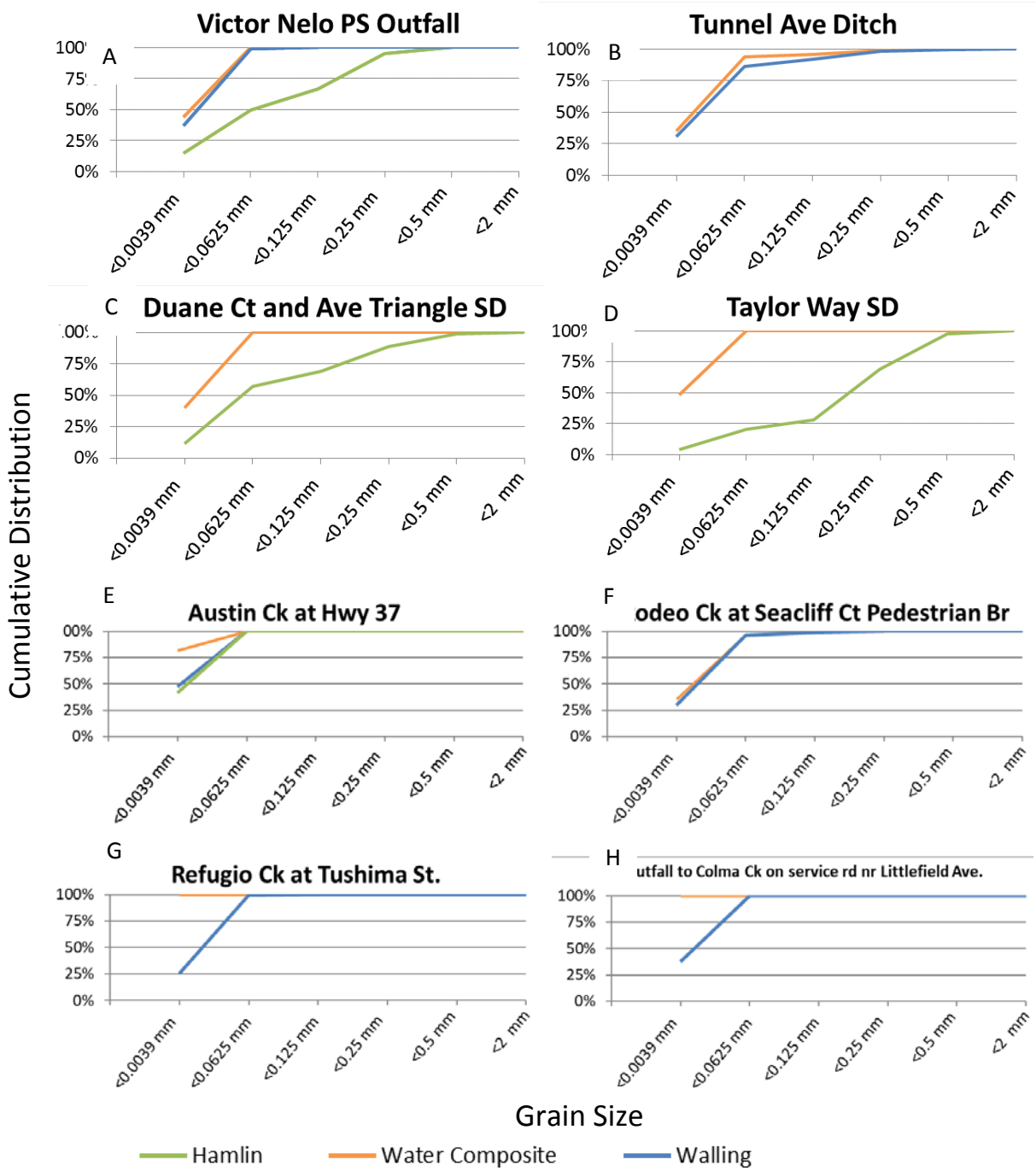

Figure 3. Cumulative grain size distribution in the Hamlin suspended-sediment sampler, Walling tube suspended-sediment sampler, and water composite samples at eight of the sampling locations. Note that both samplers were only used at two of these eight sites.

that the remote samplers captured a time-limited pulse of PCBs during the storm but the manual composite subsampling missed the pulse. This hypothesis may not entirely explain the high concentration in the Hamlin, however, since the EPC from the Walling tube sampler was only slightly elevated above the manual composite EPC. A key difference between the Hamlin sampler and the other two methods is that it disproportionately captures heavier and larger particles. These two ideas, taken together, may explain the very high Hamlin concentration – there may have been a time-limited pulse between manual samples causing both remote samplers to have relatively elevated concentrations, and a substantial portion of the PCBs flowing through this catchment may have been associated with larger particles, which the Hamlin is more likely to capture than the Walling tube.

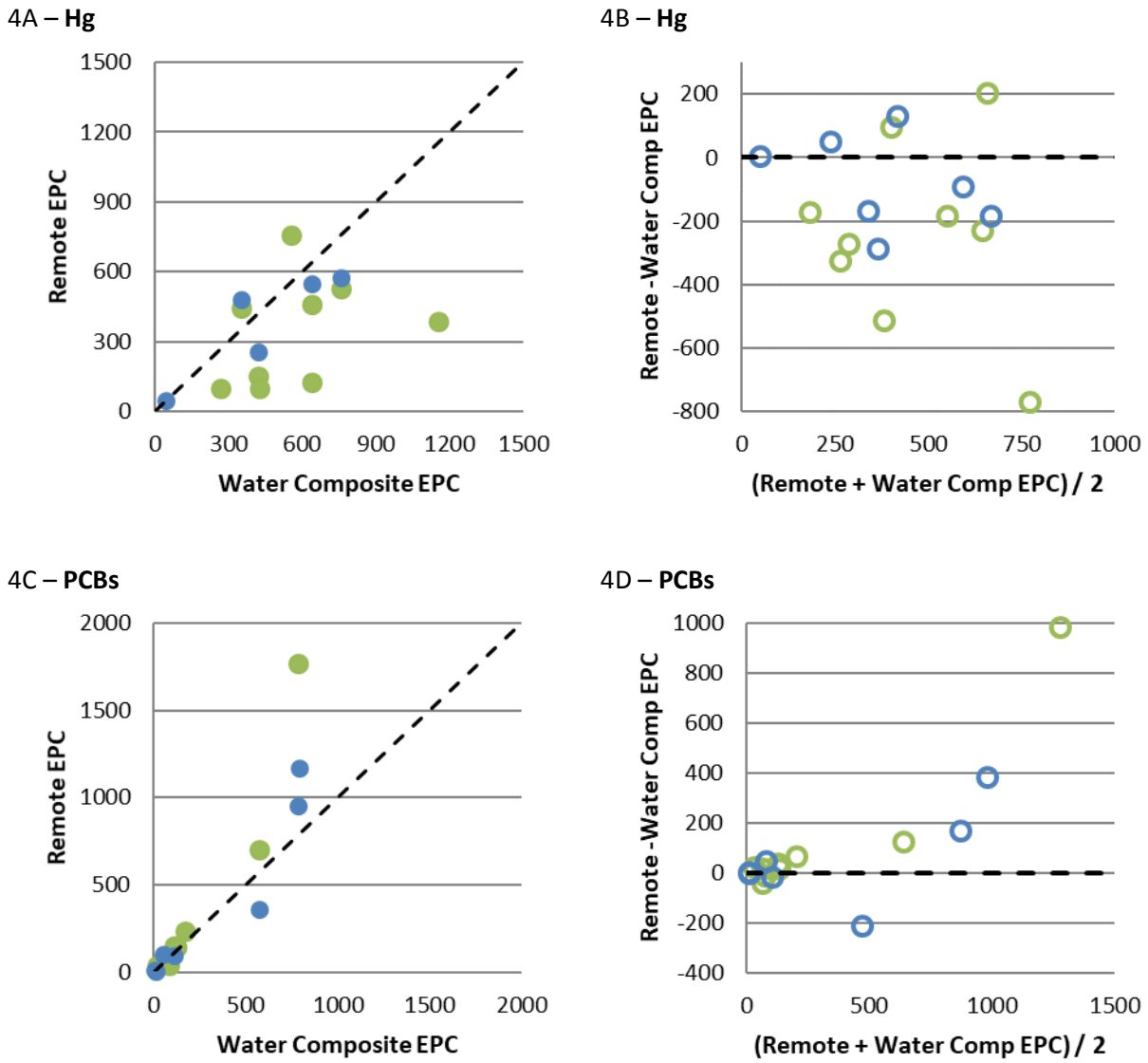

Figure 4. Estimated particle concentration comparisons between remote suspended-sediment samples versus manually collected composite samples, and comparisons of the differences between the methods against their means. Figures 4A and 4C show the 1:1 line (dashed black line), and Figures 4B and 4D show the zero line as dashed. Data for samples collected with the Hamlin sampler are green, and data for samples collected using the Walling tube are blue.

While remote sampling methods could be used as an alternative for cost saving and in places where manual sampling is not feasible, interpreting the data from remote samples and comparing them to the composite samples remains challenging. Whereas the remote methods collect primarily a concentrated, whole storm integrated suspended sediment sample, the manually composited water samples include some proportion of dissolved concentration, which conflates the metric of comparison (EPC) between the methods. In addition, the data collected thus far from the Hamlin sampler has a largely different grain size distribution than collected by the manual water composite method. Another challenge with these remote sampling data is that they cannot be used to estimate loads without corresponding sediment load estimates, which are not readily available at this point.

In summary, remote samplers show some promise as a relative ranking or prioritization tool based on the data collected to date. This pilot study will continue into WY 2018 and possibly beyond. The additional data being collected should help confirm whether these samplers have value as a reconnaissance tool. If that proves to be the case, they can be used as a low-cost screening and ranking tool to identify watersheds where greater investment in manual sampling and other methods of investigation may be needed.

Pros and cons of the remote sampling method

The pilot study to assess effectiveness of remote samplers is still in progress. The samplers have been successfully deployed at 12 locations, with the Hamlin sampler tested at nine and the Walling tube sampler tested at seven locations. A preliminary comparison between remote sampling and manual sampling methods is presented in Table 8a and 8b. Generally speaking, it is anticipated that remote sampling methods will be more cost-effective because they allow for multiple sites to be monitored during a single storm event. There would be initial costs to purchase the equipment, and labor would be required to deploy and process samples. In addition, there will always be logistical constraints (such as turbulence, tidal influences or securing the samplers in hardened channels) that complicate use of the remote devices and require manual monitoring at a particular site. The data collected from the remote sampling methodologies is generally less straightforward to interpret than water grab or composite samples, and overall would be mostly useful for ranking sites for different pollutants but not for load calculations. Therefore, the remote sampling method may best be used as a companion to manual monitoring methods to reduce costs and collect data for other purposes, providing some value as a cost-effective reconnaissance and prioritization tool.

With these concerns raised, the sampling program for WY 2018 will continue to build out the dataset for comparing samples derived from composite and remote sampling methods. The future testing of the remote samplers will need to include more side-by-side Hamlin and Walling tube sites to better compare them and confirm whether the Walling tubes indeed perform well even in circumstances when the Hamlin sampler may not. An articulated versions of the Walling tube also needs to be tested in a stormdrain setting. The additional data from this pilot effort should provide more confidence in the importance of bias and the range of differences among methods. They may also shed light on the causes of bias and differences, either broad ones across the region or specific to a site (e.g., land use) or event (e.g., storm intensity, duration, sample grain size, organic carbon).

Table 8a. Preliminary comparison of the advantages and disadvantages of the remote sampling method versus the manual sampling method for the screening of sites.

Category	Remote Sampling Relative to Manual Sampling	Notes
Cost	Less	Both manual and remote sampling include many of the same costs, though manual sampling generally requires more staff labor related to tracking the storm carefully in order to deploy field staff at just the right time. The actual sampling also requires more labor for manual sampling, especially during long storms. There are some greater costs for remote sampling related to having to drive to the site twice (to deploy and then to retrieve) and then slightly more for post-sample processing, but these additional costs are minimal relative to the amount of time required to track storms and sample on site during the storm. See additional details in Table 8b below.
Sampling Feasibility	Some advantages, some disadvantages	Remote sampling has a number of feasibility advantages over manual sampling. With remote sampling, manpower is less of a constraint; there is no need to wait on equipment (tubing, Teflon bottle, graduated cylinder) cleaning at the lab; the samplers can be deployed for longer than a single storm event, if desired; the samplers composite more evenly over the entire hydrograph; and conceivably, with the help of municipalities, remote samplers may be deployed in storm drains in the middle of streets. On the contrary, at this time there is no advantage to deploy remote samplers (and perhaps it is easier to just manually sample) in tidal locations since they must be deployed and retrieved within the same tidal cycle, although we are beginning to think of solutions to this challenge.
Data Quality	Assessment incomplete	Comparison between the remote sampler and manual sampling results are being assessed in this study. Through WY 2017 sampling, the 16 results for PCBs (using either sampler) have a range in relative percent differences (RPDs)[12] between water manual composite and remote sample of -62 – 84%, and a mean of 21%. For Hg, the range in RPD is -134 to 32%, with a mean of -42%. If remote samplers can be used consistently over multiple storm events, it is reasonable to think that the extended sample collection would improve the representativeness of the sample.
Data Uses	Equivalent or slightly lower	At this time, both the remote and manual sampling collect data for a single storm composite which is then used for screening purposes. The water concentration data from the manual water composites may also be used to estimate loads if the volume is known or can be estimated (e.g., using the RWSM). Water concentration data from remote samplers cannot be used for this purpose.
Human stresses and risks associated with sampling program	Much less	Manual sampling involves a great deal of stressful planning and logistical coordination to sample storms successfully; these stresses include irregular schedules and having to cancel other plans; often working late and unpredictable hours; working in wet and often dark conditions after irregular or insufficient sleep and added risks under these cumulative stresses. Some approaches to remote sampling (e.g., not requiring exact coincidence with storm timing) could greatly reduce many of these stresses (and attendant risks).

[12] RPD is the relative percent difference, calculated as: $\text{RPD} = \frac{\text{Difference (between replicate samples)}}{\text{Average (replicate samples)}} \times 100\%$

Table 8b. Detailed preliminary labor and cost comparison between the remote sampling method versus the manual composite sampling method for the screening of sites.

Task	Remote Sampling Labor Hours Relative to Manual Sampling	Manual Composite Sampling Task Description	Remote Sampling Task Description
Sampling Preparation in Office	Equivalent	Cleaning tubing/bottles; preparing bottles, field sampling basic materials	Cleaning sampler; preparing bottles, field sampling basic materials
Watching Storms	Much less	Many hours spent storm watching and deciding if/when to deploy	Storm watching is minimized to only identifying appropriate events with less/little concern about exact timing
Sampling Preparation at Site	Equivalent	Set up field equipment	Deploy sampler
Driving	More (2x)	Drive to and from site	Drive to and from site 2x
Waiting on Site for Rainfall to Start	Less	Up to a few hours	No time since field crew can deploy equipment prior to rain arrival
On Site Sampling	Much less	10-20 person hours for sampling and field equipment clean up	2 person hours to collect sampler after storm
Sample Post-Processing	Slightly more (~2 person hours)	NA	Distribute composited sample into separate bottles; takes two people about 1 hour per sample
Data Management and Analysis	Equivalent	Same analytes and sample count (and usually same matrices)	Same analytes and sample count (and usually same matrices)

Preliminary site rankings based on all available data (including previous studies)

A relative ranking was generated for PCBs and Hg based on both water concentrations and EPCs for all the available data. This analysis differs from the rankings reported in Table 5 in that all available data were considered, not just the data collected for this study. The additional data included in this section primarily is comprised of data collected in intensive loadings studies from 2003-2010 and 2012-2014, a similar reconnaissance study implemented in WY 2011, and studies of green infrastructure conducted between 2010 and the present.

While there are always challenges associated with interpreting data in relation to highly variable factors, including antecedent conditions, storm specific rainfall intensity, and watershed specific source-release-transport processes, the objective here is to provide evidence to help identify watersheds that might have disproportionately elevated PCB or Hg concentrations or EPCs. Given the nature of the reconnaissance sampling design, the absolute rank is much less certain but it is unlikely that the highest ranked locations would drop in ranking much if more sampling was conducted.

PCBs

Based on water composite concentrations for all available data, the 10 highest ranking sites for PCBs are (in order from higher to lower): Pulgas Pump Station-South, Santa Fe Channel, Industrial Rd Ditch, Line

12H at Coliseum Way, Sunnyvale East Channel, Outfall at Gilman St., Pulgas Pump Station-North, Ettie Street Pump Station, Ridder Park Dr Storm Drain, and Outfall to Lower Silver Creek (Table 9, Figure 6). The old industrial land use for these sites ranges from 3-79%, highlighting the challenge of using land use alone as a guide to identify high leverage areas. Using PCB EPCs, the ten most polluted sites are: Pulgas Pump Station-South, Industrial Rd Ditch, Line 12H at Coliseum Way, Santa Fe Channel, Pulgas Pump Station-North, Gull Dr SD, Outfall at Gilman St., Outfall to Colma Ck on service road near Littlefield Ave., Outfall to Lower Silver Creek, and Ettie Street Pump Station. Eight sampling sites made both of the top 10 lists; one site (Gull Dr SD) was ranked high in EPCs but very low on water concentration because of very low suspended sediment mass, and Sunnyvale East Channel exhibited elevated water concentrations but low EPC.

To a large degree, sites that rank high for PCB water concentrations also rank high for EPCs (Figure 7). Watersheds that rank high in water concentration but low in EPC suggest that there are sources present but the EPC is diluted by relatively higher rates of clean sediment. Examples include Line 13A at end of slough and Line 12K at Coliseum Entrance. Conversely, those watersheds that rank high in EPC but not high in water concentration suggest that PCB mobilization is high relative to sediment mobilization, often with samples having a relatively low SSC. Examples of this include Gull Dr. SD and Kirker Ck at Pittsburg Antioch Hwy and Verne Roberts Circle. This latter scenario is more likely to occur in watersheds that are highly impervious with little input of clean sediment.

The data collected in WY 2017 added new information to the regional dataset. In addition to identifying two new top-10 ranked PCB EPC sites, the WY 2017 stormwater sampling efforts also identified several more sites with moderately high EPCs (Figure 6). This additional large cohort of sites with moderately elevated EPCs was likely a result of a site selection process that targeted watershed areas with greater older industrial influences.

Most of the sites measured have PCB EPCs that are higher than average conditions needed for attainment of the TMDL. The PCB load allocation of 2 kg from the TMDL (SFBRWQCB 2008) translates to a mean water concentration of 1.33 ng/L and a mean particle concentration of 1.4 ng/g. These calculations assume an annual average flow from small tributaries of 1.5 km^3 (Lent et al., 2012) and an average annual suspended sediment load of 1.4 million metric tons (McKee et al., 2013). Keeping in mind that the estimates of regional flow and regional sediment loads are subject to change as further interpretations are completed, only five sampling locations observed to date (Gellert Park bioretention influent stormwater, Duane Ct. and Triangle Ave., East Antioch nr Trembath, Refugio Ck at Tsushima St. and Haig St. SD) have a composite averaged PCB water concentration of < 1.33 ng/L (Table 9) and none of 78 sampling locations have composite averaged PCB EPCs <1.4 ng/g (Table 9; Figure 6 and 7). The lowest PCB EPC measured to date is for Marsh Creek (2.9 ng/g).

Table 9. PCB and total mercury (HgT) water concentrations and estimated particle concentrations (EPCs) measured in the Bay area based on all data collected in stormwater since water year 2003 and that focused on urban sources (79 sites in total for PCBs and HgT). This dataset is sorted high-to-low for PCB EPC to provide preliminary information on potential leverage. Note: Ranks with a half number are the result of two watersheds with the same rank.

Watershed/Catchment	County	Water Year Sampled	Area (km^2)	Impervious Cover (%)	Old Industrial Land Use (%)	Polychlorinated Biphenyls (PCBs)				Total Mercury (HgT)			
						Estimated Particle Concentration		Composite/Mean Water Concentration		Estimated Particle Concentration		Composite/Mean Water Concentration	
						(ng/g)	Rank	(pg/L)	Rank	(µg/g)	Rank	(ng/L)	Rank
Pulgas Pump Station-South	San Mateo	2011-2014	0.58	87%	54%	8222	1	447,984	1	0.35	42.5	19	56
Industrial Rd Ditch	San Mateo	2016	0.23	85%	79%	6139	2	159,606	3	0.53	26	14	63
Line 12H at Coliseum Way	Alameda	2017	0.97	71%	10%	2601	3	156,060	4	0.60	18	36	42
Santa Fe Channel	Contra Costa	2011	3.3	69%	3%	1295	4	197,923	2	0.57	21.5	86	12.5
Pulgas Pump Station-North	San Mateo	2011	0.55	84%	52%	893	5	60,320	7	0.40	36	24	52.5
Gull Dr SD	San Mateo	2016	0.30	78%	54%	859	6	8,592	43	0.56	23	6	76
Outfall at Gilman St.	Alameda	2016	0.84	76%	32%	794	7	65,670	6	5.31	1	439	4
Outfall to Colma Ck on service rd nr Littlefield Ave. (359)	San Mateo	2017	0.09	88%	87%	788	8	33,875	14	0.21	62	9	73
Outfall to Lower Silver Creek	Santa Clara	2015	0.17	79%	78%	783	9	44,643	10	0.42	34	24	52.5
Ettie Street Pump Station	Alameda	2011	4.0	75%	22%	759	10	58,951	8	0.69	14	55	25.5
S Linden Ave SD (291)	San Mateo	2017	0.78	88%	57%	736	11	11,781	32	0.78	11	12	68
Austin Ck at Hwy 37	Solano	2017	4.9	61%	2%	573	12	11,450	34	0.64	16	13	67
Ridder Park Dr Storm Drain	Santa Clara	2015	0.50	72%	57%	488	13	55,503	9	0.33	46	37	41
Line 12I at Coliseum Way	Alameda	2017	3.4	63%	9%	398	14	36,974	12	0.13	72	12	70
Sunnyvale East Channel	Santa Clara	2011	15	59%	4%	343	15	96,572	5	0.20	64	50	29
Line-3A-M at 3A-D	Alameda	2015	0.88	73%	12%	337	16	24,791	18	1.17	5	86	12.5
Kirker Ck at Pittsburg Antioch Hwy and Verne Roberts Cir	Contra Costa	2017	37	18%	5%	284	17	6,528	48	0.26	55	6	75
North Richmond Pump Station	Contra Costa	2011-2014	2.0	62%	18%	241	18	13,226	30	0.81	10	47	30.5
Seabord Ave Storm Drain SC-050GAC580	Santa Clara	2015	1.4	81%	68%	236	19	19,915	23	0.55	25	47	30.5

Watershed/Catchment	County	Water Year Sampled	Area (km^2)	Impervious Cover (%)	Old Industrial Land Use (%)	Polychlorinated Biphenyls (PCBs)				Total Mercury (HgT)			
						Estimated Particle Concentration		Composite/Mean Water Concentration		Estimated Particle Concentration		Composite/Mean Water Concentration	
						(ng/g)	Rank	(pg/L)	Rank	(µg/g)	Rank	(ng/L)	Rank
Line 12M at Coliseum Way	Alameda	2017	5.3	69%	22%	222	20	24,090	19	0.36	39	40	37
Line 4-E	Alameda	2015	2.0	81%	27%	219	21	37,350	11	0.35	42.5	59	22
Glen Echo Creek	Alameda	2011	5.5	39%	0%	191	22	31,078	16	0.21	63	73	18
Seabord Ave Storm Drain SC-050GAC600	Santa Clara	2015	2.8	62%	18%	186	23	13,472	29	0.53	27	38	39.5
Line 12F below PG&E station	Alameda	2017	10	56%	3%	184	24	21,000	22	0.37	37	43	34
South Linden Pump Station	San Mateo	2015	0.14	83%	22%	182	25	7,814	46	0.68	15	29	48
Gull Dr Outfall	San Mateo	2016	0.43	75%	42%	174	26	5,758	52	0.32	48	10	72
Taylor Way SD	San Mateo	2016	0.27	67%	11%	169	27	4,227	57	1.16	6	29	49
Line 9-D	Alameda	2015	3.6	78%	46%	153	28	10,451	36	0.24	56.5	17	57.5
Meeker Slough	Contra Costa	2015	7.3	64%	6%	142	29	8,560	44	1.27	4	76	16
Rock Springs Dr Storm Drain	Santa Clara	2015	0.83	80%	10%	128	30	5,252	53	0.93	8	38	39.5
Charcot Ave Storm Drain	Santa Clara	2015	1.8	79%	24%	123	31	14,927	26	0.56	24	67	20
Veterans Pump Station	San Mateo	2015	0.52	67%	7%	121	32	3,520	61	0.47	30	14	62
Gateway Ave Storm Drain	San Mateo	2015	0.36	69%	52%	117	33	5,244	54	0.44	31	20	55
Guadalupe River at Hwy 101	Santa Clara	2003-2006, 2010, 2012-2014	233	39%	3%	115	34	23,736	20	3.60	3	603	1
Line 9D1 PS at outfall to Line 9D	Alameda	2016	0.48	88%	62%	110	35	18,086	25	0.72	13	118	8.5
Tunnel Ave Ditch	San Mateo	2016	3.0	47%	8%	109	36	10,491	35	0.76	12	73	19
Valley Dr SD	San Mateo	2016	5.2	21%	7%	109	37	10,442	37	0.28	53	27	51
Runnymede Ditch	San Mateo	2015	2.1	53%	2%	108	38	28,549	17	0.19	66	52	28
E. Gish Rd Storm Drain	Santa Clara	2015	0.45	84%	70%	99	39	14,365	27	0.59	20	85	14
Line 3A-M-1 at Industrial Pump Station	Alameda	2015	3.4	78%	26%	96	40	8,923	39	0.34	44	31	45
Line 13A at end of slough	Alameda	2016	0.83	84%	68%	96	41	34,256	13	0.33	45	118	8.5
Rosemary St SD 066GAC550C	Santa Clara	2017	3.7	64%	11%	89	42	4,112	59	0.59	19	27	50
North Fourth St SD 066GAC550B	Santa Clara	2017	1.0	68%	27%	87	43	4,174	58	0.48	29	23	54

Watershed/Catchment	County	Water Year Sampled	Area (km^2)	Impervious Cover (%)	Old Industrial Land Use (%)	Polychlorinated Biphenyls (PCBs)				Total Mercury (HgT)			
						Estimated Particle Concentration		Composite/Mean Water Concentration		Estimated Particle Concentration		Composite/Mean Water Concentration	
						(ng/g)	Rank	(pg/L)	Rank	(µg/g)	Rank	(ng/L)	Rank
Zone 4 Line A	Alameda	2007- 2010	4.2	68%	12%	82	44	18,442	24	0.17	68	30	47
Forbes Blvd Outfall	San Mateo	2016	0.40	79%	0%	80	45	1,840	69	0.64	17	15	61
Storm Drain near Cooley Landing	San Mateo	2015	0.11	73%	39%	79	46	6,473	50	0.43	32	35	43
Lawrence & Central Expwys SD	Santa Clara	2016	1.2	66%	1%	78	47	4,506	56	0.23	58	13	64.5
Condensa St SD	Santa Clara	2016	0.24	70%	32%	74	48	2,602	67	0.33	47	12	71
San Leandro Creek	Alameda	2011-2014	8.9	38%	0%	66	49	8,614	42	0.86	9	117	10
Oddstad Pump Station	San Mateo	2015	0.28	74%	11%	62	50	9,204	38	0.37	38	55	25.5
Line 4-B-1	Alameda	2015	1.0	85%	28%	57	51	8,674	41	0.28	51.5	43	33
Zone 12 Line A under Temescal Ck Park	Alameda	2016	17	30%	4%	54	52	7,804	47	0.29	50	42	35
Victor Nelo PS Outfall	Santa Clara	2016	0.58	87%	4%	51	53	2,289	68	0.35	40	16	59
Line 12K at Coliseum Entrance	Alameda	2017	16	31%	1%	48	54	31,958	15	0.43	33	288	5
Haig St SD	Santa Clara	2016	2.1	72%	10%	43	55	1,454	71	0.19	65	7	74
Colma Ck at S. Linden Blvd	San Mateo	2017	35	41%	3%	37	56	2,645	66	0.22	61	15	60
Line 12J at mouth to 12K	Alameda	2017	8.8	30%	2%	35	57	6,483	49	0.40	35	73	17
S Spruce Ave SD at Mayfair Ave (296)	San Mateo	2017	5.1	39%	1%	30	58	3,359	62	0.35	41	39	38
Lower Coyote Creek	Santa Clara	2005	327	22%	1%	30	59	4,576	55	0.24	56.5	34	44
Calabazas Creek	Santa Clara	2011	50	44%	3%	29	60	11,493	33	0.15	71	59	22
E Outfall to San Tomas at Scott Blvd	Santa Clara	2016	0.67	66%	31%	27	61	2,799	65	0.13	73	13	64.5
San Lorenzo Creek	Alameda	2011	125	13%	0%	25	62	12,870	31	0.18	67	41	36
Stevens Creek	Santa Clara	2011	26	38%	1%	23	63	8,160	45	0.22	59.5	77	15
Guadalupe River at Foxworthy Road/ Almaden Expressway	Santa Clara	2010	107	22%	0%	19	64	3,120	63	4.09	2	529	2
Duane Ct and Ave Triangle SD	Santa Clara	2016	1.0	79%	23%	17	65	832	73	0.27	54	13	66
Lower Penitencia Creek	Santa Clara	2011, 2015	12	65%	2%	16	66	1,588	70	0.16	69.5	17	57.5

Watershed/Catchment	County	Water Year Sampled	Area (km^2)	Impervious Cover (%)	Old Industrial Land Use (%)	Polychlorinated Biphenyls (PCBs)				Total Mercury (HgT)			
						Estimated Particle Concentration		Composite/Mean Water Concentration		Estimated Particle Concentration		Composite/Mean Water Concentration	
						(ng/g)	Rank	(pg/L)	Rank	(µg/g)	Rank	(ng/L)	Rank
Borel Creek	San Mateo	2011	3.2	31%	0%	15	67	6,129	51	0.16	69.5	58	24
San Tomas Creek	Santa Clara	2011	108	33%	0%	14	68	2,825	64	0.28	51.5	59	22
Zone 5 Line M	Alameda	2011	8.1	34%	5%	13	69.5	21,120	21	0.57	21.5	505	3
Belmont Creek	San Mateo	2011	7.2	27%	0%	13	69.5	3,599	60	0.22	59.5	53	27
Refugio Ck at Tsushima St	Contra Costa	2017	11	23%	0%	9	71	533	74	0.51	28	30	46
Walnut Creek	Contra Costa	2011	232	15%	0%	7	72	8,830	40	0.07	75	94	11
Rodeo Creek at Seacliff Ct. Pedestrian Br.	Contra Costa	2017	23	2%	3%	5	73	13,863	28	0.05	76	119	7
Lower Marsh Creek	Contra Costa	2011-2014	84	10%	0%	3	74	1,445	72	0.11	74	44	32
East Antioch nr Trembath	Contra Costa	2017	5.3	26%	3%	NR[a]	NR[a]	<MDL	NR[a]	0.31	49	12	69
San Pedro Storm Drain	Santa Clara	2006	1.3	72%	16%	No data				1.12	7	160	6
El Cerrito Bioretention Influent	Contra Costa	2011	0.00	74%	0%	442	NR[a]	37690	NR[a]	0.19	NR[a]	16	NR[a]
Fremont Osgood Road Bioretention Influent	Alameda	2012, 2013	0.00	76%	0%	45	NR[a]	2906	NR[a]	0.12	NR[a]	10	NR[a]
Gellert Park Daly City Library Bioretention Influent	San Mateo	2009	0.02	40%	0%	36	NR[a]	725	NR[a]	1.01	NR[a]	22	NR[a]

[a]NR = site not included in ranking. All sites that are not included in the ranking are very small catchments with unique sampling designs for evaluation of green infrastructure.

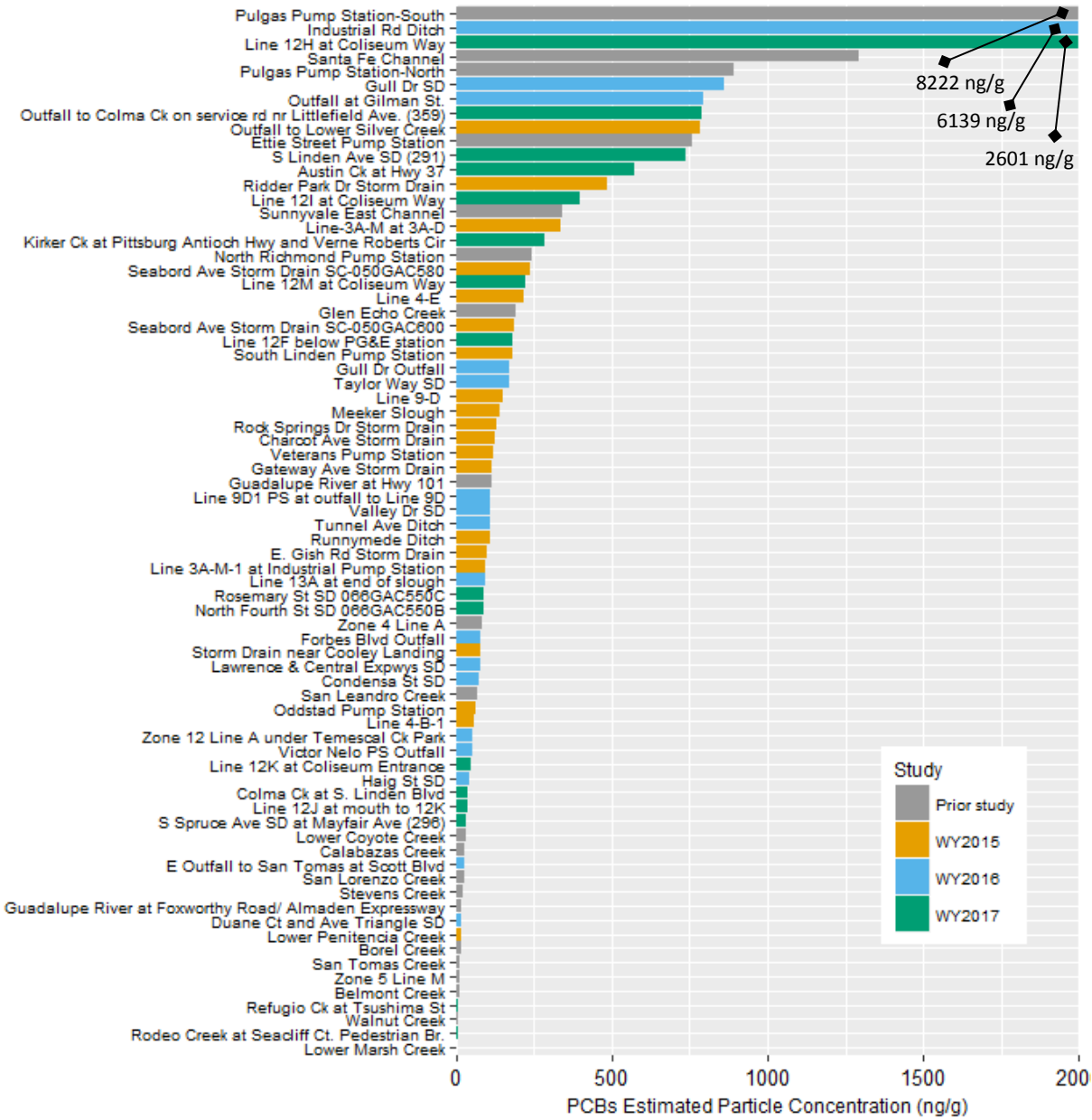

Figure 6. PCB estimated particle concentrations for watershed sampling sites measured to date (water years 2003-2017; where more than one storm is sampled at a site, the reported value is the average of the storm composite samples). Note that PCB EPCs for Pulgas Pump Station-South (8,222 ng/g), Industrial Road Ditch (6,139 ng/g) and for Line 12H at Coliseum Way (2,601 ng/g) are beyond the extent of this graph. The sample count represented by each bar in the graph is provided in Appendix B.

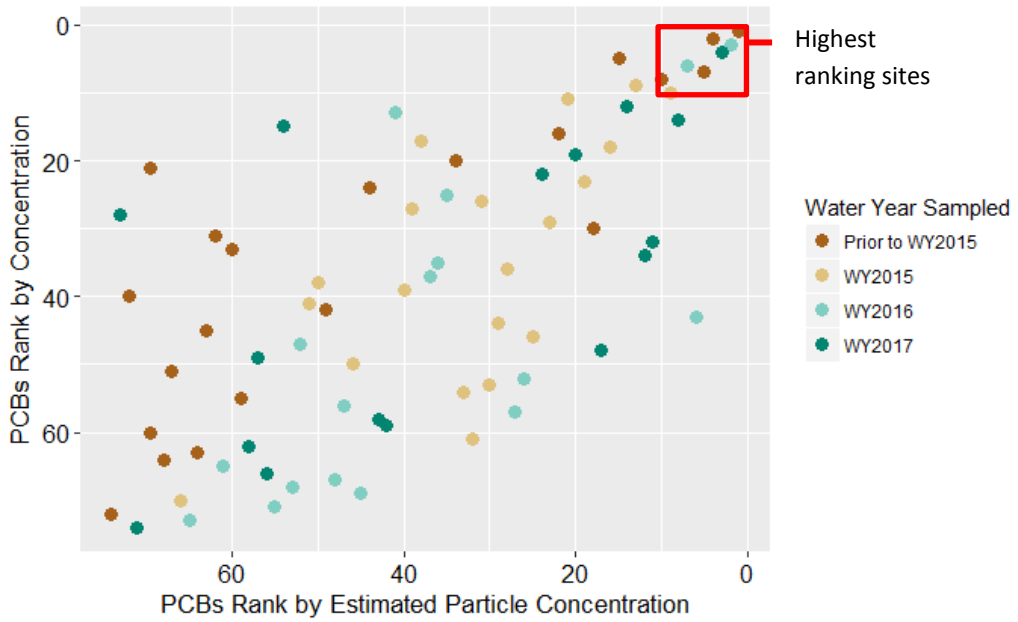

Figure 7. Comparison of site rankings for PCBs based on estimated particle concentrations versus water concentrations. 1 = highest rank; 75 = lowest rank.

Mercury

Based on composite water concentrations, the 10 highest ranking sites for HgT are the Guadalupe River at Hwy 101, Guadalupe River at Foxworthy Road/ Almaden Expressway, Zone 5 Line M, Outfall at Gilman St., Line 12K at the Coliseum Entrance, San Pedro Storm Drain, Rodeo Creek at Seacliff Ct. Pedestrian Br., Line 13-A at end of slough, Line 9-D-1 PS at outfall to Line 9-D and San Leandro Creek (Table 9). Just one of these (Outfall at Gilman St.) also ranked in the top 10 for PCBs.

In addition to the two Guadalupe River mainstem sites, the 10 most polluted sites based on EPCs are Outfall at Gilman St., Meeker Slough, Line 3A-M at 3A-D, Taylor Way SD, San Pedro Storm Drain, Rock Springs Dr. Storm Drain, San Leandro Creek and North Richmond Pump Station (Table 9; Figure 8). Management action in these watersheds might be most cost effective for reducing HgT loads. Only one of these top 10 sites was also identified as elevated for PCBs (Outfall at Gilman St.), but eight additional watersheds rank in the top 20 for both pollutants (Figure 9), providing the opportunity for treating both pollutants. Twenty-one sites measured to date have EPCs <0.25 µg/g, which, given a reasonable expectation of error bars of 25% around the measurements, could be considered equivalent to or less than 0.2 µg/g of Hg on suspended solids (the particulate Hg concentration that was specified in the Bay and Guadalupe River TMDLs (SFBRWQCB, 2006; 2008)).

Site ranking for HgT presented a different picture from PCBs. Sites ranking high based on water concentration are not necessarily ranked high for EPC with the exception of a few sites (Figure 10). Given the atmospheric deposition of Hg across the landscape (McKee et al., 2012), and the highly

variable sediment erosion in Bay Area watersheds, it is possible that a watershed could have very elevated HgT stormwater concentrations but very low EPCs. The best example of this is Walnut Creek, which was ranked 11th highest for stormwater composite concentrations but 75th for EPCs. Therefore, HgT sites need to be ranked more carefully than PCBs.

Another important point is that there are a number of watersheds that have relatively low Hg concentrations. The HgT load allocation of 80 kg from the TMDL (add citation for TMDL) translates to a mean water concentration of 53 ng/L. These calculations assume an annual average flow from small tributaries of 1.5 km^3 (Lent et al., 2012). Forty-nine of 79 sampling locations tested have composite HgT water concentrations below this concentration (Table 9). The impervious cover from these low-ranking sites ranges from 10 to 88%, and there are likely very few Hg sources in these watersheds besides atmospheric deposition[13].

Relationships between PCBs and Hg and other trace substances and land-cover attributes

Beginning in WY 2003, many sites have been evaluated for a range of trace elements in addition to PCBs and HgT. These sites include the fixed station loads monitoring sites on Guadalupe River at Hwy 101 (McKee et al., 2006), Zone 4 Line A (Gilbreath et al., 2012a), North Richmond Pump Station (Hunt et al., 2012) and at four sites for which only Cu was measured (Lower Marsh Creek, San Leandro Creek, Pulgas Pump Station-South, and Sunnyvale East Channel) (Gilbreath et al., 2015a). Copper data were also collected at the inlets to several pilot performance studies for bioretention (El Cerrito: Gilbreath et al., 2012b; Fremont: Gilbreath et al., 2015b), and Cu, Cd, Pb, and Zn data were collected at the Daly City Library Gellert Park demonstration bioretention site (David et al., 2015). During WYs 2015, 2016, and 2017, trace element data were collected at an additional 29 locations (Table 6). When all these data are pooled, the resulting dataset has samples sizes of: n=39 sites for Cu; n=33 for Cd, Pb, and Zn; and n=32 for As. Data for Mg and Se were not included due to small sample size. Organic carbon has been more widely collected, including at 28 locations in this study and an additional 21 locations in previous studies.

A Spearman rank correlation analysis was conducted to investigate relationships between EPCs of PCBs and HgT, trace elements, and impervious land cover and old industrial land use (Table 10). In the case of Guadalupe River, the HgT data were removed from the analysis because of historic mining influence in the watershed[14]. Estimated particle concentrations were chosen for this analysis for the same reasons as

[13] Multiple studies in the Bay Area on atmospheric deposition rates for HgT reported very similar wet deposition rates of 4.2 $\mu g/m^2/y$ (Tsai and Hoenicke, 2001) and 4.4 $\mu g/m^2/y$ (Steding and Flegal, 2002), and Tsai and Hoenicke reported a total (wet + dry) deposition rate of 18-21 $\mu g/m^2/y$. Tsai and Hoenicke computed volume-weighted mean mercury concentrations in precipitation based on 59 samples collected across the Bay Area of 8.0 ng/L. They reported that wet deposition contributed 18% of total annual deposition; scaled to volume of runoff, an equivalent stormwater concentration is 44 ng/L (8 ng/L/0.18 = 44 ng/L).

[14] Historic mining in the Guadalupe River watershed caused a unique positive relationship between Hg, Cr, and Ni, and there are unique inverse correlations between Hg and other typically urban metals such as Cu and Pb (McKee et al., 2005).

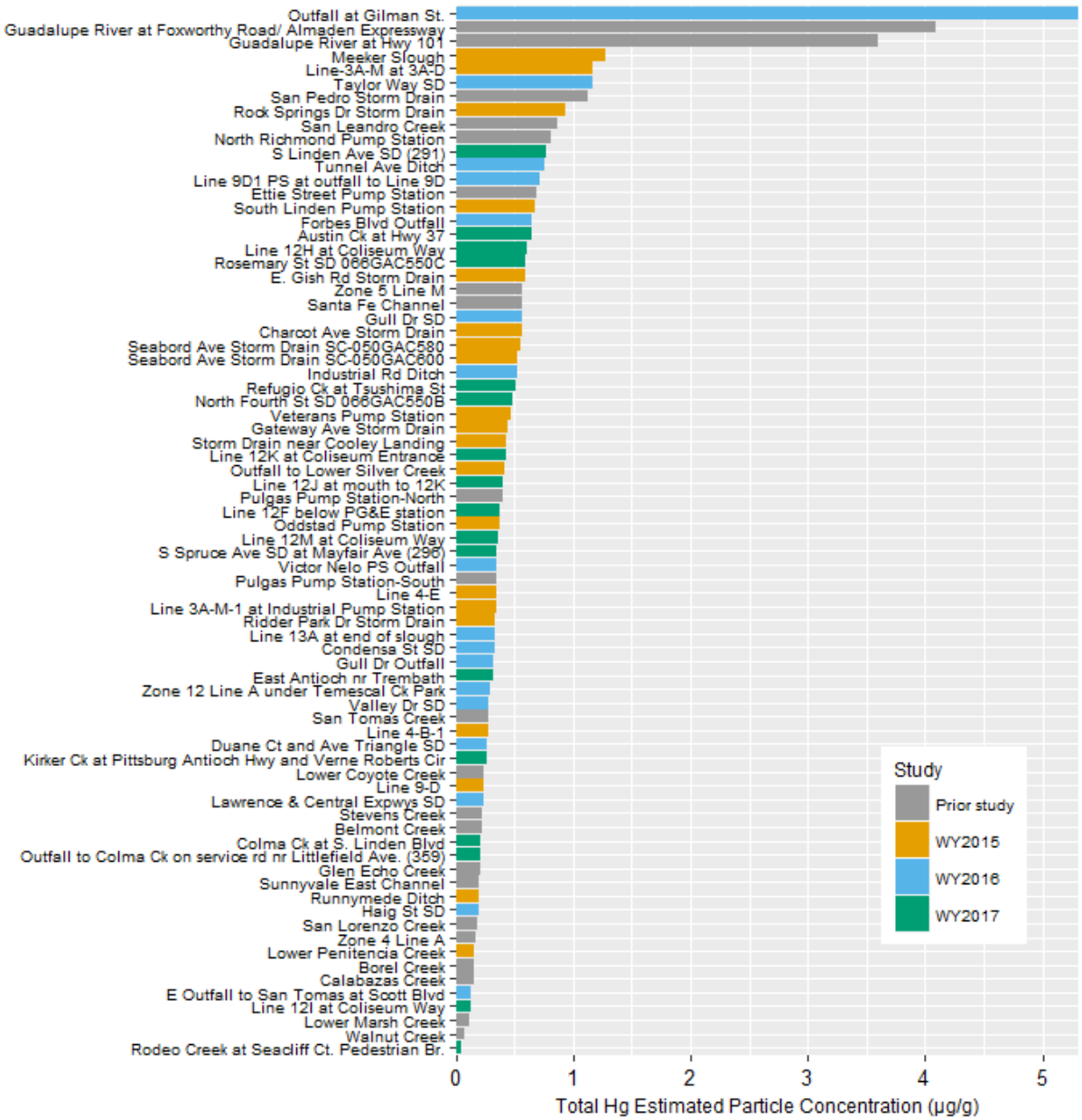

Figure 8. All watershed sampling locations measured to date (water years 2003-2017) ranked by total mercury (HgT) estimated particle concentrations. The sample count represented by each bar in the graph is provided in Appendix B.

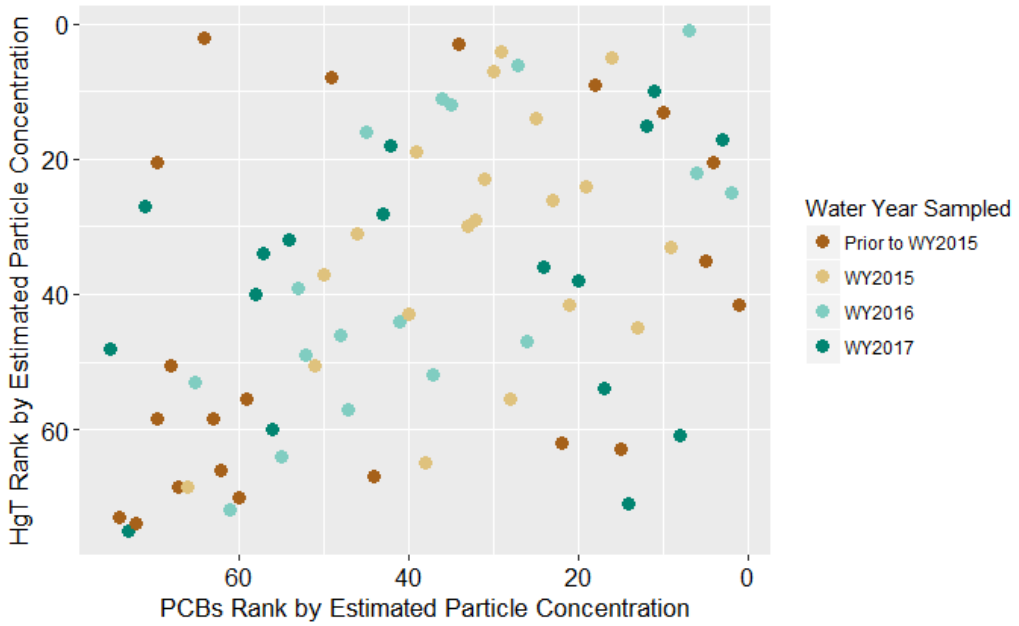

Figure 9. Comparison of site rankings for PCB and total mercury (HgT) estimated particle concentrations. 1 = highest rank; 75 = lowest rank. One watershed ranks in the top 10 for both PCBs and HgT, and nine watersheds rank in the top 20 for both pollutants.

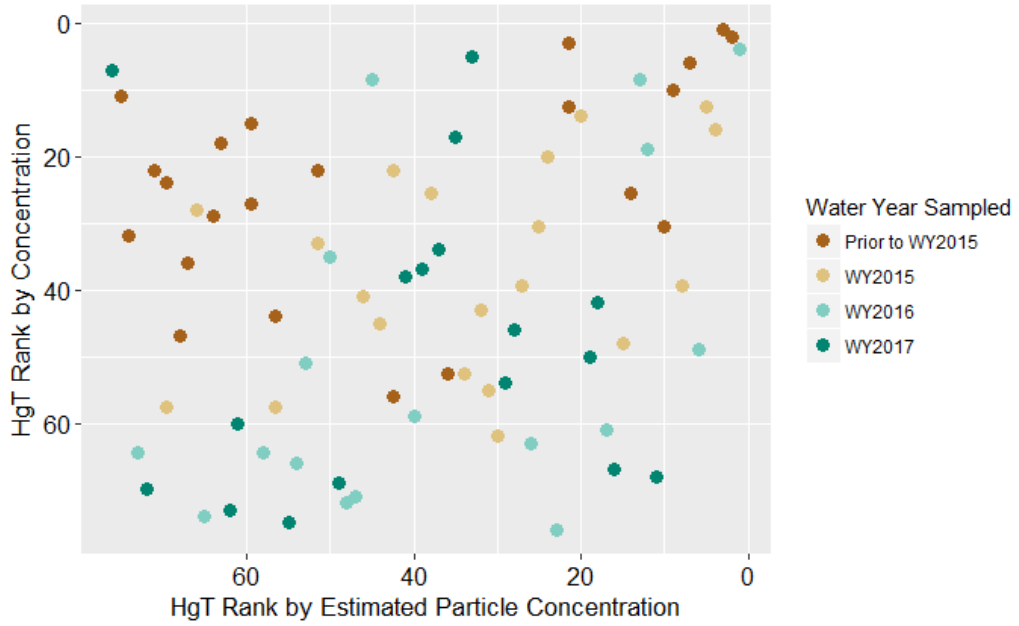

Figure 10. Comparison of site rankings for total mercury (HgT) estimated particle concentrations and water concentrations. 1 = highest rank; 76 = lowest rank.

described above and in McKee et al. (2012): the influence of variable sediment production across Bay Area watersheds is best normalized out so that variations in the influence of pollutant sources and mobilization can be more easily observed between sites.

PCBs correlate positively with impervious cover, old industrial land use and HgT, and inversely correlate with watershed area (Table 10). These observations are consistent with previous analysis (McKee et al., 2012), and make conceptual sense given that larger watersheds tend to have mixed land use and thus a lower proportional amount of PCB source areas.

There was also a positive but relatively weak correlation between PCBs and HgT which makes sense given the general relationships between impervious cover and old industrial land use and both PCBs and HgT. However, the weakness of the relationship is probably associated with the larger role of atmospheric recirculation in the mercury cycle and large differences between the use history of each pollutant. PCBs is a legacy contaminant that was used as dielectrics, plasticizers, and oils. Mercury was used in electronic devices, pressure and heat sensors, pigments, mildewcides, and dentistry and has a strong contemporary signal in addition to legacy usage.

Total Hg also has relationships to impervious cover, old industrial land use, and watershed area that are similar to but weaker than those for PCBs and these geospatial variables.

Neither PCBs nor Hg have strong correlations with other trace metals. Based on this analysis using the available pooled data, there is no support for the use of trace metals as a surrogate investigative tool for either PCB or HgT pollution sources.

To further explore these relationships, the PCB data were examined graphically (Figure 11). The graphs show that the three highest PCB concentrations are in small watersheds that have a high proportion of impervious cover and old industrial area. But the lack of a strong correlation between these metrics indicates that not all small, highly impervious watersheds have high PCB concentrations. The data also indicate the presence of outliers that may be worth exploring with additional data.

Table 10. Spearman Rank correlation matrix based on estimated particle concentrations of stormwater samples collected in the Bay Area since water year 2003 (see text for data sources and exclusions). Sample size in correlations ranged from 28 to 79. Values shaded in light blue have a *p* <0.05.

	PCBs (pg/mg)	*HgT (ng/mg)*	*Arsenic (ug/mg)*	*Cadmium (ug/mg)*	*Copper (ug/mg)*	*Lead (ug/mg)*	*Zinc (ug/mg)*	*Area (sq km)*	*% Imperviousness*	*% Old Industrial*	*% Clay (<0.0039 mm)*	*% Silt (0.0039 to <0.0625 mm)*	*% Sands (0.0625 to <2.0 mm)*
HgT (ng/mg)	0.43												
Arsenic (ug/mg)	-0.61	-0.06											
Cadmium (ug/mg)	-0.27	0.23	0.67										
Copper (ug/mg)	-0.07	0.16	0.56	0.74									
Lead (ug/mg)	-0.25	0.18	0.58	0.86	0.71								
Zinc (ug/mg)	-0.24	0.27	0.50	0.80	0.89	0.69							
Area (sq km)	-0.45	-0.34	0.01	-0.24	-0.43	-0.09	-0.41						
% Imperviousness	0.56	0.33	-0.35	0.02	0.20	-0.08	0.18	-0.77					
% Old Industrial	0.58	0.31	-0.47	-0.20	-0.22	-0.25	-0.14	-0.55	0.74				
% Clay (<0.0039 mm)	0.26	0.15	-0.12	0.04	-0.22	-0.04	-0.15	-0.23	0.04	0.10			
% Silt (0.0039 to <0.0625 mm)	-0.13	0.06	-0.14	-0.19	0.27	0.00	0.16	0.21	-0.05	-0.04	-0.35		
% Sands (0.0625 to <2.0 mm)	-0.21	-0.23	0.09	-0.01	0.02	0.07	0.00	0.24	-0.08	-0.04	-0.90	0.15	
TOC (mg/mg)	0.27	0.43	0.70	0.60	0.87	0.47	0.76	-0.49	0.45	0.17	-0.13	0.11	-0.04

p value <0.05

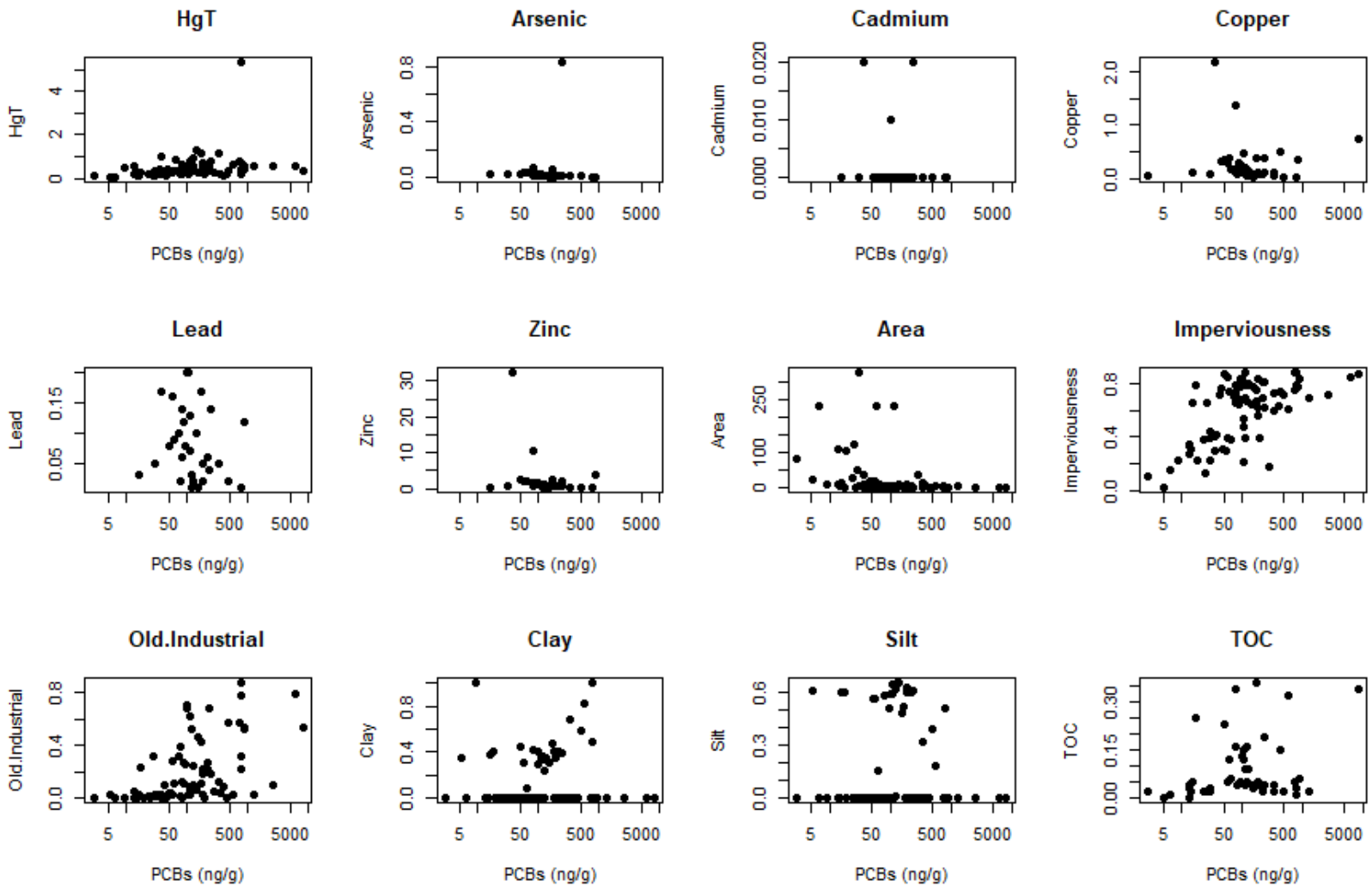

Figure 11. Relationships between observed estimated particle concentrations of PCBs and total mercury (HgT), trace elements, and impervious land cover and old industrial land use.

Sampling progress in relation to data uses

Sampling completed in older industrial areas can be used as an indicator of progress towards identifying areas for potential management. It has been argued previously that old industrial land use and the specific source areas found within or in association with older industrial areas are likely to have higher concentrations and loads of PCBs and HgT (McKee et al., 2012; McKee et al., 2015).

RMP sampling for PCBs and HgT since WY 2003 has included 34% of the old industrial land use in the region. The best effort so far has occurred in Santa Clara County (96% of this land use is in watersheds that have been sampled), followed by San Mateo County (51%) and Alameda County (41%). In Contra Costa County, only 11% of old industrial land use is in watersheds that have been sampled, and just 1% in Solano County. The disproportional coverage in Santa Clara County is due to sampling several large watersheds (Lower Penitencia Creek, Lower Coyote Creek, Guadalupe River at Hwy 101, Sunnyvale East Channel, Stevens Creek and San Tomas Creek) that have older industrial land use upstream from their sampling points. Of the remaining older industrial land use yet to be sampled, 46% of it lies within 1 km and 67% within 2 km of the Bay. These areas are more likely to be tidal, likely to include heavy industrial areas that were historically serviced by rail and ship based transport and military areas, but are often very difficult to sample due to a lack of public rights of way and tidal conditions. A different sampling strategy may be needed to effectively assess what pollution might be associated with these areas to better identify areas for potential management.

Summary and Recommendations

During WYs 2015-2017, composite water samples were collected at 55 sites during at least one storm event and analyzed for PCBs, HgT and SSC, as well as trace metals, organic carbon, and grain size for a select subset. Sampling efficiency was increased by sampling two nearby sites during a single storm. In parallel, a second sample was collected at nine of the sampling sites using a Hamlin remote suspended sediment sampler, and at seven sites using a Walling tube sampler. From this dataset, a number of sites with elevated PCB and HgT concentrations and EPCs were identified, in part because of an improved site selection process that focused on older industrial landscapes. The testing of the remote samplers showed mixed results and further testing is needed. Based on the WY 2015-2017 results, the following recommendations are made.

- Continue to select sites based on the four main selection objectives (Section 2.2). The majority of the sampling effort should be devoted to identify potential high leverage areas with high unit area loads or EPCs/concentrations. Selecting sites by focusing on older industrial and highly impervious landscapes appears successful in identifying high leverage areas and should continue.
- Continue to use the composite sampling design as developed and applied during WYs 2015-2017 with no further modifications. In the event of a higher-rainfall wet season, it may be possible to sample tidally influenced sites when there is a greater likelihood that more storm events will fall within the required tidal windows.

- If WY 2018 sampling includes resampling a site previously sampled, present an improved analysis of the potential for composite, single-storm sampling design to return false negative results (low or moderate concentrations when high concentrations are possible) (see Appendix A for discussion of the possibility for false negatives). Develop a procedure for selecting and resampling sites that return lower than expected concentrations or EPCs.
- Preliminary results from the remote sampler study indicate that the samplers show promise as a screening tool for PCBs, but less so for Hg. More Hamlin samples have been collected than Walling tube samples, and few side-by-side deployments have been made. It is therefore recommended that the testing should continue, with a focus on using the Walling tube sampler, and where the Hamlin is deployed a Walling tube should especially be deployed for comparison between the two remote samplers.
- Develop an improved (advanced) data analysis method for identifying and ranking watersheds of management interest for further characterization or investigation. This recommendation will be carried out in the 2018 calendar year.

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Appendices

Appendix A – Sampling Method Development

The monitoring program implemented in WYs 2015, 2016, and 2017 was based on a previous monitoring design that was trialed in WY 2011 when multiple sites were visited during one or two storm events. In that study, multiple discrete stormwater samples were collected at each site and analyzed for a number of POCs (McKee et al., 2012). At the 2014 SPLWG meeting, an analysis of previously collected stormwater sample data from both reconnaissance and fixed station monitoring was presented (SPLWG et al. 2014). A comparison of three sampling designs for Guadalupe River at Hwy 101 (sampling 1, 2, or 4 storms, respectively: functionally 4, 8, and 16 discrete samples) showed that PCB estimated particle concentrations (EPC) at this site can vary from 45-287 ng/g (1 storm design), 59-257 ng/g (2 storm design), and 74-183 ng/g (4 storm design) between designs, suggesting that the number of storms sampled for a given watershed has big impacts on the EPCs and therefore the potential relative ranking among sites. A similar analysis that explores the relative ranking based on a random 1-storm composite or 2-storm composite design was also presented for other monitoring sites (Pulgas Pump Station-South, Sunnyvale East Channel, North Richmond Pump Station, San Leandro Creek, Zone 4 Line A, and Lower Marsh Creek). This analysis showed that the potential for a false negative could occur due to a low number of sampled storms, especially in smaller and more urbanized watersheds where transport events can be more acute due to lack of channel storage. The analysis further highlighted the trade-off between gathering information at fewer sites with more certainty versus at more sites with less certainty. Based on these analyses, the SPLWG recommended a 1-storm composite per site design with allowances that a site could be revisited if the measured concentrations were lower than expected, either because a low-intensity storm was sampled or other information suggested that potential sources exist.

In addition to composite sampling, a pilot study was designed and implemented to test remote suspended sediment samplers based on enhanced water column settling. Four sampler types were considered: the single-stage siphon sampler, the CLAM sampler, the Hamlin sampler, and the Walling tube. The SPLWG recommended the single-stage siphon sampler be dropped because it allowed for collection of only a single stormwater sample at a single time point, and therefore offers no advantage over manual sampling but requires more effort and expense to deploy. The CLAM sampler was also dropped as it had limitations affecting the interpretation of the data; primarily its inability to estimate the volume of water passing through the filters and the lack of performance tests in high turbidity environments. As a result, the remaining two samplers (Hamlin sampler and Walling tube) were selected for the pilot study as previous studies showed the promise of using these devices in similar systems (Phillips et al., 2000; Lubliner, 2012). The SPLWG recommended piloting these samplers at 12 locations[15] where manual water composites would be collected in parallel to test the comparability between sampling methods.

[15] Note that so far due to climatic constraints, only 9 and 7 locations have been sampled with the Hamlin and Walling samplers, respectively. Additional samples using the Walling sampler are planned for WY 2018.

Appendix B – Quality assurance

The sections below report quality assurance reviews on WYs 2015, 2016, and 2017 data only. The data were reviewed using the quality assurance program plan (QAPP) developed for the San Francisco Bay Regional Monitoring Program for Water Quality (Yee et al., 2017). That QAPP describes how RMP data are reviewed for possible issues with hold times, sensitivity, blank contamination, precision, accuracy, comparison of dissolved and total phases, magnitude of concentrations versus concentrations from previous years, other similar local studies or studies described from elsewhere in peer-reviewed literature and PCB (or other organics) fingerprinting. Data handling procedures and acceptance criteria can differ among programs, however, for the RMP the underlying data were never discarded. Because the results for "censored" data were maintained, the effects of applying different QA protocols can be assessed by a future analyst if desired.

Suspended Sediment Concentration and Particle Size Distribution

In WY 2015, the SSC and particle size distribution (PSD)[16] data from USGS-PCMSC were acceptable, aside from failing hold-time targets. SSC samples were all analyzed outside of hold time (between 9 and 93 days after collection, exceeding the 7-day hold time specified in the RMP QAPP); hold times are not specified in the RMP QAPP for PSD. Minimum detection limits (MDLs) were generally sufficient, with <20% non-detects (NDs) reported for SSC and the more abundant Clay and Silt fractions. Extensive NDs (>50%) were generally reported for the sand fractions starting as fine as 0.125 mm and larger, with 100% NDs for the coarsest (Granule + Pebble/2.0 to <64 mm) fraction. Method blanks and spiked samples are not typically reported for SSC and PSD. Blind field replicates were used to evaluate precision in the absence of any other replicates. The relative standard deviation (RSD) for two field blind replicates of SSC were well below the 10% target. Particle size fractions had average RSDs ranging from 12% for Silt to 62% for Fine Sand. Although some individual fractions had average relative percent difference (RPD) or RSDs >40%, suspended sediments in runoff (and particle size distributions within that SSC) can be highly variable, even when collected by minutes, so results were flagged as estimated values rather than rejected. Fines (clay and silt) represented the largest proportion (~89% average) of the mass.

In 2016 samples, SSC and PSD was analyzed beyond the specified 7-day hold time (between 20 and 93 days after collection) and qualified for holding-time violation but not censored. No hold time is specified for grain-size analysis. Method detection limits were sufficient to have some reportable results for nearly all the finer fractions, with extensive NDs (> 50%) for many of the coarser fractions. No method blanks or spiked samples were analyzed/reported, common with SSC and PSD. Precision for PSD could not be evaluated as no replicates were analyzed for 2016. Precision of the SSC analysis was evaluated using the field blind replicates and the average RSD of 2.12% was well within the 10% target Method Quality Objective (MQO). PSD results were similar to other years, dominated by around 80% Fines.

[16] Particle size data were captured for % Clay (<0.0039 mm), % Silt (0.0039 to <0.0625 mm), % V. Fine Sand (0.0625 to <0.125 mm), % Fine Sand (0.125 to <0.25 mm), % Medium Sand (0.25 to <0.5 mm), % Coarse Sand (0.5 to <1.0 mm), % V. Coarse Sand (1.0 to <2.0 mm), and % Granule + Pebble (>2.0 mm). The raw data can be found in appendix B.

Average SSC for whole-water samples (excluding those from passive samplers) was in a reasonable range of a few hundred mg/L.

In 2017, method detection limits were sufficient to have at least one reportable result for all analyte/fraction combinations. Extensive non-detects (NDs > 50%) were reported for only Granule + Pebble/2.0 to <64 mm (90%). The analyte/fraction combinations Silt/0.0039 to <0.0625 mm; Sand/Medium 0.25 to <0.5 mm; Sand/Coarse 0.5 to <1.0 mm; Sand/V. Coarse 1.0 to <2.0 mm all had 20% (2 out of 10) non-detects. No method blanks were analyzed for grain size analysis. SSC was found in one of the five method blanks at a concentration of 1 mg/L. The average SSC concentration for the 3 method blanks in that batch was 0.33 mg/L < than the average method blank method detection limit of 0.5 mg/L. No blank contamination qualifiers were added. No spiked samples were analyzed/reported. Precision for grain size could not be evaluated as there was insufficient amount of sample for analysis of the field blind replicate. Precision of the SSC analysis was examined using the field blind replicates with the average RSD of 29.24% being well above the 10% target MQO, therefore they were flagged with the non-censoring qualifier "VIL" as an indication of possible uncertainty in precision.

Organic Carbon in Water

Reported TOC and DOC data from EBMUD and ALS were acceptable. In 2015, TOC samples were field acidified on collection, DOC samples were field or lab filtered as soon as practical (usually within a day) and acidified after, so were generally within the recommended 24-hour holding time. MDLs were sufficient with no NDs reported for any field samples. TOC was detected in only one method blank (0.026 mg/L), just above the MDL (0.024 mg/L), but the average blank concentration (0.013 mg/L) was still below the MDL, so results were not flagged. Matrix spike samples were used to evaluate accuracy, although many samples were not spiked high enough for adequate evaluation (must be at least two times the parent sample concentration). Recovery errors in the remaining DOC matrix spikes were all below the 10% target MQO. TOC errors in WY 2015 averaged 14%, above the 10% MQO, and TOC was therefore qualified but not censored. Laboratory replicate samples evaluated for precision had an average RSD of <2% for DOC and TOC, and 5.5% for POC, within the 10% target MQO. RSDs for field replicates were also within the target MQO of 10% (3% for DOC and 9% for TOC), so no precision qualifiers were needed.

POC and DOC were also analyzed by ALS in 2016. One POC sample was flagged for a holding time of 104 days (past the specified 100 days). All OC analytes were detected in all field samples and were not detected in method blanks, but DOC was detected in filter blanks at 1.6% of the average field sample and 5% of the lowest field sample. The average recovery error was 4% for POC evaluated in LCS samples, and 2% for DOC and TOC in matrix spikes, within the target MQO of 10%. Precision on POC LCS replicates averaged 5.5% RSD, and 2% for DOC and TOC field sample lab replicates, well within the 10% target MQO. No recovery or precision qualifiers were needed. The average 2016 POC was about three times higher than 2014 results. DOC and TOC were 55% and 117% of 2016 results, respectively.

In 2017, method detection limits were sufficient with no non-detects (NDs) reported except for method blanks. DOC and TOC were found in one method blank in one lab batch for both analytes. Four DOC and 8 TOC results were flagged with the non-censoring qualifier "VIP". TOC was found in the field blank and

it's three lab replicates at an average concentration of 0.5375 mg/L which is 8.6% of the average concentration found in the field and lab replicate samples (6.24 mg/L). Accuracy was evaluated using the matrix spikes except for POC which was evaluated using the laboratory control samples. The average %error was less than the target MQO of 10% for all three analytes; DOC (5.2%), POC (1.96%), and TOC (6.5%). The laboratory control samples were also examined for DOC and TOC and the average %error was once again less than the 10% target MQO. No qualifying flags were needed. Precision was evaluated using the lab replicates with the average RSD being well below the 10% target MQO for all three analytes; DOC (1.85%), POC (0.97%), and TOC (1.89%). The average RSD for TOC including the blind field replicate and its lab replicates was 2.32% less than the target MQO of 10%. The laboratory control sample replicates were examined and the average RSD was once again well below the 10% target MQO. No qualifying flags were added.

PCBs in Water and Sediment

PCBs samples were analyzed for 40 PCB congeners (PCB-8, PCB-18, PCB-28, PCB-31, PCB-33, PCB-44, PCB-49, PCB-52, PCB-56, PCB-60, PCB-66, PCB-70, PCB-74, PCB-87, PCB-95, PCB-97, PCB-99, PCB-101, PCB-105, PCB-110, PCB-118, PCB-128, PCB-132, PCB-138, PCB-141, PCB-149, PCB-151, PCB-153, PCB-156, PCB-158, PCB-170, PCB-174, PCB-177, PCB-180, PCB-183, PCB-187, PCB-194, PCB-195, PCB-201, PCB-203). Water (whole water and dissolved) and sediment (separately analyzed particulate) PCB data from AXYS were acceptable. EPA 1668 methods for PCBs recommend analysis within a year, and all samples were analyzed well within that time (maximum 64 days). MDLs were sufficient with no NDs reported for any of the PCB congeners measured. Some blank contamination was detected in method blanks for about 20 of the more abundant congeners, with only two PCB 008 field sample results censored for blank contamination exceeding one-third the concentration of PCB 008 in those field samples. Many of the same congeners detected in the method blank also were detected in the field blank, but at concentrations <1% the average measured in the field samples and (per RMP data quality guidelines) always less than one-third the lowest measured field concentration in the batch. Three target analytes (part of the "RMP 40 congeners"), PCBs 105, 118, and 156, and numerous other congeners were reported in laboratory control samples (LCS) to evaluate accuracy, with good recovery (average error on target compounds always <16%, well within the target MQO of 35%). A laboratory control material (modified NIST 1493) was also reported, with average error 22% or better for all congeners. Average RSDs for congeners in the field replicate were all <18%, within the MQO target of 35%, and LCS RSDs were ~2% or better. PCB concentrations have not been analyzed in remote sediment sampler sediments for previous POC studies, so no inter-annual comparisons could be made. PCBs in water samples were similar to those measured in previous years (2012-2014), ranging from 0.25 to 3 times previous averages, depending on the congener. Ratios of congeners generally followed expected abundances in the environment.

AXYS analyzed PCBs in dissolved, particulate, and total fraction water samples for 2016. Numerous congeners had several NDs, but extensive NDs (>50%) were reported for only PCBs 099 and 201 (both 60% NDs). Some blank contamination was detected in method blanks, with results for some congeners in field samples censored due to concentrations that were less than 3 times higher than the highest concentration measured in a blank. This was especially true for dissolved-fraction field samples with low

concentrations. Accuracy was evaluated using the laboratory control samples. Again, only three of the PCBs (PCB 105, PCB 118, and PCB 156) reported in the field samples were included in LCS samples (most being non-target congeners), with average recovery errors for those of <10%, well below the target MQO of 35%. Precision on LCS and blind field replicates was also good, with average RSDs <5% and <15%, respectively, well below the 35% target MQO. Average PCB concentrations in total fraction water samples were similar to those measured to previous years, but total fraction samples were around 1% of those measured in 2015, possibly due to differences in the stations sampled.

AXYS also analyzed PCBs in dissolved, particulate, and total fraction water samples for 2017. Numerous congeners had several NDs but none extensively. Some blank contamination was detected in method blanks, with results for some congeners in field samples censored due to concentrations that were less than 3 times higher than the highest concentration measured in a blank. This was especially true for dissolved-fraction field samples with low concentrations. Accuracy was evaluated using the laboratory control samples. Again, only three of the PCBs (PCB 105, PCB 118, and PCB 156) reported in the field samples were included in LCS samples (most being non-target congeners), with average recovery errors for those of <10%, well below the target MQO of 35%. Precision on LCS replicates was also good, with average RSDs <5%, well below the 35% target MQO.

Trace Elements in Water

Overall the 2015 water trace elements (As, Cd, Pb, Cu, Zn, Hg) data from Brooks Rand Labs (BRL) were acceptable. MDLs were sufficient with no NDs reported for any field samples. Arsenic was detected in one method blank, and mercury in four method blanks; the results were blank corrected, and blank variation was <MDL. No analytes were detected in the field blank. Recoveries in certified reference materials (CRMs) were good, averaging 2% error for mercury to 5% for zinc, all well below the target MQOs (35% for arsenic and mercury; 25% for all others). Matrix spike and LCS recovery errors all averaged below 10%, well within the accuracy MQOs. Precision was evaluated in laboratory replicates, except for mercury, which was evaluated in certified reference material replicates (no mercury lab replicates were analyzed). RSDs on lab replicates ranged from <1% for zinc to 4% for arsenic, well within target MQOs (35% for arsenic and mercury; 25% for all the other analytes). Mercury CRM replicate RSD was 1%, also well within the target MQO. Matrix spike and laboratory control sample replicates similarly had average RSDs well within their respective target MQOs. Even including the field heterogeneity from blind field replicates, precision MQOs were easily met. Average concentrations were up to 12 times higher than the average concentrations of 2012-2014 POC water samples, but whole water composite samples were in a similar range those measured in as previous years.

For 2016 the quality assurance for trace elements in water reported by Brooks Applied Lab (BRL's name post-merger) was good. Blank corrected results were reported for all elements (As, Cd, Ca, Cu, Hardness (as $CaCO_3$), Pb, Mg, Hg, Se, and Zn). MDLs were sufficient for the water samples with no NDs reported for Cd, Cu, Pb, Hg, and Zn. Around 20% NDs were reported for As, Ca, Hardness, and Mg, and 56% for Se. Mercury was detected in a filter blank, and in one of the three field blanks, but at concentrations <4% of the average in field samples and (per RMP data quality guidelines) always less than one-third the lowest measured field concentration in the batch. Accuracy on certified reference materials was good, with average %error for the CRMs ranging from 2 to 18%, well within target MQOs (25% for Cd, Ca, Cu, Pb,

Mg, Zn; 35% for As, Hg, and Se). Recovery errors on matrix spike and LCS results on these compounds was also good, with the average errors all below 9%, well within target MQOs. The average error of 4.8% on a Hardness LCS was within the target MQO of 5%. Precision was evaluated for field sample replicates, except for Hg, where matrix spike replicates were used. Average RSDs were all < 8%, and all below their relevant target MQOs (5% for Hardness; 25% for Cd, Ca, Cu, Pb, Mg, Zn; 35% for As, Hg, and Se). Blind field replicates were also consistent, with average RSDs ranging from 1% to 17%, all within target MQOs. Precision on matrix spike and LCS replicates was also good. No qualifiers were added. Average concentrations in the 2016 water samples were in a similar range of POC samples from previous years (2003-2015), with averages ranging 0.1x to 2x previous years' averages.

In 2017, the data was overall good and all field samples were usable. Blank corrected results were reported for all elements (As, Cd, Ca, Cu, Hardness (as $CaCO_3$), Pb, Mg, Hg, Se, and Zn). MDLs were sufficient for the water samples with no NDs reported. The Hg was also not detected. Accuracy on certified reference materials was good, with average %error for the CRMs within 12%, well within target MQOs (25% for Cd, Ca, Cu, Pb, Mg, Zn; 35% for As, Hg, and Se). Recovery errors on matrix spike and LCS results on these compounds were also all within target MQOs. Precision was evaluated for field sample replicates. Average RSDs were all < 8%, and all below their relevant target MQOs (5% for Hardness; 25% for Cd, Ca, Cu, Pb, Mg, Zn; 35% for As, Hg, and Se).

Trace Elements in Sediment

A single sediment sample was obtained in 2015 from fractionating one Hamlin sampler and analyzing for As, Cd, Pb, Cu, Zn, and Hg concentration on sediment. Overall the data were acceptable. MDLs were sufficient with no NDs for any analytes in field samples. Arsenic was detected in one method blank (0.08 mg/kg dw) just above the MDL (0.06 mg/kg dw), but results were blank corrected and the blank standard deviation was less than the MDL so results were not blank flagged. All other analytes were not detected in method blanks. CRM recoveries showed average errors ranging from 1% for copper to 24% for mercury, all within their target MQOs (35% for arsenic and mercury; 25% for others). Matrix spike and LCS average recoveries were also within target MQOs when spiked at least 2 times the native concentrations. Laboratory replicate RSDs were good, averaging from <1% for zinc to 5% for arsenic, all well within the target MQOs (35% for arsenic and mercury; 25% for others). Matrix spike RSDs were all 5% or less, also well within target MQOs. Average results ranged from 1 to 14 times higher than the average concentrations for the RMP Status and Trend sediment samples (2009-2014). Results were reported for Mercury and Total Solids in one sediment sample analyzed in two laboratory batches. Other client samples (including lab replicates and Matrix Spike/Matrix Spike replicates), a certified reference material (CRM), and method blanks were also analyzed. Mercury results were reported blank corrected.

In 2016, a single sediment sample was obtained from a Hamlin sampler, which was analyzed for total Hg by BAL. MDLs were sufficient with no NDs reported, and no target analytes were detected in the method blanks. Accuracy for mercury was evaluated in a CRM sample (NRC MESS-4). The average recovery error for mercury was 13%, well within the target MQO of 35%. Precision was evaluated using the laboratory replicates of the other client samples concurrently analyzed by BAL. Average RSDs for Hg and Total

Solids were 3% and 0.14%, respectively, well below the 35% target MQO. Other client sample matrix spike replicates also had RSDs well below the target MQO, so no qualifiers were needed for recovery or precision issues. The Hg concentration was 30% lower than the 2015 POC sediment sample.

Appendix C – Figures 7 and 10 Supplementary Info

Table 11: Sample counts for data displayed in Figures 7 and 10 bar graphs. For samples with a count of 2 or more, the central tendency was used which was calculated as the sum of the pollutant water concentrations divided by the sum of the SSC data.

Catchment	Year Sampled	PCB Sample Count	HgT Sample Count
Belmont Creek	Prior to WY2015	3	4
Borel Creek	Prior to WY2015	3	5
Calabazas Creek	Prior to WY2015	5	5
Charcot Ave Storm Drain	WY2015	1	1
Condensa St SD	WY2016	1	1
Duane Ct and Ave Triangle SD	WY2016	1	1
E Outfall to San Tomas at Scott Blvd	WY2016	1	1
E. Gish Rd Storm Drain	WY2015	1	1
Ettie Street Pump Station	Prior to WY2015	4	4
Forbes Blvd Outfall	WY2016	1	1
Gateway Ave Storm Drain	WY2015	1	1
Glen Echo Creek	Prior to WY2015	4	4
Guadalupe River at Foxworthy Road/ Almaden Expressway	Prior to WY2015	14	46
Guadalupe River at Hwy 101	Prior to WY2015	119	261
Gull Dr Outfall	WY2016	1	1
Gull Dr SD	WY2016	1	1
Haig St SD	WY2016	1	1
Industrial Rd Ditch	WY2016	1	1
Lawrence & Central Expwys SD	WY2016	1	1
Line 13A at end of slough	WY2016	1	1
Line 3A-M-1 at Industrial Pump Station	WY2015	1	1
Line 4-B-1	WY2015	1	1
Line 9-D	WY2015	1	1
Line 9D1 PS at outfall to Line 9D	WY2016	1	1
Line-3A-M at 3A-D	WY2015	1	1
Line4-E	WY2015	1	1
Lower Coyote Creek	Prior to WY2015	5	6
Lower Marsh Creek	Prior to WY2015	28	31
Lower Penitencia Creek	WY2015	4	4
Meeker Slough	WY2015	1	1
North Richmond Pump Station	Prior to WY2015	38	38
Oddstad Pump Station	WY2015	1	1

Outfall at Gilman St.	WY2016	1	1
Outfall to Lower Silver Creek	WY2015	1	1
Pulgas Pump Station-North	Prior to WY2015	4	4
Pulgas Pump Station-South	Prior to WY2015	29	26
Ridder Park Dr Storm Drain	WY2015	1	1
Rock Springs Dr Storm Drain	WY2015	1	1
Runnymede Ditch	WY2015	1	1
San Leandro Creek	Prior to WY2015	39	38
San Lorenzo Creek	Prior to WY2015	5	6
San Pedro Storm Drain	Prior to WY2015		3
San Tomas Creek	Prior to WY2015	5	5
Santa Fe Channel	Prior to WY2015	5	5
Seabord Ave Storm Drain SC-050GAC580	WY2015	1	1
Seabord Ave Storm Drain SC-050GAC600	WY2015	1	1
South Linden Pump Station	WY2015	1	1
Stevens Creek	Prior to WY2015	6	6
Storm Drain near Cooley Landing	WY2015	1	1
Sunnyvale East Channel	Prior to WY2015	42	41
Taylor Way SD	WY2016	1	1
Tunnel Ave Ditch	WY2016	1	1
Valley Dr SD	WY2016	1	1
Veterans Pump Station	WY2015	1	1
Victor Nelo PS Outfall	WY2016	1	1
Walnut Creek	Prior to WY2015	6	5
Zone 12 Line A under Temescal Ck Park	WY2016	1	1
Zone 4 Line A	Prior to WY2015	69	94
Zone 5 Line M	Prior to WY2015	4	4
Line 12H at Coliseum Way	WY2017	1	1
Outfall to Colma Ck on service rd nr Littlefield Ave. (359)	WY2017	1	1
S Linden Ave SD (291)	WY2017	1	1
Austin Ck at Hwy 37	WY2017	1	1
Line 12I at Coliseum Way	WY2017	1	1
Kirker Ck at Pittsburg Antioch Hwy and Verne Roberts Cir	WY2017	1	1
Line 12M at Coliseum Way	WY2017	1	1
Line 12F below PG&E station	WY2017	1	1
Rosemary St SD 066GAC550C	WY2017	1	1
North Fourth St SD 066GAC550B	WY2017	1	1
Line 12K at Coliseum Entrance	WY2017	1	1

Colma Ck at S. Linden Blvd	WY2017	1	1
Line 12J at mouth to 12K	WY2017	1	1
S Spruce Ave SD at Mayfair Ave (296)	WY2017	1	1
Refugio Ck at Tsushima St	WY2017	1	1
Rodeo Creek at Seacliff Ct. Pedestrian Br.	WY2017	1	1
East Antioch nr Trembath	WY2017	1	1