CONTRA COSTA
CLEAN WATER
PROGRAM

Urban Creeks Monitoring Report
Water Year 2016
(October 2015 – September 2016)

Submitted to the San Francisco Bay and
Central Valley Regional Water Quality Control Boards
in Compliance with NPDES Permit
Provisions C.8.h.iii and C.8.g.iii

NPDES Permit Nos. CAS612008 and CAS083313

March 22, 2017

A Program of Contra Costa County, its Incorporated Cities and Towns,
and the Contra Costa Flood Control & Water Conservation District

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This report is submitted by the agencies of the

CONTRA COSTA
CLEAN WATER
PROGRAM

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- Cities and Towns of: Antioch, Brentwood, Clayton, Concord, Danville (Town), El Cerrito, Hercules, Lafayette, Martinez, Moraga (Town), Oakley, Orinda, Pinole, Pittsburg, Pleasant Hill, Richmond, San Pablo, San Ramon and Walnut Creek
- Contra Costa County
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List of Acronyms

ACCWP	Alameda County Clean Water Program
BASMAA	Bay Area Stormwater Management Agencies Association
B-IBI	benthic index of biological integrity
BMI	benthic macroinvertebrate
BMP	best management practice
CCCWP	Contra Costa Clean Water Program
CCFCD	Contra Costa Flood Control District
CSCI	California Stream Condition Index
CVRWQB	Central Valley Regional Water Quality Control Board
DO	dissolved oxygen
EPA	U.S. Environmental Protection Agency
FSURMP	Fairfield-Suisun Urban Runoff Management Program
GI plan	green infrastructure plan
IBI	index of biological integrity
IMS	information management system
IPM	integrated pest management program
MCL	maximum contaminant level
mg/L	milligram per liter
MMI	multi-metric index
MPC	Monitoring and Pollutants of Concern Committee
MRP	Municipal Regional Permit
MRP 1	Order R2-2009-0079
MRP 2	Order R2-2015-0049
MWAT	maximum weekly average temperature
NPDES	National Pollutant Discharge Elimination System
PCBs	polychlorinated biphenyls
POC	pollutants of concern
QAPP	quality assurance project plan
RMC	Regional Monitoring Coalition
RMP	Regional Monitoring Program for Water Quality in the San Francisco Estuary
RWQCB	regional water quality control board
SAP	sampling and analysis plan
SCVURPPP	Santa Clara Valley Urban Runoff Pollution Prevention Program
SFEI	San Francisco Estuary Institute
SFBRWQCB	San Francisco Bay Regional Water Quality Control Board
SMCWPPP	San Mateo Countywide Water Pollution Prevention Program
SOP	standard operating procedure
SSID	stressor/source identification
STLS	small tributaries loading strategy
SWAMP	Surface Water Ambient Monitoring Program
TMDL	total maximum daily load
TU	toxicity units
UCMR	Urban Creeks Monitoring Report
WLA	wasteload allocation
WQO	water quality objective
WY	water year

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Table 1. Water Year 2016 Summary Table

Site ID	Creek Name	Land Use	Latitude	Longitude	Bioassessment	Nutrient	Chlorine	Water Column Toxicity (dry)	Sediment Toxicity & Chemistry	Pathogen Indicators	Temp. Loggers	General Water Quality	Water Column Pesticides & Toxicity (wet)[1]
207R00779	Las Trampas Creek	Region 2/5, Urban	37.84714	-122.10892	X						X		
207R01271	Walnut Creek	Region 2/5, Urban	37.92031	-122.05124	X								
207R01291	Grayson Creek	Region 2/5, Urban	37.98503	-122.06891	X								
207R01307	Lafayette Creek	Region 2/5, Urban	37.88772	-122.13563	X						X		
204R01412	West Branch Alamo Creek	Region 2/5, Urban	37.787959	-121.92410	X						X	X	
204R00388	West Branch Alamo Creek[2]	Region 2/5, Urban	37.80526	-121.89915					X				
204R01604	West Branch Alamo Creek	Region 2/5, Urban	37.81911	-121.89583	X						X		
207R01447	Franklin Creek	Region 2/5, Urban	37.99012	-122.13346	X					X			
206R01495	Pinole Creek	Region 2/5, Urban	37.97844	-122.26257						X			
204R01519	Rimer Creek	Region 2/5, Urban	37.81545	-122.11620	X			X	X	X	X	X	
206R01536	Ohlone Creek	Region 2/5, Urban	38.00738	-122.27424	X								
207R01611	San Ramon Creek	Region 2/5, Urban	37.89076	-122.05710	X								
206SPA020	San Pablo Creek[3]	Region 2, Urban	37.96283	-122.34562						X			
206SPA030	San Pablo Creek[3]	Region 2, Urban	37.96293	-122.34497						X			

[1] Per RMC decision, with Regional Water Board staff concurrence, in accordance with MRP 2 provision C.8.g.iii.(3), this monitoring will commence in WY 2018.

[2] WY 2015 probabilistic site

[3] Target site ID assigned

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Executive Summary

This Urban Creeks Monitoring Report (UCMR) was prepared by the Contra Costa Clean Water Program (CCCWP) per the Municipal Regional Permit (MRP) for urban stormwater issued by the San Francisco Bay Regional Water Quality Control Board (SFRWQCB; Order No. R2-2015-0049, MRP 2) and the East Contra Costa County Municipal NPDES Permit (Central Valley Permit) issued by the Central Valley Regional Water Quality Control Board (CVRWQCB; Order No. R5-2010-0102). This report, including all appendices and attachments, fulfills the requirements of MRP 2 provision C.8.h.iii (and C.8.g.iii for Central Valley Permit) for interpreting and reporting monitoring data collected during water year (WY) 2016 (October 1, 2015-September 30, 2016). Monitoring discussed herein was performed in accordance with the Central Valley Permit and MRP 2. Key technical findings are summarized below and presented in more detail in the body of the report and in its corresponding appendices.

Note: WY 2016 marked the fifth year of drought and it is important to recognize these dry conditions may affect the water quality results.

Monitoring Protocols and Data Quality (C.8.b)

Permittees are required to report annually on water quality data collected in compliance with MRP 2. For creek status monitoring, the Regional Monitoring Coalition (RMC) adapted existing creek status monitoring Standard Operating Protocols (SOPs) and Quality Assurance Project Plan (QAPP) developed by the Surface Water Ambient Monitoring Program (SWAMP) to document the field procedures necessary to maintain comparable, high quality data among RMC participants. Additionally, the RMC participants developed an Information Management System (IMS) to provide SWAMP-compatible storage and import/export of data for all RMC programs.

For POC loads monitoring, BASMAA contracted with Dan Sterns to configure a design and maintain an IMS for management of POC data collected by the RMC programs. Local agencies conduct quality assurance review of the data collected by RMC programs, consistent with the QAPP for data collected. The IMS provides standardized data storage formats which allow RMC participants to share data among themselves and to submit data electronically to the SFBRWQCB and CVRWQCB.

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

The CCCWP contributes to the San Francisco Estuary Institute’s (SFEI’s) Regional Monitoring Program (RMP). Specifically, the Status & Trends Monitoring Program and the Pilot and Special Studies efforts are useful tools for the CCCWP. CCCWP staff participates in many of the RMP committees. Findings of Status & Trends Monitoring and Pilot and Special Studies results are summarized and/or referenced in the body of this report.

Creek Status Monitoring (C.8.d)

The RMC monitoring strategy for complying with MRP 2 requirements includes continuing a regional ambient/probabilistic monitoring (**Appendix 1**) component and a component based on local/targeted monitoring (**Appendix 2**), as in the previous permit term. During WY 2016, 10 sites were monitored under the regional/probabilistic design for bioassessment, physical habitat, and related water chemistry parameters. One of the 10 sites was also monitored for water and sediment toxicity and sediment chemistry. In WY 2016, within Contra Costa County, targeted monitoring was conducted at four continuous water temperature monitoring locations, two general water quality monitoring locations, and five pathogen indicator monitoring locations. Findings from this monitoring are summarized in the body of this report and described in detail in the appendices.

Stressor/Source Identification (SSID) Projects (C.8.e)

MRP 2 requires stressor/source identification (SSID) projects when any monitoring result(s) triggers a follow-up project. Permittees were focused on conducting Part C of the SSID projects during WY 2016. In WY 2012 and WY 2013, the CCCWP's creek status monitoring triggered exceedances for water and sediment toxicity parameters. Part A results were reported in the WY 2014 UCMR, and confirmed current use pesticides, namely pyrethroids, were the cause of the toxicity measured in Dry Creek and Grayson Creek. SSID study Part B efforts to identify potential sources of the pyrethroid pesticides, and therefore potential source controls, were summarized in the WY 2015 UCMR. A summary of the BASMAA RMC SSID projects is attached as **Appendix 3**.

Pollutants of Concern Monitoring (C.8.f)

Pollutants of concern (POC) load monitoring is intended to assess inputs of POCs to the bay from local tributaries and urban runoff, assess progress toward achieving wasteload allocations (WLAs) for total maximum daily loads (TMDLs), and help resolve uncertainties associated with loading estimates for these pollutants. An updated QAPP and SOP were developed in WY 2016 to implement the POC, toxicity, and pesticide monitoring requirements in MRP 2 provisions C.8.f and C.8.g.

CCCWP and permittee staff conducted source area screening to delineate high likelihood parcels for consideration in focused implementation planning for PCBs and mercury load reductions. Street dirt, drop inlet sediments and stormwater runoff were sampled to locate high opportunity areas for PCBs parcel referral and abatement. A summary report of this data is presented in the Pollutants of Concern Sediment Screening 2016 Annual Sampling and Analysis Report (**Appendix 4**).

MRP 2 places an increased focus on finding watersheds, source areas, and source properties potentially more polluted and upstream from sensitive bay margin areas (high leverage). To support this focus, a stormwater characterization monitoring program was developed and implemented beginning in WY 2015 by the RMP. This same design was implemented in the winter of WY 2016 by the RMP and the Santa Clara and San Mateo countywide stormwater programs, and will be implemented for CCCWP at the following five locations in WY 2017: Kirker Creek (Pittsburg), East Antioch Creek (Antioch), Little Bull Valley (Carquinez Shoreline, East Bay Parks), Refugio Creek (Hercules), and Rheem Creek at Giant Road (Richmond/San Pablo border). In addition, the RMP is piloting an effort and exploring the use of alternative, un-manned remote suspended sediment samplers. The UCMR summarizes the WY 2016 findings and provides a preliminary interpretation of data collected during WY 2016 (the detailed report is included as **Appendix 5**). The RMP's POC report is designed to be updated in subsequent years as more data are collected.

CCCWP began implementation of a methylmercury control study in 2012 to fulfill requirements of the Central Valley Permit (c.11.l). A methylmercury control study work plan was prepared to 1) evaluate the effectiveness of existing best management practices (BMPs) for the control of methylmercury; 2) evaluate additional or enhanced BMPs, as needed, to reduce mercury and methylmercury discharges to the delta; and 3) determine the feasibility of meeting methylmercury waste load allocations. The progress report submitted to the CVRWQB on October 30, 2015 presents preliminary findings of the methylmercury control study work plan monitoring efforts from spring 2012 through spring 2015. A final report will be submitted in 2018, per schedule.

In addition to the methylmercury control study, CCCWP delayed the collection of mercury, methylmercury and suspended sediment concentrations at the existing March Creek POC loads station to capture upper watershed flow (i.e., flow from the Marsh Creek Reservoir). On January 11, 2017, Marsh Creek Reservoir spilled for the first time in over 5 years due to drought conditions. Crews collected four samples on the rising hydrograph. The results of those samples will be reported in the WY 2017 POC report.

Finally, the cleanup of the Mount Diablo mercury mine is one of the county's priority projects. The mine represents an ongoing point source of mercury in the watershed and must be cleaned up. It is unknown if the identified responsible parties will be required to remediate the entire mine site or a portion of the site. The Contra Costa Flood Control District (CCFCD) hired a consultant to review options to resolve mercury in the reservoir. The consultant identified three options to pursue which would provide CCFCD with a preferred alternative plan to move forward. CCFCD met with the Regional Water Quality Control Board (RWQCB) in Region 5 and reviewed a pilot project option. Water Board staff were very interested in this option and may be able to provide some small funding to cover laboratory costs for some of the testing. The CCFCD is currently in the process of trying to decide which option to pursue.

Pesticides and Toxicity Monitoring (C.8.g)

Pesticides and toxicity monitoring are separated into their own sub-provision in MRP 2. Per RMC decision, with Water Board staff concurrence, in accordance with MRP 2 provision C.8.g.iii.(3), pesticide monitoring will commence in WY 2018 (fall 2017).

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1.0 Introduction

This Urban Creeks Monitoring Report (UCMR) was prepared by the Contra Costa Clean Water Program (CCCWP) per the Municipal Regional Permit (MRP) for urban stormwater issued by the San Francisco Bay Regional Water Quality Control Board (SFRWQCB; Order No. R2-2015-0049; MRP 2) and the East Contra Costa County Municipal NPDES Permit (Central Valley Permit) issued by the Central Valley Regional Water Quality Control Board (CVRWQCB; Order No. R5-2010-0102). This report, including all appendices and attachments, fulfills the requirements of MRP 2 (provision C.8.h.iii) and the Central Valley Permit (provision C.8.g.iii) for interpreting and reporting monitoring data collected during water year (WY) 2016 (October 1, 2015-September 30, 2016). All monitoring data presented in this report were submitted electronically to the Water Boards by the CCCWP and may be obtained via the San Francisco Bay Area Regional Data Center (http://www.sfei.org/sfeidata.htm).

This report is organized into two parts – the main body and appendices. The main body provides brief summaries of accomplishments made in WY 2016 in compliance with MRP 2 and provision C.8 of the Central Valley Permit. Summaries are organized by sub-provisions of MRP 2 and the Central Valley Permit, and are grouped into the following sections:

1. Introduction (C.8.a)
2. Monitoring Protocols and Data Quality (C.8.b)
3. San Francisco Estuary Receiving Water Monitoring (C.8.c)
4. Creek Status Monitoring (C.8.d)
5. Stressor/Source Identification (SSID) Projects (C.8.e)
6. Pollutants of Concern Monitoring (C.8.f)
7. Pesticides and Toxicity Monitoring (C.8.g)

Appendices to this report include interpretive reports focused on specific types of water quality monitoring required by MRP 2, and are referenced within the applicable sections of the main body of this report.

Provision C.8.a of MRP 2 and the Central Valley Permit allows permittees to address monitoring requirements either through regional collaboration, through their area-wide stormwater programs, or third-party monitoring. In June 2010, permittees notified the SFBRWQCB and CVRWQCB in writing of their agreement to participate in a regional monitoring collaboration to address requirements in provision C.8. The collaboration is known as the Bay Area Stormwater Management Agencies Association (BASMAA) Regional Monitoring Coalition (RMC), as shown in Table 2. The RMC Work Group is a subgroup of the BASMAA Monitoring and Pollutants of Concern Committee (MPC), which meets and communicates regularly to coordinate planning and implementation of monitoring-related activities. RMC Work Group meetings are coordinated by a RMC coordinator funded by the participating county stormwater programs. This workgroup includes staff from the SFBRWQCB at two levels – those generally engaged with the MRP, as well as those working regionally with the State of California’s Surface Water Ambient Monitoring Program (SWAMP). Through the RMC Work Group, the BASMAA RMC developed a Quality Assurance Program Plan (QAPP; BASMAA, 2016a), Standard Operating Procedures (SOPs; BASMAA, 2016b), data management tools, and reporting templates and guidelines. Regionally-implemented activities of the RMC 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 project implementation mechanisms for BASMAA regional projects follow BASMAA’s operational policies and procedures, approved by the BASMAA board of directors. MRP permittees, through their stormwater program representatives on the board of directors and its subcommittees, collaboratively authorize and participate in BASMAA regional projects and tasks. Regional project costs are shared by either all BASMAA members or among those Phase I municipal stormwater programs subject to MRP 2[1].

Table 2. Regional Monitoring Coalition Participants

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

The following MRP 2 and Central Valley Permit reporting requirements are addressed within this report and the associated appendices:

- Water Year Summary Table
- Stressor/Source Identification Studies
- Statement of Data Quality
- Analysis of Data Collected

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[1] 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.

2.0 Monitoring Protocols and Data Quality (C.8.b)

MRP 2 requires permittees to report annually on water quality data collected in compliance with MRP 2 and the Central Valley Permit. Annual reporting requirements include:

- Water quality standard exceedances
- Creek status monitoring electronic reporting
- Urban creeks monitoring reporting

For RMC participants, annual reporting requirements began with the initial creek status monitoring electronic data submittal to the SFBRWQCB and CVRWQCB, which occurred on January 15, 2013 and continue annually. Preliminary evaluations of data compared to water quality objectives are included in these submittals. Additional evaluations of data collected pursuant to provision C.8 are included in this UCMR and associated appendices.

Provision C.8.b requires water quality data collected by permittees in compliance with MRP 2 and the Central Valley Permit be of a quality consistent with the State of California’s SWAMP standards, set forth in the SWAMP QAPP. The RMC was developed to assist permittees with meeting SWAMP data quality standards and to develop data management systems which allow for easy access of water quality monitoring data by permittees.

Standard Operating and Data Quality Assurance Procedures

For creek status monitoring, the RMC adapted existing SOPs and the QAPP developed by SWAMP to document the field procedures necessary to maintain comparable, high quality data among RMC participants. The RMC creek status monitoring program QAPP was finalized in March 2016 (BASMAA, 2016a).

For POC monitoring, a draft field manual and QAPP were developed through the Small Tributaries Loading Strategy (STLS) work group and described in the STLS multi-year plan. BASMAA implemented a master contract with SFEI to contract for laboratory analyses of all sites operated by RMC programs, as well as those operated by SFEI for the RMP.

Information Management System Development/Adaptation

For creek status monitoring, the RMC participants developed an Information Management System (IMS) to provide SWAMP-compatible storage and import/export of data for all RMC programs.

For POC loads monitoring, BASMAA contracted with Dan Sterns to configure a design and maintain an IMS for management of POC data collected by the RMC programs. Local agencies conduct quality assurance review of the data collected by RMC programs, consistent with the QAPP for data collected. The IMS provides standardized data storage formats which allow RMC participants to share data among themselves and to submit data electronically to the SFBRWQCB and CVRWQCB.

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3.0 San Francisco Estuary Receiving Water Monitoring (C.8.c)

As described in MRP 2 provision C.8.c, permittees are required to financially contribute their fair-share on an annual basis toward implementing an estuary receiving water monitoring program which, at a minimum, is equivalent to the RMP. All permittees comply with this provision by making financial contributions to the RMP. Additionally, permittees actively participate in RMP committees and work groups through permittee and/or stormwater program representatives.

The RMP is a long-term monitoring program which is discharger funded and shares direction and participation by regulatory agencies and the regulated community, with the goal of assessing water quality in San Francisco Bay. The regulated community includes permittees, publicly owned treatment works, dredgers, and industrial dischargers. 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 CCCWP contributes annually to the RMP. In FY 2016-2017, the CCCWP contributed $153, 640. The RMP budget is generally broken into two major program elements: status and trends monitoring and pilot/special studies. The RMP publishes reports and study results on their website at www.sfei.org/rmp.

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4.0 Creek Status Monitoring (C.8.d)

MRP 2 provision C.8.d requires permittees to conduct creek status monitoring 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, duration, and minimum number of sampling sites for each stormwater program are described in provision C.8.d of MRP 2 and provision C.8.c in the Central Valley Permit. Creek status monitoring coordinated through the RMC began in October 2011 and continues annually.

4.1 Regional and Local Monitoring Designs

The RMC's regional monitoring strategy for creek status monitoring is described in *Creek Status and Long-Term Trends Monitoring Plan* (BASMAA, 2011) and follows the BASMAA RMC creek status and pesticides and toxicity monitoring program QAPP (version 3; BASMAA, 2016a). In March 2016, SOPs for creek status and pesticide and toxicity monitoring were developed (BASMAA, 2016b). The purpose of these SOPs is to provide RMC participants with a common basis for application of consistent monitoring protocols across jurisdictional boundaries. These protocols form part of the RMC's quality assurance program to help ensure validity of resulting data and comparability with SWAMP protocols. These SOPs complement the comprehensive RMC 2016 QAPP.

The creek status monitoring parameters required by MRP provisions C.8.d and C.8.g are divided into two types: those conducted under a regional probabilistic design, and those conducted under a local, targeted design. This distinction is shown in Table 3 for the required creek status monitoring parameters. The combination of these monitoring designs allows each individual RMC-participating program to assess the status of beneficial uses in local creeks within its program (jurisdictional) area, while also contributing data to answer management questions at the regional scale (e.g., differences between aquatic life condition in urban and non-urban creeks).

Creek status monitoring data were submitted by the CCCWP to the SFBRWQCB and CVRWQCB by February 1, 2017. The analysis of results from creek status monitoring conducted in WY 2016 is presented in **Appendix 1** (the regional/probabilistic creek status monitoring report for WY 2016) and **Appendix 2** (the local/targeted creek status monitoring report for WY 2016).

Table 3. Creek Status Monitoring Parameters Sampled in Compliance with MRP Provisions C.8.d. and C.8.g. as Either Regional/Probabilistic or Local/Targeted Parameters

Bioassessment, physical habitat assessment, CSCI	X	
Nutrients (and other water chemistry associated with bioassessment)	X	
Chlorine	X	
Water toxicity (wet and dry weather)	X	
Water chemistry (pesticides, wet weather) *	X	
Sediment toxicity	X	
Sediment chemistry	X	
General water quality (sonde data: temperature, dissolved oxygen, pH, specific conductance)		X
Temperature (HOBO data loggers)		X
Bacteria		X

* Per RMC decision, with Water Board staff concurrence, in accordance with MRP provision C.8.g.iii.(3), this monitoring will commence in WY 2018.

Table 4 provides a list of which parameters are included in regional and local reports and the following sections provide a summary of each report.

Table 4. Location of Monitoring Results and Analysis for Each Required Parameter

Bioassessment (benthic macroinvertebrates and algae) and physical habitat assessments	X	
Chlorine	X	
Nutrients	X	
Water toxicity	X	
Sediment toxicity	X	
Sediment chemistry	X	
Pesticides	X*	
General water quality (continuous)		X
Temperature (continuous)		X
Bacteria		X

*Per RMC decision, with Water Board staff concurrence, in accordance with MRP 2 provision C.8.g.iii.(3), this monitoring will commence in WY 2018.

4.1.1 Regional/Probabilistic Monitoring

The regional/probabilistic creek status monitoring report (**Appendix 1**) documents the results of monitoring performed by CCCWP during WY 2016 under the regional/probabilistic monitoring design developed by the RMC. During WY 2016, 10 sites were monitored by the CCCWP under the regional/probabilistic design for bioassessment, physical habitat, and related water chemistry parameters. One of the 10 sites was also monitored for water and sediment toxicity and sediment chemistry.

Status and trends monitoring was conducted in non-tidally influenced, flowing water bodies (i.e., creeks, streams and rivers). The water bodies monitored were drawn from a master list which included all perennial and non-perennial creeks and rivers running through urban and non-urban areas within the portions of the five RMC participating counties within the SFBRWQCB boundary, and the eastern portion of Contra Costa County which drains to the CVRWQCB region. A map of the BASMAA RMC area, equivalent to the area covered by the regional/probabilistic design "sample frame", is shown in Figure 1**.**

Sample sites were selected and attributed from a sample frame consisting of a creek network geographic information system (GIS) data set within the RMC boundary[2] (BASMAA, 2011). The regional/probabilistic sites monitored in WY 2016 are shown graphically in Figure 2.

The creek status monitoring results are subject to potential follow-up actions, per MRP 2 provisions C.8.d. and C.8.g., if they meet certain specified threshold triggers. If monitoring results meet the requirements for follow-up actions, the results are compiled on a list for consideration as potential Stressor/Source Identification (SSID) projects per MRP 2 provision C.8.e. In addition to those threshold triggers for potential SSID projects, the results are compared to other regulatory standards, including Basin Plan water quality objectives, where available and applicable.

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[2] Based on discussion during RMC meetings, with SFBRWQCB staff present, the sample frame was extended to include the portion of Eastern Contra Costa County that ultimately drains to San Francisco Bay to address parallel provisions in CCCWP's Central Valley Region Permit for Eastern Contra Costa County.

Figure 1. BASMAA Regional Monitoring Coalition Area, County Boundaries and Major Creeks

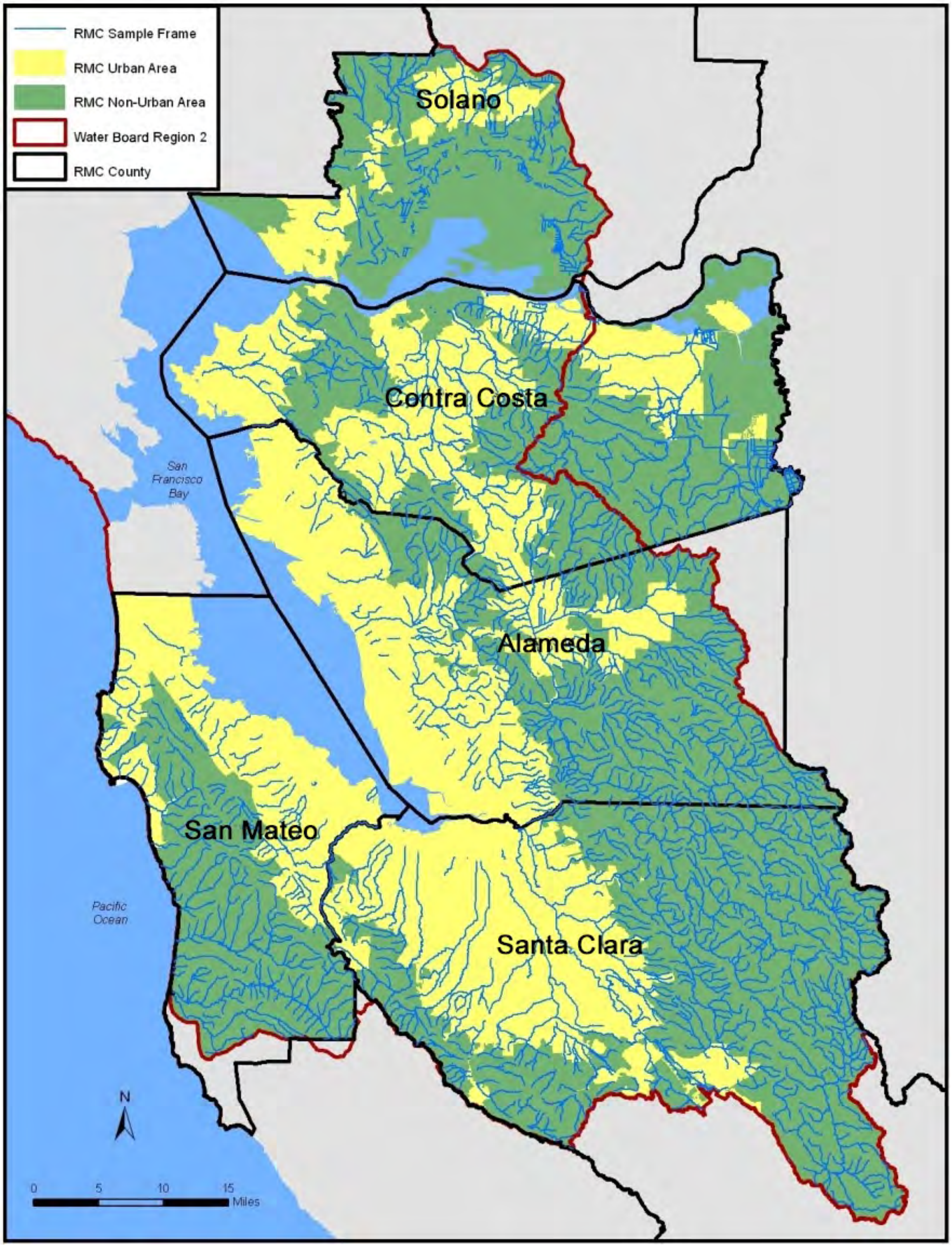
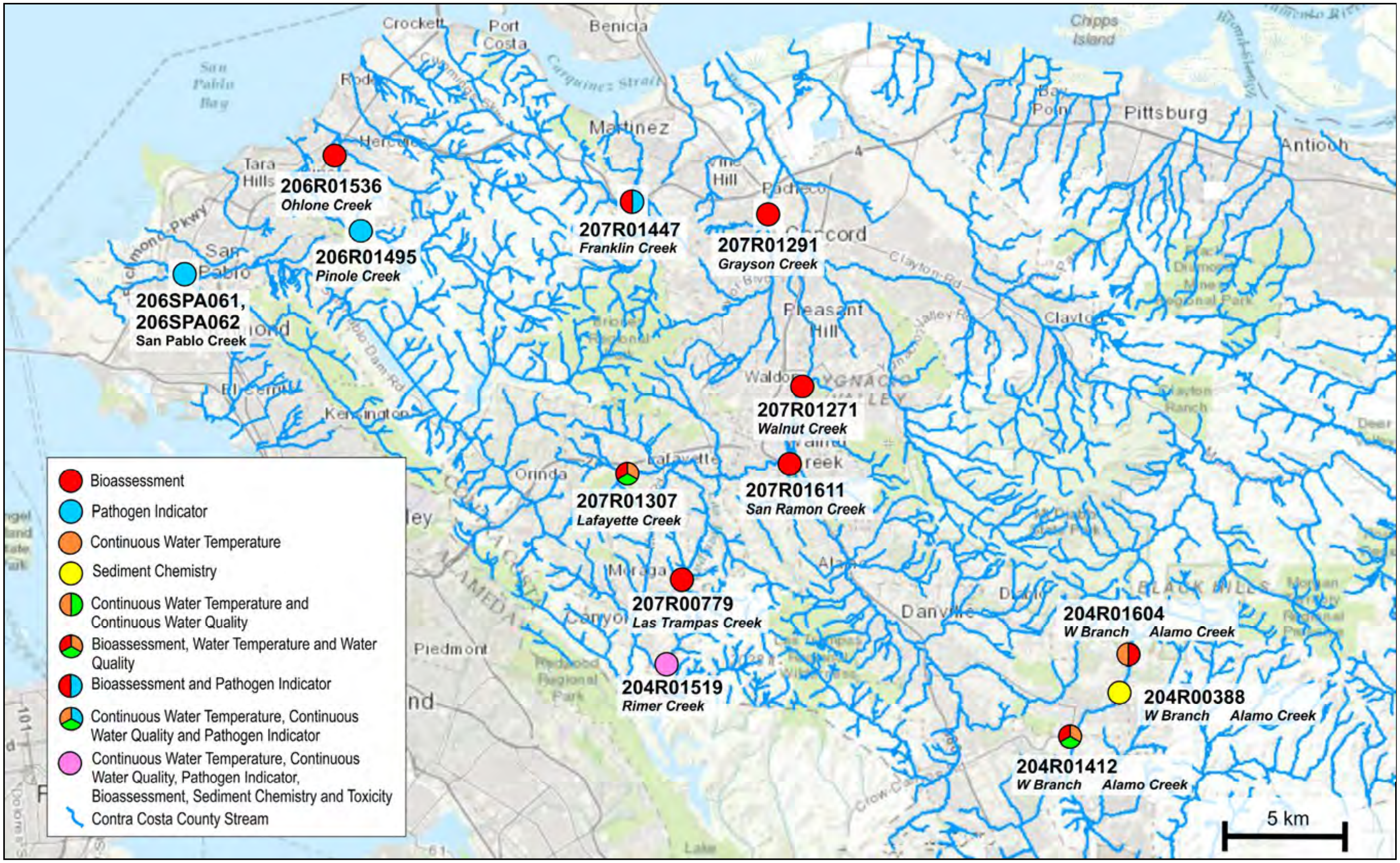


Figure 2. Contra Costa County Creek Status Sites Monitored in Water Year 2016



Note: Bioassessment sites are those selected from the RMC probabilistic monitoring design.

4.1.1.1 Bioassessments

In accordance with the RMC QAPP (BASMAA, 2016a), bioassessments were conducted during the spring index period (approximately April 15-July 15) and typically at a minimum of 30 days after any significant storm event (roughly defined as at least 0.5 inch of rainfall within a 24-hour period). Bioassessments were performed at 10 probabilistic sites in WY 2016.

Each bioassessment monitoring site consisted of an approximately 150 meter (m) stream reach divided into 11 equidistant transects placed perpendicular to the direction of flow. The sampling position within each transect alternated between 25, 50 and 75 percent distance of the wetted width of the stream (see SOP FS-1, BASMAA, 2016b).

Samples were collected and analyzed per SWAMP protocols for benthic macroinvertebrate (BMI) taxonomy, benthic algae taxonomy and related parameters (chlorophyll-*a*, pebble count algae information, and reach-wide algal percent cover, algal biomass as ash-free dry weight), water chemistry (nutrients and related parameters), and physical habitat assessment (per the full SWAMP protocol).

Benthic Macroinvertebrates

The California Stream Condition Index (CSCI) score is computed as the average of two other indices: O/E, the observed taxonomic diversity at the monitoring site divided by the taxonomic composition expected at a reference site with similar geographical characteristics, and the MMI, a multi-metric index incorporating several metrics reflective of BMI community attributes, such as measures of assemblage richness, composition, and diversity, as predicted for a site with similar physical characteristics. The six metrics selected for inclusion in the MMI calculations were taxonomic richness, number of shredder taxa, percent clinger taxa, percent Coleoptera taxa, percent EPT (Ephemeroptera, Plecopter and Trichoptera) taxa, and percent intolerant taxa. For consistency and comparison with the 2012 regional UCMR, subsequent UCMRs, and other RMC programs, the Southern California B-IBI score is also computed for condition assessment in this report.

Algae

Algae taxonomic data are evaluated through a variety of metrics and indices. Eleven diatom metrics, 11 soft algae metrics, and five algal IBIs were calculated following protocols developed from work in Southern California streams. IBI scoring ranges and values were provided by Dr. A. Elizabeth Fetscher. After each metric was scored, values were summed and then converted to a 100-point scale by multiplying the sum by the number of metrics (e.g., sum x (100/50) if five metrics included in the IBI).

Physical Habitat (PHab) Conditions

Physical habitat condition was assessed for the bioassessment monitoring sites using “mini-PHab” scores. Mini-PHab scores range from 0 to 60, representing a combined score of three physical habitat sub-categories (epifaunal substrate/cover, sediment deposition, and channel alteration), each of which can be scored on a range of 0 to 20 points. Higher PHab scores reflect higher quality habitat. Numerous additional PHab endpoints can also be calculated. Further analyses of various PHab endpoints are possible and will be considered in future reports, as the science is further developed.

CSCI Scores

California Stream Condition Index (CSCI) scores were calculated from the CCCWP bioassessment data for the first time in WY 2016. CSCI uses location-specific GIS data to compare the observed BMI taxonomic data to expected BMI assemblage characteristics from reference sites with similar geographical characteristics.

Nutrients and Conventional Analytes

Water samples were collected for nutrient and other conventional analyses using the standard grab sample collection method, as described in SOP FS-2 (BASMAA, 2016b), at all 10 bioassessment sites. Standard field parameters (temperature, dissolved oxygen, pH and specific conductance) were also measured in the field using a portable multi-meter and sonde.

Of the 12 water quality constituents monitored in association with the bioassessment monitoring, water quality standards or established thresholds are available only for ammonia (unionized form[3]), chloride[4], and nitrate + nitrite[5] – the latter for waters with MUN beneficial use only. There were no exceedances of those applicable criteria at any of the ten sites monitored in WY 2016; however, all 10 sites monitored for bioassessments were below the CSCI threshold.

4.1.1.2 Chlorine

Water samples were collected and analyzed for free and total chlorine in the field (using CHEMetrics test kits) during bioassessment monitoring. No water samples produced measurable levels of free or total chlorine (all results were 0.0).

4.1.1.3 Water Column Toxicity (dry weather)

Water samples were collected on July 11, 2016 from one regional/probabilistic monitoring site (Rimer Creek, 204R01519), and tested for toxicity to several different aquatic species, as required by MRP 2.

All test results were determined not to be toxic except one: the *Ceriodaphnia dubia* chronic effects assay for reproduction. The average reproduction for the Rimer Creek test samples was 12.5 neonates/female, compared to 34.3 neonates/female for the control samples. At 36 percent of the control result, this test was required to be repeated by the follow-up provisions of MRP 2 provision C.8.g.iv. (toxicity test results less than 50 percent of the control).

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[3] For ammonia, the standard provided in the Basin Plan (SFBRWQCB, 2013; section 3.3.20) applies to the un-ionized fraction, as the underlying criterion is based on un-ionized ammonia, which is the more toxic form. Conversion of RMC monitoring data from the measured total ammonia to un-ionized ammonia was based on a formula provided by the American Fisheries Society, and calculates un-ionized ammonia in freshwater systems from analytical results for total ammonia and field-measured pH, temperature, and electrical conductivity; see: http://fisheries.org/hatchery

[4] For chloride, a Secondary Maximum Contaminant Level (MCL) of 250 mg/L applies to those waters with MUN beneficial use, per the Basin Plan (Table 3-5), Title 22 of the California Code of Regulations, and the USEPA Drinking Water Quality Standards, and also applies per the Basin Plan (Table 3-7) to waters in the Alameda Creek watershed above Niles. For all other waters, the Criteria Maximum Concentration (CMC) water quality criterion of 860 mg/L (acute) and the Criterion Continuous Concentration (CCC) of 230 mg/L (USEPA Water Quality Criteria*) for the protection of aquatic life can be used for comparison. Per the WY 2012 UCMR (BASMAA, 2012) the RMC participants used the 230 mg/L threshold as a conservative benchmark for comparison purposes for all locations not specifically identified within the Basin Plan, i.e. sites not within the Alameda Creek watershed above Niles nor identified as MUN; rather than the maximum concentration criterion of 830mg/L. *See: http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm

[5] The nitrate+nitrite primary MCL applies to those waters with MUN beneficial use, per the Basin Plan (Table 3-5), Title 22 of the California Code of Regulations, and the USEPA Drinking Water Quality Standards.

The *Ceriodaphnia* chronic test was repeated with samples collected on August 15, 2016. This sample was also found to be toxic, but the result was not less than 50 percent of the control. Because the second test result did not meet the MRP 2 threshold for follow-up, these results are not considered to be candidates for a SSID project.

Water toxicity test results are shown in **Appendix 1**.

4.1.1.4 Sediment Toxicity and Sediment Chemistry

Sediment samples were collected on July 11, 2016 (after water samples were collected) at Rimer Creek (204R01519) and tested for acute toxicity (survival) to *Hyalella azteca* and *Chironomus dilutus*. Neither sample was determined to be toxic to either of the two sediment test species. The sediment toxicity test results are shown in **Appendix 1**.

Two sediment samples also were tested for a suite of potential sediment pollutants, as required by MRP 2, and the results were compared to the trigger thresholds specified for follow-up. The complete sediment chemistry results are shown in **Appendix 1**.

The only constituent result with a threshold effect concentration (TEC) value greater than 1.0 is nickel in the Rimer Creek sediment sample. Nickel is a naturally occurring element throughout much of the San Francisco Bay area which commonly occurs at elevated levels in creek status monitoring.

4.1.1.5 Biological Condition Assessment

Biological condition assessment addresses the RMC core management question, “What is the condition of aquatic life in creeks in the RMC area; are aquatic life beneficial uses supported?” Future reports will provide additional analysis of biological condition at the countywide program and regional levels, as well as comparisons between urban and non-urban land use sites. This analysis is complicated by the change in MRP requirements for bioassessment analysis to include the CSCI as of WY 2016.

Sediment Triad Analysis

Pyrethroid pesticide sediment concentrations appear to be potent predictors of sediment toxicity, as all five CCCWP samples with calculated pyrethroid toxicity units (TU) equivalents greater than 1.0 during water years 2012-2016 exhibited sediment toxicity. The four samples with TU equivalents less than one did not exhibit sediment toxicity.

The current and previous regional/probabilistic reports have identified several potentially impacted sites that may deserve further evaluation and/or investigation to provide better understanding of the sources/stressors that may be contributing to reduced water quality and lower biological condition at these sites.

CCCWP and the other RMC participants will continue to implement the regional probabilistic monitoring design in WY 2017, under the terms of MRP 2. Additional data also may permit a better assessment as to the potential effects of drought and rising temperatures on urban stream quality.

4.1.2 Local/Targeted Monitoring

The local/targeted creek status monitoring report (**Appendix 2**) documents the results of targeted monitoring performed by CCCWP during WY 2016. Within Contra Costa County, targeted monitoring was conducted at:

- Four continuous water temperature monitoring locations
- Two general water quality monitoring locations
- Five pathogen indicator monitoring locations

Site locations for WY 2016 were identified using a targeted monitoring design based on the directed principle to address the following management questions:

- What is the range of general water quality measurements at targeted sites of interest?
- Do general water quality measurements indicate potential impacts to aquatic life?
- What are the pathogen indicator concentrations at creek sites where water contact recreation may occur?

During the five years studied so far, winter seasons were very dry relative to average annual conditions. Targeted monitoring data were evaluated against numeric water quality objectives (WQOs) or other applicable criteria, as described in MRP 2. None of the targeted monitoring locations sampled in WY 2016 were in the jurisdiction of the Central Valley Permit, so none of the Central Valley Permit thresholds apply. The results are summarized below:

Temperature

Numeric water quality objectives for temperature are defined in MRP 2 as follows: for all streams, 20 percent of instantaneous results shall not exceed 24 °C. For streams documented to support steelhead fisheries (i.e. steelhead streams), a maximum temperature of 17 °C is used as the applicable criterion to evaluate temperature data. Per MRP 2, if the temperature data is recorded by a HOBO® device, at most, one WAT can reach a threshold of 17 °C. For temperature recorded by sonde devices, all WAT must be below 17 °C.

At the four locations with continuously recorded temperature data from April until September, two creeks (Lafayette Creek and Rimer Creek) were classified as steelhead streams. The West Branch Alamo Creek, on which there were two monitoring stations, were not considered to be so. Temperature was continuously monitored by sondes during two time periods (April and August of 201) at Rimer Creek and West Branch Alamo Creek. No location recorded an instantaneous temperature above 24 °C. At those locations classified as steelhead streams, there were exceedances of the 17 °C threshold in three of four cases. These locations were Lafayette and Rimer Creeks for the HOBO® recorded data, and Rimer Creek for the sonde recorded data during the August deployment.

Dissolved Oxygen

WQOs for dissolved oxygen in non-tidal waters are applied as follows: for waters designated as steelhead habitat, 20 percent of instantaneous dissolved oxygen results shall not drop below 7.0 mg/L.

At those locations classified as steelhead streams, there was one exceedance during the August deployment at Rimer Creek, where 47 percent of dissolved oxygen concentrations were measured below the threshold.

pH

Water quality objectives for pH in surface waters are defined as follows: 20 percent of instantaneous pH results shall not be depressed below 6.5 nor raised above 8.5. This range was used to evaluate the pH data collected at all targeted locations in WY 2016. During both monitoring periods, pH measurements at West Branch Alamo Creek and Rimer Creek did not exceed stated WQOs.

Specific Conductance

WQOs for specific conductance in surface waters are applied as follows: 20 percent of instantaneous specific conductance results should not exceed 2000 µS, or readings should not detect any spike in specific conductance with no obvious natural explanation. During both monitoring periods, specific conductance measurements at both West Branch Alamo Creek and Rimer Creek did not exceed stated numeric water quality objectives. However, the August deployment in Rimer Creek displayed a spike in readings with no obvious natural explanation. This spike constitutes an exceedance as defined by MRP 2 provision C.8.d.iv.(4).

Pathogen Indicator Bacteria

Single sample maximum concentrations of 130 cfu/100 ml enterococci and 410 cfu/100 ml *E. coli* (USEPA, 2012) were used as water contact recreation evaluation criteria for this evaluation. Samples for enterococci at one of the five stations (Rimer Creek) exceeded the maximum single sample concentration, while two samples for *E. coli* (Rimer Creek and Pinole Creek) exceeded the single sample maximum concentration.

CCCWP will continue to conduct monitoring for local/targeted parameters in WY 2017. All permit-related water quality threshold exceedances will be included in a compilation of water quality triggers for consideration by the RMC as potential SSID projects, and for other potential follow-up investigations and/or monitoring.

Table 5. CCCWP Threshold Exceedances for Water Year 2016

Creek	Index Period	Parameter	Criterion Exceedance
Lafayette Creek	June 23-June 29, 2016; July 21-August 3, 2016	Continuous Water Temperature (HOBO)	More than one WAT exceeds 17 °C or when 20 percent of instantaneous results > 24 °C
Rimer Creek	June 2-June 8, 2016; June 23-June 29, 2016; July 21-August 3, 2016	Continuous Water Temperature (HOBO)	More than one WAT exceeds 17 °C or when 20 percent of instantaneous results > 24 °C
Rimer Creek	August 1-15, 2016	Continuous Water Temperature (sonde)	When one WAT exceeds 17 °C or when 20 percent of instantaneous results > 24 °C
Rimer Creek	August 1-15, 2016	Continuous Water Quality - DO	When 20 percent of instantaneous results drop below 7.0 mg/L
Rimer Creek	August 1-15, 2016	Continuous Water Quality - Conductivity	When 20 percent of instantaneous results exceed 2,000 µS/cm or there is a spike with no natural explanation
Rimer Creek	July 20, 2016	Enterococci	Single grab sample exceeded EPA criterion of 130 CFU/100ml
Pinole Creek	July 20, 2016	*E. coli*	Single grab sample exceeded EPA criterion of 410 CFU/100ml
Rimer Creek	July 20, 2016	*E. coli*	Single grab sample exceeded EPA criterion of 410 CFU/100ml
West Branch of Alamo Creek	May 9, 2016	CSCI	California Stream Condition Index (CSCI) score <0.795
Rimer Creek	April 28, 2016	CSCI	California Stream Condition Index (CSCI) score <0.795
West Branch of Alamo Creek	April 26, 2016	CSCI	California Stream Condition Index (CSCI) score <0.795
Ohlone Creek	April 27, 2016	CSCI	California Stream Condition Index (CSCI) score <0.795
Las Trampas Creek	May 10, 2016	CSCI	California Stream Condition Index (CSCI) score <0.795
Walnut Creek	May 11, 2016	CSCI	California Stream Condition Index (CSCI) score <0.795
Grayson Creek	May 11, 2016	CSCI	California Stream Condition Index (CSCI) score <0.795
Lafayette Creek	April 28, 2016	CSCI	California Stream Condition Index (CSCI) score <0.795
Franklin Creek	May 12, 2016	CSCI	California Stream Condition Index (CSCI) score <0.795
San Ramon Creek	May 10, 2016	CSCI	California Stream Condition Index (CSCI) score <0.795
Rimer Creek	July 11, 2016	*C. dubia*, Chronic Toxicity Test (Reproduction)	Test result <50 percent of control; retest sample collected on 8/15/16 was also toxic, but not at <50 percent of the control
Rimer Creek	July 11, 2016	Sediment Chemistry: Nickel TEC	TEC ratio > 1.0
West Branch of Alamo Creek	July 11, 2016	Sediment Chemistry: Sum of Pyrethroids Toxic Units	Sum of pyrethroids toxic units >1.0

WAT = weekly average temperature

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5.0 Stressor/Source Identification Studies (C.8.e)

MRP 2 requires a minimum of eight new SSID projects for permittees who participate in a regional collaborative, with at least one project for toxicity. The process for identifying MRP 2 SSID projects includes the following elements:

- Construct a new trigger exceedance matrix template to accommodate MRP 2 thresholds (include pyrethroid TUs)
- RMC programs each populate the new matrix template with RMC monitoring data, beginning with WY 2015
- Eight SSID projects are required during the permit term, with the one required project estimated for CCCWP beginning by the third year of the permit term (i.e., beginning fall 2017)

The threshold exceedance table compiled for Contra Costa County from the WY 2016 CCCWP data is included in the SSID status report in **Appendix 3**. The WY 2016 data produced several results with the potential to be considered SSID projects. For local/targeted parameters, the data trigger thresholds exceeded included temperature, dissolved oxygen, conductivity, and bacteria (*E.coli* and *Enterococci*). For the regional/probabilistic parameters, the only notable thresholds triggered by WY 2016 data involves sediment chemistry, specifically pyrethroid pesticide toxic unit equivalents, and 10 bioassessment sites (CSCI below threshold). The RMC will discuss potential regional SSID projects in early 2017 by collectively evaluating the potential SSID projects as indicated by WY 2015 and 2016 data which trigger MRP 2 threshold exceedances.

Per MRP 1, the CCCWP was responsible for performing related follow-up studies triggered by the creek status monitoring. In WY 2012 and WY 2013, the CCCWP's creek status monitoring triggered exceedances for water and sediment toxicity parameters. CCCWP's SSID projects follow an orderly process, from trigger exceedance and confirmation to define the problem (Phase A), to source investigation activities which identified sources and causes (Phase B), to the present-day actions which address the sources and causes (Phase C), in preparation for monitoring to document outcomes (Phase D). Phase C is an active waiting period, during which actions are carried out to address the problem, while allowing sufficient time for the actions to translate to meaningful change in the effects as evidenced by monitoring data. The principal actions carried out during Phase C, as defined under provision C.9 of MRP 2, include:

- Maintaining an integrated pest management program (IPM)
- Training municipal operators in the IPM
- Requiring contractors to implement IPM
- Interfacing with county agricultural commissioners
- Conducting public outreach to stores, pesticide professionals, and customers of pesticide professionals to encourage irrigation management that minimize pesticide runoff and appropriate pesticide disposal practices
- Tracking and participating in relevant regulatory processes; potential coordination with STORMS statewide pesticides/toxicity monitoring framework
- Evaluating the implementation of pesticide source control actions
    - Phase B of this SSID study included an update on the sales of pyrethroid pesticides in Contra Costa County as a means of evaluating the effectiveness of implementation measures carried out to date.

Based on lessons learned about diazinon and chlorpyrifos from statewide collaboration through CASQA, product re-registration leading to reduction in uncontrolled consumer use is the most effective way to prevent pesticides in stormwater discharges from impacting water quality. This is a long-term process. Control actions were completed for diazinon and chlorpyrifos, and long-term monitoring programs documented the positive outcomes in terms of reduced incidents of diazinon and chlorpyrifos toxicity in receiving waters. Similar regulatory processes are expected to lead to similar outcomes during the implementation of Phase C of the CCCWP SSID study for pyrethroid pesticides. To implement Phase D, the CCCWP has a monitoring program, funding process, and the staff and consultant resources needed to direct monitoring to evaluate the success of SSID Phase C implementation at the appropriate time. In the meantime, CCCWP permittees are developing green infrastructure plans (GI plans). This action is motivated by the fact that urban stormwater has the potential to convey a multitude of pollutants, including ubiquitous legacy pollutants, such as mercury and PCBs, which are subject to load reduction requirements through TMDLs and associated permit requirements. The implementation of GI plans would promote stormwater treatment via detention and infiltration as a means of reducing pollutant loads. To address funding gaps needed to implement GI plans, CCCWP is also developing a stormwater resources plan to enable permittees to seek grant funding to assist with GI plan implementation.

In summary, Phase C of SSID implementation combines actions specific to reducing pyrethroids through existing programs with planning actions to more generally address reducing pollutant loads discharged through treatment by GI. The timeline of the current active waiting period of Phase C actions for pyrethroids means Phase D effectiveness monitoring activities are most likely warranted in the five to 10-year time frame (i.e., during the implementation of MRP 3 or MRP 4). Progress on Phase C implementation and the resulting timeline anticipated for Phase D implementation will be updated annually through the annual reports, and through the five-year cycle of preparing a report of waste discharge in preparation for permit renewal.

Per MRP 1, CCCWP was responsible for performing related follow-up studies triggered by the creek status monitoring. In WY 2012 and WY 2013, CCCWP’s creek status monitoring triggered exceedances for water and sediment toxicity parameters. A summary of the BASMAA RMC SSID project locations, rationales and status from 2010-2016 are provided in an attachment to **Appendix 3**.

6.0 Pollutants of Concern Monitoring (C.8.f)

Pollutants of Concern (POC) load monitoring is required by MRP 2 and the Central Valley Permit. Loads monitoring is intended to assess inputs of POCs to the bay from local tributaries and urban runoff, assess progress toward achieving WLAs for TMDLs, and help resolve uncertainties associated with loading estimates for these pollutants. There are five priority POC management information needs to be addressed though POC loads monitoring:

- Source identification
- Contributions to bay impairment
- Management action effectiveness
- Loads and status
- Trends

In October 2016, a POC monitoring report summarizing accomplishments in WY 2016 and the allocation of efforts for WY 2017 was submitted to the SFBRWQCB (ADH, 2016). That report fulfills provision C.8.h.iv of MRP 2 and describes monitoring goals, CCCWP's dual jurisdiction between the SFBRWQCB and CVRWQCB, lessons learned from the past five years of permit implementation, and POC load estimates from currently identified source areas.

During WY 2016, the following monitoring activities were completed to increase CCCWP's understanding of the geographic distribution of PCBs and mercury within the county's urban landscape.

- Countywide street dirt sampling (Tier 1 approach) in areas targeted for historic land uses and halo extent not previously sampled

- Sediment sampling within MS4 drop inlets (Tier 2 approach) within Rumrill Boulevard and Giant Highway areas to characterize spatial distribution of PCBs and mercury within these halos of interest due to historic land uses

- Stormwater sampling (Tier 3 approach) on West Gertrude Avenue in the City of Richmond adjacent to a suspected source property for PCBs and mercury to confirm if elevated concentrations are present in runoff

Additionally, BMP effectiveness monitoring for mercury, methylmercury and suspended sediment concentration was performed at bioretention cells on Cutting Boulevard in the City of Richmond. This work was piggybacked on the EPA grant-funded study (Clean Watersheds for a Clean Bay, Task 5 Phase 2) and was performed for a two-fold purpose: 1) to inform treatment BMP effectiveness, and 2) to provide continued monitoring data for a methylmercury control study investigation, per Central Valley RWQCB permit requirements.

All monitoring activities were performed in accordance with CCCWP's POC Sampling and Analysis Plan (SAP) and QAPP guidance documents (ADH and AMS, 2016a; ADH and AMS, 2016b). Results are presented in **Appendix 4**. Additional monitoring information, background and context, including a discussion of permit-driven goals, can be found in the CCCWP WY 2016 POCs report (ADH, 2016).

MRP 2 places an increased focus on finding watersheds, source areas, and source properties that are potentially more polluted and upstream from sensitive bay margin areas (high leverage). To support this focus, a stormwater characterization monitoring program was developed and implemented beginning in WY 2015 by the RMP. This same design was implemented in the winter of WY 2016 by the RMP and the Santa Clara and San Mateo countywide stormwater programs, and will be implemented for CCCWP at the following five locations in WY 2017: Kirker Creek (Pittsburg), East Antioch Creek (Antioch), Little Bull Valley (Carquinez Shoreline and East Bay Parks), Refugio Creek (Hercules), Rheem Creek at Giant Road (Richmond/San Pablo border). In addition, the RMP is piloting an effort and exploring the use of alternative, un-manned remote suspended sediment samplers. The UCMR summarizes the WY 2016 findings and provides a preliminary interpretation of data collected during WY 2016 (the detailed report is included as **Appendix 5**). The RMP's POC report is designed to be updated in subsequent years as more data are collected.

6.1 Sampling and Analysis Plan and Quality Assurance Project Plan

A QAPP and SOP were developed in WY 2016 to implement the new requirements of MRP 2 (BASMAA, 2016a and 2016b). The SAP is a living document intended to be updated on an annual basis. Its primary intention is to memorialize field sampling (procedures, documentation and methods) and analytical methods, which will be used to conduct analyses and testing in accordance with the MRP 2 provision C.8.f and C.8.g requirements. The 2016 QAPP and SOPs will be updated as necessary to remain accurate with the SAP.

7.0 Pesticides and Toxicity Monitoring (C.8.g)

Pesticides and toxicity monitoring is a new section in MRP 2. Per RMC decision, with Water Board staff concurrence, in accordance with MRP 2 provision C.8.g.iii. (3), wet weather pesticide monitoring will commence in WY 2018. Any pesticide and toxicity monitoring conducted in WY 2016 is included in the regional/probabilistic monitoring report (see **Appendix 1**, Section 4.1). The QAPP and SOPs were developed in WY 2016 to implement the new requirements of MRP 2 provision C.8.g (BASMAA, 2016a and 2016b).

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Appendix 1

Regional/Probabilistic Creek Status Monitoring Report
Water Year 2016

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CONTRA COSTA
CLEAN WATER
PROGRAM

Regional/Probabilistic Creek Status Monitoring Report
Water Year 2016
(October 2015 – September 2016)

Submitted to the San Francisco Bay and
Central Valley Regional Water Quality Control Boards
in Compliance with NPDES Permit
Provisions C.8.h.iii and C.8.g.iii

NPDES Permit Nos. CAS612008 and CAS083313

March 22, 2017

A Program of Contra Costa County, its Incorporated Cities and Towns,
and the Contra Costa Flood Control & Water Conservation District

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This report is submitted by the participating agencies of the

CONTRA COSTA
CLEAN WATER
PROGRAM

Program Participants:

- Cities and Towns of: Antioch, Brentwood, Clayton, Concord, Danville (Town), El Cerrito, Hercules, Lafayette, Martinez, Moraga (Town), Oakley, Orinda, Pinole, Pittsburg, Pleasant Hill, Richmond, San Pablo, San Ramon and Walnut Creek
- Contra Costa County
- Contra Costa County Flood Control & Water Conservation District

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In addition to the Regional Monitoring Coalition participants, San Francisco Bay Regional Water Quality Control Board staff member Kevin Lunde and Jan O’Hara participated in the Regional Monitoring Coalition work group meetings, which contributed to the design and implementation of the Regional Monitoring Coalition Monitoring Plan. These staff members also provided input on the outline of the initial regional urban creeks status monitoring report and threshold trigger analyses conducted herein.

Staff of the Contra Costa Clean Water Program, specifically Lucile Paquette and Tom Dalziel, provided project supervision and review of draft documents. Alessandro Hnatt served as project manager for ADH Environmental, lead consultant to CCCWP. The staff of ADH Environmental also contributed to both the content and production of this report, with respect to data compilation and extraction, organization of metadata, graphics production, and analysis of the GIS and related data necessary to compute CSCI scores.

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List of Acronyms

ACCWP	Alameda Countywide Clean Water Program
ADH	ADH Environmental
AFDM	ash-free dry mass
A-IBI	algal index of biological integrity
ARC	Armand Ruby Consulting
Basin Plan	common term for the Regional Water Quality Control Plan
BASMAA	Bay Area Stormwater Management Agencies Association
B-IBI	benthic index of biological integrity
BMI	benthic macroinvertebrate
CCCWP	Contra Costa Clean Water Program
CCMAP	Contra Costa Monitoring and Assessment Program
CDFW	California Department of Fish and Wildlife
Central Valley Permit	East Contra Costa County Municipal NPDES Permit
cm	centimeter
CSCI	California Stream Condition Index
CU	clinical utility
CVRWQCB	Central Valley Regional Water Quality Control Board
DOC	dissolved organic carbon
DQO	data quality objective
EPA	U.S. Environmental Protection Agency
FSURMP	Fairfield-Suisun Urban Runoff Management Program
GIS	geographic information system
GRTS	Generalized Random Tessellated Stratified
IBI	Index of Biological Integrity
LC_{50}	lethal concentration to 50 percent of test organisms
m	meters
MCL	maximum contaminant level
MDL	method detection limit
MPC	Monitoring and Pollutants of Concern Committee
MRP	Municipal Regional Permit
MUN	municipal and domestic water supply
ND	non-detect
NPDES	National Pollutant Discharge Elimination System
NT	non-target
PAH	polycyclic aromatic hydrocarbon
PEC	probable effect concentration
PHab	physical habitat assessment
PRM	pathogen-related mortality
PSA	perennial streams assessment
QA/QC	quality assurance/quality control
QAPP	quality assurance project plan
RL	reporting limit
RMC	Regional Monitoring Coalition
RWB	reach-wide benthos
RWQCB	regional water quality control board
SCCWRP	Southern California Coastal Water Research Project
SCVURPPP	Santa Clara Valley Urban Runoff Pollution Prevention Program

SFBRWQCB	San Francisco Bay Regional Water Quality Control Board
SMC	Southern California Stormwater Monitoring Coalition
SMCWPPP	San Mateo Countywide Water Pollution Prevention Program
SOP	standard operating procedure(s)
SSID	stress/source identification
SWAMP	Surface Water Ambient Monitoring Program
TEC	threshold effect concentration
TNS	target not sampled (or sampleable)
TOC	total organic carbon
TS	target sampled
TU	toxicity unit
U	unknown
UCMR	urban creeks monitoring report
Vallejo	City of Vallejo and Vallejo Sanitation and Flood Control District
WQO	water quality objective
WY	water year

Preface

The Bay Area Stormwater Management Agencies Association (BASMAA) Regional Monitoring Coalition (RMC) developed a probabilistic design for regional characterization of selected creek status monitoring parameters. The following program participants make up the RMC:

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

This report fulfills reporting requirements for the portion of the regional/probabilistic creek status monitoring data generated within Contra Costa County during water year (WY) 2016 (October 1, 2015-September 30, 2016) through the RMC's probabilistic design for certain parameters monitored, per provision C.8.c. This report is an appendix to the combined urban creeks monitoring report (UCMR), which contains reports submitted by each of the participating RMC programs on behalf of their respective permittees.

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Executive Summary

This Regional/Probabilistic Creek Status Monitoring Report documents the results of monitoring performed by CCCWP during WY 2016 under the regional/probabilistic monitoring design developed by the RMC. This report is a component of the Urban Creeks Monitoring Report (UCMR) for WY 2016. Together with the creek status monitoring data reported in the Local/Targeted Creek Status Monitoring Report (ADH, 2017), this submittal fulfills reporting requirements for creek status monitoring specified in provisions C.8.d and C.8.g of the Municipal Regional Permit (MRP) for urban stormwater issued by the San Francisco Bay Regional Water Quality Control Board (SFRWQCB; Order No. R2-2015-0049) and the East Contra Costa County Municipal NPDES Permit (Central Valley Permit) issued by the Central Valley Regional Water Quality Control Board (CVRWQCB; Order No. R5-2010-0102).

Other creek status monitoring parameters were addressed using a targeted design, with regional coordination and common methodologies. The local/targeted parameters are reported in Appendix 2 of the CCCWP WY 2016 UCMR (ADH, 2017).

During WY 2016, 10 sites were monitored by CCCWP under the regional/probabilistic design for bioassessment, physical habitat, and related water chemistry parameters. One of the 10 sites was monitored for water and sediment toxicity, while two of the 10 sites were monitored for sediment chemistry.

The bioassessment and related data are used to develop a preliminary conditional assessment for the monitored sites, to be used in conjunction with the stressor assessment based on sediment chemistry and toxicity. The water and sediment chemistry and toxicity data are used to evaluate potential stressors which may affect aquatic habitat quality and beneficial uses. The probabilistic design requires several years to produce sufficient data to develop a statistically robust characterization of regional creek conditions, so the analysis and interpretation to be completed with the initial years of data collection are necessarily limited.

California Stream Condition Index (CSCI) scores were calculated from the CCCWP bioassessment data for the first time in WY 2016. The CSCI uses location-specific geographic information system (GIS) data to compare the observed bentho macroinvertebrate (BMI) taxonomic data to expected BMI assemblage characteristics from reference sites with similar geographical characteristics. All calculated CSCI scores were below the MRP 2 threshold of 0.795, indicating degraded benthic biological communities at the 10 sites monitored by CCCWP in WY 2016. Additional work will need to be completed with the CSCI scores in relation to this threshold to make a clearer assessment of relative biological conditions for these urban streams. The CSCI scores did correlate well with the Contra Costa benthic index of biological integrity (B-IBI) scores for WY 2016 data.

There was one instance of toxicity in the limited dry weather testing performed in WY 2016, in the chronic *Ceriodaphnia dubia* test for the Rimer Creek sample. This result was inconsistent with previous years in which toxicity to *Hyalella azteca* was more common.

The principal stressors identified in the chemical analyses continue to be pyrethroid pesticides in sediments. The stressor analysis is summarized as follows, based on an analysis of the regional/probabilistic data collected by CCCWP during WY 2016:

- **Physical Habitat Conditions** – Limited analysis of physical habitat assessment (PHab) metrics did not produce any significant correlations with biological condition indicators for WY 2016 data.

- **Water Quality –** Of 12 water quality parameters required in association with bioassessment monitoring, applicable water quality standards were only identified for ammonia, chloride, and nitrate + nitrite (for sites with municipal and domestic water supply [MUN] beneficial use only). None of the results generated at the 10 sites monitored by CCCWP for those three parameters during WY 2016 exceeded the applicable water quality standard or threshold.

- **Water Toxicity –** Toxicity testing was performed for four test species in water samples collected from one site (Rimer Creek, 204R01519), from one dry season sampling event in WY 2016. Only one of the tests was significantly toxic: *C. dubia* chronic (reproduction) test. In a later retest, the second sample was also toxic in the chronic test, but results did not meet the MRP threshold for followup.

- **Sediment Toxicity –** The Rimer Creek sediment sample was not toxic to either of the test species (*Hyalella azteca and Chironomus dilutus*).

- **Sediment Chemistry –** The pyrethroid pesticide bifenthrin was found in both creek sediment samples.

- **Sediment Triad Analyses –** Bioassessment, sediment toxicity, and sediment chemistry results were evaluated as the three lines of evidence used in the triad approach for assessing overall stream condition, and added to the compiled results for water years 2012-2016. Good correlation is observed in the triad samples between pyrethroid concentrations and sediment toxicity.

The chemical stressors– particularly pesticides – may be contributing to the degraded biological conditions indicated by the low B-IBI scores in many of the monitored streams.

Efforts are currently underway by the RMC to evaluate data for selection of a new set of stressor/source identification (SSID) projects for implementation during the current MRP term. CCCWP will continue to collaborate in this regional effort. Eight SSID projects are required regionally per MRP 2, if performed within a regional collaborative. CCCWP is required to perform one new SSID project during the MRP 2 permit term, per agreement within the RMC; this project will likely not involve toxicity.

CCCWP and the other RMC participants will continue to implement the regional probabilistic monitoring design in WY 2017, under the terms of the newly-adopted MRP 2 (effective January 1, 2016). Additional data also might permit a better assessment as to the potential effects of drought and rising temperatures on urban stream quality. Wet season toxicity and chemistry monitoring will commence in WY 2018, as required by MRP 2.

Additional creek status monitoring will be undertaken in WY 2017 to further add to the data applicable to the regional/probabilistic design, along with further work regarding stressor/source investigations.

1. Introduction

Contra Costa County lies within the jurisdictions of both the San Francisco Bay Regional Water Quality Control Board (SFBRWQCB; Region 2) and the Central Valley Regional Water Quality Control Board (CVRWQCB; Region 5). Municipal stormwater discharges in Contra Costa County are regulated by the requirements of two National Pollutant Discharge Elimination System (NPDES) stormwater permits: Municipal Regional Permit (MRP) in Region 2 (Order No. R2-2015-0049[1]), and the East Contra Costa County Municipal NPDES Permit (Central Valley Permit) in Region 5 (Order No. R5-2010-0102[2]).

CCCWP conducted extensive bioassessment monitoring prior to MRP 1. Summaries of the findings can be found in *Preliminary Assessment of Aquatic Life Use Condition in Contra Costa Creeks, Summary of Benthic Macroinvertebrate Bioassessment Results (2001-2006)* (CCCWP, 2007), and *Contra Costa Monitoring and Assessment Program, Summary of Benthic Macroinvertebrate Bioassessment Results (2011)* (Ruby, 2012).

Prior to the reissuance of the MRP in 2015, the requirements of the two permits were effectively identical. With the reissued MRP, there are some differences between the permits, though in most respects the creek status monitoring and reporting requirements remain similar. Until the Central Valley Permit is reissued, the creek status monitoring and reporting requirements specified in the reissued MRP are considered the prevailing requirements. Sites in the Central Valley Region will be sampled when they come up as part of the RMC probablistic design.

This report is a component of the Urban Creeks Monitoring Report (UCMR) for WY 2016 (October 1, 2015-September 30, 2016), covering creek status monitoring conducted under a regional probabilistic design. Together with the creek status monitoring data reported in the Local/Targeted Creek Status Monitoring Report (ADH, 2017), this submittal fulfills reporting requirements for creek status monitoring performed per the requirements of provisions C.8.d and C.8.g of the MRP, as well as complementary requirements in the Central Valley Permit.

The regional probabilistic design was developed and implemented by the Regional Monitoring Coalition (RMC) of the Bay Area Stormwater Management Agencies Association (BASMAA). This monitoring design allows each RMC participating program to 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 conditions in the creeks of the San Francisco Bay Area.

The RMC was formed in early 2010 as a collaboration among several BASMAA members and all MRP permittees (Table 1.1) to collaboratively implement the creek status monitoring requirements of the MRP through a regionally-coordinated effort.

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[1] The San Francisco Bay Regional Water Quality Control Board (SFBRWQCB) adopted the reissued Municipal Regional Stormwater NPDES Permit (MRP, Order No. R2-2015-0049) to 76 cities, counties and flood control districts (i.e., permittees) in the Bay Area on November 19, 2015 (SFBRWQCB, 2015), effective January 1, 2016. The BASMAA programs supporting MRP regional projects include all MRP permittees, plus the eastern Contra Costa County cities of Antioch, Brentwood, and Oakley, which have voluntarily elected to participate in the RMC. The RMC regional monitoring design was expanded to include the eastern portion of eastern Contra Costa County which is within the Central Valley Region (Region 5) to assist CCCWP in fulfilling parallel provisions in the Central Valley Permit.

[2] The Central Valley Regional Water Quality Control Board (CVRWQCB) issued the East Contra Costa County Municipal NPDES Permit (Central Valley Permit, Order No. R5-2010-0102) on September 23, 2010 (CVRWQCB 2010).

The RMC Work Group is a subgroup of the BASMAA Monitoring and Pollutants of Concern Committee (MPC) which meets and communicates regularly to coordinate planning and implementation of monitoring-related activities. The RMC Work Group meetings are coordinated by a RMC coordinator funded by the participating county stormwater programs. This work group includes staff from the SFBRWQCB at two levels – those generally engaged with the MRP, as well as those working regionally with the State of California's Surface Water Ambient Monitoring Program (SWAMP). Through the RMC Work Group, the BASMAA RMC developed a quality assurance project plan (QAPP; BASMAA, 2016a), standard operating procedures (SOPs; BASMAA, 2016b), data management tools, and reporting templates and guidelines. Costs for these activities are shared among RMC members.

Table 1.1. Regional Monitoring Coalition Participants

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

The goals of the RMC are to:

- Assist RMC permittees in complying with requirements in MRP provision C.8 (water quality monitoring);
- Develop and implement regionally consistent creek monitoring approaches and designs in the San Francisco Bay Area through improved coordination among RMC participants and other agencies sharing common goals (e.g., regional water quality control boards, Regions 2 and 5, and SWAMP); and
- Stabilize the costs of creek monitoring by reducing duplication of effort and streamlining monitoring and reporting.

The RMC divided the creek status monitoring requirements required by MRP provisions C.8.d and C.8.g into those parameters which could reasonably be included within a regional/probabilistic design, and those which, for logistical and jurisdictional reasons, should be implemented locally using a targeted (non-probabilistic) design. The monitoring elements included in each category are specified in Table 1.2. Creek status monitoring data collected by CCCWP at local/targeted sites (not included in the regional probabilistic design) are reported separately in Appendix 2 of the CCCWP WY 2016 UCMR.

The remainder of this report addresses study area and monitoring design (Section 2.0), data collection and analysis methods (Section 3.0), results and data interpretation (Section 4.0), and conclusions and next steps (Section 5.0). Additional information on other aspects of permit-required monitoring is found in other appendices and the main CCCWP WY 2016 UCMR.

Table 1.2 Creek Status Monitoring Parameters Sampled in Compliance with MRP Provisions C.8.d and C.8.g as Either Regional/Probabilistic or Local/Targeted Parameters

Bioassessment, physical habitat assessment, CSCI	X	
Nutrients (and other water chemistry associated with bioassessment)	X	
Chlorine	X	
Water toxicity (wet and dry weather)	X	
Water chemistry (pesticides, wet weather) *	X	
Sediment toxicity	X	
Sediment chemistry	X	
General water quality (sonde data: temperature, dissolved oxygen, pH, specific conductivity)		X
Temperature (HOBO data loggers)		X
Bacteria		X

* Per RMC decision, with Water Board staff concurrence, in accordance with MRP provision C.8.g.iii.(3), this monitoring will commence in WY 2018.

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2. Study Area and Monitoring Design

2.1 Regional Monitoring Coalition Area

For the purposes of the regional probabilistic monitoring design, the study area is equal to the RMC area, encompassing the political boundaries of the five RMC participating counties, including the eastern portion of Contra Costa County which drains to the Central Valley region. A map of the BASMAA RMC area, equivalent to the area covered by the regional probabilistic design sample frame, is shown in Figure 2.1.

2.2 Regional Monitoring Design

In 2011, the RMC developed a regional probabilistic monitoring design to identify ambient conditions of creeks in the five main counties subject to the requirements of the MRP. The regional design was developed using the Generalized Random Tessellation Stratified (GRTS) approach developed by the U.S. Environmental Protection Agency (EPA) and Oregon State University (Stevens and Olson, 2004). The GRTS approach was implemented in California by several agencies, including the statewide perennial streams assessment (PSA) conducted by SWAMP (Ode et al., 2011) and the Southern California Stormwater Monitoring Coalition’s (SMC’s) regional monitoring (SMC, 2007). The RMC area is considered to define the sample frame and represent the sample universe.

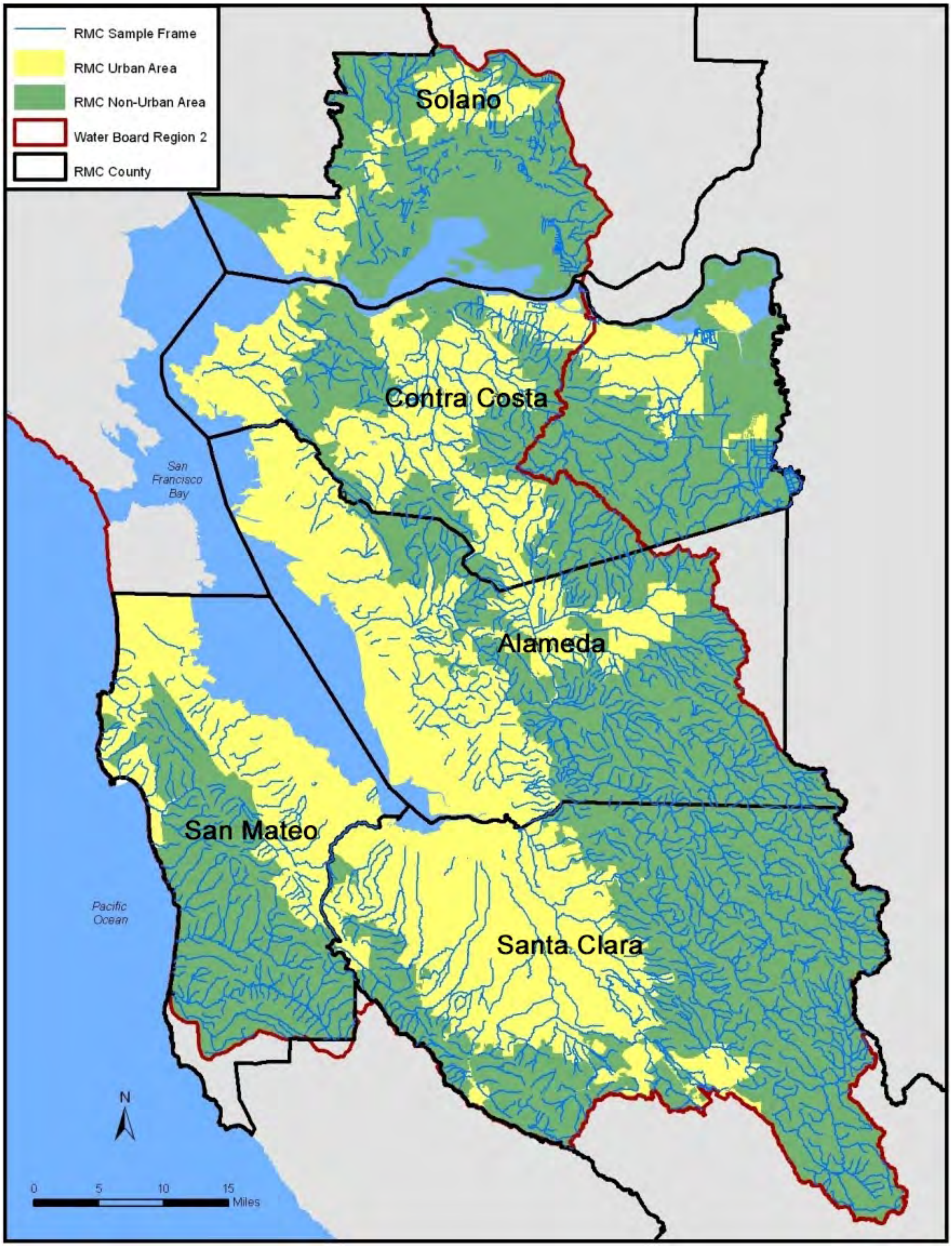
2.2.1 Management Questions

The RMC regional monitoring probabilistic design was developed to address the following management questions:

1. What is the condition of aquatic life in creeks in the RMC area; are water quality objectives met and are beneficial uses supported?
    a. 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?
    b. What is the condition of aquatic life in RMC participant counties; are water quality objectives met and are beneficial uses supported?
    c. To what extent does the condition of aquatic life in urban and non-urban creeks differ in the RMC area?
    d. 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?
    a. 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 regional design involves bioassessment monitoring to address the first set of questions regarding aquatic life condition. Assemblages of freshwater organisms are commonly used to assess the biological integrity of water bodies because they provide direct measures of ecological condition (Karr and Chu, 1999).

Figure 2.1. Map of BASMAA RMC Area, County Boundaries and Major Creeks



Benthic macroinvertebrates (BMIs) are an essential link in the aquatic food web, providing food for fish and consuming algae and aquatic vegetation (Karr and Chu, 1999). The presence and distribution of BMIs can vary across geographic locations based on elevation, creek gradient, and substrate (Barbour et al., 1999). These organisms are sensitive to disturbances in water and sediment chemistry, as well as physical habitat, both in the stream channel and along the riparian zone. Due to their relatively long life cycles (approximately one year) and limited migration, BMIs are particularly susceptible to site-specific stressors (Barbour et al., 1999). Algae also are increasingly used as indicators of water quality, as they form the autotrophic base of aquatic food webs and exhibit relatively short life cycles which respond quickly to chemical and physical changes. Diatoms are found to be particularly useful for interpreting some causes of environmental degradation (Hill et al., 2000); therefore, both BMI and algae taxonomic data are therefore sed in the aquatic life assessments.

Additional water quality parameters, including water and sediment toxicity testing and chemical analysis, are then used along with physical habitat characteristics to assess potential stressors to aquatic life.

Table 2.1 shows conservative estimates of the expected cumulative progress toward establishing statistically representative sample sizes (estimated to be achieved at approximately n≥30) for each of the classified strata in the regional monitoring design, based on early planning efforts. As of WY 2016, four of the five RMC participating counties achieved the cumulative sample numbers required for such statistical analysis.

Table 2.1. Cumulative Numbers of Planned Bioassessment Samples Per Monitoring Year

Monitoring Year	Totals for RMC Area (Region-wide)		Santa Clara County		Alameda County		Contra Costa County		San Mateo County		Fairfield, Suisun City, and Vallejo	
Land Use	*Urban*	*Non-Urban*	*Urban*	*Non-Urban*	*Urban*	*Non-Urban*	*Urban*	*Non-Urban*	*Urban*	*Non-Urban*	*Urban*	*Non-Urban*
Year 1 (WY 2012)	48	22	16	6	16	6	8	4	8	4	0	2
Year 2 (WY 2013)	100	44	32	12	32	12	16	8	16	8	8	0
Year 3 (WY 2014)	156	66	48	18	48	18	24	12	24	12	12	6
Year 4 (WY 2015)	204	88	64	24	64	24	32	16	32	16	12	8
Year 5 (WY 2016)	256	110	80	30	80	30	40	20	40	20	16	10

Shaded cells indicate when a minimum sample size (estimated to be n≥30) may be available to develop a statistically representative data set to address management questions related to condition of aquatic life for the strata included within the regional probabilistic design.
Non-urban site tallies assume SFBRWQCB/SWAMP personnel will monitor an average of two non-urban sites annually in each RMC county.

2.2.2 Site Selection

Status and trends monitoring was conducted in non-tidally influenced, flowing water bodies (i.e., creeks, streams and rivers). The water bodies monitored were drawn from a master list which included all perennial and non-perennial creeks and rivers running through urban and non-urban areas within the portions of the RMC area. Sample sites were selected and attributed using the GRTS approach from a sample frame consisting of a creek network GIS data set within the RMC boundary (BASMAA, 2011), within five management units which represent the five participating RMC counties. The National

Hydrography Dataset Plus (1:100,000) was selected as the creek network data layer to provide consistency with both the statewide PSA and the SMC, and the opportunity for future data coordination with these programs.

The RMC sample frame was classified by county and land use (i.e., urban and non-urban) to allow for comparisons within those strata. Urban areas were delineated by combining urban area boundaries and city boundaries defined by the U.S. Census Bureau (2000). Non-urban areas were defined as the remainder of the areas within the sample universe (RMC area). Based on discussion during RMC meetings, with SFBRWQCB staff present, RMC participants weight their sampling to ensure at least 80 percent of annually monitored sites are in urban areas and not more than 20 percent in non-urban areas. RMC participants coordinated with SWAMP/RWQCB staff by identifying additional non-urban sites from their respective counties for SWAMP monitoring. For Contra Costa County, SWAMP monitoring included non-urban bioassessment sites chosen from the probabilistic sample drawn in the Region 2 (San Francisco Bay) area of Contra Costa County, with the regional focus varying annually.

2.3 Monitoring Design Implementation

The numbers of probabilistic sites monitored annually in WY 2012-2016 by CCCWP are shown by land use category in Table 2.2. This tally includes non-urban sites monitored by SWAMP personnel.

Table 2.2. Number of Urban and Non-Urban Bioassessment Sites Sampled By CCCWP and SWAMP in Contra Costa County During Water Years 2012-2016

	Contra Costa County	
	Land Use	
Monitoring Year	Urban Sites	Non-Urban Sites[1]
WY 2012	8	2/2
WY 2013	10	0/3
WY 2014	10	0/1
WY 2015	10	0/1
WY 2016	10	0/0
Total	48	9

[1] Non-urban sites are shown as sampled by CCCWP/SWAMP for each year; total represents combined non-urban sites

3. Monitoring Methods

3.1 Site Evaluation

Sites identified in the regional sample draw were evaluated by each RMC participant in chronological order using a two-step process, consistent with Southern California Coastal Water Research Project (SCCWRP, 2012)[3]. Each site was evaluated to determine if it met the following RMC sampling location criteria:

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

In the first step, these criteria were evaluated to the extent possible using desktop analysis.

For sites which successfully passed the initial desktop analysis, site evaluations were completed during the second step via field reconnaissance visits. Based on the outcome of the site evaluations, sites were classified into one of four categories:

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

The outcomes of these site evaluations for CCCWP sites for WY 2016 are illustrated in Figure 3.1. A relatively small fraction of sites evaluated each year are classified as target sampleable sites.

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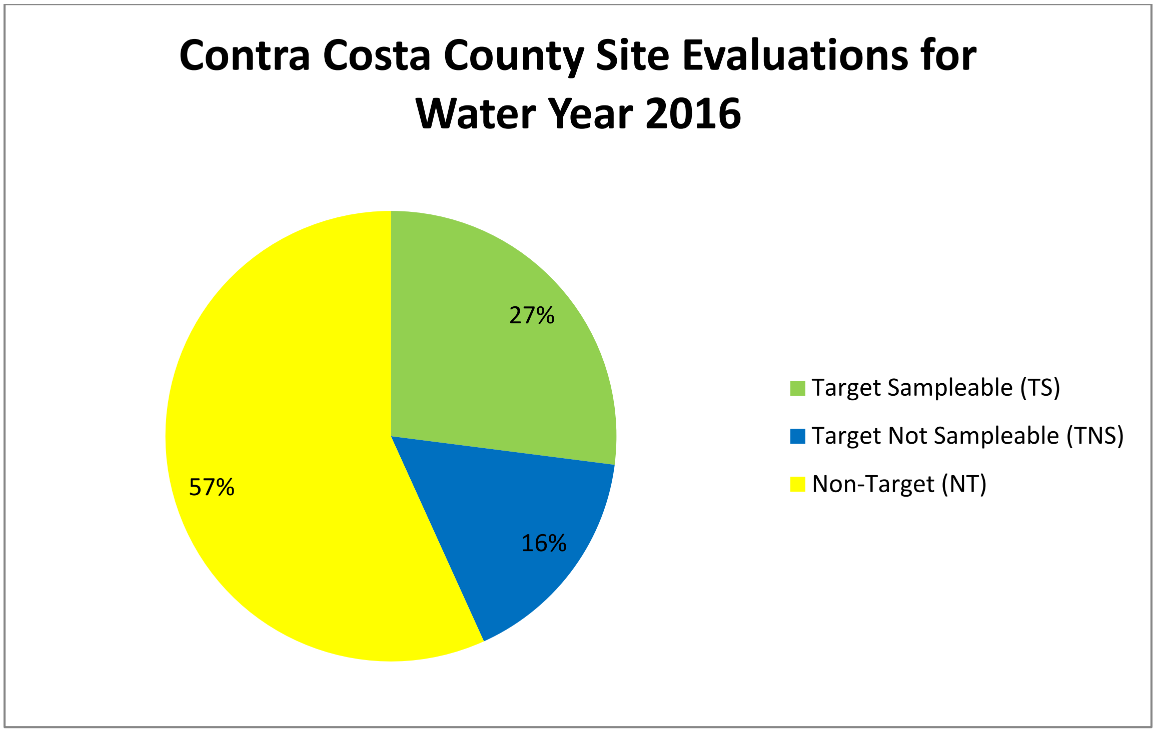
[3] Communication with managers for SMC and PSA are ongoing to ensure the consistency of site evaluation protocols.

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

Figure 3.1. Results of CCCWP Site Evaluations for WY 2016



During the site evaluation field visits, flow status was recorded as one of five categories:

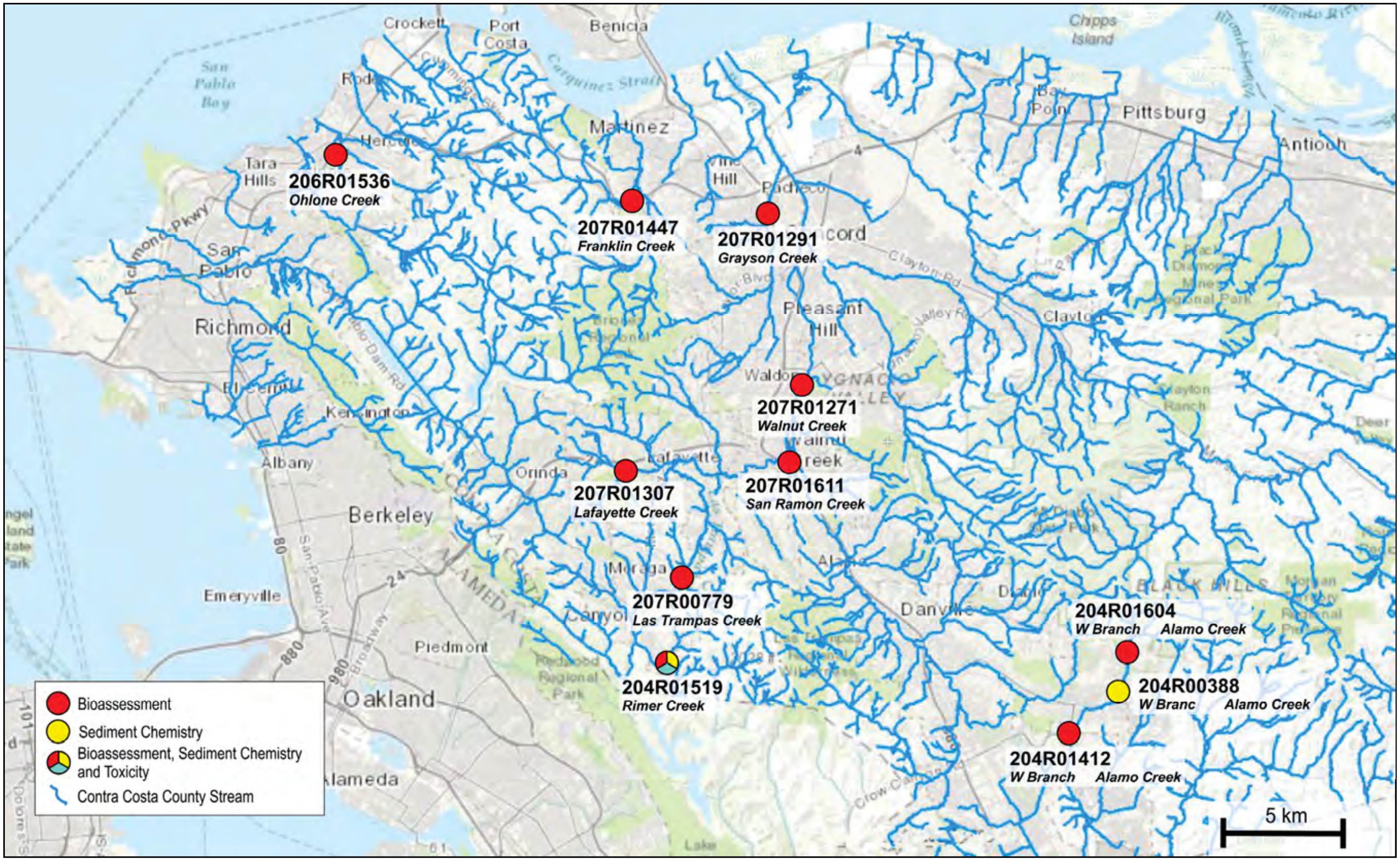
- Wet Flowing (continuously wet or nearly so; flowing water)
- Wet Trickle (continuously wet or nearly so; very low flow; trickle less than 0.1 L/second)
- Majority Wet (discontinuously wet; greater than 25 percent by length of stream bed covered with water; isolated pools)
- Minority Wet (discontinuously wet; less than 25 percent of stream bed by length covered with water; isolated pools)
- No Water (no surface water present)

Observations of flow status during pre-wet-weather, fall site reconnaissance events and during post-wet-weather, spring sampling were combined to classify sites as perennial or nonperennial as follows:

- **Perennial:** Fall flow status is either Wet Flowing or Wet Trickle, and spring flow is sufficient to sample.
- **Non-Perennial:** Fall flow status is Majority Wet, Minority Wet, or No Water, and spring flow is sufficient to sample.

The probabilistic sites selected for monitoring in WY 2016, following site evaluation, are shown graphically in Figure 3.2 as the bioassessment sites, and are listed with additional site information in Table 3.1. As indicated in Table 3.1, of the 10 bioassessment monitoring sites in WY 2016, the selected site for dry weather water toxicity, sediment toxicity and sediment chemistry testing was Rimer Creek (204R01519). A site on West Branch Alamo Creek also was tested for sediment chemistry.

Figure 3.2. Contra Costa County Creek Status Sites Monitored in WY 2016



Note: Bioassessment sites are those selected from the RMC Probabilistic Monitoring Design.

Table 3.1. Site Locations, Monitoring Parameters and Dates Sampled at CCCWP Sites from the RMC Probabilistic Monitoring Design in WY 2016

Site ID	Creek Name	Land Use	Latitude	Longitude	Bioassessment, PHab, Chlorine, Nutrients	Water Toxicity (Dry Weather)	Sediment Toxicity and Chemistry (Dry Weather)
204R00388	West Branch Alamo Creek[1]	Urban	37.80526	-121.89915			07/11/16[2]
204R01412	West Branch Alamo Creek	Urban	37.78737	-122.92374	05/09/16		
204R01519	Rimer Creek	Urban	37.81951	-122.11655	04/28/16	07/11/16[3]	07/11/16
204R01604	West Branch Alamo Creek	Urban	37.81911	-121.89583	04/26/16		
206R01536	Ohlone Creek	Urban	38.00738	-122.27424	04/27/16		
207R00779	Las Trampas Creek	Urban	37.84714	-122.10892	05/10/16		
207R01271	Walnut Creek	Urban	37.92031	-122.05124	05/11/16		
207R01291	Grayson Creek	Urban	37.98503	-122.06891	05/11/16		
207R01307	Lafayette Creek	Urban	37.88612	-122.13754	04/28/16		
207R01447	Franklin Creek	Urban	37.99012	-122.13346	05/12/16		
207R01611	San Ramon Creek	Urban	37.89093	-122.05594	05/10/16		

[1] 2015 probabilistic site
[2] Sediment chemistry only
[3] Site was resampled for limited toxicity retesting on 08/15/16
Note: No East County/Region 5 sites were monitored in WY 2016

3.2 Field Sampling and Data Collection Methods

Field data and samples were collected in accordance with existing SWAMP-comparable methods and procedures, as described in the RMC QAPP (BASMAA, 2016a) and the associated SOPs (BASMAA, 2016b). The SOPs were developed using a standard format describing health and safety cautions and considerations, relevant training, site selection, and sampling methods/procedures. Sampling methods/ procedures include pre-fieldwork mobilization activities to prepare equipment, sample collection, and demobilization activities to preserve and transport samples, as well as to avoid transporting invasive species between creeks. The SOPs relevant to the monitoring discussed in this report are listed in Table 3.2.

Procedures for sample container size and type, preservative type, and associated holding times for each regional/probabilistic analyte are described in RMC SOP FS-9 (BASMAA, 2016b). Procedures for completion of field data sheets are provided in RMC SOP FS-10, and procedures for sample bottle labeling are described in RMC SOP FS-11 (BASMAA, 2016b).

Table 3.2. RMC Standard Operating Procedures Pertaining to Regional Creek Status Monitoring

SOP #	Procedure
FS-1	BMI and algae bioassessments and physical habitat assessments
FS-2	Water quality sampling for chemical analysis, pathogen indicators, and toxicity testing
FS-3	Field measurements, manual
FS-6	Collection of bedded sediment samples
FS-7	Field equipment cleaning procedures
FS-8	Field equipment decontamination procedures
FS-9	Sample container, handling, and chain-of-custody procedures
FS-10	Completion and processing of field data sheets
FS-11	Site and sample naming convention
FS-12	Ambient creek status monitoring site evaluation
FS-13	QA/QC data review

3.2.1 Bioassessments

In accordance with the RMC QAPP (BASMAA, 2016a), bioassessments were conducted during the spring index period (approximately April 15 to July 15) and at a minimum of 30 days after any significant storm (roughly defined as at least 0.5 inch of rainfall within a 24-hour period).

Each bioassessment monitoring site consisted of an approximately 150m stream reach divided into 11 equidistant transects placed perpendicular to the direction of flow. The sampling position within each transect alternated between 25, 50 and 75 percent distance of the wetted width of the stream (see SOP FS-1, BASMAA, 2016b).

3.2.1.1 Benthic Macroinvertebrates (BMI)

BMIs were collected via kick net sampling using the reach-wide benthos (RWB) method described in RMC SOP FS-1 (BASMAA, 2016b), based on the SWAMP bioassessment procedures (Ode et al., 2016a and 2016b). Samples were collected from a 1-square-foot area approximately 1 m downstream of each transect. The benthos was disturbed by manually rubbing areas of coarse substrate, followed by disturbing the upper layers of finer substrate to a depth of 4 to 6 inches to dislodge any remaining invertebrates into the net. Slack water habitat procedures were used at transects with deep and/or slow-moving water. Material collected from the 11 subsamples was composited in the field by transferring the entire sample into one to two 1,000mL wide-mouth jar(s), and the samples were preserved with 95 percent ethanol.

3.2.1.2 Algae

Filamentous algae and diatoms also were collected using the RWB method described in SOP FS-1 (BASMAA, 2016b), based on the SWAMP bioassessment procedures (Ode et al., 2016a and 2016b). Algae samples were collected synoptically with BMI samples. The sampling position within each transect was the same as used for BMI sampling, except algae samples were collected 6 inches upstream of the BMI sampling position and following BMI collection from that location. The algae were collected using a range of methods and equipment, depending on the substrate occurring at the site (e.g., erosional, depositional, large and/or immobile) per RMC SOP FS-1. Erosional substrates included any material (substrate or organics) small enough to be removed from the stream bed, but large enough to isolate an area equal to a rubber delimiter (12.6 cm^2 in area).

When a sample location along a transect was too deep to sample, a more suitable location was selected, either on the same transect or from one further upstream. Algae samples were collected at each transect prior to moving on to the next transect. Sample material (substrate and water) from all 11 transects was combined in a sample bucket, agitated, and a suspended algae sample was then poured into a 500mL cylinder, creating a composite sample for the site. A 45mL subsample was taken from the algae composite sample and combined with 5mL glutaraldehyde into a 50mL sample tube for taxonomic identification of soft algae. Similarly, a 40mL subsample was taken from the algae composite sample and combined with 10mL of 10 percent formalin into a 50mL sample tube for taxonomic identification of diatoms.

The algae composite sample also was used for collection of chlorophyll-*a* and ash-free dry mass (AFDM) samples following methods described in Fetscher et al. (2009). For the chlorophyll-*a* sample, 25mL of the algae composite volume was removed and run through a glass fiber filter (47 mm, 0.7 µm pore size) using a filtering tower apparatus in the field. The AFDM sample was collected using a similar process which employs pre-combusted filters. Both filter samples were placed in Whirl-Pak® bags, covered in aluminum foil, and immediately placed on ice for transport to the analytical laboratory.

3.2.1.3 Physical Habitat (PHab)

PHab assessments were conducted during each BMI bioassessment monitoring event using the SWAMP PHab protocols (Ode et al., 2016a and 2016b) and RMC SOP FS-1 (BASMAA, 2016b). PHab data were collected at each of the 11 transects and 10 additional inter-transects (located between each main transect) by implementing the “Full” SWAMP level of effort (as prescribed in the MRP). At algae sampling locations, additional assessment of the presence of micro- and macroalgae was conducted during the pebble counts. In addition, water velocities were measured per SWAMP protocols at a single location in the sample reach (when possible).

3.2.2 Physicochemical Measurements

Dissolved oxygen, temperature, conductivity, and pH were measured during bioassessment monitoring using a multi-parameter probe (see SOP FS-3, BASMAA, 2016b). Dissolved oxygen, specific conductivity, water temperature, and pH measurements were made either by direct submersion of the instrument probe into the sample stream or by collection and immediate analysis of grab sample in the field. Water quality measurements were taken approximately 0.1m below the water surface at locations of the stream appearing to be completely mixed, ideally at the centroid of the stream. Measurements should occur upstream of sampling personnel and equipment and upstream of areas where bed sediments have been disturbed, or prior to such bed disturbance.

3.2.3 Chlorine

Water samples were collected and analyzed for free and total chlorine using CHEMetrics test kits (K-2511 for low range and K-2504 for high range). Chlorine measurements in water were conducted during bioassessment monitoring and again during dry season monitoring for sediment chemistry, sediment toxicity, and water toxicity.

3.2.4 Nutrients and Conventional Analytes (Water Chemistry)

Water samples were collected for nutrient analyses using the standard grab sample collection method, as described in SOP FS-2 (BASMAA, 2016b) and associated with bioassessment monitoring. Sample containers were rinsed, as appropriate, using ambient water and filled and recapped below water surface whenever possible. An intermediate container was used to collect water for all sample containers with preservative already added in advance by the laboratory. Sample container size and type, preservative type and associated holding times for each analyte are described in Table 1 of FS-9 (BASMAA, 2016b). Syringe filtration method was used to collect samples for analyses of dissolved orthophosphate and dissolved organic carbon. All sample containers were labeled and stored on ice for transport to the analytical laboratory, except for analysis of AFDM and chlorophyll-*a* samples, which were field-frozen on dry ice by sampling teams, where appropriate.

3.2.5 Water Toxicity

Samples were collected using the standard grab sample collection method described above, filling the required number of labeled 2.25-liter amber glass bottles with ambient water, putting them on ice to cool to 4°C ± 2°C, and delivered to the laboratory within the required hold time. The laboratory was notified of the impending sample delivery to help ensure meeting the 24-hour sample delivery time requirement. Procedures used for sample collection and transport are described in SOP FS-2 (BASMAA, 2016b).

3.2.6 Sediment Chemistry and Sediment Toxicity

In the case where sediment samples and water samples/measurements were collected at the same event, sediment samples were collected after water samples were collected. Before conducting sampling, field personnel surveyed the proposed sampling area to identify appropriate fine-sediment depositional areas to avoid disturbing possible sediment collection sub-sites. Personnel carefully entered the stream and began sampling at the closest appropriate reach, continuing upstream. Sediment samples were collected from the top 2 cm of sediment in a compositing container, thoroughly homogenized, and then aliquotted into separate jars for chemical and toxicological analysis using standard clean sampling techniques (see SOP FS-6, BASMAA, 2016b). Sample jars were submitted to the respective laboratories per SOP FS-9 (BASMAA, 2016b).

3.3 Laboratory Analysis Methods

RMC participants agreed to use the same set of analytical laboratories for regional/probabilistic parameters, developed standards for contracting with the labs, and coordinated quality assurance issues. All samples collected by RMC participants sent to laboratories for analysis were analyzed and reported per SWAMP-comparable methods, as described in the RMC QAPP (BASMAA, 2016a). The following analytical laboratory contractors were used for chemical and toxicological analysis:

- **BioAssessment Services, Inc. – BMI taxonomic identification**

  The laboratory performed taxonomic identification nominally on a minimum of 600 BMI individuals for each sample, per standard taxonomic effort Level 1, as established by the Southwest Association of Freshwater Invertebrate Taxonomists, with additional identification of Chironomids to subfamily/tribe level (corresponding to a Level 1a STE).

- **EcoAnalysts, Inc. – Algae taxonomic identification**

  Samples were processed in the laboratory following draft SWAMP protocols to provide count (diatom and soft algae), biovolume (soft algae), and presence (diatom and soft algae) data. Laboratory processing included identification and enumeration of 300 natural units of soft algae and 600 diatom valves to the lowest practical taxonomic level. Diatom and soft algae identifications were not fully harmonized with the California Algae and Diatom Taxonomic Working Group's Master Taxa List, and 12 taxa were not included in the data analysis.

- **Caltest Analytical Laboratory, Inc. – Water chemistry (nutrients, etc.), sediment chemistry, chlorophyll-*a*, AFDM**

  Upon receipt at the laboratory, samples were immediately logged and preserved as necessary. EPA-approved testing protocols were then applied for analysis of water and sediment samples.

- **Pacific EcoRisk, Inc. – Water and sediment toxicity**

  Testing of water and sediment samples was performed per species-specific protocols published by EPA.

3.4 Data Analysis

Only data collected by CCCWP during WY 2016 for regional/probabilistic parameters are presented and analyzed in this report. This includes data collected during bioassessment monitoring, including BMI and algae taxonomy, water chemistry, and physical habitat evaluations at 10 sites, as well as water and sediment toxicity and sediment chemistry data from one of those 10 sites. The bioassessment data are used to evaluate stream conditions, and the associated physical, chemical and toxicity testing data are then analyzed to identify potential stressors which may impact water quality and biological conditions. As the cumulative RMC sample sizes increase through monitoring conducted in future years, it will be possible to develop a statistically representative data set for the RMC region to address management questions related to condition of aquatic life.

Creek status monitoring data generated by CCCWP for local/targeted parameters (not included in the probabilistic design), per MRP provision C.8.d, are reported in the Local/Targeted Creek Status Monitoring Report, found in Appendix 2 of the CCCWP WY 2016 UCMR (ADH, 2017).

The creek status monitoring results are subject to potential follow-up actions, per MRP 2 provisions C.8.d and C.8.g, if they meet certain specified threshold triggers, as shown in Table 3.3 for the regional/probabilistic parameters. If monitoring results meet the requirements for follow-up actions as shown in Table 3.3, the results are compiled on a list for consideration as potential SSID projects, per MRP provision C.8.e in Appendix 3 of the CCCWP WY 2016 UCMR.

As part of the stressor assessment for this report, water and sediment chemistry and toxicity data generated during WY 2016 also were analyzed and evaluated against these threshold triggers to identify potential stressors which might contribute to degraded or diminished biological conditions.

In addition to those threshold triggers for potential SSID projects, the results are compared to other regulatory standards, including Basin Plan water quality objectives, where available and applicable.

Table 3.3. Requirements for Followup for Regional/Probabilistic Creek Status Monitoring Results per MRP Provisions C.8.d and C.8.g

Constituent	Threshold Trigger Level	MRP 2 Provision	Provision Text
CSCI Score	< 0.795 (plus see provision text =>)	C.8.d.i.(8)	Sites scoring less than 0.795 per CSCI are appropriate for a SSID project, as defined in provision C.8.e. Such a score indicates a substantially degraded biological community relative to reference conditions. Sites where there is a substantial difference in CSCI score observed at a location relative to upstream or downstream sites are also appropriate for a SSID project. If many samples show a degraded biological condition, sites where water quality is most likely to cause and contribute to this degradation may be prioritized by the permittee for a SSID project.
Chlorine	> 0.1 mg/L	C.8.d.ii.(4)	The permittees shall immediately resample if the chlorine concentration is greater than 0.1 mg/L. If the resample is still greater than 0.1 mg/L, then permittees shall report the observation to the appropriate permittee central contact point for illicit discharges so 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.
Toxicity	TST "fail" on initial and follow-up sample test; both results have > 50% effect	C.8.g.iv	The permittees shall identify a site as a candidate SSID project when analytical results indicate any of the following: A toxicity test of growth, reproduction, or survival of any test organism is reported as “fail” in both the initial sampling and a second, followup sampling, and both have ≥ 50 percent effect. Note: Applies to dry and wet weather, water column and sediment tests.
Pesticides (Water)[1]	> Basin Plan WQO	C.8.g.iv	The permittees shall identify a site as a candidate SSID project when analytical results indicate a pollutant is present at a concentration exceeding its water quality objective in the Basin Plan.
Pesticides and Other Pollutants (Sediment)	Result exceeds PCE or TCE (per MacDonald et al., 2000)	C.8.g.iv	The permittees shall identify a site as a candidate SSID project when analytical results indicate any of the following: (1) A pollutant is present at a concentration exceeding its water quality objective in the Basin Plan; (2) for pollutants without WQOs, results exceed Probable Effects Concentrations or Threshold Effects Concentrations.

Note: Per MRP provision C.8.d. and C.8.g., these are the data thresholds which trigger listings as candidate SSID projects per MRP provision. C.8.e.

[1] Per RMC decision, with Water Board staff concurrence, in accord with MRP provision C.8.g.iii.(3), this monitoring will commence in WY 2018.

TEC = threshold effects concentrations

PEC = probable effects concentrations

3.4.1 Biological Data

In this report the biological condition of each probabilistic site monitored by CCCWP in WY 2016 was evaluated principally through analysis of BMI and algal taxonomic metrics, and calculation of associated index of biological integrity (IBI) scores. An IBI is an analytical tool involving calculation of a site condition score based on a compendium of biological metrics.

3.4.1.1 Benthic Macroinvertebrate Data Analysis

Under MRP 2, the BMI taxonomic data are evaluated principally through calculation of the CSCI, a recently-developed bioassessment index (Rehn et al., 2016; Mazor et al., 2016). The CSCI scores evaluate stream health based on comparison of the observed BMI taxonomy, as reported by the lab, versus the expected BMI community characteristics that would, in theory, be present in a reference stream with similar geographic characteristics as the monitored stream, based on a specific set of watershed parameters.

The CSCI score is computed as the average of two other indices: O/E, the observed taxonomic diversity at the monitoring site divided by the taxonomic composition expected at a reference site with similar geographical charateristics, and MMI, a multi-metric index incorporating several metrics reflective of BMI community attributes, such as measures of assemblage richness, composition, and diversity, as predicted for a site with similar physical characteristics. The six metrics selected for inclusion in the MMI calculations were taxonomic richness, number of shredder taxa, percent clinger taxa, percent Coleoptera taxa, percent EPT (Ephemeroptera, Plecopter, and Trichoptera) taxa, and percent intolerant taxa (Rehn et al., 2016).

CSCI scores run from a minimum of 0 (indicating no correspondence to modeled reference site conditions) to a maximum of 1 (perfect correspondence with modeled reference site conditions). A CSCI score below 0.795 indicates biological degradation and a potential candidate site for an SSID project, per MRP 2. This index produces conservative values relative to urban creeks.

Prior to the adoption of the first MRP, work was initiated on a San Francisco Bay Region B-IBI in a collaborative effort by BASMAA participants and others, and the results were provisionally tested in Contra Costa (CCCWP, 2007) and Santa Clara (SCVURPPP, 2007) Counties. The Contra Costa County version of the Bay Area B-IBI was subsequently used in analysis and reporting of BMI data over the course of several years for the annual Contra Costa Monitoring and Assessment Program (CCMAP) bioassessment monitoring (see summary, Ruby, 2012). Calculation of the preliminary Contra Costa B-IBI is also presented for CCCWP’s BMI data in this report, to allow for comparisons with the historical CCMAP data set. For consistency and comparison with the 2012 regional UCMR, subsequent UCMRs, and other RMC programs, the Southern California B-IBI score (per Ode et al., 2005) is also computed for condition assessment in this report.

3.4.1.2 Algae Data Analysis

Algae taxonomic data are evaluated through a variety of metrics and indices. MRP 2 does not specify threshold trigger levels for algae data. Eleven diatom metrics, eleven soft algae metrics, and five algal IBIs (A-IBI; D18, H20, H21, H23 and S2) were calculated for this report following protocols developed from work in Southern California streams (Fetscher et al., 2014). These A-IBIs were not tested for Bay Area waters; however, because the Southern California A-IBI D18 (per Fetscher et al., 2014) relies only on diatoms and is thought to be more transferable to other areas of the state (Marco Sigala, personal communication), it was determined the D-18 A-IBI could be used provisionally for assessment of stream conditions for this report.

Diatom and soft algae metrics fall into five categories:

- Tolerance/Sensitivity (association with specific water-quality consituents like nutrients; tolerance to low dissolved oxygen; tolerance to high-ionic-strength/saline waters),
- Autoecological Guild (nitrogen fixers; saprobic/heterotrophic taxa),
- Morphological Guild (sedimentation indicators; motility)
- Taxonomic Groups (Chlorophyta, Rhodophyta, Zygnemataceae, heterocystous cyanobacteria)
- Relationship to Reference sites

IBI scoring ranges and values were provided by Dr. A. Elizabeth Fetscher (Marco Sigala, personal communication). After each metric was scored, values were summed and then converted to a 100-point scale by multiplying the sum by the number of metrics (e.g., sum x (100/50) if five metrics included in the IBI).

3.4.2 Physical Habitat Condition

Physical habitat condition was assessed for the bioassessment monitoring sites using “mini-PHab” scores. Mini-PHab scores range from 0 to 60, representing a combined score of three physical habitat sub-categories (epifaunal substrate/cover, sediment deposition, and channel alteration), each of which can be scored on a range of 0 to 20 points. Higher PHab scores reflect higher quality habitat. Numerous additional PHab endpoints can also be calculated. Further analyses of various PHab endpoints are possible and will be considered in future reports, as the science becomes further developed.

3.4.3 Water and Sediment Chemistry and Toxicity

As part of the stressor assessment for this report, water and sediment chemistry and toxicity data generated during WY 2016 were analyzed and evaluated to identify potential stressors that may be contributing to degraded or diminished biological conditions. The threshold triggers for chlorine and toxicity were modified slightly in MRP 2, as shown in Table 3.3, but the evaluative approach is like that used in MRP 1. Water chemistry results were evaluated with respect to applicable water quality objectives, where feasible.

For sediment chemistry trigger criteria, threshold effects concentrations (TECs) and probable effects concentrations (PECs) are as defined in MacDonald et al. (2000). For each constituent for which there is a published TEC or PEC value, the ratio of the measured concentration to the respective TEC or PEC value was computed as the TEC or PEC quotient, respectively. All results where a TEC quotient was equal to or greater than 1.0 were identified. For each site, the mean PEC quotient was then computed, and any sites where mean PEC quotient was equal to or greater than 0.5 were identified.

Pyrethroids toxic unit equivalents (TUs) were computed for pyrethroid pesticides in sediment, based on available literature LC50 values (LC50 is the concentration of a chemical which is lethal on average to 50 percent of test organisms). Because organic carbon mitigates the toxicity of pyrethroid pesticides in sediments, the LC50 values were derived based on organic carbon-normalized pyrethroid concentrations. Therefore, the RMC pyrethroid concentrations reported by the lab also were divided by the measured total organic carbon (TOC) concentration at each site (as a percentage), and the TOC-normalized concentrations were then used to compute TU equivalents for each pyrethroid. For each site, the TU equivalents for the individual pyrethroids were summed, and sites where the summed TU was equal to or greater than 1.0 were identified.

3.5 Quality Assurance/Quality Control

Data quality assurance and quality control procedures are described in detail in the BASMAA RMC QAPP (BASMAA, 2016a) and in RMC SOP FS13, QA/QC Data Review (BASMAA, 2016b).

Data quality objectives (DQOs) were established to ensure the data collected were of sufficient quality for the intended use. DQOs include both quantitative and qualitative assessment of the acceptability of data. The qualitative goals include representativeness and comparability. The quantitative goals include completeness, sensitivity (detection and quantitation limits), precision, accuracy, and contamination. To ensure consistent and comparable field techniques, pre-monitoring field training and *in situ* field assessments were conducted.

Data were collected per the procedures described in the relevant SOPs (BASMAA, 2016b), including appropriate documentation of data sheets and samples, and sample handling and custody. Laboratories providing analytical support to the RMC were selected based on demonstrated capability to adhere to specified protocols.

All data were thoroughly reviewed by the programs responsible for collecting them, for conformance with QAPP requirements, and review of field procedures for compliance with the methods specified in the relevant SOPs. Data review was performed per protocols defined in RMC SOP FS13, QA/QC Data Review (BASMAA, 2016b). Data quality was assessed and qualifiers were assigned as necessary in accordance with SWAMP requirements.

4. Results and Discussion

4.1 Statement of Data Quality

The RMC established a set of guidance and tools to help ensure data quality and consistency implemented through the collaborating programs. Additionally, the RMC participants continue to meet and coordinate on an ongoing basis to plan and coordinate monitoring, data management, and reporting activities, among others.

A comprehensive QA/QC program was implemented by each of the RMC programs, each of which is solely responsible for the quality of the data submitted on its behalf, covering all aspects of the regional/probabilistic monitoring. In general, QA/QC procedures were implemented as specified in the RMC QAPP (BASMAA, 2016a), and monitoring was performed per protocols specified in the RMC SOPs (BASMAA, 2016b) and in conformity with SWAMP protocols. QA/QC issues noted by the laboratories and/or RMC field crews are summarized below.

4.1.1 Bioassessment

Duplicate BMI samples were collected at West Branch Alamo Creek (204R01604). The CSCI scores produced for this duplicate set produced a relative percent difference of 21 percent, which is considered an acceptable level of variation between duplicate sets of taxonomic data.

4.1.2 Sediment Chemistry

Samples were incorrectly collected at a second dry weather site (West Branch Alamo Creek 204R00388), and analyzed for sediment chemistry parameters. No significant issues were reported with the data.

4.1.3 Water Chemistry

No significant issues were reported.

4.1.4 Sediment Toxicity

No significant issues were reported.

4.1.5 Water Toxicity

No significant issues were reported.

Pathogen-related mortality (PRM) was not observed in any samples tested for WY 2016.

4.2 Biological Condition Assessment

Biological condition assessment addresses the RMC's core management question, what is the condition of aquatic life in creeks in the RMC area and are aquatic life beneficial uses supported? The designated beneficial uses listed in the San Francisco Bay Region Basin Plan (SFBRWQCB, 2015) for RMC creeks sampled by CCCWP in WY 2016 are shown in Table 4.1.

Future reports will provide additional analysis at the countywide program and regional levels, as well as comparisons between urban and non-urban land use sites.

Table 4.1. Designated Beneficial Uses Listed in the San Francisco Bay Region Basin Plan (SFBRWQCB, 2015) for CCCWP Bioassessment Sites Monitored in WY 2016

Site ID	Water Body	Human Consumptive Uses							Aquatic Life Uses									Recreational Uses		
		AGR	MUN	FRSH	GWR	IND	PROC	COMM	SHELL	COLD	EST	MAR	MIGR	RARE	SPWN	WARM	WILD	REC-1	REC-2	NAV
204R01412	West Branch Alamo Creek				E					P			E	E	E	E	E	E	E	
204R01519	Rimer Creek[1]			E						E					E	E	E	E	E	
204R01604	West Branch Alamo Creek				E					P			E	E	E	E	E	E	E	
206R01536	Ohlone Creek[2]															E	E	E	E	
207R00779	Las Trampas Creek									E				E		E	E	E	E	
207R01271	Walnut Creek									E			E	E	E	E	E	E	E	
207R01291	Grayson Creek									E			E	E		E	E	E	E	
207R01307	Lafayette Creek									E						E	E	E	E	
207R01447	Franklin Creek									E			E	E	E	E	E	E	E	
207R01611	San Ramon Creek															E	E	E	E	

[1] Tributary to Moraga Creek; Moraga Creek beneficial use data used.
[2] Tributary to Refugio Creek; Refugio Creek beneficial use data used.
E = Existing beneficial use
P = Potential beneficial use

Notes: Per Basin Plan Ch. 2 (SFBRWQCB, 2015), beneficial uses for freshwater creeks include municipal and domestic supply (MUN), agricultural supply (AGR), industrial process supply (PRO), groundwater recharge (GWR), water contact recreation (REC1), noncontact water recreation (REC2), wildlife habitat (WILD), cold freshwater habitat (COLD), warm freshwater habitat (WARM), fish migration (MIGR), and fish spawning (SPWN). The San Francisco Bay Estuary supports estuarine habitat (EST), industrial service supply (IND), and navigation (NAV) in addition to all the uses supported by streams. Coastal waters' beneficial uses include water contact recreation (REC1); noncontact water recreation (REC2); industrial service supply (IND); navigation (NAV); marine habitat (MAR); shellfish harvesting (SHELL); ocean, commercial and sport fishing (COMM); and preservation of rare and endangered species (RARE).

4.2.1 Benthic Macroinvertebrate Metrics

BMI taxonomic metrics are shown in Table 4.2 for the CCCWP creek status sites monitored in the spring index period of WY 2016. For consistency with the 2012 Regional UCMR, subsequent UCMRs, and other RMC programs, the SoCal B-IBI score is included in the condition assessment analysis in this report. The preliminary Contra Costa B-IBI also is reported for purposes of comparison with the extensive historical database of bioassessment data produced by CCCWP during 2001-2011, as well as recent UCMRs. The condition category based on the Contra Costa B-IBI score is also shown for each bioassessment site at the bottom of Table 4.2.

Table 4.2. Benthic Macroinvertebrate Metrics for CCCWP Bioassessment Sites Monitored in WY 2016

Metrics	CCCWP Bioassessment Sampling Sites Spring 2016									
	204R01412	204R01519	204R01604	206R01536	207R00779	207R01271	207R01291	207R01307	207R01447	207R01611
	West Branch Alamo Creek	Rimer Creek	West Branch Alamo Creek	Ohlone Creek	Las Trampas Creek	Walnut Creek	Grayson Creek	Lafayette Creek	Franklin Creek	San Ramon Creek
Richness										
Taxonomic	17	23	19	24	33	17	21	24	17	18
EPT	1	4	1	5	8	3	3	4	2	4
Ephemeroptera	1	2	1	1	5	2	2	1	2	2
Plecoptera	0	2	0	1	3	0	0	1	0	0
Trichoptera	0	0	0	3	0	1	1	2	0	2
Coleoptera	0	0	1	1	3	0	0	2	2	0
Predator	3	9	5	8	12	4	5	9	5	4
Diptera	6	9	7	12	9	6	5	10	6	5
Composition										
EPT Index (%)	8.4	25.1	6.4	11.9	44.2	17.8	7.5	25	12	9
Sensitive EPT Index (%)	0.0	1.1	0.0	5.8	14.1	0.0	0.0	0.3	0.0	0.0
Shannon Diversity	1.9	2.0	1.8	2.1	2.7	1.9	2.1	1.9	1.8	1.7
Dominant Taxon (%)	38	25	39	39	21	36	26	31	41	56
Non-insect Taxa (%)	18	26	21	13	12	35	33	17	18	28
Tolerance										
Tolerance Value	6.0	5.3	5.5	6.6	5.6	6.0	6.0	5.4	5.4	7.0
Intolerant Organisms (%)	0.0	1.1	0.0	5.8	4.5	0.0	0.0	0.3	0.0	0.0
Intolerant Taxa (%)	0.0	13.0	0.0	8.3	12.1	0.0	0.0	8.3	0.0	0.0
Tolerant Organisms (%)	27	3	6	52	26	21	19	3	20	63
Tolerant Taxa (%)	29	35	37	21	24	41	43	29	24	33
Functional Feeding Groups:										
Collector-Gatherers (%)	90	87	78	39	69	47	87	84	62	32
Collector-Filterers (%)	2	6	19.0	10.8	5.2	36	0.7	9	17.5	10
Scrapers (%)	6.4	0.4	1.0	39.4	12.9	13.5	8.7	1	18	56

Table 4.2. Benthic Macroinvertebrate Metrics for CCCWP Bioassessment Sites Monitored in WY 2016

Metrics	CCCWP Bioassessment Sampling Sites Spring 2016									
	204R01412	204R01519	204R01604	206R01536	207R00779	207R01271	207R01291	207R01307	207R01447	207R01611
	West Branch Alamo Creek	Rimer Creek	West Branch Alamo Creek	Ohlone Creek	Las Trampas Creek	Walnut Creek	Grayson Creek	Lafayette Creek	Franklin Creek	San Ramon Creek
Predators (%)	0.7	5.6	2.1	4.7	9.7	2.8	3	4.8	2.6	1.6
Shredders (%)	0.0	0.5	0.0	5.8	3.1	0.0	0.0	0.5	0.0	0.0
Other (%)	0.0	1.3	0.0	0.5	0.2	0.7	0.3	0.3	0.0	0.3
Estimated Abundance										
Composite Sample (11 ft2)	635	550	5,846	9,952	1,392	11,674	1,862	727	6,170	2,653
#/ft2	58	50	531	905	127	1,061	169	66	561	241
#/m2	617	534	5,676	9,662	1,351	11,334	1,808	706	5,990	2,576
Supplemental Metrics										
Collectors (%)	93	92	97	50	74	83	88	93	80	42
Non-Gastropoda Scrapers (%)	0.0	0.0	0.0	0.0	9.6	0.0	0.0	0.0	0.0	0.0
Shredder Taxa (%)	0.0	4.3	0.0	8.3	6.1	0.0	0.0	12.5	0.0	0.0
Diptera Taxa**	3.0	6.0	4.0	9.0	7.0	4.0	2.0	7.0	3.0	2.0
SoCal B-IBI Score	16	24	17	50	56	13	14	34	33	29
CC B-IBI Score	26	34	26	43	48	30	28	36	35	34
CC B-IBI Category	Fair	Fair	Fair	Very Good	Very Good	Fair	Fair	Good	Good	Fair

Metrics are calculated from standard classifications, based on level I standard taxonomic effort except Chironomids, which are identified to subfamily/ tribe*.

*Standard taxonomic effort source: Southwest Association of Freshwater Invertebrate Taxonomists (http://www.waterboards.ca.gov/swamp/docs/safit/ste_list.pdf).

** Calculated based on Chironomids identified to family level.

CSCI scores were computed from the BMI taxonomy data and site-specific watershed characteristics for each bioassessment monitoring site. The CSCI score is computed as the average of the O/E score (the observed taxonomic diversity at the monitoring site divided by the taxonomic composition expected at a reference site with similar geographical charateristics), and the MMI score (a multi-metric index incorporating several metrics reflective of BMI community attributes, such as measures of assemblage richness, composition, and diversity, as predicted for a site with similar physical characteristics). CSCI scores run from a minimum of 0 (indicating no correspondence to modeled reference site conditions) to a maximum of 1 (perfect correspondence with modeled reference site conditions). Per MRP 2, a CSCI score less than 0.795 is degraded, and should be evaluated for consideration as a possible SSID study location.

The essential results of the CSCI calculations are presented in Table 4.3. As shown in Table 4.3, every CCCWP bioassessment site montored in WY 2016 produced a CSCI score below the MRP 2 threshold of 0.795, indicating a degraded biological community relative to reference conditions. These sites will consequently be listed as potential candidates for SSID studies.

Table 4.3 Results of CSCI Calculations for WY 2016 CCCWP Bioassessment Sites

Station Code	Water Body	Sample Date	BMI Count	O/E	MMI	CSCI
204R01412	West Branch Alamo Creek	05/09/16	609	0.51	0.23	0.366
204R01519	Rimer Creek	04/28/16	550	0.71	0.24	0.471
204R01604	West Branch Alamo Creek	04/26/16	609	0.62	0.22	0.418
206R01536	Ohlone Creek	04/27/16	622	0.90	0.40	0.652
207R00779	Las Trampas Creek	05/10/16	638	0.72	0.50	0.613
207R01271	Walnut Creek	05/11/16	608	0.53	0.31	0.418
207R01291	Grayson Creek	05/11/16	611	0.56	0.35	0.456
207R01307	Lafayette Creek	04/28/16	606	0.70	0.40	0.553
207R01447	Franklin Creek	05/12/16	617	0.58	0.31	0.448
207R01611	San Ramon Creek	05/10/16	608	0.82	0.39	0.605

CSCI scores less than 0.795 indicate a substantially degraded biological community relative to reference conditions, and such sites are candidates for SSID projects.

The WY 2016 CSCI scores ranged from a low of 0.366 at West Branch Alamo Creek (204R01412) to a high of 0.652 at Ohlone Creek (206R01536). Three sites had scores above 0.6, while six sites had scores less than 0.5.

4.2.2 Algae Metrics

The five calculated A-IBI scores are shown in summary in Table 4.4 for each bioassessment site monitored in WY 2016, with the highest and lowest scores highlighted for each of the IBIs. A discussion of the results for each of the five IBIs follows.

The average D18 diatom IBI score across all ten Contra Costa sites was 43 (Tables 4.4 and 4.5). In comparison, the average D18 scores across samples collected in 2012-2015 was 38, indicating a slight increase in the overall health of the diatom community. The highest score (72) occurred at Las Trampas Creek (207R00779), while Grayson Creek (207R01291) had the lowest score at 16. Most sites had scores between 42 and 54. Higher scores tended to be associated with a lower proportion of halobiontic species, nitrogen heterotrophic species, and sediment tolerant, highly motile species, but higher proportion of species requiring >50 percent dissolved oxygen saturation (Tables 4.5 and 4.6). Fetscher et al. (2014) found the diatom IBI (D18) to be responsive to stream order, watershed area, and percent fines, so these values could also play a role in IBI scores.

Nine of ten sites scored 1 or below for the proportion of diatom species indicative of low total phosphorous levels, suggesting phosphorous is not a limiting factor in these streams.

Cocconeis spp and *Nitzschia spp* were the dominant diatom species found at six of ten sites, although *Rhoicosphenia abbreviata* was the dominant diatom species (46.2 percent) at Las Trampas Creek (207R00779).

The soft algae S2 IBI had a low average score of 12 (see Table 4.7) compared to the average score of 34 in years 2014 and 2015 (only the D18 score was calculated for years 2012 and 2013). The highest score (50) occurred at Ohlone Creek (206R01536), while the other nine sites scored at 17 or below, including three sites with a 0 score. Ohlone Creek (206R01536) scored higher because it had fewer taxa, indicative of high dissolved organic carbon (DOC) concentrations and little or no soft algae species belonging to the green algae group CRUS (*Cladophora glomerata, Rhizoclonium hieroglyphicum, Ulva flexuosa*, and *Stigeoclonium spp*), but exhibited all taxa belonging to algae group ZHR (Zygnemataceae, heterocystous cyanobacteria, Rhodophyta; see Tables 4.7 and 4.8). In contrast, the sites with lower scores were dominated by taxa belonging to CRUS, indicative of high copper and DOC concentrations and characteristic of non-reference conditions, and included no ZHR taxa.

All ten sites had zero soft algae species indicative of low total phosphorous concentrations. The biomass at each site was dominated (>78.9 percent) by one taxa (*Cladophera glomerata, Vaucheria spp*, Phormidium, Leptolyngbya, or *Audoouinella hermannii*), while species richness was dominated by Heteroleibleinia kossinskajae or Oedogonium at four sites. Fetscher et al. (2014) found soft algae IBIs were most responsive (negatively) to canopy cover and slope.

The hybrid IBIs (H20, H21 and H23), consisting of both soft algae and diatom metrics, produced similar results in determining the highest scores (Ohlone Creek 206R01536 and Las Trampas Creek 207R00779) and lowest scores (Grayson Creek 207R01291 and West Branch Alamo Creek 204R01604) among the ten sites (Tables 4.9, 4.10 and 4.11). However, the average IBI score varied somewhat among the three IBIs (H20 = 29, H21 = 40, and H23 = 35), which could reflect H21's inclusion of only two soft algae metrics, compared to H20 and H23 which include three soft algae metrics. The main differences in the H20 IBI scores were due to the proportion of halobiontic diatoms, highly motile diatoms, heterotroph diatoms, and diatoms requiring >50% dissolved oxygen saturation. H21 IBI scores were driven by the biomass proportion of Chlorophyta and ZHR (Zygnemataceae, Rhodophyta, heterocystous cyanobacteria) soft algae taxonomic groups and the proportion of halobiontic, heterotroph, and sediment tolerant, highly motile diatoms. The proportion of ZHR and CRUS soft algae species affected the differences in H23 IBI scores as well as the proportion of halobiontic and sediment tolerant, highly motile diatoms. Fetscher et al. (2014) designated H20 as the overall top-performing IBI for Southern California streams, although differences with H23 were not pronounced.

Overall, Ohlone Creek (206R01536) had the highest scores across three of the five IBIs (S2, H21 and H23), while Las Trampas Creek (207R00779) had the highest scores for the other two IBIs (D18 and H20), including the highest overall IBI score (D18 = 72).

Grayson Creek (207R01291) had the lowest score for four of the five IBIs (D18, H20, H21 and H23). West Branch Alamo Creek (204R01604) had the second-lowest scores for those four IBIs, and was one of three sites to score 0 for the S2 IBI.

The proportion of halobiontic and sediment tolerant, highly motile diatom species affected scores across IBIs, suggesting the importance of lower ionic strength/lower salinity and lower sediment qualities for a stronger diatom community. Soft algae scores were more affected than the other IBIs by the proportion of taxonomic groups and species found indicating an impacted community at nearly all sites.

Table 4.4 Algal-IBI Scores for Diatom (D18), Soft Algae (S2) and Hybrid (H20, H21, H23) Scores for Contra Costa Stations Sampled in 2016

Station Code	Water Body	Sample Date	D18 IBI Score	S2 IBI Score	H20 IBI Score	H21 IBI Score	H23 IBI Score
204R01412	West Branch Alamo Creek	05/09/16	32	17	20	36	32
204R01519	Rimer Creek	04/28/16	48	17	30	49	42
204R01604	West Branch Alamo Creek	04/26/16	20	0	12	21	12
206R01536	Ohlone Creek	04/27/16	46	50	38	61	61
207R00779	Las Trampas Creek	05/10/16	72	3	48	51	46
207R01271	Walnut Creek	05/11/16	52	0	32	37	32
207R01291	Grayson Creek	05/11/16	16	3	10	13	11
207R01307	Lafayette Creek	04/28/16	52	17	32	51	45
207R01447	Franklin Creek	05/12/16	54	17	42	51	41
207R01611	San Ramon Creek	05/10/16	42	0	26	30	26
		Average:	43	12	29	40	35

High scores for each of the five algal IBIs are highlighted in light green. Low scores are highlighted in gray, except for S2 IBI, which had a three-way tie at 0.

Table 4.5. Diatom IBI (D18) and Individual Metric Scores for Contra Costa Stations Sampled in 2016

Station Code	Water Body	Sample Date	D18 IBI Score	Proportion Halobiontic (d) Score	Proportion Low TP Indicators (d) Score	Proportion N Heterotrophs (d) Score	Proportion Requiring >50% DO Saturation (d) Score	Proportion Sediment Tolerant (Highly Motile) (d) Score
204R01412	West Branch Alamo Creek	05/09/16	32	3	2	8	2	1
204R01519	Rimer Creek	04/28/16	48	5	1	8	4	6
204R01604	West Branch Alamo Creek	04/26/16	20	4	1	2	3	0
206R01536	Ohlone Creek	04/27/16	46	5	1	7	7	3
207R00779	Las Trampas Creek	05/10/16	72	9	1	9	8	9
207R01271	Walnut Creek	05/11/16	52	0	1	9	7	9
207R01291	Grayson Creek	05/11/16	16	2	1	2	2	1
207R01307	Lafayette Creek	04/28/16	52	5	0	8	6	7
207R01447	Franklin Creek	05/12/16	54	5	1	6	8	7
207R01611	San Ramon Creek	05/10/16	42	2	1	8	3	7

Metric scores were assigned based on metric results as shown in Table 3.3, using scoring ranges and values provided by Dr. A. Elizabeth Fetscher (personal communication). The overall IBI score was calculated by converting the sum of individual scores to a 100-point scale by summing the scores and multiplying by the number of metrics [sum x (100/50).

Table 4.6 Diatom Metric Results for Contra Costa Stations Samples in 2016 (all calculations based on count data; proportions are individual counts/total count for each sample)

Station Code	Sample Date	Proportion A Minutissimum (d)	Proportion Halobiontic (d)	Proportion Highly Motile (d)	Proportion Low TN Indicators (d)	Proportion Low TP Indicators (d)	Proportion N Heterotrophs (d)	Proportion oligo- & beta Mesosaprobic (d)	Proportion poly- & eutrophic (d)	Proportion Requiring >50% DO Saturation (d)	Proportion Requiring Nearly 100% DO Saturation (d)	Proportion Sediment Tolerant (Highly Motile) (d)
204R01412	05/09/16	0.053	0.386	0.445	0.118	0.107	0.065	0.574	0.614	0.705	0.181	0.445
204R01519	04/28/16	0.043	0.264	0.201	0.084	0.083	0.095	0.582	0.851	0.781	0.081	0.201
204R01604	04/26/16	0.003	0.335	0.583	0.032	0.032	0.43	0.186	0.894	0.735	0.016	0.583
206R01536	04/27/16	0.002	0.279	0.359	0.018	0.018	0.117	0.745	0.754	0.893	0.05	0.359
207R00779	05/10/16	0	0.058	0.053	0.038	0.039	0.05	0.907	0.873	0.922	0.022	0.053
207R01271	05/11/16	0.01	0.811	0.062	0.012	0.02	0.016	0.565	0.904	0.909	0.022	0.062
207R01291	05/11/16	0.003	0.452	0.346	0.023	0.015	0.416	0.416	0.703	0.708	0.3	0.461
207R01307	04/28/16	0	0.25	0.166	0	0	0.102	0.723	0.892	0.859	0.013	0.166
207R01447	05/12/16	0.003	0.278	0.152	0.023	0.023	0.191	0.628	0.938	0.917	0.024	0.159
207R01611	05/10/16	0	0.448	0.116	0.031	0.037	0.088	0.656	0.808	0.728	0.08	0.153

Table 4.7 Soft Algae IBI (S2) and Individual Metric Scores for Contra Costa Stations Samples in 2015 (the overall IBI score was calculated by converting the sum of individual scores to a 100-point scale by summing the scores and multiplying by the number of metrics [sum x (100/60])

Station Code	Water Body	Sample Date	S2 IBI Score	Proportion High CU Indicators (s, sp) Score	Proportion High DOC Indicators (s, sp) Score	Proportion Los TP Indicators (s, sp) Score	Proportion Non-reference Indicators (s, sp) Score	Proportion Green Algae Belonging to CRUS (s, b) Score	Proportion ZHR (s, m) Score
204R01412	West Branch Alamo Creek	05/09/16	17	0	0	0	0	10	0
204R01519	Rimer Creek	04/28/16	17	0	0	0	0	10	0
204R01604	West Branch Alamo Creek	04/26/16	0	0	0	0	0	0	0
206R01536	Ohlone Creek	04/27/16	50	1	6	0	3	10	10
207R00779	Las Trampas Creek	05/10/16	3	1	1	0	0	0	0
207R01271	Walnut Creek	05/11/16	0	0	0	0	0	0	0
207R01291	Grayson Creek	05/11/16	3	0	0	0	1	1	0
207R01307	Lafayette Creek	04/28/16	17	0	0	0	0	10	0
207R01447	Franklin Creek	05/12/16	17	1	6	0	3	0	0
207R01611	San Ramon Creek	05/10/16	0	0	0	0	0	0	0

Table 4.8 Soft Algae Metric Results for Contra Costa Stations Samples in 2015 (calculations based on either species counts [sp] or biovolume [b]; proportion ZHR (s, m) was based on the mean of the species and biovolume results)

Station Code	Sample Date	Proportion High CU Indicators (s, sp)	Proportion High DOC Indicators (s, sp)	Proportion Low TP Indicators (s, sp)	Proportion Non-reference Indicators (s, sp)	Proportion ZHR (s, sp)	Proportion Chlorophyta (s, b)	Proportion High DOC Indicators (s, b)	Proportion Non-reference Indicators (s, b)	Proportion Green Algae Belonging to CRUS (s, b)	Proportion ZHR (s, b)	Proportion ZHR (s, m)
204R01412	05/09/16	0.75	0.75	0	0.75	0	0.006	1	1	0	0	0
204R01519	04/28/16	1	1	0	1	0	0	0	0	0	0	0
204R01604	04/26/16	0.4	0.8	0	0.6	0	0.5	1	0.5	1	0	0
206R01536	04/27/16	0.333	0.333	0	0.333	0.25	0	0	0	0	1	0.625
207R00779	05/10/16	0.333	0.667	0	0.667	0	1	1	1	1	0	0
207R01271	05/11/16	0.667	0.889	0	0.667	0	1	1	1	1	0	0
207R01291	05/11/16	0.545	0.714	0	0.429	0	0.905	1	0.9	0.942	0	0
207R01307	04/28/16	1	1	0	1	0	0	0	0	0	0	0
207R01447	05/12/16	0.333	0.333	0	0.333	0	0.103	0.103	0.103	1	0	0
207R01611	05/10/16	1	1	0	1	0	1	1	1	1	0	0

Table 4.9 Hybrid (diatom and soft algae) IBI (H20) and Individual Metric Scores for Contra Costa Stations Samples in 2015 (te overall IBI score was calculated by converting the sum of individual scores to a 100-point scale by summing the scores and multiplying by the number of metrics [sum x (100/80])

Station Code	Water Body	Sample Date	H20 IBI Score	Proportion Halobiontic (d) Score	Proportion High CU Indicators (s, sp) Score	Proportion High DOC Indicators (s, sp) Score	Proportion Low TN Indicators (d) Score	Proportion Low TP Indicators (s, sp) Score	Proportion N Heterotrophs (d) Score	Proportion Requiring >50% DO Saturation (d) Score	Proportion Sediment Tolerant (Highly Motile) (d) Score
204R01412	West Branch Alamo Creek	05/09/16	20	3	0	0	2	0	8	2	1
204R01519	Rimer Creek	04/28/16	30	5	0	0	1	0	8	4	6
204R01604	West Branch Alamo Creek	04/26/16	12	4	0	0	1	0	2	3	0
206R01536	Ohlone Creek	04/27/16	38	5	1	6	1	0	7	7	3
207R00779	Las Trampas Creek	05/10/16	48	9	1	1	1	0	9	8	9
207R01271	Walnut Creek	05/11/16	32	0	0	0	1	0	9	7	9
207R01291	Grayson Creek	05/11/16	10	2	0	0	1	0	2	2	1
207R01307	Lafayette Creek	04/28/16	32	5	0	0	0	0	8	6	7
207R01447	Franklin Creek	05/12/16	42	5	1	6	1	0	6	8	7
207R01611	San Ramon Creek	05/10/16	26	2	0	0	1	0	8	3	7

Table 4.10 Hybrid (diatom and soft algae) IBI (H21) and Individual Metric Scores for Contra Costa Stations Sampled in 2015 (the overall IBI score was calculated by converting the sum of individual scores to a 100-point scale by summing the scores and multiplying by the number of metrics [sum x (100/70])

Station Code	Water Body	Sample Date	H21 IBI Score	Proportion Chlorophyta (s, b) Score	Proportion Halobiontic (d) Score	Proportion Low TP Indicators (d) Score	Proportion N Heterotrophs (d) Score	Proportion Requiring >50% DO Saturation (d) Score	Proportion Sediment Tolerant (Highly Motile) (d) Score	Proportion ZHR (s, b) Score
204R01412	West Branch Alamo Creek	05/09/16	36	9	3	2	8	2	1	0
204R01519	Rimer Creek	04/28/16	49	10	5	1	8	4	6	0
204R01604	West Branch Alamo Creek	04/26/16	21	5	4	1	2	3	0	0
206R01536	Ohlone Creek	04/27/16	61	10	5	1	7	7	3	10
207R00779	Las Trampas Creek	05/10/16	51	0	9	1	9	8	9	0
207R01271	Walnut Creek	05/11/16	37	0	0	1	9	7	9	0
207R01291	Grayson Creek	05/11/16	13	1	2	1	2	2	1	0
207R01307	Lafayette Creek	04/28/16	51	10	5	0	8	6	7	0
207R01447	Franklin Creek	05/12/16	51	9	5	1	6	8	7	0
207R01611	San Ramon Creek	05/10/16	30	0	2	1	8	3	7	0

Table 4.11 Hybrid (diatom and soft algae) IBI (H23) and Individual Metric Scores for Contra Costa Stations Samples in 2015 (the overall IBI score was calculated by converting the sum of individual scores to a 100-point scale by summing the scores and multiplying by the number of metrics [sum x (100/80])

Station Code	Water Body	Sample Date	H23 IBI Score	Proportion Halobiontic (d) Score	Proportion High DOC Indicators (s, sp) Score	Proportion Low TP Indicators (d) Score	Proportion N Heterotrophs (d) Score	Proportion Green Algae Belonging to CRUS (s, b) Score	Proportion Requiring >50% DO Saturation (d) Score	Proportion Sediment Tolerant (Highly Motile) (d) Score	Proportion ZHR (s, m) Score
204R01412	West Branch Alamo Creek	05/09/16	32	3	0	2	8	10	2	1	0
204R01519	Rimer Creek	04/28/16	42	5	0	1	8	10	4	6	0
204R01604	West Branch Alamo Creek	04/26/16	12	4	0	1	2	0	3	0	0
206R01536	Ohlone Creek	04/27/16	61	5	6	1	7	10	7	3	10
207R00779	Las Trampas Creek	05/10/16	46	9	1	1	9	0	8	9	0
207R01271	Walnut Creek	05/11/16	32	0	0	1	9	0	7	9	0
207R01291	Grayson Creek	05/11/16	11	2	0	1	2	1	2	1	0
207R01307	Lafayette Creek	04/28/16	45	5	0	0	8	10	6	7	0
207R01447	Franklin Creek	05/12/16	41	5	6	1	6	0	8	7	0
207R01611	San Ramon Creek	05/10/16	26	2	0	1	8	0	3	7	0

4.3 Stressor Assessment

This section addresses the question, what are major stressors to aquatic life in the RMC area?. The biological, physical, chemical, and toxicity testing data produced by CCCWP during WY 2016 were compiled and evaluated, and analyzed against the threshold trigger criteria shown in Table 3.3. When the data analysis indicated the associated trigger criteria were exceeded, those sites and results were identified as potentially warranting further investigation.

When interpreting analytical chemistry results, it is important to account for laboratory data reported as either below method detection limits (MDLs) or between detection and reporting limits (RLs). Dealing with data in this range of the analytical spectrum introduces some level of uncertainty, especially when attempting to generate summary statistics for a data set. In the following compilation of statistics for analytical chemistry, in some cases non-detect data (ND) were substituted with a concentration equal to half of the respective MDL, as reported by the laboratory.

4.3.1 Physical Habitat Parameters

The metrics included in calculation of the mini-PHab scores are summarized in Table 4.12 for bioassessment sites monitored in WY 2016.

Table 4.12 Physical Habitat Metrics and Scores for CCCWP Bioassessment Sites Monitored in WY 2016

Site Code	Creek name	Sample Date	Epifaunal Substrate	Sediment Deposition	Channel Alteration	Mini-PHab Score
204R01412	West Branch Alamo Creek	05/09/16	11	7	15	33
204R01519	Rimer Creek	04/28/16	7	9	12	28
204R01604	West Branch Alamo Creek	04/26/16	8	12	13	33
206R01536	Ohlone Creek	04/27/16	11	14	12	37
207R00779	Las Trampas Creek	05/10/16	7	7	13	27
207R01271	Walnut Creek	05/11/16	2	2	0	4
207R01291	Grayson Creek	05/11/16	7	4	5	16
207R01307	Lafayette Creek	04/28/16	13	11	15	39
207R01447	Franklin Creek	05/12/16	11	12	13	36
207R01611	San Ramon Creek	05/10/16	9	3	12	24

The principal biological condition scores are shown together with the mini-PHab scores in Table 4.13, and correlations between mini-Phab scores and the key biological condition scores are shown in Table 4.14.

The CC-IBI scores correlated well with the CSCI scores, and with both the D18 and H20 algal-IBI scores. The two algal-IBI scores also correlated well to each other.

The mini-PHab scores did not correlate well with any of the biological condition indicators, following a pattern observed in prior years. Based on these observations, it is difficult to conclude that the physical habitat, as represented by these limited metrics, has any significant effect on the biological parameters.

Table 4.13 PHab and Biological Condition Scores for CCCWP Bioassessment Sites Monitored in WY 2016

Site Code	Creek name	CSCI Score	D18 Algal IBI Score	H20 Algal IBI Score	CC IBI	Mini-PHab Score
204R01412	West Branch Alamo Creek	0.366	32	20	26	33
204R01519	Rimer Creek	0.471	48	30	34	28
204R01604	West Branch Alamo Creek	0.418	20	12	26	33
206R01536	Ohlone Creek	0.652	46	38	43	37
207R00779	Las Trampas Creek	0.613	72	48	48	27
207R01271	Walnut Creek	0.418	52	32	30	4
207R01291	Grayson Creek	0.456	16	10	28	16
207R01307	Lafayette Creek	0.553	52	32	36	39
207R01447	Franklin Creek	0.448	54	42	35	36
207R01611	San Ramon Creek	0.605	42	26	34	24

Table 4.14 Correlations for PHab and Biological Condition Scores for CCCWP Bioassessment Sites Monitored in WY 2016

Comparison	Correlation Coefficient	R Squared
CSCI:D18 A-IBI	0.49	0.24
CSCI:H20 A-IBI	0.54	0.29
D18 A-IBI:H20 A-IBI	0.96	0.92
CSCI:Mini-PHab	0.25	0.065
D18 A-IBI:Mini-PHab	0.08	0.006
H20 A-IBI:Mini-PHab	0.20	0.04
CSCI:CC-IBI	0.84	0.71
D18 A-IBI:CC-IBI	0.79	0.63
H20 A-IBI:CC-IBI	0.85	0.72
Contra Costa B-IBI:Mini-PHab	0.27	0.07

4.3.2 Water Chemistry Parameters

At all 10 bioassessment sites, water samples were collected for nutrient and other conventional analyses using the standard grab sample collection method, as described in SOP FS-2 (BASMAA, 2016b). Standard field parameters (temperature, dissolved oxygen, pH, and specific conductance) were also measured in the field using a portable multi-meter and sonde.

Of the 12 water quality constituents monitored in association with the bioassessment monitoring, water quality standards or established thresholds are available only for ammonia (unionized form[5]), chloride[6], and nitrate-plus-nitrite[7] – the latter for waters with MUN beneficial use only, as indicated in Table 4.15.

The comparisons of the measured nutrients data to the thresholds listed in Table 4.15 are shown in Table 4.16. There were no exceedances of the applicable criteria at any of the 10 sites monitored in WY 2016.

Table 4.15. Water Quality Thresholds Available for Comparison to WY 2016 Water Chemistry Constituents

Sample Parameter	Threshold	Units	Frequency/ Period	Application	Source
Ammonia	0.025	mg/L	Annual median	Un-ionized ammonia, as N (maxima also apply to Central Bay and u/s (0.16) and Lower Bay (0.4))	SF Bay Basin Plan (Ch. 3)
Chloride	230	mg/L	Criterion Continuous Concentration	Freshwater aquatic life	EPA Nat'l. Rec. Water Quality Criteria, Aquatic Life Criteria
Chloride	860	mg/L	Criteria Maximum Concentration	Freshwater aquatic life	EPA Nat'l. Rec. Water Quality Criteria, Aquatic Life Criteria Table
Chloride	250	mg/L	Secondary Maximum Contaminant Level	Alameda Creek Watershed above Niles and MUN waters, Title 22 Drinking Waters	SF Bay Basin Plan (Ch. 3); CA Code Title 22; EPA Drinking Water Stds. Secondary MCL
Nitrate + Nitrite (as N)	10	mg/L	Maximum Contaminant Level	Areas designated as MUN	SF Bay Basin Plan (Ch. 3)

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[5] For ammonia, the standard provided in the Basin Plan (SFBRWQCB, 2013; section 3.3.20) applies to the un-ionized fraction, as the underlying criterion is based on un-ionized ammonia, which is the more toxic form. Conversion of RMC monitoring data from the measured total ammonia to un-ionized ammonia was based on a formula provided by the American Fisheries Society, and calculates un-ionized ammonia in freshwater systems from analytical results for total ammonia and field-measured pH, temperature, and electrical conductivity; see: http://fisheries.org/hatchery

[6] For chloride, a Secondary Maximum Contaminant Level (MCL) of 250 mg/L applies to those waters with MUN beneficial use, per the Basin Plan (Table 3-5), Title 22 of the California Code of Regulations, and the EPA drinking water quality standards, and also applies per the Basin Plan (Table 3-7) to waters in the Alameda Creek watershed above Niles. For all other waters, the criteria maximum concentration water quality criterion of 860 mg/L (acute) and the Criterion Continuous Concentration (CCC) of 230 mg/L (EPA Water Quality Criteria*) for the protection of aquatic life can be used for comparison. Per the WY 2012 UCMR (BASMAA, 2012) the RMC participants used the 230 mg/L threshold as a conservative benchmark for comparison purposes for all locations not specifically identified within the Basin Plan (i.e., sites not within the Alameda Creek watershed above Niles nor identified as MUN, rather than the maximum concentration criterion of 830mg/L).

*See:-http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm

[7] The nitrate+nitrite primary MCL applies to those waters with MUN beneficial use, per the Basin Plan (Table 3-5), Title 22 of the California Code of Regulations, and the EPA Drinking Water Quality Standards.

Table 4.16 Comparison of Water Quality (Nutrient) Data to Associated Water Quality Thresholds for WY 2016 Water Chemistry Results

Site Code	Creek Name	MUN	Parameter and Threshold			# of Parameters >Threshold/ Water Body
			Un-ionized Ammonia (as N)	Chloride	Nitrate + Nitrite (as N)	
			25 µg/L	230/250 mg/L [1]	10 mg/L [2]	
204R01412	West Branch Alamo Creek		0.3	39	0.015	0
204R01519	Rimer Creek		0.4	25	0.078	0
204R01604	West Branch Alamo Creek		0.3	29	0.20	0
206R01536	Ohlone Creek		0.3	50	0.048	0
207R00779	Las Trampas Creek		0.9	34	0.12	0
207R01271	Walnut Creek		1.3	46	0.011	0
207R01291	Grayson Creek		1.9	140	0.015	0
207R01307	Lafayette Creek		1.3	38	0.059	0
207R01447	Franklin Creek		0.7	60	0.57	0
207R01611	San Ramon Creek		1.6	39	0.012	0
# Values >Threshold:			0	0	0	0
% Values >Threshold:			0%	0%	0%	0%

[1] 250 mg/L threshold applies for sites with MUN beneficial use and Alameda Creek above Niles per Basin Plan

[2] Nitrate + nitrite threshold applies only to sites with MUN beneficial use. No WY 2016 sites have MUN beneficial use.

Water samples also were collected and analyzed for free and total chlorine in the field using CHEMetrics test kits during bioassessment monitoring.

As shown in Table 4.17, no water samples produced measurable levels of free or total chlorine (all results were 0.0).

Table 4.17 Summary of Chlorine Testing Results for Samples Collected in WY 2016 in Comparison to Municipal Regional Permit Trigger Criteria

Site Code	Creek Name	Sample Date	Chlorine, Free	Chlorine, Total	Exceeds Trigger Threshold?
204R01412	West Branch Alamo Creek	050/9/16	0	0	No
204R01519	Rimer Creek	04/28/16	0	0	No
204R01604	West Branch Alamo Creek	04/26/16	0	0	No
206R01536	Ohlone Creek	04/27/16	0	0	No
207R00779	Las Trampas Creek	05/10/16	0	0	No
207R01271	Walnut Creek	05/11/16	0	0	No
207R01291	Grayson Creek	05/11/16	0	0	No
207R01307	Lafayette Creek	04/28/16	0	0	No
207R01447	Franklin Creek	05/12/16	0	0	No
207R01611	San Ramon Creek	05/10/16	0	0	No
Number of samples exceeding 0.1 mg/L:			0	0	
Percentage of samples exceeding 0.08 mg/L:			0%	0%	

4.3.3 Water Column Toxicity (Dry Weather)

Water samples were collected on July 11, 2016 from one regional/probabilistic monitoring site (Rimer Creek 204R01519), and tested for toxicity to several different aquatic species, as required by the MRP. The dry weather water toxicity test results are shown in Table 4.18.

All test results were determined not to be toxic except one: the *Ceriodaphnia dubia* chronic effects assay for reproduction. The average reproduction for the Rimer Creek test samples was 12.5 neonates/female, compared to 34.3 neonates/female for the control samples. At 36 percent of the control result, this test was required to be repeated by the followup provisions of MRP provision C.8.g.iv. (toxicity test results which are less than 50 percent of the control; see Table 4.18).

The *Ceriodaphnia* chronic test was repeated with samples collected on August 15, 2016. This sample was also found to be toxic, but the result was not less than 50 percent of the control. Because the second test result did not meet the MRP threshold for followup, these results are not considered to be candidates for a SSID project.

Table 4.18 Summary of CCCWP WY 2016 Dry Season Water Toxicity Results

Dry Season Water Samples			Toxicity Test Results						
			Selenastrum capricornutum	Ceriodaphnia dubia		Chiron. dilutus	Hyalella azteca	Pimephales promelas	
Site Code	Creek Name	Sample Collection Date	Growth (cells/mL x 10^6)	Survival (%)	Repro-duction (# neonates/ female)	Survival (%)	Survival (%)	Survival (%)	Growth (mg)
Control			1.25	100	34.3	100	98	97.5	0.69
204R01519	Rimer Creek	07/11/16	5.40	100	12.5*	100	100	90.0	0.62
Re-Test (*C. dubia* reproduction only):									
Control					41.8				
204R01519	Rimer Creek	08/15/16			27.4*				

*The response at this test treatment was significantly less than the lab control treatment response at $p < 0.05$, and determined to be toxic.
The bolded test result was determined to be highly toxic, and met the MRP aquatic toxicity threshold for followup, at less than 50 percent of the control.

4.3.4 Sediment Toxicity and Sediment Chemistry

Sediment samples were collected on July 11, 2016 after water samples were collected at the same regional/probabilistic monitoring site sampled for water column toxicity (Rimer Creek 204R01519), and tested for acute toxicity (survival) to *Hyalella azteca* and *Chironomus dilutus*.

Neither sample was determined to be toxic to either of the two sediment test species. The sediment toxicity test results are shown in Table 4.19.

Table 4.19 Summary of CCCWP WY 2016 Dry Season Sediment Toxicity Results

Dry-Season Sediment Samples			Toxicity Test Results	
			Hyalella azteca	*Chironomus dilutus*
Site Code	Creek Name	Sample Collection Date	Survival (%)	Survival (%)
Control			100	92.5
204R01519	Rimer Creek	07/11/16	98.8	90.0

No test treatment was determined to be significantly less than the lab control treatment response at $p < 0.05$

Two sediment samples also were tested for a suite of potential sediment pollutants, as required by the MRP, and the results were compared to the trigger threshold levels specified for followup in MRP provision C.8.g.iv. (see Table 3.3). Although only one sediment chemistry sample is required annually by MRP provision C.8.g.ii, sediment samples were collected and analyzed from two sites for chemistry in WY 2016. The complete sediment chemistry results are shown in Table 4.20, and the results are shown in comparison to the applicable MRP threshold triggers in Table 4.21.

As shown in Table 4.21, the only constituent result with a TEC value greater than 1.0 is nickel in the Rimer Creek sediment sample. Nickel is a naturally occurring element throughout much of the San Francisco Bay area, and commonly occurs at elevated levels in creek status monitoring.

Table 4.20 CCCWP WY 2016 Sediment Chemistry Results

Analyte	Units*	204R00388			204R01519		
		West Branch Alamo Creek			Rimer Creek		
		Result	MDL	RL	Result	MDL	RL
Metals							
Arsenic	mg/Kg	2.8	0.64	1.1	3.9	0.62	1
Cadmium	mg/Kg	0.09	0.021	0.09	0.11	0.021	0.08
Chromium	mg/Kg	18	0.13	0.21	38	0.12	0.21
Copper	mg/Kg	17	0.16	0.43	13	0.15	0.41
Lead	mg/Kg	5.5	0.085	0.21	5.6	0.083	0.21
Nickel	mg/Kg	16	0.13	0.21	44	0.12	0.21
Zinc	mg/Kg	71	0.85	2.1	39	0.83	2.1
Polycyclic Aromatic Hydrocarbons (PAHs)							
Acenaphthene	ng/g	ND	3.2	5	ND	3.1	5
Acenaphthylene	ng/g	ND	3.2	5	ND	3.1	5
Anthracene	ng/g	ND	3.2	5	ND	3.1	5
Benz(a)anthracene	ng/g	ND	3.2	5	3.1	3.1	5
Benzo(a)pyrene	ng/g	ND	3.2	5	ND	3.1	5
Benzo(b)fluoranthene	ng/g	ND	3.2	5	ND	3.1	5
Benzo(e)pyrene	ng/g	ND	3.2	5	ND	3.1	5
Benzo(g,h,i)perylene	ng/g	ND	3.2	5	ND	3.1	5
Benzo(k)fluoranthene	ng/g	ND	3.2	5	ND	3.1	5
Biphenyl	ng/g	ND	3.5	5	ND	3.4	5
Chrysene	ng/g	ND	3.2	5	3.1	3.1	5
Dibenz(a,h)anthracene	ng/g	ND	3.2	5	ND	3.1	5
Dibenzothiophene	ng/g	ND	3.5	5	ND	3.4	5
Dimethylnaphthalene, 2,6-	ng/g	ND	3.2	5	ND	3.1	5
Fluoranthene	ng/g	ND	3.2	5	5.1	3.1	5
Fluorene	ng/g	ND	3.2	5	ND	3.1	5
Indeno(1,2,3-c,d)pyrene	ng/g	ND	3.2	5	ND	3.1	5
Methylnaphthalene, 1-	ng/g	ND	3.2	5	ND	3.1	5
Methylnaphthalene, 2-	ng/g	ND	3.2	5	ND	3.1	5
Methylphenanthrene, 1-	ng/g	ND	3.2	5	ND	3.1	5
Naphthalene	ng/g	ND	3.2	5	ND	3.1	5
Perylene	ng/g	ND	3.2	5	ND	3.1	5
Phenanthrene	ng/g	ND	3.2	5	ND	3.1	5
Pyrene	ng/g	ND	3.2	5	4.1	3.1	5
Pyrethroid Pesticides							
Bifenthrin	ng/g	9.2	0.11	0.33	0.69	0.1	0.33
Cyfluthrin, total	ng/g	0.56	0.12	0.33	ND	0.11	0.33
Cyhalothrin, Total lambda-	ng/g	0.1	0.064	0.33	ND	0.061	0.33

Table 4.20 CCCWP WY 2016 Sediment Chemistry Results

		204R00388			204R01519		
		West Branch Alamo Creek			Rimer Creek		
Analyte	Units*	Result	MDL	RL	Result	MDL	RL
Cypermethrin, total	ng/g	0.11	0.11	0.33	ND	0.1	0.33
Deltamethrin/Tralomethrin	ng/g	0.9	0.13	0.33	ND	0.12	0.33
Esfenvalerate/Fenvalerate, total	ng/g	ND	0.14	0.33	ND	0.13	0.33
Permethrin, Total	ng/g	2.8	0.12	0.33	ND	0.11	0.33
Other Pesticides							
Carbaryl	ng/g	ND	0.21	0.30	ND	0.20	0.30
Fipronil	ng/g	ND	0.11	0.33	ND	0.10	0.33
Organic Carbon							
Total Organic Carbon	%	0.19	0.01	0.10	0.15	0.01	0.10

* All measurements reported as dry weight
ND = not detected

Table 4.21 Threshold Effect Concentration (TEC) and Probable Effect Concentration (PEC) Quotients for WY 2016 Sediment Chemistry Constituents

		204R00388			204R01519		
		West Branch Alamo Creek			Rimer Creek		
Metals	Sample Units*	Sample	TEC Ratio	PEC Ratio	Sample	TEC Ratio	PEC Ratio
Arsenic	mg/Kg	2.8	0.29	0.08	3.9	0.40	0.12
Cadmium	mg/Kg	0.09	0.09	0.02	0.11	0.11	0.02
Chromium	mg/Kg	18	0.41	0.16	38	0.88	0.34
Copper	mg/Kg	17	0.54	0.11	13	0.41	0.09
Lead	mg/Kg	5.5	0.15	0.04	5.6	0.16	0.04
Nickel	mg/Kg	16	0.70	0.33	44	1.94	0.91
Zinc	mg/Kg	71	0.59	0.15	39	0.32	0.08
PAHs							
Anthracene	ng/g	ND			ND		
Fluorene	ng/g	ND			ND		
Naphthalene	ng/g	ND			ND		
Phenanthrene	ng/g	ND			ND		
Benz(a)anthracene	ng/g	ND			3.1	0.03	0.003
Benzo(a)pyrene	ng/g	ND			ND		
Chrysene	ng/g	ND			3.1	0.02	0.002
Fluoranthene	ng/g	ND			5.1	0.01	0.002
Pyrene	ng/g	ND			4.1	0.02	0.003
Total PAHs*	ng/g	ND			15	0.01	0.00
Number with TECq > 1.0:			0			1	
COMBINED TEC RATIOS			2.77			4.30	
AVERAGE TEC RATIO			0.20			0.31	
COMBINED PEC RATIOS				0.91			1.61
AVERAGE PEC RATIO				0.06			0.12

Note: TECs and PECs are as per MacDonald et al., 2000. All measurements reported as dry weight.
Bolded TEC or PEC ratio indicates ratio > 1.0
ND = not detected
* Total PAHs include 24 individual PAH compounds; NDs were substituted at 1/2 MDL to compute total

Pyrethroid pesticide concentrations were compared to sediment concentrations known to cause toxicity, as in previous years. Table 4.22 provides a summary of the calculated TU equivalents for the pyrethroids for which there are published toxic levels, known as LC_{50} values, and a sum of the calculated TU equivalents for each monitored site. Because organic carbon mitigates the toxicity of pyrethroid pesticides in sediments, the LC_{50} values are based on organic carbon-normalized pyrethroid concentrations. Therefore, the pyrethroid concentrations, as reported by the lab, were divided by the measured TOC concentration (as a percentage) at each site, and the TOC-normalized concentrations were then used to compute TU equivalents for each pyrethroid.

The most common urban pyrethroid pesticide, bifenthrin, was detected at both WY 2016 monitoring sites (Table 4.22), along with several other pyrethroid pesticides. The resulting range of predicted toxicity (the

TUs in Table 4.22) was used in a sediment triad analysis to relate observed instances of sediment toxicity to measured pesticide concentrations, as discussed in Section 4.3.5 below.

Table 4.22 Calculated Pyrethroid Toxic Unit Equivalents, WY 2016 Sediment Chemistry Data

Pyrethroid Pesticides	LC_{50} (µg/g organic carbon)	204R00388			204R01519		
		West Branch Alamo Creek			Rimer Creek		
		Sample (ng/g)	Sample (µg/g organic carbon)	TU Equiv.	Sample	Sample (µg/g organic carbon)	TU Equiv.
Bifenthrin	0.52	9.2	4.84	**9.31**	0.69	0.46	0.88
Cyfluthrin	1.08	0.56	0.29	0.273	ND		
Cyhalothrin, lambda	0.45	0.1	0.053	0.117	ND		
Cypermethrin	0.38	0.11	0.058	0.152	ND		
Deltamethrin/Tralomethrin	0.79	0.9	0.47	0.600	ND		
Esfenvalerate/Fenvalerate	1.54	ND			ND		
Permethrin	10.8	2.8	1.47	0.136	ND		
Sum (Pyrethroid TUs):				**10.6**			0.88

Notes: Bold value indicates result exceeds one toxic unit equivalent
All sample measurements reported as dry weight; ND = not detected
Toxic Unit Equivalents (TUs) are calculated as ratios of organic carbon-normalized pyrethroid sample concentrations to published *Hyalella azteca* LC_{50} values.
See: http://www.tdcenvironmental.com/resources/Pyrethroids-Aquatic-Tox-Summary.pdf for associated references.

4.3.5 Sediment Triad Analysis

Table 4.23 summarizes stressor evaluation results for sites with data collected for sediment chemistry, sediment toxicity, and bioassessment parameters by CCCWP over the first five years of the RMC regional/probabilistic monitoring effort (WY 2012-2016).

Pyrethroid pesticide sediment concentrations appear to be potent predictors of sediment toxicity, as samples with calculated pyrethroid TU equivalents greater than 1.0 exhibited significant sediment toxicity. The samples with TU equivalents less than 1.0 did not exhibit sediment toxicity, as shown in Table 4.23.

Table 4.23 Summary of Sediment Quality Triad Evaluation Results, WY 2012 - WY 2016 Data

Water Year	Water Body	Site ID	B-IBI Condition Category	Sediment Toxicity	# TEC Quotients ≥ 1.0	Mean PEC Quotient	Sum of TU Equiv.
2012	Grayson Creek	207R00011	Very Poor	Yes	10	0.14	2.17
2012	Dry Creek	544R00025	Very Poor	Yes	11	0.51	3.62
2013	Sycamore Creek	207R00271	Very Poor	Yes	0	0.04	10.5
2013	Marsh Creek	544R00281	Very Poor	Yes	4	0.13	1.03
2014	San Pablo Creek	206R00551	Very Poor	No	1	0.09	.016
2014	Grizzly Creek	207R00843	Very Poor	No	1	0.12	.11
2015	Rodeo Creek	206R01024	Poor	No	1	0.11	0.32
2015	Green Valley Creek	207R00891	Very Poor	Yes	3	0.12	1.11
2016	Rimer Creek	204R01519	Degraded (CSCI)	No	1	0.12	0.89

Note: Yellow-highlighted cells indicate results exceed Permit trigger threshold

4.3.6 Analysis of Condition Indicators and Stressors

CSCI scores were calculated from the CCCWP bioassessment data for the first time in WY 2016. The CSCI uses location-specific GIS data to compare the observed BMI taxonomic data to expected BMI assemblage characteristics from reference sites with similar geographical characteristics. All calculated CSCI scores were below the MRP 2 threshold of 0.795, indicating degraded benthic biological communities at the 10 sites monitored by CCCWP in WY 2016, per the MRP threshold. Additional work will need to be done with the CSCI scores in relation to this threshold to make a clearer assessment of relative biological conditions for these urban streams. The CSCI scores did correlate well with the Contra Costa benthic-IBI scores for WY 2016 data.

There was one instance of toxicity in the limited dry weather testing performed in WY 2016, in the chronic *Ceriodaphnia dubia* test for the Rimer Creek sample. This result was inconsistent with previous years, in which toxicity to *Hyalella azteca* was more common.

The principal stressors identified in the chemical analyses continue to be pyrethroid pesticides in sediments.

5. Conclusions and Next Steps

During WY 2016, 10 sites were monitored by CCCWP under the RMC regional probabilistic design for bioassessment, physical habitat, and water chemistry parameters. Two sites were also monitored for water and sediment toxicity and sediment chemistry. The water and sediment chemistry and toxicity data were used to evaluate potential stressors which may affect aquatic habitat quality and beneficial uses. The bioassessment and related data are also used to develop a preliminary condition assessment for the monitored sites, to be used in conjunction with the stressor assessment based on sediment chemistry and toxicity.

5.1 Summary of Stressor Analyses

Based on an analysis of the regional/probabilistic data collected by CCCWP during WY 2016, the stressor analysis is summarized as follows:

- **Physical Habitat Conditions** – Limited analysis of PHab metrics did not produce any significant correlations with biological condition indicators for WY 2016 data.

- **Water Quality –** Of 12 water quality parameters required in association with bioassessment monitoring, applicable water quality standards were only identified for ammonia, chloride, and nitrate + nitrite (for sites with MUN beneficial use only). None of the results generated at the 10 sites monitored by CCCWP for those three parameters during WY 2016 exceeded the applicable water quality standard or threshold.

- **Water Toxicity –** Toxicity testing was performed for four test species in water samples collected from Rimer Creek (204R01519) during one dry season sampling event in WY 2016. Only one of the tests was significantly toxic: *C. dubia* chronic (reproduction) test. In a later retest, the second sample was also toxic in the chronic test, but results did not meet the MRP threshold for followup.

- **Sediment Toxicity –** The Rimer Creek sediment sample was not toxic to either of the test species (*H. azteca and C. dilutus*).

- **Sediment Chemistry –** The pyrethroid pesticide bifenthrin was found in both creek sediment samples; the concentration of this pesticide was particularly high in the West Branch Alamo Creek sample. Total toxic unit equivalents for the West Branch Alamo Creek sample exceeded 10 TUs.

- **Sediment Triad Analyses –** Bioassessment, sediment toxicity, and sediment chemistry results were evaluated as the three lines of evidence used in the triad approach for assessing overall stream condition, and added to the compiled results for water years 2012-2016. Good correlation is observed in the triad samples between pyrethroid concentrations and sediment toxicity.

The chemical stressors – particularly pesticides – may be contributing to the degraded biological conditions indicated by the low B-IBI scores in many of the monitored streams.

5.2 Next Steps

The analysis presented in this report has identified several potentially impacted sites which may deserve further evaluation and/or investigation to provide better understanding of the sources/stressors which might contribute to reduced water quality and lower biological condition at these sites.

During the initial MRP term, the RMC collaboratively reviewed trigger results from WY 2012 and selected a total of 10 sites in four counties for implementation of SSID projects, based on prioritization of the type, extent, and geographic spread of the triggers. For CCCWP, this involved two projects designed to evaluate and further characterize causes of toxicity impacting urban creek systems, specifically Grayson Creek (Region 2) and Dry Creek (Region 5).

Efforts are currently underway by the RMC to evaluate data for selection of a new set of SSID projects for implementation during the current MRP term. CCCWP will continue to collaborate in this regional effort. Eight SSID projects are required regionally per MRP 2 if performed within a regional collaborative; CCCWP will be required to perform one new SSID project during the MRP 2 permit term per agreement within the RMC; this project will not involve toxicity. The current list of threshold triggers and potential SSID projects is included as Appendix 3 to the CCCWP WY 2016 UCMR.

CCCWP and the other RMC participants will continue to implement the regional probabilistic monitoring design in WY 2017, under the terms of the newly-adopted MRP 2 (effective January 1, 2016). Additional data also might permit a better assessment as to the potential effects of drought and rising temperatures on urban stream quality. Wet season toxicity and chemistry monitoring will commence in WY 2018, as required by MRP 2.

Candidate probabilistic sites previously classified with “unknown" sampling status in the RMC probabilistic site evaluation process may continue to be evaluated for potential sampling in WY 2017.

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Appendix 2

Local/Targeted Creek Status Monitoring Report
Water Year 2016

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CONTRA COSTA
CLEAN WATER
PROGRAM

Local/Targeted Creek Status Monitoring Report
Water Year 2016
(October 2015 - September 2016)

Submitted to the San Francisco Bay and
Central Valley Regional Water Quality Control Boards
in Compliance with NPDES Permit
Provisions C.8.h.iii and C.8.g.iii

NPDES Permit Nos. CAS612008 and CAS083313

March 22, 2017

A Program of Contra Costa County, its Incorporated Cities and Towns,
and the Contra Costa Flood Control & Water Conservation District

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This report is submitted by the participating agencies of the

CONTRA COSTA
CLEAN WATER
PROGRAM

Program Participants:

- Cities and Towns of: Antioch, Brentwood, Clayton, Concord, Danville (Town), El Cerrito, Hercules, Lafayette, Martinez, Moraga (Town), Oakley, Orinda, Pinole, Pittsburg, Pleasant Hill, Richmond, San Pablo, San Ramon and Walnut Creek
- Contra Costa County
- Contra Costa County Flood Control & Water Conservation District

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List of Acronyms and Abbreviations

ACCWP	Alameda Countywide Clean Water Program
ADH	ADH Environmental
ARC	Armand Ruby Consulting
BASMAA	Bay Area Stormwater Management Agencies Association
CCCWP	Contra Costa Clean Water Program
CDFW	California Department of Fish and Wildlife
CFU	colony forming units
COLD	cold freshwater habitat
CVRWQB	Central Valley Regional Water Quality Control Board
DO	dissolved oxygen
EBRPD	East Bay Regional Park District
EBMUD	East Bay Municipal Utility District
EPA	U.S. Environmental Protection Agency
FSURMP	Fairfield-Suisun Urban Runoff Management Program
GM	geometric mean
MPN	most probable number
MRP	municipal regional permit
MWAT	maximum weekly average temperature
NPDES	National Pollution Discharge Elimination System
QAPP	quality assurance project plan
Region 2	San Francisco Regional Water Quality Control Board
Region 5	Central Valley Regional Water Quality Control Board
RMC	Regional Monitoring Coalition
SCVURPPP	Santa Clara Valley Urban Runoff Pollution Prevention Program
SFBRWQCB	San Francisco Bay Regional Water Quality Control Board
SMCWPPP	San Mateo Countywide Water Pollution Prevention Program
SOP	standard operating procedure
SSID	stressor/source identification
STV	statistical threshold value
SWAMP	Surface Water Ambient Monitoring Program
SWRCB	State Water Resources Control Board
WARM	warm water habitat
WAT	weekly average temperature
WQOs	water quality objectives
WY	water year
YSI	Yellow Springs International

Preface

Contra Costa County lies within both the Region 2 and Region 5 jurisdictions of the State Water Resources Control Board. The countywide stormwater program is subject to both the Region 2 Municipal Regional Stormwater National Pollutant Discharge Elimination System (NPDES) Permit (MRP)[1] and the equivalent Region 5 permit (Central Valley Permit)[2].

This Local/Targeted Creek Status Monitoring Report documents the results of targeted (non-probabilistic) monitoring performed by Contra Costa Clean Water Program (CCCWP) in water year (WY) 2016 (October 1, 2015-September 30, 2016). Together with the creek status monitoring data reported in the Regional/Probabilistic Creek Status Monitoring Report (ARC, 2017; in preparation), this submittal fulfills monitoring requirements specified in provision C.8.d of the permit, complies with reporting provision C.8.h of the MRP (SWRCB, 2015), and fulfills the monitoring requirements highlighted in Table 8.1 and the reporting requirements of provision C.8.g of the Central Valley Permit.

In early 2010, several members of the Bay Area Stormwater Management Agencies Association (BASMAA) joined together to form the Regional Monitoring Coalition (RMC) to coordinate and oversee water quality monitoring required by the MRP. The RMC includes the following stormwater program participants:

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

In accordance with the RMC Creek Status and Long-Term Trends Monitoring Plan (EOA and ARC, 2011), targeted monitoring data were collected following methods and protocols specified in the BASMAA RMC Quality Assurance Project Plan (QAPP; BASMAA, 2014a) and BASMAA RMC Standard Operating Procedures (BASMAA, 2014b). Where applicable, monitoring data were derived using methods comparable with methods specified by the California Surface Water Ambient Monitoring Program (SWAMP) QAPP[3]. Data presented in this report were also submitted to the San Francisco Estuary Institute for submittal to the State Water Resources Control Board (SWRCB) on behalf of CCCWP's permittees and pursuant to permit provision C.8.h. requirements for electronic data reporting.

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[1] The San Francisco Bay Regional Water Quality Control Board (SFBRWQCB) issued the MRP to 76 cities, counties and flood control districts (i.e., the permittees) in the Bay Area on October 14, 2009 (SFBRWQCB, 2009). On November 19, 2015, SFBRWQCB issued Order No. R2-2015-0049. This amendment supersedes and rescinds Order Nos. R2-2009-0074 and R2-2011-0083, and became effective January 1, 2016. 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 Central Valley Regional Water Quality Control Board (CVRWQCB) issued the East Contra Costa County Municipal NPDES Permit (Central Valley Permit, Order No. R5-2010-0102) on September 23, 2010 (CVRWQB, 2010).

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

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Executive Summary

This Local/Targeted Creek Status Monitoring Report documents the results of targeted monitoring performed by CCCWP during WY 2016. Together with the creek status monitoring data reported in the Regional/Probabilistic Creek Status Monitoring Report, this submittal fulfills reporting requirements for status monitoring specified under provision C.8.d of the Municipal Regional Permit (MRP) for urban stormwater issued by the San Francisco Bay Regional Water Quality Control Board (SFBRWQCB; Order No. R2-2015-0049) and for monitoring specified in Table 8.1 under provision C.8.c of the East Contra Costa County Municipal NPDES Permit (Central Valley Permit) issued by the Central Valley Regional Water Quality Control Board (CVRWQCB; Order No. R5-2010-0102). Reporting requirements for constituents under SFBRWQCB (Order No. R2-2015-0049) are established in provision C.8.d and reporting requirements for CVRWQCB (Order No. R5-2010-0102) are established in provision C.8.g.iii. Both permits follow provisions that promote a coordinated countywide program of water quality management.

Within Contra Costa County, targeted monitoring was conducted at:

- Four continuous water temperature monitoring locations
- Two continuous water quality monitoring locations
- Five pathogen indicator monitoring locations

Continuous Water Temperature

Hourly water temperature measurements were recorded at 60-minute intervals using Onset® HOBO® data loggers (HOBOs) deployed at three creeks in four separate locations on April 13, 2016. One device each was deployed in Lafayette Creek and Rimer Creek, and two devices were deployed in West Branch Alamo Creek. The HOBOs were retrieved on September 30, 2016.

Pathogen Indicators

Samples were collected on July 20, 2016 at five stations along four separate creeks in Contra Costa County. Samples were analyzed for enterococci and *E. coli.* The five sampling locations were located at Franklin Creek, Pinole Creek, Rimer Creek, and two locations along San Pablo Creek.

General Water Quality

Temperature, dissolved oxygen, pH and specific conductance were continuously monitored at 15-minute intervals by sondes during two time periods (April 15-25 and August 1-15, 2016) at Rimer Creek and at one site on West Branch Alamo Creek (204R01412).

Results of Targeted Monitoring Data

All targeted monitoring data were evaluated against numeric water quality objectives (WQOs) or other applicable criteria, as described in MRP provision C.8.d. Targeted monitoring locations for WY 2016 were located entirely within SFBRWQCB Region 2 boundaries. Therefore, numeric WQOs only as they are stated in MRP provision C.8.d will be discussed. The results are summarized below.

Temperature – HOBO and Sonde

Numeric WQOs for temperature are defined in the MRP for all streams as less than 20 percent of instantaneous results exceeding 24 °C. For streams documented to support steelhead fisheries (i.e., steelhead streams), a maximum temperature of 17 °C is used as the applicable criterion to evaluate temperature data. According to the MRP, if the temperature data is recorded by a HOBO device (versus a sonde), a maximum of one weekly average temperature (WAT) can reach a threshold of 17 °C. For temperature recorded by sonde devices, all WATs must be below 17 °C. The variation in total number of WATs signaling an exceedance are adjusted as deployment times between the two devices differ.

At the four locations with continuously recorded HOBO temperature data from April until September, two creeks (Lafayette Creek and Rimer Creek) are classified as steelhead streams. West Branch Alamo Creek, on which there were two monitoring stations, is not classified as a steelhead stream.

Temperature was continuously monitored by sondes during two time periods (April 15-25 and August 1-15, 2016) at Rimer Creek and West Branch Alamo Creek (204R01412), which were classified as steelhead and non-steelhead streams, respectively.

No location where water temperature was measured recorded an instantaneous temperature above 24 °C. There were no exceedances of this criterion. At locations classified as steelhead streams, there were exceedances of the 17 °C threshold in three of four cases. These locations were Lafayette and Rimer Creek for the HOBO recorded data, and Rimer Creek for the sonde recorded data during the August deployment.

For the purpose of this report, designated beneficial uses listed and defined by Table ES.1 as cold freshwater habitat ( ) will be discussed as steelhead streams, per the MRP definition. Streams designated as a warm freshwater habitat (WARM) are referred to as such or as a non-steelhead stream, per the MRP definition.

Table ES.1. Designated Beneficial Uses Listed in the San Francisco Bay Region Basin Plan (SFBRWQCB, 2015) for CCCWP Targeted Monitoring Sites in WY 2016

		Human Consumptive Uses							Aquatic Life Uses									Recreational Uses		
Site ID	Water Body	AGR	MUN	FRSH	GWR	IND	PROC	COMM	SHELL	COLD	EST	MAR	MIGR	RARE	SPWN	WARM	WILD	REC-1	REC-2	NAV
207R01307	Lafayette Creek									E						E	E	E	E	
204R01412	West Branch Alamo Creek				E					P			E	E	E	E	E	E	E	
204R01519	Rimer Creek[1]			E						E					E	E	E	E	E	
204R01604	West Branch Alamo Creek				E					P			E	E	E	E	E	E	E	

[1] Tributary to Moraga Creek; Moraga Creek beneficial use data used.
E = Existing beneficial use
P = Potential beneficial use

Notes: Per Basin Plan Ch. 2 (SFBRWQCB, 2015), beneficial uses for freshwater creeks include municipal and domestic supply (MUN), agricultural supply (AGR), industrial process supply (PRO), groundwater recharge (GWR), water contact recreation (REC1), noncontact water recreation (REC2), wildlife habitat (WILD), cold freshwater habitat (COLD), warm freshwater habitat (WARM), fish migration (MIGR), and fish spawning (SPWN). The San Francisco Bay Estuary supports estuarine habitat (EST), industrial service supply (IND), and navigation (NAV) in addition to all of the uses supported by streams. Coastal waters' beneficial uses include water contact recreation (REC1); noncontact water recreation (REC2); industrial service supply (IND); navigation (NAV); marine habitat (MAR); shellfish harvesting (SHELL); ocean, commercial and sport fishing (COMM); and preservation of rare and endangered species (RARE).

Dissolved Oxygen

WQOs for dissolved oxygen (DO) in non-tidal waters are applied as follows: for waters designated as steelhead habitat, less than 20 percent of instantaneous DO results may drop below 7.0 mg/L.

At those locations classified as steelhead streams, there was one exceedance during the August deployment at Rimer Creek, where 47 percent of DO concentrations were measured below the threshold.

pH

WQOs for pH in surface waters are defined as follows: less than 20 percent of instantaneous pH results may fall outside the range of 6.5 to 8.5. This range was used to evaluate the pH data collected at all targeted locations over WY 2016.

During both monitoring periods, pH measurements at West Branch Alamo Creek (204R01412) and Rimer Creek did not exceed stated WQOs.

Specific Conductance

WQOs for specific conductance in surface waters are applied as follows: less than 20 percent of instantaneous specific conductance results may exceed 2,000 µS/cm, or readings should not detect any spike in specific conductance with no obvious natural explanation.

During both monitoring periods, specific conductance measurements at both West Branch Alamo (204R01412) Creek and Rimer Creek did not exceed stated numeric WQOs. However, the August deployment in Rimer Creek displayed a spike in readings with no obvious natural explanation on August 9 beginning at approximately 06:00. Specific conductance measurements increased from recorded baseline values of 800 µS/cm, to a peak reading of 1,499 µS/cm on August 9 at 09:15. Following this spike, specific conductance levels declined for a 36-hour period until returning to baseline values of 800 µS/cm on August 10 around 21:00. This spike constitutes an exceedance as defined by MRP provision C.8.d.iv.(4)c.

Pathogen Indicator Bacteria

Single sample maximum concentrations of 130 CFU/100 ml enterococci and 410 CFU/100 ml *E. coli* (EPA, 2012) were used as water contact recreation evaluation criteria for the purposes of this evaluation. Samples for enterococci at one of the five stations (Rimer Creek) exceeded the maximum single sample concentration, while two samples for *E. coli* (Rimer Creek and Pinole Creek) exceeded the single sample maximum concentration.

All exceedances for all of the parameters above are summarized in Table ES.2.

Table ES.2 CCCWP Exceedances for Water Year 2016

Creek	Index Period	Parameter	Criterion Exceedance
Lafayette Creek	June 23-June 29, 2016; July 21-August 3, 2016	Continuous Water Temperature (HOBO)	More than one WAT exceeds 17 °C or when 20 percent of instantaneous results > 24 °C
Rimer Creek	June 2-June 8, 2016; June 23-June 29, 2016; July 21-August 3, 2016	Continuous Water Temperature (HOBO)	More than one WAT exceeds 17 °C or when 20 percent of instantaneous results > 24 °C
Rimer Creek	August 1-15, 2016	Continuous Water Temperature (sonde)	When one WAT exceeds 17 °C or when 20 percent of instantaneous results > 24 °C
Rimer Creek	August 1-15, 2016	Continuous Water Quality - DO	When 20 percent of instantaneous results drop below 7.0 mg/L
Rimer Creek	August 1-15, 2016	Continuous Water Quality - Conductivity	When 20 percent of instantaneous results exceed 2,000 µS/cm or there is a spike with no natural explanation
Rimer Creek	July 20, 2016	Enterococci	Single grab sample exceeded EPA criterion of 130 CFU/100ml
Pinole Creek	July 20, 2016	*E. Coli*	Single grab sample exceeded EPA criterion of 410 CFU/100ml
Rimer Creek	July 20, 2016	*E. Coli*	Single grab sample exceeded EPA criterion of 410 CFU/100ml

WAT = weekly average temperature

1.0 Introduction

Contra Costa County lies within the jurisdictions of both the San Francisco Bay Regional Water Quality Control Board (Region 2) and the Central Valley Regional Water Quality Control Board (Region 5). Municipal stormwater discharges in Contra Costa County are regulated by the requirements of both the MRP for urban stormwater in Region 2 (Order No. R2-2015-0049), and the East Contra Costa County Municipal NPDES Permit (Central Valley Permit) in Region 5 (Order No. R5-2010-0102)[4,5]. This Local/Targeted Creek Status Monitoring Report documents the results of targeted (non-probabilistic) monitoring performed by CCCWP during WY 2016, and complies with reporting provision C.8.h of the Region 2 Municipal NPDES permit, and provision C.8.g of the Region 5 Municipal NPDES permit for creek status monitoring data collected during WY 2016 (October 1, 2015-September 30, 2016). Together with the creek status monitoring data reported in the Regional/Probabilistic Creek Status Monitoring Report, this submittal fulfills monitoring requirements in permit provision C.8.d of the Region 2 MRP and for Table 8.1 monitoring specified in provision C.8.c of the Region 5 Central Valley Permit.

Members of BASMAA formed the RMC in early 2010 to collaboratively implement the monitoring requirements found in provision C.8 of the MRP (see Table 1.1). The BASMAA RMC developed a QAPP (BASMAA, 2014a), standard operating procedures (SOPs; BASMAA, 2014b), data management tools, and reporting templates and guidelines. Costs for these activities are shared among RMC members on a population-weighted basis by direct contributions and provision of in-kind services by RMC members to complete required tasks. Participation in the RMC is facilitated through the BASMAA Monitoring and Pollutants of Concern Committee.

The goals of the RMC are to:

1. Assist RMC permittees in complying with requirements of MRP provision C.8 (Water Quality Monitoring);
2. Develop and implement regionally consistent creek monitoring approaches and designs in the Bay Area through improved coordination among RMC participants and other agencies (e.g., regional water quality control boards, Regions 2 and 5, and the State Water Resources Control Water Board) which share common goals; and
3. Stabilize the costs of creek monitoring by reducing duplication of efforts and streamlining reporting.

The RMC divided the creek status monitoring requirements specified by permit provisions into those parameters which could reasonably be included within a regional/probabilistic design, and those which, for logistical and jurisdictional reasons, should be implemented locally using a targeted (non-probabilistic) design. The monitoring elements included in each category are specified in Table 1.2.

This report focuses on the creek status and long-term trends monitoring activities conducted to comply with provision C.8.d using a targeted (non-probabilistic) monitoring design (see Table 1.2).

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[4] The San Francisco Bay Regional Water Quality Control Board (SFBRWQCB) issued the five-year Municipal Regional Permit for Urban Stormwater (MRP, Order No. R2-2015-0049) to 76 cities, counties and flood control districts (i.e., permittees) in the Bay Area on November 19, 20215 (SFBRWQCB, 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.

[5] The Central Valley Regional Water Quality Control Board (CVRWQCB) issued the East Contra Costa County Municipal NPDES Permit (Central Valley Permit, Order No. R5-2010-0102) on September 23, 2010 (CVRWQB, 2010).

Table 1.1 Regional Monitoring Coalition 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)	City of Antioch, City of Brentwood, City of Clayton, City of Concord, Town of Danville, City of El Cerrito, City of Hercules, City of Lafayette, City of Martinez, Town of Moraga, City of Oakley, City or Orinda, City of Pinole, City of Pittsburg, City of Pleasant Hill, City of Richmond, City of San Pablo, City of San Ramon, City of Walnut Creek, Contra Costa County Flood Control and Water Conservation District and Contra Costa County Watershed Program
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

Table 1.2 Creek Status Monitoring Parameters Sampled in Compliance with MRP Provisions C.8.d. and C.8.g. as Either Regional/Probabilistic or Local/Targeted Parameters

Bioassessment , physical habitat assessment, CSCI	X	
Nutrients (and other water chemistry associated with bioassessment)	X	
Chlorine	X	
Water toxicity (wet and dry weather)	X	
Water chemistry (Pesticides, wet weather)	X	
Sediment toxicity	X	
Sediment chemistry	X	
Continuous water quality (sonde data: temperature, DO, pH, specific conductance)		X
Temperature (HOBO data loggers)		X
Bacteria		X

As a professional fisheries biologist relatively familiar with Contra Costa County streams, Scott Cressey reviewed the tabulated and graphed water quality monitoring data from WY 2016 and compared these data to the San Francisco Bay Basin Plan's (CRWQCB, 2015) beneficial use designations for these streams and the Basin Plan WQOs, especially those associated with COLD objectives. His assessment of these data were provided to ADH in a memorandum (Cressey, 2016). Relevant information from this assessment are incorporated into the narrative in the following sections, as appropriate.

The remainder of this report describes the study area and design (Section 2.0), monitoring methods (Section 3.0), results and discussion (Section 4.0), and next steps (Section 5.0).

2.0 Study Area and Design

2.1 Regional Monitoring Coalition Area

The RMC area encompasses 3,407 square miles of land in the San Francisco Bay Area. This includes the portions of the five participating counties that fall within the jurisdiction of the SFBRWQCB (Figure 2.1). Figure 2.2 illustrates the boundaries of State Water Resources Control Board (SWRCB), Regions 2 and 5, as well as the Contra Costa County delta boundaries[6]. The eastern portion of Contra Costa County drains to the CVRWQCB region (Region 5), while the rest of the county drains into Region 2. Status and trends monitoring is conducted in flowing water bodies (i.e., creeks, streams and rivers) interspersed among the RMC area, including perennial and non-perennial creeks and rivers running through both urban and non-urban areas.

2.2 Contra Costa County Targeted Monitoring Areas and Siting Rationale

Contra Costa County has 31 major watersheds and sub-watersheds containing more than 1,300 miles of creeks and drainages (CCCDD, 2003). The County's creeks discharge into the Sacramento-San Joaquin delta in the east, along the series of bays to the north (including Suisun and San Pablo bays) and to North San Francisco Bay in the west. In addition, two watersheds (Upper San Leandro and Upper Alameda Creek) originate in Contra Costa County and continue through Alameda County before reaching San Francisco Bay.

Walnut Creek, San Pablo Creek, Upper San Leandro and Upper Alameda Creek watersheds were the focus of the CCCWP's targeted sampling in WY 2016. All of the above watersheds were sampled for pathogen indicators or selected for monitoring of continuous water temperature or continuous water quality parameters. Further details and discussion about the targeted sampling areas can be found in the Monitoring Methods and Results sections of this report (Sections 3 and 4, respectively).

All targeted sampling in WY 2016 was conducted in Region 2.

2.2.1 Walnut Creek Watershed – Las Trampas Creek Subwatershed

The Walnut Creek watershed is located in central Contra Costa County, with boundaries demarcated by the west side of Mount Diablo and the east side of the East Bay Hills. At 93,556 acres, it is the largest watershed in the county. The watershed has eight major tributaries which flow into the generally south-north trending direction of Walnut Creek. These tributaries include San Ramon Creek, Bollinger Creek, Las Trampas Creek, Lafayette Creek, Grayson Creek, Murderers Creek, Pine Creek, and Galindo Creek.

Due to steep slopes and land protection efforts, the upper watersheds along the perimeter of the Walnut Creek watershed generally remain undeveloped open space. The valleys of the watershed are densely urbanized and populated by the cities of Walnut Creek, Lafayette, Pleasant Hill and Danville. The cities of Concord, Martinez, and small areas of Moraga and San Ramon also are partly within the watershed (Walkling, 2013).

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[6] Divide between the basin boundary watershed/hydrologic sub basins within the Sacramento-San Joaquin Rivers and Delta Waterways.

Walnut Creek has the second longest running stream length in the county at 28.74 miles. Its highest elevation lies at 3,849 feet, while the mouth joins sea level at Suisun Bay. An estimated 71.5 percent of its stream channel remains in a natural state, with the remaining portion containing man-made reinforcements. Estimated impervious surfaces make up 30 percent of its watershed. Walnut Creek's estimated mean daily flow is 81.4 cubic feet per second (CCCDD, 2003).

Figure 2.1 Map of BASMAA RMC Area, County Boundaries and Major Creeks

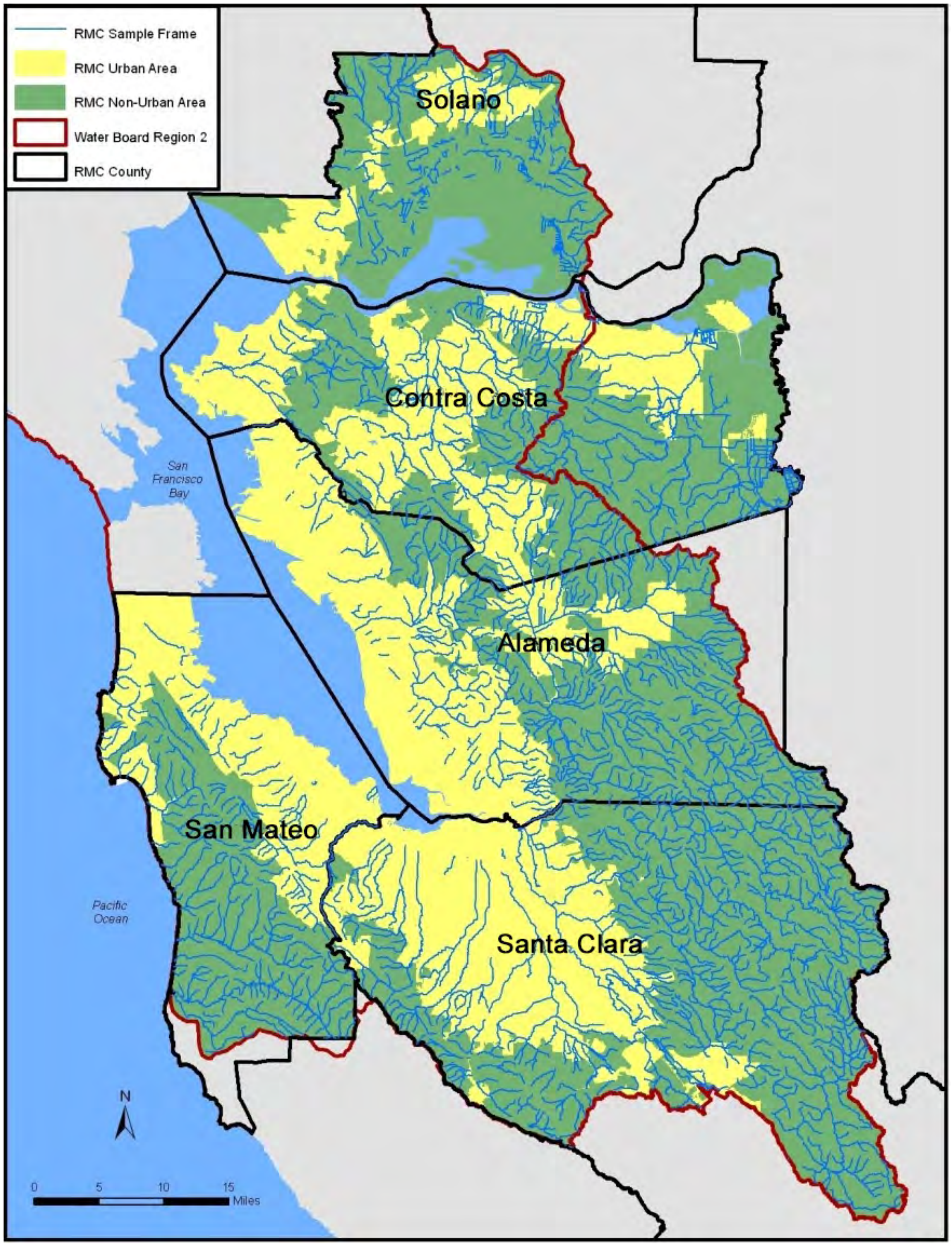
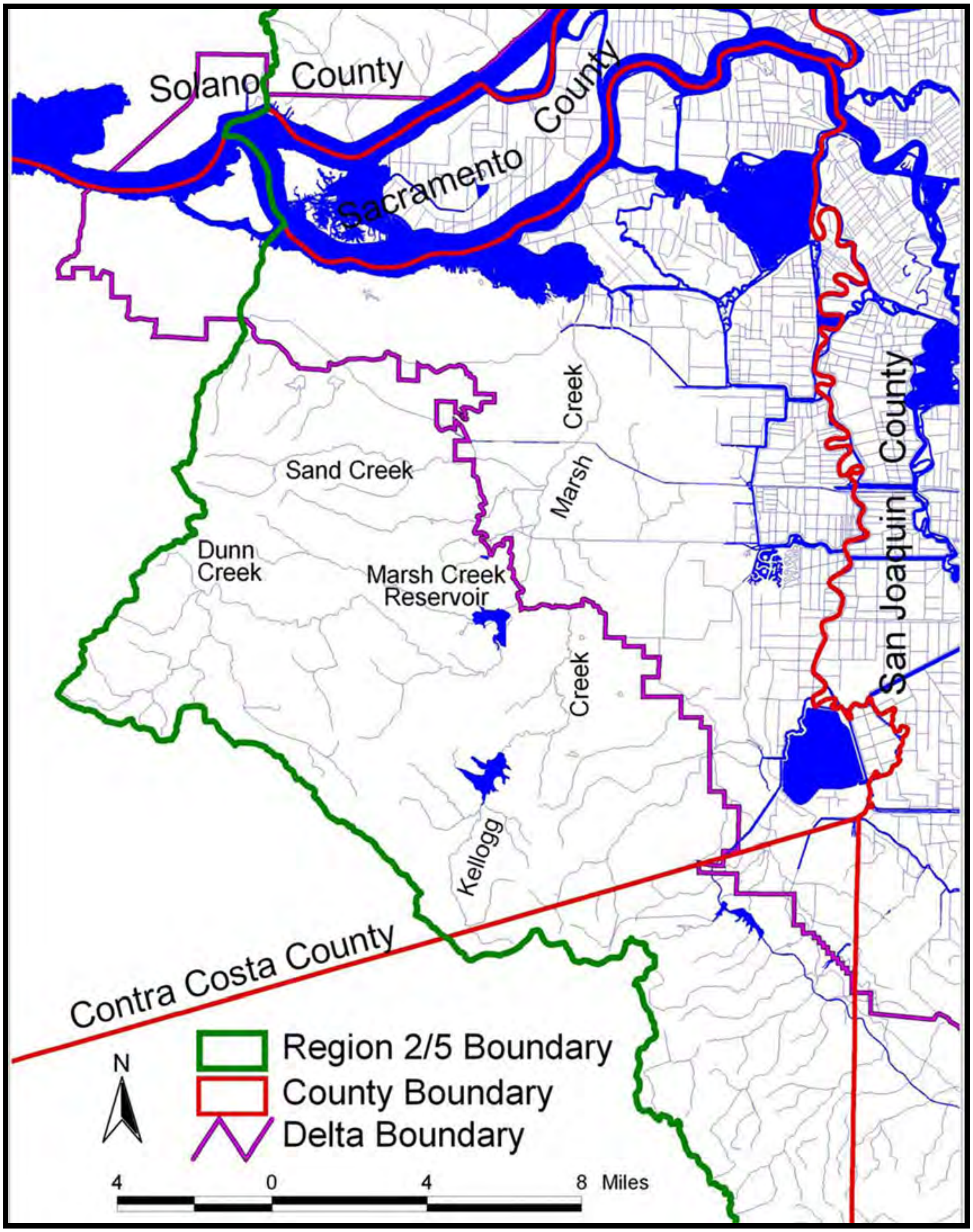


Figure 2.2 State Water Resources Control Board Region 2 and 5 Boundaries (Source Map: CVRWQB 2010)



There is one location in the Walnut Creek watershed, Lafayette Creek, which is selected for targeted monitoring in WY 2016. Lafayette Creek is a three mile long tributary of Las Trampas Creek which eventually joins with San Ramon Creek to form Walnut Creek on the south side of the City of Walnut Creek. The 17,238-acre Las Trampas Creek subwatershed is predominantly natural with 79.1 percent of the 64.1 miles of channel containing no obvious reinforcements. Impervious surface in the Las Trampas Creek subwatershed is calculated at 13.5 percent (CCCDD, 2003).

Historically, Lafayette Creek likely had a population of steelhead, but steelhead are not present in this creek today (Leidy et al., 2005). Leidy found no salmonids in Lafayette Creek in 1980 and 1999, but states rainbow trout were reported in Lafayette Creek as recently as 2002. However, those fish are believed to come from Lafayette Reservoir and transported into the creek by storm flows and spill events. The 2015 Basin Plan designates Lafayette Creek as having both COLD and WARM beneficial uses. This indicates the upstream portion of this creek has year round water temperatures suitably cold to support salmonids, but the lower portions of the creek are too warm to support salmonids through the summer. The location of targeted temperature monitoring for WY 2016 within Lafayette Creek was selected along the upper portion of the stream to monitor the potential to support cold water fisheries.

2.2.2 San Pablo Creek Watershed

The full watershed of San Pablo Creek is 27,640 acres, arising in the City of Orinda at a maximum elevation of 1,905 feet and flowing westerly 19.65 miles to San Pablo Bay. After leaving Orinda, San Pablo Creek flows across East Bay Municipal Utility District (EBMUD) land into San Pablo Reservoir. Water releases from San Pablo Dam to feed lower San Pablo Creek, where it flows through first rural, then heavily urbanized residential and commercial property. Earth or concrete channelized portions of San Pablo Creek amount to 10.6 percent of the entire channel and occur as it passes through the City of San Pablo. Impervious surface in the San Pablo Creek watershed is calculated at 20 percent (CCCDD, 2003).

With a heavily urbanized area in the lower end of the San Pablo Creek watershed, the Contra Costa County Flood Control District and Clean Water Program expressed interest in further investigating the relation between illegal encampments and adverse water quality (CCCFCD, 2013). Two locations were targeted for pathogen indicator sampling in the lower San Pablo Creek watershed for WY 2016 due to the potential for public contact with the creek within the vicinity of active illegal encampments. The San Pablo Creek watershed was not targeted for water temperature monitoring during WY 2016.

2.2.3 Upper Alameda Creek Watershed – Alamo/Tassajara Subwatershed

One of the largest watersheds in the Bay Area, the Alameda Creek watershed, stretches from the Mount Diablo foothills in the north to Mount Hamilton in the south. A little less than a tenth of that watershed lies in Contra Costa County. In the Contra Costa County portion of the watershed, targeted monitoring was performed in the Alamo/Tassajara Creeks subwatershed. This 26,390-acre watershed is predominantly natural with 97.1 percent of the 100.99 miles of channel containing no obvious reinforcements. Impervious surface in the Alamo/Tassajara subwatershed is calculated at 10 percent (CCCDD, 2003).

Targeted monitoring was performed at two locations in West Branch Alamo Creek, which merges with the main stem of Alamo Creek and eventually South San Ramon Creek. The waters then enter the Alamo Canal and flow south into Alameda County to the Arroyo de la Laguna, and then into Alameda Creek. It is not known if Alamo Creek ever supported steelhead trout, but Leidy et al. (2005) reports no steelhead in the creek at present. The 2015 Basin Plan states Alamo Creek has a “potential beneficial use” as COLD, but its present designation is WARM.

Two targeted monitoring stations were selected along West Branch Alamo Creek. The upstream monitoring station is located near Fox Creek Road in Danville (204R01604), and the downstream monitoring station (204R01412) was along Red Willow Road in the City of San Ramon. The two sites bracket a small impoundment, and were selected to investigate the impact of the impoundment on the downstream corridor temperatures, which are currently affecting the designated beneficial use (ADH, 2015).

2.2.4 Upper San Leandro Creek Watershed – Moraga Creek Subwatershed

The Upper San Leandro and Moraga Creek watersheds (containing 13,059 acres) are located within Contra Costa County. These creeks flow into the Upper San Leandro Reservoir, managed by EBMUD. The reservoir spans the county line and its outlet is in Alameda County. Water then flows through Alameda County to the San Francisco Bay (CCCDD, 2003).

The channels of the creeks throughout the area are relatively unmodified, with 93.8 percent of the 50.47 miles of stream channel containing no obvious reinforcements. Within Contra Costa County, the southern extent of Orinda and a major portion of Moraga are the local jurisdictions in the area. Portions of Moraga Creek are routed underground to accommodate urbanization and infrastructure-based development. Targeted monitoring for WY 2016 took place in Rimer Creek as it runs through the urban developments in the City of Moraga.

Rimer Creek is a relatively short creek (3.14 miles), entering Moraga Creek shortly before it flows into Upper San Leandro Reservoir on San Leandro Creek. Via San Leandro Creek, Rimer Creek’s waters eventually flow into San Francisco Bay. Historically, steelhead migrated up San Leandro Creek to its headwater tributaries, including Rimer Creek (Leidy et al., 2005). There are presently three reservoirs on San Leandro Creek located between Rimer Creek and the San Francisco Bay: Upper San Leandro Reservoir, Lower San Leandro Reservoir, and Lake Chabot, located 6.2 miles above San Francisco Bay. The construction of Chabot Reservoir in 1875 blocked the historical run of steelhead to the upstream portions of San Leandro Creek and its tributaries, including Rimer Creek (Leidy et al., 2015).

Creeks flowing in the Upper San Leandro and Moraga Creek watersheds mostly all support populations of resident rainbow trout. Leidy et al. (2005) report that both California Department of Fish and Wildlife (CDFW) electrofishing in 1987 and East Bay Regional Park District (EBRPD) in 1990 found rainbow trout in Moraga Creek which migrate up Rimer Creek to spawn and rear a portion of their juveniles. For this purpose, Rimer Creek was targeted for water temperature and continuous water quality monitoring during WY 2016.

2.3 Contra Costa Targeted Monitoring Design

During WY 2016 (October 1, 2015-September 30, 2016), water temperature, continuous water quality, and pathogen indicators were monitored at the targeted locations listed in Table 2.1 and illustrated in the Figure 2.3 overview map.

Site locations were identified using a targeted monitoring design based on the directed principle[7] to address the following management questions:

1. What is the range of continuous water quality measurements at targeted sites of interest?
2. Do continuous water quality measurements indicate potential impacts to aquatic life?
3. What are the pathogen indicator concentrations at creek sites where water contact recreation may occur?

Within Contra Costa County, targeted monitoring was conducted with the following:

- Four continuous water temperature monitoring locations
- Two continuous water quality monitoring locations
- Five pathogen indicator monitoring locations

Table 2.1 Targeted Sites and Local Reporting Parameters Monitored in Water Year 2016 in Contra Costa County

Site Code	Creek Name	Latitude	Longitude	Temperature	Continuous Water Quality	Pathogen Indicators
207R01307	Lafayette Creek	37.88772	-122.13563	X		
204R01412	West Branch Alamo Creek	37.78795	-121.92410	X	X	
207R01447	Franklin Creek	37.99012	-122.13346			X
206R01495	Pinole Creek[1]	37.97844	-122.26257			X
204R01519	Rimer Creek	37.81545	-122.11620	X	X	X
206R01536	Ohlone Creek	38.00738	-122.27424			
204R01604	West Branch Alamo Creek	37.81911	-121.89583	X		
206SPA061	San Pablo Creek[1]	37.96283	-122.34562			X
206SPA062	San Pablo Creek[1]	37.96293	-122.34497			X

[1] Target site code assigned.

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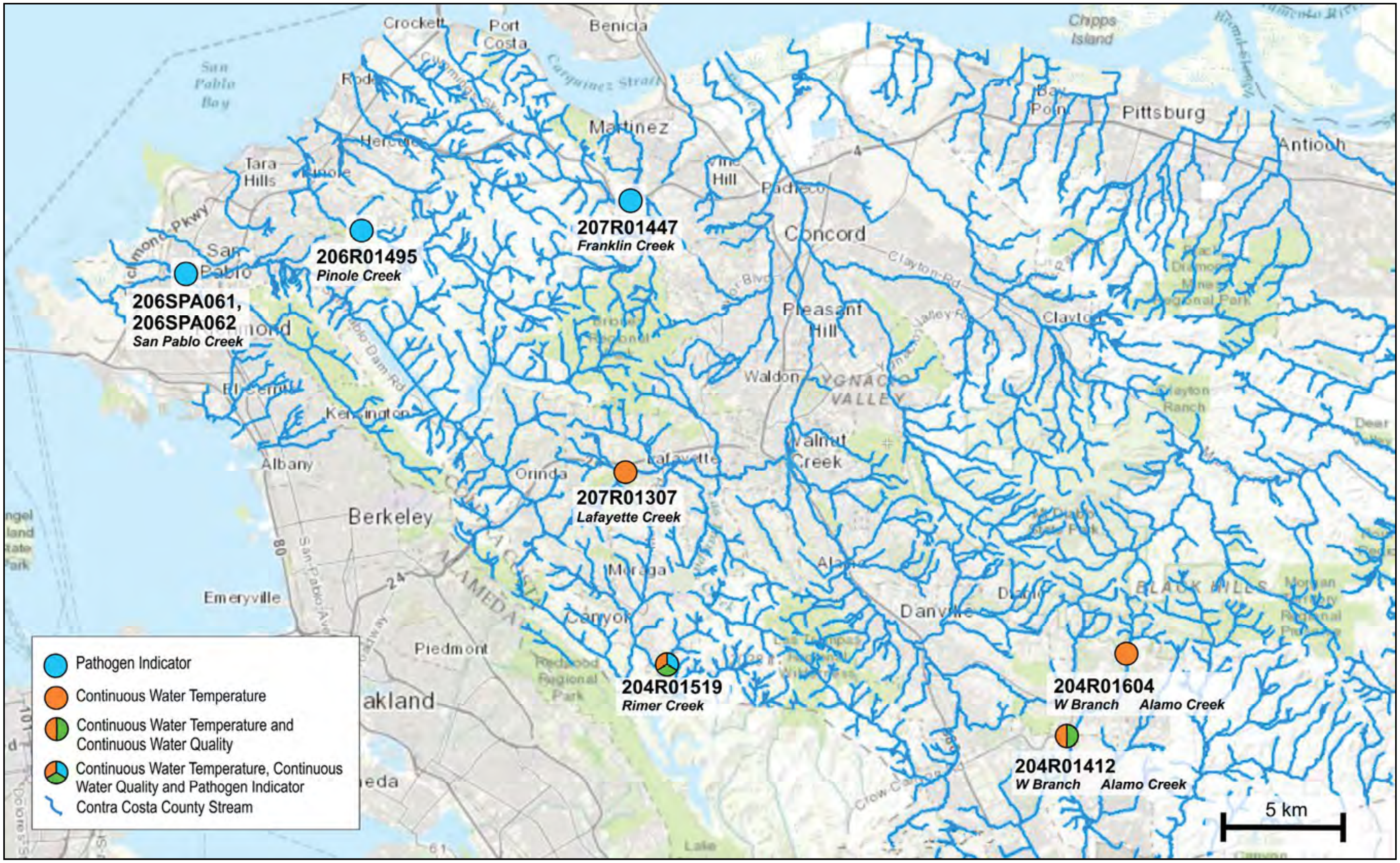
[7] Directed Monitoring Design Principle: A deterministic approach in which points are selected deliberately based on knowledge of their attributes of interest as related to the environmental site being monitored. This principle is also known as "judgmental," "authoritative," "targeted," or "knowledge-based."

Figure 2.3 Overview of Targeted Sites Monitored by CCCWP in Water Year 2016



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3.0 Monitoring Methods

Targeted monitoring data were collected in accordance with the BASMAA RMC QAPP (BASMAA, 2016a) and BASMAA RMC SOP (BASMAA, 2016b). Where applicable, monitoring data were collected using methods comparable to those specified by the SWAMP QAPP[8], and were submitted in SWAMP-compatible format by CCCWP to the SFBRWQCB and the CVRWQCB on behalf of CCCWP permittees and pursuant to provision C.8.h.

3.1 Data Collection 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). These documents are updated as needed to maintain current and optimal applicability. The SOPs were developed using a standard format that describes health and safety precautions and considerations, relevant training, site selection, and sampling methods/procedures, including pre-fieldwork mobilization activities to prepare equipment, sample collection, and demobilization activities to preserve and transport samples.

The monitoring locations for continuous water quality parameters (DO, specific conductivity, pH, and temperature) were located in West Branch Alamo Creek and Rimer Creek for this monitoring year, as discussed below.

3.1.1 Continuous Water Quality Measurements

Continuous water quality monitoring equipment (YSI 6600 V2 sondes) were deployed over two time periods at one location each in both West Branch Alamo Creek and Rimer Creek. Continuous water quality parameters (DO, specific conductivity, pH, and temperature) were recorded every 15 minutes. The equipment was deployed for two time periods at each creek as follows:

- West Branch Alamo Creek: Once during spring concurrent with bioassessment sampling (April 15-25) and once during summer (August 1-15)
- Rimer Creek: Once during spring concurrent with bioassessment sampling (April 15-25) and once during summer (August 1-15)

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

3.1.2 Continuous Temperature Monitoring

In WY 2016, CCCWP monitored water temperature at four locations in the county. Digital temperature loggers (Onset HOBO Water Temp Pro V2) were deployed at each of the following locations: Lafayette Creek, West Branch Alamo Creek, and Rimer Creek. Hourly temperature measurements were recorded at each respective site from April 13, 2016 to September 30, 2016.

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

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

3.1.3 Pathogen Indicator Sampling

In compliance with permit requirements, a set of pathogen indicator samples was collected on July 20, 2016 at five locations. All five sampling locations were selected based upon their potential to detect anthropogenic sources of contamination or targeted due to site location within public parks, giving increased potential of public contact with waterways. Pathogen indicator samples for enterococci and *E. coli* were analyzed at all sites.

Sampling techniques included direct filling of containers and immediate transfer of samples to analytical laboratories within specified holding time requirements. Procedures used for sampling and transporting samples are described in RMC SOP FS-2 (BASMAA, 2016b).

3.2 Quality Assurance/Quality Control

Data quality assessment and quality control procedures are described in detail in the BASMAA RMC QAPP (BASMAA, 2016a). Data quality objectives were established to ensure data collected are of adequate quality and sufficient for the intended uses. Data quality objectives address both quantitative and qualitative assessment of the acceptability of data. The qualitative goals include representativeness and comparability. The quantitative goals include specifications for completeness, sensitivity (detection and quantization limits), precision, accuracy, and contamination. Data were collected according to the procedures described in the relevant BASMAA RMC SOPs (BASMAA, 2016b), including appropriate documentation of data sheets and samples, and sample handling and custody. Laboratories providing analytical support to the RMC were selected based on demonstrated capability to adhere to specified protocols.

3.3 Data Quality Assessment Procedures

Following completion of the field and laboratory work, the field data sheets and laboratory reports were reviewed by the local quality assurance officer, and compared against the methods and protocols specified in the RMC SOPs and QAPP. The findings and results were then evaluated against the relevant data quality objectives to provide the basis for an assessment of programmatic data quality. A summary of data quality steps associated with water quality measurements is shown in Table 3.1. The data quality assessment consisted of the following elements:

- Conformance with field and laboratory methods, as specified in RMC SOPs and QAPP, including sample collection and analytical methods, sample preservation, sample holding times, etc.
- Numbers of measurements/samples/analyses completed versus planned, and identification of reasons for any missed samples.
- Temperature data were checked for accuracy by comparing measurements taken by HOBOs with National Institute of Standards Technology thermometer readings in room temperature water and ice water.

- Continuous water quality data were checked for accuracy by comparing measurements taken before and after deployment with measurements taken in standard solutions to evaluate potential drift in readings.
- Quality assessment laboratory procedures for accuracy and precision (i.e., lab duplicates and lab blanks) were not implemented for pathogen samples collected this year, but will be in subsequent years.

Table 3.1 Data Quality Steps Implemented for Temperature and Continuous Water Quality Monitoring

Step	Temperature (HOBOs)	Continuous Water Quality (Sondes)
Pre-event calibration / accuracy check conducted	X	X
Readiness review conducted	X	X
Check field datasheets for completeness	X	X
Post-deployment accuracy check conducted		X
Post-sampling event report completed	X	X
Post-event calibration conducted		X
Data review-compare drift against SWAMP MQOs		X
Data review-check for outliers / out of water measurements	X	X

3.4 Data Analysis and Interpretation

Targeted monitoring data were evaluated against WQOs or other applicable thresholds, as described in provision C.8.d of the MRP and Table 8.1 of the Central Valley Permit. Table 3.2 defines thresholds used for selected targeted monitoring parameters, as they apply to WY 2016. The subsections below provide details on thresholds selected and the underlying rationale.

Table 3.2 Requirements for Follow-Up for Local/Targeted Creek Status Monitoring Results Per MRP Provision C.8.d

Constituent	Trigger Level[1]	MRP 2 Provision	Provision Text
Temperature	≥ 2 weekly averages > 17 °C (steelhead streams); or 20% of results > 24 °C instantaneous maximum (per station)	C.8.d.iii.(4)	The temperature trigger is defined as when two or more WAT[2] measurements exceed the MWAT[3] of 17 °C for a steelhead stream, or when 20 percent of the results at one sampling station exceed the instantaneous maximum of 24 °C. Permittees shall calculate the WAT by breaking the measurements into non-overlapping, 7-day periods.
Temperature (continuous, sonde)	A weekly average >17.0°C (steelhead streams); OR 20% of results >24.0°C instant. max. (per station)	C.8.d.iv.(4)a.	The temperature trigger is defined as any of the following: MWAT exceeds 17 °C for a steelhead stream or 20 percent of the instantaneous results exceed 24 °C. The permittees shall calculate the WAT by separating the measurements into non-overlapping, 7-day periods.
pH (continuous, sonde)	≥ 20% results < 6.5 or > 8.5	C.8.d.iv.(4)b.	The pH trigger is defined as 20 percent of instantaneous pH results are < 6.5 or > 8.5.
Electrical conductivity (continuous, sonde)	≥ 20% results > 2000 µS	C.8.d.iv.(4)c.	The conductivity trigger is defined as 20 percent of the instantaneous specific conductance results are >2000 µS or there is a spike in readings with no obvious natural explanation.
Dissolved Oxygen (continuous, sonde)	≥ 20% results < 7 mg/L (cold water fishery streams)	C.8.d.iv.(4)d.	The DO trigger is defined as 20 percent of instantaneous DO results are < 7 mg/L in a cold fishery stream.
Enterococci	>130 CFU/100 mL	C.8.d.v.(4)	If the EPA's statistical threshold value for 36 per 1000 primary contact recreators is exceeded, the water body reach shall be identified as a candidate SSID[4] project. (Per RMC/SFBRWQCB staff agreement, CFU and MPN units are deemed to be comparable for this purpose.)
E. coli	> 410 CFU/100 mL	C.8.d.v.(4)	If the EPA's statistical threshold value for 36 per 1000 primary contact recreators is exceeded, the water body reach shall be identified as a candidate SSID project. (Per RMC/SFBRWQCB staff agreement, CFU and MPN units are deemed to be comparable for this purpose.)

[1] Per MRP provision C.8.d., these are the data thresholds that trigger listings as candidate SSID projects per MRP provision C.8.e.
[2] WAT = weekly average temperature
[3] MWAT = maximum weekly average temperature
[4] SSID = stressor/source identification

3.4.1 Dissolved Oxygen (DO)

The Basin Plan (SFBRWQCB, 2015) lists WQOs for DO in non-tidal waters as follows: 7.0 mg/L minimum for waters designated as COLD (i.e., a steelhead stream). Although this WQO is suitable criteria for an initial evaluation of water quality impacts, further evaluation may be needed to determine the overall extent and degree that cold water beneficial uses are supported at a site. For example, further analyses may be necessary at sites in lower reaches of a water body that may not support salmonid spawning or rearing habitat, but may be important for upstream or downstream fish migration. In these cases, DO data will be evaluated for the salmonid life stage and/or fish community that is expected to be present during the monitoring period. Such evaluations of both historical and current ecological conditions will be made, where possible, when evaluating water quality information.

To evaluate the results against the relevant trigger in MRP section C.8.d, the DO data were evaluated to determine whether 20 percent or more of the measurements were below the applicable WQOs.

3.4.2 pH

WQOs for pH in surface waters are stated in the Basin Plan (SFBRWQCB, 2015) as follows: the pH shall not be depressed below 6.5 nor raised above 8.5. This range was used in this report to evaluate the pH data collected from creeks.

To evaluate the results against the relevant trigger in MRP provision C.8.d, the pH data were evaluated to determine whether 20 percent or more of the measurements were outside of the WQOs.

3.4.3 Pathogen Indicators

In 2012, the U.S. Environmental Protection Agency (EPA) released its recreational water quality criteria recommendations for protecting human health in all coastal and non-coastal waters designated for primary contact recreation use. The RWQC includes two sets of recommended criteria, as shown in Table 3.3. Primary contact recreation is protected if either set of criteria recommendations are adopted into state water quality standards. However, these recommendations are intended as guidance to states, territories and authorized tribes in developing water quality standards to protect swimmers from exposure to water containing organisms that indicate the presence of fecal contamination. They are not regulations themselves (EPA, 2012), but are considered to represent “established thresholds” for purposes of evaluating threshold triggers per the MRP and Central Valley Permit. In regard to the EPA 2012 RWQC standard threshold values, since the geometric mean (GM) cannot be determined from the data collected, the only applicable recommended exceedance is the *E. coli* standard threshold values (STV) of 410 colony forming units (CFU) per 100 ml and 320 CFU/ml, for Recommendation 1 and 2, respectively. For interpretive purposes, CFU and most probable number (MPN) are considered equivalent.

Section C.8.d.v of the MRP requires use of the EPA statistical threshold value for 36/1000 primary contact recreation for determining if a pathogen indicator collection sample site is a candidate for a stressor/source identification *(*SSID) project.

Table 3.3 EPA 2012 Recreational Water Quality Criteria

Criteria Elements	Recommendation 1 Estimated Illness Rate 36/1,000		Recommendation 2 Estimated Illness Rate 32/1,000	
Indicator	GM (CFU/100 mL)	STV (CFU/100 mL)	GM (CFU/100 mL)	STV (CFU/100 mL)
Enterococci	35	130	30	110
E.coli (fresh)	126	410	100	320

3.4.4 Temperature

Temperature is one indicator of the ability of a water body to support a salmonid fisheries habitat (e.g., a steelhead stream). In California, the beneficial use of a steelhead stream is generally associated with suitable spawning habitat and passage for anadromous fish.

In Section C.8.d.iii.(4) of the MRP, the temperature trigger threshold specification is defined as follows:

> “The permittees shall identify a site for which results at one sampling station exceed the applicable temperature trigger or demonstrate a spike in temperature with no obvious natural explanation as a candidate SSID project. The temperature trigger is defined as when two or more weekly average temperatures exceed …17 °C for a steelhead stream,

> or when 20 percent of the results at one sampling station exceed the instantaneous maximum of 24 °C."

In Section C.8.d.iv.(4).a of the MRP, which deals with continuous monitoring of DO, temperature and pH, the temperature trigger threshold specification is defined as follows:

> "…(the) maximum weekly average temperature exceeds 17 °C for a steelhead stream, or 20 percent of the instantaneous results exceed 24 °C."

The first cited section applies to temperature data recorded by the HOBO devices through the period of April to September 2016. The second cited section applies to temperature data recorded by the YSI sonde devices during the two periods in April and August, 2016.

In either case, the WAT was calculated as the average of seven daily average temperatures in non-overlapping seven day periods. In all cases of the recorded temperature data, the first day's data was not included in the WAT calculations to eliminate the probable high bias of the average daily temperature of that day because the recording devices were all deployed during daylight hours – the typically warmer part of a standard 24-hour day. As the WATs were calculated over the disjunctive seven-day periods, the last periods which did not contain a full seven days of data were also excluded from the calculations.

In compliance with the cited sections of the MRP, sites for which results exceeded the applicable temperature trigger were identified as candidates for a SSID project in the following three ways:

1. If a site had temperature recorded by a HOBO device, and two or more WATs calculated from the data were above 17 °C.
2. If a site had temperature recorded by a YSI sonde device, and one or more WATs calculated from the data were above 17 °C. This is equivalent to determining the MWAT at one of these sites was above 17 °C for the period in question.
3. If a site had 20 percent of its instantaneous temperature results above 24 °C, regardless of the recording device.

As the maximum recorded temperature at all sites during all deployments was 22.7 °C, none were identified as SSID candidates based upon the third criterion cited above.

The potential responsive action to the analysis of temperature as it relates to fish habitat in Lafayette Creek, West Branch Alamo Creek, and Rimer Creek is discussed below. After a brief description of the site locations monitored, the potential responsive action to the analysis of temperature as it relates to fish habitats follows.

3.4.4.1 Lafayette Creek

The WY 2016 water temperature monitoring station (207R01307) on Lafayette Creek was located south of Mt. Diablo Boulevard in Lafayette. Lafayette Creek is a 3-mile long tributary of Las Trampas Creek, which eventually joins with San Ramon Creek to form Walnut Creek on the south side of the City of Walnut Creek. The 2015 edition of the Basin Plan for the San Francisco Bay Region designates Lafayette Creek as having both COLD and WARM beneficial uses. This indicates the upstream portion of this creek has year-round water temperatures suitably cold enough to support salmonids, but the lower portions of the creek are too warm to support salmonids through the summer. As discussed in Section 2.2.1, monitoring at Lafayette Creek was specifically targeted in the upper watershed in an effort to focus on the creek's potential to support cold water fisheries.

3.4.4.2 West Branch Alamo Creek

There were two water temperature monitoring stations located in West Branch Alamo Creek for WY 2016. The downstream location (204R01412) is located by Red Willow Park in the City of San Ramon and the upstream location (204R01604) is located within a private country club, in the unincorporated community of Blackhawk. The distance between the two locations is approximately 3.3 miles as the stream flows down the riparian corridor.

The waters of West Branch Alamo Creek drain into Alameda County. Shortly after merging with the main stem of Alamo Creek and South San Ramon Creek, the waters of West Branch Alamo Creek enter the Alamo Canal and flow south into Alameda County to the Arroyo de la Laguna and then into Alameda Creek. It is not known if Alamo Creek ever supported steelhead, but Leidy et al. (2005) reports there are no steelhead/rainbow trout in the creek at present. The 2015 Basin Plan states Alamo Creek has a “potential beneficial use” as a COLD habitat, but its present designation is as a WARM habitat. Leidy et al. (2005) found no indication Alamo Creek and its branches presently support resident rainbow trout. This creek is not considered to be a steelhead stream.

3.4.4.3 Rimer Creek

The water quality and water temperature monitoring devices located on Rimer Creek (204R01519) were deployed in a section of natural stream, west of Camino Pablo in the City of Moraga. Rimer Creek is a relatively short creek that enters Moraga Creek shortly before it flows into Upper San Leandro Reservoir on San Leandro Creek. Via San Leandro Creek, Rimer Creek’s waters eventually flow into San Francisco Bay. Historically, steelhead migrated up San Leandro Creek to its headwater tributaries, including Rimer Creek (Leidy et al., 2005). There are presently three reservoirs on San Leandro Creek located between Rimer Creek and San Francisco Bay: Upper San Leandro Reservoir, Lower San Leandro Reservoir, and Lake Chabot, located 6.2 miles above San Francisco Bay. The construction of Chabot Reservoir in 1875 blocked the historical run of steelhead to the upstream portions of San Leandro Creek and its tributaries, including Rimer Creek, but a remnant population of steelhead still spawn downstream of Lake Chabot when rains and runoff are suitable (Leidy et al., 2015).

San Leandro Creek’s tributaries flowing into Upper San Leandro Reservoir or above it mostly all support populations of resident rainbow trout. In 1984, the EBRPD obtained 53 yearling rainbow trout from nearby Redwood Creek and performed genetic analysis on them. The results showed these fish were non-hybridized descendants of the coastal anadromous steelhead which once spawned throughout the San Leandro Creek watershed and were trapped in the upper watershed when the dams were built. Therefore, although the upper watershed’s rainbow trout are presently resident fish, their genetic stock appears to be that of San Leandro Creek’s original population of anadromous steelhead un-hybridized with stocked rainbow trout from hatcheries (Leidy, et al., 2005).

Leidy et al. (2005) reports both CDFW electrofishing in 1987 and EBRPD in 1990 found rainbow trout in Moraga Creek. The Leidy report contains a map showing historical and present steelhead/rainbow trout populations in Alameda County creeks, and Moraga Creek is depicted as having a “definite run or population” of *O. mykiss*. Bert Mulchaey of EBMUD confirmed (personal communication between Scott Cressey and Bert Mulchaey, December 15, 2016) rainbow trout from Upper San Leandro Reservoir migrate up Rimer Creek to spawn and rear a portion of their juveniles. Based on this information, it is assumed Rimer Creek, a tributary to lower Moraga Creek, also supports a resident rainbow trout population carrying the genetic stock of the original steelhead of San Leandro Creek. Likely supporting a viable population of rainbow trout, Rimer Creek is considered a steelhead stream for the purpose of this report (Cressey, 2016).

4.0 Results

4.1 Statement of Data Quality

Field data sheets and laboratory reports were reviewed by the local quality assurance officer, and the results evaluated against the relevant data quality objectives. Results were compiled for qualitative metrics (representativeness and comparability) and quantitative metrics (completeness, precision, accuracy). The following summarizes the results of the data quality assessment:

- Temperature data from HOBOs were collected from four stations. HOBOs were deployed on April 13, 2016 and remained deployed until the target pickup date of September 30, 2016. One hundred percent of the expected data was collected at three out of four locations: Lafayette Creek (207R01307), the downstream location of West Branch Alamo Creek (204R01412), and Rimer Creek (204R01519), while 71 percent of the expected data was collected at the upstream location on West Branch Alamo Creek (204R01604). This location logged an incomplete set of temperature data for the following reason:
    - The HOBO at station 204R01604 (upstream location of West Branch Alamo Creek), experienced a drop in surface flow conditions, exposing the stream bed. The monitoring device could no longer be submerged and temperature data past August 11 at 07:00 no longer reflect water temperature. This resulted in a data loss due to seasonal conditions.
- Continuous water quality data (temperature, pH, DO, conductivity) were collected during the spring and summer seasons; 100 percent of the expected data was collected.
- Continuous water quality data generally met measurement quality objectives (accuracy) as presented in Table 4.1.
- Quality assurance laboratory procedures were implemented for pathogen indicator analyses this year. All quality assurance samples successfully met data quality objectives.

Table 4.1 Accuracy[1] Measurement Taken for DO, pH and Specific Conductivity

Parameter	Measurement Quality Objectives	Site 204R01412 West Branch Alamo Creek		Site 204R01519 Rimer Creek	
		Event 1[2]	Event 2[2]	Event 1[2]	Event 2[2]
DO (mg/l)	± 0.2 mg/L	0.31	0.34	0.31	0.0
pH 7.0	± 0.2	0.04	0.11	-0.05	0.12
pH 10.0	± 0.2	-0.11	-0.16	-0.07	0.13
Specific conductivity (µS/cm)	± 2 µS/cm	0.0	0.24	0.0	0.0

[1] Accuracy of the water quality measurements were determined by calculating the difference between the YSI sonde readings using a calibration standard versus the actual concentration of the calibration standard. The results displayed are those taken following measurements taken within the stream, defined as "post calibration" as opposed to the "pre calibration values", where all the YSI sonde probes were offset to match the calibration standard prior to deployment.

[2] Values in **Bold** exceed the data quality objectives.

4.2 Water Quality Monitoring Results

4.2.1 Water Temperature

Summary statistics for water temperature data collected at the four continuous monitoring locations from April to September 2016 are shown in Table 4.2. At Lafayette Creek, the downstream location of West Branch Alamo Creek (Red Willow Road) and Rimer Creek, approximately 171 days of hourly temperature data was collected. All data was collected successfully with no device issues or equipment movement, resulting in 100 percent capture of targeted data. At the upstream location of West Branch Alamo Creek (Fox Creek Drive), approximately 121 days of hourly temperature data were recorded. Water temperatures measured at each station, along with the WAT threshold of 17 °C for juvenile salmonid rearing, are illustrated in Figures 4.1, 4.2 and 4.3.

Table 4.2 Descriptive Statistics for Continuous Water Temperature Measured at Four Sites in Contra Costa County (Lafayette Creek, West Branch Alamo Creek, and Rimer Creek), April 13-September 30, 2016

Site	207R01307	204R01412	204R01519	204R01604
Temperature	Lafayette Creek	West Branch Alamo Creek (Red Willow Rd)	Rimer Creek	West Branch Alamo Creek (Fox Creek Dr)
Minimum	11.69	10.32	10.30	10.32
Median	15.63	15.92	15.89	15.77
Mean	15.62	15.72	15.86	15.60
Maximum	20.53	22.59	21.39	22.58
MWAT[1]	18.14	19.41	17.77	17.19
Number of Measurements	4,077	4,074	4,077	2,875

[1] The maximum of the 7-day average of the daily average temperature

The minimum and maximum temperature for all four stations was 10.30 °C and 22.59 °C, respectively. The median temperature range for all four stations was 15.63 °C to 15.92 °C, and the MWAT range was 18.14 °C to 19.41 °C.

Figure 4.1 Water Temperature Data Collected Using HOBOs at Four Sites in Contra Costa County (Lafayette Creek, West Branch Alamo Creek, Rimer Creek), April 13-September 30, 2016

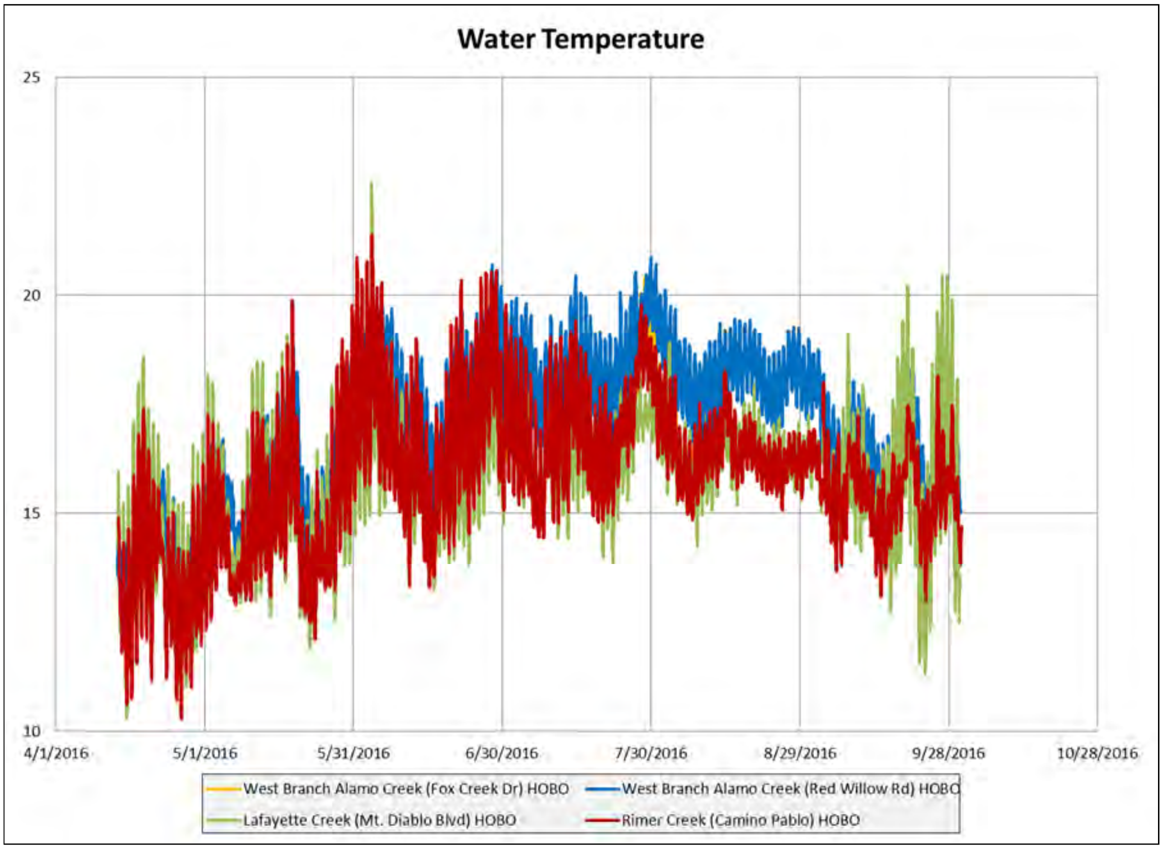


Figure 4.2 Weekly Average Maximum Temperature Data Collected Using HOBOs ® at Four Sites in Contra Costa County (Lafayette Creek, West Branch Alamo Creek, Rimer Creek), April 13-September 30, 2016

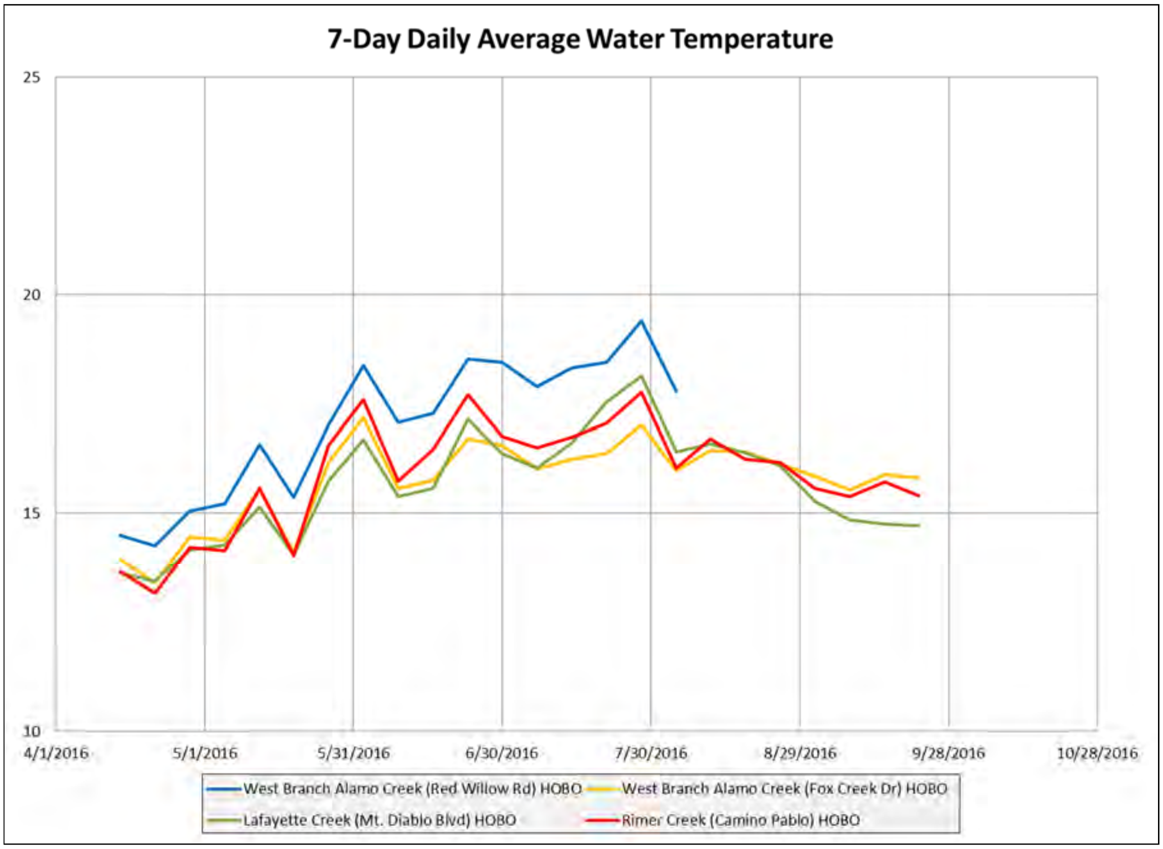
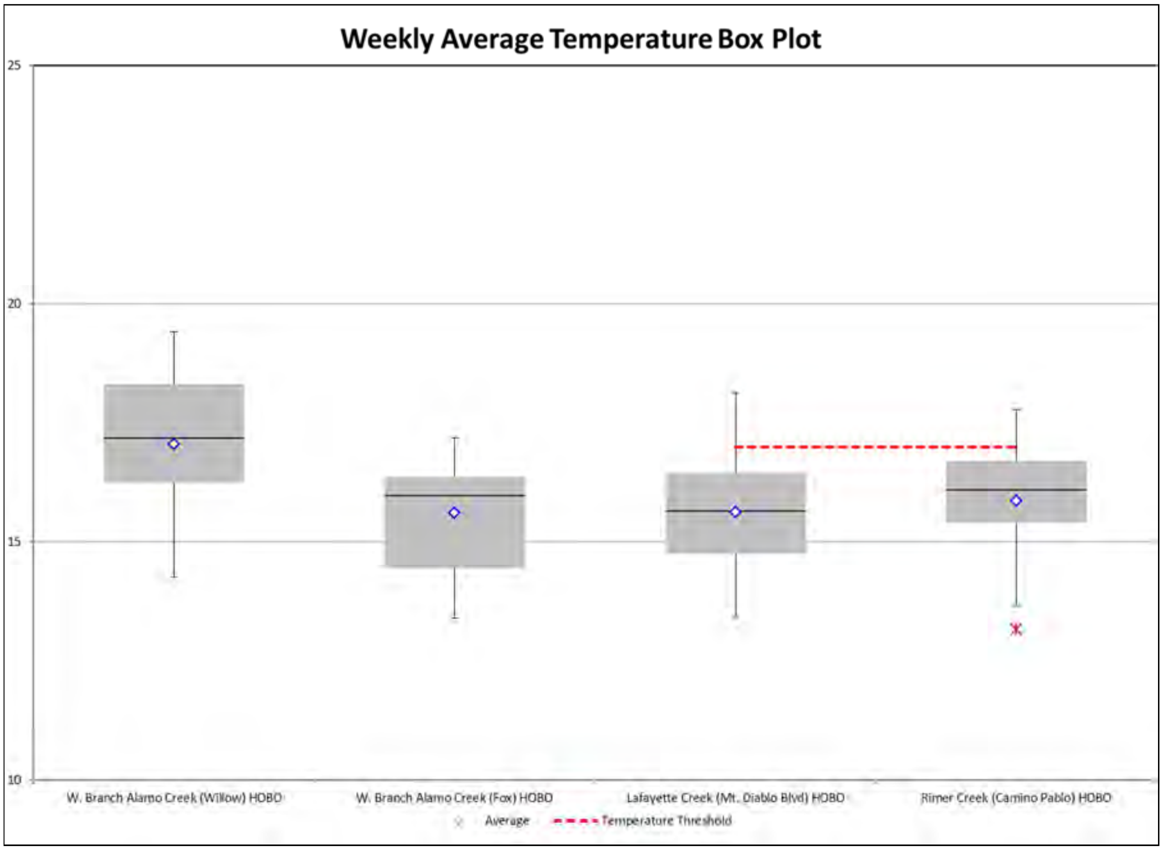


Figure 4.3 Box Plots of Weekly Average Maximum Temperature at Four Sites in Contra Costa County (Lafayette Creek, West Branch Alamo Creek, Rimer Creek), April 13-September 30, 2016



As shown in Table 4.3, over the course of the monitoring period, the MWAT measured at Lafayette Creek and Rimer Creek exceeded the threshold for steelhead streams during three and four instances, respectively. Therefore, both stations exceeded the MRP trigger thresholds for temperature (two or more values exceed the applicable threshold; see Table 4.3).

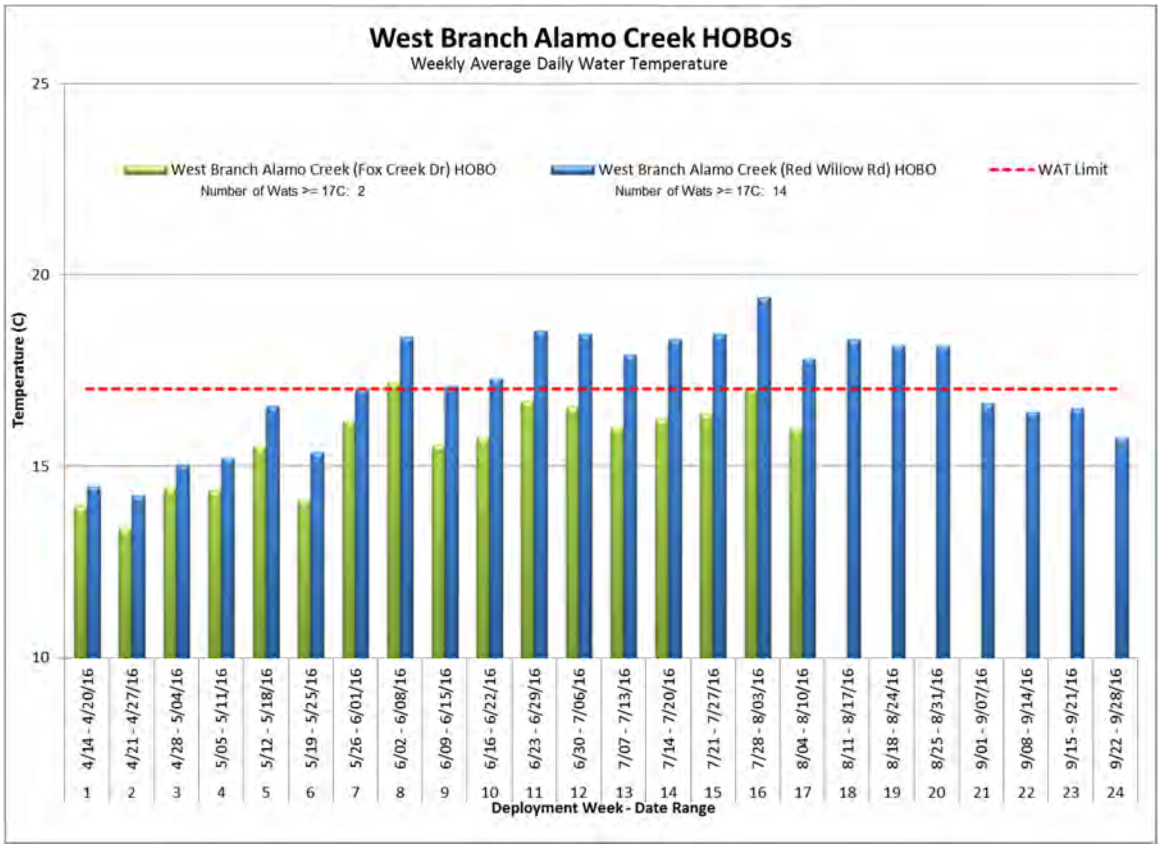
Table 4.3 Water Temperature Data Measured at Two Sites Exceeding Water Quality Criteria for Steelhead Streams

Site ID	Creek Name	Monitoring Period	Number of Results Where WAT > 17 °C
207R01307	Lafayette Creek	April 13-September 30, 2016	3
204R01519	Rimer Creek	April 13-September 30, 2016	4

As shown in Figure 4.4, the MWAT for the two HOBO water temperature loggers at West Branch Alamo Creek display a significant difference in the total number of WATs that exceed a maximum temperature criterion of 17 °C. Further analysis of temperature data along West Branch Alamo Creek suggest the impoundment located on the creek at the private country club likely contribute to the rise in stream water temperature downstream for the following reasons:

- The impoundment located in the private country club disrupts stream flow, effectively slowing the rate of flow or concentrating the flow into a large pool, where the flow rate is stopped altogether. The natural stream canopy is absent in this location, and the water is distributed over a large surface area, where the water is warmed during periods of prolonged exposure to warm temperatures and direct sunlight.
- The increase in water temperature downstream of the impoundment occurred during periods directly associated with an increase of air temperature, such as those experienced during local heat waves (ADH, 2015).

Figure 4.4 Weekly Average Daily Water Temperature for West Branch Alamo Creek HOBOs, April 13-September 30, 2016



4.2.2 Continuous Water Quality

Summary statistics for continuous water quality measurements collected at stations on West Branch Alamo Creek and Rimer Creek during two separate periods (once in April and once during August) are shown in Table 4.4. WAT and MWAT for both stations over the same monitoring period are displayed in Table 4.5. Data collected during both periods, along with the required thresholds, are plotted in Figures 4.5 through 4.8.

Table 4.4 Descriptive Statistics for Daily and Monthly Continuous Water Quality Parameters (Temperature, DO, Conductivity and pH) Measured at Two Sites in Contra Costa County (West Branch Alamo Creek and Rimer Creek), April 15-25 and August 1-15, 2016

Parameter		Site 204R01412 West Branch Alamo Creek		Site 204R01519 Rimer Creek	
		April	August	April	August
Temperature (º C)	Minimum	12.7	16.8	10.6	14.6
	Median	14.7	18.2	13.8	16.8
	Mean	14.8	18.2	13.7	17.2
	Maximum	16.8	20.6	17.4	21.7
Dissolved oxygen (mg/l)	Minimum	3.89	3.03	8.89	5.69
	Median	6.71	5.14	9.62	7.44
	Mean	6.75	5.14	9.64	7.58
	Maximum	9.36	6.51	10.48	10.46
pH	Minimum	7.82	7.77	7.82	7.86
	Median	7.94	7.92	8.16	8.08
	Mean	7.94	7.91	8.14	8.09
	Maximum	8.16	7.98	8.21	8.31
Specific conductivity (µS/cm)	Minimum	215	936	127	727
	Median	954	1515	714	821
	Mean	943	1520	693	845
	Maximum	1167	1641	729	1499

Table 4.5 Maximum Weekly Average Temperatures of YSI Sondes at Two Sites (West Branch Alamo Creek and Rimer Creek) for Both Events

Site Name	Creek Name	Monitoring Period	WAT	MWAT
204R01412	West Branch Alamo Creek	April 15-25, 2016	15.01	15.01
		August 1-15, 2016	18.51, 18.15	18.51
204R01519	Rimer Creek	April 15-25, 2016	14.07	14.07
		August 1-15, 2016	17.03, 17.48	17.48

Values in **Bold** exceed MRP criterion of 17.0 °C for steelhead streams.

Figure 4.5 Continuous Water Quality Data (Continuous Temperature) Collected in Contra Costa County (West Branch Alamo Creek and Rimer Creek), April 15-25 and August 1-15, 2016

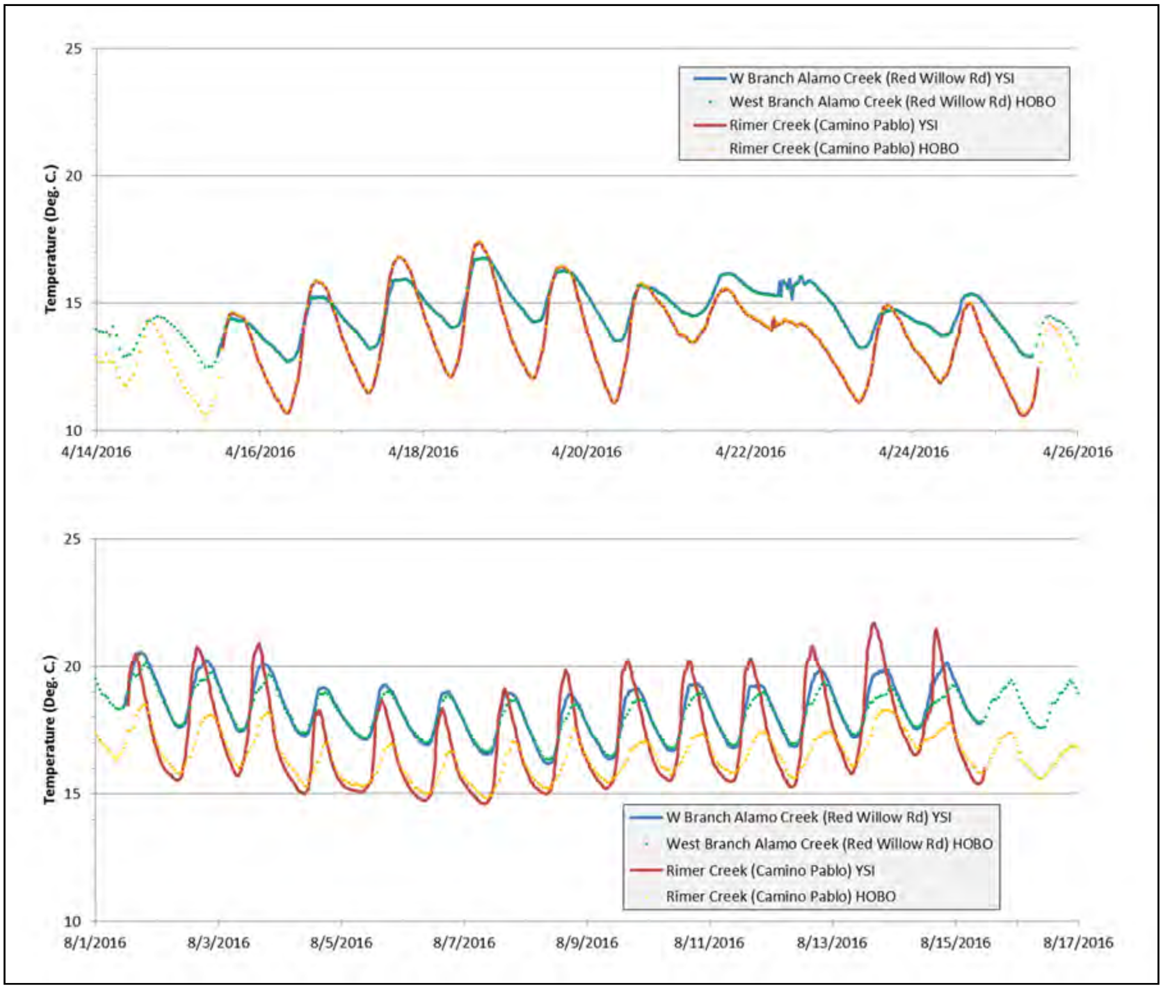


Figure 4.6 Continuous Water Quality Data (Continuous pH) Collected in Contra Costa County (West Branch Alamo Creek and Rimer Creek), April 15-25 and August 1-15, 2016

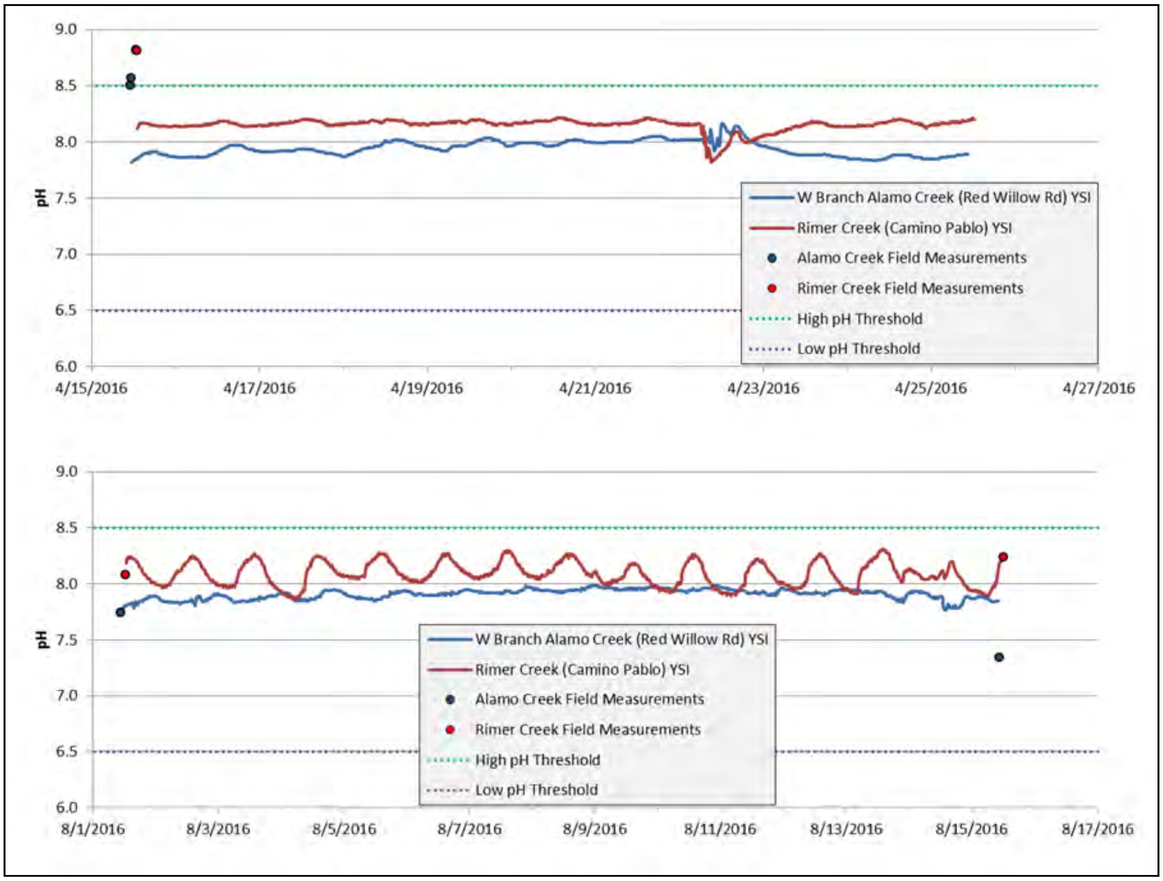


Figure 4.7 Continuous Water Quality Data (Continuous DO) Collected in Contra Costa County (West Branch Alamo Creek and Rimer Creek), April 15-25 and August 1-15, 2016

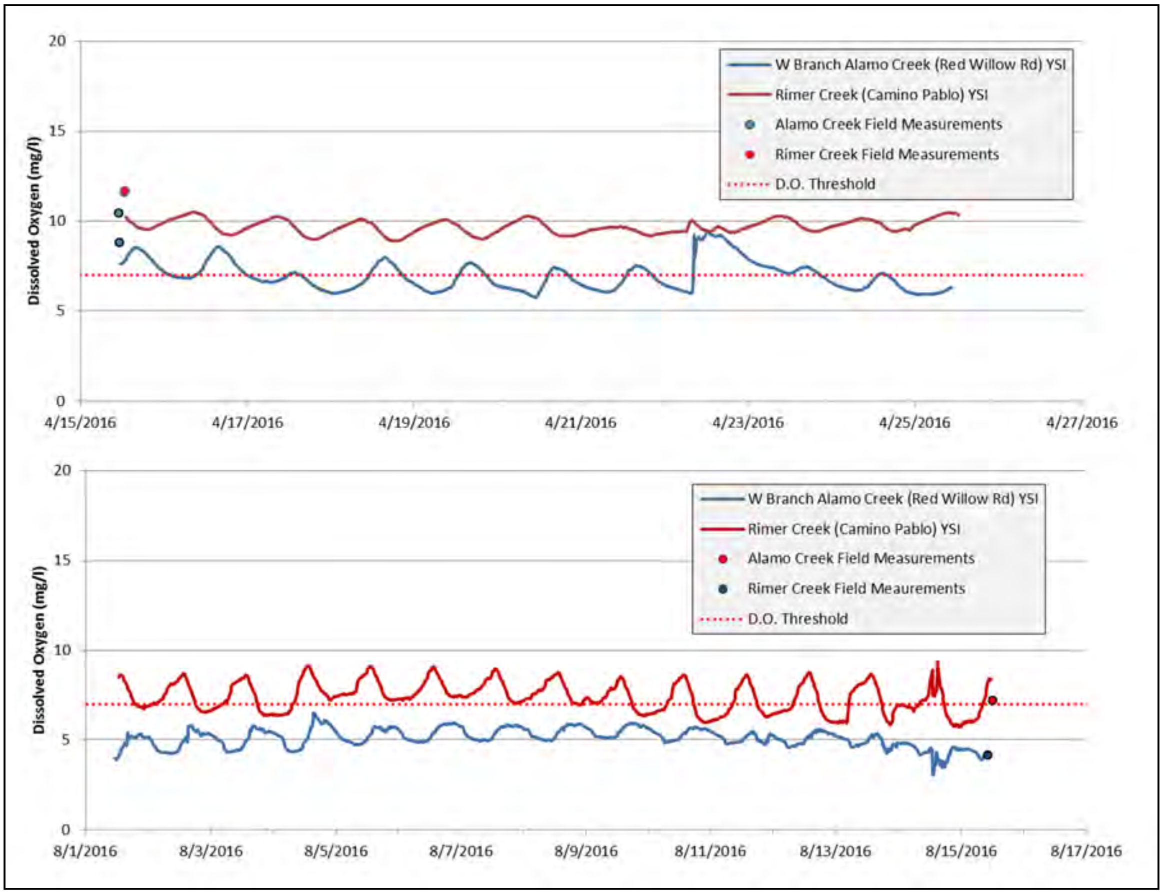
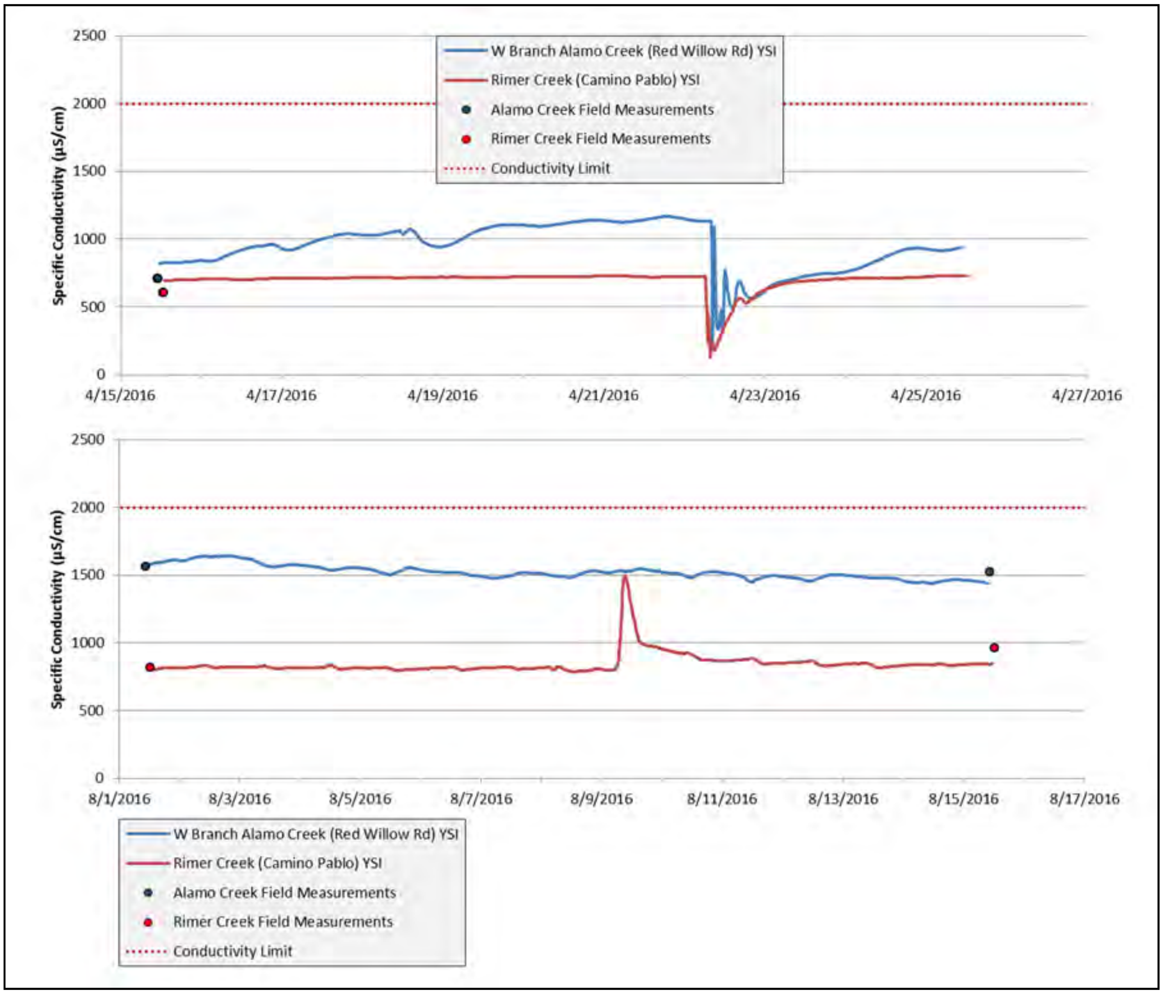


Figure 4.8 Continuous Water Quality Data (Continuous Specific Conductivity) Collected in Contra Costa County (West Branch Alamo Creek and Rimer Creek), April 15-25 and August 1-15, 2016



The lowest DO concentration (3.03 mg/l) at West Branch Alamo Creek occurred during August 2016. The lowest DO concentration (5.69 mg/l) at Rimer Creek occurred in August 2016 as well. The minimum and maximum pH measurements for West Branch Alamo Creek during both deployment periods were 7.77 and 8.16, respectively. The minimum and maximum pH measurements at Rimer Creek during both periods was 7.82 and 8.31, respectively.

On April 22, there is a noticeable change in the data displayed in Figures 4.5 to 4.8. This was due to the intrusion of water in West Branch Alamo Creek and Rimer Creek from a storm that produced about 0.5 inch of rain in the vicinity of the two locations from 05:00 to 15:00 on April 22. The net effect of this runoff was the following in both streams:

- A series of temperature fluctuations within the typical diurnal curve (Figure 4.5, top)
- A decrease and then slight increase in pH (Figure 4.6, top)
- An increase and subsequent decrease in DO, particularly at Alamo Creek (Figure 4.7, top)
- A sudden decrease in conductivity (Figure 4.8, top)

These phenomena are all consistent with warmer, relatively oxygen-rich, fresh water running into the measurement locations from storm rainfall.

Prior to and following the April 22 storm event, continuous water quality data at both West Branch Alamo Creek and Rimer Creek generally met WQOs.

Continuous water temperature data at both locations display a diurnal cycle typical of the region. During the August deployment at both locations, YSI sonde temperatures were consistently recorded to be warmer during peak temperatures. Field crew observations suggest the YSI temperature measurements were subject to temperature stratification, recording warmer temperatures near the water's surface, due to a shallower deployment depth in the water column (Figure 4.5).

Continuous conductivity data display readings typical of the region. During the August deployment at Rimer Creek, a conductivity spike with no natural explanation occurs on August 9. As no other water quality parameters followed this trend, it is unclear whether this result is due to a change in environmental conditions or the result of a malfunctioning monitoring probe. As the value of the spike is below acceptable criterion, it is not likely this exceedance will be targeted for a SSID study.

Table 4.6 presents the percentages of continuous water quality data exceeding the selected water quality criteria for temperature, DO and pH, as measured at West Branch Alamo Creek and Rimer Creek stations during both monitoring periods. The data are compared to water quality evaluation criteria specified in provision C.8.d of the MRP (Table 3.3).

Table 4.6 Percent of DO and pH Data Measured at Two Sites (West Branch Alamo Creek and Rimer Creek) for Both Events that Exceed Water Quality Evaluation Criteria Identified in Table 3.3

Site Name	Creek Name	Monitoring Period	Specific Conductance	DO Percent Results < 7.0 mg/L	pH Percent Results < 6.5 or > 8.5
204R01412	West Branch Alamo Creek	April 15-25, 2016	0%	58%	0%
		August 1-15, 2016	0%	100%	0%
204R01519	Rimer Creek	April 15-25, 2016	0%	0%	0%
		August 1-15, 2016	0%	47%	0%

Following is a summary of water quality evaluation criteria exceedances occurring at either creek.

West Branch Alamo Creek

During the April and August 2016 deployments, DO fell below the steelhead stream threshold 58 percent and 100 percent of the time, respectively. As there is no historical record of this creek ever supporting a run of steelhead, and it currently does not support either steelhead or resident rainbow trout, West Branch Alamo Creek does not qualify as a steelhead stream and is not subject to the 7.0 mg/L criterion. As such, the 2015 Basin Plan lists West Branch Alamo Creek as having a designated beneficial use as WARM, listing WQOs for DO as 5.0 mg/L (SFBRWQCB, 2015). DO levels during April did not drop below the minimum in-stream habitat criterion of 5.0 mg/L for its current beneficial use, but the August deployment saw 41 percent of DO levels fall below the suggested threshold.

Rimer Creek

During the August 2016 deployment, DO fell below the steelhead stream threshold 47 percent of the time; therefore, Rimer Creek exceeded MRP trigger thresholds for DO (20 percent or more of values exceed the applicable threshold; see Table 3.3) during the August measurement period.

4.2.3 Water Quality Data Evaluation for Steelhead Suitability

4.2.3.1 Lafayette Creek (207R01307)

Water Temperature

At the HOBO monitoring station, the median water temperature in this stream was 15.63 °C and its MWAT was 18.14 °C (see Table 4.2). The 17 °C criterion was exceeded on three occasions, once in June, and twice in the final weeks of July.

Lafayette Creek no longer supports a steelhead population due to a channelized portion of Las Trampas Creek and drop structures just downstream of the City of Walnut Creek that prevent the upstream migration of anadromous salmonid runs. However, this creek likely supports small numbers of resident rainbow trout; therefore, this creek should be considered a steelhead stream for purposes of water quality monitoring status.

4.2.3.2 West Branch Alamo Creek – Red Willow Road (204R01412)

Water Temperature

The 2015 Basin Plan states Alamo Creek has a “potential beneficial use” as COLD (i.e., steelhead stream), but its present designation is listed as WARM. WQOs for steelhead streams are discussed in this section to examine the potential of West Branch Alamo Creek as a steelhead stream.

At the HOBO monitoring station, the median water temperature in this small stream was 15.92 °C and its MWAT was 22.59 °C (Table 4.2). The monitored water temperatures at this site in San Ramon exceeded the MRP criterion of 17 °C on 14 occasions from mid-April to the end of September.

As shown in Table 4.4, at the YSI sonde monitoring station, the median water temperature recorded for the April and August deployments was 14.7 °C and 18.2 °C, respectively. The maximum WAT over the two deployment periods was 15.01 °C and 18.51 °C, respectively. The temperature criterion was exceeded at the YSI sonde monitoring location during the August deployment where the WAT exceeded 17 °C.

As there is no historical record of this creek ever supporting a run of steelhead, and it currently does not support either steelhead or resident rainbow trout, the lower West Branch Alamo Creek does not qualify as a steelhead stream as suggested by MRP criterion, despite 2015 Basin Plan designation as a potential cold water fishery. Therefore, this location under the terms of the MRP is not a candidate for a SSID study, as the only applicable threshold is a maximum of 24 °C for any single temperature measurement for this location.

Dissolved Oxygen

DO levels in West Branch Alamo Creek during the April and August deployments failed to meet steelhead stream criterion of 7.0 mg/L 58 percent and 100 percent of the recorded monitoring period.

DO levels during April did not drop below the minimum in stream habitat criterion of 5.0 mg/L for its current beneficial use as WARM, but the August deployment saw 41 percent of DO levels fall below the suggested threshold.

pH

The pH of West Branch Alamo Creek always met the Basin Plan criterion during the monitoring period (see Table 4.6).

Specific Conductance

The specific conductance of West Branch Alamo Creek always met MRP criterion during the monitoring period (see Table 4.6). The median specific conductance of 954 µS/cm to 1515 µS/cm is normal for this region.

4.2.3.3 Rimer Creek (204R01519)

Water Temperature

During the 2016 temperature monitoring period, the HOBO monitoring station (Rimer Creek at the City of Moraga) had a median water temperature of 15.89 °C and a MWAT of 21.39 °C (see Table 4.2). The water temperature exceeded the 17 °C WAT criterion for a steelhead stream at this location on four occasions during the April to August monitoring period (see Table 4.3).

As shown in Table 4.4, at the YSI sonde monitoring station, Rimer Creek recorded a median temperature of 13.8 °C and 16.8 °C for the April and August deployments, respectively. The MWAT over the two deployment periods was 17.4 °C and 21.7 °C. The temperature criterion was exceeded at the YSI sonde monitoring location during the August deployment where the WAT exceeded 17 °C.

While no longer supporting an anadromous steelhead population traveling San Leandro Creek to San Francisco Bay, Rimer Creek likely supports small numbers of resident rainbow trout descended from this steelhead population. Because this creek appears to support a viable population of resident rainbow trout, and likely provides spawning and/or rearing habitat for rainbow trout from Upper San Leandro Reservoir, MRP criterion for a steelhead stream apply to Rimer Creek. As such, this stream should be considered a steelhead stream for the purposes of water quality monitoring status.

Dissolved Oxygen

DO levels in Rimer Creek during April did not drop below the minimum in-stream habitat criterion of 7.0 mg/L. During the August period, 47 percent of results failed to meet the minimum DO criterion, exceeding the MRP threshold of 20 percent of instantaneous results < 7.0 mg/L.

pH

The pH of Rimer Creek always met MRP criterion during the monitoring period (see Table 4.6).

Specific Conductance

The specific conductance of Rimer Creek always met MRP numeric WQOs during the monitoring period (see Table 4.6). As shown in Table 4.4, specific conductance medians for both April and August were within MRP criterion (714-821 µS/cm).

4.2.3.4 West Branch Alamo Creek – Fox Creek Drive (204R01604)

Water Temperature

This site is located in the upper watershed of West Branch Alamo Creek, upstream of the 1.7 surface acre impoundment in Danville. The graphed weekly average daily water temperatures (see Figure 4.8), indicate two occasions during the summer when the creek's water temperature slightly exceeded the 17 °C threshold. Although the creek at this location nearly met the temperature criterion, this location was reported by field staff to have gone dry during the final weeks of monitoring in summer (around August 7, 2016). It is unknown if this creek ever historically supported a run of steelhead, but it currently does not support either steelhead or resident rainbow trout. This information, in addition to the tendency of the upper portion of the creek to go dry during summer months, indicate the upper West Branch Alamo Creek does not qualify as a steelhead stream subject to the 17 °C criterion.

Analysis of water temperature data display a significant reduction in water temperature criterion exceedances when located above the impoundment structure in the private country club, as compared to the monitoring site located below the impoundment.

4.3 Pathogen Indicators

In compliance with MRP provision C.8.d and Central Valley Permit provision C.8.c, a set of pathogen indicator samples were collected on July 20, 2016 at five stations on creeks in Contra Costa County. They were analyzed for enterococci and *E. coli*. The site on Rimer Creek also had a continuous monitoring device deployed there. Two sites were located on San Pablo Creek, and the other two sampling sites were located along Pinole Creek and Franklin Creek. The sampling points on San Pablo Creek were targeted to investigate possible anthropogenic sources of contamination from nearby illegal encampments. Pinole Creek was targeted due to its proximity to a public park to investigate if the water quality could be impacted by regular human recreational activity, such as the nearby off-leash dog park. All sites were chosen based upon the likelihood of water-contact recreation or to investigate areas of possible anthropogenic induced contamination.

As described previously (Section 3.4.3), single sample maximum concentrations of 130 CFU/100ml enterococci and 410 CFU/100ml *E. coli* were used (per EPA, 2012). Recreational water quality criteria statistical threshold values were used as water contact recreation evaluation criteria for the purposes of this evaluation. Enterococci concentrations ranged from 31 to 330 CFU/100 ml and *E. coli* concentrations ranged from 170 to 1,100 CFU/100 ml. One enterococci sample exceeded the applicable criteria, while two samples collected for *E. coli* exceeded applicable EPA criteria. Samples collected at 204R01519 (Rimer Creek) and 206R01495 (Pinole Creek) exceeded criteria for *E. coli,* while one sample collected at 204R01519 (Rimer Creek) exceeded the enterococci objective.

Table 4.7 Enterococci and *E. coli* Levels Measured From Water Samples Collected at Five Locations in Creeks in Contra Costa County, June 30, 2016

Site ID	Creek Name	Enterococci (CFU/100ml)	E. Coli (CFU/100ml)
206SPA020	San Pablo Creek	52	300
206SPA030	San Pablo Creek	31	170
207R01447	Franklin Creek	63	220
206R01495	Pinole Creek	52	1100[2]
204R01519	Rimer Creek	330[1]	700[2]

[1] Exceeded EPA criterion of 130 CFU/100ml enterococci
[2] Exceeded EPA criterion of 410 CFU/100ml *E. coli*

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5.0 Next Steps

Under the requirements of provision C.8 in the MRP and the Central Valley Permit, the following next steps will be taken:

1. CCCWP will continue to conduct monitoring for local/targeted parameters in WY 2017.
2. All permit-related water quality threshold exceedances will be included in a compilation of water quality triggers for consideration by the RMC as potential SSID projects, and for other potential follow-up investigations and/or monitoring.
3. Based on the analysis of the local targeted data, the results exceeding the MRP trigger thresholds (Table 5.1) will be listed in the SSID data evaluation form as potential SSID projects.

Table 5.1 Summary of CCCWP Exceedances for Water Year 2016

Creek	Index Period	Parameter	Criterion Exceedance	Result
Lafayette Creek	June 23-June 29, 2016; July 21-August 3, 2016	Continuous Water Temperature (HOBO)	More than one WAT exceeds 17 °C or when 20 percent of instantaneous results > 24 °C	3 WAT > 17.0°C
Rimer Creek	June 2-June 8, 2016; June 23-June 29, 2016; July 21-August 3, 2016	Continuous Water Temperature (HOBO)	More than one WAT exceeds 17 °C or when 20 percent of instantaneous results > 24 °C	4 WAT > 17.0°C
Rimer Creek	August 1-15, 2016	Continuous Water Temperature (sonde)	When one WAT exceeds 17 °C or when 20 percent of instantaneous results > 24 °C	2 WAT > 17.0°C
Rimer Creek	August 1-15, 2016	Continuous Water Quality - DO	When 20 percent of instantaneous results drop below 7.0 mg/L	47% > 7.0 mg/L
Rimer Creek	August 1-15, 2016	Continuous Water Quality - Conductivity	When 20 percent of instantaneous results exceed 2,000 µS/cm or there is a spike with no natural explanation	Creek experienced a conductivity spike with no natural explanation
Rimer Creek	July 20, 2016	Enterococci	Single grab sample exceeded EPA criterion of 130 CFU/100ml	330 CFU/100 ml
Pinole Creek	July 20, 2016	*E. coli*	Single grab sample exceeded EPA criterion of 410 CFU/100ml	1,100 CFU/100 ml
Rimer Creek	July 20, 2016	*E. coli*	Single grab sample exceeded EPA criterion of 410 CFU/100ml	700 CFU/100 ml

WAT = weekly average temperature

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6.0 References

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Appendix 3

Stressor/Source Identification Studies Status Report
Water Year 2016

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CONTRA COSTA
CLEAN WATER
PROGRAM

Stressor/Source Identification Projects
Status Report
Water Year 2016
(October 2015 - September 2016)

Submitted to the San Francisco Bay and
Central Valley Regional Water Quality Control Boards
in Compliance with NPDES Permit
Provisions C.8.h.iii and C.8.g.iii

NPDES Permit Nos. CAS612008 and CAS083313

March 22, 2017

A Program of Contra Costa County, its Incorporated Cities and Towns,
and the Contra Costa Flood Control & Water Conservation District

This report is submitted by the participating agencies of the

CONTRA COSTA
CLEAN WATER
PROGRAM

Program Participants:

- Cities and Towns of: Antioch, Brentwood, Clayton, Concord, Danville (Town), El Cerrito, Hercules, Lafayette, Martinez, Moraga (Town), Oakley, Orinda, Pinole, Pittsburg, Pleasant Hill, Richmond, San Pablo, San Ramon and Walnut Creek
- Contra Costa County
- Contra Costa County Flood Control & Water Conservation District

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ARC
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In Association With:

ADH
Environmental

Table of Contents

List of Tables

List of Acronyms and Abbreviations

ACCWP	Alameda Countywide Clean Water Program
ADH	ADH Environmental
ARC	Armand Ruby Consulting
BASMAA	Bay Area Stormwater Management Agencies Association
CCCWP	Contra Costa Clean Water Program
CSCI	California Stream Condition Index
CVRWQB	Central Valley Regional Water Quality Control Board
EPA	U.S. Environmental Protection Agency
FSURMP	Fairfield-Suisun Urban Runoff Management Program
MRP	municipal regional permit
NPDES	National Pollution Discharge Elimination System
PEC	probably effect concentration
Region 2	San Francisco Regional Water Quality Control Board
Region 5	Central Valley Regional Water Quality Control Board
RMC	Regional Monitoring Coalition
SCVURPPP	Santa Clara Valley Urban Runoff Pollution Prevention Program
SFBRWQCB	San Francisco Bay Regional Water Quality Control Board
SMCWPPP	San Mateo Countywide Water Pollution Prevention Program
SSID	stressor/source identification
SWRCB	State Water Resources Control Board
TEC	threshold effect concentration
WAT	weekly average temperature
WQO	water quality objective
WY	water year

Preface

The Bay Area Stormwater Management Agencies Association (BASMAA) Regional Monitoring Coalition (RMC) coordinates creek status monitoring under the terms of provisions C.8.d. and C.8.g. of the Municipal Regional Permit (MRP) for urban stormwater issued by the San Francisco Bay Regional Water Quality Control Board (SFRWQCB; Order No. R2-2015-0049). The following program participants make up the RMC:

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

Both the initial MRP (MRP 1, Order No. R2-2009-0074) and the renewed MRP (MRP 2, Order No. R2-2015-0049) require permittees to evaluate creek status monitoring results and investigate selected results as stressor/source identification (SSID) studies. The RMC participants have worked collaboratively to address the MRP requirements for SSID studies under both permit terms. For MRP 2, the SSID requirements are specified per provision C.8.e. This report fulfills reporting requirements for an annual SSID status report pursuant to MRP provisions C.8.e.iii.(3)(c) and C.8.h.iii.(2), as a part of the water year 2016 urban creeks monitoring report.

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Stressor/Source Identification Studies

MRP 1 SSID Projects – RMC Process

Under MRP 1, the RMC programs worked collaboratively to fulfill the requirements for implementation of SSID studies (per provision C.8.d.i), based on the results of creek status monitoring performed in compliance with permit provision C.8.c.

Per MRP 1 provision C.8.d.i, when the creek status monitoring is performed under a regional collaborative (such as the RMC), a maximum of ten SSID studies must be initiated during the permit term; two of those studies must be related to toxicity. During the MRP 1 term, the RMC collectively reviewed trigger results from water year 2012 and selected a total of 10 sites in four counties (two each from Contra Costa and San Mateo; three each from Alameda and Santa Clara) for implementation of SSID projects, based on regional collaboration and consideration of the type, extent, and geographic spread of the trigger exceedances. By agreement within the RMC, the Contra Costa County permittees were responsible for initiating two toxicity-related SSID studies during the MRP 1 permit term. The SSID projects undertaken regionally per MRP 1 requirements are shown in tabular form in Attachment A to this status report.

MRP 1 SSID Projects – CCCWP

For the Contra Costa Clean Water Program (CCCWP), the MRP 1 SSID projects involved two sites with demonstrated toxicity and evidence of elevated pyrethroids sediment concentrations, located on Grayson Creek (Region 2) and Dry Creek (Region 5). These SSID projects were designed to evaluate and further characterize causes of toxicity impacting these urban creek systems.

The results of the two SSID Part A studies confirmed current-use pesticides (particularly pyrethroids) appear to be the principal cause of the toxicity observed in the two study watersheds. Those pesticides, therefore, constitute the stressors being investigated in the CCCWP SSID studies.

In the SSID Part B studies, the magnitudes and patterns of pesticide applications were further investigated to more explicitly identify the sources of the identified stressors[1]. The results of the Part B studies provided a basis for identifying the pesticide source controls to be selected and implemented as described in the SSID Study Concept Plan, Part C. The Part C process is currently being fulfilled through CCCWP's implementation of pesticide/toxicity controls through the requirements of MRP provision C.9 (Pesticides Toxicity Control).

Eventually, in Part D of these two SSID studies, CCCWP will conduct follow-up monitoring to determine the effectiveness of the implemented pesticide source controls.

Per MRP 1, the CCCWP was responsible for performing related follow-up studies triggered by the creek status monitoring. In WY 2012 and WY 2013, the CCCWP's Creek Status Monitoring triggered exceedances for water and sediment toxicity parameters. Contra Costa Clean Water Program's Stressor

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[1] Report of Stressor/Source Identification Studies in Dry Creek and Grayson Creek, Part B, Rev. Draft ("SSID Part B Report"), prepared for CCCWP by ARC and ADH, December 4, 2015.

Source ID projects follow an orderly process, from trigger exceedance and confirmation to define the problem (Phase A), to source investigation activities which identified sources and causes (Phase B), to the present-day actions which address the sources and causes (Phase C), in preparation for monitoring to document outcomes (Phase D). Phase C is an “active waiting” period, during which actions are carried out to address the problem, while allowing sufficient time for the actions to translate to meaningful change in the effects as evidenced by monitoring data. The principal actions carried out during Phase C, as defined under provision C.9 of MRP 2, include:

- Maintaining and Integrated Pest Management Program (IPM)
- Training Municipal Operators in the IPM
- Requiring contractors to implement IPM
- Interfacing with County Agricultural Commissioners
- Conducting public outreach to stores, pesticide professionals, and customers of pesticide professionals to encourage irrigation management that minimize pesticide runoff and appropriate pesticide disposal practices
- Tracking and participating in Relevant Regulatory Processes; potential coordination with STORMS statewide pesticides/toxicity monitoring framework
- Evaluating the implementation of Pesticide Source Control Actions
    - Phase B of this Stressor Source ID study included an update on the sales of pyrethroid pesticides in Contra Costa County as a means of evaluating the effectiveness of implementation measures carried out to date.

Based on lessons learned about diazinon and chlorpyrifos from statewide collaboration through CASQA, product re-registration leading to reduction in uncontrolled consumer use is the most effective way to prevent pesticides in stormwater discharges from impacting water quality. This is a long term process. Control actions have been completed for diazinon and chlorpyrifos, and long term monitoring programs have documented the positive outcomes in terms of reduced incidents of diazinon and chlorpyrifos toxicity in receiving waters. Similar regulatory processes are expected to lead to similar outcomes during the implementation of Phase C of the CCCWP SSID study for pyrethroid pesticides. To implement Phase D, the CCCWP has a monitoring program, funding process, and staff and consultant resources needed to direct monitoring to evaluate the success of SSID Phase C implementation at the appropriate time. In the meantime, CCCWP permittees are developing green infrastructure plans (GI Plans). This action is motivated by the fact that urban stormwater has the potential to convey a multitude of pollutants, including ubiquitous legacy pollutants such as mercury and PCBs that are subject to load reduction requirements through Total Maximum Daily Loads and associated permit requirements. The implementation of GI plans would promote stormwater treatment via detention and infiltration as a means of reducing pollutant loads. To address funding gaps needed to implement GI plans, the CCCWP is also developing a Stormwater Resources Plan to enable permittees to seek grant funding to assist with GI Plan implementation.

In summary, Phase C of SSID implementation combines actions specific to reducing pyrethroids through existing programs with planning actions that more generally address reducing pollutant loads discharged through treatment by GI. The timeline of the current “active waiting” period of Phase C actions for pyrethroids means that Phase D effectiveness monitoring activities are most likely warranted in the five to ten-year time frame, i.e., during the implementation of MRP 3 or MRP 4. Progress on Phase C implementation and the resulting timeline anticipated for Phase D implementation will be updated annually through the annual reports, and through the five-year cycle of preparing a report of waste discharge in preparation for permit renewal.

MRP 2 SSID Projects – RMC Process

Efforts are currently underway by the RMC to evaluate data for selection of a new set of SSID projects for implementation during the current MRP term. MRP 2 requires a minimum of 8 new SSID projects for permittees who participate in a regional collaborative (i.e., the RMC), and at least one must be for toxicity (the toxicity project will be undertaken by a county other than Contra Costa). The trigger/threshold criteria for evaluation of creek status monitoring data per MRP 2 provisions C.8.d. and C.8.g. are shown in Table 1.

In concept, RMC programs agreed the distribution of MRP 2 SSID projects will be as follows:

- 1 jointly: Fairfield/Suisun and Vallejo
- 1 each: San Mateo and Contra Costa counties
- 2 each: Santa Clara and Alameda counties
- 1 wild card: To be determined; this could be the required toxicity project, possibly conducted regionally

RMC programs agreed the process for identifying MRP 2 SSID projects will include the following elements, on the approximate timeline indicated below:

Summer 2016: (Completed)

- Construct a new SSID trigger exceedance matrix template, updating the previous version from WY 2012 to accommodate MRP 2 thresholds (include pyrethroid TUs); update annually (will also satisfy MRP provision C.8.e.i, ii).

Fall 2016: (Completed)

- RMC programs each populate the new matrix template with RMC monitoring data, beginning with WY 2015; programs could fill in back to WY 2013, if desired.
- RMC coordinator compiles five RMC program trigger matrices into single package; distribute to RMC.

Winter 2016-17/Spring 2017:

- RMC programs jointly review and discuss options for selection of projects
- RMC programs select four SSID projects to commence during WY 2018 (begins fall quarter, 2017): one project each in Alameda, Contra Costa, Santa Clara and San Mateo counties
- RMC Programs consider how to address the one required toxicity project; possibly coordinate with dry weather pesticides/toxicity monitoring; also consider potential coordination with STORMS statewide pesticides/toxicity monitoring framework

Fall/Winter 2017-Spring 2018:

- RMC programs commence half of the projects by the third year of the permit term (WY 2018; i.e., beginning fall quarter of 2017); start one project each in Alameda, Contra Costa, Santa Clara and San Mateo counties in that time frame

Table 1. Creek Status Monitoring Data Trigger Thresholds for Follow-up Per MRP

Constituent	Threshold Trigger Level	MRP 2 Provision	Provision Text
CSCI Score	<0.795 (plus see provision text =>)	C.8.d.i.(8)	Sites scoring less than 0.795 according to the California Stream Condition Index (CSCI) are appropriate for a SSID project, as defined in C.8.e. Such a score indicates a substantially degraded biological community relative to reference conditions. Sites where there is a substantial difference in CSCI score observed at a location relative to upstream or downstream sites are also appropriate for a SSID project. If many samples show a degraded biological condition, sites where water quality is most likely to cause and contribute to this degradation may be prioritized by the permittee for a SSID project.
Chlorine	>0.1 mg/L	C.8.d.ii.(4)	The permittees shall immediately resample if the chlorine concentration is greater than 0.1 mg/L. If the resample is still greater than 0.1 mg/L, then permittees shall report the observation to the appropriate permittee central contact point for illicit discharges so 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.
Temperature	>2 weekly averages >17 °C (steelhead streams); or 20 percent of results >24 °C instantaneous maximum (per station)	C.8.d.iii.(4)	The temperature trigger is defined as when two or more WAT exceed the MWAT of 17 °C for a steelhead stream, or when 20 percent of the results at one sampling station exceed the instantaneous maximum of 24 °C. Permittees shall calculate the WAT by separating the measurements into non-overlapping, 7-day periods.
Temperature (continuous, sonde)	A weekly average >17 °C (steelhead streams); or 20 percent of results >24 °C instant. max. (per station)	C.8.d.iv.(4)a.	The permittees shall calculate the WAT by separating the measurements into non-overlapping, 7-day periods. The temperature trigger is defined as any of the following: MWAT exceeds 17 °C for a steelhead stream, or 20 percent of the instantaneous results exceed 24 °C.
pH (continuous, sonde)	>20 percent results <6.5 or >8.5	C.8.d.iv.(4)b.	The pH trigger is defined as 20 percent of instantaneous pH results are <6.5 or >8.5
Electrical Conductivity (continuous, sonde)	>20 percent results >2000 µS	C.8.d.iv.(4)c.	The conductivity trigger is defined as 20 percent of the instantaneous specific conductance results are >2000 µS, or there is a spike in readings with no obvious natural explanation.
Dissolved Oxygen (continuous, sonde)	>20 percent results <7 mg/L (COLD water fishery streams)	C.8.d.iv.(4)d.	The dissolved oxygen trigger is defined as 20 percent of instantaneous dissolved oxygen results are <7 mg/L in a cold water fishery stream.
Enterococci	>130 CFU/100 mL	C.8.d.v.(4)	If EPA's statistical threshold value for 36 per 1000 primary contact recreators is exceeded, the water body reach shall be identified as a candidate SSID project. [Per RMC/SFBRWQCB staff agreement, CFU and MPN units are deemed to be comparable for this purpose.]
E. coli	>410 CFU/100 mL	C.8.d.v.(4)	If EPA's statistical threshold value for 36 per 1000 primary contact recreators is exceeded, the water body reach shall be identified as a candidate SSID project. [Per RMC/SFBRWQCB staff agreement, CFU and MPN units are deemed to be comparable for this purpose.]
Toxicity	TST "fail" on initial and follow-up sample test; both results have >50 percent effect	C.8.g.iv	The permittees shall identify a site as a candidate SSID project when analytical results indicate any of the following: 1) A toxicity test of growth, reproduction or survival of any test organism is reported as "fail" in both the initial sampling and a second follow-up sampling, and 2) both have ≥ 50 percent effect. [Note: applies to dry and wet weather, water column and sediment tests.]
Pesticides (Water)*	>Basin Plan WQO (see WQOs TECs PECs worksheet)	C.8.g.iv	The permittees shall identify a site as a candidate SSID project when analytical results indicate a pollutant is present at a concentration exceeding its water quality objective in the Basin Plan.

Table 1. Creek Status Monitoring Data Trigger Thresholds for Follow-up Per MRP

Constituent	Threshold Trigger Level	MRP 2 Provision	Provision Text
Pesticides and Other Pollutants (Sediment)	Result exceeds PEC or TCE (per MacDonald et al., 2000)	C.8.g.iv	The permittees shall identify a site as a candidate SSID project when analytical results indicate any of the following: 1) A pollutant is present at a concentration exceeding its water quality objective in the Basin Plan; 2) for pollutants without WQOs, results exceed Probable Effects Concentrations or Threshold Effects Concentrations.

Note: Per MRP provisions C.8.d. and C.8.g., these are the data thresholds which trigger listings as candidate SSID projects, per MRP provision C.8.e.
* Per RMC decision, with Water Board staff concurrence, in accord with MRP provision C.8.g.iii.(3), this monitoring will commence in WY 2018.

MRP 2 SSID Projects – Initial CCCWP Data Triggers

The WY 2016 data produced several results with the potential to be considered SSID projects, as shown in Table 2. For local/targeted parameters, the data trigger thresholds exceeded include temperature (Lafayette Creek and Rimer Creek), dissolved oxygen (Rimer Creek), conductivity (Rimer Creek), and bacteria (*E.coli* and enterococci in Rimer Creek, and *E.coli* in Pinole Creek). For the regional/probabilistic parameters, the only notable thresholds triggered by WY 2016 data involve sediment chemistry, specifically pyrethroid pesticide toxic unit equivalents, and CSCI bioassessment scores (all 10 sites were below the CSCI threshold of 0.795).

Table 2. CCCWP Threshold Exceedances for Water Year 2016

Creek	Index Period	Parameter	Criterion Exceedance
Lafayette Creek	June 23-June 29, 2016; July 21-August 3, 2016	Continuous Water Temperature (HOBO)	More than one WAT exceeds 17 °C or when 20 percent of instantaneous results > 24 °C
Rimer Creek	June 2-June 8, 2016; June 23-June 29, 2016; July 21-August 3, 2016	Continuous Water Temperature (HOBO)	More than one WAT exceeds 17 °C or when 20 percent of instantaneous results > 24 °C
Rimer Creek	August 1-15, 2016	Continuous Water Temperature (sonde)	When one WAT exceeds 17 °C or when 20 percent of instantaneous results > 24 °C
Rimer Creek	August 1-15, 2016	Continuous Water Quality - DO	When 20 percent of instantaneous results drop below 7.0 mg/L
Rimer Creek	August 1-15, 2016	Continuous Water Quality - Conductivity	When 20 percent of instantaneous results exceed 2,000 µS/cm or there is a spike with no natural explanation
Rimer Creek	July 20, 2016	Enterococci	Single grab sample exceeded EPA criterion of 130 CFU/100ml
Pinole Creek	July 20, 2016	*E. coli*	Single grab sample exceeded EPA criterion of 410 CFU/100ml
Rimer Creek	July 20, 2016	*E. coli*	Single grab sample exceeded EPA criterion of 410 CFU/100ml
West Branch of Alamo Creek	May 9, 2016	CSCI	California Stream Condition Index (CSCI) score <0.795
Rimer Creek	April 28, 2016	CSCI	California Stream Condition Index (CSCI) score <0.795
West Branch of Alamo Creek	April 26, 2016	CSCI	California Stream Condition Index (CSCI) score <0.795
Ohlone Creek	April 27, 2016	CSCI	California Stream Condition Index (CSCI) score <0.795
Las Trampas Creek	May 10, 2016	CSCI	California Stream Condition Index (CSCI) score <0.795
Walnut Creek	May 11, 2016	CSCI	California Stream Condition Index (CSCI) score <0.795

Table 2. CCCWP Threshold Exceedances for Water Year 2016

Creek	Index Period	Parameter	Criterion Exceedance
Grayson Creek	May 11, 2016	CSCI	California Stream Condition Index (CSCI) score <0.795
Lafayette Creek	April 28, 2016	CSCI	California Stream Condition Index (CSCI) score <0.795
Franklin Creek	May 12, 2016	CSCI	California Stream Condition Index (CSCI) score <0.795
San Ramon Creek	May 10, 2016	CSCI	California Stream Condition Index (CSCI) score <0.795
Rimer Creek	July 11, 2016	*C. dubia*, Chronic Toxicity Test (Reproduction)	Test result <50 percent of control; retest sample collected on 8/15/16 was also toxic, but not at <50 percent of the control
Rimer Creek	July 11, 2016	Sediment Chemistry: Nickel TEC	TEC ratio > 1.0
West Branch of Alamo Creek	July 11, 2016	Sediment Chemistry: Sum of Pyrethroids Toxic Units	Sum of pyrethroids toxic units >1.0

WAT = weekly average temperature

Next Steps

The detailed CCCWP SSID trigger/threshold data evaluation matrix will be populated with the WY 2016 results on completion of the annual analysis. These results will be evaluated along with the WY 2015 data threshold triggers for consideration of potential SSID projects under MRP 2.

The RMC will begin discussing potential regional SSID projects in early 2017 by collectively evaluating the potential SSID projects, as indicated by WY 2015 and 2016 data which trigger MRP threshold exceedances.

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Attachment A: BASMAA Regional Monitoring Coalition, MRP 1 SSID Project Locations

(updated February 2017)

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BASMAA Regional Monitoring Coalition: Status of Regional Stressor/Source Identification (SSID) Projects Updated February 2017
For Projects Initiated Under MRP 1 (Municipal Regional Stormwater NPDES Permit, Order No. R2-2009-0074, Prov. C.8.d.i)

SSID Project ID	Date Updated	County/ Program	Creek/Channel Name	Site Code(s) or Alternative Site ID	Primary Indicator(s) Triggering SSID Project									Indicator Result Summary	Rationale for Proposing/Selecting Project	Current Status of SSID Project	Complete?
					Bioassess	General WQ	Chlorine	Temp	Water Tox	Sed Tox	Sed Chem	Pathogen Indicators	Other				
AL-1	01/23/17	Alameda/ ACCWP	Castro Valley Creek	204R00047	X						X			IBI Score = 24 (Poor); relatively high bifenthrin (pyrethroid) in sediment; >3 chemicals exceed TECs	Triad triggers were accompanied by *Hyalella azteca* water toxicity that did not reach trigger on retest. Potential sources for investigation in small watershed include freeway and urban land use areas.	SSID project began in 2013 with sediment sampling and watershed records review; no specific sources to local MS4 identified during 2014. Pesticides as the primary stressor are supported by additional WY 2015 sediment chemistry/toxicity results from another site higher in this watershed that also showed high *Hyalella* mortality in wet season water toxicity. March 2016 UCMR included Appendix 4A summary report describing BMPs implemented and completion of the site-specific elements of this project; March 2017 UCMR includes commentary on additional WY 2016 results from nearby sites in the same creek.	
AL-2	01/23/17	Alameda/ ACCWP	Dublin Creek	204R00084	X		X				X			IBI Score = 17 (Very Poor); relatively high bifenthrin (pyrethroid) in sediment; >3 chemicals exceed TECs	Potential sources for different triad triggers may be separable by monitoring between freeway and urban land use areas, altered vs. natural channels.	SSID project began in 2013 with sediment sampling, watershed records review and bioassessment sampling at RMC plus a supplemental site. Bioassessment impacts were strongly associated with channel alteration and habitat quality. Review of inspection information identified no specific sources of pesticides or metals to sediment. March 2017 UCMR provides update on review of land use inputs and freeway runoff, for final monitoring report to be submitted in September 2017.	
AL-3	01/23/17	Alameda/ ACCWP	Crow Creek	204CRW030		X								67 percent of DO results < 7 mg/L in September	Potentially significant stressor on COLD beneficial use; potential source for investigation from lake discharge or nutrient sources.	SSID project began in 2013 with DO and water sampling; initial hypothesis regarding reservoir runoff not supported by first year's special study. Further monitoring in WY 2014 and 2015 indicated there may have been episodic contributions from urban runoff to low DO incidents observed in WY2014, but not during WY 2015. March 2017 UCMR includes Appendix 4C progress report with WY 2016 monitoring evaluation of summer inflows using continuous monitoring of conductivity as well as temperature.	
CC-1	01/23/17	Contra Costa/ CCCWP	Grayson Creek	207R00011	X				X	X	X			32 percent survival of *Hyalella azteca* in water during spring of 2012; 43.8 percent survival of *Hyalella azteca* in sediment during summer 2012; relatively high bifenthrin in sediment; IBI Score = 13 (Very Poor). Water toxicity confirmed by retest, 2013.	Evidence of water and sediment toxicity to *Hyalella azteca*, with concurrent high concentration of bifenthrin in sediment. Recent publications by CASQA and others indicate pyrethroid pesticide-caused toxicity is a pervasive problem in urban areas of California. Investigation of sources and solutions could be widely beneficial.	SSID project Part A completed in WY 2014 with testing of water and sediments from sites upstream and downstream of original Grayson Creek site. Only water samples were toxic to *Hyalella*. Water TIE and concurrent chemistry point to pyrethroid pesticides as likely causes of *Hyalella* toxicity in waters of Grayson Creek. SSID project Part B completed in WY 2015, computing urban use amounts for six pyrethroid pesticides detected in Part A monitoring. Based on county pesticide use data from 2009-2013, uses of the most toxic and impactful pyrethroids (bifenthrin and cyfluthrin) increased in urban areas in Contra Costa County in recent years. Urban uses account for most of the annual use amounts for those six pyrethroids in Contra Costa County. CCCWP is implementing study Part C (pesticide/toxicity controls) via compliance with MRP provision C.9 (Pesticides Toxicity Control).	

BASMAA Regional Monitoring Coalition: Status of Regional Stressor/Source Identification (SSID) Projects
For Projects Initiated Under MRP 1 (Municipal Regional Stormwater NPDES Permit, Order No. R2-2009-0074, Prov. C.8.d.i)

Updated February 2017

SSID Project ID	Date Updated	County/ Program	Creek/Channel Name	Site Code(s) or Alternative Site ID	Primary Indicator(s) Triggering SSID Project									Indicator Result Summary	Rationale for Proposing/Selecting Project	Current Status of SSID Project	Complete?
					Bioassess	General WQ	Chlorine	Temp	Water Tox	Sed Tox	Sed Chem	Pathogen Indicators	Other				
CC-2	01/23/17	Contra Costa/ CCCWP	Dry Creek	544R00025	X		X		X	X	X			60 percent survival of *Hyalella azteca* in sediment during summer 2012; 0 percent survival of *Hyalella azteca* in water during spring 2012; relatively high bifenthrin in sediment; IBI Score = 3 (Very Poor). Water toxicity confirmed by retest, 2013.	Evidence of water and sediment toxicity to *Hyalella azteca*, with concurrent high concentration of bifenthrin in sediment. Recent publications by CASQA and others indicate pyrethroid pesticide-caused toxicity is a pervasive problem in urban areas of California. Investigation of sources and solutions could be widely beneficial.	SSID project Part A completed in WY 2014 with testing of water and sediments from sites upstream and downstream of original Dry Creek site. All samples were toxic to *Hyalella*. Water and sediment TIEs and concurrent chemistry point to pyrethroid pesticides as likely causes of *Hyalella* toxicity in water and sediments of Dry Creek. SSID project Part B completed in WY 2015 computing urban use amounts for six pyrethroid pesticides detected in Part A monitoring. Based on county pesticide use data from 2009-2013, uses of the most toxic and impactful pyrethroids (bifenthrin and cyfluthrin) increased in urban areas in Contra Costa County in recent years. Urban uses account for most of the annual use amounts for those six pyrethroids in Contra Costa County. CCCWP is implementing study Part C (pesticide/toxicity controls) via compliance with MRP provision C.9 (Pesticides Toxicity Control).	
SC-1	05/11/15	Santa Clara/ SCVURPPP	Coyote Creek	205COY235 (Coyote Cr. - Watson Park to Julian St.)		X								100 percent < 5mg/L DO in spring and summer periods 2012; and Pre-MRP Data	Coyote Creek supports a productive fish community and the project reach exhibits depressed DO that could cause biological impacts.	Project began in 2011 and was completed in 2013. Summary report was submitted in March 2014 as Appendix B1 in Part A of the Integrated Monitoring Report.	Yes
SC-2	05/11/15	Santa Clara/ SCVURPPP	Guadalupe River (and Alviso Slough)										X	Fish kills observed in 2008, 2009 and 2010.	The Guadalupe River supports a productive fish community and the project reaches exhibited fish kills that are a concern to local agencies.	Project began in 2011 and was completed in 2013. Summary report was submitted in March 2014 as Appendix B2 in Part A of the Integrated Monitoring Report.	Yes
SC-3	02/23/17	Santa Clara/ SCVURPPP	Upper Penitencia Creek	205R00035	X									IBI Score = 23 (Poor)	Upper Penitencia Creek supports one of the most productive steelhead communities in the Santa Clara Valley. Poor biological integrity scores may indicate impacts to steelhead and other biological communities.	SCVURPPP submitted a work plan with their WY 2015 UCMR which follows Step 5 of the USEPA Causal Analysis/Diagnosis Decision Information System (CADDIS). Implementation of the work plan was delayed two years due to drought conditions. In WY 2016, in compliance with the work plan, SCVURPPP conducted bioassessments at two stations (case and comparator sites) twice during the spring index period – before and after initiation of stream augmentation from a nearby SCVWD-operated pond. Stressor data collected at the sites included continuous temperature and water quality, nutrients, sediment chemistry and toxicity. A technical report submitted in March 2017 with the WY 2016 UCMR suggests low bioassessment scores are the result of natural hydrologic conditions rather than MS4 or pond discharges. Potential management options will be evaluated in WY 2017.	

BASMAA Regional Monitoring Coalition: Status of Regional Stressor/Source Identification (SSID) Projects
For Projects Initiated Under MRP 1 (Municipal Regional Stormwater NPDES Permit, Order No. R2-2009-0074, Prov. C.8.d.i)

Updated February 2017

SSID Project ID	Date Updated	County/ Program	Creek/Channel Name	Site Code(s) or Alternative Site ID	Primary Indicator(s) Triggering SSID Project									Indicator Result Summary	Rationale for Proposing/Selecting Project	Current Status of SSID Project	Complete?
					Bioassess	General WQ	Chlorine	Temp	Water Tox	Sed Tox	Sed Chem	Pathogen Indicators	Other				
SM-1	02/10/16	San Mateo/ SMCWPPP	San Mateo Creek	204SMA059		X								Pre-MRP data demonstrating temperatures > 19 °C and DO < 7mg/L. WY 2013 creek status data confirmed DO < 7 mg/L at 204SMA059, but not at 204SMA122 located approximately 4 miles upstream. Temperatures in WY 2013 rarely exceeded the 19 °C threshold.	San Mateo Creek is one of two creeks on the bay side of San Mateo County that supports a productive cold water community. Warm temperatures and/or low DO levels may impact this valuable community.	WY 2014 monitoring was conducted to investigate spatial and temporal extent of low DO. Monitoring consisted of sonde installments and a creek walk. Low DO was not observed in WY 2014. Review of flow data at USGS gage below Crystal Springs Reservoir confirmed higher dry season flows in WY 2014 compared to WY 2013. The higher flows were the result of a new SFPUC release schedule following dam improvements which will continue into perpetuity. It appears higher dry season flows result in reduced water temperatures and higher DO levels. Confirmation monitoring conducted in WY 2015 supported the findings. Final project report was submitted to RWQCB staff on 07/09/15 and with the WY 2015 UCMR.	Yes
SM-2	02/10/16	San Mateo/ SMCWPPP	San Mateo Creek	204SMA060								X		Pre-MRP data and WY 2012 creek status grab samples had pathogen indicator (fecal coliform) densities exceeding the REC-1 WQO.	San Mateo Creek is a perennial creek with two creekside parks. It flows through residential and commercial areas and discharges to San Francisco Bay just north of Marina Lagoon, which is 303(d)-listed for bacteria.	WY 2014 monitoring was conducted to investigate the magnitude and seasonal variability pathogen indicator densities. Microbial source tracking methodologies (i.e., bacteroidales) were employed to investigate whether human and/or dog markers were present in the samples. Final project report submitted with the WY 2015 UCMR.	Yes

Appendix 4

CCCWP Pollutants of Concern Status Report
Water Year 2016

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Contra Costa Clean Water Program

Pollutants of Concern Monitoring Report: Water Year 2016 Sampling and Analysis

January 2017

Submitted to:

Contra Costa Clean Water Program
255 Glacier Drive
Martinez, California 94553

Submitted by:

ADH Environmental
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Soquel, California 95073

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Contra Costa Clean Water Program

Pollutants of Concern Monitoring Report: Water Year 2016 Sampling and Analysis

January 2017

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List of Acronyms and Abbreviations

ADH	ADH Environmental
AMEC	AMEC Foster Wheeler
AMS	Applied Marine Sciences
ASTM	American Society for Testing and Materials
BART	Bay Area Rapid Transit
BMP	best management practice
CCCWP	Contra Costa Clean Water Program
EPA	U.S. Environmental Protection Agency
MRP	municipal regional stormwater permit
MS4	municipal separate storm sewer system
PCB	polychlorinated biphenyl
POC	pollutants of concern
ppb	parts per billion
PSD	particle size distribution
QAPP	quality assurance project plan
RMP	Regional Monitoring Program
RWQCB	regional water quality control board
SSC	suspended sediment concentration
TOC	total organic carbon
WY	water year

1. INTRODUCTION

This report summarizes pollutants of concern (POC) monitoring conducted by the Contra Costa Clean Water Program (CCCWP) during water year (WY) 2016 (October 1, 2015 through September 30, 2016). This report fulfills provision C.8.h.iv of the Municipal Regional Stormwater Permit (MRP) 2.0, Order No. R2-2015-0049.

During WY 2016, the following monitoring activities were completed to increase CCCWP's understanding of the geographic distribution of PCBs and mercury within the county's urban landscape.

- Street dirt sampling countywide (Tier 1 approach) in areas targeted for historic land uses and halo extent not previously sampled.
- Sediment sampling within MS4 drop inlets (Tier 2 approach) within Rumrill Boulevard and Giant Highway areas to characterize spatial distribution of PCBs and mercury within these halos of interest due to historic land uses.
- Stormwater sampling (Tier 3 approach) on West Gertrude Avenue in the City of Richmond adjacent to suspected source property for PCBs and mercury to confirm if elevated concentrations are present in runoff.

Additionally, BMP effectiveness monitoring for mercury, methylmercury and suspended sediment concentration (SSC) was performed at bioretention cells on Cutting Boulevard in the City of Richmond. This work was piggybacked on the EPA grant-funded study Clean Watersheds for a Clean Bay Task 5 Phase 2, and was performed for a two-fold purpose: 1) to inform treatment BMP effectiveness and, 2) to provide continued monitoring data for a methylmercury control study investigation, per Central Valley RWQCB permit requirements.

All monitoring activities were performed in accordance with CCCWP's POC Sampling and Analysis Plan and Quality Assurance Project Plan, draft guidance documents (ADH and AMS, 2016a; ADH and AMS, 2016b). Each of these monitoring efforts is described herein.

Additional monitoring information, background and context including a discussion of permit-driven goals can be found in the CCCWP WY 2016 POCs report (ADH, 2016b).

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2. STREET DIRT SAMPLING AND ANALYSIS (TIER 1 SCREENING FOR SOURCE ID)

In WY 2016, eight street dirt locations throughout the county were sampled and analyzed for PCBs, mercury, total organic carbon (TOC), and particle size distribution (PSD). Street dirt is surface material within the public right-of-way available for stormwater entrainment into the MS4. It is found in street gutters, on sidewalks and driveway aprons, or accumulated near an MS4 entry point (e.g., adjacent to a drop inlet grate). WY 2016 sampling took place at sites known to have, or suspected of having, elevated levels of PCBs, or were sites requested for survey by CCCWP Permittees.

Table 1 provides site IDs, sampling dates, position coordinates and site descriptions (rationale for selection) for each location. Table 2 provides results of PCBs, mercury, TOC and PSD testing. Refer to Table 3 for analytical test methods, reporting limits and holding times. Refer to Figures 1 and 2 for the general locations of street dirt sampling.

For context from recent sampling prior to WY 2016, see the *Contra Costa Clean Water Program Pollutants of Concern Sediment Screening 2015 Annual Sampling and Analysis Report* (ADH, 2016a) for a summary of WY 2015 sampling efforts and locations.

Table 1. Street Dirt Sampling Locations and Selection Rationale (WY 2016)

Site ID[1]	Date Sampled	Latitude (decimal degrees)	Longitude (decimal degrees)	General Description and Selection Rational
CC-ANT-901-R	09/27/16	37.99699	-121.84398	EnviroStor site. Antioch PG&E substation
CC-ANT-921-DI	09/27/16	38.01235	-121.77752	Sampled low point where contribution from two known hot sites flow into drop inlet
CC-OAK-922-R	09/28/16	38.00763	-121.75099	Recently identified, high potential, recommended for testing by CCCWP
CC-OAK-923-R	09/28/16	38.00502	-121.74364	Recently identified, high potential, recommended for testing by CCCWP
CC-PTZ-915-R	09/27/16	38.01571	-121.86083	Site was recommended for sampling in WY 2015, but was not sampled due to access issues. Requires a key from the county Flood Control and Water Conservation District to access the levee at 1600 Loveridge Road.
CC-RCH-912-R	09/28/16	37.95408	-122.37690	Site doesn't exist in Geotracker. Site was a drum recycling facility pre-1961-1983. Received casting sand from Atlas Foundry, may have been involved in burning hazardous chemical drums, along with Atlas. Chevron removed some contaminated soil at least by 1987. Adjacent to Fass Metals, which is known to have very high levels of PCBs. The information above could not be confirmed in EnviroStor or Geotracker. Tier 1 category was designated as a conservative measure due to reported use and proximity to PCBs-impacted FASS Metals site at 818 W. Gertrude Avenue.
CC-RCH-924-R	09/28/16	37.92583	-122.36911	Known hot spot at PG&E property along 1st Street and Cutting; recommended for testing by CCCWP.
CC-RCH-926-DI	09/27/16	37.92406	-122.36285	Sampled at low point where known hot site appears to flow into drop inlet; recommended for testing by CCCWP.

[1] Site ID Key:

ANT	Antioch	D	field duplicate	OAK	Oakley	R	right-of-way
CC	Contra Costa	DI	drop inlet	PTZ	Pittsburgh	RCH	Richmond

Table 2. Street Dirt Sampling Results (WY 2016)

Sample ID	Total PCBs (µg/Kg) 1	Total Hg (µg/Kg)	TOC (%)	*Particle Size Distribution* Gravel (%)	Sand (%)	Silt (%)	Clay (%)
CC-ANT-901-R	3	65	1.91	12	64	23	3
CC-ANT-921-DI	3	62	0.567	40	64	6	0
CC-OAK-922-R	42	181	0.92	22	63	13	1
CC-OAK-923-R	185	373	1.652	40	53	6	1
CC-PTZ-915-R	4	265	2.2	44	38	14	2
CC-RCH-912-R	119	351	13	40	41	18	3
CC-RCH-924-R	87	312	3.79	12	67	19	2
CC-RCH-926-DI	199	415	2.63	18	78	3	0

1 Sum of RMP 40 congeners.

Table 3. Sediment Analytical Tests, Methods, Reporting Limits and Holding Times

Sediment Analytical Test	Method	Reporting Limit	Holding Time
Total PCBs (RMP 40 congeners)[1]	EPA 8082A	0.5 µg/kg	1 year
Total Mercury	EPA 7471B	5 µg/kg	1 year
Total Organic Carbon (TOC)	ASTM D4129-05M	0.05%	28 days
Particle Size Distribution (PSD)[2]	ASTM D422M	0.01%	28 days

1 San Francisco Bay RMP 40 PCB congeners include PCB-8, 18, 28, 31, 33, 44, 49, 52, 56, 60, 66, 70, 74, 87, 95, 97, 99, 101, 105, 110, 118, 128, 132, 138, 141, 149, 151, 153, 156, 158, 170, 174, 177, 180, 183, 187, 194, 195, 201, and 203.

2 Particle size distribution by the Wentworth scale; percent fines (slit and clay) are less than 62.5 microns.

Figure 1. Street Dirt Sampling Locations – West County (WY 2016)

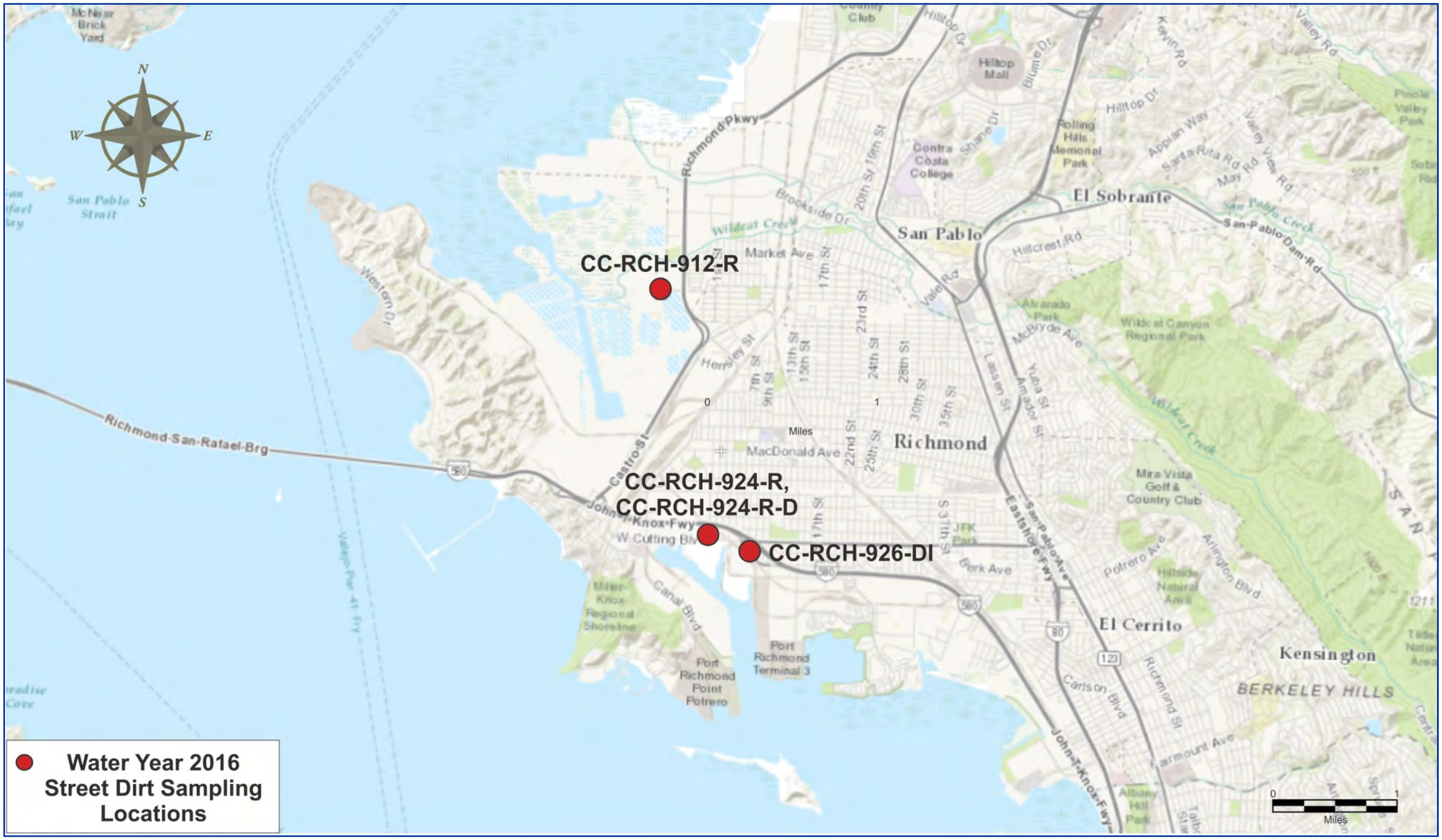
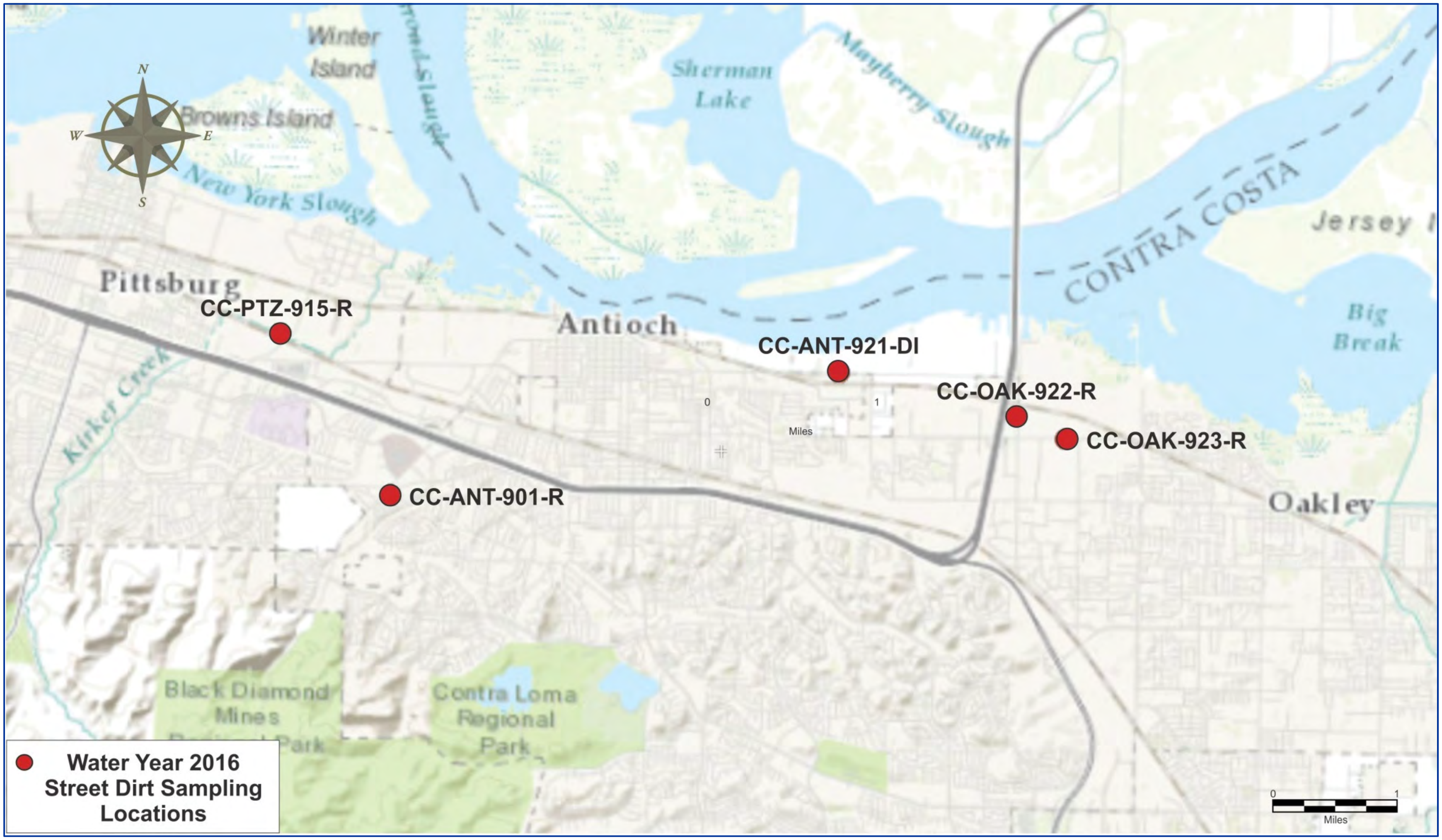


Figure 2. **Street Dirt Sampling Locations – East County (WY 2016)**



3. MS4 DROP INLET SEDIMENT SAMPLING AND ANALYSIS (TIER 2 SCREENING FOR SOURCE ID)

During WY 2016, seven drop inlet locations were sampled in the Rumrill Boulevard area (Table 4 and Figure 3), and seven drop inlet locations were sampled in the Giant Highway area (Table 4 and Figure 4). Analytical results for PCBs, mercury, TOC and PSD are presented in Table 5.

The Rumrill Boulevard area is in the City of San Pablo and starts at the Bay Area Rapid Transit (BART) station to the south and runs north to Folsom Avenue. This area has three prominent sections of source PCBs that may continue to migrate outward and contaminate the surrounding areas. The lower section is near the BART station off Rumrill Boulevard; the middle section is around a soccer field and a vacant lot; and the northern section is around an automobile dismantler near Market Street and Rumrill Boulevard. MS4 drop inlets serving runoff from these areas were identified as sampling locations. Based on field conditions, sites were sampled where sufficient sediment accumulated within drop inlets vaults and where sites were safely accessible.

The Giant Highway area is in the City of San Pablo and runs north from Parr Boulevard to John Avenue. The monitoring approach for this area was to sample 6 to 8 drop inlets along Giant Highway that had sediment present within the drop inlet and that were safely accessible. The intention of sampling was to characterize PCBs and mercury levels within the MS4 in a somewhat uniform spatial distribution along Giant Highway. Relatively great amounts of sediment migrate along Giant Highway and, even if concentrations of PCBs and mercury are not highly elevated, the large mass of mobile sediment available may point toward this area as having a high opportunity for source control measures.

MS4 drop inlet sediment samples were tested for PCBs, mercury, TOC and PSD. Refer to Table 3 above for test methods, reporting limits and holding times.

Table 4. Rumrill Boulevard and Giant Highway Sampling Locations and Selection Rationale (WY 2016)

Site ID[1]	Date Sampled	Latitude (decimal degrees)	Longitude (decimal degrees)	General Description and Selection Rational[2]
CC-RUM-947-DI	08/31/16	37.96002	-122.36148	Drop inlet contained sufficient sediment for sampling, moderate amount of plant material, no trash
CC-RUM-948-DI	08/31/16	37.95870	-122.36045	Drop inlet contained sufficient sediment for sampling, moderate amount of plant material, no trash
CC-RUM-949-DI	08/31/16	37.95855	-122.35922	Drop inlet contained sufficient sediment for sampling, no plant material, no trash
CC-RUM-950-DI	09/01/16	37.95807	-122.35686	Drop inlet contained sufficient sediment for sampling, moderate amount of plant material, no trash
CC-RUM-951-DI	09/01/16	37.95611	-122.35697	Drop inlet contained sufficient sediment for sampling, great amount of plant material, trash present
CC-RUM-952-DIC	09/01/16	37.95336[3]	-122.35774[3]	Three adjacent drop inlets were sampled in this composite, all contained sufficient sediment, no plant material, no trash
CC-RUM-953-C	09/01/16	37.95208	-122.35853	Location sampled is within target area, but is a composite from an outfall pipe

Table 4. Rumrill Boulevard and Giant Highway Sampling Locations and Selection Rationale (WY 2016)

Site ID[1]	Date Sampled	Latitude (decimal degrees)	Longitude (decimal degrees)	General Description and Selection Rational[2]
CC-GNT-940-DI	08/31/16	37.97876	-122.35315	Drop inlet at northern boundary of Giant Highway, contained sufficient sediment for sampling, no plant material, no trash
CC-GNT-941-DI	08/31/16	37.97719	-122.35355	Drop inlet contained sufficient sediment for sampling, minor plant material, no trash, flows directly into Wildcat Creek
CC-GNT-942-DI	08/31/16	37.97634	-122.35379	Drop inlet in front of industrial complex noted for elevated levels of PCBs in past testing, sufficient sediment present to sample
CC-GNT-943-DI	08/31/16	37.97319	-122.35464	Drop contained great amounts of plant material but had sufficient amount of sediment for sampling
CC-GNT-944-DI	08/31/16	37.97096	-122.35522	Drop inlet sampled contained sufficient sediment for sampling and located in area known to have elevated PCBs
CC-GNT-945-DI	08/31/16	37.96910	-122.35573	Drop inlet at southern boundary of Giant Highway, contained sufficient sediment for sampling, small amounts of plant material and trash, soil was moist
CC-GNT-946-C	08/31/16	37.97396[3]	-122.35486[3]	Composite sample collected from open channel that runs along southbound lane of Giant Highway

1 Site ID Key:

C composite CC Contra Costa DI drop inlet DIC drop inlet composite RUM Rumrill Boulevard

2 Site sampled due to availability of sufficient sediment, safety, and proximity to target area as provided by geo spatial distribution.

3 This location is the approximate midpoint of the composite sampling locations.

Table 5. Rumrill Boulevard and Giant Highway Sampling Results (WY 2016)

Sample ID	Total PCBs (µg/Kg) [1]	Total Hg (µg/Kg)	TOC (%)	*Particle Size Distribution*			
				Gravel (%)	Sand (%)	Silt (%)	Clay (%)
CC-RUM-947-DI	138	169	4.2	36	54	7	0
CC-RUM-948-DI	72	162	3.83	23	68	6	1
CC-RUM-949-DI	31	278	1.85	28	61	5	0
CC-RUM-950-DI	92	145	4.44	9	87	2	0
CC-RUM-951-DI	211	161	8.79	21	72	4	0
CC-RUM-952-DI-C	***4,881***	292	9.11	16	70	9	0
CC-RUM-953-C	17	354	3.39	14	63	20	2
CC-GNT-940-DI	19	135	1.39	30	45	21	2
CC-GNT-941-DI	30	170	5.91	12	78	6	1
CC-GNT-942-DI	14	70	2.01	9	88	2	0
CC-GNT-943-DI	29	143	3.72	11	84	3	0
CC-GNT-944-DI	24	108	3.21	8	87	0	0
CC-GNT-945-DI	12	217	4.51	29	60	7	2
CC-GNT-946-C	17	181	2.43	40	41	17	1

[1] Sum of RMP 40 congeners.

Values in bold italics indicate that the result exceeds 500 µg/Kg (ppb).

Figure 3. **MS4 Drop Inlet Sediment Sampling Locations – Rumrill Boulevard Area, San Pablo (WY 2016)**

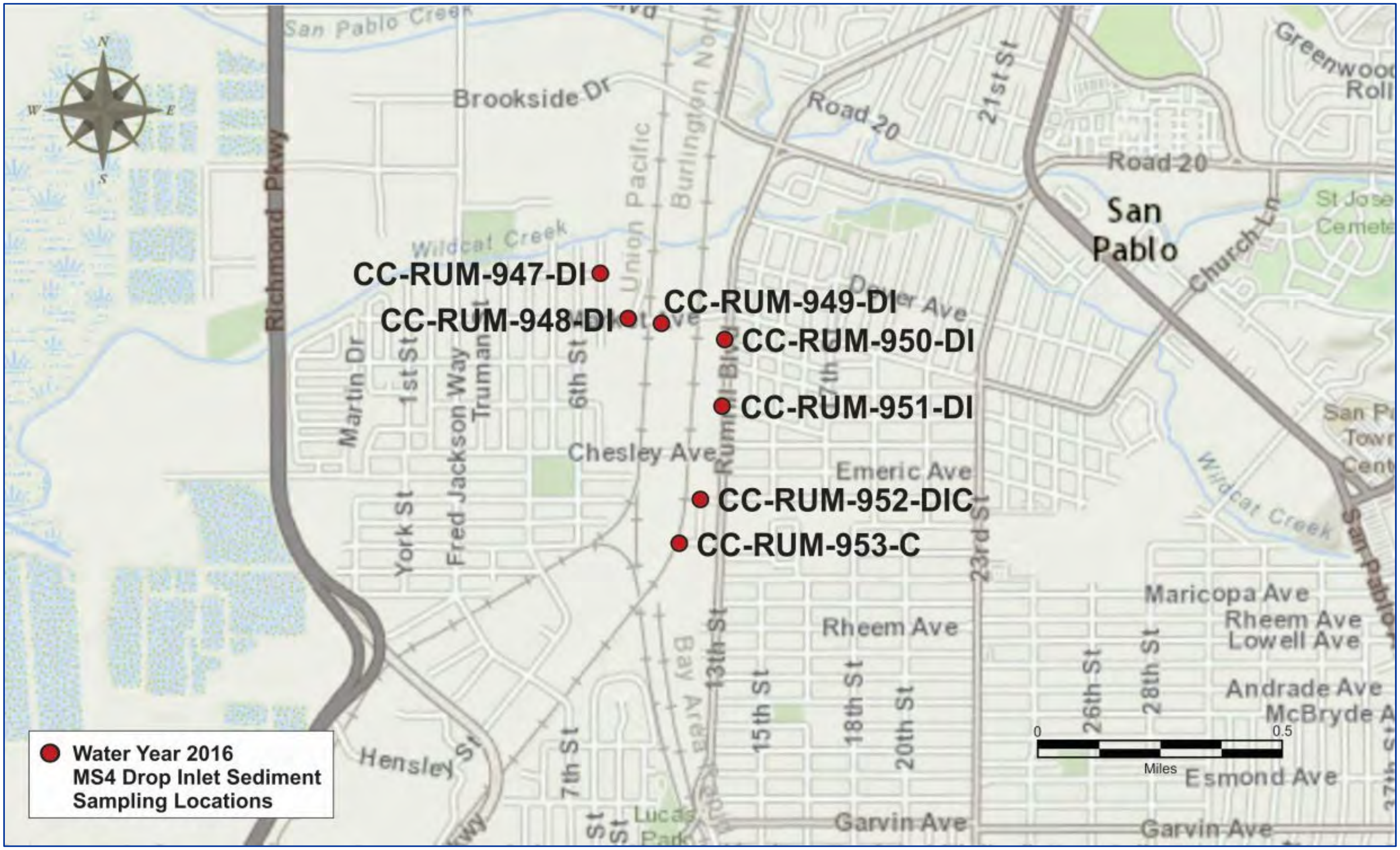
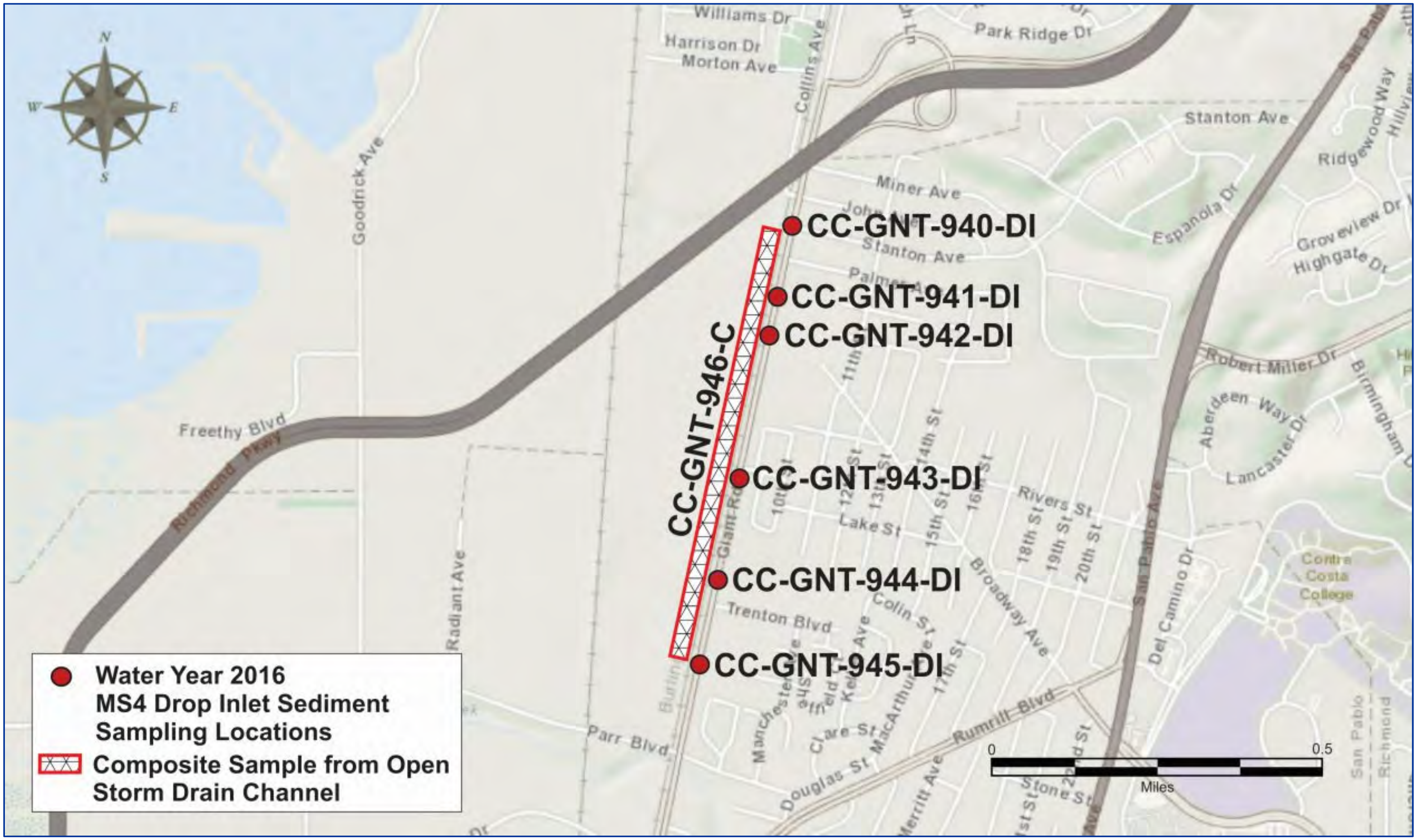


Figure 4. **MS4 Drop Inlet Sediment Sampling Locations – Giant Highway Area, San Pablo (WY 2016)**



4. STORMWATER SAMPLING AND ANALYSIS (TIER 3 SCREENING FOR SOURCE ID)

WY 2016 stormwater samples were collected along West Gertrude Avenue in the City of Richmond as a follow up to the determination of high PCBs and mercury concentrations found in street dirt samples collected in WY 2015. Stormwater sampling point WGA-SF1-01 (Table 6 and Figure 5) was in the same general location as street dirt sample CC-RCH-401-U, which had the highest concentration of PCBs and mercury of all sites tested in WY 2015 (ADH, 2016a).

Stormwater sampling results corroborated street dirt sampling results and indicated runoff to the MS4 is high in PCBs and mercury along West Gertrude Avenue, especially at the farthest west drop inlet (site WGA-DI1-01) which is adjacent to the suspected source property. Particle ratios in suspended sediment for PCBs were 473 parts per billion (ppb) at WGA-DI1-01 and were 700 ppb at WGA-SF1-01 (runoff coming directly off the suspected source property).

Table 6. Stormwater Sampling Results – West Gertrude Avenue, Richmond (WY 2016)

Site ID[1]	WGA-DI1-01	WGA-DI2-01	WGA-DI3-01	WGA-DI4-01	WGA-DI5-01	WGA-SF1-01
Date Sampled	1/19/2016	1/19/2016	1/19/2016	1/19/2016	1/19/2016	1/19/2016
Latitude	37˚ 57.246'	37˚ 57.246'	37˚ 57.246'	37˚ 57.246'	37˚ 57.246'	37˚ 57.248'
Longitude	-122˚ 22.655'	-122˚ 22.634'	-122˚ 22.603'	-122˚ 22.551'	-122˚ 22.488'	-122˚ 22.655'
Total PCBs[2] (ng/L)	69.5	13.2	3.88	40.6	71.1	35.9
Total Hg (µg/L)	3.75	1.11	2.01	3.37	0.97	16.9
Total MeHg (ng/L)	0.32	0.39	0.49	0.41	0.39	0.22
MeHg/Hg Ratio (%)	8.5	35	24	12	40	1.3
SSC (mg/L)	147	44.4	262	113	226	51.3
TOC (mg/L)	2.12	1.31	6.68	6.31	4.28	3.80
PCBs/SSC Ratio (ppb)[3]	***473***	297	15	359	315	***700***
THg/SSC Ratio (ppb)	25.5	25.0	7.67	29.8	4.29	329

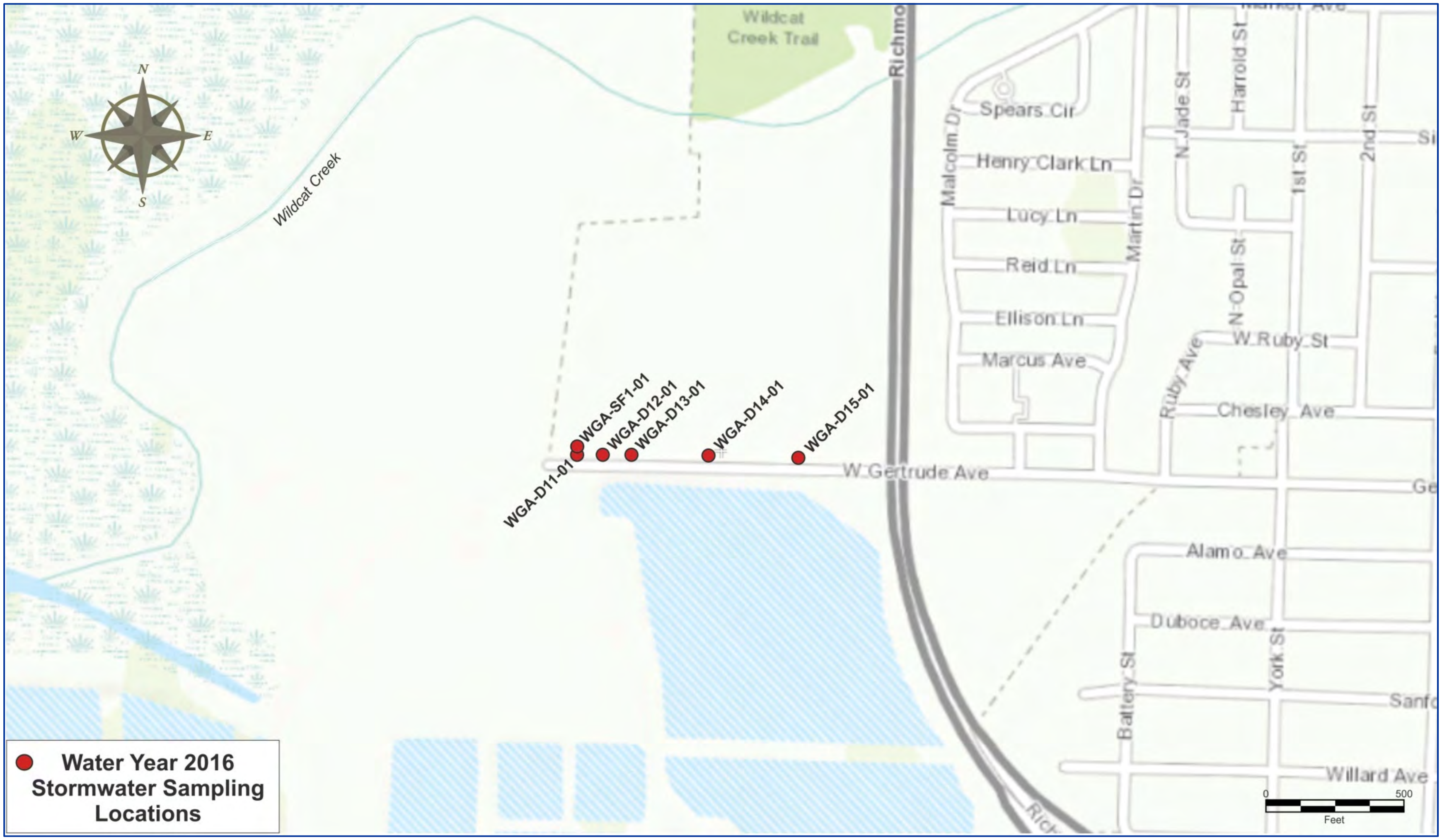
1 Site ID Key:

DI drop inlet SF sheet flow WGA West Gertrude Avenue

2 PCBs in water analyzed by method EPA 1668

3 Values in bold italics indicate a likely high source area for PCBs

Figure 5. Stormwater Sampling Locations – West Gertrude Avenue, Richmond (WY 2016)



5. BMP EFFECTIVENESS EVALUATION

BMP effectiveness monitoring for mercury and methylmercury was conducted at two adjacent pilot biofiltration BMPs (LAU3 and LAU4) on Cutting Boulevard in the City of Richmond (Figure 6). These BMPs were selected for monitoring in part because monitoring costs were shared with a concurrent EPA-funded water quality study implemented at the same location (Clean Watersheds for a Clean Bay, Task 5 Phase 2). Influent and effluent stormwater samples were collected from each biofiltration BMP at three time points per storm.

Results from this BMP effectiveness evaluation for mercury, methylmercury and SSC will be reported in a forthcoming update to the *Contra Costa Clean Water Program Methylmercury Control Study Progress Report* (ADH and AMEC, 2015).

Figure 6. BMP Effectiveness Monitoring Locations LAU3 and LAU4 on Cutting Boulevard in the City of Richmond

6. SUMMARY OF MONITORING COMPLETED IN WATER YEAR 2016

As a whole, WY 2016 monitoring is summarized in Table 7. The table lists the total number of tests completed for each pollutant class, and the corresponding targets outlined in MRP 2.0.

Table 7. Monitoring Completed in Water Year 2016 by Pollutant Class and MRP 2.0 Targets

Pollutant Class	Number of Samples Collected and Analyzed in WY 2016[1]	Annual Minimum Samples Required by MRP 2.0	Total Samples Required By MRP 2.0 Over 5 Year Term
PCBs - water	6	8	80
PCBs - sediment	22	8	80
Mercury - water	24	8	80
Mercury - sediment	22	8	80
Copper[2] - water	0	2	20
Emerging Contaminants[3]	0	3	3
Nutrients[4] – water	0	2	20

1 Exclusive of field QA/QC samples

2 Total and dissolved copper

3 Emerging contaminants (alternative flame retardants) need only be tested during one special study over the 5-year term of the permit

4 Ammonium, nitrate, nitrite, total Kjeldahl nitrogen, orthophosphate and total phosphorus

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7. QUALITY ASSURANCE / QUALITY CONTROL ANALYSIS

ADH performed verification and validation of all laboratory data per the project draft QAPP and consistent with SWAMP 2013 measurement quality objectives (MQOs).

Of 23 sediment samples collected overall, one was a blind field duplicate samples(CC-RCH-925-R). The relative percent difference (RPD) for the sum of PCB congeners of this duplicate sample was 3 percent; the RPD for mercury was 36 percent. The PCBs RPD of 3 percent is well within the acceptable range. The mercury RPD of 36 percent is outside of the acceptable range of 25 percent; however, the distribution of mercury in street dirt samples can display micro-heterogeneity therefore the RPD range between original and field duplicate samples is considered acceptable.

All samples for all analyses met quality control objectives, except the samples for PCB congeners shown in Table 8 below. Given that all the quality control issues described in Table 8 show the issues were of relatively minor consequence, the data from these samples are of acceptable quality and have been included in the data set for this annual report.

Table 8. Quality Control Issues and Analysis for PCB Congeners in the WY 2016 Project Data Set

Sample ID & Type	Issue	Analysis
CC-RCH-926-DI (Sediment)	Matrix interference in matrix spike and matrix spike duplicate samples for many congeners due to presence of non-target background components. Recoveries of several congeners outside of control limits.	Recovery in the Laboratory Control Sample was acceptable for most congeners. PCB 31, PCB 49 and PCB 95 excepted. However, accurate quantitation was not possible. The results are flagged to indicate matrix interference. No further correction action was taken.
CC-RCH-912-R (Sediment)	Sample extract was diluted because of relatively high levels of non-target background components. The extract was highly colored and contained visible settled extract. The dilution resulted in elevated detection limits for all congeners. The result was flagged to indicate matrix interference and dilution.	The dilution resulted in elevated detection limits for all congeners. The result was flagged to indicate matrix interference and dilution.
CC-GNT-941-DI (Sediment)	Matrix spike recovery outside of control limits due to matrix interference (the presence of non-target background components prevented adequate resolution of the target analytes.	Based on the method and historic data, the recoveries observed were in the range of expected for this procedure. However, accurate quantitation was not possible. The results are flagged to indicate matrix interference. No further correction action was taken.
Samples in service request K1610489 (Sediment)	The detection limit was elevated for all analytes in all field samples. The sample extract was diluted prior to analysis due to relatively high levels of non-target background components. The result was flagged to indicate matrix interference and dilution.	The results were flagged to indicate matrix interference and dilution.
CC-RUM-952-DI-C (Sediment)	Additional dilution was required due to elevated levels of target analytes.	Reporting limits were adjusted to reflect the dilution.
Samples in service request K1600671 (Stormwater)	The ion abundance ratios did not meet the acceptance criteria for one or two congeners in all but one sample.	Reported value is an estimated maximum.

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8. REFERENCES

ADH and AMEC. 2015. Contra Costa Clean Water Program Methylmercury Control Study Progress Report. ADH Environmental and Amec Foster Wheeler. October 2015.

ADH and AMS. 2016a. Contra Cost County Clean Water Program Sampling and Analysis Plan DRAFT Pollutants of Concern Monitoring; Pesticides and Toxicity Monitoring. ADH Environmental and Applied Marine Sciences. January 21, 2016.

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ADH. 2016a. Contra Costa Clean Water Program Pollutants of Concern Sediment Screening 2015 Annual Sampling and Analysis Report. ADH Environmental. March 4, 2016.

ADH. 2016b. Contra Costa Clean Water Program Pollutants of Concern Report: Accomplishments in Water Year 2016 and Allocation of Effort for Water Year 2017. ADH Environmental. October, 2016.

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Appendix 5

Pollutants of Concern (POC) Reconnaissance Monitoring Final Program Report for Water Years 2015 and 2016 (DRAFT)

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Pollutants of concern (POC) reconnaissance monitoring draft final progress report, water years (WYs) 2015 and 2016

Prepared by

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San Francisco Estuary Institute, Richmond, California

On

February 24, 2017

For

Regional Monitoring Program for Water Quality in San Francisco Bay (RMP)
Sources Pathways and Loadings Workgroup (SPLWG)
Small Tributaries Loading Strategy (STLS)

Preface

WYs 2015 and 2016 reconnaissance monitoring was completed with funding provided by the Regional Monitoring Program for Water Quality in San Francisco Bay (RMP). This report is designed to be updated each year until completion of the study. At least one additional water year (WY 2017) is planned for this study. This initial full draft report was submitted to BASMAA in February 2017 in support of materials being submitted on or before March 31st 2017 in compliance with the Municipal Regional Stormwater Permit (MRP) Order No. R2-2015-0049. Minor additional changes will likely be made in response to SPLWG and TRC review comments before the report is lodged on the RMP website.

Acknowledgements

We appreciate the support and guidance from members of the Sources, Pathways and Loadings Workgroup of the Regional Monitoring Program for Water Quality in San Francisco Bay. The detailed work plan behind this work was developed through the Small Tributaries Loading Strategy (STLS) Team during a series of meetings in the summer of 2014, with slight modifications made during the summers of 2015 and 2016. Local members on the STLS Team at that time were Arleen Feng (for the Alameda Countywide Clean Water Program), Bonnie de Berry (for the San Mateo Countywide Water Pollution Prevention Program), Lucile Paquette (for the Contra Costa Clean Water Program) and Chris Sommers (for the Santa Clara Valley Urban Runoff Pollution Prevention Program); and Richard Looker, and Jan O'Hara (for the Regional Water Board). San Francisco Estuary Institute (SFEI) field and logistical support over the first year of the project was provided by Patrick Kim, Carolyn Doehring and Phil Trowbridge, and in the second year of the project by Patrick Kim, Amy Richie, and Jennifer Sun. SFEI's data management team is acknowledged for their diligent delivery of quality assured well-managed data. Over both years of this project, this team included: Cristina Grosso, Amy Franz, John Ross, Adam Wong, and Michael Weaver. Helpful written reviews of this report were provided by Arleen Feng (ACCWP), Lisa Sabin (EOA/ SCVURPPP), and Bonnie de Berry (EOA/ SMCWPPP).

Suggested citation:

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Executive Summary

The San Francisco Bay mercury and PCB TMDLs called for implementation of control measures to reduce PCB and mercury loads entering the Bay via stormwater. Subsequently, the San Francisco Bay Regional Water Quality Control Board (Regional Water Board) issued the first combined Municipal Regional Stormwater Permit (MRP). This first MRP contained provisions aimed at improving information on stormwater pollutant loads in selected watersheds (Provision C.8.) and piloted a number of management techniques to reduce PCB and Hg loading entering the Bay from smaller urbanized tributaries (Provisions C.11. and C.12.). In November 2015, the Regional Water Board issued the second MRP. "MRP 2.0" places an increased focus on finding watersheds, source areas, and source properties that are potentially more polluted and are therefore more likely to be cost effective areas for addressing load reduction requirements through implementation of control measures.

To support this increased focus, a stormwater characterization monitoring program was developed and implemented in Water Year (WY) 2015 and 2016. Most of the sites monitored in WY 2015 and 2016 were located within Alameda, Contra Costa, and San Mateo Counties with just a few sites so far located in Contra Costa County. In addition, and with funding independent of the RMP efforts, this same design is being implemented in the winter of WY 2017 by the RMP, the San Mateo Countywide Water Pollution Prevention Program and the Santa Clara Valley Urban Runoff Pollution Prevention Program. In addition, the RMP is piloting a project to explore the use of alternative un-manned "remote" suspended sediment samplers (the Hamlin and Walling Tube samplers). During WYs 2015 and 2016, composite stormwater samples were collected from 37 watershed locations. At eight of these locations, data were also collected using one or, in three examples, two remote suspended sediment sampler devices, both of which are designed to enhance settling and capture of suspended sediment particles from the water column. This report summarizes and provides a preliminary interpretation of data collected during WY 2015 and 2016. The data collected is contributing to a broader effort to identify potential management areas. The report is designed to be updated in subsequent years as more data are collected.

Despite climatically challenging conditions resulting in a limited number of storms of appropriate magnitude for sample capture, a total of 20 additional sites were sampled during WY 2015 and an additional 17 sites were sampled and characterized for concentrations during WY 2016. At these sites, composite water samples collected during one storm event were analyzed for PCBs, HgT, SSC, selected trace metals, organic carbon, and grain size. Sampling efficiency was increased by sampling two sites during a single storm that had similar runoff characteristics and were near enough to each other to allow safe and rapid transport and reoccupation repeatedly during a rain event. At eight of these locations, simultaneous samples were also collected using a Hamlin remote suspended sediment sampler and at three sites a third method (the Walling tube remote suspended sediment sampler) was also trialed successfully. Based on this dataset, a number of sites with elevated PCB and Hg concentrations and particle ratios were successfully identified, in part based on an improved effort of site selection focusing on older industrial and highly impervious landscapes. With careful selection of sample timing, some success even occurred at tidal sites, but overall, tidal sites remain the most challenging to sample. Although optimism remains about future applications, the remote sampler trial showed mixed results and need further testing.

Total PCB concentrations measured in the composite water samples collected from the 37 sites varied 192-fold between 832 and 159,606 pg/L. The four highest ranking sites for PCB whole water concentrations were Industrial Rd Ditch in San Carlos, Outfall at Gilman St. in Berkeley, Ridder Park Dr SD in San Jose, and Outfall to Lower Silver Ck in San Jose. When normalized by suspended sediment concentrations (SSC) to generate particle ratios, the four sites with highest particle ratios were Industrial Rd Ditch in San Carlos (6,139 ng/g), Gull Dr SD in South San Francisco (859 ng/g), Outfall at Gilman St. in Berkeley (794 ng/g), and Outfall to Lower Silver Ck in San Jose (783 ng/g). Particle ratios of this magnitude are among the most extreme examples in the Bay Area (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): McKee et al., 2012; Gilbreath et al., 2016)[1]

Total Hg (HgT) concentrations in composite water samples collected during WY 2015 and 2016 ranged over 78-fold between 5.6 and 439 ng/L. The greatest HgT concentrations were observed in four Alameda County sites, the Outfall at Gilman St. in Berkeley, Line 9-D-1 PS at outfall to Line 9-D in San Leandro, Line 13-A at end of slough in San Leandro, and Line 3A-M at 3A-D in Union City. When the data were normalized by SSC, the four most highly ranked sites were Outfall at Gilman St. in Berkeley (5.3), Meeker Slough in Richmond (1.3), Line 3A-M at 3A-D in Union City (1.2), and Taylor Way SD in San Carlos (1.2). Particle ratios of this magnitude are similar to the upper range of those observed previously (mainly in WY 2011). The ten highest ranking sites for PCBs based on particle ratios only ranked 14th, 11th, 1st, 19th, 26th, 3rd, 13th, 22nd, 15th, and 8th respectively in relation to HgT particle ratios.

Both of the remote suspended sediment sampler types that were used (Walling sampler and Hamlin sampler) generally characterized sites similarly to the composite stormwater sampling methods (higher concentrations matching higher and lower matching lower), but results appear to be better for PCBs relative to Hg and there is a hint, based on just three samples, that the Walling sampler performs better than the Hamlin. Given that the data that result from remote samplers are less versatile (cannot be used for estimating loads without estimates of sediment load and are trickier to use in model calibration applications), one option is to consider using remote 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. 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.

Based on data collated from all sampling programs completed by SFEI since WY 2003 on stormwater in the Bay Area and the use of a Spearman Rank correlation analysis, PCB particle ratios appear to positively correlate with impervious cover, old industrial land use, and HgT. PCBs inversely correlate with watershed area and the other trace metals analyzed (As, Cu, Cd, Pb, and Zn). Total mercury does not appear to correlate with any of the other trace metals and showed similar but weaker relationships to impervious cover, old industrial land use, and watershed area than did PCBs. In contrast, the trace

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[1] Note, these particle ratios 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.

metals all appear to correlate with each other more generally. Overall, the data collected to date do not support the use of any of the trace metals analyzed as a tracer for either PCB or HgT pollution sources.

Climatic conditions may affect the interpretations of relative ranking between watersheds. WY 2015 was a drier than average year and WY 2016 was about average in San Francisco and San Jose. A total of 62 sites have so far been sampled for PCBs and HgT in stormwater by SFEI during various field sampling efforts since WY 2003. About 29% of the old industrial land use in the region has been sampled to date. The largest sample size so far has occurred in Santa Clara County (96% of this land use has been sampled), followed by San Mateo County (43%), Alameda County (33%), and Contra Costa County (4%). The disproportional coverage in Santa Clara County is due to a number of larger watersheds being sampled and because there were older industrial areas of land use further upstream in the Coyote Creek and Guadalupe River watersheds. Of the remaining older industrial land use yet to be sampled (~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, likely to include heavy industrial areas that were historically serviced by rail and ship based transport, and are often very difficult to sample due to a lack of public right of ways. A different sampling strategy may be needed to effectively determine what pollution might be associated with these areas.

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Introduction

The San Francisco Bay mercury and polychlorinated biphenyl (PCB) total maximum daily load plans (TMDLs) (SFBRWQCB, 2006; 2007) called for implementation of control measures to reduce stormwater PCB loads from about 20 kg to 2 kg by 2030 and to reduce stormwater total mercury (HgT) loads from about 160 kg down to 80 kg by 2028 with an interim milestone of 120 kg of Hg by 2018. Subsequently, the San Francisco Bay Regional Water Quality Control Board (Regional Water Board) issued the first combined Municipal Regional Stormwater Permit (MRP) for MS4 phase I stormwater agencies (SFBRWQCB, 2009; 2011(update)). MRP 1.0, as it came to be known, contained a provision that aimed to improve information on stormwater loads for a number of pollutants in selected watersheds (Provision C.8.) and additional provisions specific to Hg and PCBs (Provisions C.11. and C.12.) that called for piloting a number of management techniques to reduce PCB and Hg loads entering the Bay from smaller urbanized tributaries. To help address these information needs, a Small Tributaries Loading Strategy (STLS) was developed that outlined four key management questions (MQs) about loadings and a general plan to address these questions (SFEI, 2009). These questions were developed to be consistent with Provision C.8.e of MRP 1.0 and to link with the Hg and PCB specific provisions.

> MQ1. Which Bay tributaries (including stormwater conveyances) contribute most to Bay impairment from pollutants of concern (POCs);
>
> MQ2. What are the annual loads or concentrations of POCs from tributaries to the Bay;
>
> MQ3. What are the decadal-scale loading or concentration trends of POCs from small tributaries to the Bay; and,
>
> MQ4. What are the projected impacts of management actions (including control measures) on tributaries and where should these management actions be implemented to have the greatest beneficial impact.

During the first term of the MRP (2009-15) for MS4 Phase I stormwater permittees[2], the STLS Team focused the majority of the STLS-budgeted portion of RMP funds on refining pollutant loadings (Provision C.8.e) with some additional but more minor effort on finding and prioritizing potential “high leverage” watersheds and subwatersheds (those with disproportionately high concentrations or loads with connections to sensitive Bay margins). These RMP efforts with additional contract funds from Bay Area Stormwater Management Agencies Association (BASMAA)[3] resulted in the completion of a number of technical products that were consistent with the implementation plans outlined in the PCBs and Hg policy documents. These technical products in rough order of completion included the

1. 2009/2010 study to explore relationships between watershed characteristics (Greenfield et al., 2010) (RMP funds),

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[2] For a full list of permittees, the reader is referred to the individual countywide program websites or the reissued MRP (SFBRWQCB, 2015).

[3] BASMAA is made up of a number of programs which represent Permittees and other local agencies

2. 2009/2010 study to explore optimal sampling design for loads and trends (Melwani et al., 2010) (RMP funds),
3. reconnaissance study in water year 2011 to characterize concentrations during winter storms at 17 locations (McKee et al., 2012) (RMP funds),
4. completion of a number of "pollutant profiles" describing what is known about the sources and release processes for each pollutant (McKee et al., 2014) (BASMAA funds),
5. the development and operation of a loads monitoring program at six fixed station locations for water years 2012-2014 (Gilbreath et al., 2015a) (BASMAA and RMP funds),
6. completion of a loads monitoring synthesis report (McKee et al., 2015) (RMP funds), and
7. further refinement of geographic information about land uses and source areas of PCBs and Hg and the development of a regional watershed spreadsheet model (2010-present) (Wu et al., 2016; Wu et al., 2017) (BASMAA and RMP funds).

As a result of all this effort (several million dollars of funding spread over six years and a huge number of people and team members), sufficient pollutant data have been collected at sites with discharge measurements to make computations of pollutant loads of varying degrees of certainty at Mallard Island on the Sacramento River and 11 urban sites (McKee et al. 2015), and a reasonable calibration of the regional watershed spreadsheet model (RWSM) has been achieved for water, Cu, Hg, and PCBs (Wu et al., 2016; Wu et al., 2017), although we anticipate further improvements with the inclusion of WY 2016 data and further calibration and testing using 2017 RMP funding.

Discussions between BASMAA and the SFBRWQCB regarding the second term of the MRP, and parallel discussions at the October 2013 and May 2014 Sources Pathways and Loadings Workgroup (SPLWG) meetings, highlighted the need for an increasing focus on finding watersheds and land areas within watersheds that have relatively higher unit area load production or higher particle ratios or sediment pollutant concentrations at scales paralleling management practices (areas as small as subwatersheds, areas of old industrial land use, or source properties). This changed focus was consistent with the management trajectory outlined in the Fact Sheet (MRP Appendix I) issued with the November 2011 revision of the October 2009 MRP (SFBRWQCB, 2009; 2011). The Fact Sheet described a transition from pilot-testing in a few specific locations during the first MRP term to a greater amount of focused implementation in areas where benefits would be most likely to accrue in the second MRP term.

During 2014 and early 2015, the SPLWG and Small Tributaries Loadings Strategy (STLS) Team discussed alternative monitoring designs that could address this focus and settled upon the "reconnaissance design" described in this report. In November 2015, the Regional Water Board issued the second MRP (SFBRWQCB, 2015). "MRP 2.0" places an increased focus on finding high leverage watersheds, source areas, and source properties that are more polluted and located upstream from sensitive Bay margin areas. Specifically the permit retains the four Management Questions from MRP 1.0 but adds a new one stating that effort should be made to identify which sources or watershed source areas provide the greatest opportunities for reductions of mercury and PCBs in urban stormwater runoff. To help support this focus and also refine information addressing other Management Questions, the SPLWG and the STLS local team developed and implemented a stormwater reconnaissance characterization monitoring program in Water Year (WY) 2015 and 2016. The methods employed were modified from those first proposed at the October 2004 SPLWG meeting (study proposal #2), discussed again by the workgroup in 2005/06 as an alternative option to a loading study at Zone 4 Line A in Hayward, Alameda County, and implemented for the first time in WY 2011 (McKee et al., 2012). The nimble design implemented during the winter of WY 2015 and 2016 benefited from lessons learned during the WY 2011 effort and provides data primarily to support identification of potential high leverage areas as part of multiple lines of evidence being considered by the stormwater programs. The data also support improved calibration of the RWSM being developed to estimate regional scale watershed loads. This same design was implemented in the winter of WY 2016 by the San Mateo Countywide Water Pollution Prevention Program, and the Santa Clara Valley Urban Runoff Pollution Prevention Program. It is possible that this highly comparable data will be made available in time for the next calibrations of the RWSM planned for early 2017.

In parallel, the STLS team is designing a sampling program for monitoring stormwater loading trends in response to management efforts. Data collected using the reconnaissance characterization sampling design implemented in WYs 2011, 2015, 2016, and 2017 may also help to provide baseline data for observing concentration or particle ratio trends through time if the trends monitoring design effort provides evidence of suitability for that purpose.

This report summarizes and provides a preliminary interpretation of data collected during WY 2015 and 2016. The data collected and presented here is contributing to a broader based effort to identify potential management areas. The report was designed to be updated annually and will be updated again in approximately 12 months to include data from WY 2017 that is presently being collected.

Sampling methods

Methods selection

Water Year 2014 saw the conclusion of three years of pollutant loads monitoring at six fixed locations near the Bay margins for suspended sediment, total organic carbon (TOC), PCBs, HgT, total methylmercury (MeHgT), nitrate (NO_3), phosphate (PO_4)[4], and total phosphorus (TP). In addition, a fewer number of samples were gathered at the loading sites to characterize polybrominated diphenyl ether (PBDEs), polyaromatic hydrocarbons (PAHs), toxicity, pyrethroid pesticides, copper (Cu), and selenium (Se) (Gilbreath et al., 2015a). With the increasing focus of management efforts to identify areas of elevated PCBs (and mercury), a new monitoring design was needed to broaden the spatial coverage of information gathering and allow for relative comparisons of PCB and mercury concentrations across the region. In order to collect this information, a reconnaissance design was selected. This type of design is efficient, cost-effective, allows for a larger number of sites monitored,

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[4] Is also often referred to as dissolved orthophosphate or dissolved reactive phosphorous (DRP) or dissolved inorganic phosphorous (DIP). All these terms are functionally equivalent and refer to a sample that is filtered before analysis and analyzed using the ascorbic acid + molybdate blue reagents.

and can be used on a relative scale for identifying drainages with high PCB and mercury concentrations (McKee et al., 2012; SPLWG, May 2014; McKee et al., 2015).

The design implemented in WYs 2015 and 2016 was based on a previous monitoring design (WY 2011) in which multiple sites were visited during 1-2 storm events and stormwater samples were collected for a number of POCs. Based on discussions at the May 2014, SPLWG meeting, modifications were made to the WY 2011 design to increase cost-effectiveness. At the SPLWG meeting an analysis of previously collected stormwater sample data from both reconnaissance and fixed station monitoring was presented. An analysis of three sampling designs (sampling just 1, 2, or 4 storms, respectively: functionally 4, 8, and 16 discrete samples) showed that, for Guadalupe River at Hwy 101, PCB particle ratios could vary from 45-287 ng/g (1 storm design), 59-257 ng/g (2 storm design), and 74-183 ng/g (4 storm design). Although the Guadalupe River at Hwy 101 represents a more extreme example of variability due to smaller storms favoring runoff from just the lower and more urbanized part of the watershed versus larger storms causing runoff from the upper cleaner areas of the watershed, this analysis was used to imply that the number of storms sampled for a given system would have had quite a large influence on the resulting particle ratio and the potential relative ranking among sites. A similar analysis was then presented for the other fixed loads monitoring sites (Pulgas Pump Station-South, Sunnyvale East Channel, North Richmond Pump Station, San Leandro Creek, Zone 4 Line A, and Lower Marsh Creek) to explore the relative ranking based on a random 1-storm composite or 2-storm composite design. This analysis highlighted the potential for a false negative that could occur due to a lower number of sampled storms in Sunnyvale East Channel (3 of the 8 storms represented were < 200 ng/g which would have ranked it only slightly more polluted than San Leandro Creek, Zone 4 Line A or Guadalupe River at Hwy 101). This further highlighted the trade-off between generating information about water quality at fewer sites with more certainty or more sites with less certainty. The SPLWG agreed that a 1-storm composite per site design was preferable since the design has the flexibility to return to a site if the initial results did not make sense (either because the storm intensity was low or other information suggested potential sources).

In addition to collection of stormwater composites, a pilot study exploring in-line suspended sediment samplers based on enhanced water column settling was designed and implemented. Four sampler types were initially considered (single-stage siphon sampler, the CLAM sampler, the Hamlin sampler, and the Walling tube). After SPLWG discussion, the single-stage siphon sampler was dropped from consideration because it allowed for collection of only a single stormwater sample at a single time point, which offers no advantage over collecting a single manual stormwater sample, yet would require more effort and expense to set up. The CLAM sampler also has some limitations that affect interpretation of the data, primarily the lack of ability to estimate the volumes of water passing through the filters and the lack of performance tests in high turbidity environments. The remaining two sampler types (the Hamlin sampler and the Walling tube) were selected for the pilot study based on previous studies showing use of these devices in similar systems (velocities and analytes). However, there was a lot of discussion about how to analyze the samples and how to ensure their comparability to the composite water sample design. To test the comparability of sampling methods, the SPLWG Science Advisors recommended piloting the samplers at 12 locations[5] where manual water composites would be collected in parallel.

Watershed physiography and sampling locations

In the May 2014 SPLWG meeting, sample site selection rationale was discussed. The potential site selection rationales fall into four basic categories.

1. Identifying potential high leverage watersheds and subwatersheds (distributed across Phase I permittees)
    a. Watersheds with suspected high pollution
    b. Sites with ongoing or planned management actions
    c. Identifying sources within a larger watershed of known concern (nested sampling design)
2. Sampling strategic large watersheds with USGS gauges to provide first order loading estimates and to support calibration of the RWSM
3. Validating unexpected low (potential false negative) concentrations (to address the possibility of a single storm composite poorly characterizing a sampling location)
4. Filling gaps along environmental gradients or source areas (to support the RWSM)

It was agreed that the majority of samples each year (60-70% of the effort) would be dedicated to identifying potential high leverage watersheds and subwatersheds. The remaining resources would be allocated to addressing the other three rationales. In order to address this focus, SFEI worked with the respective Countywide Clean Water Programs to identify priority drainages including storm drains, ditches/culverts, tidally influenced areas, and natural areas for monitoring. A large pool of sites was visited during the summers of 2014 and 2015. We surveyed each for safety, logistical constraints, and to identify feasible drainage line entry points. From this larger set, a final set of ~25 sites were identified for monitoring during each WY (2015 and 2016). Due to drought conditions and challenges with sampling sites with tidal influence, of these 25 sites, 20 and 17 sites were sampled in WY 2015 and 2016 respectively (Figure 1; Table 1). The remaining unsampled sites were carried over for possible sampling in WY 2017.

It is seen, from Figure 1 and Table 1, that watershed sites with a wide variety of characteristics were sampled in WYs 2015 and 2016. In total, 14 sites were sampled in Santa Clara County, 13 sites in San Mateo County, nine sites in Alameda County, and just one site in Contra Costa County[6]. To-date, there has only been one watershed sampled in Contra Costa County (CCC) (Table 1). This represents a large data gap given the long history of industrial zoning along much of the CCC waterfront. Areas upstream

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[5] Note that in WYs 2015 and 2016 combined, only 8 and 3 locations could be sampled with the Hamlin and Walling samplers, respectively, due to climatic constraints. Five samples using the Walling sampler samples are planned for WY 2017.

[6] Two additional sites in Contra Costa County had been identified for WY 2015 but were not sampled because they are tidally influenced with only short sampling windows. Storms in WY 2015 did not align with these short windows.

from sample locations ranged between 0.11 km^2 and 17.5 km^2 and were characterized by a high degree of imperviousness (21%-88%: mean = 72%). The percentage of the watersheds designated as old industrial[7] ranged between 0% and 79% and averaged 29%. Although the sites were mainly selected to address site selection rationale number one (identifying potential high leverage watersheds and subwatersheds), Lower Penitencia Creek represents an example of a site that was previously sampled yet the resulting concentrations were surprisingly low, and therefore warranted re-sampling. The wide variety of imperviousness and industrial characteristics of these watersheds will help to broaden the environmental gradient of watershed characteristics that will potentially support an improved calibration of the RWSM (Wu et al., 2016). Although a matrix of site characteristics for sampling strategic larger watersheds was also developed (Table 2), none of these could be sampled during WY 2015 or 2016 because climatic conditions for rainfall and flow were not met.

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[7] 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).

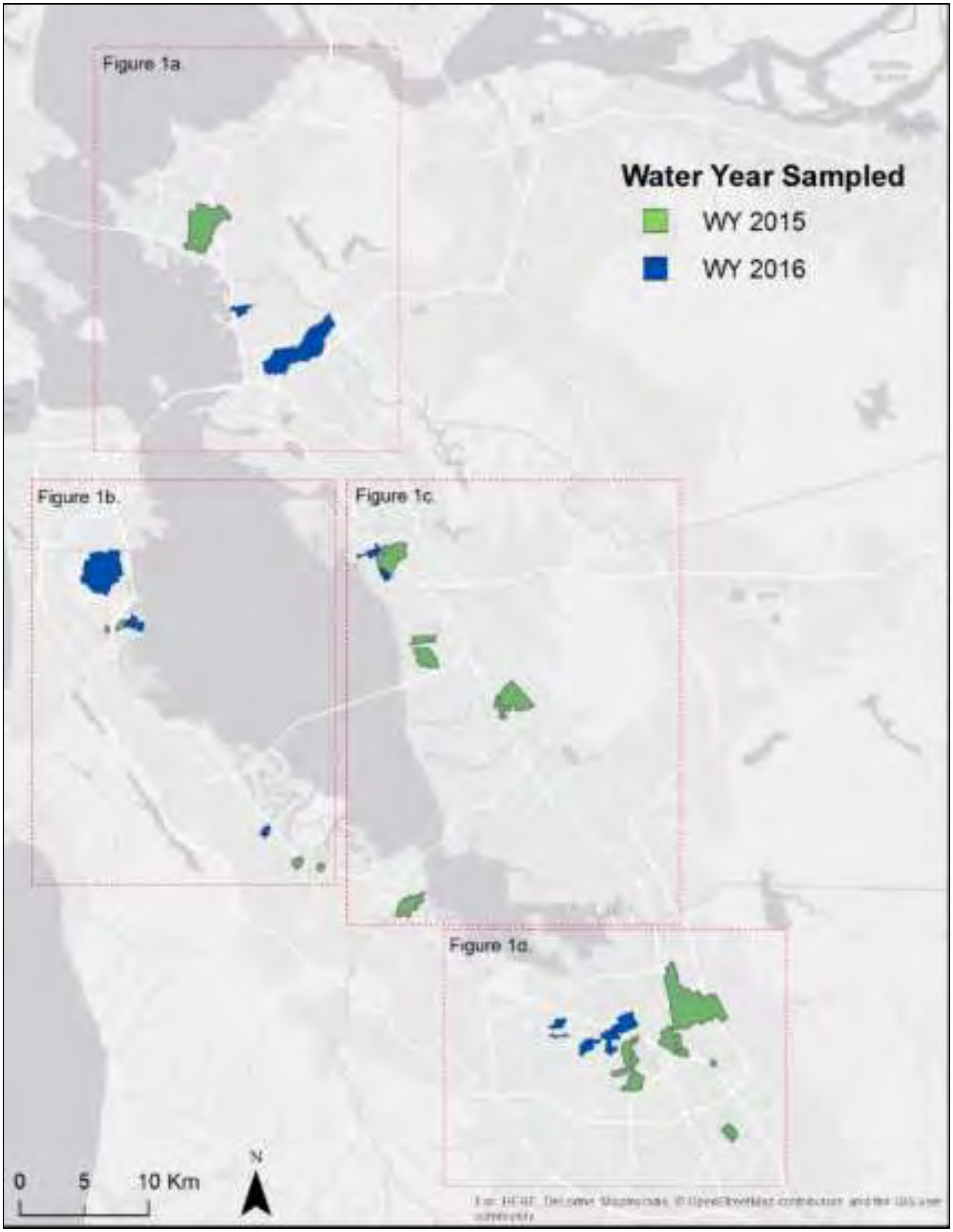

Figure 1. Sampling locations (marked by the dots) and watershed boundaries (shown in green and blue).

Figure 1a. Sampling locations (marked by the dots) and watershed boundaries (shown in green (WY 2015) and blue (WY 2016)) in northern Alameda and Contra Costa counties.

Figure 1b. Sampling locations (marked by the dots) and watershed boundaries (shown in green (WY 2015) and blue (WY 2016)) in central and northern San Mateo County.

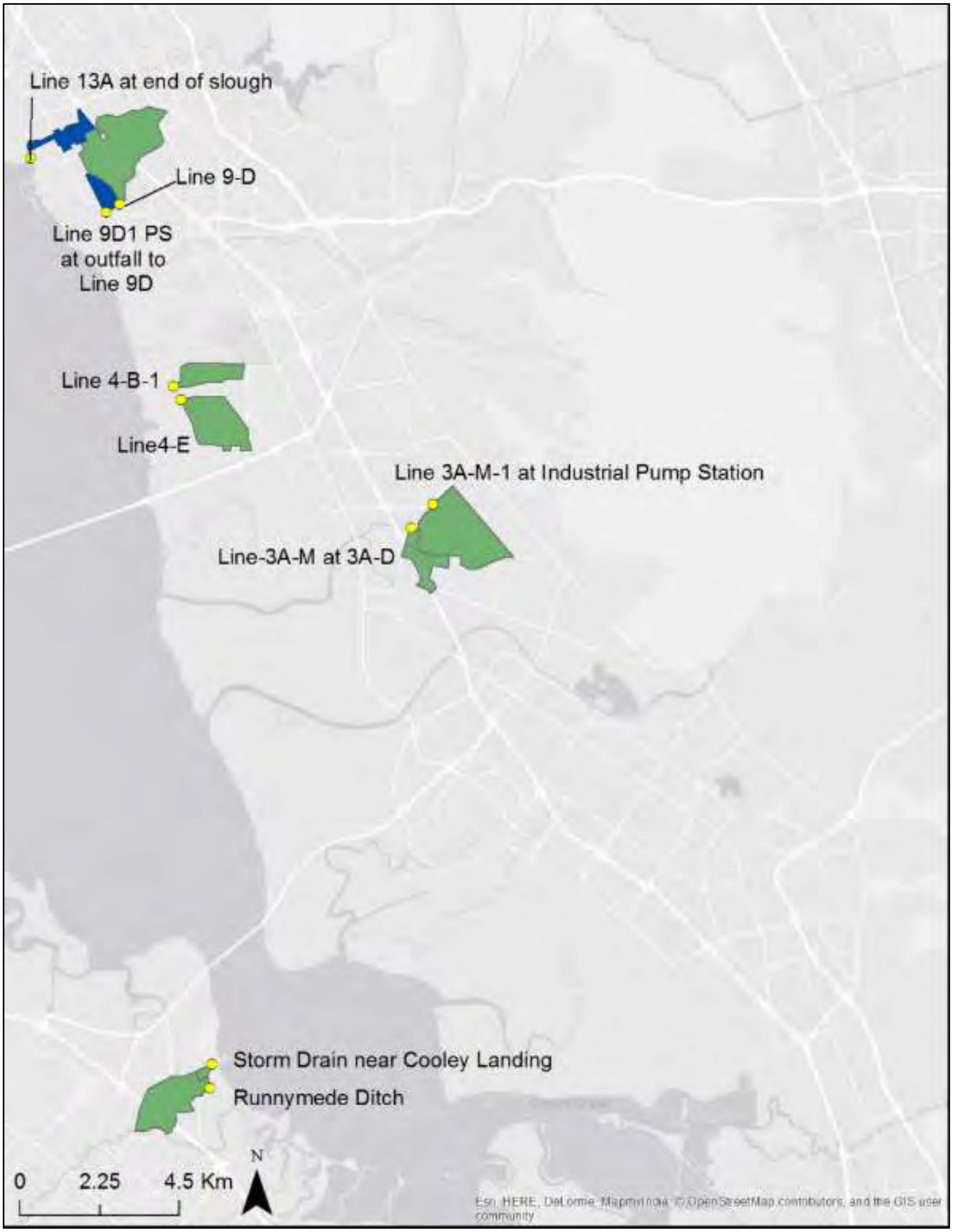

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Figure 1c. Sampling locations (marked by the dots) and watershed boundaries (shown in green (WY 2015) and blue (WY 2016)) in southern Alameda and San Mateo counties.

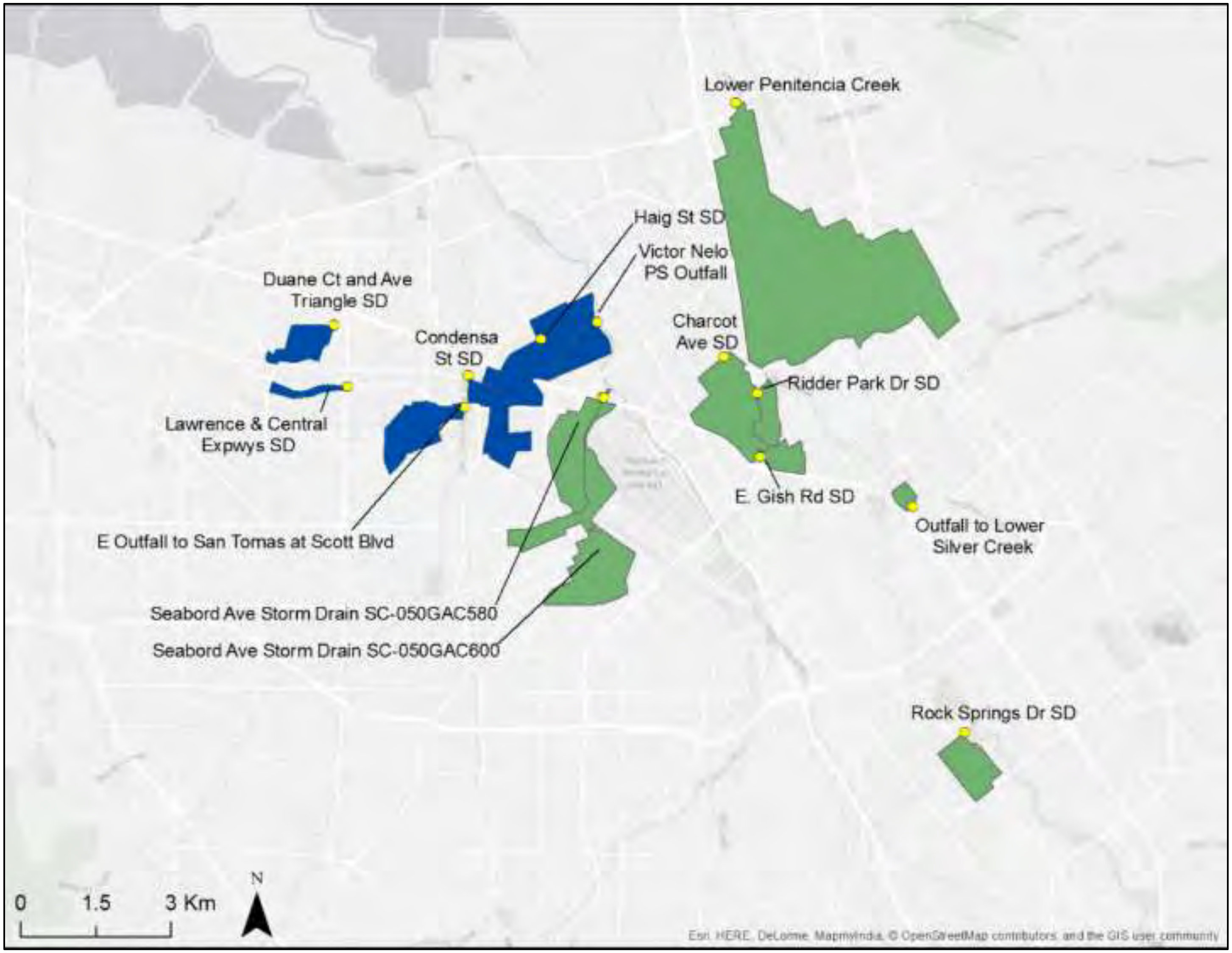

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Figure 1d. Sampling locations (marked by the dots) and watershed boundaries (shown in green (WY 2015) and blue (WY 2016)) in Santa Clara County.

Table 1. Key characteristics of WY 2015 and 2016 sampling locations.

County	**City**	**Watershed name**	**Catchment Code**	**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	37.61893	-122.05949	12/11/14	3.44	78%	26%
Alameda	Union City	Line 3A-M at 3A-D	AC-Line 3A-M	37.61285	-122.06629	12/11/14	0.88	73%	12%
Alameda	Hayward	Line 4-B-1	AC-Line 4-B-1	37.64752	-122.14362	12/16/14	0.96	85%	28%
Alameda	Hayward	Line 4-E	AC-Line 4-E	37.64415	-122.14127	12/16/14	2.00	81%	27%
Alameda	San Leandro	Line 9-D	AC-Line 9-D	37.69383	-122.16248	4/7/15	3.59	78%	46%
Alameda	San Leandro	Line 9-D-1 PS at outfall to Line 9-D	AC-2016-15	37.69168	-122.16679	1/5/16	0.48	88%	62%
Alameda	Berkeley	Outfall at Gilman St.	AC-2016-1	37.87761	-122.30984	12/21/15	0.84	76%	32%
Alameda	Emeryville	Zone 12 Line A under Temescal Ck Park	AC-2016-3	37.83450	-122.29159	1/6/16	17.47	30%	4%
Alameda	San Leandro	Line 13-A at end of slough	AC-2016-14	37.70497	-122.19137	3/10/16	0.83	84%	68%
Contra Costa	Richmond	Meeker Slough	Meeker Slough	37.91786	-122.33838	12/3/14	7.34	64%	6%
San Mateo	Redwood City	Oddstad PS	SM-267	37.49172	-122.21886	12/2/14	0.28	74%	11%
San Mateo	Redwood City	Veterans PS	SM-337	37.49723	-122.23693	12/15/14	0.52	67%	7%
San Mateo	South San Francisco	Gateway Ave SD	SM-293	37.65244	-122.40257	2/6/15	0.36	69%	52%
San Mateo	South San Francisco	South Linden PS	SM-306	37.65018	-122.41127	2/6/15	0.14	83%	22%
San Mateo	East Palo Alto	Runnymede Ditch	SM-70	37.46883	-122.12701	2/6/15	2.05	53%	2%
San Mateo	East Palo Alto	SD near Cooley Landing	SM-72	37.47492	-122.12640	2/6/15	0.11	73%	39%
San Mateo	South San Francisco	Forbes Blvd Outfall	SM-319	37.65889	-122.37996	3/5/16	0.40	79%	0%
San Mateo	South San Francisco	Gull Dr Outfall	SM-315	37.66033	-122.38502	3/5/16	0.43	75%	42%
San Mateo	South San Francisco	Gull Dr SD	SM-314	37.66033	-122.38510	3/5/16	0.30	78%	54%
San Mateo	Brisbane	Tunnel Ave Ditch	SM-350/368/more	37.69490	-122.39946	3/5/16	3.02	47%	8%
San Mateo	Brisbane	Valley Dr SD	SM-17	37.68694	-122.40215	3/5/16	5.22	21%	7%
San Mateo	San Carlos	Industrial Rd Ditch	SM-75	37.51831	-122.26371	3/11/16	0.23	85%	79%
San Mateo	San Carlos	Taylor Way SD	SM-32	37.51320	-122.26466	3/11/16	0.27	67%	11%
Santa Clara	Milpitas	Lower Penitencia Ck	Lower Penitencia	37.42985	-121.90913	12/11/14	11.50	65%	2%
Santa	Santa	Seabord Ave SD	SC-	37.37637	-121.93793	12/11/14	1.35	81%	68%

County	**City**	**Watershed name**	**Catchment Code**	**Latitude**	**Longitude**	**Sample Date**	**Area (sq km)**	**Impervious cover (%)**	**Old industrial (%)**
Clara	Clara	SC-050GAC580	050GAC580						
Santa Clara	Santa Clara	Seabord Ave SD SC-050GAC600	SC-050GAC600	37.37636	-121.93767	12/11/14	2.80	62%	18%
Santa Clara	San Jose	E. Gish Rd SD	SC-066GAC550	37.36632	-121.90203	12/11/14	0.44	84%	71%
Santa Clara	San Jose	Ridder Park Dr SD	SC-051CTC400	37.37784	-121.90302	12/15/14	0.50	72%	57%
Santa Clara	San Jose	Outfall to Lower Silver Ck	SC-067SCL080	37.35789	-121.86741	2/6/15	0.17	79%	78%
Santa Clara	San Jose	Rock Springs Dr SD	SC-084CTC625	37.31751	-121.85459	2/6/15	0.83	80%	10%
Santa Clara	San Jose	Charcot Ave SD	SC-051CTC275	37.38413	-121.91076	4/7/15	1.79	79%	25%
Santa Clara	Santa Clara	Duane Ct and Ave Triangle SD	SC-049CZC200	37.38852	-121.99901	12/13/15 and 1/6/16	1.00	79%	23%
Santa Clara	Santa Clara	Lawrence & Central Expwys SD	SC-049CZC800	37.37742	-121.99566	1/6/16	1.20	66%	1%
Santa Clara	Santa Clara	Condensa St SD	SC-049STA710	37.37426	-121.96918	1/19/16	0.24	70%	32%
Santa Clara	San Jose	Victor Nelo PS Outfall	SC-050GAC190	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	37.37991	-121.96842	3/6/16	0.67	66%	31%
Santa Clara	San Jose	Haig St SD	SC-050GAC030	37.38664	-121.95223	3/6/16	2.12	72%	10%

Table 2. Characteristics of larger watersheds to be monitored, proposed sampling location, and proposed sampling trigger. None of these watersheds could be sampled during WY 2015 or 2016 because climatic conditions for flow and rainfall were not met.

Proposed sampling location							Relevant USGS gauge for 1st order loads computations	
Watershed system	**Watershed area (sq km)**	**Impervious surface (%)**	**Industrial (%)**	**Sampling objective**	**Commentary**	**Proposed sampling triggers**	**Gauge number**	**Area at USGS gauge (sq km)**
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 decent forecast for the East Bay interior valley's (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 decent forecast for the East Bay Hills (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 decent forecast for the Peninsula Hills (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 decent forecast for the Peninsula Hills (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 decent forecast (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

Based on a minimum rainfall weather forecast for at least a quarter inch[8] over six hours, sampling teams were deployed to each of the sampling sites, ideally reaching the sampling site about one hour before the onset of rainfall[9]. When possible, one team sampled two sites in close proximity to one another to increase sample capture efficiency and decrease staffing costs to the program. Once arriving on site, the team worked together to assemble the equipment and carry out final safety checks. Sampling equipment varied between sites depending on the characteristics of the access point to the drainage line. Some sites were sampled by attaching laboratory prepared trace metal clean Teflon sampling tubing to a painters pole and a peristaltic pump (also installed with lab cleaned silicone pump roller tubing) (Figure 2a). During sampling, the tube was dipped into the channel or drainage line aiming for mid-channel mid-depth (if shallow) or depth integrating if the depth was more than about 0.5 m. In other cases, a DH 84 (Teflon) sampler was used that had also been cleaned prior to sampling, also aiming for mid-channel, mid-depth, or depth integrated depending on channel conditions.

Manual time-paced composite stormwater sampling procedures

At each site, a time-paced composite sample was collected comprising a variable number of sub-samples, or aliquots. Depending on the weather forecast, the prevailing on site conditions, and radar imagery, staff estimated the duration of the storm and selected the aliquot size and number to ensure that the minimum volume requirements for each analyte would be reached before the storm's end (Table 3). Because the minimum volume requirements were less than the size of the sample bottle, there was flexibility built into the sub-sampling program to add aliquots in the event that the storm ended up longer than predicted (e.g., minimally 5 aliquots but up to 10 aliquots could be collected; Table 3). The final decision on the aliquot volume was made just before the first aliquot was taken and remained fixed for the rest of the event. The ultimate number of aliquots, as long as the minimum volume was reached, was usually adjusted depending upon how rainfall progressed. All aliquots for the sample were collected into the same bottle throughout the storm, which was kept in a cooler on ice.

Remote suspended sediment sampling procedures

The Hamlin and Walling tube remote suspended sediment samplers were deployed approximately mid-channel/ storm drain. The Hamlin sampler sat flush, or nearly flush, with the bed of either the stormdrain or concrete channel[10], and was weighted down to the bed either by itself (the sampler weighs approximately 25 lbs) or additionally using barbell weight plates attached to the bottom of the sampler (see Figure 2b). The Walling tube could not be deployed in storm drains due to its size and

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[8] Note, this was relaxed due to a lack of larger storms. Ideally, mobilization would only proceed with a 0.5" forecast.

[9] Antecedent dry-weather was not considered prior to deployment. Although this would likely have a bearing on the concentration of certain build-up/wash-off pollutants like metals and perhaps even mercury. For PCBs, antecedent dry-weather is less important than the mobilization of in-situ legacy sources.

[10] In future years, if the Hamlin is deployed within a natural bed channel, elevating the sampler more off the bed may be necessary but was not the case in WY 2015.

requirement for staying horizontal, but was secured in open channels either by being weighted down to a concrete bed using hose clamps to secure to barbell weights, or secured to a natural bed using hose clamps attached to temporarily installed rebar. To minimize the chances of sampler loss, both samplers were additionally secured via a stainless steel cable attached on one end to the sampler and on the other end to a temporary rebar anchor or another object such as a tree or fence post.

The remote suspended sediment samplers were deployed for the duration of the manual water quality sampling (Table 4 for site list and success rate). At the end of sample collection with a remote sampler, the device was removed from the channel bed /storm drain bottom shortly after the last water quality sample aliquot. Water and sediments collected into the sediment sampler were decanted into one or two large glass bottles. Staff flushed all sediments into the collection bottles. When additional water was needed to flush the settled sediments from the remote samplers into the collection bottles, site water from the sampled channel was used. The samples were taken back to SFEI and refrigerated upon arrival until processing. Samples were split and placed into laboratory containers and then shipped to the laboratory for analysis. Samples collected by remote samplers from seven locations were analyzed as whole water samples (due to insufficient solid mass to analyze as a sediment sample), and one was analyzed as a sediment sample.

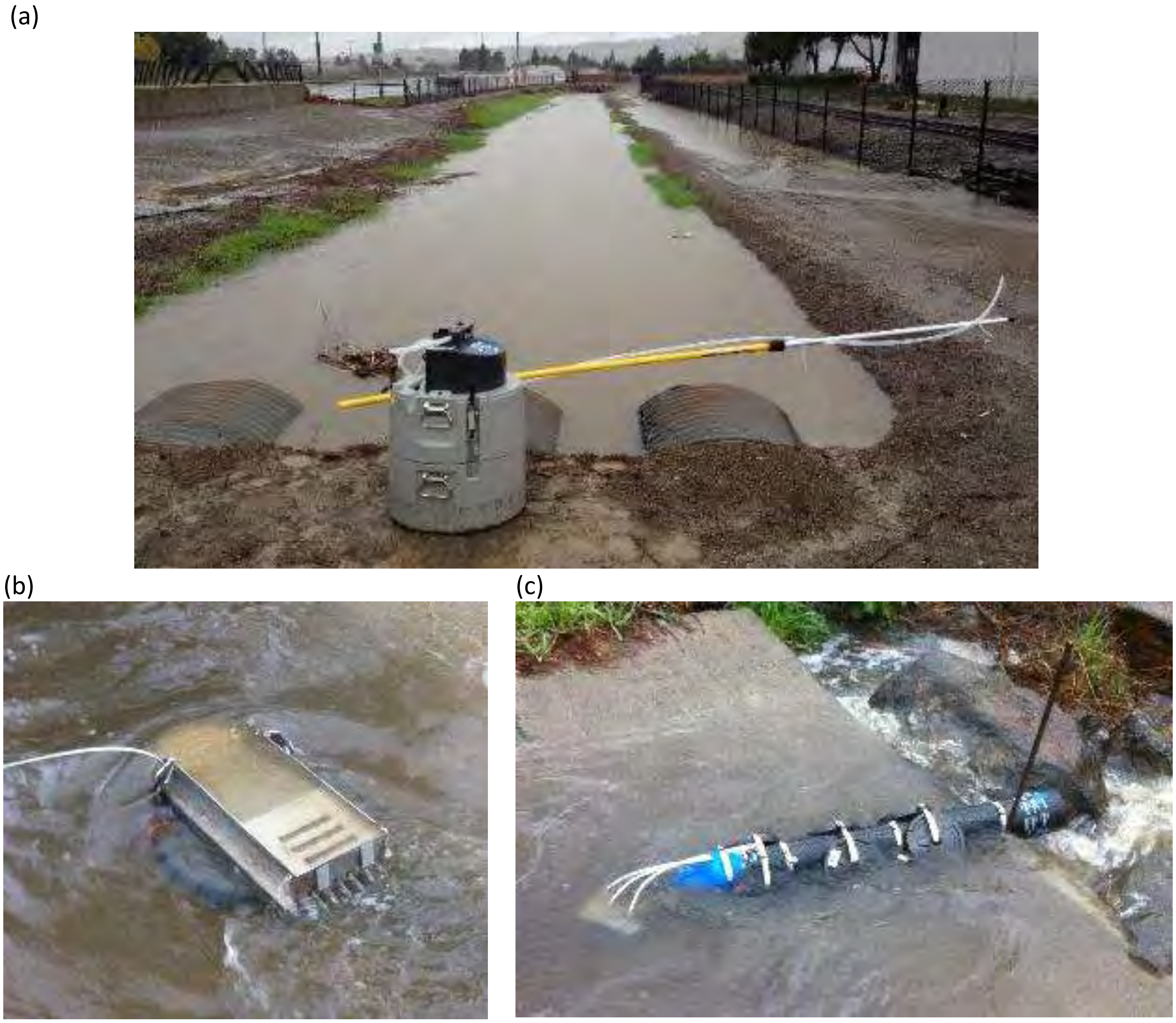

Figure 2. Sampling equipment used in the field. (a) Painters pole, Teflon tubing and an ISCO used as a slave pump; alternatively a Teflon bottle is attached to the end of a painters pole (DH84) and used for sample water collection as opposed to using an ISCO as a pump (b) Hamlin suspended sediment sampler; and (c) the Walling tube suspended sediment sampler.

Table 3. Sub-sample sizes in relation to analytes and sample container volumes.

Analyte	**Bottle size (L)**	**Minimum volume (L)**	**Aliquots (sub-samples) (minimum to maximum number, and required volumes (L)**			
			3 to 6	**4 to 8**	**5 to 10**	**6 to 12**
HgT/ trace metals	2	0.25	0.33	0.25	0.2	0.17
SSC	1	0.3	0.17	0.13	0.1	0.08
PCBs	2.5	1	0.33	0.25	0.2	0.17
Grain size	2	1	0.33	0.25	0.2	0.17
TOC	1	0.25	0.17	0.13	0.1	0.08

Table 4. Locations where remote sediment samplers were pilot tested.

Site	Date	Sampler(s) deployed	Comments
Meeker Slough	11/2015	Hamlin and Walling	Sampling effort was unsuccessful due to very high velocities. Both samplers washed downstream because they were not weighted down enough and debris caught on the securing lines.
Outfall to Lower Silver Creek	2/06/15	Hamlin and Walling	Sampling effort was successful. This sample was analyzed as a water sample.
Charcot Ave Storm Drain	4/07/15	Hamlin	Sampling effort was successful. This sample was analyzed as 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.

Laboratory analytical methods

All samples were labeled, placed on ice, transferred back to SFEI, and refrigerated at 4 °C until transport to the laboratory for analysis, except for TOC/DOC. DOC has a 24-hour hold time for filtration. Samples were mostly dropped to the analytical laboratory within the 24-hour filtration hold time. In those cases where the laboratory was not open during the 24-hour hold time window, SFEI staff filtered DOC samples using a Hamilton 50 mm glass syringe with a 25 mm, 0.45 um filter. Laboratory methods shown in Table 5 were used to ensure the optimal combination of method detection limits, accuracy and precision, and costs (BASMAA, 2011; 2012) (Table 5). As seen in the table, Hg, PCBs and OC were analyzed for both particulate and dissolved phases. However, this was only completed for a small subset of samples that were gathered from sites where the remote samplers were being deployed and trialed (please see the remote sampler section for more details).

Table 5. Laboratory analysis methods.

Analysis	Matrix	Analytical Method	Lab	Filtered	Field preservation	Contract Lab / Preservation hold time
PCBs (40)-Dissolved	Water	EPA 1668	AXYS	Yes	NA	NA
PCBs (40)-Total	Water	EPA 1668	AXYS	No	NA	NA
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)	Water	EPA 9060A	ALS	No	HCL	NA
Organic carbon-Dissolved (WY 2016)	Water	EPA 9060A	ALS	Yes	HCL	NA
Mercury	Particulate	EPA 1631E, Appendix	BRL	NA	NA	
PCBs (40)	Particulate	EPA 1668	AXYS	NA	NA	NA
Organic carbon (WY 2016)	Particulate	EPA 440.0	ALS	NA	NA	NA

Interpretive methods

Particle normalized concentrations

Each site was only monitored at the characterization level, so there was no averaging of data for a site across multiple storm events. In the Bay Area, erosion of sediment varied greatly between watersheds (McKee et al., 2003). Given, PCBs and Hg are dominantly transported in particulate form and that erosion of contaminated particulate from sources and source areas is likely the main process of release and transport (McKee et al., 2015), it is reasoned that the ratio of concentrations of PCBs or Hg measured in stormwater to the suspended sediment concentration in stormwater is likely a better summary of water quality of a site than a single water concentration (McKee et al., 2012; Rügner et al., 2013; McKee et al., 2015). Although normalizing for SSC helps increase our ability to compare relative contamination between sites, the effects of climate cannot be as easily removed. Climatic conditions can influence the interpretations of relative ranking between watersheds although the absolute nature of that influence may differ between watershed locations depending on source characteristics. For example, for some watersheds, dry years or lower storm intensity might cause a greater particle ratio if transport of the sources of polluted sediments are activated and entrained into runoff but overall less diluted by lower erosion rates of cleaner particles from other parts of the watershed (this would be likely in mixed land use watersheds with larger proportions 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 could such processes be teased out. For example, WY 2015 in particular was drier than average and in WY 2016, about half of the Bay Area was approximately normal (San Francisco was 102% of the 40 year normal) and the other half slightly drier than average. The San Francisco gauge (047772) recorded 18.2 in or 80% of the 40 year (1977-2016) normal in WY 2015. While this was not greatly below average, most of this rainfall (11.7 in) fell in a single month (December), resulting in a rainfall year of one wet month and otherwise mostly dry conditions. In contrast, WY 2011 (when the last spatially intensive sampling occurred) was a wetter year with 128% of the 40 year San Francisco normal. These climatic challenges acknowledged, the particle ratio (PR) (mass of a given pollutant of concern in relation to mass of suspended sediment) was computed for each composite water sample collected for each analyte at each site by taking the water concentration (mass per unit volume) and dividing it by its suspended sediment concentration pair (mass of suspended sediment per unit volume) (Equation 1).

Equation 1 (example PCBs): $PR\ (ng/mg) = \ (PCB\ (ng/L))/(SSC\ (mg/L)\ )$

These ratios were then used as the primary comparison method between sites without regard to climate or rainfall intensity. 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. However, to generate information on the absolute relative ranking between individual sites, a much more rigorous sampling campaign sampling many storms over many years would be required (c.f. the Guadalupe River study: McKee et al., 2006, or the Zone 4 Line A study: Gilbreath et al., 2012a).

Derivations of central tendency for comparisons with past data

As commonly discussed in water quality literature, mean, median, geomean, or flow-weighted mean can be used as measures of central tendency of a dataset. In the Bay Area, the average or median of water concentrations at a site has sometimes been used, or the average or median of the particle ratios (McKee et al., 2012; McKee et al., 2014; Wu et al., 2016). To best compare WY 2015 and 2016 composite results with past data that was previously collected as discrete stormwater samples rather than as composites, a different technique was used to estimate the central tendency than has been used in the past. A timed interval water composite collected over a single storm is similar to giving equal weight to discrete samples over a storm and mixing them all into a single bottle for analysis. Although variation across storms might be expected to bigger than within a single storm for any given site, for previously collected discrete grab data, the sum all of the water concentration samples divided by the sum of all the suspended sediment concentrations for each site (note: this method is mathematically not equivalent to averaging together the particle ratios of each discrete sample paired with its SSC) would be the best represented estimate of a site's central tendency.

Equation 2 (example PCBs): $PR\ (ng/mg) = \ (\Sigma PCB\ (ng/L))/(\Sigma SSC\ (mg/L))$

Due to the use of this alternate method for estimating the central tendency, particle ratios reported here in the current report differ slightly from those reported previously for the same site (e.g. McKee et al., 2012; McKee et al., 2014; Wu et al., 2016).

Results and Discussion

This section presents the data in the context of two key questions.

a) What are the concentrations and particle ratios observed at each of the sites based on the composite water samples?
b) How do the particle ratios observed at each of the sites based on the composite water samples compare to particle ratios derived from the remote sedimentation based samplers?

The reader is reminded that the data collected and presented here is contributing to a broader based effort to identify potential management areas. The rankings provided here based on either stormwater concentration or particle ratios are part of a weight of evidence approach being used for locating, prioritizing and managing areas in the landscape that may be disproportionately impacting downstream water quality.

PCBs Concentrations and Particle Ratios

Total PCB concentrations measured in the composite water samples across the 37 watershed sampling sites ranged almost 200-fold from 832-159,606 pg/L (Table 6) (Note that the Duane Ct and Ave Triangle SD site was sampled twice because the first storm sampled was very low intensity and we wanted to avoid the potential for a false negative result). The highest concentration was observed in Industrial Rd Ditch in San Carlos, a site downstream from Delta Star, a known PCB contamination site, and with 79% of its estimated drainage area in old industrial land use. This concentration was relatively high in relation to previous observations in the Bay Area (e.g., Zone 4 Line A FWMC = 14,500 pg/L: Gilbreath et al., 2012a; Ettie Street Pump Station mean = 59,000 pg/L; Pulgas Pump Station-North: 60,300 pg/L: McKee et al., 2012). When normalized to SSC to generate particle ratios, the three highest ranking sites were the Industrial Rd Ditch in San Carlos (6,139 ng/g) (79% old industrial), Gull Dr Storm Drain in South San Francisco (859 ng/g) (54% old industrial), and the Outfall at Gilman St. in Berkeley (794 ng/g) (32% old industrial). Particle ratios of this magnitude are among the most extreme examples in the Bay Area (Pulgas Pump Station-South (8,222 ng/g) (54% old industrial), Santa Fe Channel (1,295 ng/g) (3% old industrial), Pulgas Pump Station-North (893 ng/g) (52% old industrial), Ettie St. Pump Station (759 ng/g) (22% old industrial): McKee et al., 2012; Gilbreath et al., 2016)[11]. The sample taken in Lower Penitencia Creek corroborates a similar finding that was previously reported (McKee et al., 2012). Similarly, two samples taken at the Duane Ct and Ave Triangle SD site during separate storm events on December 13, 2015 and January 6, 2016 indicate relatively consistent and low particle ratios (Table 6). In general, on average, the particle ratios for the WY 2015 and 2016 sampling effort were greater than those from WY 2011 (McKee et al., 2012). This likely resulted from a much greater average imperviousness and proportion of old industrial land use in the catchment areas of the WY 2015 and 2016 sites and other stakeholder knowledge that contributed to selection of sites with a higher likelihood of PCB discharge to stormwater.

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[11] Note, these particle ratios 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.

Table 6. Concentrations of total mercury, sum of PCBs (RMP 40), and ancillary constituents measured at each of the sites during winter storms of water years 2015 and 2016. Both the sum of PCBs and total mercury are also expressed at a particle ratio (mass of pollutant divided by mass of suspended sediment). The table was sorted from high to low based on PCB particle ratios.

Watershed/Catchment	County	City	Sample Date	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	26			159,606	1	6,140	1	13.9	29	0.535	14
Gull Dr SD	San Mateo	South San Francisco	3/5/16	10			8,592	20	859	2	5.62	38	0.562	11
Outfall at Gilman St.	Alameda	Berkeley	12/21/15	83			65,670	2	794	3	439	1	5.31	1
Outfall to Lower Silver Ck	Santa Clara	San Jose	2/6/15	57	8.6	8.3	44,643	4	783	4	24.1	24	0.423	19
Ridder Park Dr SD	Santa Clara	San Jose	12/15/14	114	7.7	8.8	55,503	3	488	5	37.1	17	0.326	26
Line 3A-M at 3A-D	Alameda	Union City	12/11/14	74	9.5	7.3	24,791	8	337	6	85.9	4	1.17	3
Seabord Ave SD SC-050GAC580	Santa Clara	Santa Clara	12/11/14	85	9.5	10	19,915	9	236	7	46.7	12	0.553	13
Line 4-E	Alameda	Hayward	12/16/14	170	2.8	3.6	37,350	5	219	8	59.0	9	0.346	22
Seabord Ave SD SC-050GAC600	Santa Clara	Santa Clara	12/11/14	73	7.9	8.6	13,472	13	186	9	38.3	15	0.528	15
South Linden PS	San Mateo	South San Francisco	2/6/15	43	7.4	7.4	7,814	22	182	10	29.2	20	0.679	8
Gull Dr Outfall	San Mateo	South San Francisco	3/5/16	33			5,758	25	174	11	10.4	35	0.315	27
Taylor Way SD	San Mateo	San Carlos	3/11/16	25	4.5	9.1	4,227	29	169	12	28.9	22	1.16	4
Line 9-D	Alameda	San Leandro	4/7/15	69	5	4.6	10,451	15	153	13	16.6	26	0.242	32
Meeker Slough	Contra Costa	Richmond	12/3/14	60	4.4	5.3	8,560	21	142	14	76.4	6	1.27	2
Rock Springs Dr SD	Santa Clara	San Jose	2/6/15	41	11	11	5,252	26	128	15	38	16	0.927	5
Charcot Ave SD	Santa Clara	San Jose	4/7/15	121	20	20	14,927	11	123	16	67.4	8	0.557	12
Veterans PS	San Mateo	Redwood City	12/15/14	29	5.9	6.3	3,520	30	121	17	13.7	30	0.469	16
Gateway Ave SD	San Mateo	South San Francisco	2/6/15	45	9.9	10	5,244	27	117	18	19.6	25	0.436	17
Line 9-D-1 PS at outfall to Line 9-D	Alameda	San Leandro	1/5/16	164			18,086	10	110	19	118	2.5	0.720	7

Watershed/Catchment	County	City	Sample Date	SSC	DOC	TOC	PCBs				Total Hg			
				(mg/L)	(mg/L)	(mg/L)	(pg/L)	Rank	(ng/g)	Rank	(ng/L)	Rank	(µg/g)	Rank
Tunnel Ave Ditch	San Mateo	Brisbane	3/5/16	96	5.8	11.3	10,491	14	109	20	73.0	7	0.760	6
Valley Dr SD	San Mateo	Brisbane	3/5/16	96			10,442	16	109	21	26.5	23	0.276	30
Runnymede Ditch	San Mateo	East Palo Alto	2/6/15	265	16	16	28,549	7	108	22	51.5	11	0.194	36
E. Gish Rd SD	Santa Clara	San Jose	12/11/14	145	12	13	14,365	12	99.2	23	84.7	5	0.585	10
Line 13-A at end of slough	Alameda	San Leandro	3/10/16	357			34,256	6	96.0	24	118	2.5	0.331	24
Line 3A-M-1 at Industrial PS	Alameda	Union City	12/11/14	93	4.2	4.5	8,923	18	95.8	25	31.2	19	0.335	23
Forbes Blvd Outfall	San Mateo	South San Francisco	3/5/16	23	3.4	7.9	1,840	36	80.0	26	14.7	28	0.637	9
SD near Cooley Landing	San Mateo	East Palo Alto	2/6/15	82	13	13	6,473	24	78.9	27	35.0	18	0.427	18
Lawrence & Central Expwys SD	Santa Clara	Santa Clara	1/6/16	58			4,506	28	77.7	28	13.1	31.5	0.226	33
Condensa St SD	Santa Clara	Santa Clara	1/19/16	35			2,602	32	74.4	29	11.5	34	0.329	25
Oddstad PS	San Mateo	Redwood City	12/2/14	148	8	7.5	9,204	17	62.4	30	54.8	10	0.372	20
Line 4-B-1	Alameda	Union City	12/16/14	152	2.8	3.1	8,674	19	57	31	43.0	13	0.282	29
Zone 12 Line A under Temescal Ck Park	Alameda	Emeryville	1/6/16	143			7,804	23	54.4	32	41.5	14	0.290	28
Victor Nelo PS Outfall	Santa Clara	San Jose	1/19/16	45	4.0	10.5	2,289	33	50.9	33	15.8	27	0.351	21
Haig St SD	Santa Clara	San Jose	3/6/16	34			1,454	37	42.8	34	6.61	36	0.194	35
E Outfall to San Tomas at Scott Blvd	Santa Clara	Santa Clara	3/6/16	103			2,799	31	27.2	35	13.1	31.5	0.127	37
Duane Ct and Ave Triangle SD (Dec 13)*	Santa Clara	Santa Clara	12/13/15	79			1,947	35	24.6	36	5.91	37	0.0748	38
Duane Ct and Ave Triangle SD (Jan 6)*	Santa Clara	Santa Clara	1/06/16	48	4.2	12	832	38	17.3	37	12.9	33	0.268	31
Lower Penitencia Ck	Santa Clara	Milpitas	12/11/14	144	5.9	6.1	2,033	34	14.1	38	29.0	21	0.202	34
Minimum				10	2.8	3.1	832		14.1		5.62		0.0748	
Maximum				357	20	20	159,606		6,140		439		5.31	

Mercury Concentrations and Particle Ratios

Total Hg concentrations in composite water samples varied 78-fold between the 37 watershed sampling sites from 5.62-439 ng/L (Table 6). This relatively large variation between sites is quite a change from that reported last year for WY 2015 alone (McKee et al., 2016) when concentrations were observed to vary from 14-86 ng/L (6.1-fold) and from previous reconnaissance effort in WY 2011 when mean HgT concentrations were observed to vary from 13.9-503 ng/L (36-fold) between sites (McKee et al., 2012). Since there was very similar variation between SSC during the 2011 study and the combined results from WYs 2015 and 2016 (both ~36-fold), this greater variation reflects the addition of a high sample concentration observed at the Outfall at Gilman Street (439 ng/L). Indeed, the greatest concentration of HgT now observed during the sampling in WYs 2015 and 2016 occurred at the that outfall, a site that is 32% old industrial upstream from the sampling point. Other sites with high HgT concentrations were 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% industrial respectively), Line 3A-M at 3A-D in Union City (12% industrial), Gish Rd Storm Drain in San Jose (71% old industrial), and Meeker Slough in Richmond now ranks number 6 with a land use of just 6% old industrial upstream from the sampling location. This helps to illustrate that mercury concentrations don't appear to follow a strong relationship with old industrial land use (in contrast to PCBs where there is a weak but positive relationship between concentrations measured in water and industrial land use). When the HgT data were normalized to SSC, 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). Particle ratios at these sites were 5.3, 1.3, 1.2, 1.2, and 1.0 µg/g, respectively. Particle ratios of this magnitude exceed the upper range of those observed during the WY 2011 sampling campaign (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).[see footnote 11 above] On a regional basis, there is no discernible relationship between old industrial land use and HgT particle ratios whereas, in contrast, there does appear to be a weak relationship between PCB particle ratios and old industrial land use.

When making comparisons between all the data collected in the Bay Area to date, the particle ratio method of normalization remains the most reliable tool for ranking sites in relation to potential management follow-up. It provides a mechanism for accounting for both flow of water and sediment erosion concurrently. Another important issue during the ranking process is to consider the combined ranks of PCBs and Hg together to get an idea about how management effort might address both pollutants together. However, in general there was only a weak but positive relationship between observed PCB and HgT concentrations. The six highest ranking sites for PCBs based on particle ratios ranked 14th, 11th, 1st, 19th, 26th, and 3rd, respectively, for HgT. This observation contrasts with the conclusions drawn from the WY 2011 dataset where there appeared to be more of a general correlation (McKee et al., 2012). This might reflect a stronger focus on PCBs during the WYs 2015 and 2016 site selection process and the resulting focus on smaller watersheds with higher imperviousness and old industrial land use, or perhaps it might still be an artifact of small datasets. This observation will be explored further below.

Trace metal (As, Cd, Cu, Pb, and Zn) Concentrations

Concentrations of As, Cd, Cu, Pb, and Zn were collected during both WY 2015 and 2016 and ranged between less than the reporting limit (RL)-2.66 µg/L, 0.023-0.55 µg/L, 3.63-52.7 µg/L, 0.910-21.3 µg/L, and 39.4-337 µg/L respectively (Table 7). Total As concentrations of this magnitude have been measured in the Bay Area before (Guadalupe River at Hwy 101: mean=1.9 µg/L; Zone 4 Line A: mean=1.6 µg/L) but appear much lower than were observed in North Richmond Pump Station (mean=11 µg/L) (see Appendix A3 in McKee et al., 2015). The Cd concentrations observed at sites during the WY 2015 effort also appear similar to mean concentrations of Cd measured in Guadalupe River at Hwy 101 (0.23 µg/L), North Richmond Pump Station (0.32 µg/L), and Zone 4 Line A (0.25 µg/L) (see Appendix A3 in McKee et al., 2015). Similarly the Cu and Pb concentrations observed during the WYs 2015 and 2016 sampling effort also appear typical of other Bay Area watersheds (Guadalupe River at Hwy 101: Cu 19 µg/L, Pb 14 µg/L; Lower Marsh Creek: Cu 14 µg/L; North Richmond Pump Station: Cu 16 µg/L, Pb 1.8 µg/L; Pulgas Pump Station-South: Cu 44 µg/L; San Leandro Creek: Cu 16 µg/L; Sunnyvale East Channel: Cu 18 µg/L; and Zone 4 Line A: Cu 16 µg/L, Pb 12 µg/L) (see Appendix A3 in McKee et al., 2015). Similarly, Zn measurements at 26 of the sites measured during the WYs 2015 and 2016 sampling effort straddled the mean concentration observed in the Bay Area previously (Zone 4 Line A: 105 µg/L) (Gilbreath et al., 2012a; see Appendix A3 in McKee et al., 2015). In WY 2016, measurements of Mg (528-7350 µg/L) and Se (<RL-0.39 µg/L) were picked up. Both of these two analytes are mostly indicative of geological sources in watersheds. No measurements of Mg have been reported before in the Bay Area but these concentrations of Se are on the lower side of mean concentrations reported previously in the Bay Area (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 dissolved phase (e.g. 81% in the Guadalupe River system) and the known inverse correlation with flow (David et al., 2012; Gilbreath et al., 2012a), it is reasonable that our sampling design that focused on high would have produced lower concentrations than observed when sampling designs have included low flow and base flow 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/). With Se data, extra care should be exercised when comparing data between sites; flow conditions matter.

Table 7. Concentrations of select trace elements measured at each of the sites during winter storms of water years 2015 and 2016.

Watershed/Catchment	As (µg/L)	Cd (µg/L)	Cu (µg/L)	Pb (µg/L)	Mg (µg/L)	Se (µg/L)	Zn (µg/L)
Outfall to Lower Silver Ck	2.11	0.267	21.8	5.43			**337**
Ridder Park Dr SD	**2.66**	0.335	19.6	11.0			116
Line 3A-M at 3A-D	2.08	0.423	19.9	17.3			118
Seabord Ave SD SC-050GAC580	1.29	0.295	27.6	10.2			168

Watershed/Catchment	As (µg/L)	Cd (µg/L)	Cu (µg/L)	Pb (µg/L)	Mg (µg/L)	Se (µg/L)	Zn (µg/L)
Line 4-E	2.12	0.246	20.6	13.3			144
Seabord Ave SD SC-050GAC600	1.11	0.187	21	8.76			132
South Linden PS	0.792	0.145	16.7	3.98			141
Line 9-D	0.47	0.053	6.24	**0.91**			67
Meeker Slough	1.75	0.152	13.6	14.0			85.1
Rock Springs Dr SD	0.749	0.096	20.4	2.14			99.2
Charcot Ave SD	0.623	0.0825	16.1	2.02			115
Veterans PS	1.32	0.093	8.83	3.86			41.7
Gateway Ave SD	1.18	0.053	24.3	1.04			78.8
Runnymede Ditch	1.84	0.202	**52.7**	**21.3**			128
E. Gish Rd SD	1.52	**0.552**	23.3	19.4			152
Line 3A-M-1 at Industrial PS	1.07	0.176	14.8	7.78			105
SD near Cooley Landing	1.74	0.100	9.66	1.94			48.4
Oddstad PS	2.45	0.205	23.8	5.65			117
Line 4-B-1	1.46	0.225	17.7	8.95			108
Lower Penitencia Ck	2.39	0.113	16.4	4.71			64.6
Condensa St SD	1.07	0.055	6.66	3.37	3,650	**0.39**	54.3
Forbes Blvd Outfall	1.5	0.093	31.7	3.22	**7,350**	**0**	246
Gull Dr SD	**0**	**0.023**	**3.63**	1.18	**528**	**0**	**39.4**
Line 9-D-1 PS at outfall to Line 9-D	1.07	0.524	22.5	20.9	2,822	0.2	217
Taylor Way SD	1.47	0.0955	10.0	4.19	5,482	**0**	61.6
Victor Nelo PS Outfall	0.83	0.140	16.3	3.63	1,110	0.04	118
Minimum	0	0.023	3.63	0.91	528	0	39.4
Maximum	2.66	0.552	52.7	21.3	7,350	0.39	337

Comparisons between composite water and remote sampling methods

The 11 results from remote sedimentation samplers that were successfully gathered in WYs 2015 and 2016 were compared to the results from water composite samples collected in parallel at those sites for the same storm events (Table 8). Results for the remote samplers are all compared on a particle ratio basis.

Eight samples were collected using the Hamlin samplers, and a Walling Tube was simultaneously deployed at three of these sites. At the three locations with both samplers, the Hamlin sampler results observed SSC concentrations 1.1, 14 and 25 times greater than the Walling Tubes. These differences

Table 8. Remote sampler data and comparison with manual water composite data.

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 particle ratio (ng/g)	Bias (particle ratio: lab measured)	PCB particle ratio (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	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%
Outfall to Lower Silver Ck	Walling	57	44,643					783		956	122%
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%
Median						12%			114%		137%
Mean						15%			119%		141%

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 particle ratio (ng/g)	Bias (particle ratio: lab measured)	Hg particle ratio (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	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%
Outfall to Lower Silver Ck	Walling	57	24					423		255	60%
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%
Median						17%			120%		60%
Mean						21%			128%		69%

could be related to two physical factors that probably influenced capture performance. The Walling Tube can be positioned at any height in the water column and was set at approximately mid-depth position during each deployment. In contrast, the Hamlin samplers were positioned either on the bed or slightly elevated (~3 cm) above the bed when attached atop a weighted plate. It is likely that mountings that were closer to the bed helped to increase the capture of more sediment mass of a coarser sediment grain (Figure 3). In addition, the apparatus opening on each device differs. The Walling Tube has a single point opening with a 4 mm diameter while the Hamlin sampler has multiple rectangular openings 6.4 mm wide and 108 mm long. Perhaps the physics of the openings also helped to increase capture in the case of Hamlin sampler. In comparison, the composite samples that were collected from the water column by hand, whether collected via peristaltic pump or using a DH-81, were collected in a way that aimed for them to be representative of water column as a whole from about 5 cm through to near the surface rather than from a fixed point. As a result, relative to the other two sampling methods, the Hamlin sampler captures a portion of coarser grained near-bed or bedload sediment whereas the Walling Tube and composited stormwater samples were more representative of the mixed water column and were finer in texture.

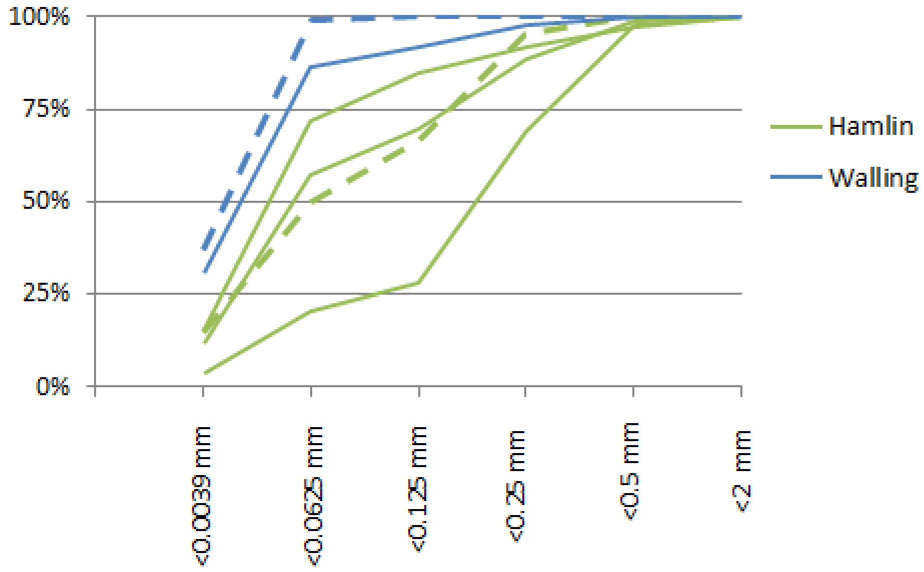

Figure 3. Cumulative grain size distribution in the Hamlin and Walling Tube samples. The dashed lined sample distributions were collected at the same site.

Figure 4 shows remote sampler particle ratio results for PCBs and Hg plotted versus particle ratios for composited stormwater samples. Both figures show a 1:1 line, which would occur if all the contaminant in composite water samples occurred in the sediment phase for those sites, and if the remote samplers collected contaminated sediments in equal proportions and grain sizes to those collected in the manual water composite method. For PCBs, the data generally show good correlation, i.e., higher remote sampler particle ratios occur for sites with higher particle ratios obtained from composite stormwater samples. The correlation for PCBs is significant ($p=1.74 \times 10^{-5}$) at alpha=0.05. Most of the remote samples for PCBs had very comparable or slightly higher particle ratios than those obtained from the composited stormwater samples (Tables 8 and 9, and Figure 4A). These results are conceptually reasonable, though somewhat surprising. The remote samplers are affixed near the channel bed and therefore preferentially sample heavier and larger particles as compared to water-column integrated stormwater composite samples. A prior settling experiment using collected runoff (Yee and McKee, 2010) showed a majority of PCBs in a sediment phase settled out of a 30 cm water column within 20 minutes or less (in contrast to the results for HgT which showed generally lower settling rates). Therefore, conceptually it is reasonable that PCBs on sediment are settling out in the remote samplers at a rate efficient enough to accurately characterize the particle ratio for the site. The surprising aspect of these results is that by using the manual water composite particle ratio (total PCBs/SSC), the dissolved proportion is included in the ratio and therefore the particle ratio is biased high relative to the particulate concentration measured in the lab (mean bias=119%; Table 8). And yet, as compared to the remote samplers which include only particulates, the manual water composite particle ratios are still mostly lower (mean ratio of remote:manual water composites = 141%, Table 8). These preliminary interpretations are only initial hypotheses being used to help refine the sampling and analytical program. Care must be taken when interpreting general patterns with such a small number of samples.

In contrast, the results for Hg showed that most of the remote samples had lower particle ratios than those obtained from the composited stormwater samples (Table 10 and Figure 4B) and the overall correlation is poor, i.e., higher remote sampler particle ratios do not consistently occur for sites with higher particle ratios obtained from composite stormwater samples. That the remote sampler particle ratios are typically lower than the manual composites is conceptually in concordance with the findings in Yee and McKee, 2010, with Hg more in dissolved and slower settling fractions than PCBs. This is consistent with the data presented in Table 8 which indicates that on average 19% of the total Hg was in the dissolved form (range 10-38%). Thus, these composited stormwater samples would be expected to show higher particle ratios than from remote samplers, due to lower sediment content and thus a greater relative proportion of Hg in the dissolved phase or on fine particles biasing the calculated particle ratio higher. Although the Hg results for the Walling Tube samples may appear better correlated, this is merely coincidental; the Hamlin samples at the same sites performed almost as well as the Walling Tubes.

The differences in particle ratio for Hg were lowest for Victor Nelo PS Outfall (RPD 31%), which could plausibly be due in part to subsampling and analytical variation given the small difference. However, the particle ratios for Hg at other sites differed up to 5-fold (as noted previously, with the composited stormwater samples biased higher). This difference is not easily accounted for through sub-sampling or analytical variation, as both the composite sample (time paced with a limited number of sub-samples) and remote sampler methods collect time-integrated samples, which reduce the influence of momentary spikes in concentration. These larger differences, as noted before, with the Hg particle ratios from the remote samplers being lower than those in composites, might be a result of differences in the proportion of coarser sediment captured due to differences between the methods in their position within the water column.

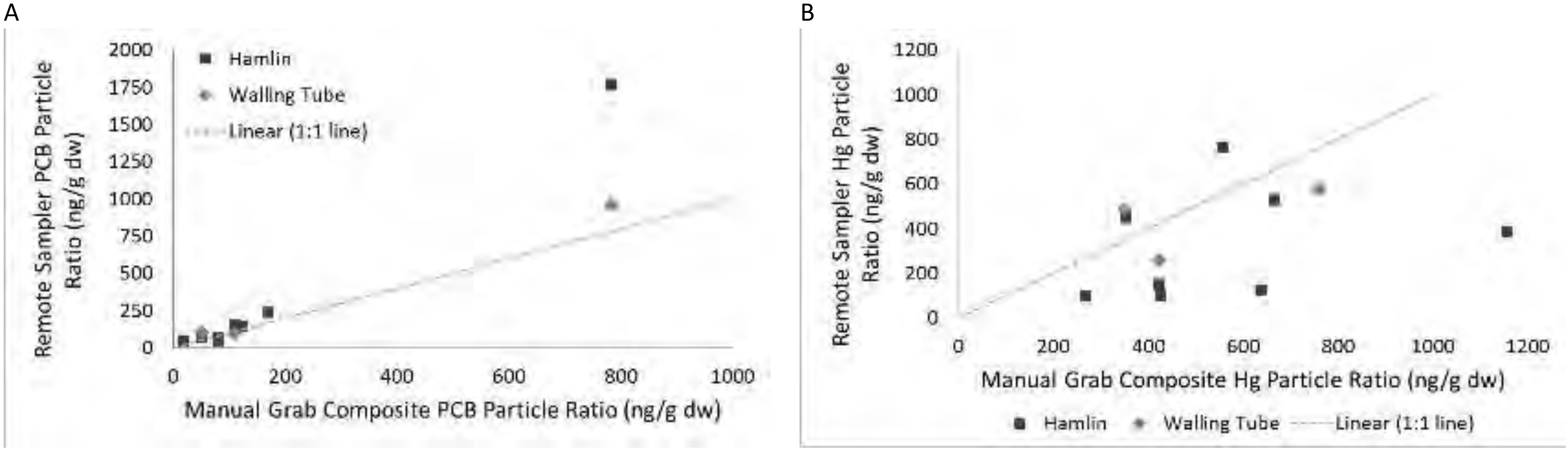

Figure 4. Particle Ratio (PR) comparisons between remote (sediment) versus composite (water) samples for A) PCBs and B) total mercury.

Table 9. Summary statistics of the relative percent difference between remote and manual water composite samples for PCBs.

	N	Minimum	Maximum	Mean	Standard Deviation
Walling Tube	3	-13%	65%	24%	39%
Hamlin	8	-62%	84%	24%	47%
All	11	-62%	84%	24%	43%

Table 10. Summary statistics of the relative percent difference between remote and manual water composite samples for Hg.

	N	Minimum	Maximum	Mean	Standard Deviation
Walling Tube	3	-49%	32%	-15%	42%
Hamlin	8	-134%	31%	-66%	64%
All	11	-134%	32%	-52%	62%

When normalized to grain size, improvement was marginal and more promising for Hg than PCBs. Figure 5 shows the relationship between the manual water composites and the remote sample particle ratios, both when the ratios are not normalized and when the ratios are normalized to particles <0.25 mm and <0.125 mm. In particular, the Hg sample with the highest manual composite particle ratio, which had a correspondingly low remote sampler particle ratio (due to a high percentage of medium and coarse sands), benefited greatly by normalizing to particles <0.125 mm. On the other hand, the same sample for PCBs (also the highest manual composite particle ratio) correlated best when not normalized. Exploration into normalizing by grain size and TOC will continue in the next progress report with WY 2017 data (expected spring 2018).

The results obtained thus far show some promise as a qualitative site ranking tool especially for PCBs, but less so for Hg although additional data will be collected in WY 2017 to continue to assess this option. For PCBs, the samples with the highest particle ratios for composited stormwater samples were also the highest in the remote samplers while the sites with lower particle ratios for the composited stormwater sample also had lower concentrations in the remote sampler. The Hg results were more difficult to distinguish, with the remotely collected sample particle ratios differing from those of the composited stormwater samples by 1.3- to 5-fold.

These variable results indicate some challenges in interpretation of data collected by composite versus remote methods. The composited stormwater water samples conflate some dissolved load in the indicator (particle ratio) where concentrations based on whole water samples were normalized to suspended sediment. In addition, the composite water collection method likely either did not sample or at least under-sampled near-bed transport of sediment and pollutants. Although no samples were collected for different events at any site, the differences among sites for the composited and remote particle ratios suggest the potential for large differences among events even within a site, depending on storm event and site characteristics. These differences also present some challenges in applications beyond ranking and prioritization. Partly due to a small data set so far, there was no consistent direction of bias between the manual stormwater composite and remote methods, and even within PCBs (the more consistent analyte), for the Hamlin sampler, the particle ratio ranged from 27% to 190% of the composite sample result. The ability to find differences among sites or within a site with less than a two-fold difference would therefore seem unlikely at this point. This would be in addition to the between site differences caused by sampling non-representative storms that are present in the water composite methodology as well; there is always going to be more certainty than the sample for water composites which better represents transport through the majority of a sample site cross section. The other challenge with samples gathered using the remote samplers is that the data cannot be used to estimate loads without corresponding sediment load estimates. Since sediment loads are not readily available for individual watersheds and, after failures to calibrate the RWSM for suspended sediments, or for PCB and HgT using a sediment model as the basis (McKee et al., 2014), the RWSM is now being calibrated with some success using flow and water-based stormwater concentrations (Wu et al., 2016). Although perhaps cheaper to deploy or logistically possible to deploy in situations where staffing a site is not possible due to logistical constraints, the data derived from the sediment remote samplers are overall less versatile and more challenging to interpret.

With these concerns raised, the sampling program for WY 2017 will continue to build out the dataset for comparing samples derived from composite and remote suspended sediment sampling methods. Based on a full set of a further five planned sample pairs focusing on testing the Walling Tube, better confidence may be obtained about how to characterize the range of differences and biases among the methods, as well as to identify some causes of these artifacts, either generally or specific to certain site (land use) or/and event characteristics (storm intensity, duration, sample grain size, organic carbon). In the event that after the pilot study is completed and a total of eight samples have been collected for each sampler, and data still does not show reasonable comparability or explainable differences between the stormwater composite and suspended sediment remote sampler methods, future efforts to further improve these methods might need to consider additional factors such as inter-storm variation, site cross-sectional variation, and relative contributions of near-bed load to total pollutant discharge.

In summary, the data obtained to date from remote samplers show some promise as a relative ranking or prioritization tool; if the data from additional planned sample pairs continue to show similar relationships to stormwater composite samples, future monitoring strategies could be envisioned, first using remote samplers as a low-cost screening and ranking tool, to be followed up by site occupation and active water sampling for the highest priority locations.

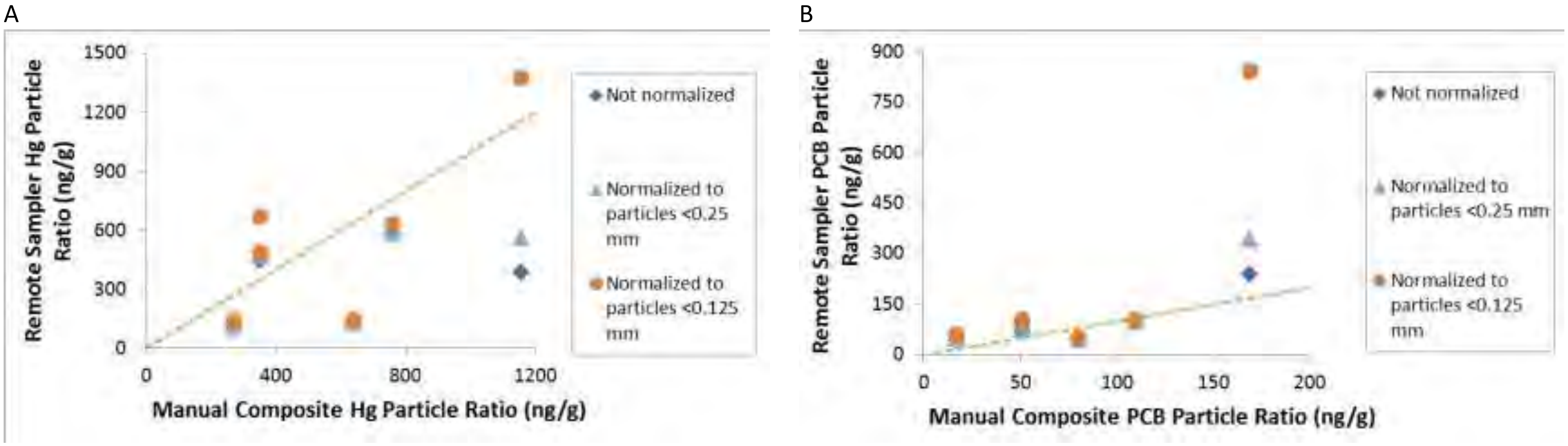

Figure 5. Grain size normalized particle ratio (PR) comparisons between remote (sediment) versus composite (water) samples for A) PCBs and B) total mercury.

What are the 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 eight locations, in which the Hamlin sampler was tested at all eight and the Walling Tube sampler was tested at only three. During the winter of WY 2017 we intend to focus remote sampling using the Walling Tube and a more comprehensive analysis of effectiveness and cost versus benefit of this method will be completed after that sampling effort is completed. An early-phase comparison is presented in Table 11a and 11b below. Generally speaking, it is anticipated that non-manual sampling methods will be more cost-effective. Conceptually, this method would allow multiple sites to be monitored during a single storm event where devices are deployed prior to the storm and retrieved after the storm. There would be initial capital 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 or tidal influences) that complicate the use of the remote settling devices and cause the need for manual monitoring at a particular site. As mentioned above, the data derived from the remote sampling methodologies may be less straightforward to interpret (relative to previously collected water grab or composite samples) and overall would have somewhat less versatility or greater complications for other uses outside ranking sites for relative pollution, for example loadings estimates. But used as a companion to manual monitoring methods, costs would most likely be reduced and data suitable for other purposes would continue to be collected. Factoring in the more limited data uses in the cost-effectiveness analysis will be challenging.

Table 11a. Preliminary comparison of the pros and cons of the remote sampling method as compared to the manual sampling method for the characterization 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 11b 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,, though we are beginning to think of solutions to this challenge.
Data Quality	Unknown	Comparison between the remote sampler and manual sampling results are being assessed in this study. If remote samplers can be used consistently over multiple storm

		events, it is reasonable to say 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 collects data for a single storm composite which is then used for characterization purposes. Although not a high quality estimate, 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).
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 avoid making 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).

Table 11b. Detailed preliminary labor and cost comparison between the remote sampling method as compared to the manual composite sampling method for the characterization 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

The PCB and HgT load allocations of 2 and 80 kg respectively translate to a mean concentration of 1.33 ng/L (PCBs) and 53 ng/L (HgT) (assuming an annual average flow from small tributaries of 1.5 km^3 (Lent et al., 2012)) and mean annual particle ratio of 1.4 ng/g (PCBs) and 0.058 µg/g (HgT) (assuming an average annual suspended sediment load of 1.4 million metric tons) (McKee et al., 2013). Keeping in mind that the estimates of regional flow and regional sediment loads are subject to change as further interpretations are completed, only two sampling locations observed to date (Gellert Park bioretention influent stormwater and the storm drain at the corner of Duane Ct. and Triangle Ave.) have a composite averaged PCB concentration of < 1.33 ng/L (Table 12) and none out of 62 sampling locations have composite averaged PCB particle ratios <1.4 ng/g (Table 12; Figure 6 and 7). The lowest observed PCB particle ratio to date remains Marsh Creek (2.9 ng/g).

Although there are always challenges associated with interpreting data in relation to highly variable climate including antecedent conditions, storm specific rainfall intensity, and watershed specific source-release-transport processes, the objective here is to provide evidence to help differentiate watersheds that might be disproportionately elevated in PCB or Hg concentrations or particle ratios from those with lower pollutant signatures. Given the nature of the reconnaissance sampling design, the absolute rank is much less certain but it is unlikely that the highest rank locations would drop in ranking very much if more sampling was conducted. With these caveats in mind, the relative ranking was generated for PCBs and Hg based on both water concentrations and particle ratios for all the available data most of which was collected during WYs 2011 (a slightly wetter than average year), WY 2015 (a slightly drier than average year), and WY 2016 (about average).

Based on water composite concentrations for all available data, the ten most polluted sites for PCBs appear to be (in order from higher to lower): Pulgas Pump Station-South, Santa Fe Channel, Industrial Rd Ditch, Sunnyvale East Channel, Outfall at Gilman St., Pulgas Pump Station-North, Ettie Street Pump Station, Ridder Park Dr Storm Drain, Outfall to Lower Silver Creek, and Line 4-E (Figure 7). The locations span a range in land use from 3-79% old industrial illustrating some of the challenges in using land use alone as a tool for locating areas of high leverage. Using PCB particle ratios, the ten most polluted sites appear to be: Pulgas Pump Station-South, Industrial Rd Ditch, Santa Fe Channel, Pulgas Pump Station-North, Gull Dr SD, Outfall at Gilman St., Outfall to Lower Silver Creek, Ettie Street Pump Station, Ridder Park Dr Storm Drain and Sunnyvale East Channel. Nine of these locations were similarly selected based on water concentrations and particle ratios but one of the sites with elevated water concentrations (Line 4-E) dropped to lower rank for particle ratios due to high sediment production and one alternative site (Gull Dr SD) was ranked in the top ten based on the relative nature of PCB mass in the water and lower suspended sediment mass. In addition to identification of three new top-10 ranked PCB particle ratio sites, the WY 2015 and 2016 stormwater sampling efforts also identified a large number of sites with moderate particle ratios (Figure 7). This additional large cohort of sites with moderately elevated particle ratios was likely a result of the site selection process that targeted watershed areas with greater imperviousness and older industrial influences. This has also led to an improving relationship over time between PCB concentrations and PCB particle ratio (due to generally less variation in SSC between urban sites relative to sites representing larger watersheds with mixed land use).

Table 12. PCB and HgT concentrations and particle ratios observed in the Bay area based on all data collected in stormwater since WY 2003 that focused on urban sources (62 sites in total for PCBs and HgT). This dataset was sorted high to low based on PCBs particle ratio to provide preliminary information on potential leverage.

Watershed/ Catchment	**County**	**Water Year sampled**	**Area (km2)**	**Impervious cover (%)**	**Old Industrial land use (%)**	**Polychlorinated biphenyls (PCBs)**				**Total Mercury (HgT)**			
						Particle Ratio		**Composite /mean water concentration**		**Particle Ratio**		**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	447984	1	0.35	31.5	19	46
Industrial Rd Ditch	San Mateo	2016	0.23	85%	79%	6139	2	159606	3	0.53	22	14	52
Santa Fe Channel	Contra Costa	2011	3.3	69%	3%	1295	3	197923	2	0.57	17.5	86	10.5
Pulgas Pump Station-North	San Mateo	2011	0.55	84%	52%	893	4	60320	6	0.4	28	24	43.5
Gull Dr SD	San Mateo	2016	0.30	78%	54%	859	5	8592	34	0.56	19	6	59
Outfall at Gilman St.	Alameda	2016	0.84	76%	32%	794	6	65670	5	5.31	1	439	4
Outfall to Lower Silver Creek	Santa Clara	2015	0.17	79%	78%	783	7	44643	9	0.42	27	24	43.5
Ettie Street Pump Station	Alameda	2011	4.0	75%	22%	759	8	58951	7	0.69	13	55	22.5
Ridder Park Dr Storm Drain	Santa Clara	2015	0.50	72%	57%	488	9	55503	8	0.33	35	37	35
Sunnyvale East Channel	Santa Clara	2011	15	59%	4%	343	10	96572	4	0.2	49	50	26
Line-3A-M at 3A-D	Alameda	2015	0.88	73%	12%	337	11	24791	14	1.17	5	86	10.5
North Richmond Pump	Contra	2011-	2.0	62%	18%	241	12	13226	23	0.81	10	47	27.5

Watershed/ Catchment	County	Water Year sampled	Area (km2)	Impervious cover (%)	Old Industrial land use (%)	Polychlorinated biphenyls (PCBs)				Total Mercury (HgT)			
						Particle Ratio		Composite /mean water concentration		Particle Ratio		Composite /mean water concentration	
						(ng/g)	Rank	(pg/L)	Rank	(µg/g)	Rank	(ng/L)	Rank
Station	Costa	2014											
Seabord Ave Storm Drain SC-050GAC580	Santa Clara	2015	1.4	81%	68%	236	13	19915	17	0.55	21	47	27.5
Line4-E	Alameda	2015	2.0	81%	27%	219	14	37350	10	0.35	31.5	59	19
Glen Echo Creek	Alameda	2011	5.5	39%	0%	191	15	31078	12	0.21	48	73	15
Seabord Ave Storm Drain SC-050GAC600	Santa Clara	2015	2.8	62%	18%	186	16	13472	22	0.53	23	38	33.5
South Linden Pump Station	San Mateo	2015	0.14	83%	22%	182	17	7814	37	0.68	14	29	40
Gull Dr Outfall	San Mateo	2016	0.43	75%	42%	174	18	5758	41	0.32	37	10	57
Taylor Way SD	San Mateo	2016	0.27	67%	11%	169	19	4227	46	1.16	6	29	41
Line 9-D	Alameda	2015	3.6	78%	46%	153	20	10451	27	0.24	43.5	17	47.5
Meeker Slough	Contra Costa	2015	7.3	64%	6%	142	21	8560	35	1.27	4	76	14
Rock Springs Dr Storm Drain	Santa Clara	2015	0.83	80%	10%	128	22	5252	42	0.93	8	38	33.5
Charcot Ave Storm Drain	Santa Clara	2015	1.8	79%	24%	123	23	14927	20	0.56	20	67	17
Veterans Pump Station	San Mateo	2015	0.52	67%	7%	121	24	3520	48	0.47	24	14	51
Gateway Ave Storm Drain	San Mateo	2015	0.36	69%	52%	117	25	5244	43	0.44	25	20	45

Watershed/ Catchment	County	Water Year sampled	Area (km2)	Impervious cover (%)	Old Industrial land use (%)	Polychlorinated biphenyls (PCBs)				Total Mercury (HgT)			
						Particle Ratio		Composite /mean water concentration		Particle Ratio		Composite /mean water concentration	
						(ng/g)	Rank	(pg/L)	Rank	(µg/g)	Rank	(ng/L)	Rank
Guadalupe River at Hwy 101	Santa Clara	2003-2006, 2010, 2012-2014	233	39%	3%	115	26	23736	15	3.6	3	603	1
Line 9-D-1 PS at outfall to Line 9-D	Alameda	2016	0.48	88%	62%	110	27	18086	19	0.72	12	118	6.5
Tunnel Ave Ditch	San Mateo	2016	3.0	47%	8%	109	28	10491	26	0.76	11	73	16
Valley Dr SD	San Mateo	2016	5.2	21%	7%	109	29	10442	28	0.28	41	27	42
Runnymede Ditch	San Mateo	2015	2.1	53%	2%	108	30	28549	13	0.19	51	52	25
E. Gish Rd Storm Drain	Santa Clara	2015	0.45	84%	70%	99	31	14365	21	0.59	16	85	12
Line 3A-M-1 at Industrial Pump Station	Alameda	2015	3.4	78%	26%	96	32	8923	30	0.34	33	31	38
Line 13-A at end of slough	Alameda	2016	0.83	84%	68%	96	33	34256	11	0.33	34	118	6.5
Zone 4 Line A	Alameda	2007-2010	4.2	68%	12%	82	34	18442	18	0.17	53	30	39
Forbes Blvd Outfall	San Mateo	2016	0.40	79%	0%	80	35	1840	54	0.64	15	15	50
Storm Drain near Cooley Landing	San Mateo	2015	0.11	73%	39%	79	36	6473	39	0.43	26	35	36
Lawrence & Central Expwys SD	Santa Clara	2016	1.2	66%	1%	78	37	4506	45	0.23	45	13	53.5

Watershed/ Catchment	County	Water Year sampled	Area (km2)	Impervious cover (%)	Old Industrial land use (%)	Polychlorinated biphenyls (PCBs)				Total Mercury (HgT)			
						Particle Ratio		Composite /mean water concentration		Particle Ratio		Composite /mean water concentration	
						(ng/g)	Rank	(pg/L)	Rank	(µg/g)	Rank	(ng/L)	Rank
Condensa St SD	Santa Clara	2016	0.24	70%	32%	74	38	2602	52	0.33	36	12	56
San Leandro Creek	Alameda	2011-2014	8.9	38%	0%	66	39	8614	33	0.86	9	117	8
Oddstad Pump Station	San Mateo	2015	0.28	74%	11%	62	40	9204	29	0.37	29	55	22.5
Line 4-B-1	Alameda	2015	0.96	85%	28%	57	41	8674	32	0.28	39.5	43	30
Zone 12 Line A under Temescal Ck Park	Alameda	2016	17	30%	4%	54	42	7804	38	0.29	38	42	31
Victor Nelo PS Outfall	Santa Clara	2016	0.58	87%	4%	51	43	2289	53	0.35	30	16	49
Haig St SD	Santa Clara	2016	2.12	72%	10%	43	44	1454	56	0.19	50	7	58
Lower Coyote Creek	Santa Clara	2005	327	22%	1%	30	45	4576	44	0.24	43.5	34	37
Calabazas Creek	Santa Clara	2011	50.1	44%	3%	29	46	11493	25	0.15	56	59	19
E Outfall to San Tomas at Scott Blvd	Santa Clara	2016	0.67	66%	31%	27	47	2799	51	0.13	57	13	53.5
San Lorenzo Creek	Alameda	2011	125	13%	0%	25	48	12870	24	0.18	52	41	32
Stevens Creek	Santa Clara	2011	26	38%	1%	23	49	8160	36	0.22	46.5	77	13
Guadalupe River at Foxworthy Road/ Almaden Expressway	Santa Clara	2010	107	22%	0%	19	50	3120	49	4.09	2	529	2
Duane Ct and Ave Triangle SD	Santa Clara	2016	1.0	79%	23%	17	51	832	58	0.27	42	13	55

Watershed/ Catchment	County	Water Year sampled	Area (km2)	Impervious cover (%)	Old Industrial land use (%)	Polychlorinated biphenyls (PCBs)				Total Mercury (HgT)			
						Particle Ratio		Composite /mean water concentration		Particle Ratio		Composite /mean water concentration	
						(ng/g)	Rank	(pg/L)	Rank	(µg/g)	Rank	(ng/L)	Rank
Lower Penitencia Creek	Santa Clara	2011, 2015	12	65%	2%	16	52	1588	55	0.16	54.5	17	47.5
Borel Creek	San Mateo	2011	3.2	31%	0%	15	53	6129	40	0.16	54.5	58	21
San Tomas Creek	Santa Clara	2011	108	33%	0%	14	54	2825	50	0.28	39.5	59	19
Zone 5 Line M	Alameda	2011	8.1	34%	5%	13	55.5	21120	16	0.57	17.5	505	3
Belmont Creek	San Mateo	2011	7.2	27%	0%	13	55.5	3599	47	0.22	46.5	53	24
Walnut Creek	Contra Costa	2011	232	15%	0%	7	57	8830	31	0.07	59	94	9
Lower Marsh Creek	Contra Costa	2011-2014	84	10%	0%	3	58	1445	57	0.11	58	44	29
San Pedro Storm Drain	Santa Clara	2006	1.3	72%	16%	No data				1.12	5	160	4
El Cerrito Bioretention Influent	Contra Costa	2011	0.004	74%	0%	442	NR[a]	37690	NR[a]	0.19	NR[a]	16	NR[a]
Fremont Osgood Road Bioretention Influent	Alameda	2012, 2013	0.0008	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	0.015	40%	0%	36	NR[a]	725	NR[a]	1.01	NR[a]	22	NR[a]

[a] NR = site not included in ranking. These are very small catchments with unique sampling designs for evaluation of green infrastructure.

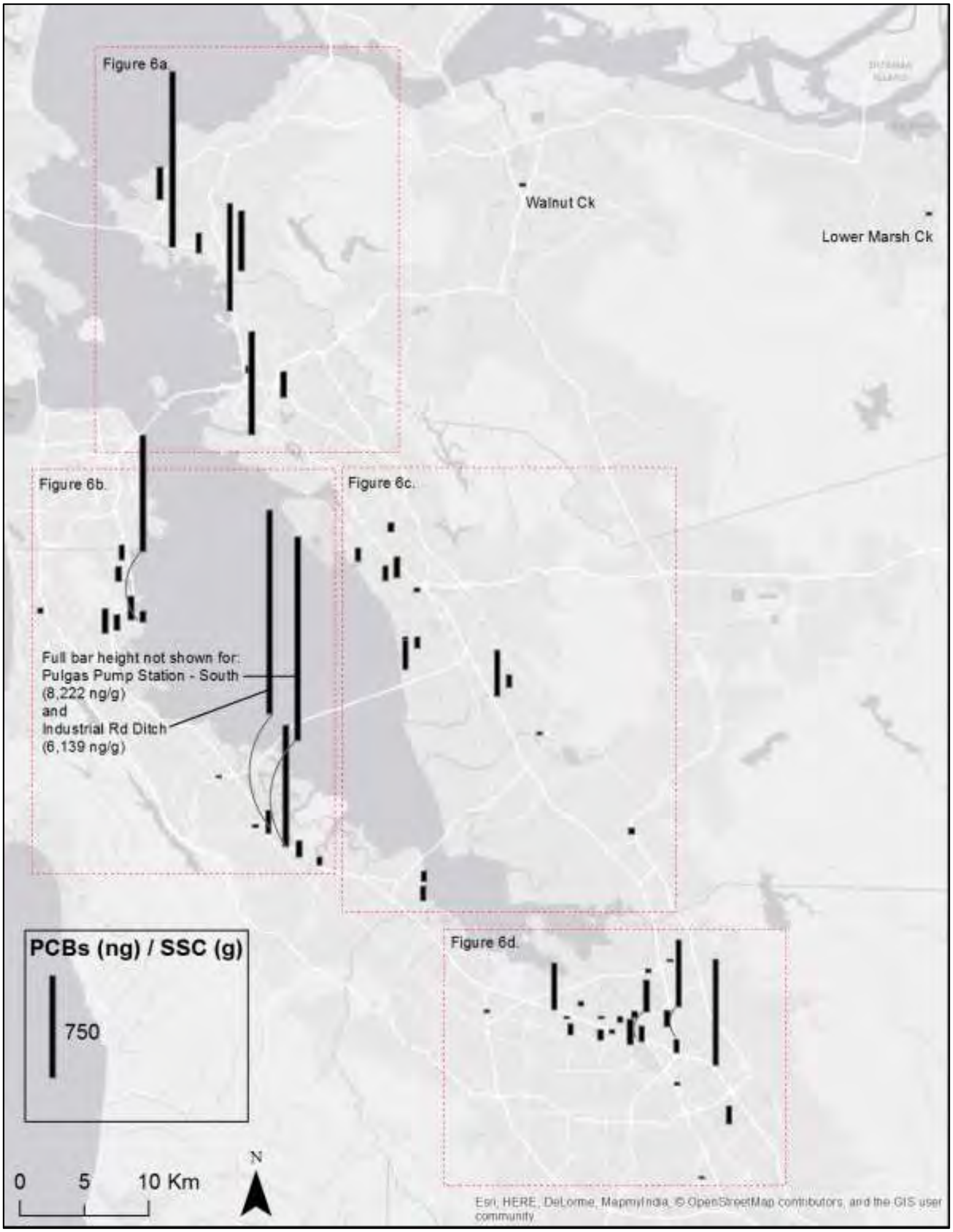

Figure 6. Regional distribution of particle ratios of polychlorinated biphenyl (PCB) in stormwater samples collected to date.

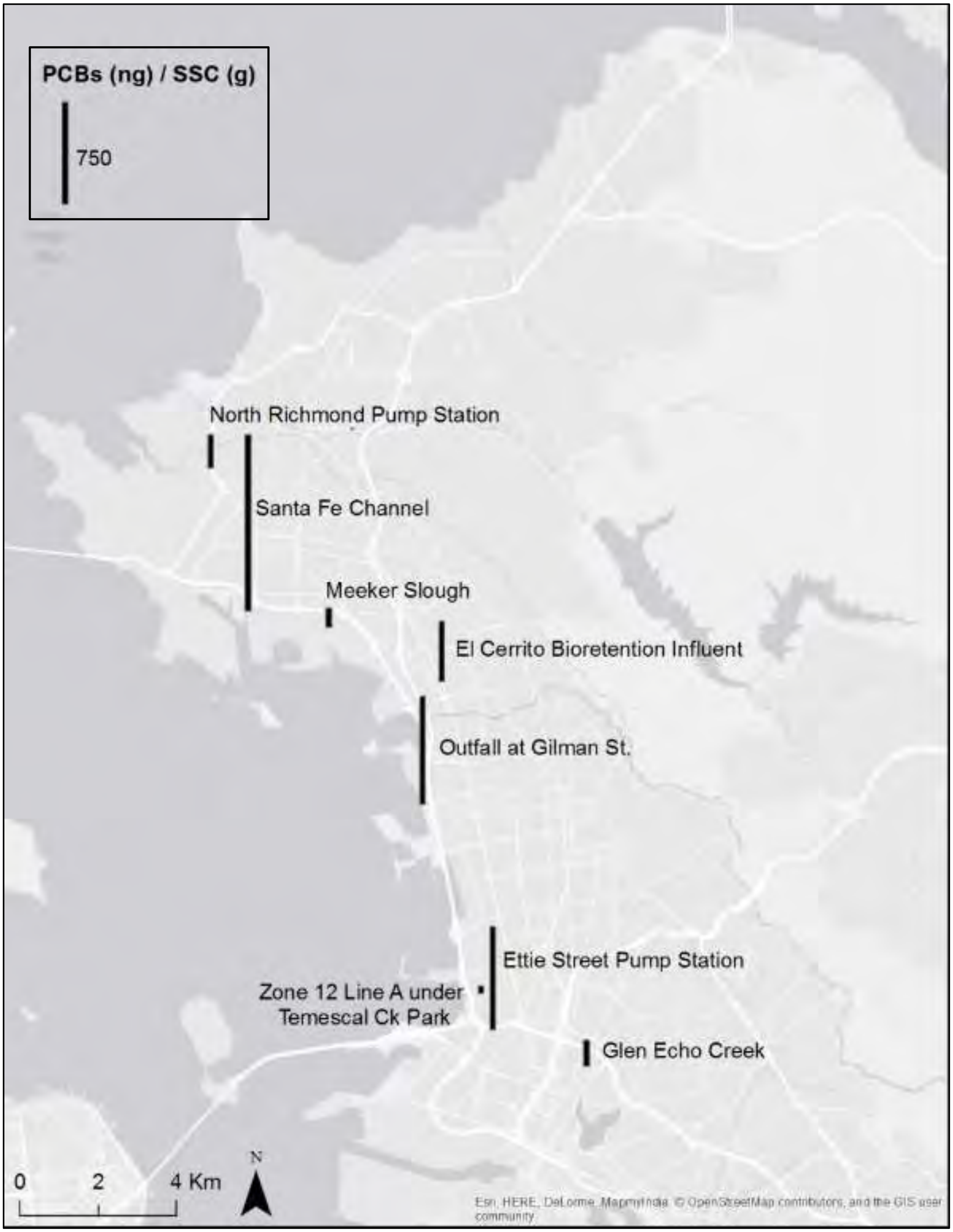

Figure 6a. Distribution of particle ratios of polychlorinated biphenyl (PCB) in stormwater samples collected to date in northern Alameda and Contra Costa counties.

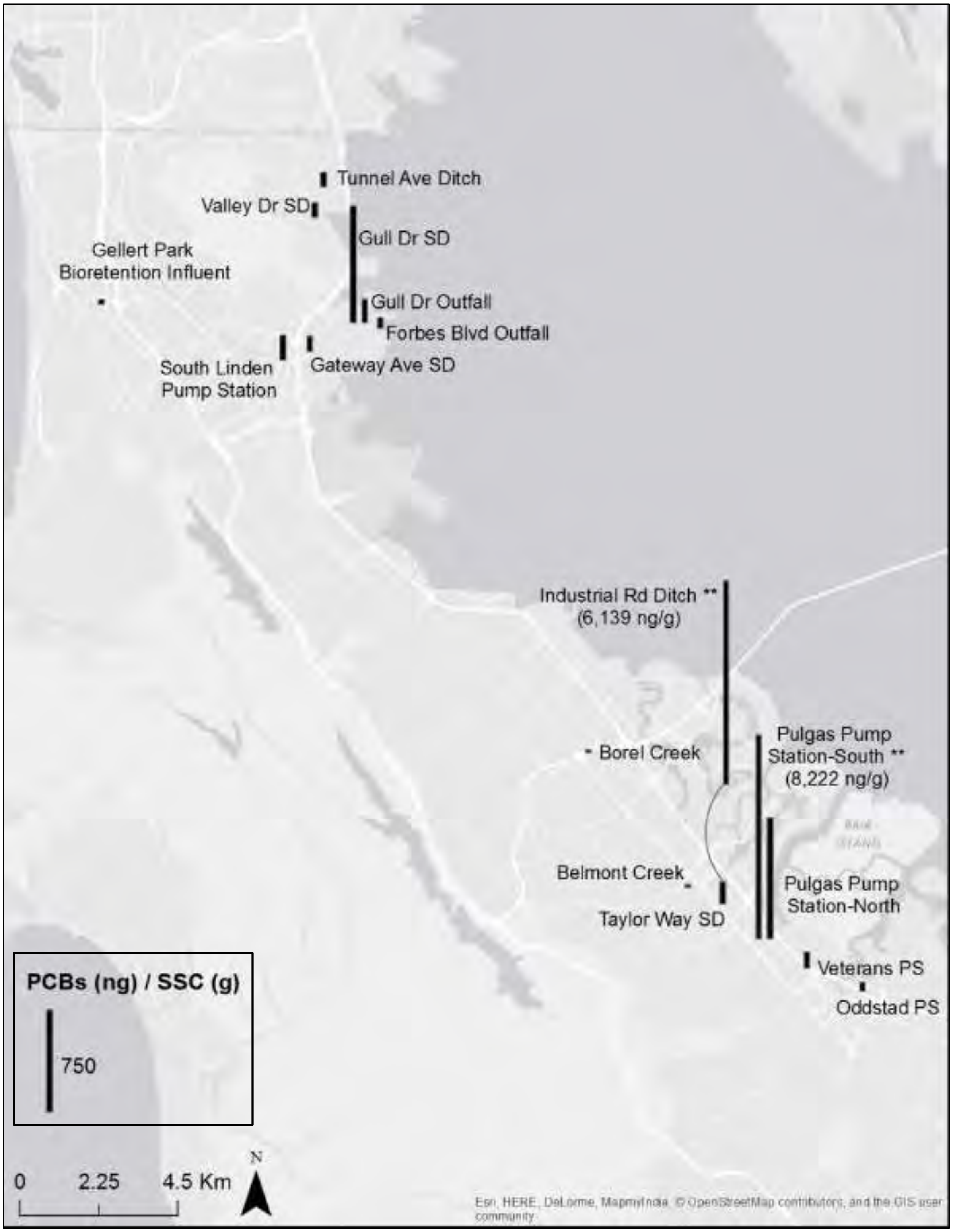

Figure 6b. Distribution of particle ratios of polychlorinated biphenyl (PCB) in stormwater samples collected to date in central and northern San Mateo County.

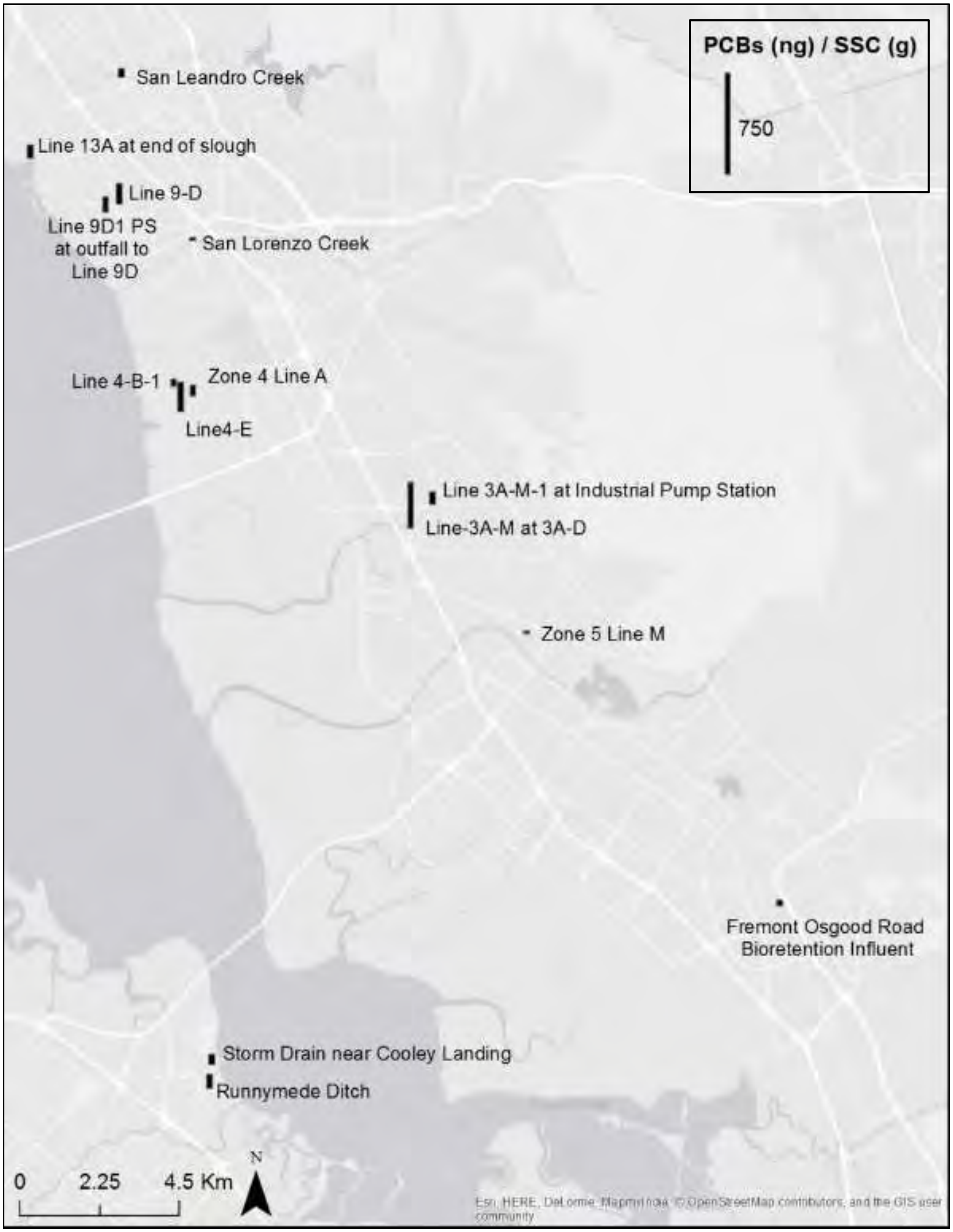

Figure 6c. Distribution of particle ratios of polychlorinated biphenyl (PCB) in stormwater samples collected to date in southern Alameda and San Mateo counties.

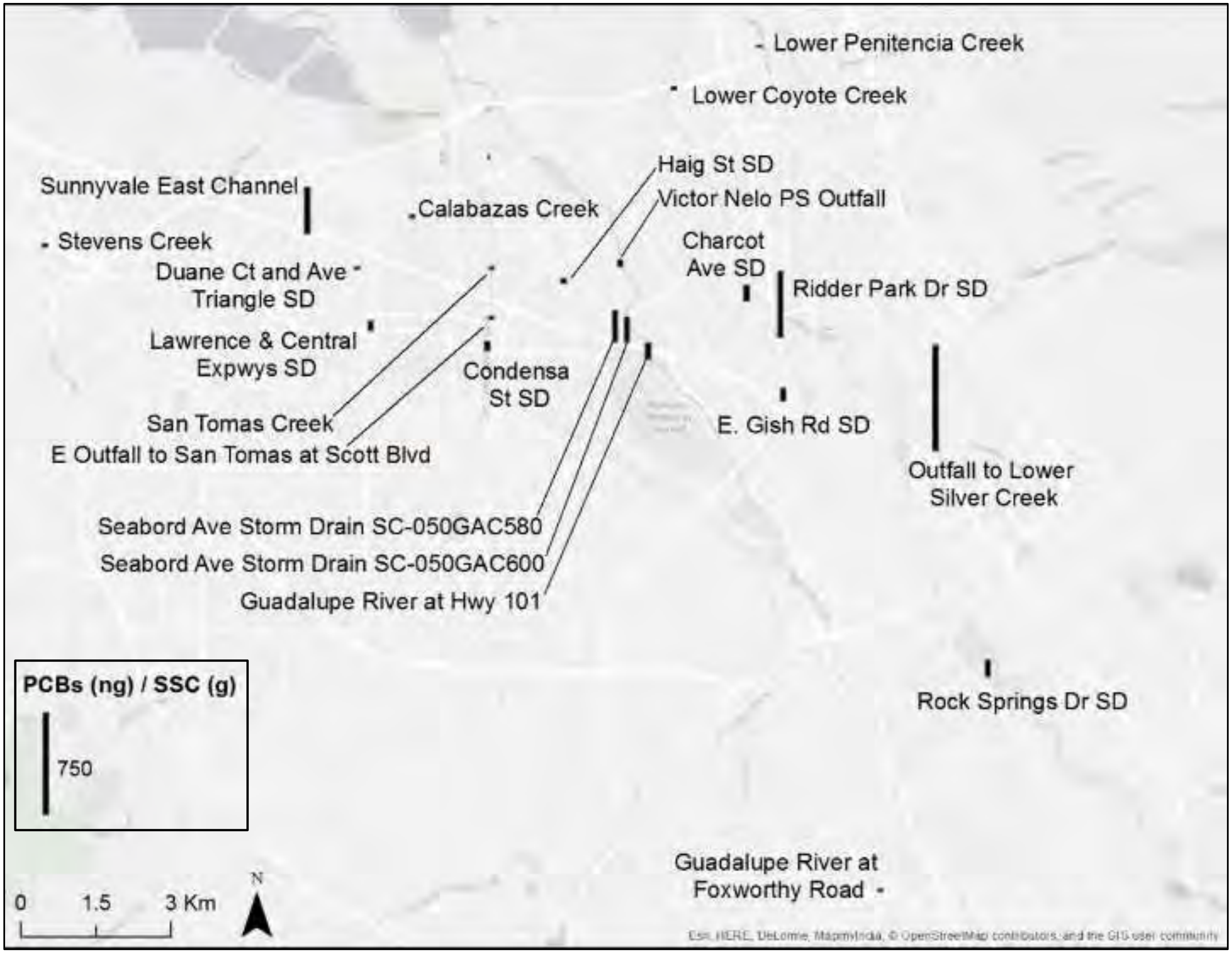

Figure 6d. Distribution of particle ratios of polychlorinated biphenyl (PCB) in stormwater samples collected to date in Santa Clara County.

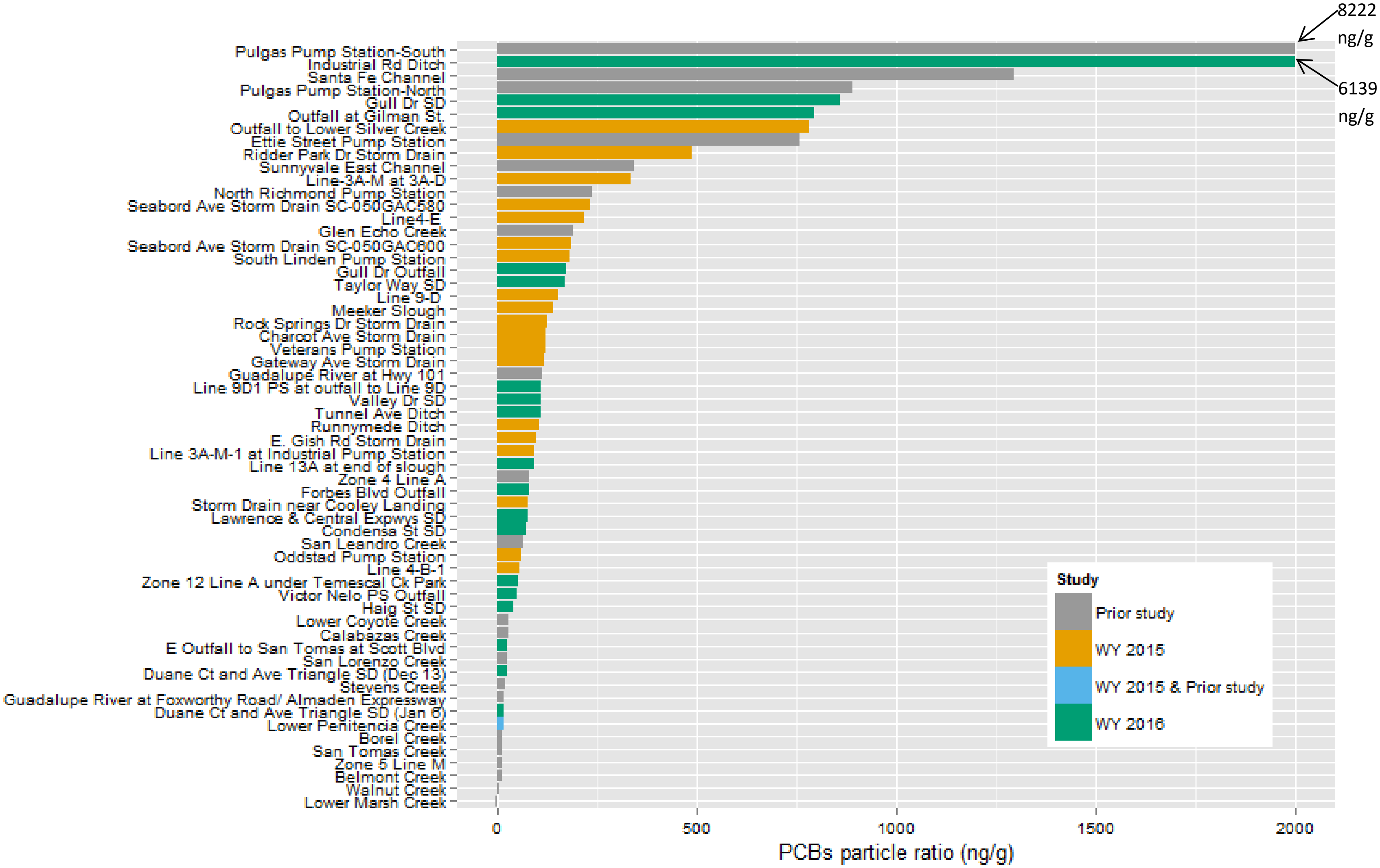

Figure 7. All watershed sampling locations measured to date ranked using PCB particle ratios. Note Pulgas Pump Station-South is beyond the extent of this graph at 8,222 ng/g as well as Industrial Road Ditch at 6139 ng/g.

To a large degree, sites that rank high for PCB water concentrations also rank high for particle ratios (Figure 8) however, comparisons between the ranking methodologies provide a hint as to the main vector for transport at each of the sites (contaminated soil erosion versus emulsion of liquid PCBs). For example, a high ranking for water concentration but low ranking for particle ratio can indicate high rates of erosion of relatively clean sediment, which is more typical of larger and less pervious watersheds. On the other hand, a high ranking for water concentrations and high ranking for particle ratio can indicate that sediment is not the dominant vector for transport and that PCB emulsions are possibly in transport, which is likely to be more typical of smaller and more impervious watersheds with a greater proportion of source areas. Conversely, a lower rank for concentration coupled with a higher ranking for particle ratio could possibly indicate erosion of highly contaminated particles. If this occurs in a smaller watershed, this would indicate sediment transport is the main vector. These hints can be instructive for helping to consider main source areas and release processes.

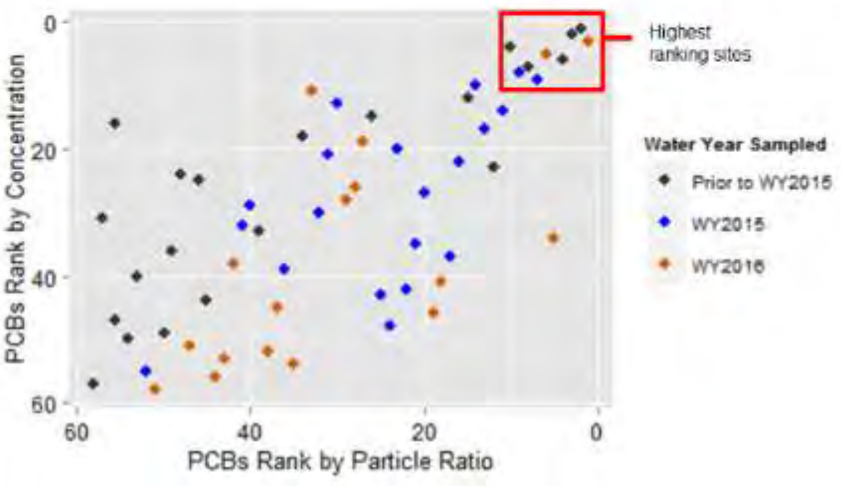

Figure 8. Correlation between site rankings for PCBs based on particle ratios versus water concentrations. 1 = highest rank; 58 = lowest rank.

There are a number of watersheds that appear to show relatively low Hg concentrations. In contrast to PCBs, 38 out of 62 sampling locations have composite averaged HgT water concentrations less than 53 ng/L (Table 12), the regionally averaged concentration derived from the TMDL target. These lower ranking sites based on water concentrations ranged in impervious cover between 10-87% with a median of 72%. However, none of the locations sampled to date have composite averaged HgT particle ratios <0.058 µg/g (the regionally averaged particle ratio based on the TMDL target combined with estimated average annual regional total suspended sediment loads[12]); the lowest observation so far has been Walnut Creek at 0.07 µg/g (0.07 mg/kg) (Table 12; Figure 9; Figure 10). But 17 sites measured to date (Walnut Creek, Lower Marsh Creek, E Outfall to San Tomas at Scott Blvd, Calabazas Creek, Lower Penitencia Creek, Borel Creek, Zone 4 Line A, San Lorenzo Creek, Runnymede Ditch, Haig St SD, Sunnyvale East Channel, Glen Echo Creek, Stevens Creek, Belmont Creek, Lawrence & Central Expressways SD, Lower Coyote Creek, and Line 9-D) do have particle ratios <0.25 µg/g that, given a reasonable expectation of error bars of 25% around our measurements, could be considered equivalent to or less than 0.2 µg/g of Hg on suspended solids (the particulate Hg concentration that was specified in the Bay and Guadalupe River TMDLs) (SFBRWQCB, 2006; 2008).

There have been several studies in the Bay Area on atmospheric deposition rates for HgT (Tsai and Hoenicke, 2001; Steding and Flegal, 2002). These studies measured very similar wet deposition rates of 4.2 µg/m^2/y (Tsai and Hoenicke, 2001) and 4.4 µg/m^2/y (Steding and Flegal, 2002) with Tsai and Hoenicke reporting a total (wet + dry) deposition rate of 18-21 µg/m^2/y. Tsai and Hoenicke observed volume-weighted average mercury concentrations in precipitation based on 59 samples collected across the Bay Area of 8.0 ng/L. They reported that wet deposition comprised 18% of total annual deposition; thus scaled to volume of runoff, an equivalent stormwater concentration of 44 ng/L can be derived. If a runoff coefficient (the proportion of rainfall that manifests as runoff) equivalent to the impervious cover of a watershed is assumed, it can be hypothesized that all of the runoff from the sites exhibiting composite averaged concentration of <53 ng/L could be accounted for by atmospheric deposition alone; indeed a high proportion of the runoff from any watershed exhibiting concentrations in stormwater of, for example, < 100 ng/L could also be atmospherically derived. This is not to say that there are no other sources in these watersheds, but rather that loads from any other sources are diluted out by cleaner runoff sustained by relatively low but relatively constant atmospheric deposition rates. Thus, a number of watersheds have been sampled for Hg that show relatively low concentrations and will likely continue to do so in alignment with atmospheric deposition. Given the data set now amassed, it is likely that many future sampling locations would show similar outcomes. However, this may not be the case for methylmercury, where in situ production in anoxic saturated zones may provide additional input not directly correlating to atmospheric loads.

On the other end of the spectrum, there are some watersheds that display elevated HgT concentrations that, if the sources could be found and treated, would help to reduce HgT loads entering the Bay (Table 12). Based on composite averaged HgT water concentrations, the 10 most polluted sites (ranked in order from high to lower) would include the Guadalupe River at Hwy 101, Guadalupe River at Foxworthy Road/ Almaden Expressway, Zone 5 Line M, Outfall at Gilman St., San Pedro Storm Drain, Line 13-A at end of slough, Line 9-D-1 PS at outfall to Line 9-D, San Leandro Creek, Walnut Creek, and Santa Fe Channel (Figure 10). Just two of these (Santa Fe Channel and the Outfall at Gilman St.) are also ranked in the top 10 for PCB concentrations in water, while 10 watersheds rank in the top 20 for both pollutants.

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[12] Again the reader is reminded that these regional estimates total suspended sediment loads are subject to change if future interpretations are completed.

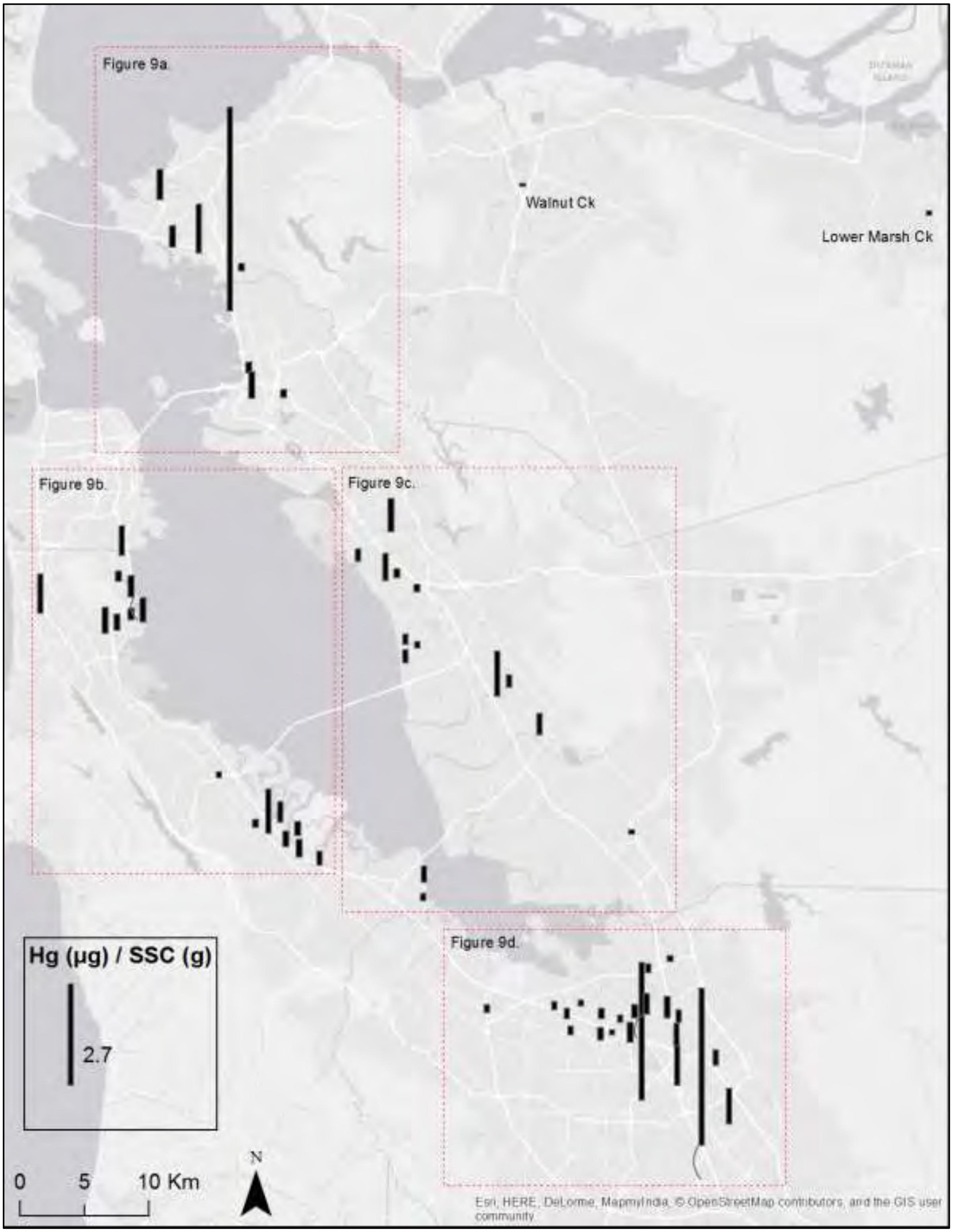

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Figure 9. Regional distribution of sites and particle ratios of total mercury (HgT) in stormwater samples collected to date.

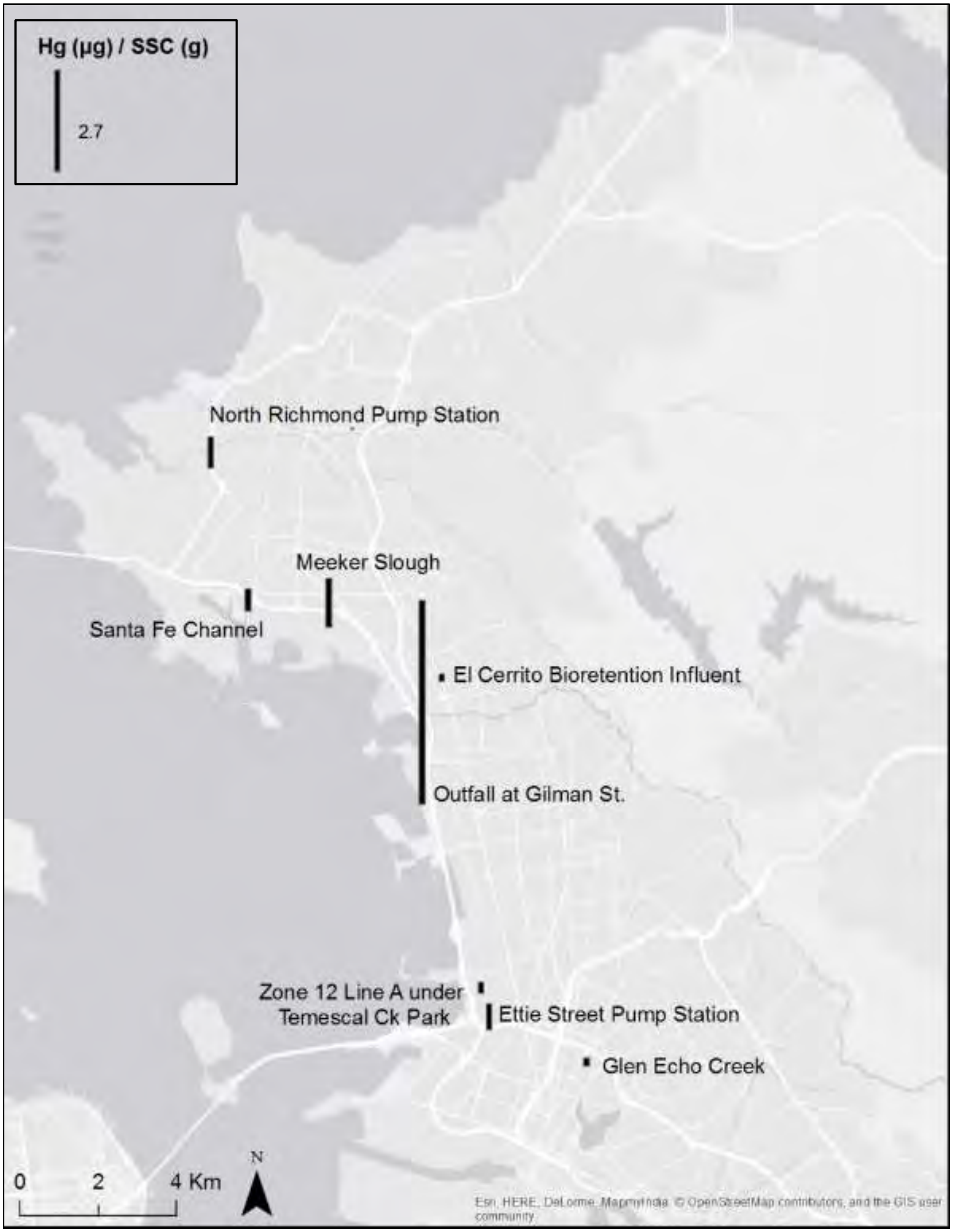

Figure 9a. Distribution of sites and particle ratios of total mercury (HgT) in stormwater samples collected to date in northern Alameda and Contra Costa counties.

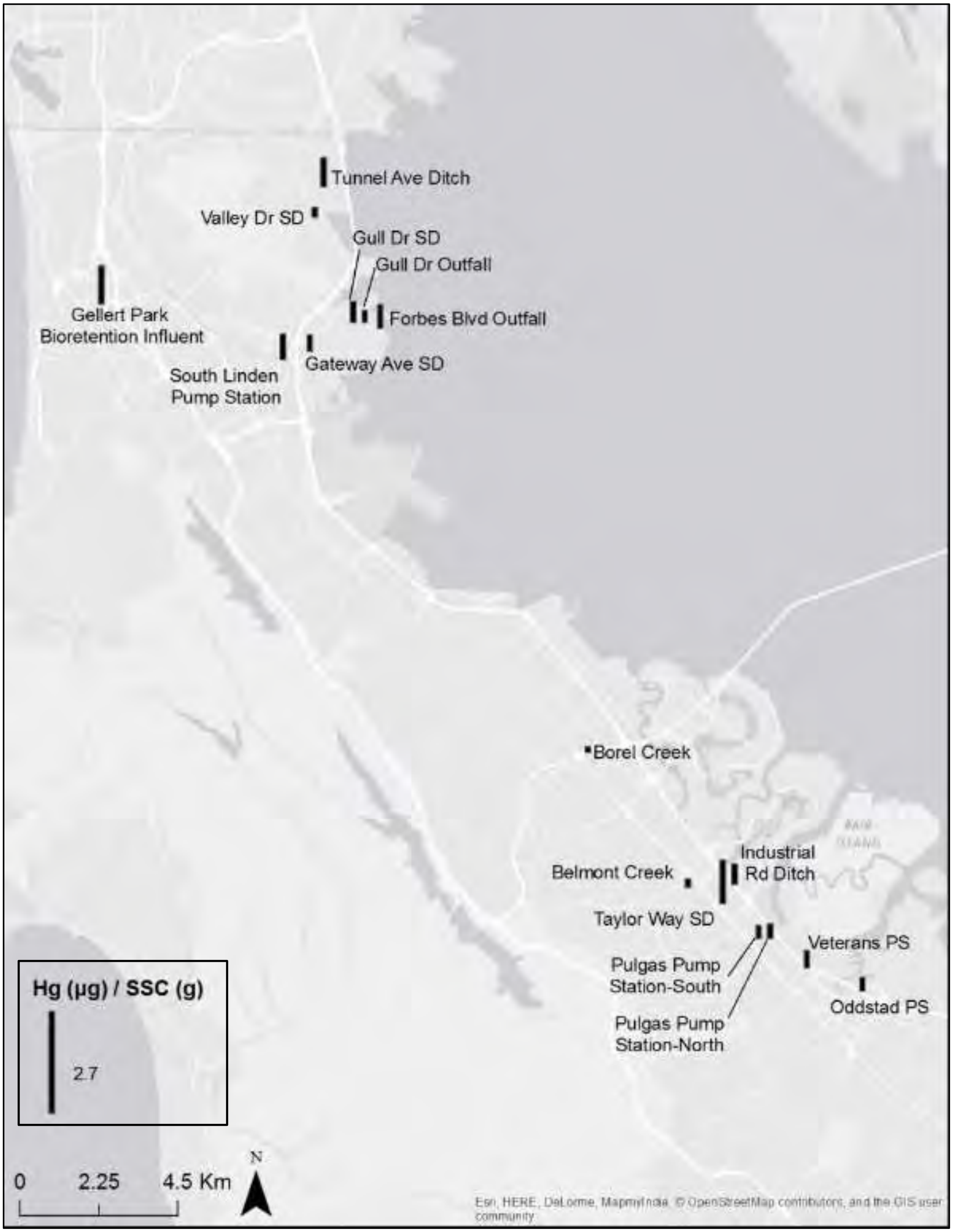

Figure 9b. Distribution of sites and particle ratios of total mercury (HgT) in stormwater samples collected to date in central and northern San Mateo County.

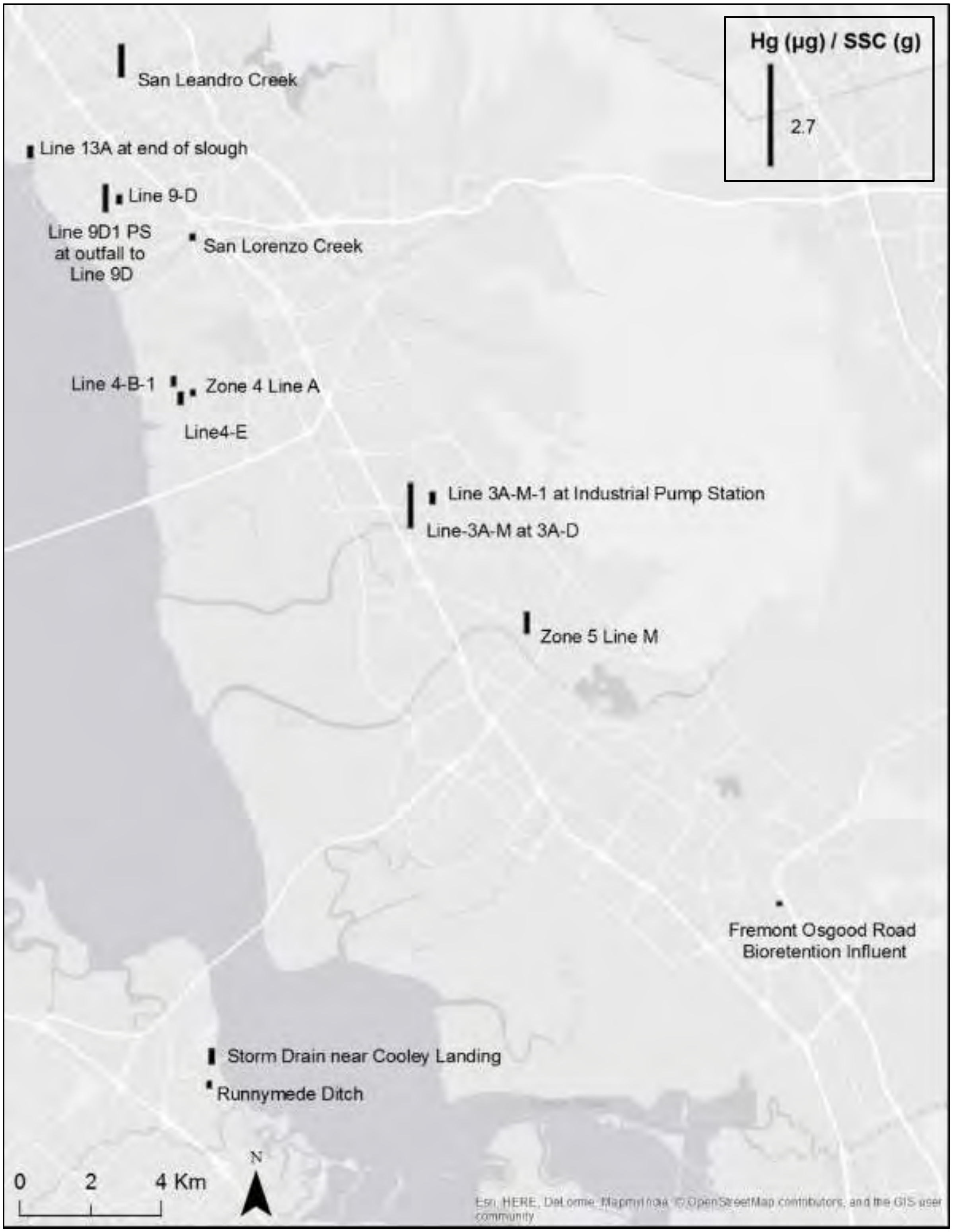

Figure 9c. Distribution of sites and particle ratios of total mercury (HgT) in stormwater samples collected to date in southern Alameda and San Mateo counties.

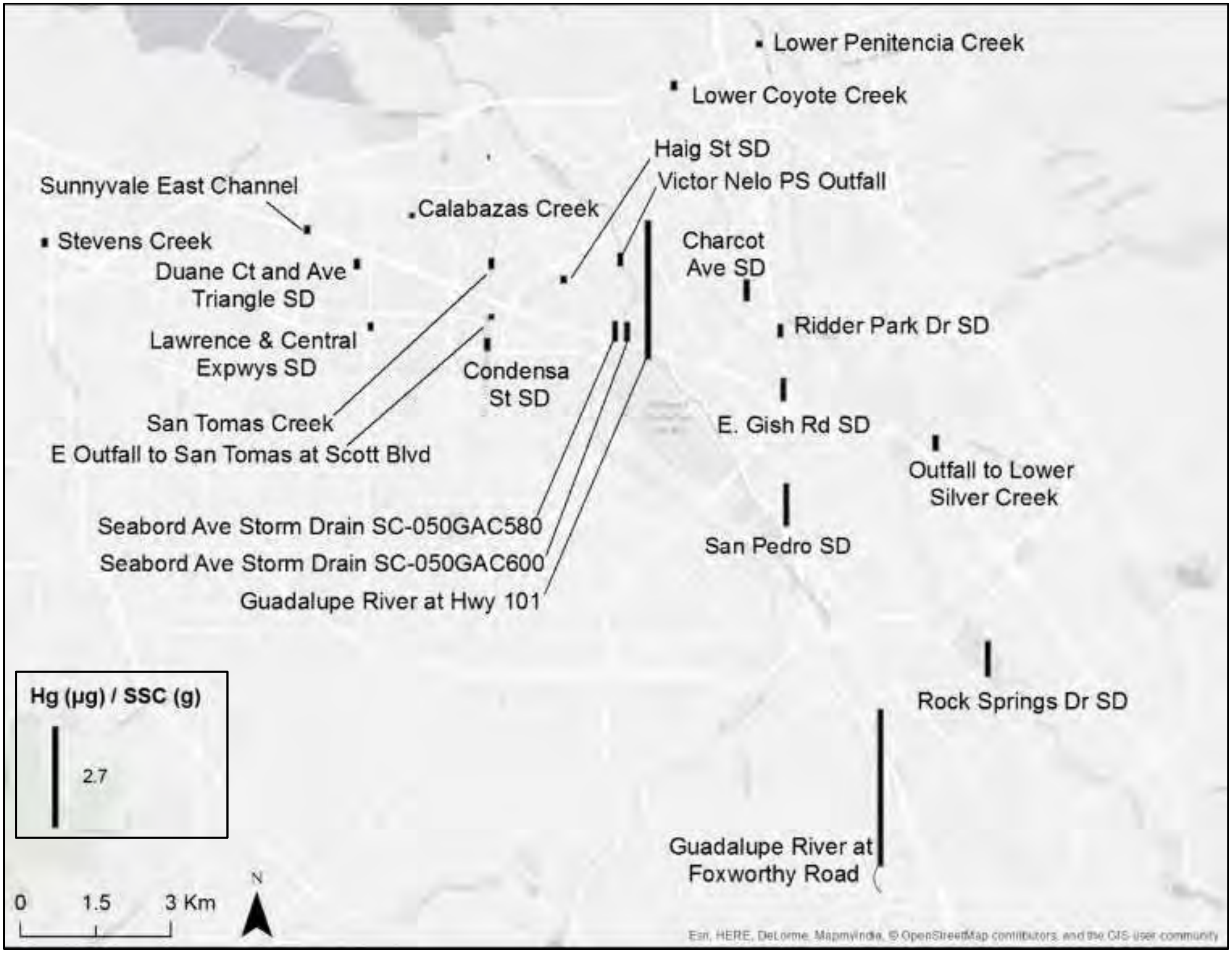

Figure 9d. Distribution of sites and particle ratios of total mercury (HgT) in stormwater samples collected to date in Santa Clara County.

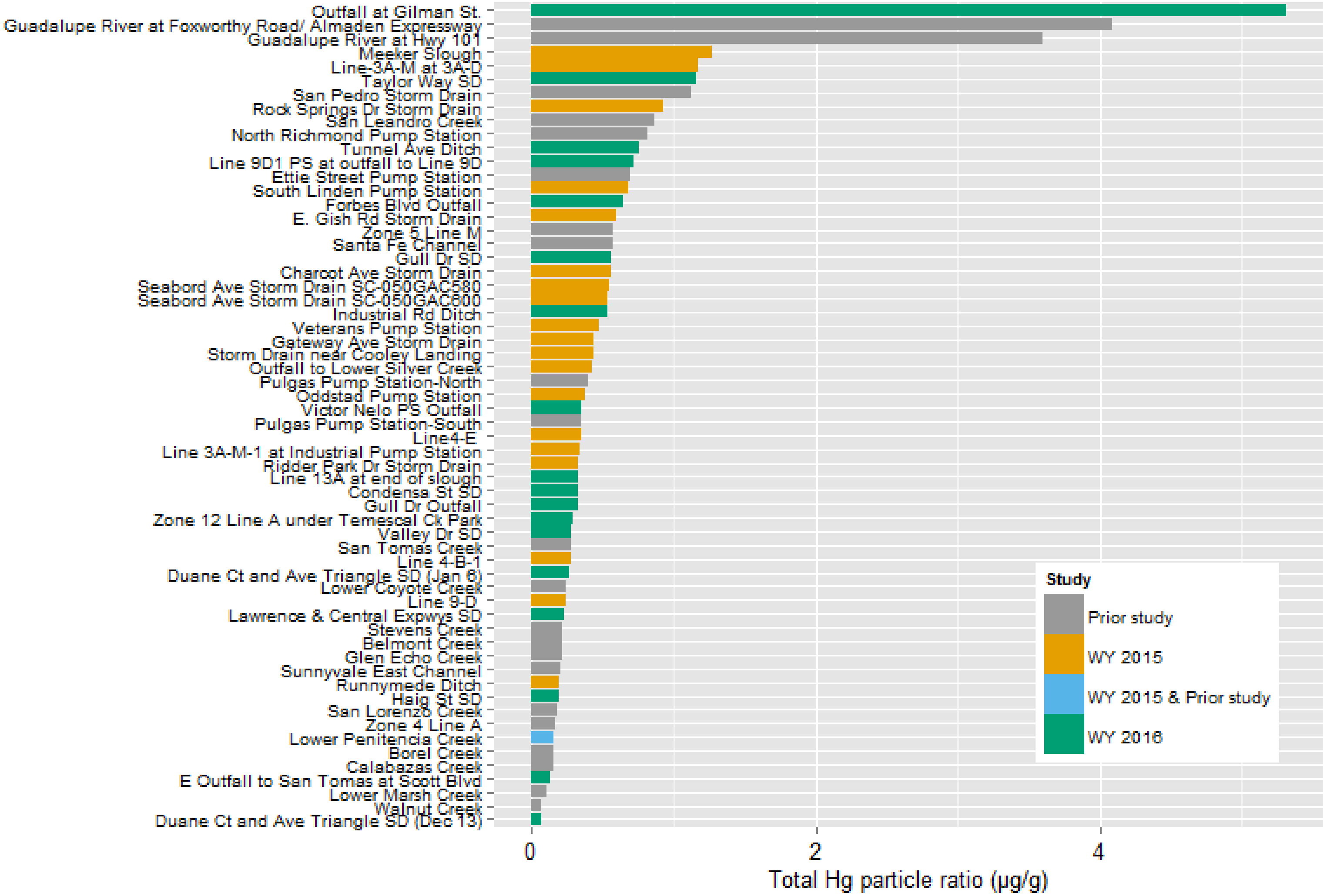

Figure 10. All watershed sampling locations measured to data ranked using total mercury (HgT) particle ratios.

Unlike for PCBs, sites ranking high for HgT concentration in water are not necessarily ranked high for particle ratio with the exception of a few very polluted cases (Guadalupe River at Hwy 101, Guadalupe River at Foxworthy Road/ Almaden Expressway, Outfall at Gilman St., San Pedro Storm Drain, and San Leandro Creek) (Figure 11). As discussed above and introduced by McKee et al. (2012), given the atmospheric sources of Hg and highly variable sediment erosion in Bay Area watersheds, it is possible to get very elevated HgT stormwater concentrations but very low particle ratios. The best example of this is Walnut Creek that was ranked 9th highest in terms of stormwater composite averaged concentrations but lowest (59th out of 62 ranked watershed locations) in terms of particle ratios (but other examples include Zone 5 Line M, Line 13-A at end of slough, Stevens Creek, Glen Echo Creek, Calabazas Creek, Guadalupe River at Hwy 101). Thus, much more care is needed when ranking the sites for HgT than for PCBs (for which the atmospheric pathway plays less of a role in dispersion). This is consistent with the relative results from the most recent calibrations of the RWSM based on the hydrology where better calibrations for PCBs than for Hg were achieved (Wu et al., 2016; Wu et al., 2017); a sediment model basis may be more appropriate for Hg.

Based on particle ratios (the preferred method), the 10 most polluted sites appear to be (in addition to the two Guadalupe River mainstem sites) 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, North Richmond Pump Station, Tunnel Ave Ditch, and Line 9-D-1 PS at outfall to Line 9-D (Table 12; Figure 10). Management in these watersheds might be most cost effective for HgT. The Daly City library bioretention demonstration project (at Gellert Park) with a particle ratio of 1.0 ug/g appears to have been placed (quite by accident) in a cost effective manner and appears to be functioning reasonably well for HgT removal, however, there were some concerns about methylmercury production (David et al., 2015). Just one of these top 10 locations were also identified as elevated for PCB particle ratios (Outfall at Gilman St.) while nine watersheds rank in the top 20 for both pollutants (Figure 12)) providing the opportunity for multiple benefits. Thus the reconnaissance sampling methods coupled with the use of particle ratio in the interpretative process has indicated a number of watersheds with elevated HgT. However, unlike concentrations in water, when normalized to SSC, there appears to be no useful relationship between HgT and PCB particle ratios; sites that are elevated for PCBs based on particle ratio may or may not be elevated for Hg. This fits our conceptual model for Hg where atmospheric deposition and soil erosion play a larger role in the transport of Hg relative to PCBs.

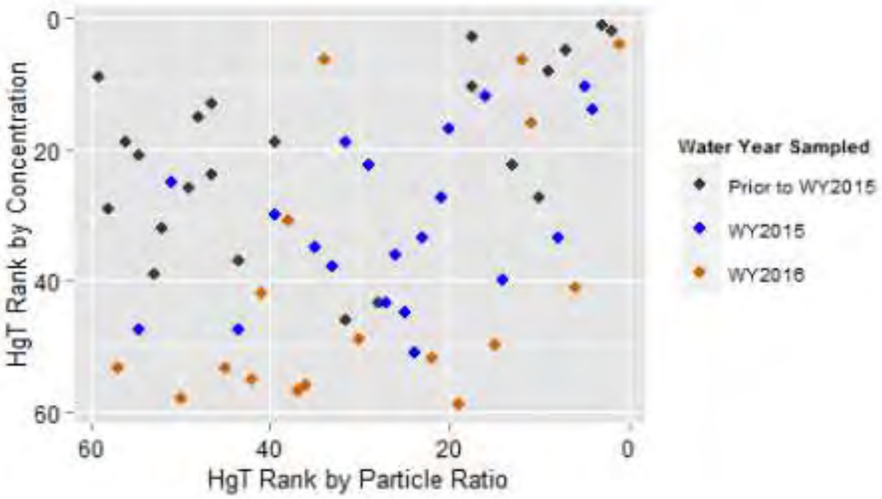

Figure 11. Relationship between site rankings for HgT based on particle ratios versus water concentrations. 1 = highest rank; 59 = lowest rank.

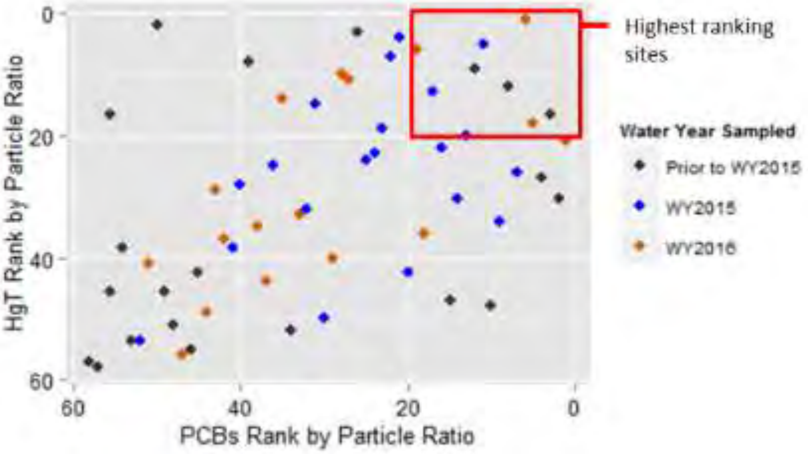

Figure 12. Relationship between site rankings for PCB particle ratios versus HgT particle ratios. 1 = highest rank; 58 = lowest rank. One watershed ranks in the top 10 for both PCBs and HgT, while nine watersheds rank in the top 20 for both pollutants.

Relationships between PCBs and Hg and other trace substances and land cover attributes

The data can be used to explore relationships between pollutants and with landscape attributes. Beginning in WY 2003, a number of sites have been evaluated for not only PCB and HgT concentrations in stormwater but also for a range of trace elements. These sites have included the fixed station loads monitoring sites on Guadalupe River at Hwy 101 (McKee et al., 2006), Zone 4 Line A (Gilbreath et al., 2012a), North Richmond Pump Station (Hunt et al., 2012) and for Cu only (Lower Marsh Creek, San

Leandro Creek, Pulgas Pump Station-South, and Sunnyvale East Channel) (Gilbreath et al., 2015a). Copper data have also been collected at the inlets to several pilot performance studies for bioretention (El Cerrito: Gilbreath et al., 2012b); Fremont: Gilbreath et al., 2015b) and Cu, Cd, Pb, and Zn data were collected at the Daly City Library Gellert Park demonstration bioretention site (David et al., 2015). In addition, during WYs 2015 and 2016, trace element data were collected at an additional 26 locations (See Table 6 earlier in this report). All these data (n=36 sites for Cu; n=30 for Cd, Pb, and Zn; n=28 for As; Mg and Se not included due to small sample size) were pooled to complete an analysis of relationships between observed particle ratios of PCBs and HgT, trace elements, and impervious land cover and old industrial land use using a Spearman Rank correlation analysis (Table 13). In the case of Guadalupe River, the HgT data were removed from the analysis due the historic mining influence in that watershed[13]. Particle ratios were chosen for this analysis for the same reasons as described above and in McKee et al. (2012); the influence of variable sediment production across Bay Area watersheds is best normalized out so that variations in the influence of pollutant sources and mobilization can be more easily observed between sites.

The relationships to trace metals are weak for both PCBs and Hg. Based on the available appropriate data and the particle ratio method, PCBs appear to positively correlate with impervious cover, old industrial land use and HgT. PCBs appear to inversely correlate with watershed area. These observations are consistent with previous analysis (McKee et al., 2012) and make conceptual sense given larger watersheds tend to have mixed land use and thus a lower proportional amount of PCB source areas. The positive but relatively weak correlation between PCBs and HgT also makes sense given the general relationships between impervious cover and old industrial land use and both PCBs and Hg. 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 was used as dielectrics, plasticizers, and oils whereas Hg was used in electronic devices, pressure and heat sensors, pigments, mildewcides, and dentistry). Correlations between PCBs and other trace metals are generally weak and not explained by these data. Total mercury does not appear to correlate with any of the other trace metals, and compared with PCBs, shows similar but weaker relationships to impervious cover, old industrial land use, and watershed area. To explore these relationships a little further, the PCB data were examined graphically (Figure 13). All relationships appear to be linear and there is no evidence that a log transformation would help explain the variances between PCBs and other potential indicators. The data do indicate the presence of outliers which may be worth exploring once additional data are obtained in WY 2017. Overall, based on this analysis using the available pooled data, there is no support for the use of these trace metals as a surrogate investigative tool for either PCB or HgT pollution sources.

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[13] Historic mining in the Guadalupe River watershed is known to cause a unique positive relationship between Hg, Cr, and Ni and it is known that there are unique inverse correlations between Hg and other typical urban metals such as Cu and Pb (McKee et al., 2005).

Table 13. Spearman Rank correlation matrix based on stormwater samples collected in the Bay Area since WY 2003 (see text for data sources and exclusions).

	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)*	*TOC (mg/mg)*
PCBs (pg/mg)	1													
HgT (ng/mg)	0.51	1												
Arsenic (ug/mg)	-0.57	0.00	1											
Cadmium (ug/mg)	-0.35	0.24	0.77	1										
Copper (ug/mg)	-0.14	0.14	0.78	0.77	1									
Lead (ug/mg)	-0.29	0.17	0.73	0.90	0.71	1								
Zinc (ug/mg)	-0.32	0.27	0.63	0.78	0.90	0.68	1							
Area (sq km)	-0.41	-0.36	-0.14	-0.24	-0.40	-0.06	-0.41	1						
% Imperviousness	0.52	0.35	-0.23	0.03	0.13	-0.13	0.22	-0.68	1					
% Old Industrial	0.55	0.35	-0.44	-0.26	-0.29	-0.32	-0.21	-0.46	0.70	1				
% Clay (<0.0039 mm)	0.28	0.18	-0.12	0.06	-0.22	-0.04	-0.15	-0.41	0.15	0.30	1			
% Silt (0.0039 to <0.0625 mm)	-0.04	0.11	-0.11	-0.18	0.26	0.00	0.19	0.30	-0.07	-0.14	-0.11	1		
% Sands (0.0625 to <2.0 mm)	-0.26	-0.14	0.13	-0.07	0.12	0.01	0.04	0.25	-0.17	-0.33	-0.87	-0.50	1	
TOC (mg/mg)	0.20	0.37	0.69	0.59	0.88	0.47	0.76	-0.53	0.47	0.19	-0.24	0.24	0.20	1

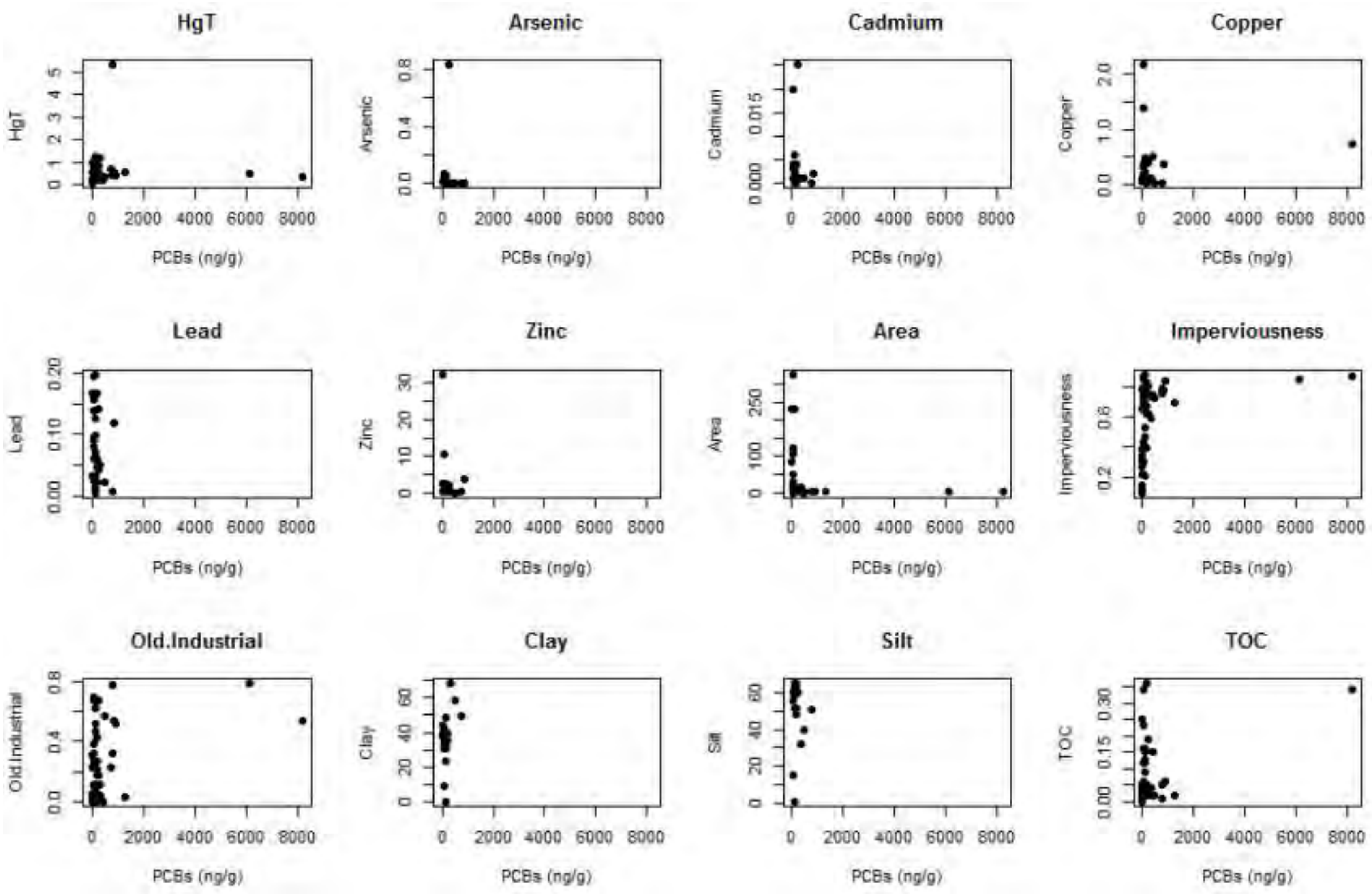

Figure 13. Relationships between observed particle ratios of PCBs and HgT, trace elements, and impervious land cover and old industrial land use.

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 (McKee et al., 2012; McKee et al., 2015) that old industrial land use and the specific source areas found within or in association with older industrial areas are likely to exhibit higher concentrations and loads with respect to PCBs and HgT. Although on a regional basis, this argument holds true (%old industrial land use describes in excess of 50% of the variability in PCB water concentrations and particle ratios), it is not reliable at the scale of individual sites; likely reasons include because the maps are out of date due to ongoing redevelopment and because of the nuanced nature of PCB sources and individual site characteristics such as differential soil erosion and runoff. A total of 62 sites have been sampled for PCBs and HgT during various field sampling efforts since WY 2003. The sampling locations have been selected to help answer a variety of questions, in some cases to make measurements of loads to the Bay from selected watersheds and in other cases to help characterize concentrations of PCBs, HgT and other trace pollutants in stormwater. Although land redevelopment is occurring at a rapid pace in some areas, the currently available old industrial land use layer that was based on the overlay of ABAG, 2005 industrial land use and an older urban land use coverage from 1968 (e.g. Wu et al., 2016) was used to evaluate the proportion of old industrial land use within each sampled watershed in relation to the regional and county based totals. In this way, progress towards characterizing concentrations in these areas was evaluated. This analysis (which excluded nested sampling sites) showed that about 29% of the so defined old industrial land use in the region has been sampled to date. The best effort so far has occurred in Santa Clara County (96% of this land use has been sampled), followed by San Mateo County (43%), Alameda County (33%), and Contra Costa County (4%). The disproportional coverage in Santa Clara County is due to a number of larger watersheds being sampled (Lower Penitencia Creek, Lower Coyote Creek, Guadalupe River at Hwy 101, Sunnyvale East Channel, Stevens Creek, and San Tomas Creek) and also because there were older industrial land use areas further upstream in the Coyote Creek and Guadalupe River watersheds. Of the remaining older industrial land use yet to be sampled, 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, likely to include heavy industrial areas that were historically serviced by rail and ship based transport, and military areas, and are often very difficult to sample due to a lack of public right of ways. A different sampling strategy may be needed to effectively determine what pollution might be associated with these areas to further progress towards identifying areas for potential management.

Data collected will also be used to calibrate the Regional Watershed Spreadsheet Model (RWSM) (Wu et al., 2016). The present version of the model was calibrated using data from 37 watershed areas. Parameterization of the model is currently limited because many of the key source areas are not present in sufficient amounts within the calibration watersheds to strongly influence the calibration procedures. For example, various forms of waste recycling (general waste, metals, auto, drum) only produce an estimated <1.5% of the runoff within the calibration watersheds and were present in <16 of the 37 watersheds (Wu et al., 2017). Based on the extended dataset (now 62 watersheds), the number of sampled watersheds where these types of source areas are present will likely increase. In addition, many of the new watersheds characterized in WY 2016 (described for the first time in this current report) are much smaller in size (0.23-17.5 km^2; mean = 2.1 km^2) compared to previous characterization or loading based sampling efforts (0.0008-327 km^2; mean = 31 km^2) and as such are less heterogeneous in relation to land uses and source areas. This may also help the model to calibrate better for ranking smaller watershed by placing stronger constraints on the calibration process for key source areas. The large variety of watershed sizes and land use characteristics also provides an opportunity to continue to question and evaluate the most appropriate choice of calibration watershed for estimating regional scale loads. Thus, apart from the use of the data to support watershed characterization in relation to pollution sources and higher potential leverage (along with other evidence being generated by the stormwater programs), another potential use of the data is for improving the calibration of the RWSM and by extension improved estimates of regional scale watershed loads.

Summary and Recommendations

Despite climatically challenging conditions resulting in a limited number of storms of appropriate magnitude for sample capture, a total of 20 additional sites were sampled during WY 2015 and an additional 17 sites were sampled and characterized for concentrations during WY 2016. At these sites, composite water samples collected during one storm event were analyzed for PCBs, HgT, SSC, selected trace metals, organic carbon, and grain size. Sampling efficiency was increased by sampling two sites during a single storm that had similar runoff characteristics and were near enough to each other to allow safe and rapid transport and reoccupation repeatedly during a rain event. At eight of these locations, simultaneous samples were also collected using a Hamlin remote suspended sediment sampler and at three sites a third method (the Walling tube remote suspended sediment sampler) was also trialed successfully. Based on this dataset, a number of sites with elevated PCB and Hg concentrations and particle ratios were successfully identified, in part based on an improved effort of site selection focusing on older industrial and highly impervious landscapes. With careful selection of sample timing, some success even occurred at tidal sites, but overall, tidal sites remain the most challenging to sample. Although optimism remains about future applications, the remote sampler trial showed mixed results and need further testing. Based on the WY 2015 and 2016 results, the following recommendations were made:

- Continue to select sites based on the four main selection rationales (Section 2.2). The majority of the samples should be devoted to identifying areas of potential high leverage (indicated by high unit area loads or particle ratios/ concentrations relative to other sites) with a smaller number of sites allocated to sampling potentially cleaner and variably-sized watersheds to help broaden the dataset for regional model calibration and to inform consideration of cleanup potential. The method of selection of sites of potentially higher leverage focusing on older industrial and highly impervious landscapes appears successful and should continue.
- Continue to use the composite water sampling design as developed and applied during WY 2015 and 2016 with no further modifications. In the event of a higher rainfall wet season, greater success may even occur at sites influenced by tidal processes since, with more storms to choose

from, there will be a greater likelihood that more storm events will fall within the needed tidal windows.

- In the next progress report, complete and present a final analysis of the statistical potential of the composite, single storm sampling design to return false negative (low or moderate) results. Make recommendations for a procedure to select and resample sites that return lower than expected concentrations or particle ratios.
- While conceivably cheaper and logistically easier to deploy, preliminary results from the remote sampler pilot study show promise as a characterization tool for PCBs, though maybe not for Hg. That said, we recommend continuation of the trial with a focus on collecting samples using the Walling Tube remote suspended sediment samplers to amass a full dataset of eight side-by-side sample pairs for comparison to the composite water column sampling design with the objective of evaluating usefulness and comparability of the data obtained in relation to the management questions.
- Although the Spearman rank analysis did not support the use of other trace metals as good indicators of PCB or Hg sources, the analysis revealed positive and negative correlations that were perplexing and encouraging of further investigation which could be completed in the next technical report.

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Appendices

Appendix A – Quality assurance

The sections below report quality assurance reviews on WY 2015 and 2016 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., 2015). 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. The results for "censored" data were maintained so the impacts of applying different QA protocols can be assessed by a future analyst if desired. Quality assurance (QA) summary tables can be found in this Appendix A in addition to the following narrative.

Suspended Sediment Concentration and Particle Size Distribution

The SSC and particle size distribution (PSD)[14] 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 particle size distribution. Minimum detection limits (MDLs) were generally sufficient, with <20% non-detects reported for SSC and the more abundant Clay and Silt fractions. Extensive non-detects (>50% NDs) 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, as would be expected. 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 RSD for two field blind replicates of SSC were well below the 10% target. Particle size fractions had average relative standard deviation (RSD) ranging from 12% for Silt to 62% for Fine Sand. Although some individual fractions had average percent difference (RPD) or RSDs >40%, suspended sediments in runoff (and particle size distributions within that SSC) can be highly variable even separated by minutes, so results were flagged as estimated values, rather than rejected. Fines (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 non-detects (NDs > 50%) for many of the coarser fractions. No

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[14] Data of particle size was captured for % Clay (<0.0039 mm), % Silt (0.0039 to <0.0625 mm), % V. Fine Sand (0.0625 to <0.125 mm), % Fine Sand (0.125 to <0.25 mm), % Medium Sand (0.25 to <0.5 mm), % Coarse Sand (0.5 to <1.0 mm), % V. Coarse Sand (1.0 to <2.0 mm), and % Granule + Pebble (>2.0 mm). The raw data can be found in appendix B.

method blanks or spiked samples were analyzed/reported, common with SSC and PSD. Precision for PSD 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 MQO. PSD results were similar to other years, dominated by around 80% Fines. Average SSC for whole water samples (excluding those from passive samplers) was in a reasonable range of a few hundred mg/L.

Organic Carbon in Water

Reported TOC and DOC data from EBMUD and ALS were acceptable. 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 non-detects reported for any field samples. TOC was detected in only one method blank (0.026 mg/L), just above the MDL (0.024 mg/L), but the average blank concentration (0.013 mg/L) was still below the MDL, so results were not flagged. Matrix spike samples were used to evaluate accuracy, although many were not spiked at high enough concentrations (at least 2x) the parent sample to evaluate. 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 was therefore qualified but not censored. Lab replicate samples evaluated for precision had 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 (past the specified 100 days). All OC analytes were detected in all field samples and were not detected in method blanks, but DOC was found in filter blanks at 3% the average in field samples. 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 3x higher than 2014 results. DOC and TOC were 55% and 117% of 2016 results, respectively.

PCBs in Water and Sediment

Overall the water (whole water and dissolved) and sediment (separately analyzed particulate) PCB data from AXYS were acceptable. EPA 1668 methods for PCBs recommend analysis within a year, and all samples were analyzed well within that time (maximum 64 days). MDLs were sufficient with no non-detects reported for any of the PCB congeners measured. Some blank contamination was found in method blanks for about 20 of the more abundant congeners, with only two PCB 008 water results censored for blank contamination exceeding 1/3 the concentration in field samples. Many of the same congeners were detected in the field blank, but at concentrations <1% the average found in the field samples. Three target analytes, PCB 105, 118, and 156, and numerous non-RMP 40 congeners were reported in laboratory control samples (LCS) to evaluate accuracy, with good recovery (average error on target compounds always <16%, well within the target MQO of 35%). A laboratory control material (modified NIST 1493) was also reported, with 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 getter. PCB concentrations have not been analyzed in remote sediment sampler sediments for previous POC studies, so no interannual comparisons could be made. PCBs in water samples were similar to previous years (2012-2014) ranging from 0.25x to 3x of 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 non-detects, but extensive non-detects (>50% NDs) were reported for only PCBs 099 and 201 (both 60% NDs). Some blank contamination was found in method blanks, with results for some congeners in field samples censored due to concentrations less than 3x higher than in blanks, especially in dissolved fraction 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 previous years, but total fraction samples were around 1% of those in 2015, possibly due to differences in the stations sampled.

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 non-detects reported for any field samples. Arsenic was detected in one method blank, and mercury in 4 method blanks, but the results were blank corrected, and blank variation was <MDL. No analytes were detected in the field blank. Recoveries in certified reference materials (CRMs) were good, averaging 2% error for mercury up to 5% for zinc, all well below the target MQOs (35% for arsenic and mercury; 25% for all others). Matrix spike and LCS recovery errors all averaged below 10%, well within the accuracy MQOs. Precision was evaluated in lab replicates, except for mercury which was evaluated in certified reference material replicates (no mercury lab replicates were analyzed). RSDs on lab replicates ranged from <1% for zinc up to 4% for arsenic, well within target MQOs (35% for arsenic and mercury; 25% for all the other analytes). Mercury CRM replicate RSD was 1%, also well within the target MQO. Matrix spike and laboratory control sample replicates similarly had average RSDs well within their respective target MQOs. Even including the field heterogeneity from blind field replicates, precision MQOs were easily met. Average concentrations were up to 12 times higher than the average concentrations of 2012-2014 POC water samples, but whole water composite samples were in a similar range as previous years.

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 non-detects (NDs) reported for Cd, Cu, Pb, Hg, and Zn. Around 20% non-detects were reported for As, Ca, Hardness, and Mg, and 56% for Se. Mercury was found in a filter blank, and in one of the three field blanks, but at concentrations <4% of the average in field samples. 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.

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 non-detects for any analytes in field samples. Arsenic was detected in one method blank (0.08 mg/kg dw) just above the MDL (0.06 mg/kg dw), but results were blank corrected and the blank standard deviation was less than the MDL so results were not blank flagged. All other analytes were not detected in method blanks. CRM recoveries showed average errors ranging from 1% for copper to 24% for mercury, all within their target MQOs (35% for arsenic and mercury; 25% for others). Matrix spike and LCS average recoveries were also within target MQOs when spiked at least 2x the native concentrations. Lab replicate RSDs were good, averaging from <1% for zinc to 5% for arsenic, all well within the target MQOs (35% for arsenic and mercury; 25% for others). Matrix spike RSDs were all 5% or less, also well within target MQOs. Average results ranged from 1 to 14 times higher than the average concentrations for the RMP Status and Trend sediment samples (2009-2014), which might be expected Results were reported for Mercury and Total Solids in 1 sediment sample analyzed in 2 lab 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.

Similarly, 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 non-detects 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 lab replicates of the other client samples analyzed by BAL at the same time. 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 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.