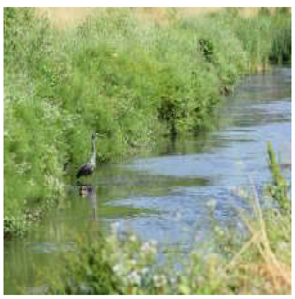
CONTRA COSTA CLEAN WATER PROGRAM

Urban Creeks Monitoring Report:

Water Year 2020

(October 2019 – September 2020)

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

NPDES Permit Nos. CAS612008 and CAS083313

March 31, 2021

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

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Contra Costa Clean Water Program

Urban Creeks Monitoring Report: Water Year 2020

(October 2019 – September 2020)

March 31, 2021

Prepared for

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

Contra Costa Clean Water Program Participants

- Cities 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
- Unincorporated 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
BASMAA	Bay Area Stormwater Management Agencies Association
CCCWP	Contra Costa Clean Water Program
CEDEN	California Environmental Data Exchange Network
CSCI	California Stream Condition Index
CVRWQCB	Central Valley Regional Water Quality Control Board
FSURMP	Fairfield-Suisun Urban Runoff Management Program
MRP	Municipal Regional NPDES Stormwater Permit
NPDES	National Pollutant Discharge Elimination System
PHab	physical habitat
POC	pollutants of concern
P/S Studies	Pilot and Special Studies
QAPP	quality assurance project plan
RMC	Regional Monitoring Coalition
RWQCB	Regional Water Quality Control Board
S&T Program	Status & Trends Monitoring Program
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
SPoT	Stream Pollution Trends
STLS	Small Tributaries Loading Strategy
SWAMP	California Surface Water Ambient Monitoring Program
USGS	United Stated Geological Survey
WY	water year

Table i. Summary of Water Year 2020 Creek Status and Pesticides/Toxicity Monitoring Stations

Station ID	Creek Name	Land Use	Latitude	Longitude	City/Town	Bioassessment PHab Chlorine Nutrients (Wet Weather)	Water Toxicity, and Sediment Toxicity and Chemistry (Dry Weather)	Temperature	Continuous Water Quality	Pathogen Indicator Bacteria
204R02628	West Branch Alamo Creek	Region 2, Urban	37.80674	-121.89896	Blackhawk	X				
204R03163	Moraga Creek	Region 2, Urban	37.83638	-122.13655	Moraga	X		X		
206PNL026	Pinole Creek[1]	Region 2, Urban	37.99233	-122.28403	Pinole			X		
206R01495	Pinole Creek[2]	Region 2, Urban	37.97938	-122.26379	Pinole			X		
206R02560	Refugio Creek	Region 2, Urban	38.00750	-122.26671	Hercules					X
207ALH015	Alhambra Creek	Region 2, Urban	38.01490	-122.13257	Martinez					X
207R01163	San Ramon Creek	Region 2, Urban	37.88757	-122.05563	Walnut Creek					X
207R01547	Grayson Creek	Region 2, Urban	37.98657	-122.06986	Pacheco					X
204R02075	San Ramon Creek	Region 2, Urban	37.86328	-122.03799	Alamo	X				
207R02379	Walnut Creek	Region 2, Urban	37.90617	-122.05698	Walnut Creek	X				
207R02615	Walnut Creek	Region 2, Urban	37.97990	-122.05176	Concord	X X				
207R02884	Sycamore Creek	Region 2, Urban	37.80159	-121.93654	Danville	X				
207R02891	Las Trampas Creek	Region 2, Urban	37.88686	-122.09305	Lafayette	X		X		
			37.88656	-122.09382	Lafayette					X
207R03087	West Fork Sycamore Creek	Region 2, Urban	37.83015	-121.91699	Blackhawk	X				
207R03191	Galindo Creek	Region 2, Urban	37.96182	-122.00580	Concord	X				
207R03435	Donner Creek	Region 2, Non-Urban	37.92031	-121.92677	Clayton	X				
544MSHM0	Marsh Creek[3]	Region 5, Urban	37.99046	-121.69599	Oakley				X	
544MSHM2	Marsh Creek[4]	Region 5, Urban	37.96268	-121.68785	Brentwood				X	

1 Downstream deployment location
2 Upstream deployment location
3 Monitoring station downstream of Brentwood wastewater treatment plant discharge
4 Monitoring station upstream of Brentwood wastewater treatment plant discharge

Preface

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 Municipal Regional Stormwater Permit (MRP). The RMC includes the following stormwater program participants:

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

In accordance with the BASMAA RMC multi-year work plan (Work Plan) (BASMAA, 2011) and the creek status and long-term trends monitoring plan (BASMAA, 2012), monitoring data were collected in accordance with the BASMAA RMC quality assurance project plan (QAPP) (BASMAA, 2020) and the BASMAA RMC standard operating procedures (SOPs) (BASMAA, 2016). Where applicable, monitoring data were derived using methods comparable with methods specified by the California Surface Water Ambient Monitoring Program (SWAMP) QAPP. Data presented in this report were also submitted in electronic SWAMP-comparable formats to Moss Landing Marine Laboratory for transmittal to the Regional Water Quality Control Board on behalf of the CCCWP permittees and pursuant to the MRP Provision C.8.h.ii requirements for electronic data reporting.

This Urban Creeks Monitoring Report complies with MRP Provision C.8.h.iii for reporting of all data in water year 2020 (Oct. 1, 2019-Sept. 30, 2020). Data were collected pursuant to Provision C.8 of the MRP. Data presented in this report were produced under the direction of the RMC and the Contra Costa Clean Water Program (CCCWP) using regional/probabilistic and local/targeted monitoring designs as described herein.

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1 Introduction

This Urban Creeks Monitoring Report (UCMR) was prepared by the Contra Costa Clean Water Program (CCCWP) on behalf of its 21 member agencies (19 cities/towns, County of Contra Costa, and Contra Costa County Flood Control and Water Conservation District). CCCWP gathers and reports monitoring data to help its program members comply with the Municipal Regional Stormwater National Pollutant Discharge Elimination System (NPDES) Permit (MRP). This UCMR and its appendices present monitoring data through statistical and graphical analysis and summarizes results to understand creek health in Contra Costa County.

As Contra Costa County lies within both the Region 2 and Region 5 jurisdictions of the State Water Resources Control Board (Figure 1), the countywide stormwater program is subject to permit requirements of each jurisdiction. Municipal stormwater discharges in Contra Costa County are regulated by the requirements of the MRP in Region 2 (Order No. R2-2015-0049)[1] and the East Contra Costa County MRP (Central Valley Permit) in Region 5 (Order No. R5-2010-0102)[2]. Prior to the reissuance of MRP Order No. R2-2015-0049, the requirements of the two permits were effectively identical. With the reissued MRP in 2015, some differences between the permits led to an agreement between the Central Valley and San Francisco Bay Regional Water Quality Control Boards, where sites in the Central Valley Region (Region 5) will continue to be sampled as part of the creek status monitoring provision required by both permits, with monitoring and reporting requirements prevailing under the jurisdiction of the Region 2 MRP (Order No. R2-2019-0004)[3].

This report, including all appendices and attachments, fulfills the requirements of MRP Provision C.8.h.iii for interpreting and reporting monitoring data collected during water year (WY) 2020 (Oct. 1, 2019-Sept. 30, 2020). All monitoring data presented in this report were submitted electronically to the Water Boards by CCCWP (Attachment A). Data collected from receiving waters may be obtained via the California Environmental Data Exchange Network (CEDEN) website. Information on how this data may be obtained is available at http://www.ceden.org/find_data_page.shtml. This site contains information related to data retrieval from the CEDEN Query Tool, the California State Open Data Portal, and the Tableau Public Visualization Tool.

This report is organized by the sub-provisions of MRP Provision C.8, as follows:

1. Compliance Options (MRP Provision C.8.a), Monitoring Protocols and Data Quality (MRP Provision C.8.b)
2. San Francisco Estuary Receiving Water Monitoring (MRP Provision C.8.c)
3. Creek Status Monitoring (MRP Provision C.8.d) and Pesticides and Toxicity Monitoring (MRP Provision C.8.g) (Appendices 1 and 2)
4. Pollutants of Concern Monitoring (MRP Provision C.8.f) (Appendices 3 and 4)

[1] The 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 Nov. 19, 2015 (SFBRWQCB, 2015a). 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 CVRWQCB issued the East Contra Costa County municipal NPDES permit (Central Valley Permit, Order No. R5-2010-0102) on Sept. 23, 2010 (CVRWQCB, 2010). This permit is now superseded by Order R2-2019-0004, incorporating the eastern portion of Contra Costa County within the requirements of the MRP (Order No. R2-2015-0049).

[3] The SFBRWQCB, per agreement with the CVRWQCB, adopted Order No. R2-2019-004 on Feb. 13, 2019.

Figure 2 maps the locations of CCCWP monitoring stations associated with Provision C.8 compliance in WY 2020, including creek status, pesticides and toxicity, and pollutants of concern (POC) monitoring studies.

Monitoring discussed herein was performed in accordance with the requirements of the MRP. Key technical findings, detailed methods and results associated with these reports are summarized and provided in the respective appendices, as referenced within the applicable sections of the main body of this report.

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

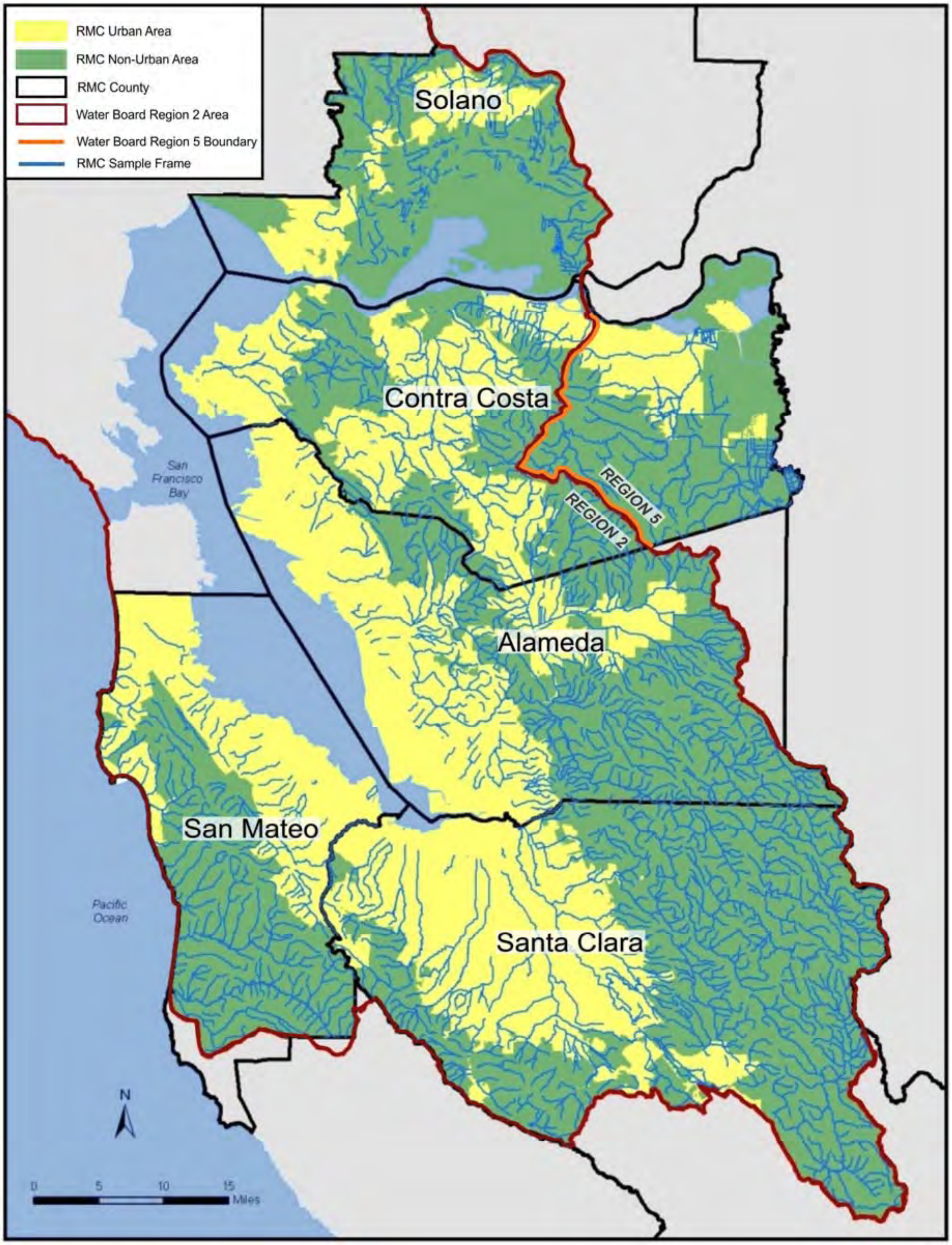
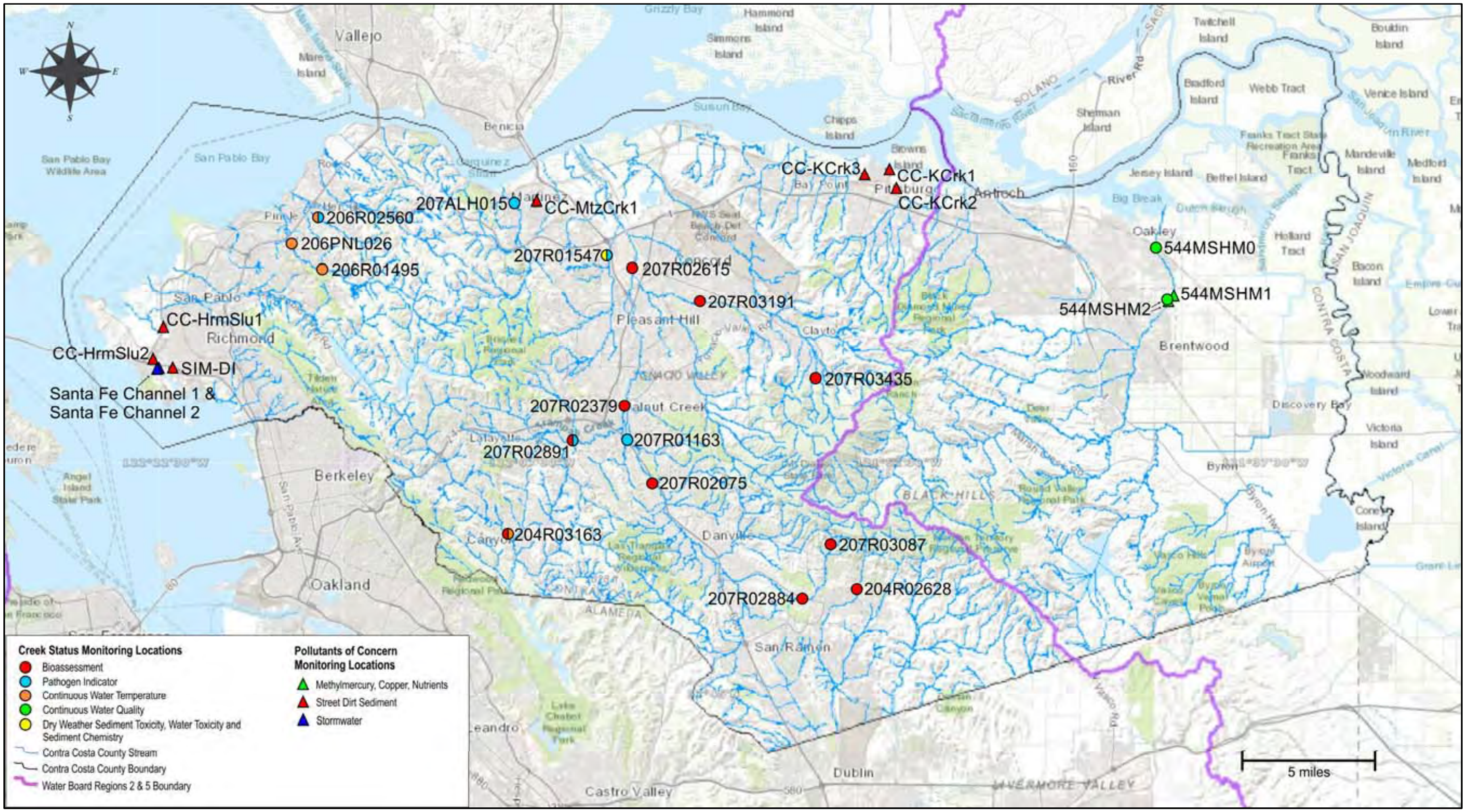


Figure 2. Creek Status and Pollutants of Concern Monitoring Stations in WY 2020



1.1 Regional Monitoring Coalition (RMC) Overview

In early 2010, CCCWP joined with several other members of the Bay Area Stormwater Management Agencies Association (BASMAA) to participate in a regional collaborative effort to coordinate water quality monitoring required by the MRP. BASMAA is a 501(c)(3) nonprofit organization comprised of the municipal stormwater programs in the San Francisco Bay Area. The resulting regional monitoring collaborative is called the BASMAA Regional Monitoring Coalition (RMC). Details of the respective RMC stormwater program participants and their co-permittees are presented in Table 1.

Table 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

In June 2010, the permittees notified the Water Board in writing of their agreement to participate in the RMC to collaboratively address creek status and related monitoring requirements in MRP Provision C.8. The RMC's goals are to:

- Assist permittees in complying with the requirements of MRP Provision C.8 (Water Quality Monitoring)
- Develop and implement regionally consistent creek monitoring approaches and designs in the Bay Area through the improved coordination among RMC participants and other agencies such as the Regional Water Quality Control Board (RWQCB), that share common goals
- Stabilize the costs of creek monitoring by reducing duplication of effort (e.g., development of quality assurance project plans)

In February 2011, the RMC developed a multi-year work plan (RMC Work Plan; BASMAA, 2011) to provide a framework for implementing regional monitoring and assessment activities required under MRP Provision C.8. The RMC Work Plan summarized RMC-related projects planned for implementation between fiscal years 2009-2010 and 2014-2015. Projects were collectively developed by RMC representatives to the BASMAA Monitoring and Pollutants of Concern Committee and were conceptually agreed to by the BASMAA Board of Directors.

Based on the requirements described in Provision C.8 of the original MRP (2009), a total of 27 regional projects were identified in the RMC Work Plan. Regionally implemented activities to provide standardization and coordination for the RMC Work Plan were conducted under the auspices of BASMAA. Scopes, budgets, and contracting 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 or tasks. Regional project costs are shared by either all BASMAA members or among those Phase I municipal stormwater programs that are subject to the MRP. CCCWP and other RMC participants coordinate their monitoring activities through meetings and communications of the RMC work groups and the BASMAA Monitoring and Pollutants of Concern Committee.

1.2 Compliance Options (C.8.a)

Provision C.8.a (Compliance Options) of the MRP allows the Permittees to comply with all monitoring requirements by contributing to their countywide stormwater program, through regional collaboration or by using data collected by a third party. The primary means for regional collaboration on Creek Status Monitoring is the RMC, which coordinates member programs on monitoring needs, including:

- Shared standard operating procedures
- Shared quality assurance project plans (QAPPs)
- Site selection and number of sites per program
- Timing of sampling events
- Data quality assurance and quality control procedures
- Database management

The main benefit of the RMC to the CCCWP Permittees is assurance that final results meet Water Board expectations for data content and quality. The MRP defines the type, amount and frequency of monitoring; however, many details of execution require operator judgements (e.g., how to screen bioassessment sites or what are acceptable data quality objectives). Discussion at the RMC provides a single point of communication and common documentation to align the details across programs and allow the Water Board to comment on approach. The RMC is likely cost-neutral, in that the staff time and consultant support necessary to collaborate is offset by the cost efficiencies achieved by sharing methods and documents.

CCCWP works with third-party water quality monitoring partners to benefit local, regional, and statewide monitoring efforts. Provision C.8.a.iii allows permittees to work with third-party organizations such as the SFBRWQCB, CVRWQCB, State Water Resources Control Board, or California Department of Pesticide Regulation to fulfill monitoring requirements if data meets water quality objectives described in Provision C.8.b. Monitoring locations in Contra Costa County are sampled in a manner to be comparable to the protocols of the state's Surface Water Ambient Monitoring Program (SWAMP) and assessed for pesticide pollution and toxicity through the Stream Pollution Trends (SPoT) Program (Phillips, B.M., et al, 2016). SPoT monitors status and trends in sediment toxicity and sediment contaminant concentrations in selected large rivers throughout California and relates contaminant concentrations and toxicity test results to watershed land uses.

CCCWP staff and other designated representatives participate with the Small Tributaries Loading Strategy (STLS) program (SFEI, 2013) of the Regional Monitoring Program for Water Quality in San Francisco Bay (RMP) to conduct pollutants of concern monitoring at Contra Costa sites, as further described in Section 4.

In addition, CCCWP supports efforts by local creek groups to monitor San Pablo, Wildcat, Walnut, Grayson, and Marsh Creek Watersheds.

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

Provision C.8.b of the MRP requires water quality data collected by the Permittees to comply with and be of a quality consistent with the State of California's SWAMP standards, set forth in the SWAMP quality assurance project plan (QAPP) and SOPs. RMC protocols and procedures were developed to assist permittees with meeting SWAMP data quality standards and to develop data management systems which allow for easy access to water quality monitoring data by Permittees.

1.3.1 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 produce SWAMP-comparable, high quality data among RMC participants[4]. The RMC creek status monitoring program SOP and QAPPs were updated to accommodate MRP 2.0 requirements in March 2016 (Version 3; BASMAA, 2016) and January 2020 (Version 4; BASMAA, 2020a), respectively.

For POC monitoring, a sampling analysis plan (SAP; ADH and AMS, 2020a) and QAPP (ADH and AMS, 2020b) were developed in 2016 and finalized in 2020 to guide the monitoring efforts for each POC task.

1.3.2 Information Management System Development/Adaptation

Permittees are required to report annually on water quality data collected in compliance with the MRP. To facilitate data management and transmittal, the RMC participants developed an Information Management System (IMS) to provide SWAMP-compatible storage and import/export of data for all RMC programs, with data formatted in a manner suitable for uploading to CEDEN.

BASMAA subsequently supplemented the IMS to accommodate management of POC data collected by the RMC programs. The expanded 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.

[4] Further details on SWAMP comparability are available at https://www.waterboards.ca.gov/water_issues/programs/quality_assurance/comparability.html

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

CCCWP contributes to the RMP, specifically the Status & Trends Monitoring Program (S&T Program) and the Pilot and Special Studies (P/S Studies). These efforts provide useful tools for CCCWP. Brief descriptions of the S&T Program and P/S Studies are provided below.

As described in MRP Provision C.8.c, Permittees are required to conduct or cause to be conducted receiving water monitoring in the Bay. Permittees comply with this provision by making financial contributions through the CCCWP to the San Francisco Bay RMP. Additionally, Permittees actively participate in RMP committees and work groups through Permittee and/or stormwater program representatives.

The Sacramento-San Joaquin River Delta (Delta) Regional Monitoring Program serves a similar function in fulfilling receiving water monitoring requirements for dischargers located within the jurisdiction of the Central Valley Regional Water Quality Control Board (CVRWQCB). Some CCCWP Permittees (the cities of Brentwood, Antioch, and Oakley, and portions of unincorporated Contra Costa County and the Contra Costa County Flood Control District) are located within the CVRWQCB's jurisdiction; however, by agreement with the SFRWQCB and the CVRWQCB, those Permittees also meet receiving water monitoring requirements through funding the San Francisco Bay RMP. This is consistent with the historic approach of managing the entire countywide program as a single, integrated program.

The RMP is a long-term, discharger-funded monitoring program directed by a steering committee and represented by regulatory agencies and the regulated community. In addition to regulators and the regulated community, the RMP Technical Committee includes participation by a local a non-governmental organization that specializes in water quality in the Bay. The goal of the RMP is to assess 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 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.

2.1 RMP Status and Trends Monitoring Program

The S&T Program is the long-term contaminant monitoring component of the RMP. The S&T Program was initiated as a pilot study in 1989 and was redesigned in 2007 based on a more rigorous statistical design aimed at enabling the detection of trends. The S&T Program is comprised of the following program elements:

- Long-term water, sediment and bivalve monitoring
- Episodic toxicity monitoring
- Sport fishing monitoring
- USGS hydrographic and sediment transport studies
- Factors controlling suspended sediment in San Francisco Bay
- USGS monthly water quality data
- Triennial bird egg monitoring (cormorant and tern)

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

2.2 RMP Pilot and Special Studies

The RMP conducts pilot and special studies on an annual basis through committees, workgroups and strategy teams. Studies usually are designed to investigate and develop new monitoring measures related to anthropogenic contamination or contaminant effects on biota in the estuary. Special studies address specific scientific issues that RMP committees and standing workgroups identify as priority for further study. These studies are developed through an open selection process at the workgroup level and are selected for further funding through RMP committees. Results and summaries of the most pertinent pilot and special studies can be found on the RMP web site (http://www.sfei.org/rmp).

2.3 Participation in Committees, Workgroups and Strategy Teams

CCCWP and/or other BASMAA representatives participate in the following RMP committees and workgroups:

- Steering Committee
- Technical Review Committee
- Sources, Pathways and Loadings Workgroup
- Emergent Contaminant Workgroup
- Nutrient Technical Workgroup
- Strategy teams (e.g., Small Tributaries, PCBs)

Committee and workgroup representation are provided by CCCWP, other stormwater program staff, and/or individuals designated by RMC participants. Representation includes participation in meetings, review of technical reports and work products, co-authoring or review of articles included in the RMP's annual publication *Pulse of the Estuary*, and general program direction to RMP staff. Representatives of the RMP also provide timely summaries and updates to and receive input from BASMAA stormwater program representatives (on behalf of the Permittees) during workgroup meetings to ensure the Permittees' interests are represented.

3 Creek Status Monitoring (C.8.d and C.8.g)

This section presents a summary of Creek Status Monitoring and Pesticides and Toxicity Monitoring conducted in compliance with Provision C.8.d and C.8.g of the MRP. After an overview of the monitoring management questions, strategy, and regional collaboration presented below, Section 3.1 describes the approach to regional/probabilistic creek status monitoring, Section 3.2 describes the approach to local/targeted creek status monitoring, and section 3.3 presents the approach to pesticide and toxicity monitoring.

The MRP requires Permittees to conduct creek status and pesticides and toxicity monitoring to assess the chemical, physical, and biological impacts of urban runoff on receiving waters, and 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 the MRP. Creek Status Monitoring, coordinated through the RMC, began in October 2011 and continues annually. Status and trends monitoring was conducted in non-tidally influenced, flowing water bodies (i.e., creeks, streams, and rivers).

The RMC's strategy for creek status monitoring is described in the Creek Status and Long-Term Trends Monitoring Plan (BASMAA, 2011). The monitoring methods follow the protocols described in the updated BASMAA RMC QAPP (Version 4; BASMAA, 2020) and SOPs for creek status and pesticides and toxicity monitoring (Version 3; BASMAA, 2016b). The purpose of these documents 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.

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 2 for the required monitoring parameters. The combination of these monitoring designs allows each 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 conditions in urban and non-urban creeks).

The RMC monitoring strategy for complying with MRP 2.0 requirements includes continuing a regional ambient/probabilistic monitoring component, and a component based on local/targeted monitoring, as in the previous permit term. The analysis of results from the two creek status monitoring components conducted in WY 2020 is presented in Appendix 1 and Appendix 2, respectively, and a summary of the monitoring stations is shown in Table i.

Creek status monitoring data for each water year are submitted annually by the CCCWP to the SFBRWQCB and CVRWQCB by March 31 of the following year.

Table 2. Creek Status Monitoring Elements per MRP Provisions C.8.d. and C.8.g., Monitored as Either Regional/Probabilistic or Local/Targeted Parameters

Bioassessment, physical habitat assessment, CSCI	X	X[1]
Nutrients (and other water chemistry associated with bioassessment)	X	X[1]
Chlorine	X	X[2]
Water toxicity (wet and dry weather)	NA	NA
Water chemistry (pesticides, wet weather)	NA	NA
Sediment toxicity (dry weather)	NA	NA
Sediment chemistry (dry weather)	NA	NA
Continuous water quality (sondes data: temperature, dissolved oxygen, pH, specific conductance)		X
Continuous water temperature (data loggers)		X
Pathogen indicators (bacteria)		X

CSCI California Stream Condition Index
1 Provision C.8.d.i.(6) allows for up to 20 percent of sample locations to be selected under a targeted monitoring design. This design change was made under MRP Order No. R2-2015-0049.
2 Provision C.8.d.ii.(2) provides options for probabilistic or targeted site selection. In water year 2020, chlorine was measured at probabilistic sites.
NA Monitoring parameter not specific to either monitoring design

3.1 Regional/Probabilistic Monitoring

The regional/probabilistic creek status monitoring report (Appendix 1) documents the results of monitoring performed by CCCWP during WY 2020 under the regional/probabilistic monitoring design developed by the RMC. During each water year, 10 sites are monitored by CCCWP for bioassessment, physical habitat, and related water chemistry parameters. To date, 90 sites have been sampled since the inception of the program in water year 2012.

RMC probabilistic monitoring sites are drawn from a sample frame consisting of a creek network geographic information system (GIS) data set within the RMC boundary[5] (BASMAA, 2011), including stream segments from 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. The sites selected from the regional/probabilistic design master sample draw and monitored in WY 2020 are shown graphically in Figure 2.

The probabilistic design required several years to produce sufficient data to develop a statistically robust characterization of regional creek conditions. BASMAA conducted a regional project to analyze bioassessment monitoring data collected during a five-year period (2012-2016), (BASMAA, 2019). That analysis can be used to help inform recommendations for potential changes to the monitoring program.

[5] 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.

The project has also developed a fact sheet presenting the report findings in a format accessible to a broad audience.

Per MRP 2.0 Provisions C.8.d. and C.8.g., the creek status monitoring results are subject to potential follow-up actions 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 SSID projects, per MRP Provision C.8.e. The results are compared to other regulatory standards, including the Basin Plan (SFBRWQCB, 2019) water quality objectives where available and applicable.

3.2 Local/Targeted Monitoring

The Local/Targeted Creek Status Monitoring Report (Appendix 2) documents the results of targeted monitoring performed by CCCWP during water year 2020. Within Contra Costa County, targeted monitoring is conducted annually at:

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

Site locations are identified using a targeted monitoring design based on the directed principle to address the following management questions:

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

Targeted monitoring data are evaluated against MRP threshold triggers, to assess the potential need for follow-up. The results of water year 2020 monitoring are summarized in Appendix 2.

3.3 Toxicity, Pesticides and Other Pollutants in Sediment – Dry Weather (C.8.g)

Once per year during the dry season (July 1 through Sept. 30), sediment samples are collected and tested for toxicity to several different aquatic species, as required by MRP 2.0. Sampling is conducted at a site selected from the probabilistic design for bioassessment monitoring, or at a site targeted to address management questions.

Concurrent with the sediment toxicity sampling described above, sediment chemistry samples are collected for analysis of a select list of pesticides, polycyclic aromatic hydrocarbons, trace elements, total organic carbon and grain size. All sediment analytical chemistry (pesticides and other pollutants), grain size analysis and toxicity test results are presented in Appendix 1.

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

POC 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.

POC monitoring addresses five priority information management needs:

1. Source Identification – identifying which sources or watershed source areas provide the greatest opportunities for reductions of POCs in urban stormwater runoff.

2. Contributions to Bay Impairment – identifying which watershed source areas contribute most to the impairment of San Francisco Bay beneficial uses (due to source intensity and sensitivity of discharge location).

3. Management Action Effectiveness – providing support for planning future management actions or evaluating the effectiveness or impacts of existing management actions.

4. Loads and Status – providing information on POC loads, concentrations, and presence in local tributaries or urban stormwater discharges.

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

Monitoring in WY 2020 continued the effort toward addressing these information needs as discussed below. Table 3 presents a summary of WY 2020 POCs monitoring locations.

4.1 Source Identification and Contribution to Bay Impairment

In WY 2020, CCCWP conducted source area assessments to investigate high interest parcels and areas for consideration of property referrals and focused implementation planning for PCBs and mercury load reductions. Street dirt, drop inlet sediments and stormwater runoff were sampled at locations throughout Contra Costa County as shown in Figure 2. These monitoring activities address source identification and contributions to Bay impairment. Additionally, stormwater monitoring was conducted in targeted locations for copper, nutrients, mercury and methylmercury (Figure 2). A summary report of these data is presented in the Pollutants of Concern Monitoring Report: Water Year 2020 (Appendix 3).

4.2 Loads, Status and Trends

MRP 2.0 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 sites). To support this focus, a stormwater reconnaissance monitoring program was developed and implemented beginning in water year 2015 by the RMP through the STLS workgroup. In WY 2020, two stormwater sampling locations within Contra Costa County were monitored for PCBs and mercury by the RMP. These monitoring results are summarized in the RMP Pollutants of Concern Reconnaissance Monitoring Progress Report, Water Years 2015-2020 (Appendix 4). The content of that report addresses loads and status as well as trends of POC loads.

Table 3. Summary of Water Year 2020 Pollutants of Concern Monitoring Stations

Station ID	Receiving Water Body	Land Use	Latitude	Longitude	City/Town	Street Dirt Sediment	Methyl Mercury, Copper, and Nutrients	Stormwater
544MSHM1	Marsh Creek	Region 5, Urban	37.96390	-121.68375	Brentwood		X	
544MSHM2[a]	Marsh Creek	Region 5, Urban	37.96265	-121.68803	Brentwood		X	
CC-HrmSlu1	Herman Slough	Region 2, Urban	37.94710	-122.37199	Richmond	X		
CC-HrmSlu2	Herman Slough	Region 2, Urban	37.92998	-122.37949	Richmond	X		
CC-KCrk1	Kirker Creek	Region 2, Urban	38.03206	-121.87733	Pittsburg	X		
CC-KCrk2	Kirker Creek	Region 2, Urban	38.02149	-121.87229	Pittsburg	X		
CC-KCrk3	Willow Creek	Region 2, Urban	38.02937	-121.89430	Pittsburg	X		
CC-MtzCrk1	Martinez Creek	Region 2, Urban	38.01486	-122.11778	Martinez	X		
Santa Fe Channel 1[b]	Santa Fe Channel	Region 2, Urban	37.92458	-122.37600	Richmond			X
Santa Fe Channel 2[b]	Santa Fe Channel	Region 2, Urban	37.92460	-122.37597	Richmond			X
SIM-DI	Lauritzen Canal	Region 2, Urban	37.92516	-122.36614	Richmond			X

a Sampling location is five meters downstream from Creek Status Monitoring Station 544MSHM2
b Sampling conducted by the RMP under the STLS Workgroup's POCs Reconnaissance Monitoring Program
STLS Small Tributaries Loading Strategy

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Appendix 1

Regional/Probabilistic Creek Status Monitoring Report:

Water Year 2020

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Contra Costa Clean Water Program

Regional/Probabilistic Creek Status Monitoring Report: Water Year 2020

(October 2019-September 2020)

March 31, 2021

Submitted to

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

Submitted by

Armand Ruby Consulting
2441 Rifle Range Drive
Royal Oaks, CA 95076

and

ADH Environmental
3065 Porter Street, Suite 101
Soquel, California 95073

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Contra Costa Clean Water Program

Regional/Probabilistic Creek Status Monitoring Report: Water Year 2020

(October 2019-September 2020)

March 31, 2021

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List of Acronyms and Abbreviations

ACCWP	Alameda Countywide Clean Water Program
AFDM	ash-free dry mass
A-IBI	algal index of biological integrity
ASCI	Algal Stream Condition Index
Basin Plan	common term for the San Francisco Bay 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
Central Valley Permit	East Contra Costa County Municipal NPDES Permit
cm	centimeter
CSCI	California Stream Condition Index
CVRWQCB	Central Valley Regional Water Quality Control Board
EPT	Ephemeroptera, Plecopter, and Trichoptera
FSURMP	Fairfield-Suisun Urban Runoff Management Program
GIS	geographic information system
GRTS	Generalized Random Tessellated Stratified
IBI	Index of Biological Integrity
IPI	Index of Physical Habitat Integrity
LC_{50}	lethal concentration to 50 percent of test organisms
LCS	laboratory control spike
m	meters
MDL	method detection limit
MMI	multi-metric index
MRP	Municipal Regional Permit
MUN	municipal and domestic water supply
ND	not detected
NPDES	National Pollutant Discharge Elimination System
NT	non-target
O/E	the observed (O) taxonomic diversity at the monitoring site divided by the taxonomic composition expected (E) at a reference site with similar geographical characteristics
PAH	polycyclic aromatic hydrocarbon
PEC	probable effect concentration
PHab	physical habitat assessment
QA/QC	quality assurance/quality control
QAPP	quality assurance project plan
PSA	perennial streams assessment
RL	reporting limit
RMC	Regional Monitoring Coalition
RPD	relative percent difference
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
SSID	stressor/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	toxic unit
U	unknown
UCMR	Urban Creeks Monitoring Report
USEPA	U.S. Environmental Protection Agency
WY	water year

Acknowledgements

This report was prepared by Armand Ruby Consulting, in association with ADH Environmental, under contract to and supervision of the Contra Costa Clean Water Program (CCCWP). The report format and organization are in part derived from the original region-wide Regional Monitoring Coalition (RMC) monitoring report for water year 2012 (Regional Urban Creeks Status Monitoring Report, Appendix A to the Water Year 2012 Urban Creeks Monitoring Report), prepared jointly by EOA, Inc. and Armand Ruby Consulting as a regional project for the RMC participants.

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

The CCCWP Monitoring Committee, facilitated by Khalil Abusaba (Wood Consulting), provided project supervision and review of draft documents. Christian Kocher 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, and graphics production. Marco Sigala of Coastal Conservation and Research in Moss Landing provided algae data analysis and interpretation, and assistance with preparation of watershed GIS information and other metrics used in computation of CSCI scores and IPI scores.

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Preface

The Regional Monitoring Coalition of the Bay Area Stormwater Management Agencies Association developed a probabilistic design for regional characterization of selected creek status monitoring parameters. The Regional Monitoring Coalition is comprised of the following program participants:

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

This report fulfills reporting requirements for the portion of the regional/probabilistic creek status monitoring data generated within Contra Costa County during water year 2020 (Oct. 1, 2019-Sept. 30, 2020) through the Regional Monitoring Coalition's probabilistic design for certain parameters monitored per the Municipal Regional Stormwater Permit, provisions C.8.d and C.8.g. This report is an appendix to the Contra Costa Clean Water Program's Urban Creeks Monitoring Report for water year 2020, and complements similar reports submitted by each of the other participating Regional Monitoring Coalition programs on behalf of their respective permittees.

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Executive Summary

This report documents the results of monitoring performed by Contra Costa Clean Water Program (CCCWP) during water year (WY) 2020 (Oct. 1, 2019-Sept. 30, 2020), for parameters originally covered under the regional/probabilistic monitoring design developed by the Regional Monitoring Coalition (RMC).

Other creek status monitoring parameters were addressed using a targeted design, with regional coordination and common methodologies. Together with the creek status monitoring data reported in the local/targeted creek status monitoring report for WY 2020 (ADH, 2021), 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 (SFBRWQCB; Order No. R2-2015-0049), as amended by Order No. R2-2019-0004, incorporating the eastern portion of Contra Costa County within the requirements of the MRP.

The probabilistic design requires several years to produce sufficient data to develop a statistically robust characterization of regional creek conditions. The Bay Area Stormwater Management Agencies Association (BASMAA) conducted a regional project involving analysis of bioassessment monitoring data collected during a five-year period (water years 2012-2016) by the RMC programs (BASMAA, 2019).

Summary of Water Year 2020 Creek Status Monitoring: Regional/Probabilistic Parameters

During WY 2020, 10 sites were monitored by CCCWP under the RMC regional/probabilistic design for bioassessment, physical habitat, and water chemistry parameters. One site also was monitored for water and sediment toxicity and sediment chemistry.

The bioassessment and related data are used to develop a preliminary condition assessment for the monitored sites. The water and sediment chemistry and toxicity data are used in conjunction with physical habitat data to evaluate potential stressors which may affect aquatic habitat quality and beneficial uses. Various metrics and indices are also computed to aid in the condition assessment and stressor analysis.

Biological Conditions

California Stream Condition Index (CSCI) scores have been calculated from the CCCWP bioassessment data since WY 2016. The CSCI uses location-specific GIS data to compare the observed benthic macroinvertebrate (BMI) taxonomic data to expected BMI assemblage characteristics from reference sites with similar geographical characteristics.

Every CCCWP bioassessment site monitored in WY 2020 produced a CSCI score below the MRP threshold of 0.795, indicating a degraded biological community relative to reference conditions. These sites consequently may be listed as potential candidates for SSID (stressor/source identification) studies.

The WY 2020 CSCI scores ranged from a low of 0.274 at Galindo Creek (207R03191) to a high of 0.606 at Donner Creek (207R03435). The Donner Creek site (207R03435) was in an area of non-urban land use, located in Mount Diablo State Park.

Algae Stream Condition Index (ASCI) scores were calculated for CCCWP bioassessment sites again in WY 2020. Except for the Donner Creek site (207R03435), which scored Possibly Altered on the hybrid MMI (multi-metric index), all sites scored either Likely Altered or Very Likely Altered on the diatoms MMI and hybrid MMI ASCI metrics. The Donner Creek site (207R03435) was in an area of non-urban land use.

Based on both the BMI and algal community indices, the biological community conditions of all CCCWP sites monitored in 2020 can be considered to be impacted.

The Grayson Creek water and sediment samples collected on July 22, 2020 were determined not to be toxic to any of the test species.

Based on an analysis of the regional/probabilistic data collected by CCCWP during WY 2020, the stressor analysis is summarized as follows.

Physical Habitat (PHab) Conditions

Index of Physical Habitat Integrity (IPI) scores were again calculated from the PHab data compiled during the spring 2020 bioassessment monitoring. Three sites were rated as Likely Intact: Moraga Creek, Walnut Creek (207R02615), and Donner Creek, while only one (Walnut Creek, 207R02379) ranked as Very Likely Altered. All other sites were ranked as Possibly Altered or Likely Altered.

For the 2020 analysis, the principal benthic invertebrate community index (CSCI) did not correlate well with either of the ASCI MMIs or the IPI.

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). Two of the results generated at the 10 sites monitored for un-ionized ammonia during WY 2020 exceeded the applicable water quality standard; all WY 2020 chloride and nitrate+nitrite results met the applicable standards.

The causes of the unexpectedly elevated ammonia results are unknown; this has occurred in prior years. A review of data and communication with RMC members shows that elevated ammonia concentrations began to occur in 2018, after a method change for ammonia analysis was initiated. To address this, CCCWP will consider analyzing ammonia samples using both the old and new methods until this issue is resolved through regional or statewide guidance.

Water Toxicity

The Grayson Creek dry weather water sample was not determined to be toxic to any of the four test species.

Sediment Toxicity

The Grayson Creek sediment sample was not determined to be toxic to either *Chironomus dilutus* or *Hyalella azteca*.

Sediment Chemistry

Several of the common urban pyrethroid pesticides were detected at the WY 2020 sediment monitoring site (Grayson Creek, 207R01547); as is typical, bifenthrin was detected at the highest concentration. The calculated toxic unit equivalent of 0.55 for the combined pyrethroid concentrations is less than that normally required to cause toxicity to either *Chironomus dilutus* or *Hyalella azteca* in the sediment toxicity testing.

The most notable result of the sediment chemistry testing is the detection of 10 PAH compounds, including pyrene at a concentration sufficient to produce a calculated TEC ratio >1.

Sediment Triad Analyses

Bioassessment, sediment toxicity, and sediment chemistry results from WY 2020 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 2012-2020. Good correlation is observed throughout that period in the triad analysis between pyrethroid concentrations with toxic unit (TU) $\geq$1 and sediment toxicity.

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 generally did not exhibit sediment toxicity, as shown in Table 4.16 (the 2018 sample being the exception, as the calculated TU equivalent was 0.95, and toxicity was observed to *Hyalella azteca* in the sediment sample).

Based on the results of the past nine years, chemical stressors, particularly pesticides, may be contributing to the degraded biological conditions indicated by the low B-IBI (benthic index of biological integrity) scores in many of the monitored streams. Atypically, the principal stressors identified in the chemical analyses from the 2020 monitoring are PAHs.

Comparisons to Conclusions of the Comprehensive Integrated Monitoring Report (IMR) Multi-Year Analysis

The multi-year analysis of regional/probabilistic parameters included within the WY 2019 Integrated Monitoring Report (IMR) produced the following conclusions:

- Biological conditions in Contra Costa County urban creeks are generally impacted, as indicated by analysis of bioassessment results from 76 monitoring sites over the course of eight years, 2012-2019. Physical habitat factors play a significant role in degradation of in-stream biota, with water quality factors (e.g., dissolved oxygen, temperature, pH, conductivity) and antecedent rainfall also contributing to in-stream conditions.

- Factors that have a positive influence on in-stream biological conditions for BMI and algae include higher percentages of fast water within the reach, higher percentages of coarse gravel, and higher diversity of natural substrate types.

- Factors that tend to negatively impact in-stream biota include higher percentages of fines or substrate smaller than sand, higher percentages of slow water in the reach, and elevated chloride or conductivity.

- Algae assemblages tend to benefit from higher antecedent rainfall in the 60- to 90-day range and are negatively impacted by elevated temperatures.

- Throughout the study period, sediment toxicity and occasional water toxicity are chronic occurrences, with toxicity typically attributable to the presence of pyrethroid and sometimes other pesticides, including the recent presence of fipronil and imidacloprid.

These findings are supported in the WY 2020 analysis with respect to biological conditions, although toxicity was not observed in the WY 2020 dry weather water or sediment monitoring. The one WY 2020 bioassessment site located in an area of non-urban land use (Donner Creek, 207R03435) generally scored better on the biological condition and physical habitat metrics than the sites located in urban watersheds.

1 Introduction

This report documents the results of monitoring performed by Contra Costa Clean Water Program (CCCWP) during water year (WY) 2020 (Oct. 1, 2019-Sept. 30, 2020), for parameters originally covered under the regional/probabilistic monitoring design developed by the Regional Monitoring Coalition (RMC). Other creek status monitoring parameters were addressed using a targeted design, with regional coordination and common methodologies. Together with the creek status monitoring data reported in the local/targeted creek status monitoring report for WY 2020 (ADH, 2021), 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 (SFBRWQCB; Order No. R2-2015-0049), as amended by Order No. R2-2019-0004, incorporating the eastern portion of Contra Costa County within the requirements of the MRP.

1.1 Regulatory Context

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 previously were regulated by the requirements of two National Pollutant Discharge Elimination System (NPDES) stormwater permits: the 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]).

Prior to the reissuance of the MRP in 2015, the requirements of the two permits were effectively identical. With the reissued MRP, there were some differences between the MRP and the Central Valley Permit, although in most respects the creek status monitoring and reporting requirements remained similar. For this report, the creek status monitoring and reporting requirements specified in the reissued MRP are considered the prevailing requirements. Sites in the Central Valley Region have been monitored as part of the creek status monitoring required by both permits. Per agreement between the Central Valley and San Francisco Regional Water Quality Control Boards on Feb. 13, 2019, the SFBRWQCB adopted Order No. R2-2019-0004, to include the eastern portion of Contra Costa County under the jurisdiction of the MRP, rendering the Central Valley Permit obsolete for the purposes of this report.

CCCWP conducted extensive bioassessment monitoring prior to the adoption of the original MRP (SFBRWQCB, 2009). Summaries of those 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).

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[1] The San Francisco Bay Regional Water Quality Control Board adopted the reissued Municipal Regional Stormwater NPDES Permit (Order No. R2-2015-0049) to 76 cities, counties and flood control districts (i.e., permittees) in the Bay Area on Nov. 19, 2015 (SFBRWQCB, 2015), effective Jan. 1, 2016. The Bay Area Stormwater Management Agencies Association (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 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 issued the East Contra Costa County Municipal NPDES Permit (Order No. R5-2010-0102) on Sept. 23, 2010 (CVRWQCB, 2010). This Order was superseded by Order No. R2-2019-0004, incorporating the eastern portion of Contra Costa County within the requirements of the MRP, Order No. R2-2015-0049, on Feb. 13, 2019.

1.2 Regional Monitoring Coalition

The regional/probabilistic design was developed and implemented by the Regional Monitoring Coalition of 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 representing MRP permittees (Table 1.1), to implement the creek status monitoring requirements of the MRP through a regionally coordinated effort.

Table 1.1 Regional Monitoring Coalition (RMC) Participants

Stormwater Programs	RMC Participants
Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP)	Cities of Campbell, Cupertino, Los Altos, Milpitas, Monte Sereno, Mountain View, Palo Alto, San Jose, Santa Clara, Saratoga, Sunnyvale, Los Altos Hills, and Los Gatos; Santa Clara Valley Water District; and Santa Clara County
Alameda Countywide Clean Water Program (ACCWP)	Cities of Alameda, Albany, Berkeley, Dublin, Emeryville, Fremont, Hayward, Livermore, Newark, Oakland, Piedmont, Pleasanton, San Leandro, and Union City; Alameda County; Alameda County Flood Control and Water Conservation District; and Zone 7 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)
- Stabilize the costs of creek monitoring by reducing duplication of effort and streamlining monitoring and reporting

The RMC Work Group is a subgroup of the BASMAA Monitoring and Pollutants of Concern Committee, which meets and communicates regularly to coordinate planning and implementation of monitoring-related activities. The RMC Work Group meetings are coordinated by an RMC coordinator and funded by the RMC's 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, 2020), standard operating procedures (SOPs; BASMAA, 2016), data management tools, and reporting templates and guidelines. Costs for these activities are shared among RMC members.

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 assignments of the various activities have adapted over time; the monitoring elements currently included in each category are specified in Table 1.2. Creek status monitoring data collected by CCCWP at local/targeted sites (and not included in the regional/probabilistic design) are reported separately in Appendix 2 of the 2020 urban creeks monitoring report (UCMR; ADH, 2021).

Table 1.2 Creek Status Monitoring Elements per MRP Provisions C.8.d. and C.8.g., Monitored as Either Regional/Probabilistic or Local/Targeted Parameters

Bioassessment, physical habitat assessment, CSCI	X	X[1]
Nutrients (and other water chemistry associated with bioassessment)	X	X[1]
Chlorine	X	X[2]
Water toxicity (wet and dry weather)	NA	NA
Water chemistry (pesticides, wet weather)	NA	NA
Sediment toxicity (dry weather)	NA	NA
Sediment chemistry (dry weather)	NA	NA
Continuous water quality (sondes data: temperature, dissolved oxygen, pH, specific conductance)		X
Continuous water temperature (data loggers)		X
Pathogen indicators (bacteria)		X

1 Provision C.8.d.i.(6) allows for up to 20 percent of sample locations to be selected under a targeted monitoring design. This design change was made under MRP Order No. R2-2015-0049.

2 Provision C.8.d.ii.(2) provides options for probabilistic or targeted site selection. In WY 2020, chlorine was measured at probabilistic sites.

CSCI California Stream Condition Index

NA Monitoring parameter not specific to either monitoring design

1.3 Report Organization

The remainder of this report addresses study area and monitoring design (Section 2), data collection and analysis methods (Section 3), results and data interpretation (Section 4), and conclusions and next steps (Section 5). Additional information on other aspects of permit-required monitoring is found elsewhere in the CCCWP WY 2020 UCMR and its appendices.

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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

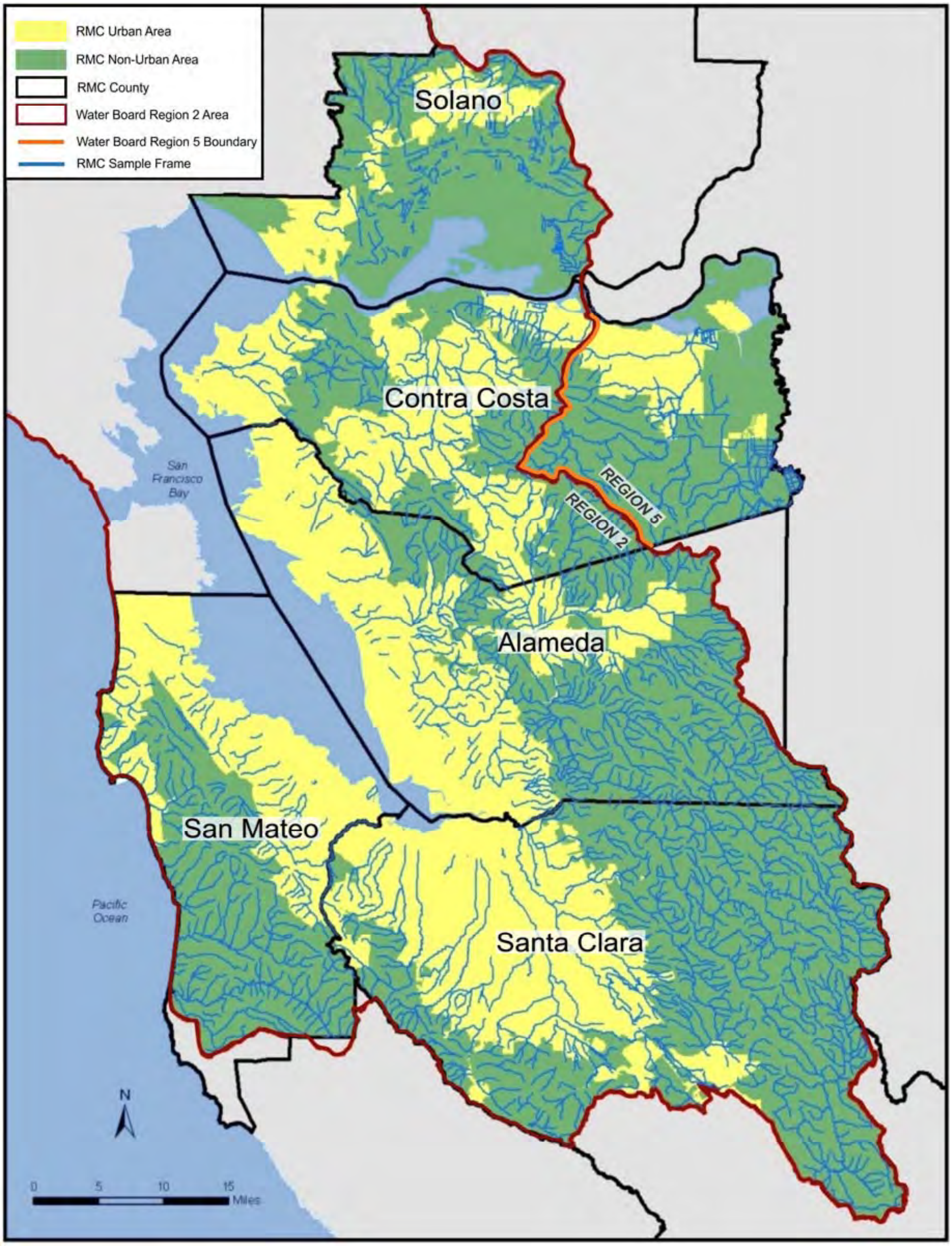
In 2011, the RMC developed a regional/probabilistic monitoring design to identify ambient conditions of creeks in the five main counties subject to the requirements of the MRP. The regional design was developed using the Generalized Random Tessellation Stratified (GRTS) approach developed by the U.S. Environmental Protection Agency (USEPA) and Oregon State University (Stevens and Olson, 2004). The GRTS approach has been 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 (Southern California Stormwater Monitoring Coalition, 2007). The RMC area is considered to define the sample frame and represent the sample universe from which the regional "sample draw" (the randomized list of potential monitoring sites) is produced.

2.2.1 Management Questions

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

- What is the condition of aquatic life in creeks in the RMC area? Are water quality objectives met and are beneficial uses supported?
- 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?
- What is the condition of aquatic life in RMC participant counties? Are water quality objectives met and are beneficial uses supported?
- To what extent does the condition of aquatic life in urban and non-urban creeks differ in the RMC area?
- To what extent does the condition of aquatic life in urban and non-urban creeks differ in each of the RMC participating counties?
- What are major stressors to aquatic life in the RMC area?
- What are major stressors to aquatic life in the urbanized portion of the RMC area?
- What are the long-term trends in water quality in creeks over time?

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



The regional design includes 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).

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 to 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 used in the aquatic life assessments.

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

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 RMC area. Sample sites were selected and attributed using the GRTS approach from a sample frame consisting of a creek network geographic information system (GIS) data set within the RMC boundary (BASMAA, 2011), within five management units corresponding to 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 stratified 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 of 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 monitored sites are in urban areas and not more than 20 percent are in non-urban areas. RMC participants coordinated with SWAMP and Regional Water Quality Control Board 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 draw in the Region 2 (San Francisco Bay) area of Contra Costa County, with the regional focus varying annually.

2.3 Monitoring Design Implementation

The number of probabilistic sites monitored annually in water years 2012-2020 by CCCWP are shown by land use category in Table 2.1. This tally includes non-urban sites monitored by SWAMP personnel.

In 2020 monitoring, only Donner Creek (207R03435) was in an area of non-urban land use.

Table 2.1 Number of Urban and Non-Urban Bioassessment Sites Sampled by CCCWP and SWAMP in Contra Costa County During Water Years 2012-2020

Monitoring Year	Contra Costa County	
	Land Use	
	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
WY 2017	10	0/0
WY 2018	9	1/0
WY 2019	9	1/0
WY 2020	9	1/0
Total	85	12

1 Non-urban sites are shown as sampled by CCCWP/SWAMP for each year. The total represents combined non-urban sites, including those monitored by SWAMP in Contra Costa County.

3 Monitoring Methods

3.1 Site Evaluation

Sites identified in the regional sample draw were evaluated by each RMC participant in numerical order using the process defined in the RMC SOPs (BASMAA, 2016). 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 wadable 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) grants permission to access the site[3]

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 not meeting at least one of criteria 5 through 7, were classified as target non-sampleable (TNS)

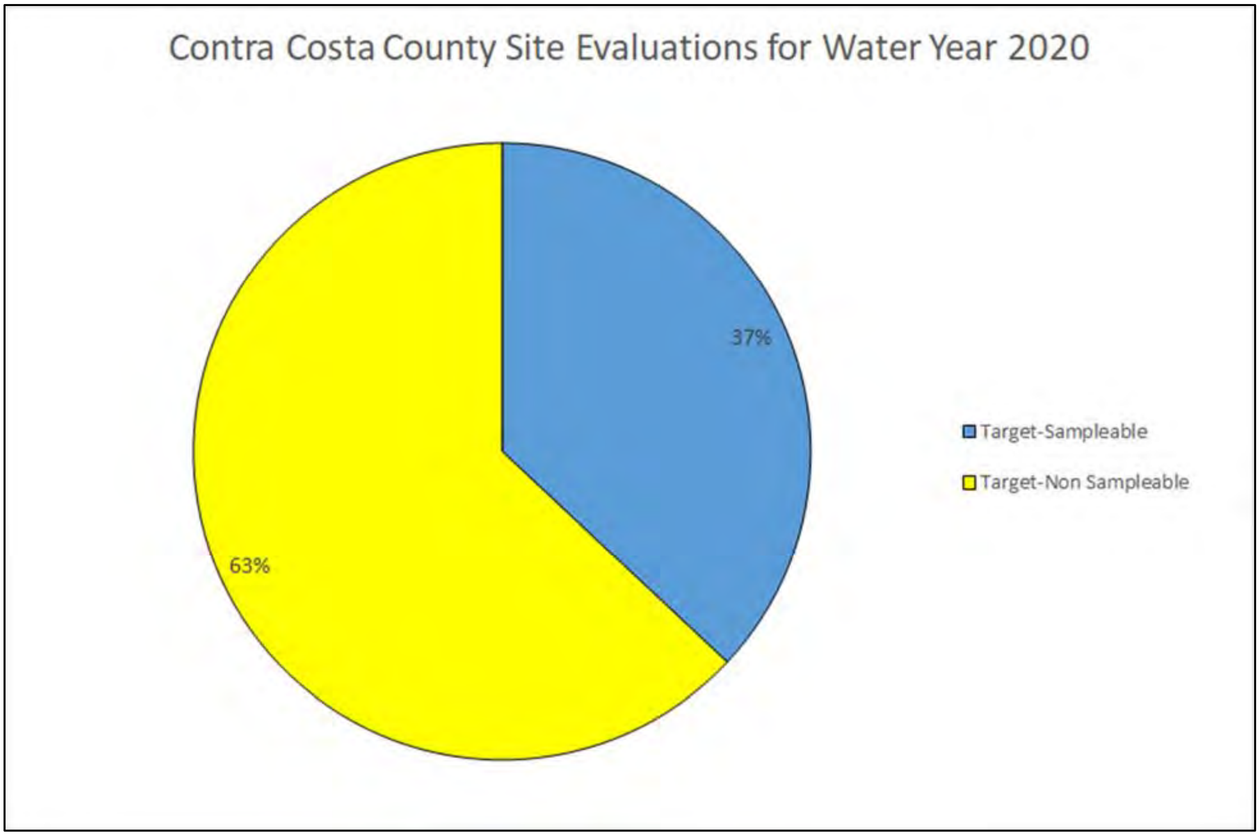
Non-Target (NT): sites not meeting at least one of criteria 1 through 4 were classified as non-target status and were not sampled

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 2020 are illustrated in Figure 3.1. A relatively small fraction of sites evaluated each year are classified as target sampleable sites, and this is true again for the sites evaluated for 2020.

[3] 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 2020



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 per 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

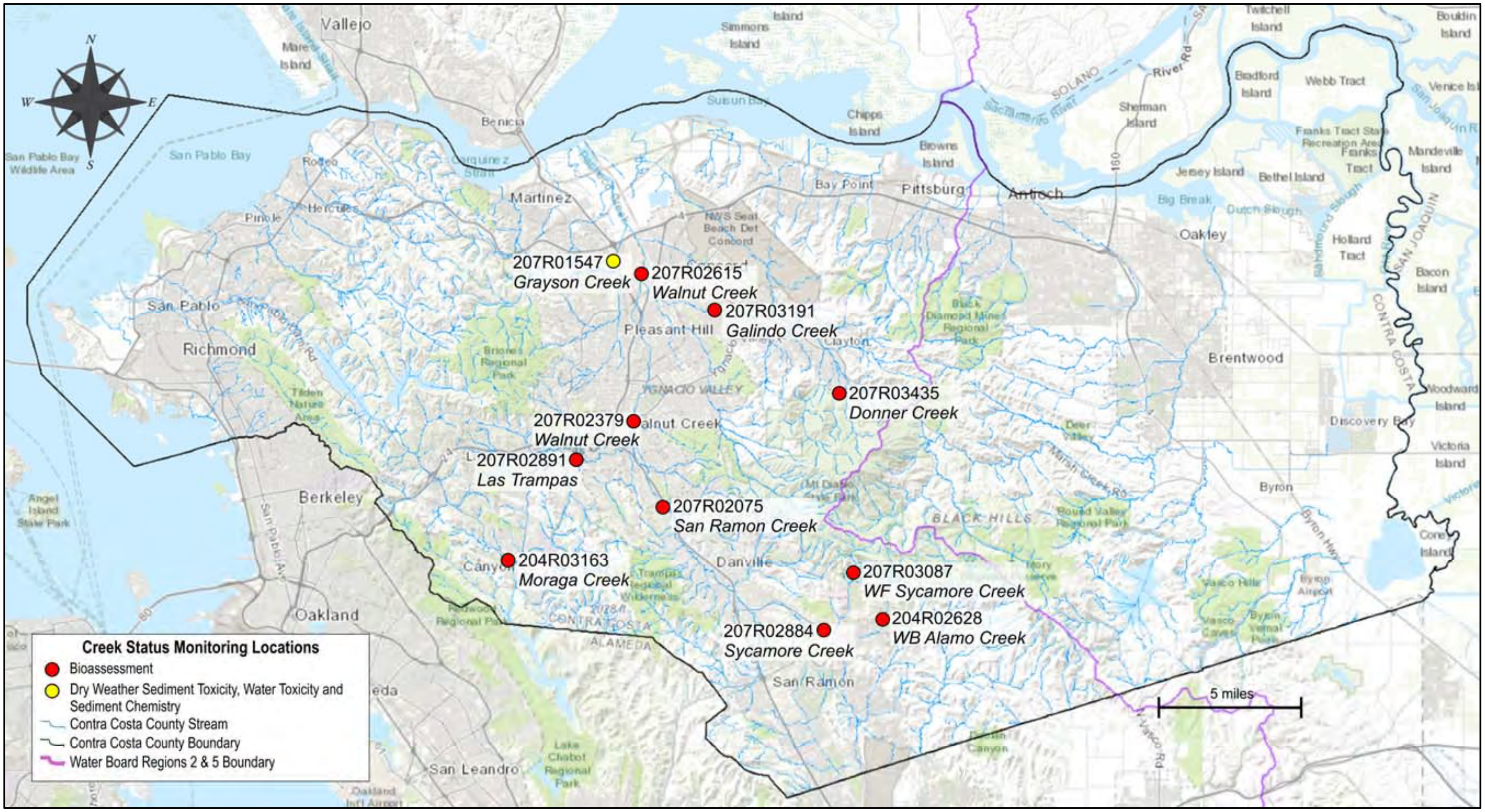
The probabilistic sites selected for monitoring in WY 2020, following site evaluation, are shown graphically in Figure 3.2 as the bioassessment sites, and are listed with additional site information in Table 3.1. As shown in Table 3.1, one additional site (Grayson Creek, 207R01547) was selected for dry weather water toxicity, sediment toxicity and sediment chemistry testing. Wet weather (stormwater) chemistry and toxicity testing was not conducted in water years 2019 or 2020, as the relevant MRP requirements had previously been met.

Table 3.1 Site Locations, Monitoring Parameters and Dates Sampled at CCCWP Sites from the RMC Probabilistic Monitoring Design in WY 2020

Site ID	Creek Name	Land Use	Latitude	Longitude	Bioassessment, PHab, Chlorine, Nutrients	Stormwater Toxicity and Chemistry[1] (Wet Weather)	Water Toxicity and Sediment Toxicity and Chemistry (Dry Weather)
207R01547	Grayson	U	37.98657	-122.06986			07/22/20
204R02628	WB Alamo	U	37.80683	-121.89874	06/19/20		
204R03163	Moraga	U	37.83638	-122.13655	06/09/20		
207R02075	San Ramon	U	37.86328	-122.03799	06/18/20		
207R02379	Walnut	U	37.90617	-122.05698	06/10/20		
207R02615	Walnut	U	37.97990	-122.05176	06/11/20		
207R02884	Sycamore	U	37.80159	-121.93654	06/08/20		
207R02891	Las Trampas	U	37.88686	-122.09305	06/10/20		
207R03087	WF Sycamore	U	37.83015	-121.91699	05/27/20		
207R03191	Galindo	U	37.96182	-122.00580	05/26/20		
207R03435	Donner	NU	37.92031	-121.92677	05/28/20		

1 Wet weather monitoring was not conducted in water years 2019 or 2020.
NU non-urban land use
U urban land use

Figure 3.2 Contra Costa County Creek Status Sites Monitored in WY 2020



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

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, 2020) and the associated SOPs (BASMAA, 2016). 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, 2016). 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, 2016).

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, 2020), 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 150-meter 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, 2016).

3.2.1.1 Benthic Macroinvertebrates (BMI)

BMIs were collected via kick net sampling using the reach-wide benthos method described in RMC SOP FS-1 (BASMAA, 2016), based on the SWAMP bioassessment procedures (Ode et al., 2016a and 2016b). Samples were collected from a one square foot area approximately one meter 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 1,000 mL wide-mouth jar(s), and the samples were preserved with 95 percent ethanol.

3.2.1.2 Algae

Filamentous ("soft") algae and diatom samples also were collected at the 10 bioassessment sites using the reach-wide benthos method per SOP FS-1 (BASMAA, 2016), 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 500 mL cylinder, creating a composite sample for the site. A 45 mL subsample was taken from the algae composite sample and combined with 5 mL glutaraldehyde into a 50 mL sample tube for taxonomic identification of soft algae. Similarly, a 40 mL subsample was taken from the algae composite sample and combined with 10 mL of 10 percent formalin into a 50 mL 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, 25 mL 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)

Physical habitat (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, 2016). 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, 2016). 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 during bioassessment monitoring for nutrient analyses using the standard grab sample collection method, as described in SOP FS-2 (BASMAA, 2016). Sample containers were rinsed using ambient water and filled and recapped below the water surface whenever possible. An intermediate container was used to collect water for all sample containers containing preservative 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 SOP FS-9 (BASMAA, 2016). The 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 ensure meeting the 24-hour sample delivery time requirement. Procedures used for sample collection and transport are described in SOP FS-2 (BASMAA, 2016).

3.2.6 Sediment Chemistry and Sediment Toxicity

In the case where sediment samples and water samples and measurements were collected at the same event, sediment samples were collected after water samples were collected. Before conducting sediment sampling, field personnel surveyed the proposed sampling area to identify appropriate fine-sediment depositional areas and 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 aliquoted into separate jars for chemical and toxicological analysis using standard clean sampling techniques (see SOP FS-6, BASMAA, 2016). Sample jars were submitted to the respective laboratories per SOP FS-9 (BASMAA, 2016).

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, 2020). The following analytical laboratory contractors were used for biological, 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 standard taxonomic effort).

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. USEPA-approved testing protocols were then applied for analysis of water and sediment samples.

PHYSIS Environmental Laboratories, Inc. – Water chemistry (pyrethroids, imidacloprid, fipronil and degradates, total and dissolved organic carbon, and suspended sediment concentration)

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

Pacific EcoRisk, Inc. – Water and sediment toxicity

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

3.4 Data Analysis – Water Year 2020 Data

Only data collected by CCCWP during WY 2020 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 dry weather water and sediment toxicity and sediment chemistry data from one additional site. 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.

For the comprehensive, multi-year analysis required for the 2020 Integrated Monitoring Report (Armand Ruby Consulting, 2020), the accumulated data from water years 2012-2019 were used 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 Local/Targeted Creek Status Monitoring Report: Water Year 2020, found in Appendix 2 of the CCCWP WY 2020 UCMR (ADH, 2021).

The creek status monitoring results are subject to potential follow-up actions, per MRP 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 stressor/source identification (SSID) projects, per MRP provision C.8.e, and used by RMC programs to help inform the SSID project selection process.

As part of the stressor assessment for this report, water and sediment chemistry and toxicity data generated during WY 2020 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 the San Francisco Bay Region Basin Plan (SFBRWQCB, 2019; Basin Plan) water quality objectives, where available and applicable.

Table 3.3 Requirements for Follow-up for Regional/Probabilistic Creek Status Monitoring Results Per MRP Provisions C.8.d and C.8.g

Constituent	Threshold Trigger Level	MRP 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 an 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 an 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 an 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 provision C.5.e (Spill and Dumping Complaint Response Program).
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 (2) a second, follow up sampling, and both have ≥ 50 percent effect. Note: Applies to dry and wet weather, water column and sediment tests.
Pesticides (Water)[1]	> Basin Plan water quality objectives	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, and (2) for pollutants without water quality objectives, results exceed PEC or TEC.

1 Per RMC decision, with Water Board staff concurrence, in accordance with MRP provision C.8.g.iii.(3), this monitoring commenced in WY 2017.
PEC probable effects concentrations
TEC 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.

3.4.1 Biological Data

The biological condition of each probabilistic site monitored by CCCWP in WY 2020 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 (BMI) Data Analysis

Under the MRP, the BMI taxonomic data are evaluated principally through calculation of the CSCI, a bioassessment index developed by California SWAMP for statewide use (Rehn et al., 2015; Rehn, 2016; Mazor et al., 2016); methods updated in 2020 (Boyle et al., 2020). CSCI scores evaluate stream health based on comparison of metric characteristics 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 (GIS) parameters.

The CSCI score is computed as the average of two other indices: O/E, the observed (O) taxonomic diversity at the monitoring site divided by the taxonomic composition expected (E) at a reference site with similar geographical characteristics, and a multi-metric index (MMI), 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., 2015; Rehn, 2016).

CSCI scores were calculated using ‘R’ statistical software (per Boyle et al. 2020). 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 the MRP. This index produces conservative values relative to urban creeks.

The various taxonomic metrics derived from the BMI taxonomic data, as produced by Tom King of Bioassessment Services, also are presented in this report. For consistency and comparison with the WY 2012 regional urban creeks monitoring report (BASMAA, 2013), subsequent urban creeks monitoring reports, and other RMC programs, the Southern California B-IBI score (per Ode et al., 2005) is also computed and presented in this report.

3.4.1.2 Algae Data Analysis

Algae taxonomic data can be evaluated through a variety of metrics and indices. The MRP does not specify analytical metrics or threshold trigger levels for algae data.

California SWAMP has recently developed a set of algae indices meant to be more robust than previous algal indices in assessing biointegrity in wadable streams in California across a broad range of environmental conditions. Three Algae Stream Condition Index (ASCI) MMIs have been developed (specifically, MMIs for diatoms, soft algae, and a diatom/soft algae hybrid), and the methods were published in 2020 (Boyle et al., 2020).

For the current analysis of algal taxonomic data, the former standard algal indices of biotic integrity (A-IBI) were abandoned in favor of the recently developed ASCI MMIs. The older A-IBIs, such as the D18, S2, and H20 indices, as they were developed for Southern California streams, and have become deficient since 2013 due to the lack of updated attribute traits (Marco Sigala, personal communication, 2020). The ASCI MMIs were developed for statewide use and are expected to be more robust across a wider range of environmental conditions.

The watershed boundaries for WY 2020 sites were delineated using the NHDPlusV2 Basin Delineation Tool (Horizon Systems Corporation). Delineations from the NHD Basin tool were checked against catchment borders and topography for accuracy using ArcGIS, and no adjustments were necessary. GIS metrics were calculated using the Indices Processor toolbox version 4.6 (Boyle et al. 2020). Watershed delineations and GIS metrics also were recalculated for sites/watersheds from previous years (water years 2012-2019), as the methods were updated in 2020 (Boyle et al. 2020).

ASCI scores were calculated using ‘R’ statistical software (ASCI R scripts version 2.3.2, Boyle et al. 2020). ASCI score categories were applied to diatom (D_ASCI) and hybrid (H_ASCI) results as defined in

Theroux et al. (2020). The soft algae (S_ASCI) output is not recommended for use at this time, since it did not perform well in development. H_ASCI includes soft algae and diatom data and performed as well or slightly less than D_ASCI. However, D_ASCI is likely to be the most frequently reported index statewide and is the preferred index for assessment (S. Theroux and R. Mazor, SCCWRP, per Marco Sigala, personal communication, 2020).

3.4.1.3 Biological Condition Categories

During development of the CSCI and ASCI indices, the range of possible scores for each index was divided into categories to represent the likelihood that the biota were intact or altered, with respect to conditions judged to prevail in similar creeks under unimpacted conditions (Rehn et al., 2015; Theroux et al., 2020). Those condition categories are defined in Table 3.4 for the CSCI and the three ASCI MMI algae indices.

Table 3.4 CSCI and ASCI Multi-metric Scoring ranges by Condition Category

	Likely Intact	Possibly Altered	Likely Altered	Very Likely Altered
B-IBI (BMI) Index				
CSCI	≥ 0.92	≥ 0.79 and < 0.92	≥ 0.63 and < 0.79	< 0.63
ASCI (Algae) Indices				
Diatom MMI	≥ 0.94	≥ 0.86 and < 0.94	≥ 0.76 and < 0.86	< 0.76
Soft Algae MMI	≥ 0.86	≥ 0.65 and < 0.86	≥ 0.38 and < 0.65	< 0.38
Hybrid MMI	≥ 0.94	≥ 0.86 and < 0.94	≥ 0.76 and < 0.86	< 0.76

3.4.2 Physical Habitat (PHab) Condition

PHab condition was assessed for the CCCWP bioassessment monitoring sites principally using the Index of Physical Habitat Integrity (IPI), a multi-metric index recently developed by California SWAMP to characterize physical habitat condition for streams in California (Rehn et al., 2018a). The IPI is based on the concept that physical habitat characteristics have a profound effect on stream health, and that high-quality physical habitat is essential for maintaining beneficial uses. Interim instructions for calculating IPI using GIS and the analytical software platform “R” were published by SWAMP in 2018 (Rehn et al., 2018b), and updated in 2020 (Boyle et al., 2020).

During method development, the IPI model was calibrated such that:

- the mean score of reference sites is 1
- scores near 0 indicate substantial departure from reference condition and serious degradation of physical condition
- scores greater than 1 indicate greater physical complexity than predicted for a site, given its natural environmental setting

IPI scores were calculated according to SWAMP IPI protocols (Rehn et al., 2018b) using ‘R’ statistical software (per Boyle et al. 2020). The IPI is calculated from empirical data organized into two input files: the “stations” data, which are derived from the GIS characteristics associated with each monitoring site, and “PHab” data, which include about a dozen physical habitat characteristics derived from metrics present in the bioassessment EDD produced from the bioassessment fieldwork.

SWAMP has provided guidance on four IPI score condition categories that can be used to facilitate interpretation of the calculated IPI scores (Rehn et al., 2018a). The SWAMP IPI protocols established thresholds based on the 30th, 10th, and 1st percentiles of IPI scores at reference sites, to divide the IPI scoring range into four categories of physical condition as follows:

- IPI $\geq$ 0.94 = Likely Intact condition
- IPI $\geq$ 0.84 and < 0.94 = Possibly Altered condition
- IPI $\geq$ 0.71 and < 0.84 = Likely Altered condition
- IPI < 0.71 = Very Likely Altered condition

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 2020 were analyzed and evaluated to identify the potential stressors which may contribute to degraded or diminished biological conditions. Results were evaluated in relation to MRP threshold triggers, and water chemistry results were evaluated with respect to applicable water quality objectives, where feasible.

For sediment chemistry trigger criteria, comparisons to threshold effects concentrations (TECs) and probable effects concentrations (PECs) are calculated as defined in MacDonald et al. (2000), as specified in the MRP. 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.

Toxic unit equivalents also were computed for pyrethroid pesticides in sediment, based on available literature LC_{50} values (LC_{50} 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 LC_{50} 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 compound (TOC) concentration at each site (as a percentage), and the TOC-normalized concentrations were then used to compute toxic unit (TU) equivalents for each pyrethroid. For each site, the TU equivalents for the individual pyrethroids were summed, and sites where the summed TU equivalents were equal to or greater than 1.0 were identified.

3.5 Quality Assurance/Quality Control (QA/QC)

Data quality assurance and quality control (QA/QC) procedures are described in detail in the BASMAA RMC QAPP (BASMAA, 2020) and in RMC SOP FS13, QA/QC Data Review (BASMAA, 2016).

Data quality objectives were established to ensure the data collected were of sufficient quality for the intended use. Data quality objectives 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, 2016), 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, 2016). 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, 2020), and monitoring was performed per protocols specified in the RMC SOPs (BASMAA, 2016) 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

Taxonomic procedures for BMI identification and enumeration included components identified in the RMC QAPP (BASMAA, 2020):

- Minimum 600 organism subsample when possible
- Sorting measurement quality objective: a check of remnants for organisms missed by original subsampler
- Interlaboratory quality control: submission of 10 percent of processed samples (one sample for this project) to an independent lab for review of taxonomic accuracy/precision and conformance to standard taxonomic level

All WY 2020 samples met the minimum sample count threshold of 600 individuals specified in the QAPP.

The interlaboratory quality control review was completed, with measurement quality objectives well below error threshold rates.

Field duplicate BMI samples were collected at Sycamore Creek (207R02884). An analysis of the comparative results produced the following:

- The average relative percent difference (RPD) between the duplicate samples for 25 individual BMI taxonomic metrics was 22.4 percent
- The CSCI scores computed for this duplicate data set differed by RPD of just 6.1 percent, with RPDs of 1.3 percent for the O/E component and 14 percent for the MMI component
- RPD for each of the three ASCI scores was 12.4 percent (diatoms MMI), 34.1percent (soft algae MMI), and 34.1 percent (hybrid MMI); these results provide further evidence of the enhanced reliability of the diatoms MMI as a measure of algal community health

The RPD results for the BMI and ASCI metrics are considered to represent an acceptable level of variation between duplicate sets of taxonomic data.

The New Zealand mudsnail (*Potamopyrgus antipodarum*), a non-native invasive species, was confirmed at seven sites: Galindo, Sycamore, Moraga, Walnut (2 sites), Las Trampas, and San Ramon creeks.

4.1.2 Sediment Chemistry

The sediment sample was collected from Grayson Creek (207R01547) on July 22, 2020. This sample selected by the laboratory (Caltest) for the batch matrix spike/matrix spike duplicate quality control sample. The percent recovery of the matrix spike duplicate for this analyte was outside established control limits for lead, possibly due to matrix interferences.

The semi-volatile organics and pyrethroids pesticides samples were diluted prior to analysis in an effort to reduce matrix interferences, resulting in higher reporting limit(s).

For the carbamates pesticides analysis, the final volume of the sample extract was higher than the nominal amount, resulting in higher reporting limit(s).

The method blank analysis revealed a slight hit for lead at 0.05 mg/kg (RL = 0.04 mg/kg). The QC batch was accepted based on the corresponding batch laboratory control spike (LCS) and RPD results.

Otherwise, no significant quality control issues were reported for the sediment sample analyses (Grayson Creek, 207R01547).

4.1.3 Water Chemistry

Two CCCWP samples were selected by the laboratory (Caltest) for batch matrix spike/matrix spike duplicate quality control samples. For the silica analysis, high Matrix Spike recovery was found, due to possible matrix interferences in the QC sample. The QC batch was accepted based on the corresponding LCS and RPD results. For dissolved ortho-phosphate analysis, low Matrix Spike recovery was found, due to possible matrix interferences in the QC sample. The QC batch was accepted based on corresponding LCS and RPD results.

Field duplicate samples were collected for water quality analysis as part of the bioassessment field work from Sycamore Creek (207R02884) on June 8, 2020. The average relative percent difference (RPD) between the duplicate samples for the 10 water quality analytes was 9.1 percent. The only constituent with RPD >25 percent was chlorophyll-*a*, at 26.1 percent. The RPD was within QAPP limits for all other constituents. These water quality RPD results generally are considered to represent an acceptable level of variation between duplicates.

4.1.4 Sediment Toxicity

For the sediment sample collected from Grayson Creek (207R01547) on July 22, 2020, the *Chironomus* and *Hyalella* tests were initiated within the required holding times. No quality control issues were noted by the laboratory.

4.1.5 Water Toxicity

No significant quality control issues were reported in the laboratory toxicity testing of the water sample collected from Grayson Creek (207R01547) on July 22, 2020.

Low dissolved oxygen was measured in the lab control treatment of the water *Hyalella azteca* test on day eight. All remaining test conditions (pH, dissolved oxygen, temperature, etc.) were within acceptable limits. All analyses were performed according to laboratory Standard Operating Procedures.

The water toxicity tests were initiated within required holding times. Pathogen-related mortality was not observed in any sample replicates tested for WY 2020.

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, 2019) for RMC creeks monitored by CCCWP for bioassessment in WY 2020 are shown in Table 4.1.

The BASMAA Five-Year Bioassessment Report (BASMAA, 2019) provides additional analysis of bioassessment data to assess benthic community health at the countywide program and regional levels and includes comparisons between urban and non-urban land use sites.

Table 4.1 Designated Beneficial Uses Listed in the San Francisco Bay Region Basin Plan or CCCWP Bioassessment Sites Monitored in WY 2020

		Human Consumptive Uses							Aquatic Life Uses									Recreational Uses		
Site Code	Creek Name	AGR	MUN	FRSH	GWR	IND	PROC	COMM	SHELL	COLD	EST	MAR	MIGR	RARE	SPWN	WARM	WILD	REC-1	REC-2	NAV
204R02628	WB Alamo															E	E	E	E	
204R03163	Moraga			E						E					E	E	E	E	E	
207R02075	San Ramon															E	E	E	E	
207R02379	Walnut									E			E	E	E	E	E	E	E	
207R02615	Walnut									E			E	E	E	E	E	E	E	
207R02884	Sycamore															E	E	E	E	
207R02891	Las Trampas									E				E		E	E	E	E	
207R03087	WF Sycamore															E	E	E	E	
207R03191	Galindo									E						E	E	E	E	
207R03435	Donner									E			E		E	E	E	E	E	

E existing beneficial use

P potential beneficial use

Note: Per Basin Plan Ch. 2 (SFBRWQCB, 2019), 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). Where creek is not named in Basin Plan, designated uses for nearest named downstream tributary are shown above.

4.2.1 Benthic Macroinvertebrate (BMI) Metrics

Detailed BMI taxonomic metrics are shown in Table 4.2 for the CCCWP creek status sites monitored in the spring index period of WY 2020. For consistency with the 2012 regional UCMR, subsequent CCCWP urban creeks monitoring reports, and other RMC programs, the SoCal B-IBI score is computed from the BMI taxonomic data and included in the results shown in Table 4.2, but then is not included further in the condition assessment analysis in this report. The principal metric used to evaluate benthic biotic community health is now the CSCI score.

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 observed-to-expected score (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 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 the MRP, a CSCI score of 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. Every CCCWP bioassessment site monitored in WY 2020 produced a CSCI score below the MRP threshold of 0.795, indicating a degraded biological community relative to reference conditions. These sites consequently may be listed as potential candidates for SSID studies.

The WY 2020 CSCI scores ranged from a low of 0.274 at Galindo Creek (207R03191) to a high of 0.606 at Donner Creek (207R03435), as shown in Table 4.3. The Donner Creek site (207R03435) was in an area of non-urban land use. This CSCI score was only slightly higher than the CSCI scores at two urban sites monitored in WY 2020: 0.593 at San Ramon Creek (207R02075) and 0.563 at Walnut Creek (207R02379).

Table 4.2 Benthic Macroinvertebrate Metrics for CCCWP Bioassessment Sites Monitored in WY 2020

BMI Metrics for CCCWP Bioassessment Sites, Spring 2020										
Site Code:	WB Alamo	Moraga	San Ramon	Walnut	Walnut	Sycamore	Las Trampas	WF Sycamore	Galindo	Donner
Creek Name:	204R02628	204R03163	207R02075	207R02379	207R02615	207R02884	207R02891	207R03087	207R03191	207R03435
Richness										
Taxonomic	21	15	20	19	27	15	16	18	13	24
EPT	1	1	6	6	3	2	2	1	0	7
Ephemeroptera	1	1	3	3	2	0	1	0	0	5
Plecoptera	0	0	0	0	0	0	0	0	0	1
Trichoptera	0	0	3	3	1	2	1	1	0	1
Coleoptera	0	0	0	0	0	0	0	1	0	2
Predator	7	3	3	4	8	5	5	4	3	8
Diptera	9	6	6	8	5	4	5	5	6	9
Composition										
EPT Index (%)	1.1	1.0	6.3	52	6.8	0.3	6.1	0.3	0.0	5.7
Sensitive EPT Index (%)	0.0	0.0	0.2	0.3	0.0	0.2	0.0	0.3	0.0	1.8
Shannon Diversity	2.31	1.72	0.71	1.98	1.69	1.44	1.25	2.02	1.75	1.84
Dominant Taxon (%)	27	45	87	35	60	51	70	37	41	48
Non-insect Taxa (%)	48	47	40	26	59	40	44	44	46	21
Tolerance										
Tolerance Value	6.5	6.6	7.7	5.5	7.3	7.0	7.2	7.4	7.3	6.8
Intolerant Organisms (%)	0.0	0.0	0.2	0.3	0.0	0.0	0.0	0.0	0.0	3.1
Intolerant Taxa (%)	0.0	0.0	5.0	5.3	0.0	0.0	0.0	0.0	0.0	21
Tolerant Organisms (%)	28	55	90	9.4	77	63	72	70	76	53
Tolerant Taxa (%)	29	33	30	26	56	40	25	33	31	21
Functional Feeding Groups										
Collector-Gatherers (%)	67	31	7.6	78	77	42	16	75	73	36
Collector-Filterers (%)	5.3	16	1.3	2.0	2.3	2.1	10	3.4	0.0	1.0
Collectors (%)	72	47	8.9	80	79	44	26	78	73	37
Scrapers (%)	15	45	88	4.1	11	52	70	16	26	48
Predators (%)	13	7.6	1.3	6.7	8.7	3.4	3.5	4.9	1.1	12
Shredders (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other (%)	0.3	0.0	1.9	10	0.8	0.5	0.0	1.3	0.0	2.6

Table 4.2 Benthic Macroinvertebrate Metrics for CCCWP Bioassessment Sites Monitored in WY 2020

BMI Metrics for CCCWP Bioassessment Sites, Spring 2020										
Site Code:	WB Alamo	Moraga	San Ramon	Walnut	Walnut	Sycamore	Las Trampas	WF Sycamore	Galindo	Donner
Creek Name:	204R02628	204R03163	207R02075	207R02379	207R02615	207R02884	207R02891	207R03087	207R03191	207R03435
Estimated Abundance										
Composite Sample (11 ft^2)	4,429	2,278	29,568	13,099	4,968	2,091	2,428	6,422	4,480	7,416
#/ft^2	403	207	2,688	1,191	452	190	221	584	407	674
#/m^2	4,300	2,211	28,707	12,717	4,823	2,031	2,357	6,235	4,350	7,200
Supplemental Metrics										
Collectors (%)	72	47	8.9	80	79	44	26	78	73	37
Non-Gastropoda Scrapers (%)	0.0	0.0	0.2	0.3	0.0	0.0	0.0	0.0	0.0	0.2
Shredder Taxa (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Diptera Taxa[a]	6	3	3	5	3	2	2	2	2	5
IBI Scores										
SoCal IBI Score	19	17	24	24	16	21	26	16	13	51

a Calculated based on Chironomids identified to family level

Note: 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). The Donner Creek site (207R03435) was in an area of non-urban land use.

Table 4.3 Results of CSCI Calculations for WY 2020 CCCWP Bioassessment Sites

Site Code	Creek Name	Sample Date	BMI Count	O/E	MMI	CSCI
204R02628	WB Alamo	06/19/20	609	0.626	0.161	0.393
204R03163	Moraga	06/09/20	605	0.414	0.150	0.282
207R02075	San Ramon	06/18/20	616	0.734	0.452	0.593
207R02379	Walnut	06/10/20	614	0.663	0.464	0.563
207R02615	Walnut	06/11/20	621	0.372	0.283	0.328
207R02884	Sycamore	06/08/20	610	0.354	0.203	0.278
207R02891	Las Trampas	06/10/20	607	0.637	0.272	0.454
207R03087	WF Sycamore	05/27/20	669	0.402	0.219	0.310
207R03191	Galindo	05/26/20	616	0.445	0.103	0.274
207R03435	Donner	05/28/20	622	0.708	0.503	0.606

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

4.2.2 Algae Metrics

CCCWP sampled soft algae and diatoms at 10 sites during bioassessment monitoring in May and June 2020, following the SWAMP Reach-Wide Benthos collection method (Ode et al., 2016). A field duplicate sample was collected at Sycamore Creek (207R02884). Samples were processed in the laboratory by EcoAnalysts following SWAMP protocols (Stancheva et al., 2015) to provide count (diatom and soft algae), biovolume (soft algae), and “presence” (diatom and soft algae) data. Diatom and soft algae identifications matched the California Algae and Diatom Taxonomic Working Group’s Master Taxa List, and all taxonomic FinalIDs currently included in the SWAMP database were included in the calculations.

ASCI MMI Scores

The three MMIs included in the ASCI, recently developed by SWAMP, were calculated for the WY 2020 CCCWP bioassessment sites. Because of questions regarding the reliability of the soft algae MMI, only the diatoms MMI and hybrid MMI are reported here. Some FinalIDs were updated during data analysis to match the current ASCI Standard Taxonomic Effort (STE) list, so all records could be included in the ASCI calculations.

The ASCI scores were assigned to condition categories as described above (see Table 3.4). Except for the Donner Creek site (207R03435), which scored Possibly Altered on the hybrid MMI, all sites scored either Likely Altered or Very Likely Altered on the diatoms MMI and hybrid MMI ASCI metrics (Table 4.4). The Donner Creek site (207R03435) was in an area of non-urban land use.

Table 4.4 ASCI MMI Scores

Site Code	Creek Name	Sample Date	Diatoms MMI	Diatoms Status	Hybrid MMI	Hybrid Status
204R02628	WB Alamo	06/19/20	0.57	Very Likely Altered	0.47	Very Likely Altered
204R03163	Moraga	06/09/20	0.78	Likely Altered	0.60	Very Likely Altered
207R02075	San Ramon	06/18/20	0.62	Very Likely Altered	0.47	Very Likely Altered
207R02379	Walnut	06/10/20	0.41	Very Likely Altered	0.27	Very Likely Altered
207R02615	Walnut	06/11/20	0.35	Very Likely Altered	0.33	Very Likely Altered
207R02884	Sycamore	06/08/20	0.71	Very Likely Altered	0.68	Very Likely Altered
207R02891	Las Trampas	06/10/20	0.65	Very Likely Altered	0.57	Very Likely Altered
207R03087	WF Sycamore	05/27/20	0.78	Likely Altered	0.68	Very Likely Altered
207R03191	Galindo	05/26/20	0.52	Very Likely Altered	0.46	Very Likely Altered
207R03435	Donner	05/28/20	0.77	Likely Altered	0.89	Possibly Altered

4.3 Stressor Assessment

This section addresses the question: what are the major stressors to aquatic life in the RMC area? The biological, physical, chemical, and toxicity testing data produced by CCCWP during WY 2020 were compiled, 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

Field crews recorded an array of physical habitat characteristics on the SWAMP field data sheets during bioassessment monitoring at the 10 CCCWP bioassessment sites in 2020. These field-measured parameters, along with an array of watershed parameters generated through GIS analysis, were used to compute IPI scores, following SWAMP protocols (Boyle et al., 2020).

The IPI scores calculated from the PHab data compiled during bioassessment monitoring conducted in spring 2020 are shown in Table 4.5. Three sites were rated as Likely Intact: Moraga Creek, Walnut Creek (207R02615), and Donner Creek. Only Walnut Creek (207R02379) ranked as Very Likely Altered. The Donner Creek site (207R03435) was in an area of non-urban land use.

Table 4.5 Index of Physical Habitat Integrity (IPI) Scores for CCCWP Bioassessment Sites Monitored in WY 2020

Site Code	Creek Name	Sample Date	IPI Score	IPI Category
204R02628	WB Alamo	06/19/20	0.75	Possibly Altered
204R03163	Moraga	06/09/20	0.86	Likely Intact
207R02075	San Ramon	06/18/20	0.9	Possibly Altered
207R02379	Walnut	06/10/20	0.35	Very likely Altered
207R02615	Walnut	06/11/20	1.03	Likely Intact
207R02884	Sycamore	06/08/20	0.97	Possibly Altered
207R02891	Las Trampas	06/10/20	0.85	Possibly Altered
207R03087	WF Sycamore	05/27/20	0.75	Likely Altered
207R03191	Galindo	05/26/20	0.79	Likely Altered
207R03435	Donner	05/28/20	1.16	Likely Intact

4.3.2 Correlations of Biological and Physical Habitat Parameters

The principal biological and physical habitat condition scores are shown together in Table 4.6, and correlations between the key biological and physical habitat condition scores are shown in Table 4.7.

The Donner Creek site, which was in an area of non-urban land use, overall had the highest scores, for biological condition and physical habitat.

For the 2020 analysis, there was generally poor correlation among the various biological and physical habitat indices, except for the two algal indices, which corelated well with each other. The CSCI was very poorly correlated with the two algal indices and the physical habitat index.

The diatoms MMI and hybrid MMI algal community indices were well correlated with each other, but neither correlated well with the CSCI, and only the hybrid MMI correlated well with the IPI.

Table 4.6 Summary of PHab and Biological Condition Scores for CCCWP Bioassessment Sites Monitored in WY 2020

Site Code	Creek Name	Sample Date	CSCI Score	Diatoms MMI ASCI Score	Hybrid MMI ASCI Score	IPI Score
204R02628	WB Alamo	06/19/20	0.393	0.57	0.47	0.75
204R03163	Moraga	06/09/20	0.282	0.78	0.60	0.86
207R02075	San Ramon	06/18/20	0.593	0.62	0.47	0.9
207R02379	Walnut	06/10/20	0.563	0.41	0.27	0.35
207R02615	Walnut	06/11/20	0.328	0.35	0.33	1.03
207R02884	Sycamore	06/08/20	0.278	0.71	0.68	0.97
207R02891	Las Trampas	06/10/20	0.454	0.65	0.57	0.85
207R03087	WF Sycamore	05/27/20	0.310	0.78	0.68	0.75
207R03191	Galindo	05/26/20	0.274	0.52	0.46	0.79
207R03435	Donner	05/28/20	0.606	0.77	0.89	1.16

Table 4.7 Correlations for PHab and Biological Condition Scores for CCCWP Sites Monitored in WY 2020

Comparison	Correlation Coefficient	R Squared
CSCI:D_MMI	-0.071	0.005
CSCI:H_MMI	0.022	0.000
CSCI:IPI	-0.071	0.005
D_MMI:H_MMI	0.885	0.783
D_MMI:IPI	0.369	0.136
H_MMI:IPI	0.615	0.378

Note: Correlations are based on scores shown in Table 4.6. Well correlated results (correlated coefficient greater than 0.50) are highlighted in green.

4.3.3 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, 2016). 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 (un-ionized form[4]), chloride[5], and nitrate+nitrite[6] – the latter for waters with MUN beneficial use only, as indicated in Table 4.8.

[4] For ammonia, the standard provided in the Basin Plan (SFBRWQCB, 2019, 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, which 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).

[5] For chloride, a secondary maximum contaminant level 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 per the Basin Plan (Table 3-7) applies to waters in the Alameda Creek watershed above Niles. Per RMC decision as noted in the UCMR for WY 2012 (BASMAA, 2012), for all other waters, the Criterion Continuous Concentration of 230 mg/L (USEPA Water Quality Criteria*) for the protection of aquatic life is used as a conservative benchmark for comparison 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).

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

[6] The nitrate+nitrite primary maximum contaminant level 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.

Table 4.8 Water Quality Thresholds Available for Comparison to WY 2020 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])	Basin Plan (Ch. 3)
Chloride	230	mg/L	Criterion Continuous Concentration	Freshwater aquatic life	USEPA National Recreation Water Quality Criteria, Aquatic Life Criteria
Chloride	860	mg/L	Criteria Maximum Concentration	Freshwater aquatic life	USEPA National Recreation 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	Basin Plan (Ch. 3); California Title 22; USEPA Drinking Water Standards Secondary MCL
Nitrate+Nitrite (as N)	10	mg/L	Maximum Contaminant Level	Areas designated as MUN	Basin Plan (Ch. 3)

The comparisons of the measured nutrients data to the thresholds listed in Table 4.8 are shown in Table 4.9. There were no exceedances of the applicable criteria for chloride or nitrate+nitrite at any of the 10 sites monitored in WY 2020, but there were two exceedances of the Basin Plan standard for un-ionized ammonia, at Las Trampas Creek (207R02891), and Donner Creek (207R03435).

These are highly unusual results, as elevated ammonia levels are not expected in creeks monitored under the creek status monitoring requirements of the MRP; but they also reflect the 2018 results, in which four of 10 sites exceeded the un-ionized ammonia threshold, and the 2019 results, in which two samples exceeded the threshold, including one sample from Marsh Creek which exhibited a particularly high concentration (168 µg/L).

The samples were collected across separate dates, in different watersheds, and in each year were all analyzed on the same date by the lab, but further investigation did not reveal any clear evidence of laboratory error. These results will be flagged as questionable in the database.

The causes of the observed ammonia exceedances are unknown; the exceedances may be false positives as a result of a change in the SWAMP-required method from a distillation method to a no-distillation method. To resolve this, CCCWP will analyze ammonia samples using both methods until this issue is resolved through regional or statewide guidance.

Table 4.9 Comparison of Water Quality (Nutrient) Data to Associated Water Quality Thresholds for WY 2020 Water Chemistry Results

Site Code	Creek Name	MUN?	Parameter and Threshold			Number 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]	
204R02628	WB Alamo	No	3.47	47	0.17	0
204R03163	Moraga	No	2.25	44	0.06	0
207R02075	San Ramon	No	6.55	55	0.08	0
207R02379	Walnut	No	23.88	49	0.15	0
207R02615	Walnut	No	22.89	88	0.23	0
207R02884	Sycamore	No	3.96	73	0.21	0
207R02891	Las Trampas	No	26.40	37	0.09	1
207R03087	WF Sycamore	No	3.74	23	0.11	0
207R03191	Galindo	No	10.58	210	0.05	0
207R03435	Donner	No	31.23	9.5	0.07	1
Number of Values > Threshold			2	0	0	2
Percent of Values > Threshold			20%	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 2020 sites have MUN beneficial use.

Bolded values indicate results above applicable thresholds

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 4.10, no WY 2020 water samples produced measurable levels of free or total chlorine.

Table 4.10 Summary of Chlorine Testing Results for Samples Collected in WY 2020 in Comparison to MRP Trigger Criteria

Site Code	Creek Name	Sample Date	Chlorine, Free	Chlorine, Total	Exceeds Trigger Threshold?
204R02628	WB Alamo	06/19/20	0.0	0.0	No
204R03163	Moraga	06/09/20	0.0	0.0	No
207R02075	San Ramon	06/18/20	0.0	0.0	No
207R02379	Walnut	06/10/20	0.0	0.0	No
207R02615	Walnut	06/11/20	0.0	0.0	No
207R02884	Sycamore	06/08/20	0.0	0.0	No
207R02891	Las Trampas	06/10/20	0.0	0.0	No
207R03087	WF Sycamore	05/27/20	0.0	0.0	No
207R03191	Galindo	05/26/20	0.0	0.0	No
207R03435	Donner	05/28/20	0.0	0.0	No
Number of Samples Exceeding 0.08 mg/L			0	0	
Percentage of Samples Exceeding 0.08 mg/L			0%	0%	

4.3.4 Water Column Toxicity and Chemistry (Wet Weather)

Wet weather samples were not collected during WY 2020, as the relevant MRP monitoring requirement had already been fulfilled in previous monitoring years.

4.3.5 Water Column Toxicity (Dry Weather)

On July 22, 2020, water samples were collected from one site on Grayson Creek (207R01547) and tested for acute and chronic toxicity to several different aquatic species, as required by the MRP. The dry weather water toxicity test results are shown in Table 4.11. All the dry weather water toxicity test results were determined by laboratory analysis not to be toxic. The sample testing was initiated within required holding times. Water chemistry testing was not required for the dry season sample.

Table 4.11 Summary of CCCWP WY 2020 Dry Season Water Toxicity Results

Dry Season Water Samples			Toxicity Test Results						
			S. capricornutum	*C. dubia*		*C. dilutus*	*H. azteca*	*P. promelas*	
Site Code	Creek Name	Sample Collection Date	Growth (cells/mL x 10^6)	Survival (%)	Reproduction (No. of neonates/ female)	Survival (%)	Survival (%)	Survival (%)	Growth (mg)
Lab Control			0.891	100	34.4	90.0	96	97.5	0.72
207R01547	Grayson Creek	07/22/20	1.73	100	33.7	95.0	96	100	0.94

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

4.3.6 Sediment Toxicity and Sediment Chemistry

Sediment samples were collected on July 22, 2020 after water samples were collected at the same site sampled for water column toxicity (Grayson Creek, 207R01547), and tested for acute toxicity (survival) to *Hyalella azteca* and *Chironomus dilutus*.

The July 22, 2020 Grayson Creek sediment sample was determined not to be toxic to *Chironomus dilutus* or to *Hyalella azteca*. The sediment toxicity test results are shown in Table 4.12.

Table 4.12 Summary of CCCWP on 2020 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 (%)
Lab Control			96.3	93.8
207R01547	Grayson Creek	07/22/20	96.2	97.5

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

The sediment sample also was 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 follow-up in MRP provision C.8.g.iv. (see Table 3.3). The complete sediment chemistry results are shown in Table 4.13, and the results are shown in comparison to the applicable MRP threshold triggers in Table 4.14.

Sediment chemistry results (Tables 4.13 and 4.14) are summarized as follows:

- No metal constituents had a TEC ratio ≥1.0
- Ten PAH compounds were detected; one (pyrene) had a TEC ratio ≥1.0 (this is an unusual and notable result)
- The monitored site did not produce a mean PEC ratio ≥0.5
- Five of the seven pyrethroid pesticides were detected; the highest was bifenthrin at 6.5 ng/g
- The other pesticides tested (carbaryl and the fipronil compounds) were not detected

Table 4.13 CCCWP WY 2020 Sediment Chemistry Results

Analyte	Units[1]	Site 207R01547		
		Grayson Creek		
		Result	MDL	RL
Metals				
Arsenic	mg/Kg	3.3	0.2	0.51
Cadmium	mg/Kg	0.2	0.01	0.04
Chromium	mg/Kg	15	0.51	0.51
Copper	mg/Kg	14	0.076	0.2
Lead	mg/Kg	11	0.041	0.041
Nickel	mg/Kg	15	0.03	0.03
Zinc	mg/Kg	95	0.81	0.81
Polycyclic Aromatic Hydrocarbons (PAHs)				
Acenaphthene	ng/g	ND	15	18
Acenaphthylene	ng/g	ND	15	18
Anthracene	ng/g	ND	15	18
Benz(a)anthracene	ng/g	82	15	18
Benzo(a)pyrene	ng/g	100	15	18
Benzo(b)fluoranthene	ng/g	200	15	18
Benzo(e)pyrene	ng/g	100	15	18
Benzo(g,h,i)perylene	ng/g	ND	15	18
Benzo(k)fluoranthene	ng/g	61	15	18
Biphenyl	ng/g	ND	17	18
Chrysene	ng/g	100	15	18
Dibenz(a,h)anthracene	ng/g	ND	15	18
Dibenzothiophene	ng/g	ND	17	18
Dimethylnaphthalene, 2,6-	ng/g	ND	15	18
Fluoranthene	ng/g	200	15	18
Fluorene	ng/g	ND	15	18
Indeno(1,2,3-c,d)pyrene	ng/g	61	15	18
Methylnaphthalene, 1-	ng/g	ND	15	18
Methylnaphthalene, 2-	ng/g	ND	15	18
Methylphenanthrene, 1-	ng/g	ND	15	18
Naphthalene	ng/g	ND	15	18
Perylene	ng/g	ND	15	18
Phenanthrene	ng/g	51	15	18
Pyrene	ng/g	200	15	18
Pyrethroid Pesticides				
Bifenthrin	ng/g	6.5	0.41	1
Cyfluthrin, total	ng/g	0.93	0.45	1
Cyhalothrin, Total lambda-	ng/g	0.73	0.25	1
Cypermethrin, total	ng/g	ND	0.41	1
Deltamethrin/Tralomethrin	ng/g	0.67	0.49	1
Esfenvalerate/Fenvalerate, total	ng/g	ND	0.53	1
Permethrin	ng/g	2.6	0.45	1
Other Pesticides				
Carbaryl	ng/g	ND	0.041	0.041

Table 4.13 CCCWP WY 2020 Sediment Chemistry Results

Analyte	Units[1]	Site 207R01547 Grayson Creek		
		Result	MDL	RL
Fipronil	ng/g	ND	0.41	1
Fipronil Desulfinyl	ng/g	ND	0.41	1
Fipronil Sulfide	ng/g	ND	0.41	1
Fipronil Sulfone	ng/g	ND	0.41	1
Organic Carbon				
Total Organic Carbon	%	2.9	0.02	0.051

1 All measurements reported as dry weight
MDL method detection limit
ND not detected
RL reporting limit

Table 4.14 Threshold Effect Concentration (TEC) and Probable Effect Concentration (PEC) Quotients for WY 2020 Sediment Chemistry Constituents

		Site 207R01547		
		Grayson Creek		
	Sample Units[1]	Sample	TEC Ratio	PEC Ratio
Metals				
Arsenic	mg/Kg	3.3	0.34	0.10
Cadmium	mg/Kg	0.2	0.20	0.04
Chromium	mg/Kg	15	0.35	0.14
Copper	mg/Kg	14	0.44	0.09
Lead	mg/Kg	11	0.31	0.09
Nickel	mg/Kg	15	0.66	0.31
Zinc	mg/Kg	95	0.79	0.21
Polycyclic Aromatic Hydrocarbons (PAHs)				
Anthracene	ng/g	ND		
Fluorene	ng/g	ND		
Naphthalene	ng/g	ND		
Phenanthrene	ng/g	51	0.250	0.0436
Benz(a)anthracene	ng/g	82	0.759	0.0781
Benzo(a)pyrene	ng/g	100	0.667	0.0690
Chrysene	ng/g	100	0.602	0.0775
Fluoranthene	ng/g	200	0.473	0.0897
Pyrene	ng/g	200	1.026	0.1316
Total PAHs[a]	ng/g	1260	0.783	0.0553
Number with TEC > 1.0			1	
Combined TEC Ratio			7.64	
Average TEC Ratio			0.55	
Combined PEC Ratio				1.52
Average PEC Ratio				0.11

a Total PAHs include 24 individual PAH compounds; NDs were substituted at 1/2 MDL to compute total PAHs

Bold TEC or PEC ratio indicates ratio 1.0

ND not detected

Note: All measurements reported as dry weight. TECs and PECs per, MacDonald et al. (2000).

Sediment TU equivalents were calculated for the pyrethroid pesticides for which there are published LC_{50} levels, and a sum of the calculated TU equivalents was computed for the dry season sediment chemistry results from the monitored site (Grayson Creek, 207R01547; see Table 4.15). 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 (Table 4.15).

Several of the common urban pyrethroid pesticides were detected at the WY 2020 sediment monitoring site (see Table 4.13, above), with bifenthrin at the highest concentration, as is typical in urban creeks in California. However, the calculated TU equivalent of 0.55 for the sum of the pyrethroids (Table 4.15) is less than the level normally assumed to be sufficient to cause toxicity to *Chironomus dilutus* or *Hyalella azteca* in the sediment toxicity testing.

Table 4.15 Calculated Pyrethroid Toxic Unit Equivalents, WY 2020 Sediment Chemistry Data

Pyrethroid Pesticides	LC_{50} (µg/g organic carbon)	Site 207R01547 Grayson Creek Sample (ng/g)	Sample (µg/g organic carbon)	TU Equivalents[1]
Bifenthrin	0.52	6.5	0.22	0.43
Cyfluthrin	1.08	0.93	0.03	0.03
Cyhalothrin, lambda	0.45	0.73	0.03	0.06
Cypermethrin	0.38	ND		
Deltamethrin/Tralomethrin	0.79	0.67	0.02	0.03
Esfenvalerate/Fenvalerate	1.54	ND		
Permethrin	10.8	2.6	0.09	0.01
			Sum (Pyrethroid TUs)	0.55

1 Toxic unit equivalents (TU) are calculated as ratios of organic carbon-normalized pyrethroid sample concentrations to published *H. azteca* LC_{50} values. See http://www.tdcenvironmental.com/resources/Pyrethroids-Aquatic-Tox-Summary.pdf for associated references.

ND not detected

Note: All sample measurements reported as dry weight.

4.3.7 Analysis of Condition Indicators and Stressors – WY 2020

During WY 2020, 10 sites were monitored by CCCWP under the RMC regional/probabilistic design for bioassessment, physical habitat, and water chemistry parameters. One site also was monitored for water and sediment toxicity and sediment chemistry.

The bioassessment and related data are used to develop a preliminary condition assessment for the monitored sites. The water and sediment chemistry and toxicity data are used in conjunction with physical habitat data to evaluate potential stressors which may affect aquatic habitat quality and beneficial uses. Various metrics and indices are also computed to aid in the condition assessment and stressor analysis.

Biological Conditions

CSCI scores have been calculated from the CCCWP bioassessment data since WY 2012. 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.

Every CCCWP bioassessment site monitored in WY 2020 produced a CSCI score below the MRP threshold of 0.795, indicating a degraded biological community relative to reference conditions. These sites consequently may be listed as potential candidates for SSID studies.

The WY 2020 CSCI scores ranged from a low of 0.274 at Galindo Creek (207R03191) to a high of 0.606 at Donner Creek (207R03435). The Donner Creek site (207R03435) was in an area of non-urban land use.

In the MRP era (WY 2012-present), CCCWP performed bioassessment monitoring at 90 sites. During that period, only one monitored site (Wildcat Creek, 206R02455, May 7, 2019) scored above the MRP CSCI threshold of 0.795; this site falls into the SWAMP biological condition category of Possibly Altered. All other 89 sites scored below 0.795 on the CSCI and are therefore considered "biologically degraded" per the MRP; those sites fall into the biological condition categories of Likely Altered (N=8) or Very Likely Altered (N=81).

While the non-urban Donner Creek site (207R03435) scored highest by a very slight margin among the WY 2020 bioassessment sites, non-urban sites do not always score higher than urban sites. Of the five CCCWP non-urban sites monitored throughout water years 2012-2020, four scored within the top 15 CSCI scores, but Franklin Creek (207R01280, CSCI = 0.507 on May 9, 2019) ranks 28th of the 90 sites monitored. The five non-urban sites fall into the top 35 percent of CSCI scores for sites monitored by CCCWP. The top two CSCI scores among sites monitored by CCCWP during water years 2012-2020 are from two urban sites on Wildcat Creek.

ASCI scores were calculated for CCCWP bioassessment sites again in WY 2020. Except for the Donner Creek site (207R03435), which scored Possibly Altered on the hybrid MMI, all sites scored either Likely Altered or Very Likely Altered on the diatoms MMI and hybrid MMI ASCI metrics. The Donner Creek site (207R03435) was in an area of non-urban land use.

Based on both the BMI and algal community indices, the biological community conditions of all CCCWP sites monitored in 2020 can be considered to be impacted.

Many factors can influence biological community taxonomic composition and affect indices such as CSCI and ASCI that are meant to characterize biological community health. The comprehensive, multi-year analysis performed for the Integrated Monitoring Report (ARC, 2020) concluded that benthic and algal biological conditions are affected by a variety of physical habitat factors, including especially flow velocity (degree of fast vs slow water, with faster water being beneficial) and substrate composition (coarse gravel vs fines; the former being beneficial). Water quality factors that negatively influence benthic and algal community composition include elevated chloride or conductivity, both of which may indicate saltwater intrusion. Algal communities also tend to benefit from higher antecedent rainfall

In addition, physical factors involving stream channel alteration, riparian vegetation removal, and hydromodification are generally assumed to negatively impact in-stream biota.

These factors are relevant for stream segments in watersheds characterized by *either* urban land use or non-urban land use. The presence of current or historical grazing, agricultural, or forestry management activities, construction of flood control facilities, open space management (including in public parklands), and fire activity can affect in-stream physical and biological conditions even in areas otherwise unaffected by human development.

In the case of the non-urban site monitored in WY 2020 (Donner Creek, 207R03435), the site is both located within a managed open space area (Mount Diablo State Park), with a pedestrian greenway along the banks, and was observed with very low flow (<1 CFS) at the time of monitoring (May 28, 2020). These factors may have influenced the CSCI score for this site (0.606), which was only slightly above the scores for two other sites with urban land uses monitored in WY 2020, and ranks just fourteenth in the water years 2012-2020 CCCWP bioassessment dataset, with several urban land use sites scoring higher.

Stressor Analysis

Based on an analysis of the regional/probabilistic data collected by CCCWP during WY 2020, the stressor analysis is summarized as follows.

Physical Habitat (PHab) Conditions

IPI scores were again calculated from the PHab data compiled during the spring 2020 bioassessment monitoring. Three sites were rated as Likely Intact: Moraga Creek, Walnut Creek (207R02615), and Donner Creek. Only Walnut Creek (207R02379) ranked as Very Likely Altered. All other sites were ranked as Possibly Altered or Likely Altered.

For the 2020 analysis, the principal benthic invertebrate community index (CSCI) did not correlate well with either of the ASCI MMIs or the IPI.

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). Two of the results generated at the 10 sites monitored for un-ionized ammonia during WY 2020 exceeded the applicable water quality standard; all WY 2020 chloride and nitrate+nitrite results met the applicable standards.

The causes of the unexpectedly elevated ammonia results are unknown; this has occurred in prior years. A review of data and communication with RMC members shows that elevated ammonia concentrations began to occur in WY 2018, after a method change for ammonia analysis was initiated. The change in the ammonia laboratory analysis method eliminated the distillation step prior to analysis, with the intention of maintaining comparability with SWAMP protocols. That change, possibly intended to achieve lower detection limits, comes at a cost of reliability. Industry-accepted practice establishes that distillation prior to analysis yields more reliable data for all approved methods of ammonia analysis[7].

Thus, the ammonia exceedances reported in water years 2018-2020 may be false positives as a result of a change in the SWAMP-required method from a distillation method to a no-distillation method. To address this, CCCWP will consider analyzing ammonia samples using both methods until this issue is resolved through regional or statewide guidance.

Water Toxicity

The Grayson Creek dry weather water sample was not determined to be toxic to any of the four test species.

Sediment Toxicity

The Grayson Creek sediment sample was not determined to be toxic to either *Chironomus dilutus* or *Hyalella azteca*.

[7] Cole Parmer, 2021. "Understanding Ammonia Analysis." https://www.coleparmer.com/tech-article/understanding-ammonia-analysis-methods, last accessed Dec. 22, 2020.

Sediment Chemistry

Several of the common urban pyrethroid pesticides were detected at the WY 2020 sediment monitoring site (Grayson Creek, 207R01547); as is typical, bifenthrin was detected at the highest concentration. The calculated toxic unit equivalent of 0.55 for the combined pyrethroid concentrations is less than that normally required to cause toxicity to either *Chironomus dilutus* or *Hyalella azteca* in the sediment toxicity testing.

The most notable result of the sediment chemistry testing is the detection of 10 PAH compounds at the monitored site, including pyrene at a concentration sufficient to produce a calculated TEC ratio >1. This finding raises questions as to the spatial and temporal extent of PAHs within Grayson Creek and within the RMC study area more generally, and the degree to which the WY 2020 results could be replicated geographically or temporally.

PAH sources can be characterized by ratios of individual signature PAH compounds (e.g., Balmer et al, 2019); these same ratios can be applied to attempt to identify the sources of PAHs found in environmental samples. Previous research has shown that combustion – both anthropogenic and natural – is the primary source of PAH compounds found in the environment generally (Lima et al., 2005).

The recent increase in wildfire activity regionally could potentially cause increased PAH concentrations within the RMC study area; however, existing RMC data collected to date would not alone likely support a definitive conclusion. Future investigations may consider the extent to which wildfires are a source of PAH compounds in the urban watersheds managed by RMC programs, and explore studies to characterize removal effectiveness by green stormwater infrastructure and other stormwater management tools.

Sediment Triad Analyses

Bioassessment, sediment toxicity, and sediment chemistry results from WY 2020 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 2012-2020. Good correlation is observed throughout that period in the triad analysis between pyrethroid concentrations with TU $\geq$1 and sediment toxicity.

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 generally did not exhibit sediment toxicity, as shown in Table 4.16 (the 2018 sample being the exception, as the calculated TU equivalent was 0.95, and toxicity was observed to *Hyalella azteca* in the sediment sample).

Based on the results of the past nine years, 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. Atypically, the principal stressors identified in the chemical analyses from the 2020 monitoring are PAHs.

Table 4.16 Summary of Sediment Quality Triad Evaluation Results – WY 2012-2020 Data

Water Year	Water Body	Site ID	B-IBI Condition Category	Sediment Toxicity	No. of TEC Quotients > 1.0	Mean PEC Quotient	Sum of TU Equivalents
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
2017	West Branch Alamo Creek	204R01412	Degraded (CSCI)[1]	No	3	0.21	0.255
2018	Marsh Creek	544R01737		Yes	1	0.09	0.95
2019	Marsh Creek	544R02505		Yes	3	0.25	1.84
2020	Grayson Creek	207R01547		No	1	0.11	0.55

1 Based on WY 2016 bioassessment data

Note: Yellow-highlighted cells indicate results exceed permit trigger threshold.

Comparisons to Conclusions of the Comprehensive Integrated Monitoring Report (IMR) Multi-Year Analysis

The multi-year analysis of regional/probabilistic parameters included within the WY 2019 IMR (ARC, 2020) produced the following conclusions:

- Biological conditions in Contra Costa County urban creeks are generally impacted, as indicated by analysis of bioassessment results from 76 monitoring sites over the course of eight years, 2012-2019. Physical habitat factors play a significant role in degradation of in-stream biota, with water quality factors and antecedent rainfall also contributing to in-stream conditions.
- Factors with a positive influence on in-stream biological conditions for BMI and algae include higher percentages of fast water within the reach, higher percentages of coarse gravel, and higher diversity of natural substrate types.
- Factors which tend to negatively impact in-stream biota include higher percentages of fines or substrate smaller than sand, higher percentages of slow water in the reach, and elevated chloride or conductivity.
- Algae assemblages tend to benefit from higher antecedent rainfall in the 60- to 90-day range and are negatively impacted by elevated temperatures.
- Throughout the study period, sediment toxicity and occasional water toxicity are chronic occurrences, with toxicity typically attributable to the presence of pyrethroid and sometimes other pesticides, including the recent presence of fipronil and imidacloprid.

These findings are supported in the WY 2020 analysis with respect to biological conditions, although toxicity was not observed in the WY 2020 dry weather water or sediment monitoring.

Sediment chemistry and toxicity clearly are linked to “very poor” IBI scores and “degraded” CSCI scores, but do not always explain very poor conditions. Where the sum of TUs exceeds 1, sediment toxicity consistently occurs. Where sediment toxicity occurs, IBI and CSCI scores consistently indicate “very poor” and “degraded” conditions. In contrast, “very poor” and “degraded” conditions are often, but not always associated with sediment toxicity and TUs exceeding 1.

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5 Conclusions and Next Steps

5.1 Water Year 2020 Results

The WY 2020 data were fairly consistent with the results of previous creek status monitoring performed by CCCWP under the MRP.

Every CCCWP bioassessment site monitored in WY 2020 produced a CSCI score below the MRP threshold of 0.795, indicating a degraded biological community relative to reference conditions. These sites consequently may be listed as potential candidates for SSID studies.

ASCI scores were calculated for CCCWP bioassessment sites again in WY 2020. Except for the Donner Creek site (207R03435), which scored Possibly Altered on the hybrid MMI, all sites scored either Likely Altered or Very Likely Altered on the diatoms MMI and hybrid MMI ASCI metrics. The Donner Creek site (207R03435) was in an area of non-urban land use.

Based on both the BMI and algal community indices, the biological community conditions of all CCCWP sites monitored in 2020 can be considered to be impacted.

Physical habitat conditions were again compromised at all 10 bioassessment sites monitored in 2020. IPI scores were calculated from the PHab data compiled during the spring 2020 bioassessment monitoring. Three sites were rated as Likely Intact: Moraga Creek, Walnut Creek (207R02615), and Donner Creek. Only Walnut Creek (207R02379) ranked as Very Likely Altered. All other sites were ranked as Possibly Altered or Likely Altered.

For water year 2020 analysis, the principal benthic invertebrate community index (CSCI) did not correlate well with either of the ASCI MMIs or the IPI.

Of the 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). Two of the results generated at the 10 sites monitored for un-ionized ammonia during WY 2020 exceeded the applicable water quality standard; all WY 2020 chloride and nitrate+nitrite results met the applicable standards.

The causes of the unexpectedly elevated ammonia results are unknown; potential issues associated with the analytical method are being investigated.

Several of the common urban pyrethroid pesticides were detected at the WY 2020 sediment monitoring site (Grayson Creek, 207R01547); as is typical, bifenthrin was detected at the highest concentration. The calculated toxic unit equivalent of 0.55 for the combined pyrethroid concentrations is less than that normally required to cause toxicity to either *Chironomus dilutus* or *Hyalella azteca* in the sediment toxicity testing.

The most notable result of the sediment chemistry testing is the detection of 10 PAH compounds, including pyrene at a concentration sufficient to produce a calculated TEC ratio >1.

The Grayson Creek water and sediment samples collected on July 22, 2020 were determined not to be toxic to any of the test species.

5.2 Next Steps

The analysis presented in this report identifies a number of potentially impacted sites which might deserve further evaluation and/or investigation to provide better understanding of the sources/stressors which contribute to reduced water quality and lower biological conditions.

Based on the RMC's comprehensive, regional analysis of the first five years of bioassessment monitoring performed under the MRP, and the comprehensive, multi-year analysis contained in the 2020 IMRs, RMC programs will evaluate the existing Creek Status Monitoring Plan and probabilistic design and consider appropriate next steps to recommend for the monitoring design in the future.

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 2021.

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Appendix 2

Local/Targeted Creek Status Monitoring Report:

Water Year 2020

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Contra Costa Clean Water Program

Local/Targeted Creek Status Monitoring Report: Water Year 2020

(October 2019 – September 2020)

March 31, 2021

Submitted to

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

Submitted by

ADH Environmental
3065 Porter Street, Suite 101
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Contra Costa Clean Water Program

Local/Targeted Creek Status Monitoring Report: Water Year 2020

(October 2019 – September 2020)

March 31, 2021

Submitted to

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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
CFU	colony forming units
COLD	cold freshwater habitat (steelhead stream)
CVRWQCB	Central Valley Regional Water Quality Control Board
DO	dissolved oxygen
EBMUD	East Bay Municipal Utility District
FSURMP	Fairfield-Suisun Urban Runoff Management Program
GM	geometric mean
MPN	most probable number
MQO	measurement quality objective
MRP	municipal regional stormwater permit
MWAT	maximum weekly average temperature
NPDES	National Pollutant Discharge Elimination System
pH	hydrogen ion concentration
QAPP	quality assurance project plan
Region 2	San Francisco Bay Regional Water Quality Control Board
Region 5	Central Valley Regional Water Quality Control Board
RMC	Regional Monitoring Coalition
RPD	relative percent difference
RWQC	recreational water quality criteria
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
USEPA	U.S. Environmental Protection Agency
WARM	warm water habitat (non-steelhead streams)
WAT	weekly average temperature
WQOs	water quality objectives
WY	water year
YSI	Yellow Springs Instrument Company

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Preface

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

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

In accordance with the BASMAA RMC Creek Status and Long-Term Trends Monitoring Plan (EOA and ARC, 2011), monitoring data were collected following methods and protocols specified in the BASMAA RMC Quality Assurance Project Plan (QAPP; BASMAA, 2020) and BASMAA RMC Standard Operating Procedures (BASMAA, 2016). Where applicable, monitoring data were derived using methods comparable with methods specified by the California Surface Water Ambient Monitoring Program (SWAMP) QAPP. Data presented in this report were also submitted to the Moss Landing Marine Laboratories Regional Data Center for submittal to the State Water Resources Control Board on behalf of the Contra Costa Clean Water Program's permittees and pursuant to permit provision C.8.h.ii requirements for electronic data reporting.

This Local/Targeted Creek Status Monitoring Report documents the results of targeted (non-probabilistic) monitoring performed by the Contra Costa Clean Water Program in water year 2020 (Oct. 1, 2019-Sept. 30, 2020). Together with the creek status monitoring data reported in Regional/Probabilistic Creek Status Monitoring Report: Water Year 2020 (ARC, 2021), this submittal fulfills monitoring requirements specified in provision C.8.d and C.8.g of the permit and complies with reporting provision C.8.h.iii of the MRP (SFBRWQCB, 2015).

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Executive Summary

This Local/Targeted Creek Status Monitoring Report was prepared by the Contra Costa Clean Water Program (CCCWP) in compliance with the National Pollutant Discharge Elimination System (NPDES) Municipal Regional Stormwater Permit (MRP) issued by the San Francisco Bay Regional Water Quality Control Board (SFBRWQCB; Order No. R2-2015-0049). This report documents the results of targeted (non-probabilistic) monitoring performed by CCCWP in water year (WY) 2020 (Oct. 1, 2019-Sept. 30, 2020). Together with the creek status monitoring data reported in Regional/Probabilistic Creek Status Monitoring Report: Water Year 2020 (ARC, 2021), this submittal fulfills monitoring requirements specified in provision C.8.d and C.8.g of the permit and complies with reporting provision C.8.h.iii of the MRP (SFBRWQCB, 2015).

Within Contra Costa County, targeted monitoring was conducted at:

- Four continuous water temperature monitoring locations
- Two continuous general 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 in three creeks at four separate locations on May 27, 2020. One device each was deployed in Las Trampas Creek and Moraga Creek, and two devices were deployed in Pinole Creek. The HOBOs were retrieved on Oct. 5, 2020. As the permit term reporting requirements apply only to the extent of a given water year, all data collected after Sept. 30, 2020 are not included in this report.

Pathogen Indicators

Samples were collected on Aug. 5, 2020 at five stations along five separate creeks in Contra Costa County. Samples were analyzed for enterococci and *E. coli.* The five sampling locations were located at Alhambra Creek, Grayson Creek, Las Trampas Creek, Refugio Creek and San Ramon Creek.

General (Continuous) Water Quality

Temperature, dissolved oxygen (DO), hydrogen ion concentration (pH), and specific conductance were continuously monitored at 15-minute intervals by sonde devices during two time periods (June 10-24, 2020 and Sept. 3-16, 2020) at two locations along Marsh Creek (544MSHM2 and 544MSHM0).

Results of Targeted Monitoring Data

All targeted monitoring data were evaluated against numeric trigger thresholds, as described in MRP provision C.8.d. These thresholds, which include applicable numeric water quality objectives or other applicable criteria, indicate levels at which additional follow-up may be required under the MRP. Targeted monitoring locations for WY 2020 were located within both SFBRWQCB Region 2 and Central Valley Regional Water Quality Control Board (CVRWQCB) Region 5 boundaries. Numeric thresholds are discussed below as presented in MRP provision C.8.d.

Temperature – HOBOs and Sondes

The trigger threshold for temperature is defined in the MRP as 20 percent or more of instantaneous results exceeding 24° C. For streams documented to support steelhead fisheries (i.e., steelhead streams), a maximum weekly average temperature (MWAT) of 17° C is used as the applicable criterion to evaluate temperature data. Per the MRP, for the HOBO temperature data, a maximum of one weekly average temperature (WAT) can exceed the threshold of 17° C during the deployment period. For temperature data recorded by sonde devices, which are deployed for a much briefer period (one to two weeks), all WATs must be below 17° C.

Creeks with respective designated beneficial uses are listed in Table ES.1. For this report, creeks listed as cold freshwater habitat (COLD) are evaluated as steelhead streams, while creeks designated as warm freshwater habitat (WARM) are referred to as non-steelhead streams.

For WY 2020, streams designated as COLD freshwater habitat were targeted for temperature monitoring using HOBO devices, while Marsh Creek, which maintains a WARM freshwater habitat, was targeted for temperature monitoring using sonde devices. To investigate whether Marsh Creek could support Chinook salmon identified in the lower reaches of the watershed, COLD freshwater habitat temperature criterion was applied to the Marsh Creek monitoring locations.

At the four locations with continuously recorded HOBO temperature data from May until September, all three creeks (Las Trampas Creek, Moraga Creek and Pinole Creek) are classified as steelhead streams.

No WY 2020 temperature monitoring location within steelhead streams recorded more than 20 percent instantaneous results above 24° C; therefore, there were no exceedances of this criterion. In Marsh Creek, which maintains a WARM beneficial use, the 24° C water temperature criterion was exceeded during both the June and September deployment periods at each monitoring location. As Marsh Creek is a non-steelhead stream, this does not constitute an exceedance under MRP criterion.

There were exceedances of the 17° C WAT threshold for eight out of eight index periods in WY 2020. This includes both Marsh Creek stations during the June and September deployment periods for the sonde data, and the four monitoring stations along Las Trampas Creek, Moraga Creek and at each Pinole Creek station for the HOBO data.

Dissolved Oxygen (DO)

The MRP trigger threshold for dissolved oxygen in non-tidal waters is applied as follows: for waters designated as steelhead streams, no more than 20 percent of instantaneous dissolved oxygen results may drop below 7.0 mg/L. In waters designated as non-steelhead streams, per Basin Plan criteria (SFBRWQCB, 2019), no more than 20 percent of instantaneous dissolved oxygen results may drop below 5.0 mg/L.

During the June monitoring period, the 20 percent threshold for non-steelhead streams was not exceeded for dissolved oxygen measurements in Marsh Creek at either monitoring station. During the September deployment at Marsh Creek, dissolved oxygen measurements were recorded below the MRP trigger threshold 52 and 20 percent of the time at the upstream and downstream monitoring stations, respectively.

Table ES.1. Designated Beneficial Uses Listed in the Basin Plan for CCCWP Targeted Monitoring Sites – WY 2020

			Human Consumptive Uses							Aquatic Life Uses									Recreational Uses		
Water Year	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
2020	207R02891	Las Trampas Creek									E				E		E	E	E	E	
	544MSHM2	Marsh Creek							E						E		E	E	P	P	
	544MSHM0	Marsh Creek							E						E		E	E	P	P	
	204R03163	Moraga Creek			E						E					E	E	E	E	E	
	206PNL029	Pinole Creek									E			E	E	E	E	E	E	E	
	206R01495	Pinole Creek									E			E	E	E	E	E	E	E	

E Existing beneficial use
P Potential beneficial use
Notes:
Per Basin Plan Ch. 2 (SFBRWQCB, 2019), 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 uses supported by streams. Beneficial uses for coastal waters 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).

pH

The MRP trigger threshold for pH in surface waters is applied as follows: no more 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 targeted locations over WY 2020.

For Marsh Creek station 544MSHM2, the 20 percent threshold was not exceeded during either the June or September deployment periods, meeting MRP criterion. During the June monitoring period at Marsh Creek station 544MSHM0, 33 percent of results failed to meet pH criterion, exceeding the MRP threshold of 20 percent of instantaneous results. During the September monitoring period, the pH of Marsh Creek station 544MSHM0 always met the MRP criterion.

Specific Conductance

The MRP trigger threshold for specific conductance in surface waters is applied as follows: no more than 20 percent of instantaneous specific conductance results may exceed 2,000 µS/cm, and readings should not indicate a spike in specific conductance with no obvious natural explanation.

During both the June and September monitoring periods, specific conductance measurements at Marsh Creek stations 544MSHM2 and 544MSHM0 did not exceed the 20 percent threshold for specific conductance results above 2,000 µS/cm and no spikes in the data were observed.

Pathogen Indicator Bacteria

The single-sample maximum concentrations of 130 CFU/100 ml for enterococci and 410 CFU/100 ml for *E. coli* were used as water contact recreation evaluation thresholds for the purposes of this evaluation, based on an adaptation of the recommended water quality criteria established by U.S. Environmental Protection Agency (USEPA) to protect recreational uses (USEPA, 2012).

For enterococci, five out of five single-sample concentrations (Alhambra Creek, Grayson Creek, Las Trampas Creek, Refugio Creek and San Ramon Creek) exceeded the single-sample threshold concentration. For *E. coli,* two of the five stations (Alhambra Creek and San Ramon Creek) exceeded the threshold concentration for water contact recreation.

Exceedances for each of the above parameters are summarized in Table ES.2.

Table ES.2 CCCWP Threshold Exceedances – WY 2020

Creek	Index Period	Parameter	Threshold Exceedance
Las Trampas Creek at Olympic Blvd. Staging Area	05/27/20-09/30/20	Continuous Water Temperature (HOBO)	Two or more WATs exceed 17° C
Moraga Creek at Moraga Country Club	05/27/20-09/30/20	Continuous Water Temperature (HOBO)	Two or more WATs exceed 17° C
Pinole Creek at Pinole Library	05/27/20-06/23/20 07/08/20-09/30/20	Continuous Water Temperature (HOBO)	Two or more WATs exceed 17° C
Pinole Creek above Pinole Valley Park	05/27/20-06/02/20 06/10/20-06/30/20 07/08/20-09/08/20 09/16/20-09/30/20	Continuous Water Temperature (HOBO)	Two or more WATs exceed 17° C
Marsh Creek at Fish Ladder, Upstream of WWTP	06/10/20-06/24/20 09/03/20-09/16/20	Continuous Water Temperature (sonde)	One or more WAT exceeds 17° C, 20% of instantaneous results above 24° C
Marsh Creek at East Cypress Road, Downstream of WWTP	06/10/20-06/24/20 09/03/20-09/16/20	Continuous Water Temperature (sonde)	One or more WAT exceeds 17° C, 20% of instantaneous results above 24° C
Marsh Creek at East Cypress Road, Downstream of WWTP	06/10/20-06/24/20	Continuous Water Quality – pH	20% of instantaneous results below 6.5 or above 8.5
Marsh Creek at Fish Ladder, Upstream of WWTP	09/03/20-09/16/20	Continuous Water Quality – DO	20% of instantaneous results below 5.0 mg/L
Marsh Creek at East Cypress Road, Downstream of WWTP	09/03/20-09/16/20	Continuous Water Quality – DO	20% of instantaneous results below 5.0 mg/L
Alhambra Creek	08/05/2020	Enterococci	Single grab sample exceeded USEPA criterion of 130 CFU/100 ml
Grayson Creek	08/05/2020	Enterococci	Single grab sample exceeded USEPA criterion of 130 CFU/100 ml
Las Trampas Creek	08/05/2020	Enterococci	Single grab sample exceeded USEPA criterion of 130 CFU/100 ml
Refugio Creek	08/05/2020	Enterococci	Single grab sample exceeded USEPA criterion of 130 CFU/100 ml
San Ramon Creek	08/05/2020	Enterococci	Single grab sample exceeded USEPA criterion of 130 CFU/100 ml
Alhambra Creek	08/05/2020	*E. coli*	Single grab sample exceeded USEPA criterion of 410 CFU/100 ml
San Ramon Creek	08/05/2020	*E. coli*	Single grab sample exceeded USEPA criterion of 410 CFU/100 ml

CFU colony forming unit
DO dissolved oxygen
WAT weekly average temperature
WWTP wastewater treatment plant

1. Introduction

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) and the Region 5 permit (Central Valley Permit). Municipal stormwater discharges in Contra Costa County are regulated by the requirements of both the municipal regional permit (MRP) for urban stormwater in Region 2 (Order No. R2-2015-0049)[1] and the East Contra Costa County municipal National Pollutant Discharge Elimination System (NPDES) permit (Central Valley Permit) in Region 5 (Order No. R5-2010-0102)[2]. Prior to the reissuance of MRP Order No. R2-2015-0049, the requirements of the two permits were effectively identical. With the reissued MRP in 2015, some differences between the permits led to an agreement between the Central Valley and San Francisco Bay Regional Water Quality Control Boards, where sites in the Central Valley Region (Region 5) will continue to be sampled as part of the creek status monitoring required by both permits, with monitoring and reporting requirements prevailing under the jurisdiction of the Region 2 MRP (Order No. R2-2019-0004)[3].

Beginning in 2010, members of the Bay Area Stormwater Management Agencies Association (BASMAA) formed the Regional Monitoring Coalition (RMC) to collaboratively implement the monitoring requirements found in provision C.8 of the MRP. The participants of the RMC are listed in Table 1.1. The BASMAA RMC developed a quality assurance project plan (QAPP) (BASMAA, 2020), standard operating procedures (SOPs) (BASMAA, 2016), 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 design category are specified in Table 1.2.

[1] The 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 Nov. 19, 2015 (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.

[2] The CVRWQCB issued the East Contra Costa County municipal NPDES permit (Central Valley Permit, Order No. R5-2010-0102) on Sept. 23, 2010 (CVRWQCB, 2010). This permit is now superseded by Order R2-2019-0004, incorporating the eastern portion of Contra Costa County within the requirements of the MRP (Order No. R2-2015-0049).

[3] The SFBRWQCB, per agreement with the CVRWQCB, adopted Order No. R2-2019-004 on Feb. 13, 2019.

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)	Cities of Antioch, Brentwood, Clayton, Concord, Town of Danville, El Cerrito, Hercules, Lafayette, Martinez, Town of Moraga, Oakley, Orinda, Pinole, Pittsburg, Pleasant Hill, Richmond, San Pablo, San Ramon, 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 Elements per MRP Provisions C.8.d. and C.8.g., Monitored as Either Regional/Probabilistic or Local/Targeted Parameters

Bioassessment, physical habitat assessment, CSCI	X	X[1]
Nutrients (and other water chemistry associated with bioassessment)	X	X[1]
Chlorine	X	X[2]
Water toxicity (wet and dry weather)	NA	NA
Water chemistry (pesticides, wet weather)	NA	NA
Sediment toxicity (dry weather)	NA	NA
Sediment chemistry (dry weather)	NA	NA
Continuous water quality (sondes data: temperature, dissolved oxygen, pH, specific conductance)		X
Continuous water temperature (data loggers)		X
Pathogen indicators (bacteria)		X

CSCI California Stream Condition Index

1 Provision C.8.d.i.(6) allows for up to 20 percent of sample locations to be selected under a targeted monitoring design. This design change was made under MRP Order No. R2-2015-0049.

2 Provision C.8.d.ii.(2) provides options for probabilistic or targeted site selection. In WY 2020, chlorine was measured at probabilistic sites.

NA Monitoring parameter not specific to either monitoring design

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 (Table 1.2). The report documents the results of targeted monitoring performed by Contra Costa Clean Water Program (CCCWP) during WY 2020. Together with the creek status monitoring data reported in Regional/ Probabilistic Creek

Status Monitoring Report: Water Year 2020 (ARC, 2021), this submittal fulfills monitoring and reporting requirements for creek status monitoring in provisions C.8.d and C.8.g of the permit and complies with reporting provision C.8.h.iii of the MRP (SFBRWQCB, 2015). The remainder of this report describes the study area and design (Section 2), monitoring methods (Section 3), results and discussion (Section 4), and next steps (Section 5).

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2. 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 which fall within the jurisdiction of the SFBRWQCB. Figure 2.1 displays the BASMAA RMC area and illustrates the boundary of the State Water Resources Control Board (Regions 2 and 5) within Contra Costa County. 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.

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.

2.2. Contra Costa County Targeted Monitoring Areas and Siting Rationale

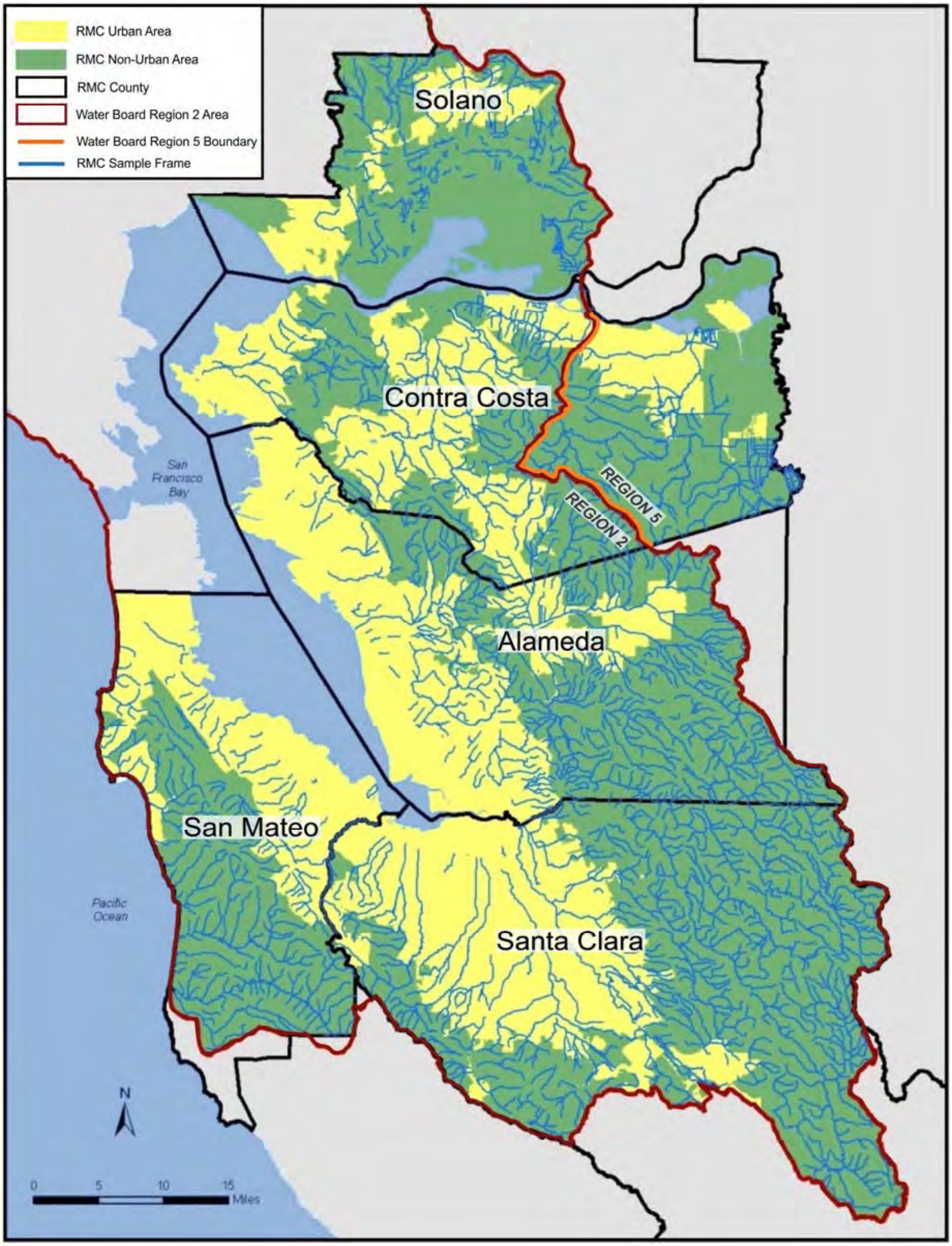
In WY 2020, four of the county's watersheds were the focus of targeted general water quality or water temperature monitoring, while five locations were selected for pathogen indicator sampling. In Region 2, the Pinole Creek, Upper San Leandro Creek, and Walnut Creek watersheds were selected for continuous water temperature monitoring, while locations along Alhambra Creek, Grayson Creek, Las Trampas Creek, Refugio Creek and San Ramon Creek were sampled for pathogen indicators. In Region 5, the Marsh Creek watershed was targeted for continuous general water quality and water temperature monitoring. Details discussing the WY 2020 siting rationale and watershed overview are discussed below.

2.2.1. Pinole Creek

Pinole Creek is a perennial stream which drains the 9,705-acre Pinole Creek watershed in western Contra Costa County. With headwaters in the Briones Hills, Pinole Creek flows roughly northwest to San Pablo Bay across woodlands, private ranchlands, and lightly developed urban landscapes. The central reaches of Pinole Creek and its tributaries run approximately six miles through a broad, open valley with a relatively intact floodplain until reaching the urbanized area around the Pinole city limits. The City of Pinole occupies the northern third of the watershed, which was originally settled in the broad alluvial floodplain of Pinole Creek. As Pinole Creek descends from the East Bay foothills into the Town of Pinole, Interstate 80 forms a man-made margin where the natural stream channel gives way to confined flood control channels. The length of the longest branch of the creek is 10.95 miles with an estimated mean daily flow of 10.4 cubic feet per second (CCCDD, 2004).

CCCWP selected two locations in the Pinole Creek watershed during WY 2020, targeted for continuous water temperature monitoring. Site 206PNL029, the more downstream of the two monitoring stations, was located adjacent to the Pinole Library along Pinole Valley Road. The most upstream

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



location of the two sites, station 206R01495, was deployed upstream of Pinole Valley Park, roughly two-thirds of the way up the Pinole Valley Watershed. The downstream location was selected to monitor the boundary between WARM and COLD beneficial uses at Pinole Creek near the Pinole Library, while the most upstream location was selected to monitor the upper watershed for current water temperature conditions in a steelhead stream. Both sites are listed as having COLD freshwater habitat and maintain potential steelhead rearing locations in Pinole Creek.

2.2.2. Upper San Leandro Creek Watershed – Moraga Creek Sub-watershed

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 the East Bay Municipal Utility District (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 make up the local jurisdictions in the watershed. Portions of Moraga Creek are routed underground, to accommodate urbanization and infrastructure-based development. Targeted monitoring for WY 2020 took place in Moraga Creek as it flows through the Moraga Country Club at St. Andrews Drive in the City of Moraga.

Moraga Creek is a relatively short creek, flowing 4.7 miles before entering Upper San Leandro Reservoir on San Leandro Creek. Via San Leandro Creek, Moraga Creek's waters eventually flow into San Francisco Bay. In the Moraga Creek sub-watershed, unincorporated county lands, including portions of protected watershed managed by the EBMUD and East Bay Regional Parks District, keep the watershed's developed area at 25 percent. The developed area of the watershed consists mainly of small ranches and single-family homes, while impervious surface makes up only 15 percent of the total watershed area. Because of the rain shadow generated by the southern extent of the East Bay Hills, annual rainfall in this watershed is some of the highest in the county, ranging from 28 to 33 inches per year. Continuous water temperature monitoring was targeted in Moraga Creek in WY 2020 to determine if the stream is meeting the designated beneficial use as a COLD freshwater habitat (CCCDD, 2004).

2.2.3. Walnut Creek Watershed – Las Trampas Creek Sub-watershed

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).

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 73 percent of its stream channel remains in a natural or earthen state, with the remaining portion containing hardened 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).

There is one location in the Walnut Creek watershed, on Las Trampas Creek, targeted for continuous water temperature monitoring in WY 2020. Las Trampas Creek is a sub-watershed to Walnut Creek, with a 12.37-mile branch 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 sub-watershed 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 sub-watershed is calculated at 13.5 percent (CCCDD, 2003). CCCWP monitored locations in the Las Trampas Creek sub-watershed in water years 2017 and 2018 and discovered water temperature and continuous water quality exceedances (ADH, 2018). As data from previous years suggest water temperature in Las Trampas Creek may be impacting its designated beneficial use, continuous water temperature was targeted in WY 2020.

2.2.4. Marsh Creek

The Marsh Creek watershed lies in the northeastern part of Contra Costa County. The headwaters flow from the eastern flank of Mount Diablo, across the Morgan Territory preserve and Mount Diablo foothills into Marsh Creek Reservoir. From its headwaters, Marsh Creek experiences a range of geologic, hydrologic, and topographic changes as it descends steep rocky terrain and enters the alluvial plain downstream of the Marsh Creek Reservoir. The second largest watershed in the county, it encompasses over 60,000 acres and flows 34.57 miles before exiting into the Sacramento-San Joaquin River Delta at Big Break Regional Shoreline (CCCWP, 2003).

Historically, Marsh Creek meandered through the alluvial plain area north of the Marsh Creek reservoir. After the turn of the century, however, farmers and flood control authorities altered the channel and surrounding landscape to protect agricultural resources which have served the area since the mid-1800s. This intended alteration of flow, including the building of levees, dams, detention basins and reservoirs, led to a severe reduction in riparian vegetation and habitat, lending to significant development within the City of Brentwood (CCCWP, 2003). The alteration from the creek's natural state in the lower watershed, along with active and historic agricultural use and growing urban development, make the Marsh Creek watershed a continued location for targeted monitoring by CCCWP when determining urban impacts on receiving waters to the Sacramento-San Joaquin Delta.

CCCWP selected two locations for continuous monitoring in the Marsh Creek watershed during WY 2020, targeted for continuous general water quality. The upstream monitoring station (544MSHM2) is located roughly 0.7 miles north of Sunset Road in Brentwood, and the downstream monitoring station (544MSHM0) is located just upstream of the East Cypress Road bridge in the City of Oakley. The two sites were located on either end of the Brentwood Wastewater Treatment Plant, which is located about 0.5 miles east of the junction of Lone Tree Way and Brentwood Boulevard in Brentwood. The upstream monitoring station is approximately 0.2 miles upstream of the Brentwood Wastewater Treatment Plant effluent discharge and reflects Marsh Creek conditions prior to the creek receiving tertiary treated water from the wastewater treatment plant. The downstream station is approximately two miles below the wastewater treatment plant effluent and represents conditions in the lower watershed augmented by flow from the treated effluent discharge. Due to sightings of adult Chinook salmon in the lower end of Marsh Creek in recent years, CCCWP applied COLD beneficial use criteria to targeted monitoring data collected at both stations in Marsh Creek.

2.3. Contra Costa Targeted Monitoring Design

In WY 2020, continuous water temperature, continuous water quality measurements, and pathogen indicator bacteria were monitored at the targeted locations listed in Table 2.1 and illustrated in the overview map (Figure 2.2).

Site locations were identified using a targeted monitoring design based on a directed principle[4] 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?
4. Are conditions in local receiving waters supportive of or likely supportive of beneficial uses?

Within Contra Costa County, the following targeted monitoring was conducted in WY 2020:

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

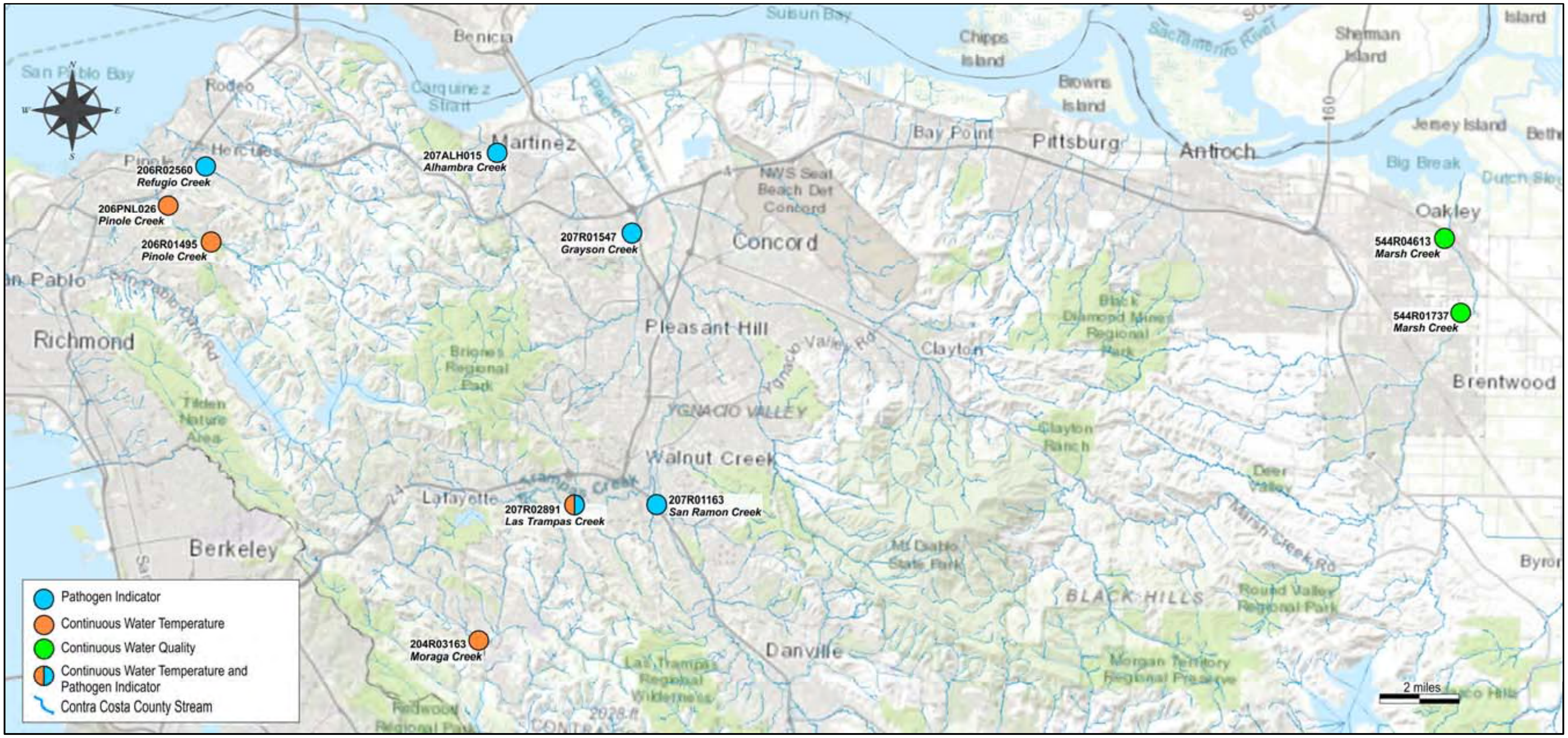
Table 2.1 Targeted Sites and Local Reporting Parameters Monitored in WY 2020 in Contra Costa County

Site Code	Creek Name	Latitude	Longitude	Continuous Water Temperature	Continuous Water Quality	Pathogen Indicator Bacteria
207R02891	Las Trampas Creek	37.88656	-122.09382	X		X
204R03163	Moraga Creek	37.83626	-122.13645	X		
206PNL026	Pinole Creek[1]	37.99233	-122.28403	X		
206R01495	Pinole Creek[2]	37.97938	-122.26379	X		
206R02560	Refugio Creek	38.00750	-122.26671			X
207ALH015	Alhambra Creek	38.01490	-122.13257			X
207R01163	San Ramon Creek	37.88757	-122.05563			X
207R01547	Grayson Creek	37.98657	-122.06986			X
544MSHM2	Marsh Creek[3]	37.96268	-121.68785		X	
544MSHM0	Marsh Creek[4]	37.99046	-121.69599		X	

1 Downstream deployment location
2 Upstream deployment location
3 Monitoring station upstream of Brentwood wastewater treatment plant discharge
4 Monitoring station downstream of Brentwood wastewater treatment plant discharge

[4] 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 2.2 Overview of Targeted Sites Monitored by CCCWP in WY 2020



3. Monitoring Methods

Targeted monitoring data were collected in accordance with the BASMAA RMC QAPP (BASMAA, 2020) and BASMAA RMC SOP (BASMAA, 2016). Where applicable, monitoring data were collected using methods comparable to those specified by the California Surface Water Ambient Monitoring Program (SWAMP) QAPP 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, 2016) and associated QAPP (BASMAA, 2020). These documents are updated as needed to maintain current and optimal applicability. The SOPs were developed using a standard format which describes health and safety precautions and considerations, relevant training, site selection, and sampling methods and procedures, (including pre-fieldwork mobilization activities to prepare equipment), sample collection, and demobilization activities to preserve and transport samples.

Monitoring frequency, timeframe, and number of site details for data evaluated are discussed below.

3.1.1. Continuous Water Quality Measurements

Continuous water quality monitoring equipment (YSI EXO 3) were deployed at two targeted locations each water year. Continuous water quality parameters (dissolved oxygen, pH, specific conductance, and water temperature) were recorded every 10 minutes at two stations over two time periods. The equipment was deployed as follows:

- Once during the spring over one to two weeks concurrent with bioassessment sampling (April-early June)
- Once during the summer over one to two weeks at the same sites (late June-September)

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

3.1.2. Continuous Water Temperature Monitoring

During each water year, continuous water temperature monitoring was conducted using digital temperature loggers (Onset® HOBO® Water Temp Pro V2) at four locations in the county. Locations were deployed at targeted sites from April-September in stream reaches that are documented to support cold water fisheries or where either past data or best professional judgment indicates that temperatures may negatively affect the designated beneficial use. Digital temperature loggers were set to record at 60-minute intervals over the course of the monitoring period.

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

3.1.3. Pathogen Indicator Sampling

In compliance with permit requirements, a set of pathogen indicator samples was collected on Aug. 5, 2020 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 recreational contact with waterbodies. 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, 2016).

3.2. Data Analysis and Interpretation Methods

Targeted monitoring data were evaluated against water quality objectives or other applicable thresholds, as described in provision C.8.d of the MRP. Table 3.1 defines thresholds used for selected targeted monitoring parameters as they apply to WY 2020. The following subsections provide details on MRP thresholds and the underlying rationale.

3.2.1. Dissolved Oxygen (DO)

The Basin Plan (SFBRWQCB, 2019) lists the applicable water quality objective for dissolved oxygen in non-tidal waters as follows: 7.0 mg/L minimum for waters designated as COLD (i.e., a steelhead stream) and 5.0 mg/L minimum for waters designated as WARM (i.e., a non-steelhead stream). Although this water quality objective is a suitable criterion for an initial evaluation of water quality impacts, further evaluation may be needed to determine the overall extent and degree to which cold or warm water beneficial uses are supported at a site. For example, further analyses may be necessary at sites in lower reaches of a water body which may not support salmonid spawning or rearing habitat but may be important for upstream or downstream fish migration. In these cases, dissolved oxygen data will be evaluated for the salmonid life stage and/or fish community 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 threshold in MRP section C.8.d, dissolved oxygen data were evaluated against water quality objectives for both steelhead and non-steelhead streams to determine whether 20 percent or more of the measurements were below the 7.0 mg/L and 5.0 mg/L minimum for COLD and WARM designated beneficial uses, respectively.

Table 3.1 Requirements for Follow-Up for Local/Targeted Creek Status Monitoring Results Per MRP Provision C.8.d

Constituent	Threshold Level[1]	MRP 2 Provision	Provision Text
Water Temperature (continuous, HOBO)	≥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 weekly average temperatures exceed the Maximum Weekly Average Temperature of 17° C for a steelhead stream, or when 20% of the results at one sampling station exceed the instantaneous maximum of 24° C. Permittees shall calculate the weekly average temperature by breaking the measurements into non-overlapping, 7-day periods.
Water Temperature (continuous, sondes)	A weekly average >17° C (steelhead streams); or 20% of results >24° C instantaneous maximum (per station)	C.8.d.iv.(4)a.	The Permittees shall calculate the weekly average temperature by separating the measurements into non-overlapping, 7-day periods. The temperature trigger is defined as any of the following: a. Maximum Weekly Average Temperature exceeds 17° C for a steelhead stream, or 20% of the instantaneous results exceed 24° C.
pH (continuous, sondes)	≥20% results <6.5 or >8.5	C.8.d.iv.(4)b.	The pH trigger is defined as 20% of instantaneous pH results are <6.5 or >8.5.
Specific Conductance (continuous, sondes)	≥20% results >2000 µS	C.8.d.iv.(4)c.	The specific conductance trigger is defined as 20% of the instantaneous specific conductance results are >2000 µS, or there is a spike in readings with no obvious natural explanation.
Dissolved Oxygen (continuous, sondes)	≥20% results <7 mg/L (cold water fishery streams); or 20% of results <5 mg/L (warm-water fishery streams)	C.8.d.iv.(4)d.	The dissolved oxygen trigger is defined as 20% of instantaneous dissolved oxygen results are <7 mg/L in a cold-water fishery stream, or 20% of instantaneous dissolved oxygen results are < 5 mg/L in a warm-water fishery stream
Enterococci	>130 CFU/100 mL	C.8.d.v.(4)	If USEPA'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 USEPA'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 which trigger listings as candidate SSID projects per MRP provision C.8.e.
CFU colony forming unit
MPN most probable number
SSID stressor/source identification

3.2.2. Hydrogen Ion Concentration (pH)

The applicable water quality objective for pH in surface waters is stated in the Basin Plan (SFBRWQCB, 2019) 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 threshold 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 water quality objectives.

3.2.3. Specific Conductance

The applicable water quality objective for specific conductance in surface waters is stated in the MRP as follows: 20 percent of instantaneous specific conductance results should not exceed 2,000 µS/cm, or there should not be a spike in readings with no obvious natural explanation.

To evaluate the results against the relevant threshold in MRP provision C.8.d, the specific conductance data were evaluated to determine whether 20 percent or more of instantaneous measurements were outside of the water quality objectives, or if data was determined to have a spike in readings with no obvious natural explanation.

3.2.4. 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 dissolved oxygen, temperature and pH, the temperature trigger threshold specification is defined as follows:

> "…(the) maximum weekly average temperature (MWAT) 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-September. The second cited section applies to temperature data recorded by sonde devices during the two shorter deployment periods in spring and summer.

In either case, the weekly average temperature 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 weekly average temperature 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 weekly average temperatures were calculated over the disjunctive seven-day periods, the last periods not containing 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 can be identified as candidates for a stressor/source identification (SSID) project in the following three ways:

1. If a site had temperature recorded by a HOBO device and two or more weekly average temperatures calculated from the data were above 17° C

2. If a site had temperature recorded by a sonde device and one or more weekly average temperatures calculated from the data were above 17° C (equivalent to determining the MWAT at one of the 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

3.2.5. Pathogen Indicator Bacteria

In 2012, the U.S. Environmental Protection Agency (USEPA) 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 Recreational Water Quality Criteria (RWQC) include two sets of recommendations (Table 3.2). 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 which indicate the presence of fecal contamination; they are not regulations themselves (USEPA, 2012), but are considered to represent established thresholds for the purpose of evaluating threshold triggers per the MRP.

Section C.8.d.v of the MRP requires use of the USEPA statistical threshold value for the 36/1000 illness rate (Recommendation 1; Table 3.2) for determining if a pathogen indicator collection sample site is a candidate for a stressor/source identification project. Because the geometric mean (GM) cannot be determined from the data collected, the MRP also requires use of the standard threshold values (STV) shown in Table 3.2. For data interpretive purposes, colony forming units (CFU) and most probable number (MPN) are considered equivalent.

Table 3.2 USEPA 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[1] (CFU/100 mL)	GM (CFU/100 mL)	STV (CFU/100 mL)
Enterococci	35	130	30	110
E. coli (fresh)	126	410	100	320

1 MRP thresholds
CFU colony forming unit
GM geometric mean
STV standard threshold values

3.3. Quality Assurance/Quality Control Procedures

Data quality assurance and quality control procedures are described in detail in the BASMAA RMC QAPP (BASMAA, 2020). 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, 2016), including appropriate documentation of data sheets and samples, and sample handling and custody. Laboratories providing analytical support to the RMC were selected based on the demonstrated ability to adhere to specified protocols.

3.4. 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 3.3. 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, precision, and contamination (i.e., lab duplicates and lab blanks) were implemented for pathogen samples collected

Table 3.3 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 measurement quality objectives		X
Data review-check for outliers / out of water measurements	X	X

4. Results

Following is a summary of water quality data monitored by CCCWP in WY 2020.

4.1. Statement of Data Quality

Field data sheets and laboratory reports were reviewed by the local quality assurance officer and results were evaluated against relevant data quality objectives. Results were compiled for qualitative metrics (representativeness and comparability) and quantitative metrics (completeness, precision, and accuracy) in accordance with the BASMAA RMC QAPP (BASMAA, 2020). Results summarizing the WY 2020 data quality assessment are discussed below:

- Hourly water temperature data were recorded at 60-minute intervals from digital data loggers deployed in three creeks at four separate locations: one location each in Las Trampas Creek and Moraga Creek, and two locations in Pinole Creek. Data loggers were deployed on May 27, 2020 and remained deployed until the pickup date of Oct. 5, 2020. As the permit term reporting requirements apply only to the extent of a given water year, all data collected after Sept. 30, 2020 were not included in this report. One hundred percent of the expected data were collected at all four locations. Due to the Covid-19 pandemic, instrument deployment dates were postponed from early April to late May.

- Continuous water quality data (water temperature, pH, dissolved oxygen, and specific conductance) were continuously monitored at 10-minute intervals by sonde devices during two time periods (June 9-24 and Sept. 3-16, 2020) in two locations along Marsh Creek. One hundred percent of the expected data were collected at both locations. Data logging intervals were increased in WY 2020, from 15 minutes to 10 minutes, as data collected were part of an ongoing SSID study.

- Quality assurance laboratory procedures were implemented for pathogen indicator analyses this year. All quality assurance samples successfully met data quality objectives.

- An assessment of the continuous water quality data related to data quality objectives for accuracy in water year 2020 is presented in Table 4.1. All accuracy measurements generally met the data quality objectives in WY 2020. YSI EXO3 pH probe sensors were replaced on both devices following the June deployment period and resulted in less sensor drift during the monitoring period on both instruments.

Table 4.1 Accuracy[1] Measurements Taken for Dissolved Oxygen, pH and Specific Conductance

Parameter	Measurement Quality Objectives	544MSHM2 Marsh Creek		544MSHM0 Marsh Creek	
		June	September	June	September
Dissolved oxygen (mg/l)	± 0.5 or 10%	2.0%	-4.5%	1.9%	-0.7%
pH 7.0	± 0.2	0.20	-0.10	0.03	-0.08
pH 10.0	± 0.2	0.60	-0.08	0.40	-0.16
Specific conductance (µS/cm)	± 10%	-0.1%	-1.1%	1.7%	1.1%

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

Values in **bold** exceed the measurement quality objective.

4.2. Water Quality Monitoring Results

All targeted water quality monitoring data were evaluated against numeric trigger thresholds, as described in MRP provision C.8.d. These thresholds, which include applicable numeric water quality objectives or other criteria, indicate levels at which additional follow-up may be required under the MRP. Targeted monitoring locations for WY 2020 were located within both SFBRWQCB Region 2 and CVRWQCB Region 5 boundaries. The results are presented below.

4.2.1. Continuous Water Temperature (HOBO)

Summary statistics for continuous water temperature data collected at the four monitoring locations from May through September 2020 are shown in Table 4.2. At Las Trampas Creek, Moraga Creek and both Pinole Creek locations, approximately 127 days of hourly temperature data were collected. All data were collected successfully with no device issues or equipment movement, resulting in 100 percent capture of targeted data. Because of the COVID-19 pandemic and shelter in place order, field staff delayed the deployment date from early April until late May.

Table 4.2 Descriptive Statistics for Continuous Water Temperature Measured at Four Sites in Contra Costa County (Las Trampas Creek, Moraga Creek and Pinole Creek) – May 27-Sept. 30, 2020

Site Temperature	207R02891	204R03163	206PNL029	206R01495
	Las Trampas Creek (° C)	Moraga Creek (° C)	Pinole Creek (° C)	Pinole Creek (° C)
Minimum	15.74	15.97	14.57	13.88
Median	19.55	19.57	17.67	17.32
Mean	19.87	19.70	17.81	17.50
Maximum	25.40	23.38	21.48	21.46
MWAT[1]	22.76	22.03	19.86	19.42
Number of Measurements	3,036	3,037	3,039	3,038

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

The minimum and maximum temperature for all four stations was 13.88° C and 25.40° C, respectively. The median temperature range for all four stations was 17.32° C to 19.57° C, and the MWAT range was 19.86° C to 22.76° C.

Continuous water temperature data measured at each station are presented in Figure 4.1. The weekly average temperature (WAT) data, WAT threshold of 17° C and acute threshold of 24° C for juvenile salmonid rearing (steelhead streams) are illustrated in Figures 4.2 and 4.3.

Figure 4.1 Water Temperature Data Collected at Four Sites in Contra Costa County (Las Trampas Creek, Moraga Creek and Pinole Creek) – May 27-Sept. 30, 2020

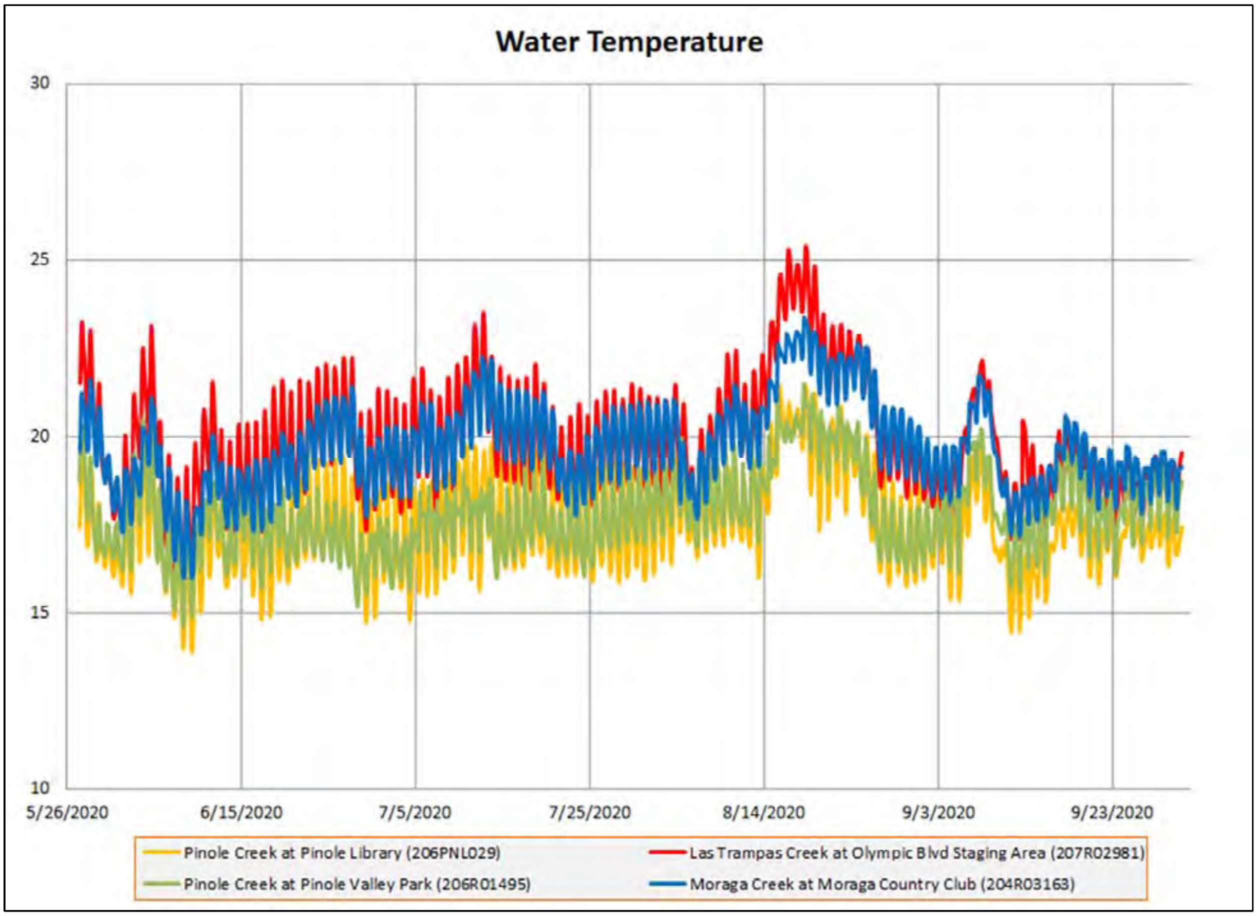


Figure 4.2 Weekly Average Water Temperature Data Collected at Four Sites (Las Trampas Creek, Moraga Creek and Pinole Creek) – May 27-Sept. 30, 2020

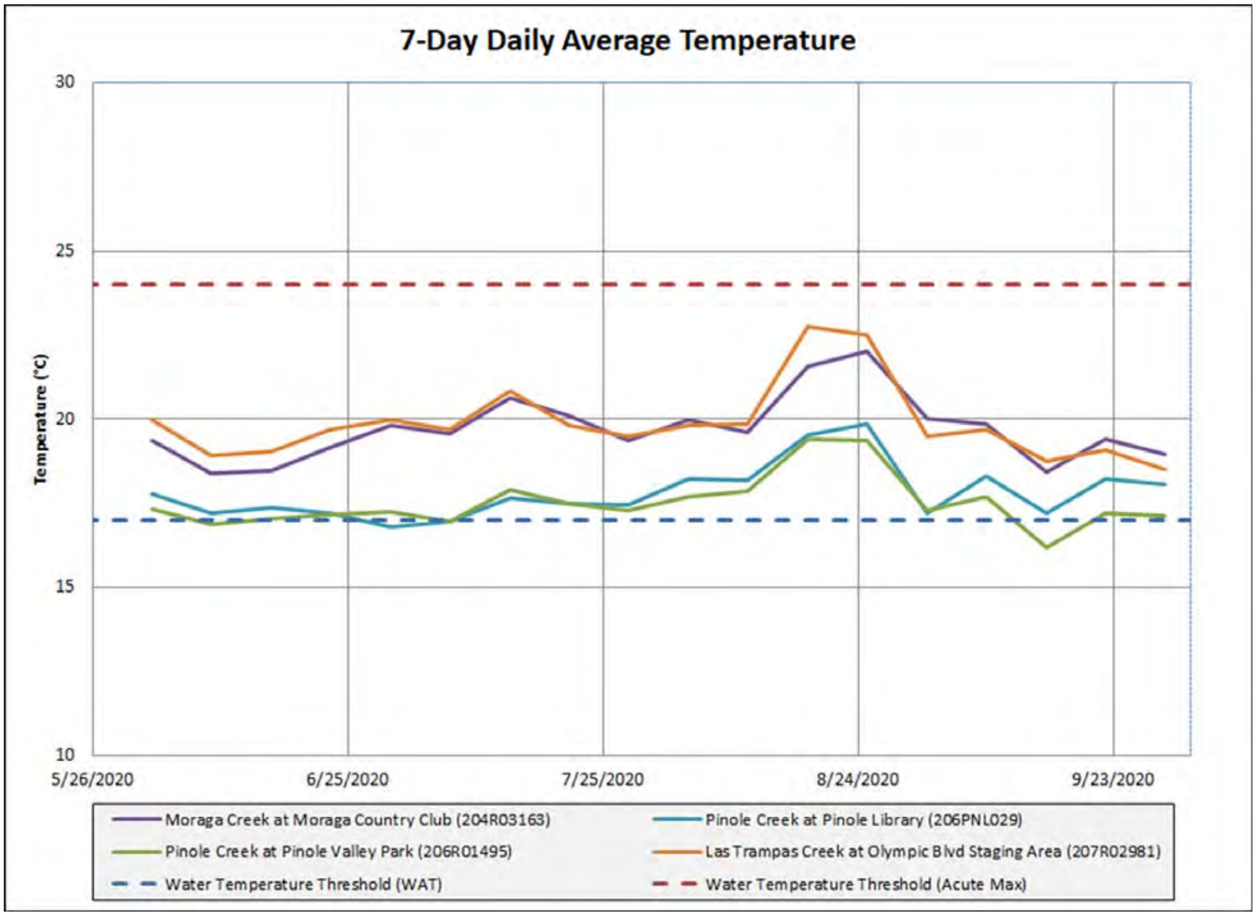
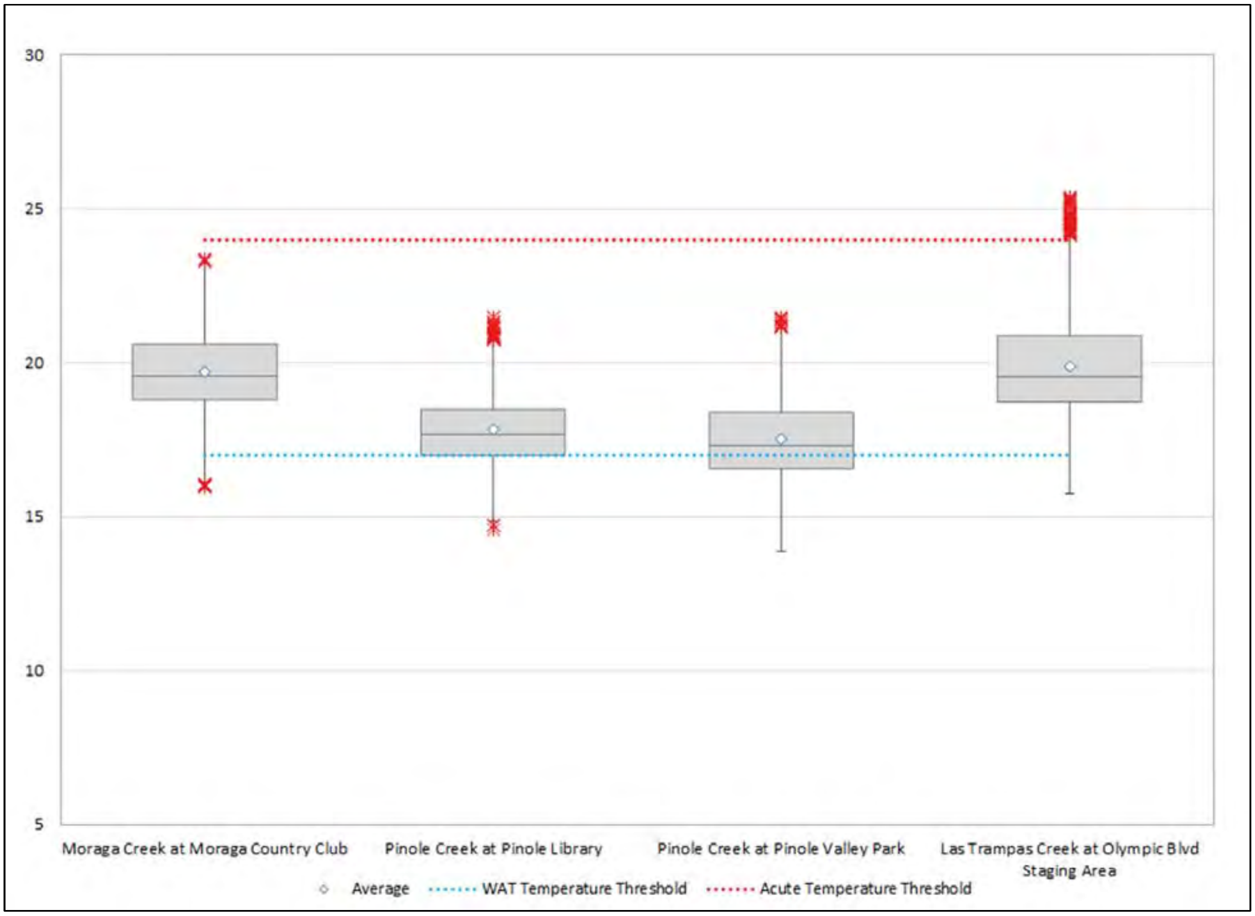


Figure 4.3 Box Plots of Weekly Average Temperature Data Collected at Four Sites in Contra Costa County (Las Trampas Creek, Moraga Creek and Pinole Creek) – May 27-Sept. 30, 2020



Over the course of the monitoring period, weekly average temperatures measured at Las Trampas Creek, Moraga Creek and both Pinole Creek locations exceeded the threshold for steelhead streams (Table 4.3). The number of exceedances ranged from 14 to 18 instances. Therefore, all four stations exceeded the MRP trigger threshold for continuous (HOBO) water temperature (two or more weekly average temperatures over the 17° C threshold; Table 4.3).

Table 4.3 Water Temperature Data Measured at Four Sites in Comparison to MRP WAT Trigger Threshold for Steelhead Streams

Site ID	Creek Name	Monitoring Period	Number of Results Where WAT > 17° C
207R02891	Las Trampas Creek	05/27/2020-09/30/2020	18
204R03163	Moraga Creek	05/27/2020-09/30/2020	18
206PNL029	Pinole Creek[1]	05/27/2020-09/30/2020	16
206R01495	Pinole Creek[2]	05/27/2020-09/30/2020	14

1 Downstream Pinole Creek monitoring station
2 Upstream Pinole Creek monitoring station
WAT weekly average temperature
Values in **bold** exceed MRP criterion

4.2.2. Continuous Water Quality

Summary statistics for continuous water quality measurements collected at both Marsh Creek locations during two separate deployment periods (once in June and once in September) 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 4.4 through 4.7.

Table 4.4 Descriptive Statistics for Daily and Monthly Continuous Water Quality Parameters (Temperature, Dissolved Oxygen, pH and Specific Conductance) Measured in Contra Costa County (Marsh Creek) – June 10-24 and Sept. 3-16, 2020

Parameter		544MSHM2 Marsh Creek[1]		544MSHM0 Marsh Creek[2]	
		June	September	June	September
Temperature (° C)	Minimum	20.79	20.04	20.84	20.76
	Median	24.96	23.32	24.47	23.46
	Mean	25.06	23.79	24.44	23.72
	Maximum	30.03	29.26	27.71	28.10
Dissolved oxygen (mg/l)	Minimum	5.44	2.29	2.84	3.70
	Median	7.57	4.79	9.24	6.26
	Mean	7.74	5.10	9.56	6.90
	Maximum	11.45	12.56	16.98	12.27
pH	Minimum	7.72	7.23	7.19	7.51
	Median	8.10	7.44	8.29	7.76
	Mean	8.15	7.55	8.21	7.82
	Maximum	8.78	8.91	8.98	8.44
Specific conductance (µS/cm)	Minimum	557	661	1028	1140
	Median	616	780	1252	1539
	Mean	634	762	1268	1526
	Maximum	803	873	1523	1698

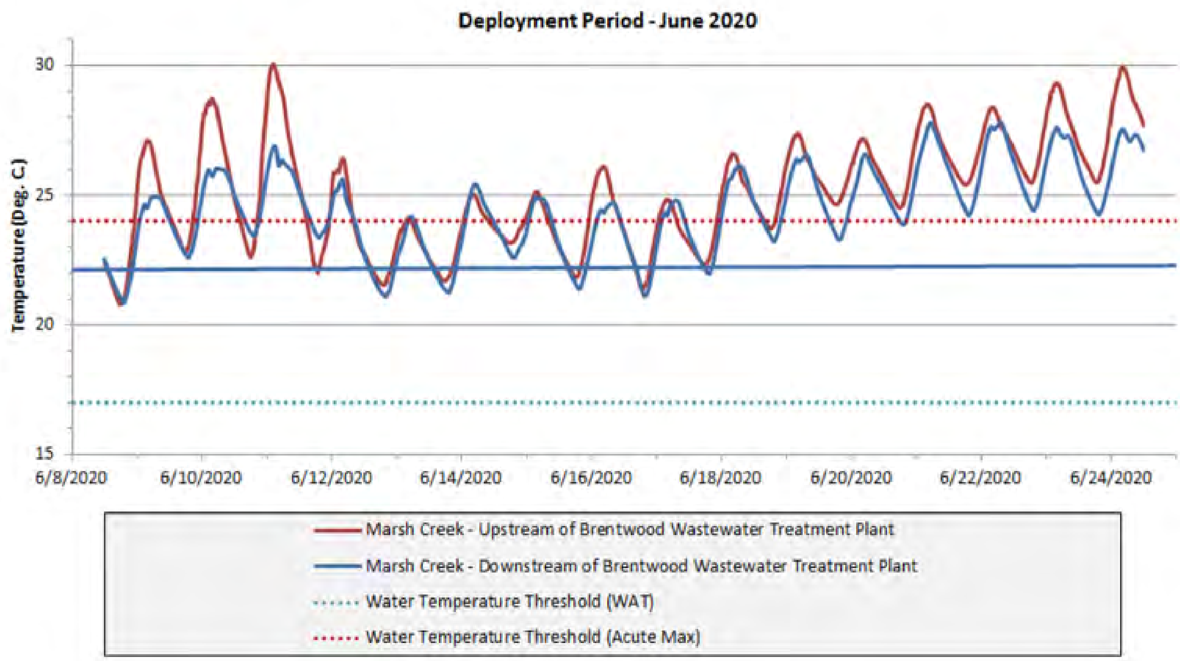
1 Monitoring Station located upstream of Brentwood Wastewater Treatment Plant
2 Monitoring station located downstream of Brentwood Wastewater Treatment Plant

Table 4.5 Weekly Average Temperatures and MWAT Measured at Two Sites Along Marsh Creek for Both Events

Site Name	Creek Name	Monitoring Period	WAT (° C)	MWAT (° C)
544MSHM2	Marsh Creek[1]	06/10/20-06/24/20	24.28, 25.64	25.64
		09/03/20-09/16/20	25.33, 22.24	25.33
544MSHM0	Marsh Creek[2]	06/10/20-06/24/20	23.81, 25.02	25.02
		09/03/20-09/16/20	24.68, 22.75	24.68

1 Monitoring Station located upstream of Brentwood Wastewater Treatment Plant
2 Monitoring station located downstream of Brentwood Wastewater Treatment Plant
MWAT maximum weekly average temperature
WAT weekly average temperature
Values in **bold** exceed MRP criterion of 17° C for steelhead streams

Figure 4.4 Continuous Water Quality Data (Temperature) Measured in Marsh Creek – June 9-24 and Sept. 3-16, 2020



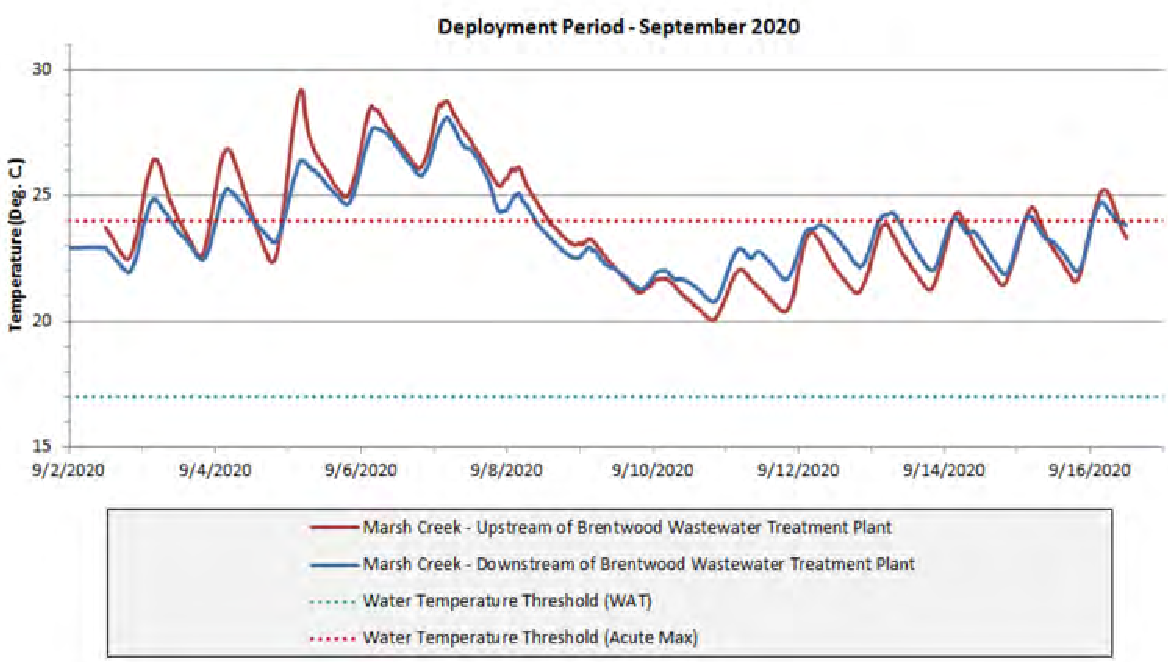
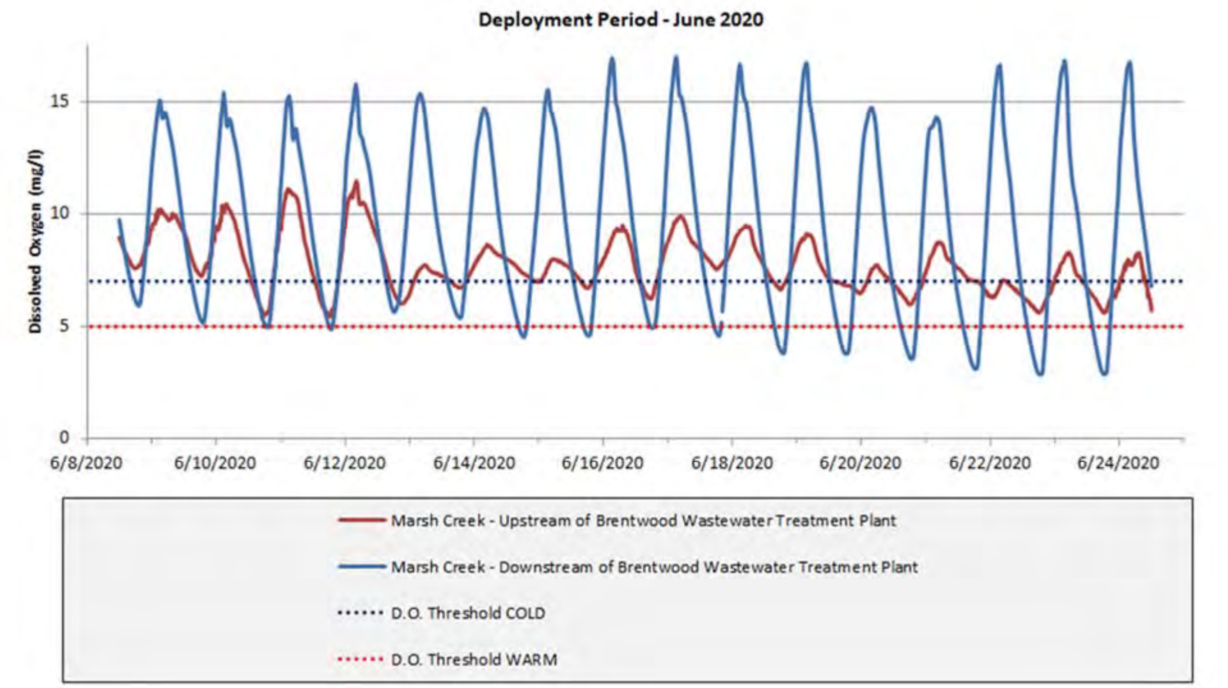


Figure 4.5 Continuous Water Quality Data (Dissolved Oxygen) Measured in Marsh Creek – June 9-24 and Sept. 3-16, 2020



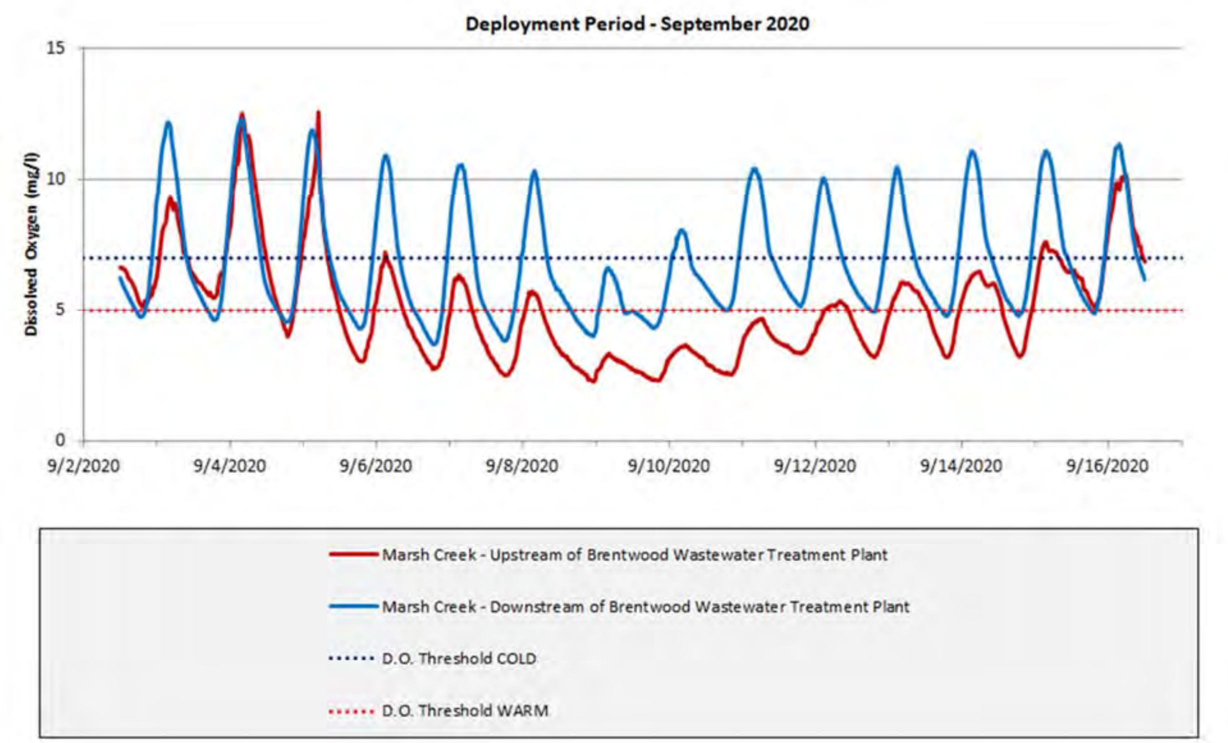
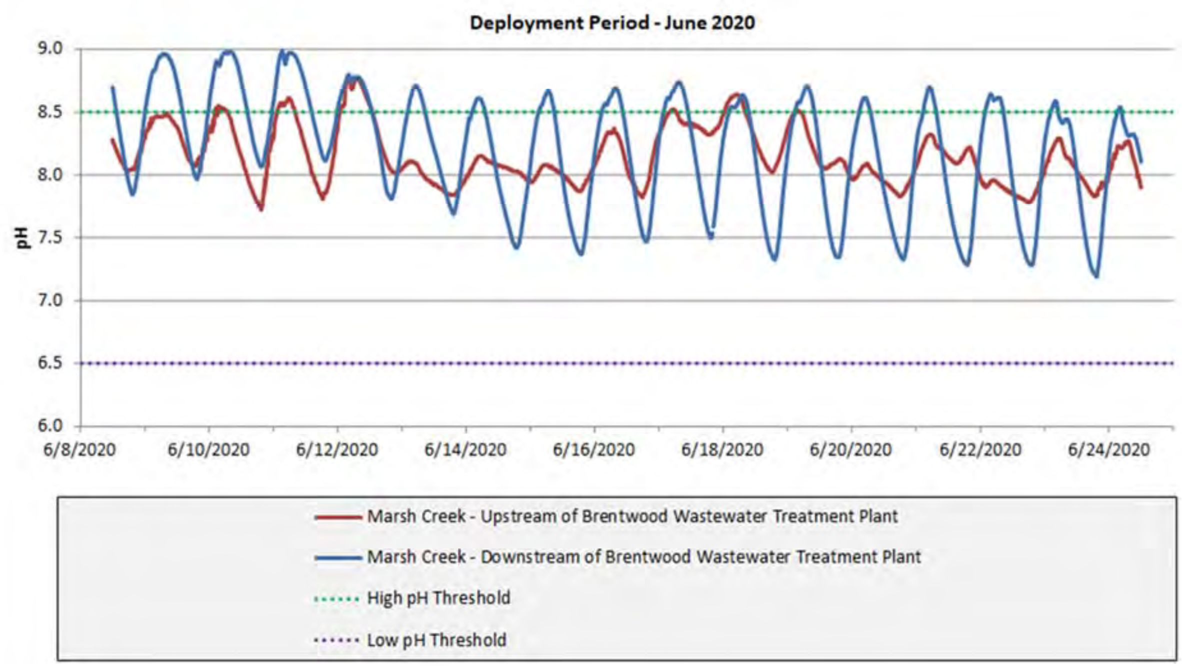


Figure 4.6 Continuous Water Quality Data (pH) Measured in Marsh Creek – June 9-24 and Sept. 3-16, 2020



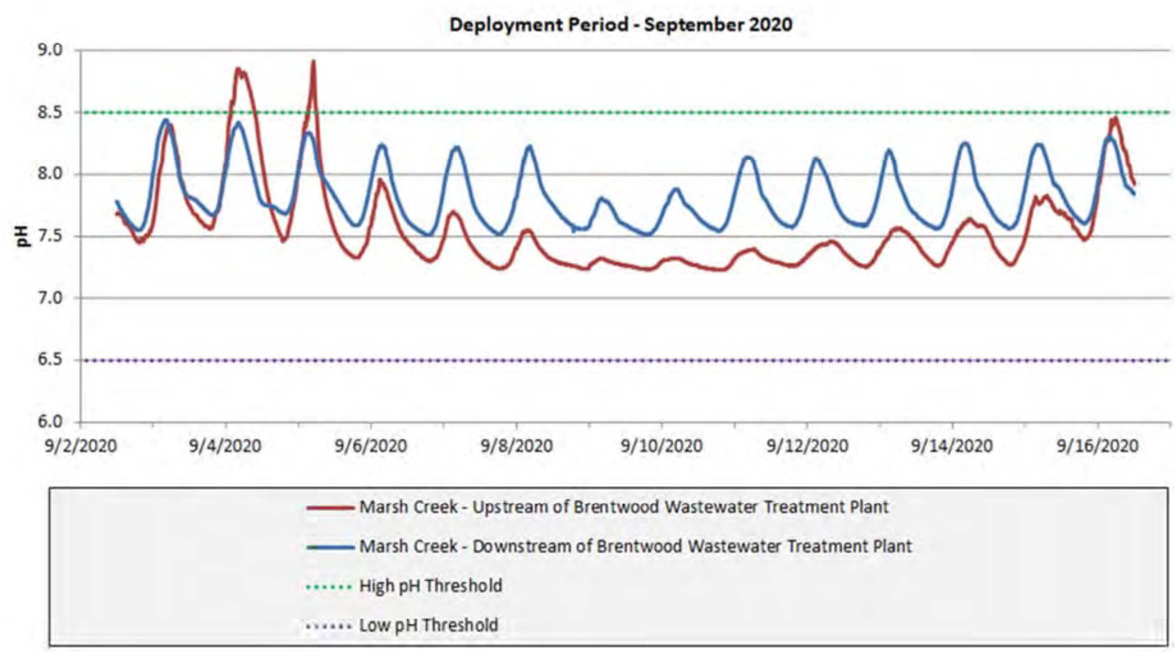
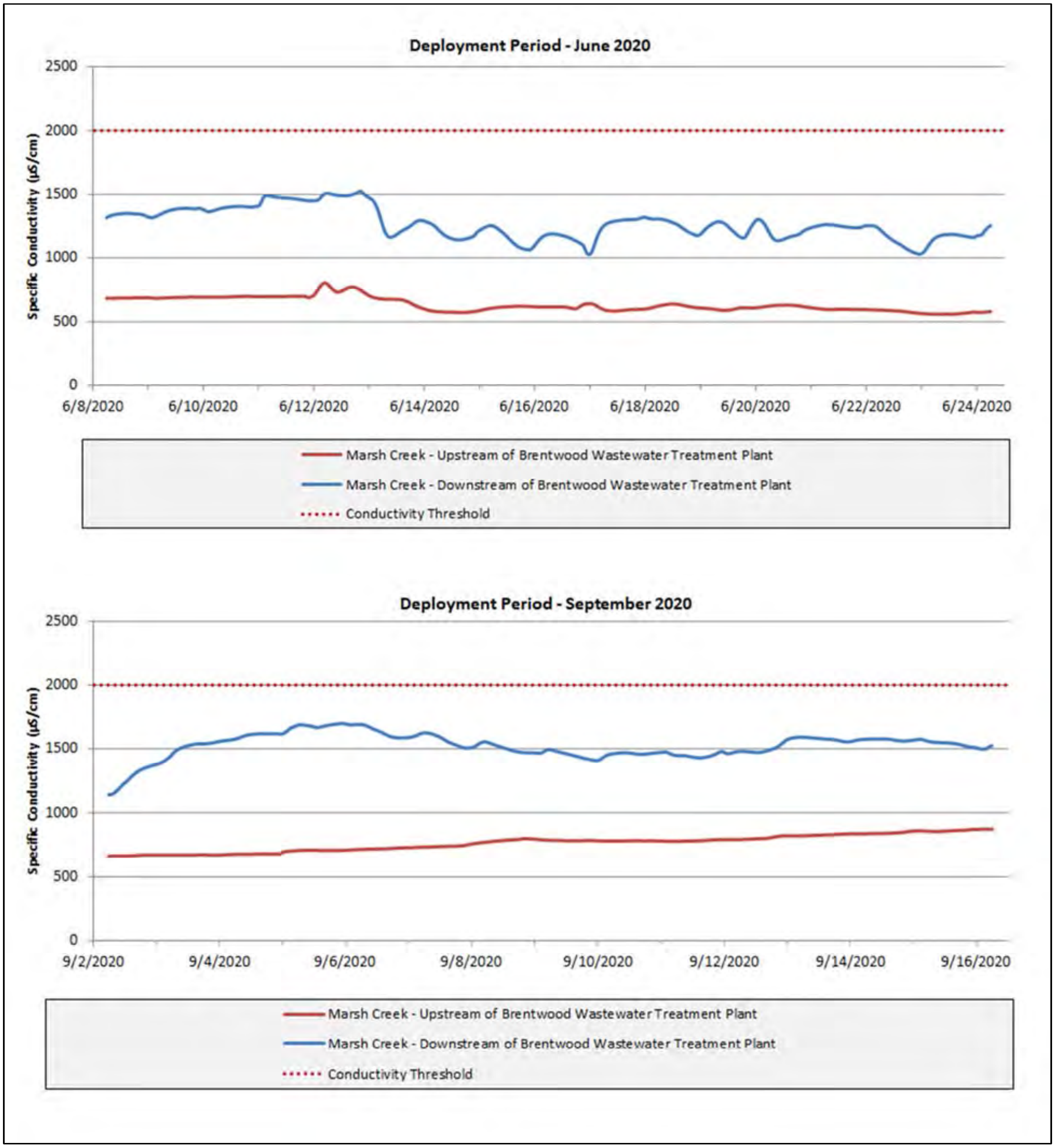


Figure 4.7 Continuous Water Quality Data (Specific Conductance) Measured in Marsh Creek – June 9-24 and Sept. 3-16, 2020



Continuous water temperature data at both sonde stations during the June and September deployment periods display a diurnal cycle typical of the region (Figure 4.4). During the June deployment period, weekly average temperature measurements at both stations measured above the MRP threshold criterion for steelhead streams (Table 4.5). For the September deployment, the weekly average temperature measurement at both Marsh Creek stations were again above MRP threshold criterion. As the Sacramento-San Joaquin River Basin Plan does not designate Marsh Creek to maintain COLD beneficial uses, and the MRP does not specify temperature criterion for WARM designated beneficial uses, these results do not constitute an exceedance, but infer Marsh Creek water temperatures are consistently too warm to continually support Chinook salmon or steelhead during the spring and summer months.

The lowest DO concentration (2.29 mg/l) at the upstream Marsh Creek monitoring station occurred in September 2020. The lowest DO concentration (2.84 mg/l) at the downstream Marsh Creek monitoring occurred in September 2020 as well. The minimum and maximum pH measurements for the upstream Marsh Creek monitoring station during both deployment periods were 7.23 and 8.91, respectively. The minimum and maximum pH measurements at the downstream Marsh Creek monitoring station during both periods was 7.19 and 8.98, respectively (Table 4.4).

During the June and September deployment periods, both Marsh Creek stations show diurnal fluctuations of dissolved oxygen and pH (Figures 4.5 and 4.6); however, this cycle is more pronounced during the June deployment than in September. The seasonal exaggeration is typically a result of instream primary production, as during the late spring and early summer month monitoring periods, longer periods of daylight increase algae production, thus increasing the production and concentration of dissolved oxygen during the day. As the sun sets and during night hours, algae and aquatic plants switch from sunlight-induced photosynthesis to respiration and the consumption of dissolved oxygen. The consumption of dissolved oxygen in the stream by decomposing plants and algae biomass display a more exaggerated diurnal curve. In low gradient sections of stream, where pool habitats do not encounter dry season flow turbulence, conditions of dissolved oxygen in water can reach supersaturated levels, as lack of wind or turbulence does not create a mixing of surface water with atmospheric oxygen, creating conditions where instream primary production can generate dissolved oxygen levels of 14-17 mg/l (Figure 4.5).

Continuous conductivity data at both Marsh Creek monitoring stations display readings typical of the region (Figure 4.7). The median concentration of specific conductance in the upstream Marsh Creek station ranged from 616 µS/cm in June to 780 µS/cm in September. The median concentration of specific conductance in the downstream Marsh Creek stations ranged from 1,252 µS/cm in June to 1,539 µS/cm in September. The increase in median specific conductance values between the two deployment periods is typical of the region, as surface water decreases in the late summer months, the surface water mixes with groundwater recharge percolating through sediment layers, often picking up conductive ions and increasing conductivity in the streams during the late summer months. During both the June and September deployment periods, neither the upstream nor downstream Marsh Creek station exceeded the MRP specific conductance threshold of 2,000 µS/cm.

Table 4.6 presents the percentages of continuous water quality data exceeding the water quality evaluation criteria specified in provision C.8.d of the MRP (Table 3.1) for specific conductance, dissolved oxygen, and pH, as measured at the two Marsh Creek stations during both monitoring periods.

Table 4.6 Percent of Dissolved Oxygen, pH and Specific Conductance Data Measured at Two Sites along Marsh Creek for Both Events Exceeding Water Quality Evaluation Criteria Identified in Table 3.1

Site Name	Creek Name	Monitoring Period	DO Percent Results < 5.0 mg/L	pH Percent Results < 6.5 or > 8.5	Specific Conductance Percent Results >2,000 µS/cm
544MSHM2	Marsh Creek[1]	06/09/20-06/24/20	0%	9%	0%
		09/03/20-09/16/20	**52%**	3%	0%
544MSHM0	Marsh Creek[2]	06/09/20-06/24/20	12%	**33%**	0%
		09/03/20-09/16/20	**20%**	0%	0%

Values in **bold** exceed MRP criterion
1 Monitoring Station located upstream of Brentwood Wastewater Treatment Plant
2 Monitoring station located downstream of Brentwood Wastewater Treatment Plant

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

4.2.2.1. Marsh Creek – upstream of wastewater treatment plant (544MSHM2)

Dissolved oxygen measurements during the September deployment in Marsh Creek station 544MSHM2 exceeded MRP criterion 52 percent of the time (20 percent of instantaneous results <5.0 mg/L; Table 3.1).

4.2.2.2. Marsh Creek – downstream of wastewater treatment plant (544MSHM0)

During the June 2020 deployment, pH levels in Marsh Creek station 544MSHM0 fell below or exceeded MRP threshold criterion 33 percent of the time, exceeding MRP threshold criterion (20 percent or more of values exceed the applicable threshold). During the September deployment, dissolved oxygen measurements exceeded MRP criterion 20 percent of the time, exceeding MRP trigger thresholds for dissolved oxygen.

4.2.3. Continuous Water Quality Data Evaluation for Steelhead Suitability

The potential responsive action to the analysis of continuous water temperature and water quality data as it relates to fish habitat in Las Trampas Creek, Moraga Creek, Pinole Creek and Marsh Creek is discussed below.

4.2.3.1. Las Trampas Creek – 207R02891

Water Temperature

The 2020 continuous water temperature monitoring station at Las Trampas Creek recorded a median temperature of 19.55° C and an MWAT of 22.76° C (Table. 4.2). The WAT failed to meet the 17° C threshold criterion during all eighteen weeks of deployment (Table 4.3). The acute instantaneous water temperature criterion of 24° C was exceeded during the day from August 15-19, with the highest recorded temperature of 25.40° C occurring on Aug. 18, 2020. Acute instantaneous temperatures exceeded the

24° C temperature criterion for less than 20 percent of the monitoring period, and therefore do not constitute an exceedance.

Steelhead Suitability

Fed by several tributaries including Lafayette Creek, Las Trampas Creek joins with San Ramon Creek to form Walnut Creek on the south side of the City of Walnut Creek. The Basin Plan for the San Francisco Bay Region designates Las Trampas Creek as having both COLD and WARM beneficial uses, indicating 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 months.

Historically, the Walnut Creek watershed supported a population of steelhead and Coho salmon until the mid-1960s. Although Las Trampas Creek once supported steelhead, as did most of the Walnut Creek drainage, the construction of drop structures on Walnut Creek downstream of the City of Walnut Creek prevent steelhead access to the watershed at present. The upper watershed of Las Trampas Creek is thought to support resident rainbow trout, as determined by its proximity to resident rainbow trout located in Lafayette Creek and Lafayette Reservoir; however, no steelhead migration is present. As summer temperatures recorded in this portion of creek in 2017, 2018 and again in 2020 consistently exceeded WAT temperature criterion, this location on Las Trampas Creek is thought to be marginal or prohibitive for steelhead rearing. It is possible that rainbow trout still survive in the upper portions of the Las Trampas Creek watershed above the confluence with Lafayette Creek; however, high summer water temperatures at the targeted monitoring station in WY 2020 may suggest why resident rainbow trout have not been observed in the surrounding area. Continuous water temperature results from 2017, 2018 and again in 2020 make this area of Las Trampas Creek unsuitable for rearing habitat and may not provide more than a migratory corridor for the resident rainbow trout in Lafayette Creek.

4.2.3.2. Moraga Creek – 204R03163

Water Temperature

At the Moraga Creek continuous water temperature monitoring station, the median water temperature was 19.57° C and the MWAT was 22.03° C (Table 4.2). The WAT failed to meet the 17° C threshold criterion during all eighteen weeks of deployment (Table 4.3). There were no exceedances of the acute instantaneous water temperature criterion of 24° C, as the maximum recorded temperature was 23.38° C.

Steelhead Suitability

Moraga Creek, along with its tributaries Laguna Creek and Rimer Creek, drain into Alameda County via the Upper San Leandro River to the San Leandro Reservoir. Historically, steelhead migrated up San Leandro Creek to its headwater tributaries, including Moraga Creek in Contra Costa County. There are presently three reservoirs on San Leandro Creek located between Moraga 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, but a remnant population of anadromous steelhead still spawn downstream of Lake Chabot when rains and runoff are suitable (Leidy et al., 2005).

Upper San Leandro Creek's tributaries flowing into Upper San Leandro Reservoir, including Moraga Creek, mostly all support populations of resident rainbow trout. East Bay Regional Parks District and the California Department of Fish and Wildlife both found rainbow trout in Moraga Creek during electrofishing studies in the 1980s and 1990s. More recently, Bert Mulchaey of EBMUD confirmed that rainbow trout from upper San Leandro Reservoir likely migrate up the tributary streams to spawn and rear juvenile fish in Moraga Creek and its tributaries. While no longer supporting an anadromous steelhead population traveling from San Leandro Creek to San Francisco Bay, Moraga Creek still provides spawning and rearing habitat for resident rainbow trout descended from this steelhead population (Leidy et al., 2005).

While Moraga Creek did not experience any acute instantaneous temperature exceedances of 24° C, the failure to meet the 17° C WAT criterion during all 18 weeks of deployment indicate the area of Moraga Creek adjacent to Moraga Country Club may be unsuitable for rearing habitat during the summer months. With the potential for Moraga Creek to support rainbow trout from nearby San Leandro Reservoir, continuous temperature and water quality monitoring may be targeted in WY 2021.

4.2.3.3. Pinole Creek – 206PNL029 and 206R01495

Water Temperature

At the downstream Pinole Creek continuous water temperature monitoring station (206PNL029), the median water temperature was 17.67° C and the MWAT was 19.86° C (Table 4.2). The 17° C WAT criterion was exceeded on 16 occasions, five times during the monitoring period of May 27-June 23, and 11 times during the monitoring period of July 8-Sept. 30, 2020.

At the upstream Pinole Creek continuous water temperature monitoring station (206R01495), the median water temperature was 17.32° C and the MWAT was 19.42° C (Table 4.2). The 17° C WAT criterion was exceeded on 14 occasions, once during the monitoring period of May 27-June 3, three times during the monitoring period of June 10-30, eight times during the monitoring period from July 8-Sept. 8, and two more times during the monitoring period of Sept. 16-30, 2020.

The 24° C acute water temperature threshold was not exceeded on any occasion at either of the Pinole Creek monitoring stations.

Steelhead Suitability

Draining into San Pablo Bay, Pinole Creek has historically sustained a population of steelhead. Several adult steelhead have been observed in the creek during the past decade, and roughly 5.8 miles of Pinole Creek are suitable and available habitat for steelhead (Becker et al., 2007). The San Francisco Estuary Watersheds Evaluation Report states that EBMUD biologists consider suitable steelhead rearing habitat to exist in Pinole Creek from Ramona Street in the City of Pinole to Bear Creek Road in the upper watershed, while the lower reach of Pinole Creek from San Pablo Bay to the Highway 80 culvert has little spawning and rearing habitat as it is channelized and extensively exposed to solar radiation (Becker et al., 2007).

In 2014, the Contra Costa Resource Conservation District coordinated a fish passage improvement project in Pinole Creek as it passes under Interstate 80. Due to extensive flood control engineering efforts in the 1950s, channel modifications to restrain floodwaters generated a barrier to upstream migration in both the wet and dry seasons by altering stream flow and velocity at the culvert. During the dry season, low flows were distributed across two culverts, reducing creek stages to levels too shallow to allow steelhead passage. During the wet season, stream velocity during storm flows was elevated due to the artificial channel dynamics. The high velocities experienced during storm flows at shallow depths and long distances constituted an upstream barrier in the creek, where the conditions in which stream flow velocity allowed fish passage rarely occurred (ADH, 2018).

Completed in 2016, the fish passage improvement project restores the upstream migration of steelhead from the lower part of Pinole Creek at the Interstate 80 culvert, upstream to suitable spawning habitat in Upper Pinole Creek. The 2020 HOBO monitoring locations in Pinole Creek were targeted to measure water temperature as it relates to fish habitat in the newly accessible areas of Pinole Creek. Upstream of the Interstate 80 culvert and approximately 500 feet downstream of Ramona Street, monitoring station 206PNL029 is roughly the divide between the Basin Plan's WARM and COLD beneficial use designations for Pinole Creek. Monitoring station 206R01495, located approximately two thirds of the way up Pinole Valley on the eastern edge of substantial residential development, is in a section of stream characteristic of available Upper Pinole Creek steelhead habitat.

At both the downstream location in Pinole Creek near the Pinole Library and the upstream location near Pinole Valley Park, the HOBO monitoring locations failed to meet WAT temperature criteria for a steelhead stream. As the upstream monitoring station is located 0.5 miles upstream of Simas Avenue, considered to be the dry year lower limit reach suitable for steelhead rearing water temperatures, this area of Pinole Creek could be targeted for further continuous temperature and water quality monitoring as summer water temperatures here also exceeded MRP criteria in 2018.

4.2.3.4. Marsh Creek – upstream of wastewater treatment plant (544MSHM2)

Water Temperature

The 2018 edition of the Basin Plan for the Sacramento River Basin and San Joaquin River Basin designates Marsh Creek as having a WARM beneficial use. Because the Basin Plan does not list Marsh Creek as having a COLD designated beneficial use, steelhead stream exceedance criterion does not apply here. However, due to adult Chinook salmon having been observed in recent years in this portion of Marsh Creek, steelhead stream criteria will be applied to Marsh Creek in this analysis.

The sonde monitoring location at Marsh Creek above the Brentwood Wastewater Treatment Plant recorded median temperatures of 24.96° C and 23.32° C for the June and September deployments, respectively (Table 4.4). The temperature at the sonde monitoring location during both the June and September deployments exceeded the 17° C WAT threshold criterion, and also exceeded the 24° C acute threshold for 65 percent and 39 percent of the recorded June and September monitoring periods, respectively. As Marsh Creek does not maintain a COLD beneficial use, these results do not constitute an exceedance according to MRP criterion.

The MWAT over the two deployment periods was 25.64° C and 25.33° C (Table 4.5).

Dissolved Oxygen

During the June and September deployment periods in Marsh Creek, dissolved oxygen levels at station 544MSHM2 dropped below the minimum steelhead stream criterion during 30 and 85 percent of the recorded monitoring periods, respectively. As Marsh Creek does not maintain a designated beneficial use of a steelhead stream, these results do not constitute an exceedance in accordance with MRP criterion (Table 3.1). Steelhead stream criterion for dissolved oxygen were applied to Marsh Creek to investigate the suitability of providing habitat for Chinook salmon identified in the stream during recent years. As Marsh Creek currently maintains a WARM beneficial use, dissolved oxygen criteria for non-steelhead streams were also applied (20 percent of instantaneous results shall not be depressed below 5.0 mg/L) to determine water quality exceedances per MRP criteria.

During the June deployment period, dissolved oxygen levels always met Basin Plan criteria for non-steelhead streams (Table 4.6). There was no WARM dissolved oxygen exceedance during the June deployment. During the September deployment period, dissolved oxygen levels for a non-steelhead stream dropped below Basin Plan criteria for 52 percent of recorded measurements, indicating an exceedance per MRP criteria.

pH

The pH of Marsh Creek station 544MSHM2 exceeded Basin Plan criteria (Table 3.1) during 9 and 3 percent of the recorded June and September monitoring periods, respectively (Table 4.6). As this is below the 20 percent threshold, these measurements do not exceed the MRP criterion for follow-up.

Specific Conductance

The median specific conductance in Marsh Creek station 544MSHM2 during the June and September deployment periods was 616 µS/cm and 780 µS/cm, respectively (Table 4.4). Therefore, the specific conductance in Marsh Creek during the spring and summer monitoring periods met the MRP criterion (<20 percent of results >2,000 µS/cm).

Steelhead Suitability

Originating on the eastern side of Mount Diablo, Marsh Creek flows 30 miles through Clayton, Brentwood and Oakley before draining into the Sacramento-San Joaquin River Delta at Big Break northeast of Oakley. Approximately 11 miles upstream from its mouth, the Marsh Creek Reservoir was constructed in the 1960s to regulate flow and provide floodwater protection through the developed areas along the lower reaches of the creek. Most of the lower portion of Marsh Creek below the reservoir was channelized between the 1930s and 1970s to help control flooding in the downstream agricultural area. Immediately below the reservoir, there remains a three-mile section of Marsh Creek that was never channelized, located roughly from Creekside Park up to the toe of the reservoir dam. This three-mile section of Marsh Creek still has a relatively natural channel, as well as mature riparian trees (Levine and Stewart, 2004).

Historical use of Marsh Creek for rearing and spawning by steelhead is considered probable, and Marsh Creek is likely to have also historically supported anadromous Chinook salmon in its lower reaches (Leidy et al., 2005). However, the construction of the Marsh Creek Reservoir as well as a 6-foot-high grade control structure on lower Marsh Creek just upstream of the Brentwood Wastewater Treatment Plant created barriers to anadromous fish ascending the creek to spawn. In 2010, a fish ladder was built to allow anadromous fish passage over the grade control structure and access to seven miles of potential upstream spawning habitat up to the Marsh Creek Reservoir. The construction of the fish ladder was driven largely by the arrival of adult Chinook salmon in Marsh Creek below the grade control barrier, as they have been spotted during the past several decades since the California Department of Fish and Wildlife began releasing hatchery-reared Chinook salmon smolt at Benicia and in the San Francisco Bay to allow them to bypass the Delta. These smolt are apparently less imprinted to home waters, as there has since been notably more straying of adult Chinook salmon into the small creeks draining into San Francisco Bay and the Sacramento-San Joaquin River Delta (Leidy et al., 2005).

Above the Marsh Creek Reservoir, several surveys by the California Department of Fish and Wildlife and East Bay Regional Parks District have concluded there are no steelhead or rainbow trout present in the Upper Marsh Creek area. Marginal summer temperatures and non-perennial flow, coupled with historic mining activities, have created contamination problems in the upper reaches of Marsh Creek, not lending to a suitable habitat for steelhead or rainbow trout restoration (Levine and Stewart, 2004).

During WY 2020, recorded water temperatures exceeded MRP criteria for WAT and acute instantaneous thresholds at the upstream Marsh Creek monitoring station for a steelhead stream. As Marsh Creek does not maintain a COLD designated beneficial use, this does not constitute an exceedance, but indicates that steelhead or Chinook salmon would not find suitable habitat in Marsh Creek during the spring and summer months.

4.2.3.5. Marsh Creek – downstream of wastewater treatment plant (544MSHM0)

Water Temperature

As discussed in section 4.2.3.4, the Central Valley Basin Plan designates Marsh Creek as having a WARM beneficial use. To determining the suitability of Marsh Creek to support Chinook salmon observed in Lower Marsh Creek, COLD water temperature criteria have been applied to Marsh Creek for the purpose of this analysis.

The sonde monitoring location at Marsh Creek below the Brentwood Wastewater Treatment Plant recorded median temperatures of 24.47° C and 23.46° C for the June and September deployments, respectively (Table 4.4). The temperature at the sonde monitoring location during both the June and September deployments exceeded the 17° C WAT threshold criterion, and also exceeded the 24° C acute threshold for 62 percent and 37 percent of the recorded June and September monitoring periods, respectively. As Marsh Creek does not maintain a COLD beneficial use, these results do not constitute an exceedance according to MRP criteria.

The MWAT over the two deployment periods was 25.02° C and 24.68° C (Table 4.5).

Dissolved Oxygen (DO)

Dissolved oxygen levels during the June deployment dropped below the minimum steelhead stream criterion of 7.0 mg/L for 33 percent of the recorded monitoring period. During the September deployment period, dissolved oxygen levels fell below steelhead stream criterion of 7.0 mg/l for 61 percent of the recorded monitoring period. As Marsh Creek does not maintain a designated beneficial use of a steelhead stream, these results do not constitute an exceedance in accordance with MRP criterion (Table 3.1).

As Marsh Creek does maintain a WARM designated beneficial use, dissolved oxygen criteria for non-steelhead streams were also applied (20 percent of instantaneous results shall not be depressed below 5.0 mg/L).

During the June deployment period, dissolved oxygen levels failed to meet Basin Plan criteria for 12 percent of the recorded monitoring period (Table 4.6). As this is below the 20 percent threshold, these measurements do not exceed MRP criterion for follow-up. During the September deployment period, dissolved oxygen levels for a non-steelhead stream dropped below Basin Plan criteria for 20 percent of recorded measurements, indicating an exceedance per MRP criteria.

pH

During the June monitoring period, 33 percent of results failed to meet pH criteria, exceeding the MRP threshold of 20 percent of instantaneous results (Table 4.6). During the September monitoring period, the pH of Marsh Creek always met MRP criterion (Table 4.6).

Specific Conductance

The specific conductance of Marsh Creek always met the MRP criterion during the monitoring period (Table 4.6). The median specific conductance of 1,252 µS/cm to 1,539 µS/cm is normal for the region.

Steelhead Suitability

General steelhead suitability of the Marsh Creek Watershed is discussed in section 4.2.3.4. For site-specific steelhead suitability at the downstream Marsh Creek monitoring station, flow augmentation from the Brentwood Wastewater Treatment Plant did not increase water quality to the extent it could be considered suitable for COLD beneficial use.

4.2.3.6. Marsh Creek – ongoing Permittee evaluation of pilot flow augmentation

Continuous monitoring sondes deployed at Marsh Creek to satisfy MRP monitoring requirements also supported voluntary actions by Permittees assessing the potential for flow augmentation to avoid lethally low DO conditions in Marsh Creek. The City of Brentwood, at the request of CCCWP, consciously augmented flow during critical night-time periods of low DO beginning in September 2020. This action is a repeat of a similar pilot in WY 2019, and documented in CCCWP’s Marsh Creek SSID Study (CCCWP, 2020), now concluded. The Contra Costa Flood Control and Water Conservation District funded sonde monitoring for an extended period, allowing data collection throughout the summer dry period to better characterize the relationship between summer and early fall dry weather flows and DO in Marsh Creek. Detailed data analysis and reporting of that extended monitoring is outside the scope and schedule for this UCMR.

No fish kills were reported in WY 2020. Water quality sonde monitoring at three locations on lower Marsh Creek indicate that conditions consistent with fish kills did not take place in WY 2020. Dissolved oxygen levels did not dip to lethal levels during the deployment from early summer 2020 through the first flush storm event of the fall. Historically, first flush storms appear to pose a fish-kill threat, potentially by mobilizing sources of biochemical oxygen demand from the watershed and / or stream bed. Interestingly, WY 2020 saw no first flush event because the first flush of the 2019-2020 storm season occurred on Sept. 17, 2019 (prior to the beginning of the WY), and the first flush of the 2020-2021 season occurred on Dec. 13, 2020 (after the end of the WY).

On Sept. 17, 2019, a first flush storm led to a fish kill where dissolved oxygen levels were greatly depressed during daily minima for five days (<1.0 mg/L). This fish kill event is chronicled in the Marsh Creek SSID Study Year 2 Report (CCCWP, 2020). The recent first flush storm of the 2020-2021 season (Dec. 13, 2020) did not lead to lethally low dissolved oxygen levels and no fish kill was reported. During this event, and in the days following it, dissolved oxygen values did not fall below 3.0 mg/L. This information helps bound the “critical condition” for fish kills in the late season. Historic data shows that no fish kills have occurred late than November, consistent with WY 2020 observations.

4.3. Pathogen Indicator Bacteria

In compliance with MRP provision C.8.d, a set of pathogen indicator samples were collected on Aug. 5, 2020 at five stations on creeks in Contra Costa County (Table 4.7). The samples were analyzed for enterococci and *E. coli*. The sites were located along Alhambra Creek, Grayson Creek, Las Trampas Creek, Refugio Creek, and San Ramon Creek. Due to their proximity to either a public park or an encampment, all sites were targeted to investigate whether the water quality could be impacted by human activity, such as off-leash dog parks or other activities or associated with encampments. All sites were chosen based upon the likelihood of recreational water contact or to investigate areas of possible anthropogenically-induced contamination.

As described previously (Section 3.2.5), single-sample maximum concentrations of 130 CFU/100ml enterococci and 410 CFU/100ml *E. coli* were used for evaluation, based on the most recently published recreational water quality criteria statistical threshold values for water contact recreation (USEPA, 2012). Enterococci concentrations ranged from 134 to 1,201 CFU/100 ml and *E. coli* concentrations ranged from 30 to 7,701 CFU/100 ml. All five enterococci samples exceeded the applicable criterion, while two samples collected for *E. coli* also exceeded the applicable USEPA criterion. Samples collected at 207ALH015 (Alhambra Creek) and 207R01163 (San Ramon Creek) exceeded criteria for both enterococci and *E. coli.*

Table 4.7 Enterococci and *E. coli* Levels Measured from Water Samples Collected at Five Locations in Creeks in Contra Costa County (Aug. 5, 2020)

Site ID	Creek Name	Enterococci (CFU/100 ml)	*E. coli* (CFU/100 ml)
206R02560	Refugio Creek	1,081[1]	288
207ALH015	Alhambra Creek	1,095[1]	7,701[2]
207R01163	San Ramon Creek	1,201[1]	2,254[2]
207R01547	Grayson Creek	183[1]	228
207R02891	Las Trampas Creek	134[1]	30

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

5. Next Steps

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

1. CCCWP will continue to conduct monitoring for local/targeted parameters in WY 2021.
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, as well as other potential follow-up investigations and/or monitoring. Based on the analysis of the local targeted data, the results exceeding the MRP trigger thresholds (Table 5.1) are and will continue to be listed in the SSID data evaluation form as potential SSID projects.

Table 5.1 Summary of CCCWP Threshold Exceedances for WY 2020

Creek	Index Period	Parameter	Threshold Exceedance
Las Trampas Creek at Olympic Blvd. Staging Area	05/27/20-09/30/20	Continuous Water Temperature (HOBO)	Two or more WATs exceed 17° C
Moraga Creek at Moraga Country Club	05/27/20-09/30/20	Continuous Water Temperature (HOBO)	Two or more WATs exceed 17° C
Pinole Creek at Pinole Library	05/27/20-06/23/20 07/08/20-09/30/20	Continuous Water Temperature (HOBO)	Two or more WATs exceed 17° C
Pinole Creek at Pinole Valley Park	05/27/20-06/02/20 06/10/20-06/30/20 07/08/20-09/08/20 09/16/20-09/30/20	Continuous Water Temperature (HOBO)	Two or more WATs exceed 17° C
Marsh Creek at Fish Ladder, Upstream of WWTP	06/10/20-06/24/20 09/03/20-09/16/20	Continuous Water Temperature (sonde)	One or more WAT exceeds 17° C, 20% of instantaneous results above 24° C
Marsh Creek at East Cypress Road, Downstream of WWTP	06/10/20-06/24/20 09/03/20-09/16/20	Continuous Water Temperature (sonde)	One or more WAT exceeds 17° C, 20% of instantaneous results above 24° C
Marsh Creek at East Cypress Road, Downstream of WWTP	06/10/20-06/24/20	Continuous Water Quality – pH	20% of instantaneous results below 6.5 or above 8.5
Marsh Creek at Fish Ladder, Upstream of WWTP	09/03/20-09/16/20	Continuous Water Quality – DO	20% of instantaneous results below 5.0 mg/L
Marsh Creek at East Cypress Road, Downstream of WWTP	09/03/20-09/16/20	Continuous Water Quality – DO	20% of instantaneous results below 5.0 mg/L
Alhambra Creek	08/05/2020	Enterococci	Single grab sample exceeded USEPA criterion of 130 CFU/100 ml
Grayson Creek	08/05/2020	Enterococci	Single grab sample exceeded USEPA criterion of 130 CFU/100 ml
Las Trampas Creek	08/05/2020	Enterococci	Single grab sample exceeded USEPA criterion of 130 CFU/100 ml
Refugio Creek	08/05/2020	Enterococci	Single grab sample exceeded USEPA criterion of 130 CFU/100 ml
San Ramon Creek	08/05/2020	Enterococci	Single grab sample exceeded USEPA criterion of 130 CFU/100 ml
Alhambra Creek	08/05/2020	*E. coli*	Single grab sample exceeded USEPA criterion of 410 CFU/100 ml
San Ramon Creek	08/05/2020	*E. coli*	Single grab sample exceeded USEPA criterion of 410 CFU/100 ml

CFU colony forming unit
DO dissolved oxygen
WAT weekly average temperature
WWTP wastewater treatment plant

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Appendix 3

Pollutants of Concern Monitoring Report:

Water Year 2020

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Contra Costa Clean Water Program

Pollutants of Concern Monitoring Report: Water Year 2020

March 31, 2021

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Contra Costa Clean Water Program

Pollutants of Concern Monitoring Report: Water Year 2020

March 31, 2021

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Acronyms and Abbreviations

BASMAA	Bay Area Stormwater Management Agencies Association
Bay	San Francisco Bay
Bay Area	San Francisco Bay Area
BMP	best management practice
CCCWP	Contra Costa Clean Water Program
CVRWQCB	Central Valley Regional Water Quality Control Board
Delta	Sacramento-San Joaquin River Delta
EPA	U.S. Environmental Protection Agency
MRP	municipal regional stormwater permit
MS4	municipal separate storm sewer system
NPDES	National Pollutant Discharge Elimination System
PCBs	polychlorinated biphenyl congeners
POC	pollutants of concern
ppb	parts per billion
PSD	particle size distribution
RMP	Regional Monitoring Program for Water Quality in San Francisco Bay
SFBRWQCB	San Francisco Bay Regional Water Quality Control Board
SSC	suspended sediment concentration
TMDL	total maximum daily load
TOC	total organic carbon
WY	water year

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1. INTRODUCTION

This report summarizes pollutants of concern (POC) monitoring conducted by Contra Costa Clean Water Program (CCCWP) during water year 2020 (Oct. 1, 2019 through Sept. 30, 2020). This report fulfills Provision C.8.h.iv of the Municipal Regional Stormwater Permit (MRP 2.0, Order R2-2015-0049) issued in 2015 by the San Francisco Bay Regional Water Quality Control Board (SFBRWQCB, 2015).

CCCWP Permittees prioritize monitoring pollutants of concern with the goal of identifying reasonable and foreseeable means of achieving load reductions of pollutants required by total maximum daily loads (TMDLs). TMDLs are watershed plans to attain water quality goals developed and established by the San Francisco Bay Regional Water Quality Control Board. The two most prominent TMDLs in driving stormwater monitoring, source control, and treatment projects under MRP 2.0 are the mercury TMDL and the polychlorinated biphenyl congeners (PCBs) TMDL. In the interest of protecting the beneficial uses of the surface waters for people and wildlife dependent on San Francisco Bay (the Bay) for food, these regulatory plans are intended to reduce concentrations of mercury and PCBs in fish within the Bay.

Mercury and PCBs tend to bind to sediments. The principal means of transport from watersheds is via sediments washed into the Municipal Separate Storm Sewer System (MS4); therefore, an important focus of POC monitoring is identifying the most significant sources of contaminated sediments to the MS4. An additional focus is quantifying the effectiveness of control measures. The highest POC monitoring priorities for Permittees are answering these two basic TMDL implementation questions: where are the most significant sources of pollutants of concern, and what can be done to control them?

During water year 2020, the following monitoring activities were completed:

- PCBs and mercury sediment screening – sampling of street dirt and/or storm drain drop inlet sediment at six locations adjacent to suspected source properties in old industrial areas of Herman Slough watershed, Martinez Creek watershed, and Kirker Creek watershed
- PCBs confirmatory sampling in stormwater runoff
- PCBs and mercury screening – stormwater reconnaissance sampling by the Regional Monitoring Program for Water Quality in San Francisco Bay (RMP) at two locations in the Santa Fe Channel watershed
- Copper and nutrients water sampling in lower Marsh Creek
- Mercury and methylmercury water sampling in lower Marsh Creek (specific to East County monitoring requirements).

All monitoring activities were performed in accordance with CCCWP's Pollutants of Concern Sampling and Analysis Plan and Quality Assurance Project Plan (ADH and AMS, 2020a; ADH and AMS, 2020b). Each of these monitoring efforts is described in the following sections.

Additional monitoring information, background and context, including a discussion of permit-driven goals, can be found in the pollutants of concern report for water year 2020 (CCCWP, 2020).

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2. PCBs AND MERCURY SEDIMENT SCREENING – STREET DIRT AND STORM DRAIN DROP INLET SAMPLING

Six composite samples of street dirt and/or storm drain drop inlet sediment in the public right of way were collected in September 2020. Sampling sites were selected from a GIS layer prepared by CCCWP's C.11/C.12 contractor, Geosyntec Consultants. The GIS layer identifies remaining old industrial properties throughout the county that may not have been thoroughly investigated in the past, and that may have the potential to contribute PCBs to the public right-of-way and the MS4. In generating the old industrial property database, careful consideration was given to the historic land use of each property and to results of previous monitoring efforts.

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

Concentrations of PCBs and mercury were quite low at all locations. PCBs concentration ranged from 2 to 26 ppb, and mercury concentrations ranged from 106 to 380 ppb. None of the results approached the high-opportunity thresholds (>500 ppb for PCBs and >750 ppb for mercury).

Table 1. Sediment Screening Sampling Locations and Sampling Notes (WY 2020)

Site ID [1]	Date Sampled	Latitude (decimal degrees)	Longitude (decimal degrees)	Sampling Notes
CC-HrmSlu1	09/29/20	37.94710	-122.37199	Sampled curb and gutter sediment from minimal trackout
CC-HrmSlu2	09/29/20	37.92998	-122.37949	Sampled trackout from BNSF railyard at asphalt/concrete interface
CC-KCrk1	09/29/20	38.03206	-121.87733	Multiple area composite along East 3rd Street
CC-KCrk2	09/29/20	38.02149	-121.87229	Multiple area composite along electrical transmission line corridor
CC-KCrk3	09/29/20	38.02937	-121.89430	Multiple area composite from drop inlets and curb/gutter along westbound 10th Street; heavy construction and trackout present
CC-MtzCrk1	09/29/20	38.01486	-122.11778	Sampled trackout from PG&E yard

1 Site ID Key:
CC Contra Costa County HrmSlu Herman Sough KCrk Kirker Creek or Willow Creek MtzCrk Martinez Creek

Table 2. Sediment Screening Analytical Tests, Methods, Reporting Limits, and Holding Times

Sediment Analytical Test	Method	Target 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	ASTM D4129-05M	0.05%	28 days
Particle Size Distribution[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.

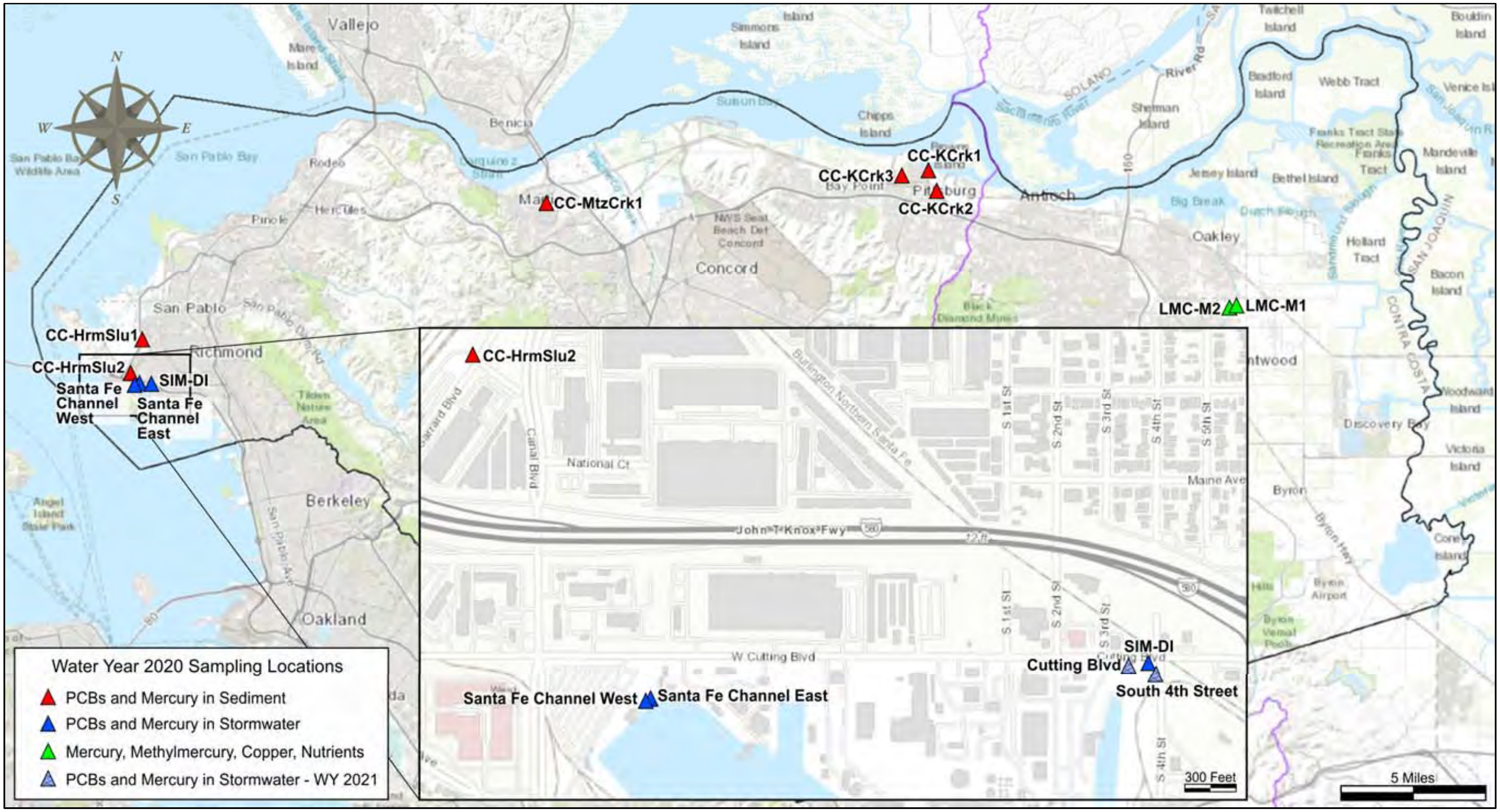
2 Particle size distribution by the Wentworth scale; percent fines (slit and clay) are less than 62.5 microns.

Table 3. Sediment Screening Sampling Results (WY 2020)

Sample ID	Total PCBs (µg/Kg or ppb) [1]	Total Hg (µg/Kg or ppb)	TOC (%)	Particle Size Distribution			
				Gravel (%)	Sand (%)	Silt (%)	Clay (%)
CC-HrmSlu1	26.24	232	4.42	3	80	15	2
CC-HrmSlu2	22.29	380	4.05	14	72	13	1
CC-KCrk1	15.71	166	4.80	16	60	21	3
CC-KCrk2	25.56	106	3.67	11	43	39	7
CC-KCrk3	26.17	181	3.43	13	58	26	3
CC-MtzCrk1	2.49	280	1.41	23	62	14	1

1 Sum of RMP 40 congeners.

Figure 1. Location of Water Year 2020 Monitoring Activities – County Overview



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3. PCBs CONFIRMATORY SAMPLING IN STORMWATER RUNOFF

A single stormwater grab sample was collected at the corner of South 4th Street and Cutting Boulevard in the City of Richmond during the initial portion of the first flush storm event of WY 2020. This sampling was performed to test whether elevated PCB concentrations persist in this area, which has a history of trackout from the Sims Metals recycling operation located at 600 South 4th Street.

Table 4 provides analytical test methods, reporting limits and holding times. Table 5 provides results of PCBs, mercury, SSC, and TOC testing. Figure 1 identifies the general sampling location.

When normalizing the analytical results of PCBs and mercury to the suspended sediment concentration, the particle ratio for PCBs is 827 ppb and the particle ratio for mercury is 1,048 ppb (Table 5). These values exceed high-opportunity thresholds and indicate that elevated concentrations of PCBs and mercury continue to be present in this sub-watershed.

Table 4. Stormwater Analytical Tests, Methods, Reporting Limits, and Holding Times

Sediment Analytical Test	Method	Target Reporting Limit	Holding Time
Total PCBs (RMP 40 congeners)[1]	EPA 1668C	0.1 µg/kg	1 year
Total Mercury	EPA 1631E	0.5 ng/L	90 days
Suspended Sediment Concentration	ASTM D 3977-97	1.5 mg/L	7 days
Total Organic Carbon	EPA 9060	0.50 mg/L	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.

Table 5. Stormwater Sampling Results – South 4th Street and Cutting Boulevard, City of Richmond (WY 2020)

Sample ID	SIM-DI-1911261535-000
Date Sampled	11/26/2019
Time Sampled	15:35
Latitude	37.92561
Longitude	-122.36612
Total PCBs (ng/L)	205
Total Hg (ng/L)	260
SSC (mg/L)	248
TOC (mg/L)	290
PCBs/SSC Ratio (ppb)	***827***
Hg/SSC Ratio (ppb)	***1,048***

Values presented in ***bold italics*** exceed the high-opportunity threshold for PCBs (>500 ppb) or mercury (>750 ppb).

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4. PCBs AND MERCURY SCREENING – STORMWATER RECONNAISSANCE SAMPLING BY THE RMP

Reconnaissance monitoring by the RMP was conducted to identify drainages with potentially elevated concentrations of PCBs and/or mercury. The intention of reconnaissance monitoring by the RMP is to guide upstream source investigations. With input from CCCWP, locations were selected to provide coverage in areas where data gaps exist. The RMP monitored two sites in Contra Costa County in water year 2020. The two sites were located in the City of Richmond at storm drain outfalls that directly discharge to the north end of Santa Fe Channel in Richmond Harbor.

Refer back to Table 4 for the analytical test methods, reporting limits and holding times. Table 6 provides results of PCBs, mercury, and SSC testing. Figure 1 identifies the general sampling locations, and shows the location of upcoming RMP reconnaissance sampling for WY 2021.

When normalizing the analytical results of PCBs and mercury to the suspended sediment concentration, the particle ratio for PCBs in both samples are well below the high-opportunity threshold for PCBs control (131 ppb and 211 ppb vs. 500 ppb). The particle ratio for mercury was low in the Santa Fe Channel West outfall (287 ppb), but was elevated in the Santa Fe Channel East outfall (1,200 ppb).

These results indicate that PCBs were within typical background range of old industrial portions of the county (<500 ppb), and that these sub-watersheds do not appear to be candidates for high-opportunity PCBs control measures. However, the results suggest that there may be an elevated source of mercury within the Santa Fe Channel East sub-watershed (result of 1,200 ppb exceeds the 750 ppb threshold for high-opportunity control).

Table 6. Stormwater Sampling Results – RMP Reconnaissance (WY 2020)

Sample ID	Santa Fe Channel West	Santa Fe Channel East
Sample Date	11/26/19	11/26/19
Latitude	37.92459	37.92462
Longitude	-122.37598	-122.37594
Total PCBs (ng/L)	45.21	31.04
Total Hg (ng/L)	98.8	176
SSC (mg/L)	344	147
PCBs/SSC Ratio (ppb)	131	211
Hg/SSC Ratio (ppb)	287	***1,200***

Values presented in ***bold italics*** exceed the high-opportunity threshold for PCBs (>500 ppb) or mercury (>750 ppb).

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5. COPPER AND NUTRIENTS MONITORING

Sampling for copper and nutrients was conducted in lower Marsh Creek during dry weather at Station M1, located immediately downstream of the Brentwood WWTP outfall. Two samples were collected: the first was collected early in the morning on August 26 at the approximate stage minimum for the day, the second was collected in the late morning on August 27 at the approximate stage maximum for the day. The early morning stage minimum occurred before the WWTP began its daily discharge, and the late morning stage maximum occurred when the WWTP was at or near its maximum daily outflow. This paired sampling strategy helps to identify variations in dry weather water quality which may exist in lower Marsh Creek where WWTP outflow is a major source of flow to the creek.

Samples were filtered in the field within 15 minutes of collection for dissolved copper, ammonia, nitrate, nitrite, and orthophosphate. Refer to Table 7 for test methods and reporting limits. Refer to Table 8 for the analytical results. Figure 1 identifies the general sampling location.

Copper and nutrients concentrations were generally low. Except for orthophosphate and phosphorus, concentration of copper and nutrients fell below the maximum permissible contaminant levels and water quality objectives. As seen in prior years in Marsh Creek, concentration of orthophosphate and phosphorus were elevated above the USEPA's Quality Criteria for Water.

Table 7. Watershed Characterization Analytical Tests, Methods and Reporting Limits – Copper and Nutrients

Analytical Test	Method	Target Reporting Limit
Suspended Sediment Concentration (SSC)	ASTM D 3977-97B	3 mg/L
Copper, total recoverable and dissolved	EPA 200.8	0.5 µg/L
Hardness	SM 2340C (titration)	5 mg/L
Ammonia as N	SM 4500-NH3 C v20	0.1 mg/L
Nitrate	EPA 300.0	0.05 mg/L
Nitrite	EPA 300.0	0.05 mg/L
Total Kjeldahl Nitrogen	SM 4500 NH3-C	0.1 mg/L
Dissolved Orthophosphate	SM 4500P-E	0.01 mg/L
Total Phosphorus	SM 4500P-E	0.01 mg/L

Table 8. Copper and Nutrients Monitoring Results – Lower Marsh Creek (Water Year 2020)

Site ID	LMC-M1	LMC-M1	Maximum Contaminant Level / Water Quality Objective
Sample Date	08/26/20	08/27/20	
Sample Time	06:39	10:54	
Latitude (decimal degrees)	37.96448	37.96448	
Longitude (decimal degrees)	-121.68392	-121.68392	
Copper, Dissolved (µg/L)	1.7	2.6	10-67[a]
Copper, Total (µg/L)	1.1	3.2	None
Hardness (mg/L)	320	320	None
Ammonia as N (mg/L)	0.15	0.089 J	None
Nitrate (mg/L)	5.5	8.4	9.0[b]
Nitrite (mg/L)	0.015 J	0.0080 J	1.0[c]
Total Kjeldahl Nitrogen (mg/L)	0.11	<0.080	None
Dissolved Orthophosphate (mg/L)	***0.58***	***1.9***	0.03[d]
Phosphorus (mg/L)	***0.69***	***1.8***	0.1[d]

Values presented in ***bold italics*** exceed the listed maximum contaminant level/water quality objective

a Range of maximum acceptable values for dissolved copper calculated from hardness as specified in the San Francisco Bay Basin (Region 2) Water Quality Control Plan (Basin Plan), May 2017, Table 3–4: Freshwater Water Quality Objectives for Toxic Pollutants for Surface Waters, 1-hr average for copper. The objectives for copper are based on hardness. The table values in the source assume a hardness of 100 mg/l CaCO3. At other hardnesses, the objectives are calculated using the following formula where H = ln (hardness): The 1-hour average for copper is e(0.9422H-1.700).

b San Francisco Bay Basin (Region 2) Water Quality Control Plan (Basin Plan), May 2017, contains maximum contaminant levels for un-ionized ammonia, but not for ammonium (ionized ammonia).

c San Francisco Bay Basin (Region 2) Water Quality Control Plan (Basin Plan), May 2017, Table 3-5: Water Quality Objectives for Municipal Supply. The table specifies WQOs of 10 mg/L for Nitrate+Nitrite as N and 1 mg/L for Nitrite as N.

d Quality Criteria for Water, U.S. Environmental Protection Agency, EPA#440/5-86-001, 1986. The recommended criterion for total phosphorus is for streams which do not empty into reservoirs.

< Analyte not detected at or above the detection limit; numeric value after the “<” symbol is the value of the detection limit

J Analyte detected below the reporting limit; result should be considered as an estimated value

6. MERCURY AND METHYLMERCURY MONITORING

Mercury and methylmercury sampling was conducted concurrent with copper and nutrient sampling on Marsh Creek during dry weather. This work builds on results of the Methylmercury Control Study Final Report (CCCWP, 2018), and should help to better understand mercury concentrations and methylation occurrences within lower Marsh Creek. Samples were collected during Brentwood WWTP outflow minimum (early morning) and outflow maximum (late morning) at Station M1 and at an upstream control location, Station M2. Samples at Station M1 were collected in triplicate for variability assessment between morning and evening averages.

This monitoring effort satisfies Central Valley requirements of the newly promulgated MRP Amendment Provision C.16.5.g for eight samples within lower Marsh Creek each year (SFBRWQCB, 2019). Refer to Table 9 for test methods and reporting limits. Refer to Table 10 for analytical results. Figure 1 identifies the general sampling locations.

Table 9. Mercury and Methylmercury in Water - Analytical Tests, Methods, Reporting Limits, and Holding Times

Sediment Analytical Test	Method	Target Reporting Limit	Holding Time
Total Mercury	EPA 1631E	0.5 ng/L	90 days
Total Methylmercury	EPA 1631	0.05 ng/L	90 days
Suspended Sediment Concentration	ASTM D 3977-97	1.5 mg/L	7 days

Table 10. Methylmercury Analytical Results

Site ID	Sample Date	Sample Time	Latitude	Longitude	SSC (mg/L)	Total Hg (ng/L)	Total Hg/SSC Ratio (ppb)	Total MeHg (ng/L)	MeHg to Hg Ratio (%)
LMC-M2-01	08/26/20	06:20	37.96265	-121.68803	8.2	1.9	232	***0.11***	***5.8***
LMC-M2-02	08/26/20	10:35	37.96265	-121.68803	12	2.7	225	***0.11***	4.1
LMC-M1-01	08/26/20	06:35	37.96390	-121.68375	4.9	1.1	224	***0.10***	***9.1***
LMC-M1-02	08/26/20	06:36	37.96390	-121.68375	4.9	1.2	245	***0.08***	***6.7***
LMC-M1-03	08/26/20	06:37	37.96390	-121.68375	4.9	1.4	286	***0.08***	***5.7***
LMC-M1-04	08/27/20	10:50	37.96390	-121.68375	3.2	1.1	344	<0.02	1.8
LMC-M1-06	08/27/20	10:51	37.96390	-121.68375	3.2	0.97	303	***0.22***	***22.7***
LMC-M1-06	08/27/20	10:52	37.96390	-121.68375	3.2	0.84	263	<0.02	2.4

MeHg methylmercury
< Analyte not detected at or above the MDL; numeric value following the "<" symbol is the associated MDL value
Values presented in ***bold italics*** exceed the Delta TMDL for methylmercury of 0.06 ng/L or indicate enhanced methylation efficiency above 5.0 percent.
Shaded cells highlight mid-morning samples.

The purpose of dry weather methylmercury monitoring is to compare concentrations found during the early morning, when flows from the Brentwood WWTP are at a minimum, to mid-morning, when WWTP flows reach a daily maximum. The data in Table 10 show that the lowest MeHg concentrations are observed in two instances of mid-morning flow, when WWTP flows presumably are a larger proportion of flow compared to dry weather flows from upstream of the WWTP; however, in two other instances, mid-morning MeHg concentrations were either the median (0.1 ng/L) or the maximum (0.22 ng/L) MeHg concentrations in the sample set. The data in Table 10 establish a range (<0.02 – 0.22) for MeHg and central tendency (median of 0.1 ng/L) concentrations in Marsh Creek dry weather flows for the purpose of modeling MeHg loads, in compliance with TMDL directives.

7. SUMMARY OF MONITORING COMPLETED IN WATER YEAR 2020

Water year 2020 monitoring is summarized in Table 11. The table lists the total number of tests completed for each pollutant class, and the corresponding targets outlined in MRP 2.0.

The number of samples collected and analyzed in water year 2020 met or exceeded the minimum annual requirements of the MRP in all pollutant categories.

Table 11. Summary of Monitoring Completed in Water Year 2020 by Pollutant Class, Analyte, and MRP Targets

Pollutant Class / Type of Monitoring	Analyte									Agency or Organization Performing the Monitoring	Number of Samples Collected and Analyzed in WY 2020	Cumulative Number of Samples Collected and Analyzed in WYs 2016-2020	Total Number of Samples Required by the MRP Over 5-Year Term
	PCBs	Mercury	Methylmercury	SSC	PSD	TOC	Copper [1]	Hardness	Nutrients [2]				
PCBs - stormwater	✓			✓		✓				CCCWP	1[a]	94	80
PCBs - stormwater	✓			✓		✓				RMP	2[b]		
PCBs - sediment	✓				✓	✓				CCCWP	6[c]		
Mercury - stormwater		✓	✓	✓		✓				CCCWP	1[a]	138	80
Mercury - stormwater		✓	✓	✓		✓				RMP	2[b]		
Mercury & MeHg - water		✓	✓	✓		✓				CCCWP	8[d]		
Mercury - sediment										CCCWP	6[c]		
Copper - water							✓	✓		CCCWP	2	20	20
Nutrients – water									✓	CCCWP	2	20	20

1 Total and dissolved fractions of copper
2 Nutrients include: ammonia, nitrate, nitrite, total Kjeldahl nitrogen, orthophosphate and total phosphorus
a Stormwater sample collected at corner of South 4th Street and Cutting Boulevard in the City of Richmond
b The RMP collected stormwater samples at Santa Fe Channel Outfall West and Santa Fe Channel Outfall East
c Sediment screening adjacent to remaining old industrial source properties in high opportunity watershed of Herman Slough, Martinez Creek, and Kirker Creek
d Mercury and methylmercury co-sampled with copper and nutrients on Marsh Creek

SSC suspended sediment concentration
PSD particle size distribution
TOC total organic carbon
WY water year
RMP Regional Monitoring Program for Water Quality in San Francisco Bay

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8. QUALITY ASSURANCE / QUALITY CONTROL ANALYSIS

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

Overall, the PCB congener data from ALS were acceptable. MDLs were sufficient with no non-detects reported for any of the PCB congeners in water measured for EPA Method 1668C. Method blanks were detected for some congeners, but only at concentrations below the reporting limit. Laboratory quality assurance checks were in control for EPA Method 8082 for PCBs in sediment.

All samples for all analyses met laboratory quality control objectives, except for instances shown in Table 12. Given that all the quality control issues described in Table 12 show the issues were of relatively minor consequence, the data from these samples are of acceptable quality and are included in the data set for this annual report.

Table 12. Quality Control Issues and Analysis in the WY 2020 Project Data Set

Sample ID & Type	Issue	Analysis
Field Sample CC-HrmSlu1 CC-HrmSlu2 CC-KCrk1 CC-KCrk2 CC-KCrk3 cc-MtzCrk1	Several of the PCB congers from Method 8082A were “P” qualified indicating that the GC or HPLC confirmation criteria was exceeded. The RPD was greater than 40% between the two results.	Exceedance of this type are common with results that are only slightly above the RL. Since the “P” qualified data represent very low detections, the sum of the RMP 40 congeners is acceptable for use.
Field Sample CC-HrmSlu1 CC-KCrk2	The upper control criterion was exceeded for several PCB congeners in continuing calibration verification KQ2015831-01.	Detections of the affected congeners were below reporting limits and since the problem indicates a high bias, the data quality was not affected.
Matrix Spike CC-HrmSlu1	The matrix spike recovery for mercury was slightly below control criteria.	Recovery in the laboratory control sample was acceptable, which indicated the analytical batch was in control.
Matrix Spike/Matrix Spike Duplicate LMC-M1-01	High matrix spike recoveries for orthophosphate, slightly above acceptability criteria of 90-110%	Possible matrix interference as the cause. Quality control batch was accepted based on LCS and RPD results.
Matrix Spike/Matrix Spike Duplicate LMC-M1-01	Low matrix spike recoveries for mercury, slightly below acceptability criteria of 71-125%.	Possible matrix interference as the cause. Quality control batch was accepted based on LCS and RPD results.

LCS laboratory control sample
GC gas chromatography
HPLC high pressure liquid chromatography
RPD relative percent difference

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9. REFERENCES

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CCCWP. 2018b. Contra Costa Clean Water Program. Contra Costa Clean Water Program, Methylmercury Control Study Final Report. October 2018.

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Appendix 4

Regional Monitoring Program Pollutants of Concern Reconnaissance Monitoring Progress Report

Water Years 2015-2020

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RMP
REGIONAL MONITORING PROGRAM FOR WATER QUALITY IN SAN FRANCISCO BAY

sfei.org/rmp

Pollutants of Concern Reconnaissance Monitoring Progress Report, Water Years 2015 - 2020

Prepared by

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San Francisco Estuary Institute

CONTRIBUTION NO. / XXX 2020

Preface

Reconnaissance monitoring for water years 2015-2020 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 (2021) is underway. An earlier draft of this report was prepared for the Bay Area Stormwater Management Agencies Association (BASMAA) in support of materials submitted on or before March 31st 2021 in compliance with the Municipal Regional Stormwater Permit (MRP) Order No. R2-2015-0049.

Acknowledgements

We appreciate the support and guidance from members of the Sources, Pathways, and Loadings Workgroup of the RMP. The detailed work plan for this study was developed by the RMP Small Tributaries Loading Strategy (STLS) Team during a series of meetings in the summer of 2014, with slight modifications made in subsequent years. Local members on the STLS Team at that time were Jim Scanlin (and Arleen Feng in earlier years [Alameda Countywide Clean Water Program]), Bonnie de Berry (San Mateo Countywide Water Pollution Prevention Program), Lucile Paquette (Contra Costa Clean Water Program), Chris Sommers and Lisa Sabin (Santa Clara Valley Urban Runoff Pollution Prevention Program), and Richard Looker and Jan O'Hara (San Francisco Bay Regional Water Board). RMP field and logistical support provided by San Francisco Estuary Institute (SFEI) in water year (WY) 2015 included Patrick Kim, Carolyn Doehring, and Phil Trowbridge; WY 2016 included Patrick Kim, Amy Richey, and Jennifer Sun; WY 2017 included Ila Shimabuku, Amy Richey, Steven Hagerty, Diana Lin, Margaret Sedlak, Jennifer Sun, Katie McKnight, Emily Clark, Don Yee, and Jennifer Hunt; WY 2018 included Nina Buzby, Amy Richey, Ila Shimabuku, Margaret Sedlak, and Don Yee; WY 2019 included Ila Shimabuku, Margaret Sedlak, Jennifer Sun, Micha Salomon, Nina Buzby and Don Yee.; and WY 2020 included Nina Buzby, Diana Lin, Don Yee, and Matt Benjamin. The RMP data management team is acknowledged for their diligent delivery of quality-assured well-managed data. This team was comprised of Amy Franz and John Ross during WYs 2015-2019, and Adam Wong, Michael Weaver and Don Yee in WYs 2015-2020. Helpful written reviews of this report were provided by members of BASMAA (Bonnie de Berry, EOA Inc. on behalf of the San Mateo Countywide Water Pollution Prevention Program; Lisa Austin, Geosyntec, Khalil Abusaba, Wood Consultants, and Christian Kocher, ADH Environmental on behalf of the Contra Costa Clean Water Program; Jim Scanlin, Alameda Countywide Clean Water Program); and Richard Looker (SFBRWQCB). External independent review was provided by SPLWG advisors (xxxxxxxxxxxxxxxxxxxxxxxxx).

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Executive Summary

The San Francisco Bay polychlorinated biphenyl (PCB) and mercury (Hg) total maximum daily loads (TMDLs) call for implementation of control measures to reduce PCB and Hg loads entering the Bay via stormwater. In 2009, the San Francisco Bay Regional Water Quality Control Board (Regional Water Board) issued the first Municipal Regional Stormwater Permit (MRP). This MRP contained a provision aimed at improving information on stormwater pollutant loads in selected watersheds (Provision C.8.) and piloted a number of management techniques to reduce PCB and Hg loading to the Bay from smaller urbanized tributaries (Provisions C.11. and C.12.). To address C8, a previously developed fixed station loads monitoring technique was refined that incorporated turbidity and stage sensors recording at 5-15 minute intervals with the collection of velocity and water samples using both manual and auto sampling techniques to compute loads. In 2015, the Regional Water Board issued the second iteration of the MRP. “MRP 2.0” placed an increased focus on identifying those watersheds, source areas, and source properties that are potentially the most polluted and are therefore most likely to be cost-effective areas for addressing load-reduction requirements.

To support this increased focus, a stormwater reconnaissance monitoring field protocol was developed and implemented in water years (WYs) 2015 through 2020. Most of the sites monitored were in Alameda, Santa Clara, and San Mateo Counties, with fewer sites in Contra Costa and one in Solano County. At 70[1] sampling sites, time-weighted composite water samples were collected during individual storm events and analyzed for 40 PCB congeners, total Hg (HgT), and suspended sediment concentration (SSC). At a subset of sites, additional samples were analyzed for selected trace metals, organic carbon (OC), and grain size. Where possible, sampling efficiency was increased by sampling two or three sites during a single storm if the sites were near enough to one another that alternating between them was safe and rapid. This same field protocol is being implemented in the winter of WY 2021 by the RMP. The San Mateo Countywide Water Pollution Prevention Program and the Santa Clara Valley Urban Runoff Pollution Prevention Program have also implemented the sampling protocol with their own funding.

During this study, beginning in WY 2015, the RMP began piloting the use of un-staffed “remote” suspended sediment samplers (Hamlin samplers and Walling Tube samplers). These remote samplers were designed to enhance settling and capture of suspended sediment from the water column.

In summary, we now have three distinct stormwater sampling methods.

Method 1. Fixed location multi-year turbidity-based sampling protocol for accurate loads estimation.

Method 2. Water-based composite sampling protocol for single storm reconnaissance characterization and site comparisons to support management prioritization.

Method 3. Remotely deployable sedimentation sampling for preliminary screening to support further field sampling using the water-based composite sampling protocol.

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[1] Includes all reconnaissance sites including sites for the Priority Margin Units study sampled since 2015.

This report presents all available stormwater data[2] collected by SFEI since WY 2003 when stormwater studies first began through SFEI contracts or RMP projects, not just the data collected for this WY 2015-2020 reconnaissance monitoring study (total of 94[3] sites). Prior to WY 2015, studies mostly employed Method 1, whereas beginning in WY 2015, sampling employed Methods 2 and 3.

Key Findings

Based on this dataset a number of sites with elevated PCB and Hg stormwater concentrations and estimated concentrations on particles were identified. Including RMP sampling prior to WY 2015, 25 sites (27%) with estimated particle concentrations of PCBs greater than 200 ng/g and 31 sites (33%) with estimated particle concentrations of Hg greater than 0.5 µg/g have been identified. Total PCB concentrations ranged 840-fold, from 533 to 448,000 pg/L (excluding one sample where PCBs were below the detection limit). The three highest ranking sites for PCB water concentrations were Pulgas Pump Station South (448,000 pg/L), Line 12H at Coliseum Way (417,000 pg/L), and Santa Fe Channel (198,000 pg/L). When normalized by SSC to generate estimated particle concentrations, total PCB concentrations ranged 4111-fold, from 2 to 8,222 ng/g excluding the non-detect. The three sites with highest estimated particle concentrations were Pulgas Pump Station South (8,220 ng/g), Industrial Rd Ditch in San Carlos (6,139 ng/g), and Line 12H at Coliseum Way in Oakland (2,601 ng/g).

Total Hg concentrations in samples collected in water years since 2003 ranged 112-fold, from 5.4 to 603 ng/L. The lower variation in HgT concentrations relative to PCBs is consistent with conceptual models for these substances. HgT is thought to be more uniformly distributed than PCBs because it has more widespread uses and sources in the urban environment, Hg is associated with fine particle sizes more so than PCBs, and Hg has a larger atmospheric component to its cycle. The highest HgT concentrations were measured at the Guadalupe River at Hwy 101 (603 ng/L), Guadalupe River at Foxworthy Road/Almaden (529 ng/L), and Zone 5 Line M (505 ng/L). Estimated particle concentration ranged between 45 and 4,090 ng/g (91-fold), similar to the variation in water concentrations. The highest estimated particle concentrations were measured at Guadalupe River at Foxworthy Road/Almaden (4.1 µg/g), Guadalupe River at Hwy 101 (3.6 µg/g), and the Outfall at Gilman St. in Berkeley (2.2 µg/g). The two Guadalupe River stations are downstream of the historic New Almaden Mining District whereas the Gilman St. sites in Berkeley drains an industrial area. Although there was a general but weak correlation between PCB and Hg concentrations in both water and on particles, the sites with the highest particle concentrations for Hg were typically not the sites with the highest concentrations for PCBs.

Remote Suspended Sediment Samplers

Pilot results from the two remote suspended sediment sampler types showed generally good consistency with the composite stormwater sampling methods. Sites with higher concentrations in the

[2] Similar data collected by BASMAA in Santa Clara and San Mateo Counties is not included in this report. Also, BASMAA partners analyze sediment collected in upland areas (e.g., catch basins, roadside ditches, private property, etc.). These data are also not presented in this report.
[3] Includes bioretention monitoring sites.

sediment collected by the remote samplers were the same as those with higher concentrations in the composite samples. Therefore, the remote suspended sediment sampler method was accepted in spring 2018 and used in WY 2019 as a stand-alone method (side-by-side sampling with the composite method ceased and just the remote samplers were deployed at three sites) to support decisions about further sampling.

Further Data Interpretation

Relationships between PCB and HgT estimated particle concentrations, watershed characteristics, and other water quality measurements were evaluated. Based on data collected since WY 2003, PCB particle concentrations were correlated with impervious cover ($r_s = 0.56$), old industrial land use ($r_s = 0.53$), and HgT particle concentrations ($r_s = 0.38$). PCB particle concentrations were inversely correlated with watershed area and particle concentrations for arsenic, cadmium, copper, lead, and zinc. HgT particle concentrations were not correlated with those of other trace metals ($p>0.1$) and had similar but weaker relationships as PCBs to impervious cover ($r_s = 0.28$, $p<0.05$), old industrial land use ($r_s = 0.23$, $p<0.05$), and watershed area ($r_s = -0.29$, $p<0.05$). Overall, the data collected to date support the ongoing use of land use as a loose and imperfect proxy but do not support the use of any of the trace metals analyzed as a proxy for either PCB or HgT pollution sources.

Most evidence suggests that, as a general category, old industrial land use exhibits the greatest loads and yields of PCBs relative to other land uses in the region. The watersheds/catchments for the 93 sites[4] that have been sampled for PCBs and Hg with RMP and grant funding since WY 2003 cover about 34% of the old industrial area in the region. Of the remaining areas in the region with old industrial land use yet to be sampled (76 km^2), 48% of it lies within 1 km of the Bay and 74% is within 2 km of the Bay. These areas nearer the Bay are more likely to be tidal and to include heavy industrial areas that were historically serviced by rail and ship-based transport and are often very difficult to sample because of a lack of public rights-of-way and tidal-related constraints. These areas may have relatively high concentrations compared to industrial areas further from the Bay margin due to a longer use period and the nature of heavy machinery associated with rail and ship transport. A different sampling strategy may be needed to effectively estimate the mass of pollution that is associated with these areas.

This Pollutants of Concern Reconnaissance Monitoring study will continue at least into WY 2021 with the goal to identify areas for follow-up investigation and possible management action. The focus will continue to be on finding new areas of concern, although follow-up sampling will occur at some sites to verify previous sampling results.

[4] One site that was sampled for Hg (San Pedro stormdrain in San Jose), was not sampled for PCBs but since it is nested within Guadalupe River watershed, it does not influence this analysis.

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1. Introduction

The San Francisco Bay polychlorinated biphenyl (PCB) and mercury total maximum daily loads (TMDLs) (SFBRWQCB, 2006; 2007) call for implementation of control measures to reduce stormwater polychlorinated biphenyl (PCB) loads from an estimated annual baseline load of 20 kg to 2 kg by 2030 and total mercury (HgT) loads from about 160 kg to 80 kg by 2028. Shortly after adoption of the TMDLs, in 2009 the San Francisco Bay Regional Water Quality Control Board (Regional Water Board) issued the first Municipal Regional Stormwater Permit (MRP) for MS4 phase I stormwater agencies (SFBRWQCB, 2009; 2011). In support of the TMDLs, MRP 1.0, as it came to be known, contained a provision for improved information on stormwater loads for pollutants of concern (POCs) in selected watersheds (Provision C.8.) and specific provisions for Hg, methylmercury and PCBs (Provisions C.11 and C.12) that called for reducing Hg and PCB loads from smaller urbanized tributaries. To help address these permit requirements, a Small Tributaries Loading Strategy (STLS) was developed that outlined four key management questions (MQs) as well as a general plan to address these questions (SFEI, 2009).

MQ1. Which Bay tributaries (including stormwater conveyances) contribute most to Bay impairment from POCs?

MQ2. What are the annual loads or concentrations of POCs from tributaries to the Bay?

MQ3. What are the decadal-scale loading or concentration trends of POCs from small tributaries to the Bay?

MQ4. What are the projected impacts of management actions (including control measures) on tributaries and where should these management actions be implemented to have the greatest beneficial impact?

During the first MRP term (2009-15), the majority of STLS effort was focused on refining pollutant loading estimates and finding and prioritizing potential “high leverage” watersheds and subwatersheds that contribute disproportionately high concentrations or loads to sensitive Bay margins. This work was funded by the RMP and the Bay Area Stormwater Management Agencies Association (BASMAA)[5]. With that additional effort, sufficient pollutant data have now been collected over a period from water years (WYs) 2003 – 2014 at 11 sites to estimate watershed scale pollutant loads with varying degrees of certainty (McKee et al., 2015, Gilbreath et al., 2015a). Also, during the first MRP term, a Regional Watershed Spreadsheet Model (RWSM) was developed as a regional-scale planning tool, primarily to estimate long-term pollutant loads from the combined area of all small tributaries, and secondarily to provide supporting information for prioritizing watersheds or sub-watershed areas for management (Wu et al., 2016; 2017).

In November 2015, the Regional Water Board issued the second iteration of the MRP (SFBRWQCB, 2015). In this second iteration (MRP 2.0), the Water Board has asked that permittees place an increased focus on finding high-leverage watersheds, source areas, and source properties that are more polluted,

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

and that are located upstream of sensitive Bay margin areas. Specifically, the Water Board, through this permit, added a stipulation to identify sources or watershed source areas that provide the greatest opportunities for reductions of PCBs and Hg in urban stormwater runoff. To help support this focus and also to refine information to address other Management Questions, the Sources, Pathways, and Loadings Work Group (SPLWG) and the Small Tributaries Loading Strategy Team developed and implemented a stormwater reconnaissance field monitoring protocol in WYs 2015-2020 to provide data, as part of multiple lines of evidence, for the identification of potential high-leverage areas. The monitoring protocol was adapted from the one first implemented in WY 2011 (McKee et al., 2012) and benefited from lessons learned from that effort. This same field monitoring protocol was also implemented in WYs 2016 - 2019 by the San Mateo Countywide Water Pollution Prevention Program and the Santa Clara Valley Urban Runoff Pollution Prevention Program (EOA, 2020a and 2020b) and in 2020 by the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP, 2020a).

This report summarizes and provides a preliminary interpretation of data collected during WYs 2015-2020, as well as from previous studies overseen by this workgroup and others dating back to WY 2003. The data collected and presented here contribute to a broad effort of identifying potential management areas for pollutant reduction. The report is designed to be updated annually and will be updated again in approximately 12 months to include WY 2021 sampling data.

During Calendar Year (CY) 2018 and 2019, the RMP also funded a data analysis project that aimed to mine and reinterpret all existing stormwater PCB data to add further supporting information to help guide management decisions. The primary goals of that analysis were to develop additional and improved methods for identifying and ranking watersheds/catchments of management interest for further investigation, and to guide future sampling design. Two methods were developed; a congener profile method (Davis and Gilbreath, 2019) and a loads and yields based ranking method (McKee et al., 2019). The project is nearing completion now (McKee et al., 2021) with the expected results being data stratification into four main bins:

1. Sites with upstream watersheds of high interest (likely management effort, such as cleanups, referrals, product disposal, would be most cost effective in these watersheds and would likely result in measurable downward trends in concentrations and loads),
2. Sites with upstream watersheds of medium interest (some other types of more general management effort may be warranted to reduce concentrations and loads)
3. Sites with upstream watersheds of low interest (no specific or general effort needed - management effort would be least cost effective and is likely not warranted)
4. Sites where the data are insufficient or deficient in some manner (resample to improve decision making)

In addition, the STLS team is evaluating sampling protocols for monitoring stormwater loading trends in response to management efforts (Melwani et al., 2018) and has developed a modeling and trends strategy that outlines key elements for modeling regional scale loads and trends using dynamic simulation as well as a framework sampling design to support the model development (Wu, et. al., 2018), laid of a plan on how to do that (Wu and McKee, 2019), and is preparing a draft progress report of phase 1 of the model development that describes the hydrology model calibration (Zi et al., 2021). Reconnaissance data collected in WYs 2011 and 2015-2020 may provide "baseline" data for identifying concentration or particle concentration trends over time, could be statistically analyzed to independently generate land use based EMCs, or could be used for model verification purposes, all this with the understanding that management actions to control PCB and Hg loads were increasingly being implemented during this period. These ideas and uses could be the subjects of future RMP projects.

2. Methods

2.1 Sampling locations

Four objectives were used as a basis for site selection.

1. Identify potential high-leverage watersheds and catchments, including
   a. Watersheds/catchments with suspected high pollution,
   b. Sites with ongoing or planned management actions,
   c. Source identification within a larger watershed of known concern (nested sampling design).
2. Sample strategic large watersheds with USGS gauges to provide first-order loading estimates and to support calibration of the regional models (RWSM (Wu et al., 2017; SFEI, 2018)); County Program RAAs[6] (ACCWP, 2018; CCCWP, 2018; SCVURPPP, 2020b; SMCWPPP, 2020; Solano Permittees, 2020); RMP regional dynamic model (Zi et al., 2021)),
3. Validate unexpected low (potential false negative) concentrations to address the possibility of a single storm composite poorly characterizing a sampling location,
4. Fill data gaps along environmental gradients or source areas to allow for the continuing reevaluation of our conceptual understanding of relationships between land uses, source areas and pollutant concentrations and loads.

The majority of samples during WYs 2015-2017 (60-80% of the effort) were dedicated to identifying potential high-leverage watersheds, subwatersheds, and storm drain catchments (Objective 1). The remaining resources were allocated to addressing the other three objectives. In WYs 2018-2020, approximately 50% of the resources were allocated to identifying potential high-leverage watersheds/catchments, while the other 50% was allocated to resampling stations previously measured in reconnaissance sampling in order to validate previously measured concentrations. RMP staff worked with the respective Countywide Programs to identify priority drainages for monitoring including storm drains, ditches/culverts, tidally influenced channels and culverts, and natural channels. During the summers of 2014-2019, approximately 100 sites were visited, and each was surveyed for safety, logistical constraints, and feasible drainage-line entry points. From this larger set, a final set of 10-20 sites was selected each year to form the sampling location pool from which field staff would select from for each storm, depending on logistics, storm characteristics and tidal phase relative to storm timing.

[6] Reasonable Assurance Analysis (RAA) is being carried out by the county clean water programs following a guidance document produced for the Bay Area (BASMAA, 2017).

Watershed sites with a wide variety of characteristics were sampled in WYs 2015-2020 (Figure 1 and Table 1). Of these sites[7], 21 were in Santa Clara County, 19 in San Mateo County, 17 in Alameda County, 12 in Contra Costa County[8] and 1 in Solano County. The drainage area for each sampling location ranged from 0.02 to 233 km^2 and imperviousness based on the National Land Cover Database (Homer et al., 2015) ranged from 2%-88%. Typically, however, the reconnaissance watersheds/catchments were characterized as small (74% had areas < 5.0 km^2) with a high degree of imperviousness (71% of watersheds/catchments had >60% impervious cover). The percentage of old industrial[9] area in watersheds/catchments ranged from 0 to 87% (mean 22%) (dataset used included the land use dataset input to the Regional Watershed Spreadsheet Model) (SFEI, 2018). Although most of the sampling sites were selected primarily to identify potential high-leverage watersheds/catchments, some sites were resampled to verify whether the first sample collected at these locations was a "false negative" (unexpectedly low concentration). Guadalupe River at Hwy 101 was also resampled for PCBs in WY 2017 as a piggyback opportunity during a large and rare storm sampled primarily to assess trends for mercury (McKee et al., 2018). A matrix of site characteristics for sampling strategic larger watersheds was also developed (Appendix A), but no larger watersheds were sampled in WYs 2015 or 2016 because the sampling trigger criteria for rainfall and flow were not met, and only one (Colma Creek) was sampled in WY 2017. Trigger criteria were met in January and February 2017 for other strategic larger watersheds under consideration (Alameda Creek at EBRPD Bridge at Quarry Lakes, Dry Creek at Arizona Street, San Francisquito Creek at University Avenue, Matadero Creek at Waverly Street), but none were sampled because staff and budgetary resources were allocated elsewhere. None of these trigger criteria were met in WYs 2018, 2019, or 2020. The sampling carried out at the reconnaissance monitoring sites completed so far complements the more in-depth sampling campaigns (2-8 years of sampling at each site) that have been carried out at sites designated as a "Loadings Study" (Figure 1).

2.2 Field methods

Mobilization and preparing to sample

Mobilization for sampling was typically triggered by a storm forecast. When a minimum rainfall of at least one-half inch[10] over 6 hours was forecast, sampling teams were deployed, ideally reaching the sampling site about one hour before the onset of rainfall[11]. When possible, one team sampled two sites close to one another to increase efficiency and reduce staffing costs per site per sample. Upon arrival,

[7] Total reported here is 69 sites. One additional site (North Emeryville Crescent) has been sampled for a different project, the Priority Margin Unit Study, for a total of 70 reconnaissance style monitoring sites since 2015. North Emeryville Crescent is within Alameda County.

[8] Given the long history of industrial zoning along much of the Contra Costa County waterfront relative to other counties, more sampling is needed to characterize these areas.

[9] Note that the definition of "old Industrial" land use used here is based on definitions developed by the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP) building on GIS development work completed during the development of the RWSM (Wu et al., 2016; 2017).

[10] This was relaxed in some years due to a lack of larger storms.

[11] Antecedent dry-weather was not considered prior to deployment. Antecedent conditions can have impacts on the concentration of certain build-up/wash-off pollutants like metals. For PCBs, however, antecedent dry-weather may be less important for the mobilization of in-situ legacy sources.

the team assembled equipment and carried out final site safety checks. Sampling equipment used at a site depended on the accessibility of drainage lines. Some sites were sampled by attaching laboratory-prepared trace-metal-clean Teflon sampling tubing to a painter's pole and a peristaltic pump with laboratory-cleaned silicone pump-roller tubing (Figure 2a). During sampling, the tube was dipped into the channel or drainage line at mid-channel mid-depth (if shallow) or depth integrating if the depth was more than 0.5 m. In other cases, a DH 81 (Teflon) sampler was used without a pump (Figure 2b).

Manual time-paced composite stormwater sampling procedures

At each site, a time-paced composite sample was collected with a variable number of sub-samples, or aliquots. Based on the weather forecast, prevailing on-site conditions, and radar imagery, field staff estimated the duration of the storm and selected an aliquot size for each analyte (0.1-0.5 L) and number of aliquots (minimum=2; mode=5) to ensure the minimum volume requirements for each analyte (Hg, 0.25 L; SSC, 0.3 L; PCBs, 1 L; Grain Size, 1 L; TOC, 0.25 L) were reached before the end of the storm. Because the minimum volume requirements were less than the size of the sample bottles, there was flexibility to add aliquots in the event a storm continued longer than predicted. The final volume of the aliquots was determined just before the first aliquot was taken and remained fixed for the sampling event. Similarly, the time period between aliquots was decided just before the second aliquot was taken and then remained the same for the rest of the event. All aliquots for a storm were collected into the same bottle, kept in a cooler on ice during sampling, and then refrigerated at 4 °C before transport to a laboratory (see Yee et al. 2017 for information about bottles, preservatives and hold times).

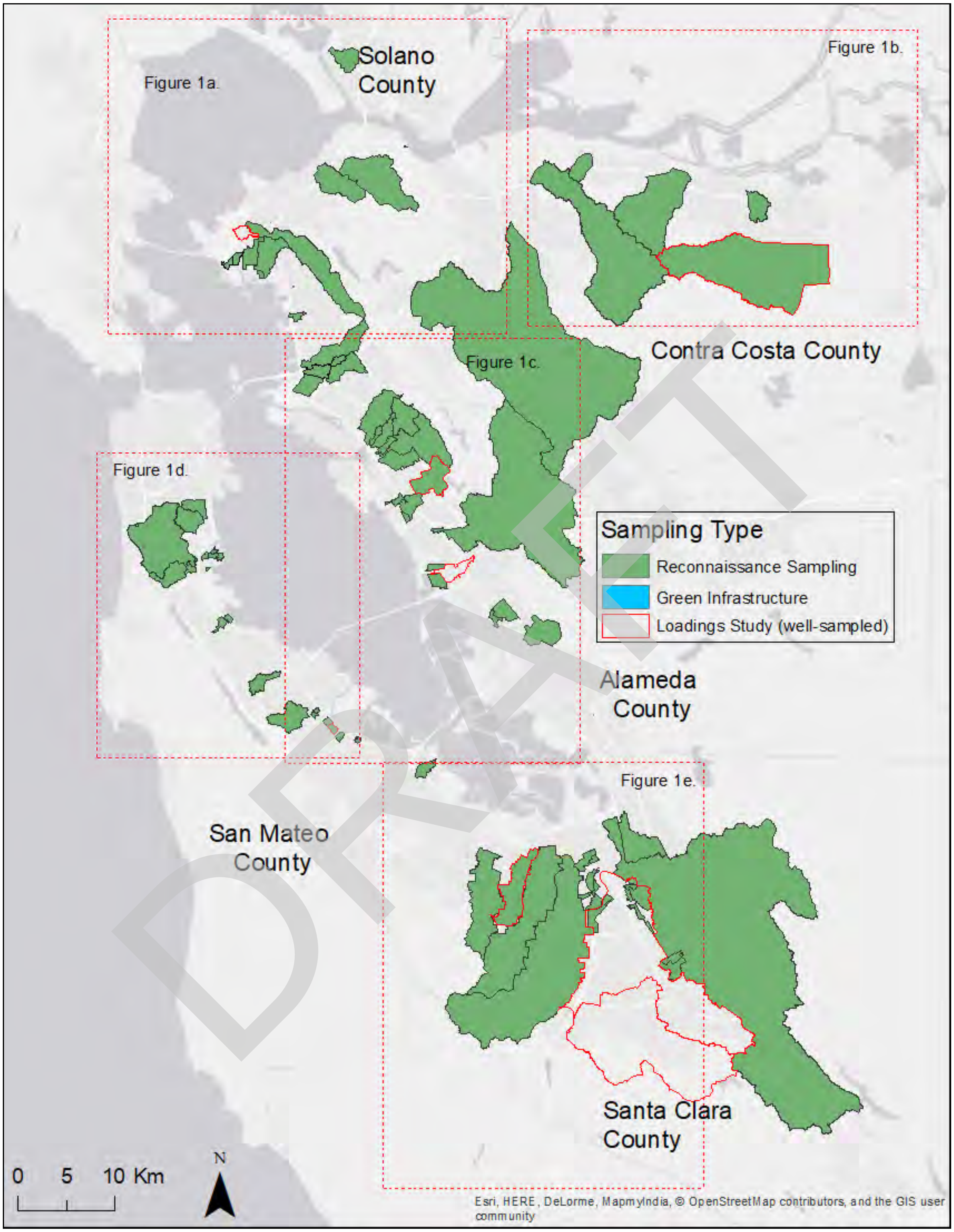

Figure 1. Watersheds/catchments sampled to date. Note: The drainage management areas (DMAs) of the green stormwater infrastructure sampling sites are so small they are not visible, though they are given a numeric map key identifier.

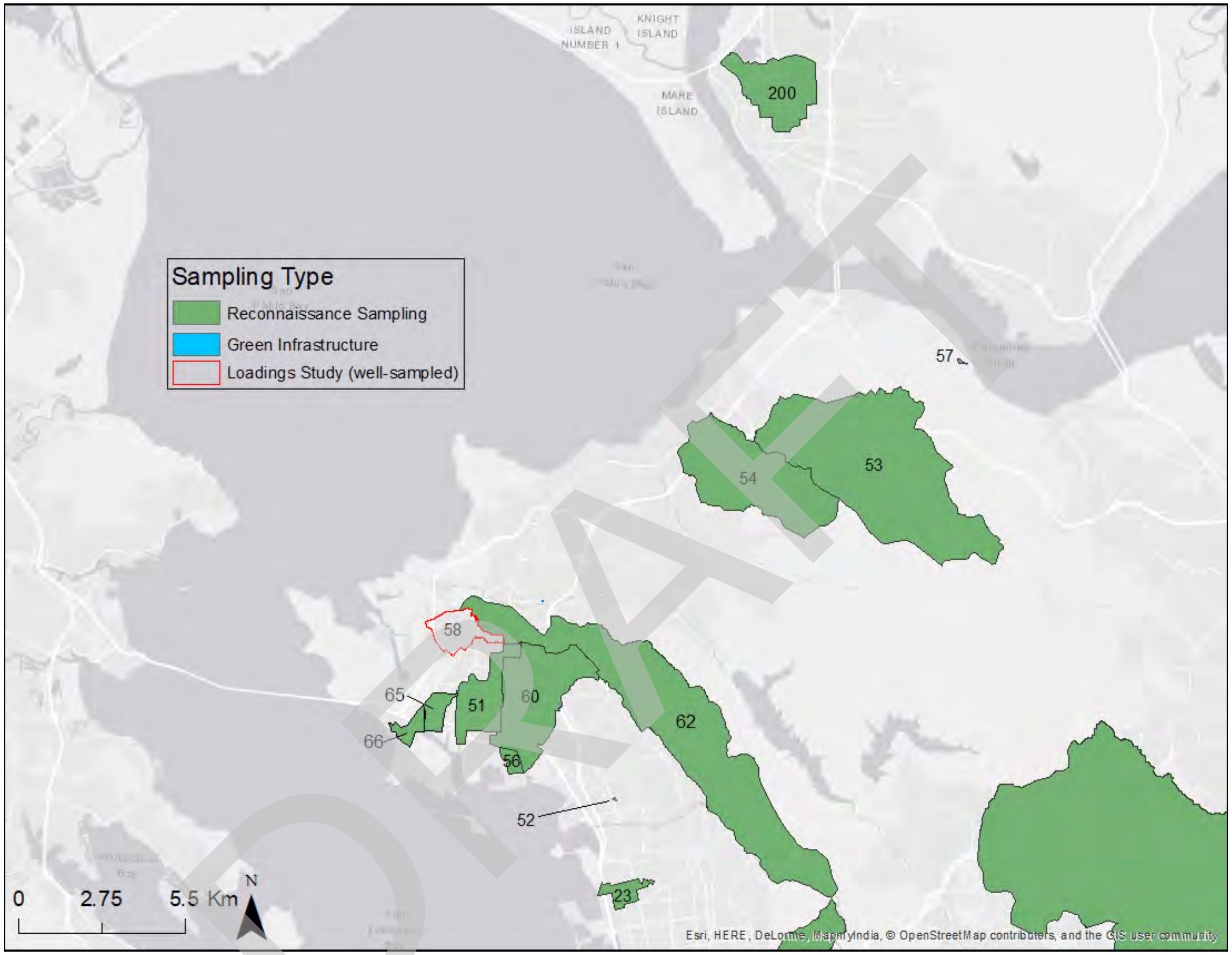

Figure 1a. Watershed boundaries of sites sampled in western Contra Costa County and Solano County. Note: The drainage management areas (DMAs) of the green stormwater infrastructure sampling sites are so small they are not visible, though they are given a numeric map key identifier. See Table 1 for information on each numbered watershed or drainage management area.

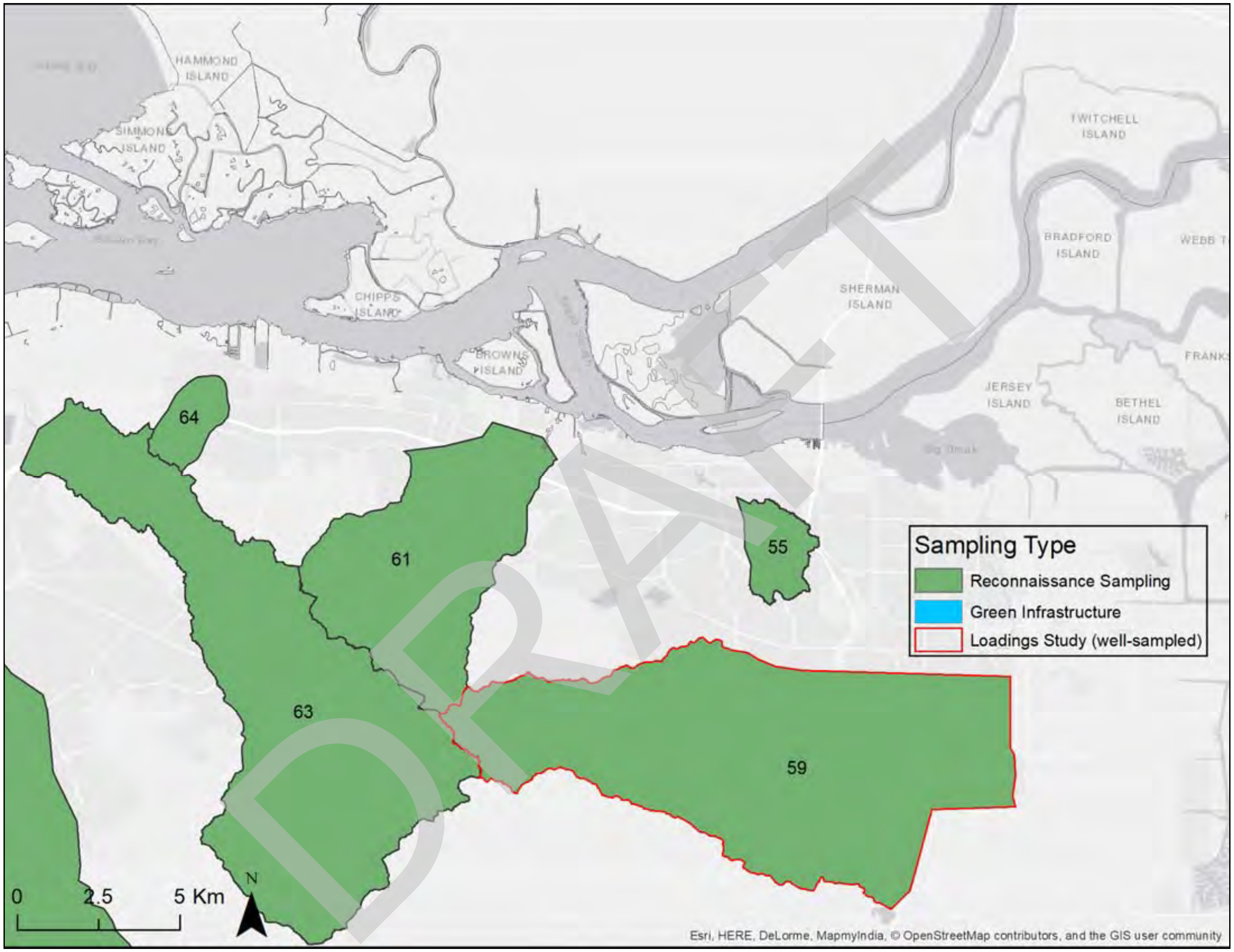

Figure 1b. Watershed boundaries of sites sampled in eastern Contra Costa County. Note: The drainage management areas (DMAs) of the green stormwater infrastructure sampling sites are so small they are not visible, though they are given a numeric map key identifier. See Table 1 for information on each numbered watershed or drainage management area.

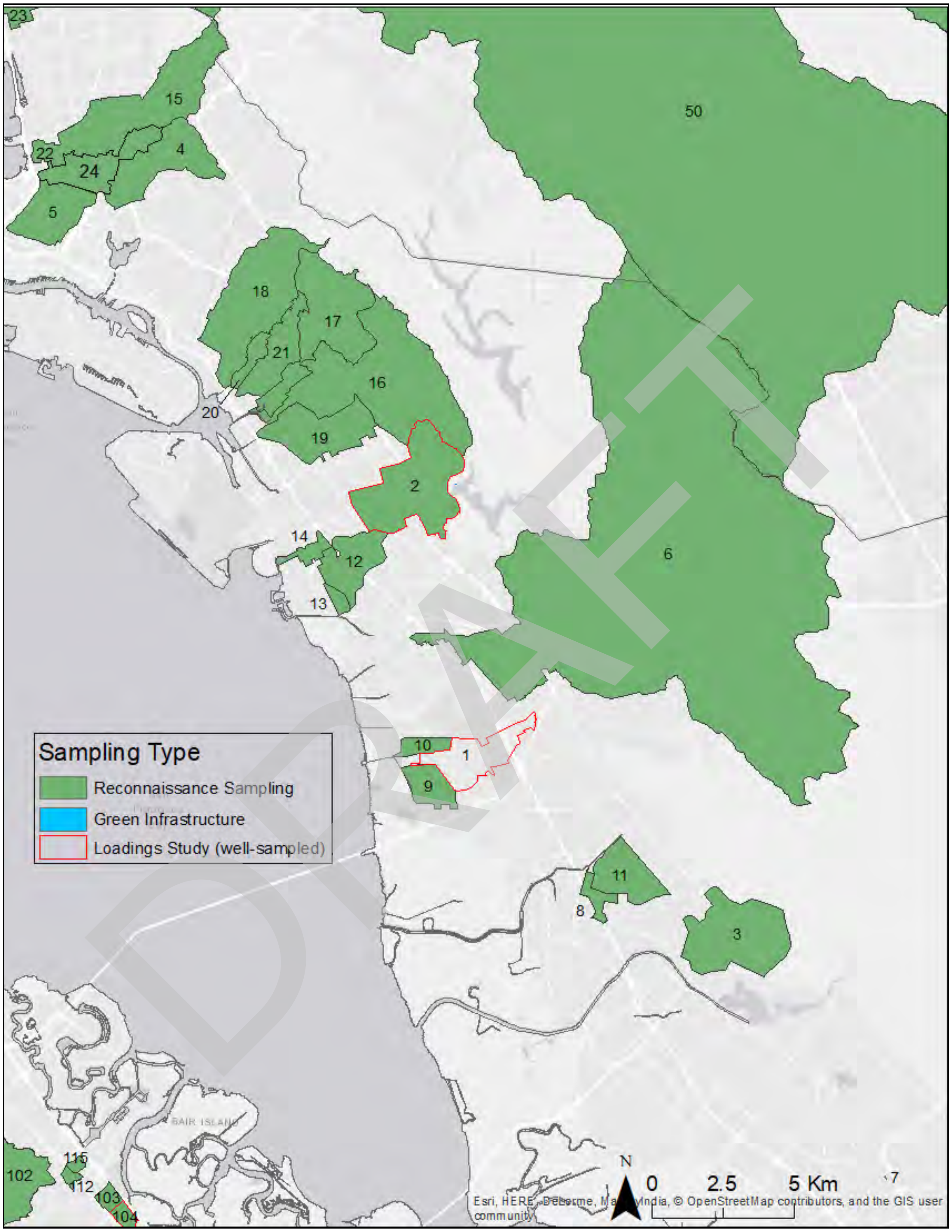

Figure 1c. Watershed boundaries of sites sampled in Alameda County. Note: The drainage management areas (DMAs) of the green stormwater infrastructure sampling sites are so small they are not visible, though they are given a numeric map key identifier. See Table 1 for information on each numbered watershed or drainage management area.

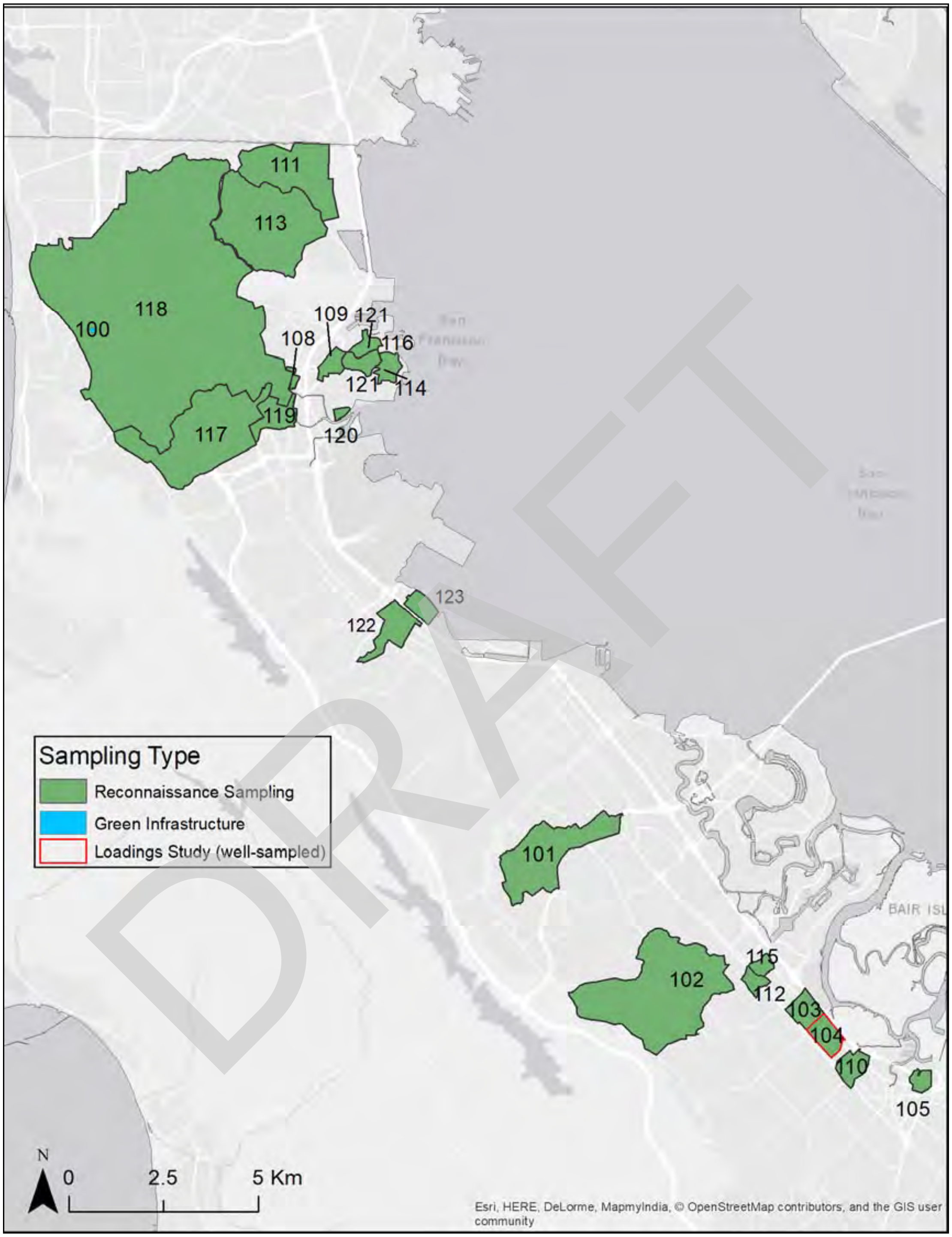

Figure 1d. Watershed boundaries of sites sampled in northern San Mateo County. Note: The drainage management areas (DMAs) of the green stormwater infrastructure sampling sites are so small they are not visible, though they are given a numeric map key identifier. See Table 1 for information on each numbered watershed or drainage management area.

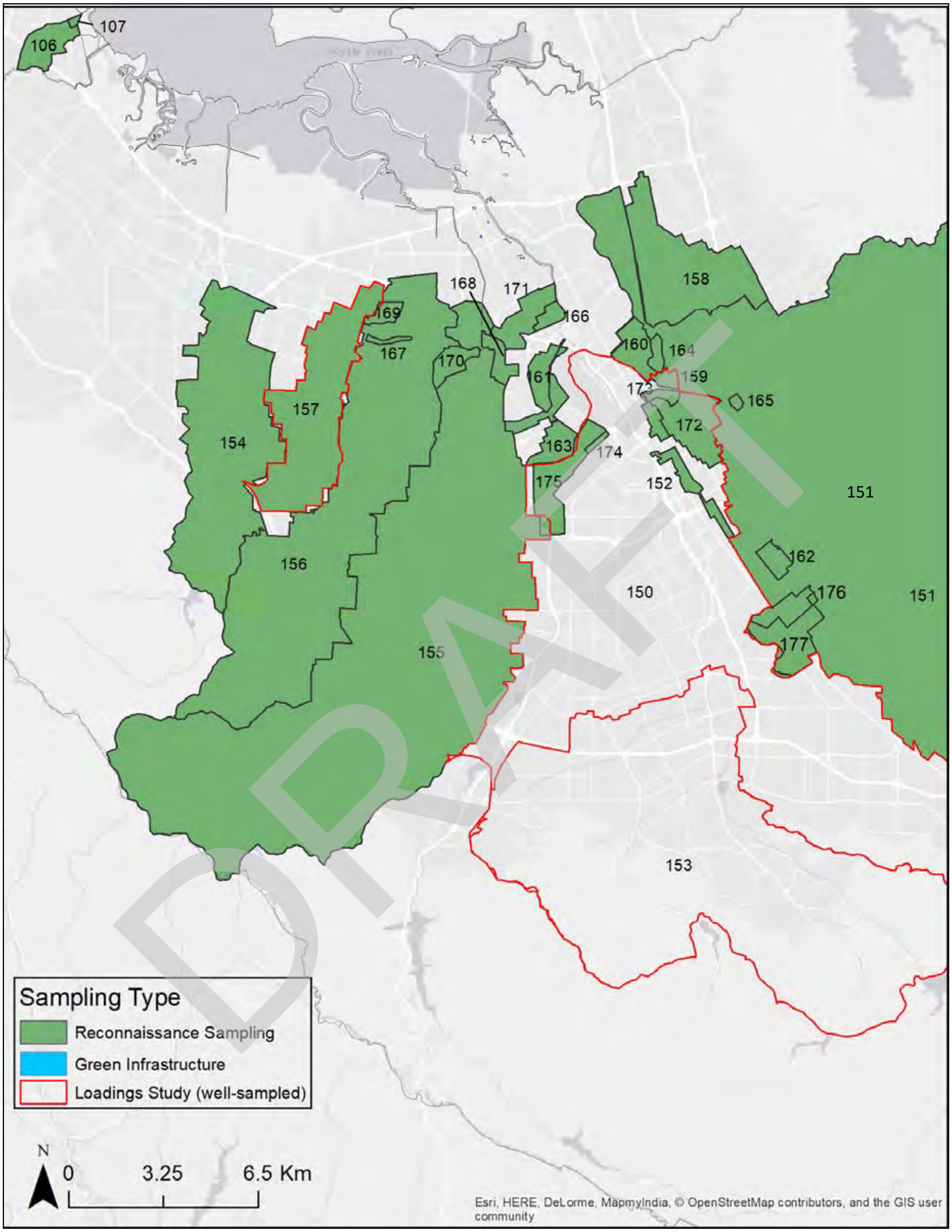

Figure 1e. Watershed boundaries of sites sampled in Santa Clara County. Note: The drainage management areas (DMAs) of the green stormwater infrastructure sampling sites are so small they are not visible, though they are given a numeric map key identifier. See Table 1 for information on each numbered watershed or drainage management area.

Table 1. Key characteristics of the 91[12] sampling locations. Gaps in continuous numbering allow for the future addition of locations so that the unique identifying numbers for each county remain in the same count of 50.

Map Key	County	City	Watershed Name	Catchment Code	MS4 or Receiving Water	Latitude	Longitude	Sample Date	Area (sq km)	Impervious Cover (%)	Old Industrial (%)
1	Alameda	Hayward	Zone 4 Line A	Z4LA	MS4	37.645328	-122.137364	WY 2007-2010	4.2	68%	12%
2	Alameda	San Leandro	San Leandro Creek	SLC	MS4	37.726119	-122.162696	12/5/10 & 12/19/10; WYs 2012-14	8.9	38%	0%
3	Alameda	Union City	Zone 5 Line M	Z5LM	MS4	37.586476	-122.028427	12/17/10 & 3/19/11	8.1	34%	5%
4	Alameda	Oakland	Glen Echo Creek	Glen Echo Creek	MS4	37.818271	-122.260326	2/15/11	5.5	39%	0%
5	Alameda	Oakland	Ettie Street Pump Station	ESPS	MS4	37.826043	-122.288942	2/17/11	4.0	75%	22%
6	Alameda	San Leandro	San Lorenzo Creek	San Lorenzo Creek	MS4	37.684836	-122.138599	12/17/10 & 12/19/10	125	13%	0%
7	Alameda	Fremont	Fremont Osgood Road Bioretention Influent	Fremont Osgood Road Bioretention Influent	Bioretention Influent	37.518394	-121.945225	2012, 2013	0.00	76%	0%
8	Alameda	Union City	Line 3A-M at 3A-D	AC-Line 3A-M	MS4	37.61285	-122.06629	12/11/14	0.88	73%	12%
9	Alameda	Hayward	Line 4-E	AC-Line 4-E	MS4	37.64415	-122.14127	12/16/14	2.00	81%	27%
10	Alameda	Hayward	Line 4-B-1	AC-Line 4-B-1	MS4	37.64752	-122.14362	12/16/14	0.96	85%	28%
11	Alameda	Union City	Line 3A-M-1 at Industrial PS	AC-Line 3A-M-1	MS4	37.61893	-122.05949	12/11/14	3.44	78%	26%
12	Alameda	San Leandro	Line 9-D	AC-Line 9-D	MS4	37.69383	-122.16248	4/7/15	3.59	78%	46%
13	Alameda	San Leandro	Line 9-D-1 PS at outfall to Line 9-D	AC-2016-15	MS4	37.69168	-122.16679	1/5/16	0.48	88%	62%
14	Alameda	San Leandro	Line 13-A at end of slough	AC-2016-14	MS4	37.70497	-122.19137	3/10/16	0.83	84%	68%
15	Alameda	Emeryville	Zone 12 Line A under Temescal Ck Park	AC-2016-3	MS4	37.83450	-122.29159	1/6/16	9.41	42%	0.6%
16	Alameda	Oakland	Line 12K at Coliseum Entrance	Line12KEntrance	MS4	37.75446	-122.20431	2/9/17	16.40	31%	1%
17	Alameda	Oakland	Line 12J at mouth to 12K	Line12J	MS4	37.75474	-122.20136	12/15/16	8.81	30%	2%
18	Alameda	Oakland	Line 12F below PG&E station	Line12F	MS4	37.76218	-122.21431	12/15/16	10.18	56%	3%

[12] There are 94 total sampling locations. Of these, 70 were sampled during WYs 2015-2020, 94 had water concentrations for HgT, and 93 had water concentrations for PCBs.

Map Key	County	City	Watershed Name	Catchment Code	MS4 or Receiving Water	Latitude	Longitude	Sample Date	Area (sq km)	Impervious Cover (%)	Old Industrial (%)
19	Alameda	Oakland	Line 12M at Coliseum Way	Line12MColWay	MS4	37.74689	-122.20069	2/9/17 & 11/28/2018	5.30	69%	22%
20	Alameda	Oakland	Line 12H at Coliseum Way	Line12H	MS4	37.76238	-122.21217	12/15/16	0.97	71%	10%
21	Alameda	Oakland	Line 12I at Coliseum Way	Line12I	MS4	37.75998	-122.21020	12/15/16	3.41	63%	9%
22	Alameda	Emeryville	Zone 12 Line A at Shellmound	Line12AShell	MS4	37.83424	-122.29352	1/8/18	10.48	41%	6%
23	Alameda	Berkeley	Outfall at Gilman St.	AC-2016-1	MS4	37.87761	-122.30984	12/21/15 & 1/9/18	0.84	76%	32%
24	Alameda	Oakland	North Emeryville Crescent (PMU)	North Emeryville Crescent (PMU)	MS4	37.827305	-122.285908	1/16/2020	3.71	71%	9%
50	Contra Costa	Concord	Walnut Creek	Walnut Creek	Receiving Water	37.96962	-122.053778	12/28/10	232	15%	0%
51	Contra Costa	Richmond	Santa Fe Channel	Santa Fe Channel	MS4	37.92118056	-122.3619972	12/05/10	3.3	69%	3%
52	Contra Costa	El Cerrito	El Cerrito Bioretention Influent	ELC	Bioretention Influent	37.905884	-122.304929	WY 2012, 2014-15, 2017	0.00	74%	0%
53	Contra Costa	Rodeo	Rodeo Creek at Seacliff Ct. Pedestrian Br.	RodeoCk	Receiving Water	38.01604	-122.25381	1/18/17	23.41	2%	3%
53[13]	Contra Costa	Rodeo	Rodeo Creek at Viewpoint Blvd.	RodeoCk	Receiving Water	38.018472	-122.256647	1/6/2019	23.5	2%	3%
54	Contra Costa	Hercules	Refugio Ck at Tsushima St	RefugioCk	Receiving Water	38.01775	-122.27710	1/18/17	10.73	23%	0%
55	Contra Costa	Antioch	East Antioch nr Trembath	EAntioch	Receiving Water	38.00333	-121.78106	1/8/17	5.26	26%	3%
56	Contra Costa	Richmond	MeekerWest	MeekerWest	Receiving Water	37.91313	-122.33871	1/9/18	0.41	70%	69%
57	Contra Costa	Port Costa	Little Bull Valley	Little Bull Valley	Receiving Water	38.03680	-122.17662	3/1/18	0.02	67%	2%
58	Contra Costa	Richmond	North Richmond Pump Station	NRPS	MS4	37.953903	-122.373997	WY 2011, 2013-14	2.0	62%	18%
59	Contra Costa	Oakley	Lower Marsh Creek	LMC	Receiving Water	37.990723	-121.696118	3/24/11; WYs 2012-14	84	10%	0%
60	Contra Costa	Richmond	Meeker Slough	Meeker Slough	Receiving Water	37.91786	-122.33838	12/3/14 & 1/9/18	7.34	64%	6%
61	Contra Costa	Pittsburg	Kirker Ck at Pittsburg Antioch Hwy and Verne Roberts Cir	KirkerCk	Receiving Water	38.01275	-121.84345	1/8/17 & 4/6/18	36.67	18%	5%
62	Contra Costa	Richmond	Wildcat Creek	Wildcat Creek	Receiving Water	37.960329°	-122.366840°	1/30/19	23.44	53%	1%
63	Contra Costa	Concord	Mount Diablo Creek	Mount Diablo Creek	Receiving Water	38.018756°	-122.026878°	1/15/19	75.56	9%	0%
64	Contra Costa	BayPoint	BayPoint	BayPoint	Receiving Water	38.034075°	-121.962504°	1/15/19	4.35	21%	0%

[13] At the scale of the map, the two Rodeo Creek sampling points are close enough that the watershed polygon on the map is the same.

Map Key	County	City	Watershed Name	Catchment Code	MS4 or Receiving Water	Latitude	Longitude	Sample Date	Area (sq km)	Impervious Cover (%)	Old Industrial (%)
65	Contra Costa	Richmond	Santa Fe Channel East	Santa Fe Channel East	MS4	37.924603	-122.375972	11/26/2019	0.87	61%	28%
66	Contra Costa	Richmond	Santa Fe Channel West	Santa Fe Channel West	MS4	37.924603	-122.375972	11/26/2019	0.66	58%	21%
100	San Mateo	Daly City	Gellert Park Daly City Library Bioretention Influent	Gellert Park	Bioretention Influent	37.663037	-122.470585	WY 2009	0.02	40%	0%
101	San Mateo	San Mateo	Borel Creek	Borel Creek	MS4	37.551273	-122.309424	3/18/11	3.2	31%	0%
102	San Mateo	Belmont	Belmont Creek	Belmont Creek	MS4	37.517328	-122.276109	3/18/11	7.2	27%	0%
103	San Mateo	San Carlos	Pulgas Pump Station-North	Pulgas Pump Station-North	MS4	37.5045833	-122.2490056	2/17/11 & 3/18/11	0.55	84%	52%
104	San Mateo	San Carlos	Pulgas Pump Station-South	Pulgas Pump Station-South	MS4	37.5045833	-122.2490056	2/17/11 & 3/18/11; WYs 2013-14	0.58	87%	54%
105	San Mateo	Redwood City	Oddstad PS	SM-267	MS4	37.49172	-122.21886	12/2/14	0.28	74%	11%
106	San Mateo	East Palo Alto	Runnymede Ditch	SM-70	MS4	37.46883	-122.12701	2/6/15	2.05	53%	2%
107	San Mateo	East Palo Alto	SD near Cooley Landing	SM-72	MS4	37.47492	-122.12640	2/6/15	0.11	73%	39%
108	San Mateo	South San Francisco	South Linden PS	SM-306	MS4	37.65018	-122.41127	2/6/15	0.14	83%	22%
109	San Mateo	South San Francisco	Gateway Ave SD	SM-293	MS4	37.65244	-122.40257	2/6/15	0.36	69%	52%
110	San Mateo	Redwood City	Veterans PS	SM-337	MS4	37.49723	-122.23693	12/15/14	0.52	67%	7%
111	San Mateo	Brisbane	Tunnel Ave Ditch	SM-350/368/more	Receiving Water	37.69490	-122.39946	3/5/16	3.02	47%	8%
112	San Mateo	San Carlos	Taylor Way SD	SM-32	MS4	37.51320	-122.26466	3/11/16	0.27	67%	11%
113	San Mateo	Brisbane	Valley Dr SD	SM-17	MS4	37.68694	-122.40215	3/5/16	5.22	21%	7%
114	San Mateo	South San Francisco	Forbes Blvd Outfall	SM-319	MS4	37.65889	-122.37996	3/5/16	0.40	79%	0%
115	San Mateo	San Carlos	Industrial Rd Ditch	SM-75	MS4	37.51831	-122.26371	3/11/16	0.23	85%	79%
116	San Mateo	South San Francisco	Gull Dr SD	SM-314	MS4	37.66033	-122.38510	3/5/16 & 1/9/18	0.30	78%	54%
117	San Mateo	South San Francisco	S Spruce Ave SD at Mayfair Ave (296)	SSpruce	MS4	37.65084	-122.41811	1/8/17	5.15	39%	1%
118	San Mateo	South San Francisco	Colma Ck at S. Linden Blvd	ColmaCk	MS4	37.65017	-122.41189	2/7/17	35.07	41%	3%
119	San Mateo	South San Francisco	S Linden Ave SD (291)	SLinden	MS4	37.64420	-122.41390	1/8/17	0.78	88%	57%

Map Key	County	City	Watershed Name	Catchment Code	MS4 or Receiving Water	Latitude	Longitude	Sample Date	Area (sq km)	Impervious Cover (%)	Old Industrial (%)
120	San Mateo	South San Francisco	Outfall to Colma Ck on service rd nr Littlefield Ave. (359)	ColmaCkOut	MS4	37.64290	-122.39677	2/7/17	0.09	88%	87%
121	San Mateo	South San Francisco	Gull Dr Outfall	SM-315	MS4	37.66033	-122.38502	3/5/16 & 1/9/18	0.43	75%	42%
122	San Mateo	Burlingame	SMBUR164A	SMBUR164A	MS4	37.5995966	-122.3752573	11/28/18	0.98	71%	37%
123	San Mateo	Burlingame	SMBUR85A	SMBUR85A	MS4	37.60194467	-122.3749872	11/28/18	0.42	81%	44%
150	Santa Clara	San Jose	Guadalupe River at Hwy 101	Guad 101	Receiving Water	37.37355	-121.93269	WYs 2003-2006, 2010, 2012-2014; 1/8/17	233.00	39%	3%
151	Santa Clara	Milpitas	Lower Coyote Creek	Lower Coyote Creek	Receiving Water	37.421814	-121.928153	2005	327	22%	1%
152	Santa Clara	San Jose	San Pedro Storm Drain	San Pedro Storm Drain	MS4	37.343769	-121.900781	2006	1.3	72%	16%
153	Santa Clara	San Jose	Guadalupe River at Foxworthy Road/ Almaden Expressway	GRFOX	Receiving Water	37.278396	-121.877944	2010	107	22%	0%
154	Santa Clara	Mountain View	Stevens Creek	Stevens Creek	Receiving Water	37.391306	-122.069586	2/18/11	26	38%	1%
155	Santa Clara	Santa Clara	San Tomas Creek	San Tomas Creek	Receiving Water	37.388992	-121.968634	12/28/10	108	33%	0%
156	Santa Clara	Santa Clara	Calabazas Creek	Calabazas Creek	Receiving Water	37.4034556	-121.9867056	12/28/10	50	44%	3%
157	Santa Clara	Sunnyvale	Sunnyvale East Channel	SunCh	Receiving Water	37.394728	-122.010441	3/19/11; WYs 2012-14	15	59%	4%
158	Santa Clara	Milpitas	Lower Penitencia Ck	Lower Penitencia	Receiving Water	37.42985	-121.90913	WY 2011; 12/11/14	11.50	65%	2%
159	Santa Clara	San Jose	E. Gish Rd SD	SC-066GAC550	MS4	37.36632	-121.90203	12/11/14	0.44	84%	71%
160	Santa Clara	San Jose	Charcot Ave SD	SC-051CTC275	MS4	37.38413	-121.91076	4/7/15	1.79	79%	25%
161	Santa Clara	Santa Clara	Seabord Ave SD SC-050GAC580	SC-050GAC580	MS4	37.37637	-121.93793	12/11/14	1.35	81%	68%
162	Santa Clara	San Jose	Rock Springs Dr SD	SC-084CTC625	MS4	37.31751	-121.85459	2/6/15	0.83	80%	10%
163	Santa Clara	Santa Clara	Seabord Ave SD SC-050GAC600	SC-050GAC600	MS4	37.37636	-121.93767	12/11/14	2.80	62%	18%
164	Santa Clara	San Jose	Ridder Park Dr SD	SC-051CTC400	MS4	37.37784	-121.90302	12/15/14	0.50	72%	57%
165	Santa Clara	San Jose	Outfall to Lower Silver Ck	SC-067SCL080	MS4	37.35789	-121.86741	2/6/15	0.17	79%	78%
166	Santa Clara	Santa Clara	Victor Nelo PS Outfall	SC-050GAC190	MS4	37.38991	-121.93952	1/19/16	0.58	87%	4%
167	Santa Clara	Santa Clara	Lawrence & Central Expwys SD	SC-049CZC800	MS4	37.37742	-121.99566	1/6/16	1.20	66%	1%

Map Key	County	City	Watershed Name	Catchment Code	MS4 or Receiving Water	Latitude	Longitude	Sample Date	Area (sq km)	Impervious Cover (%)	Old Industrial (%)
168	Santa Clara	Santa Clara	E Outfall to San Tomas at Scott Blvd	SC-049STA550	MS4	37.37991	-121.96842	3/6/16	0.67	66%	31%
169	Santa Clara	Santa Clara	Duane Ct and Ave Triangle SD	SC-049CZC200	MS4	37.38852	-121.99901	12/13/15 & 1/6/2016	1.00	79%	23%
170	Santa Clara	Santa Clara	Condensa St SD	SC-049STA710	MS4	37.37426	-121.96918	1/19/16	0.24	70%	32%
171	Santa Clara	Santa Clara	Haig St SD	SC-050GAC030	MS4	37.38664	-121.95223	3/6/16	2.12	72%	10%
172	Santa Clara	San Jose	Rosemary St SD 066GAC550C	Rosemary	MS4	37.36118	-121.90594	1/8/17	3.67	64%	11%
173	Santa Clara	San Jose	North Fourth St SD 066GAC550B	NFourth	MS4	37.36196	-121.90535	1/8/17	1.01	68%	27%
174	Santa Clara	San Jose	GR outfall 066GAC900	GR outfall 066GAC900	MS4	37.35392	-121.91223	4/7/18	0.17	66%	1%
175	Santa Clara	San Jose	GR outfall 066GAC850	GR outfall 066GAC850	MS4	37.35469	-121.91279	4/7/18	3.35	61%	6%
176	Santa Clara	San Jose	SC100CTC400A	SC100CTC400A	MS4	37.30299651	-121.8399512	1/16/19	1.38	63%	8%
177	Santa Clara	San Jose	SC100CTC500A	SC100CTC500A	MS4	37.30148661	-121.8381464	1/16/19	3.01	54%	7%
200	Solano	Vallejo	Austin Ck at Hwy 37	AustinCk	Receiving Water	38.12670	-122.26791	3/24/17	4.88	61%	2%

Remote suspended sediment sampling procedures

After pilot testing in 2015-2018 (Table 2), in spring 2018 workgroup meeting, the SPLWG independent advisors indicated they were satisfied with the results of the pilot testing and recommended the use of remote samplers for use as a screening tool based on data collected between WYs 2015-2018 (see Gilbreath et al. 2019 for in depth review of the pilot data for the remote sampler trial).

During WY 2019 sampling, a Walling Tube (Phillips et al., 2000) suspended sediment sampler was deployed at three sites prior to three storms and retrieved within two days of the end of each storm. Only the remote sampler was used at these sites to characterize water quality; no manual sampling was performed simultaneously. In WY 2020, no remote sampler deployments were made because none of the sites selected that year were feasible for remote sampling. The Walling Tube was used in open channels, deployed at approximately mid-channel, and secured to the natural bed with hose clamps attached to temporarily installed rebar (Figure 2c).

Water and sediment collected in the samplers were decanted into one or two large bottles. When additional water was needed to flush the settled sediment from the remote samplers into the collecting bottles, site water from the sampled channel was used. The collected samples were split and placed into laboratory containers and shipped to the laboratory for analysis. Samples were analyzed as whole-water samples (because of insufficient solid mass to analyze as a sediment sample). Between sampling sites, the remote samplers were thoroughly cleaned using a brush and Alconox detergent, followed by a deionized water (DI) rinse.

2.3 Laboratory analytical methods

The target analytes for this study are listed in Table 3. The analytical methods and quality control tests are further described in the RMP Quality Assurance Program Plan (Yee et al., 2019). Laboratory methods were chosen based on a combination of factors, including method detection limits, accuracy and precision, and cost (BASMAA, 2011; 2012) (Table 3). For some sites where remote samplers were deployed, both particulate and dissolved phases of Hg, PCBs, and organic carbon (OC) were analyzed for comparison with whole-water concentrations and particulate-only concentrations from manually collected water samples.

2.4 Interpretive methods

Estimated particle concentrations

The reconnaissance monitoring field protocol is designed to collect one composite whole water sample for each analyte during a single storm at each site to characterize concentrations during storm flow. Measured PCB and Hg concentrations at a site could have large inter-storm variability related to storm size, intensity and antecedent conditions, as observed from previous studies when a large number of storms were sampled (Gilbreath et al., 2015a); this variability cannot be captured in a single composite sample. However, variability can be reduced if concentrations are normalized to SSC, which produces an estimate of the pollutant concentration associated with particles in the sample. The estimated particle

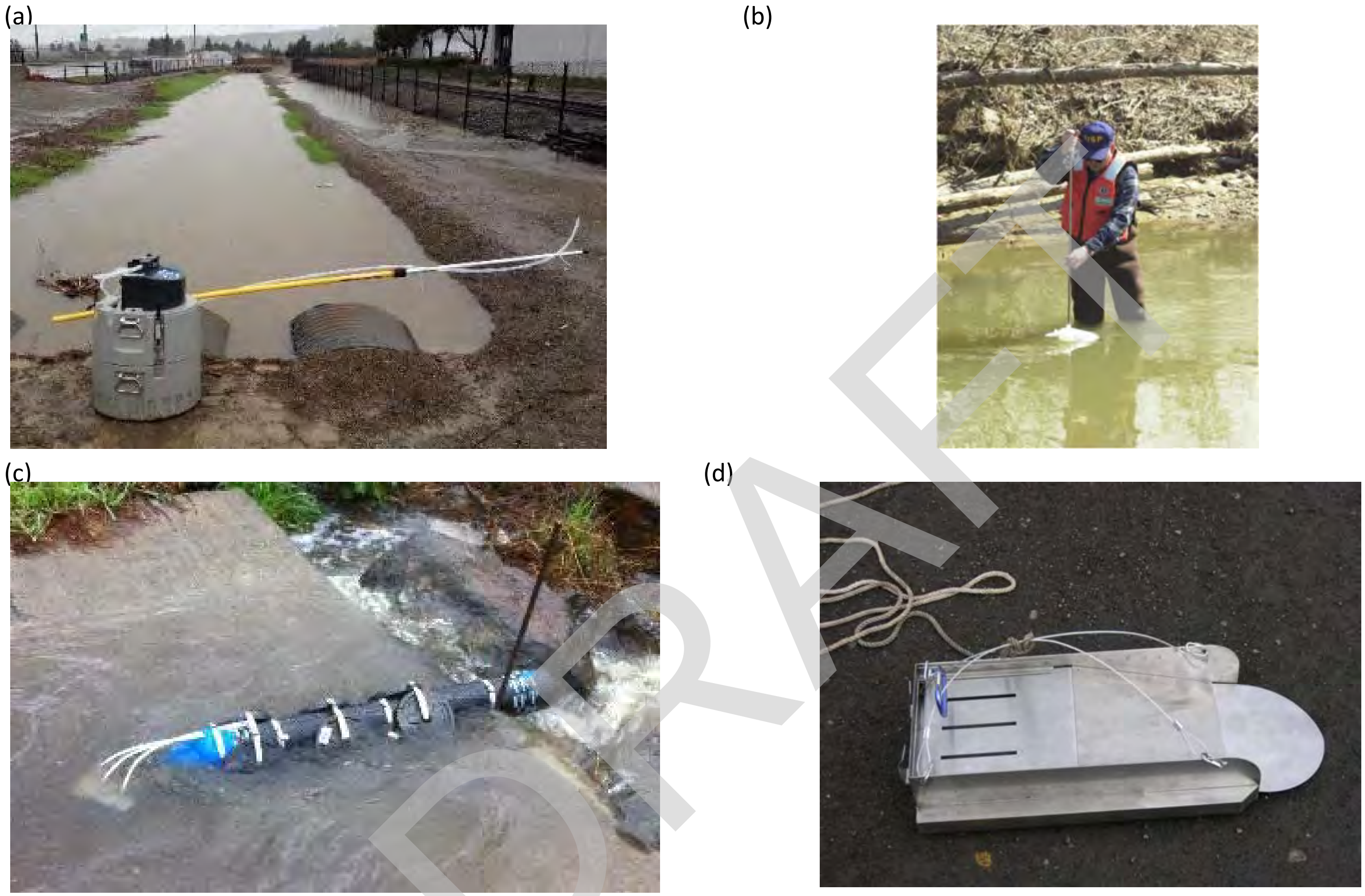

Figure 2. Sampling equipment used in the field. (a) Painter's pole, Teflon tubing and an ISCO used as a slave pump; (b) Teflon bottle attached to the end of a DH81 sampling pole; (c) a Walling Tube suspended sediment sampler secured by 5-lb weights along the body of the tube (because it is sitting atop a concrete bed) and rebar driven into the natural bed at the back of the sampler; and (d) a Hamlin Sampler.

Table 2. Locations where remote sediment samplers were pilot tested in previous sampling years and the three locations where the samplers were deployed in WY 2019.

Site	County	Date	Sampler(s) deployed	Comments	Pilot test or solo deployment?
Meeker Slough	Contra Costa	11/2015	Hamlin and Walling Tube	Sampling effort was unsuccessful because of very high velocities. Both samplers washed downstream because they were not sufficiently weighted down and debris caught on the securing lines.	Pilot test
Outfall to Lower Silver Creek	Santa Clara	2/06/15	Hamlin and Walling Tube	Sampling effort was successful. This sample was analyzed as a water sample.	Pilot test
Charcot Ave Storm Drain	Santa Clara	4/07/15	Hamlin	Sampling effort was successful. This sample was analyzed as a sediment sample.	Pilot test
Cooley Landing Storm Drain	San Mateo	2/06/15	Hamlin	Sampling effort was successful. This sample was analyzed as a water sample.	Pilot test
Duane Ct and Ave Triangle SD	Santa Clara	1/6/2016	Hamlin	Sampling effort was successful. This sample was analyzed as a water sample.	Pilot test
Victor Nelo PS Outfall	Santa Clara	1/19/2016	Hamlin and Walling Tube	Sampling effort was successful. This sample was analyzed as a water sample.	Pilot test
Forbes Blvd Outfall	San Mateo	3/5/2016	Hamlin	Sampling effort was successful. This sample was analyzed as a water sample.	Pilot test
Tunnel Ave Ditch	San Mateo	3/5/2016	Hamlin and Walling Tuber	Sampling effort was successful. This sample was analyzed as a water sample.	Pilot test
Taylor Way SD	San Mateo	3/11/2016	Hamlin	Sampling effort was successful. This sample was analyzed as a water sample.	Pilot test
Colma Creek Outfall	San Mateo	2/7/2017	Walling Tube	Sampling effort was successful; however, sampler became submerged for several hours during a high tide cycle and was retrieved afterwards. We hypothesize that this may have added cleaner sediment into the sampler and therefore the result may be biased low. This sample was analyzed as a water sample.	Pilot test
Austin Creek	Solano	3/24/2017	Hamlin and Walling Tube	Sampling effort was successful. This sample was analyzed as a water sample.	Pilot test
Refugio Creek	Contra Costa	1/18/2017	Walling Tube	Sampling effort was successful. This sample was analyzed as a water sample.	Pilot test
Rodeo Creek	Contra Costa	1/18/2017	Walling Tube	Sampling effort was successful. This sample was analyzed as a water sample.	Pilot test
Outfall at Gilman St.	Contra Costa	1/9/2018	Hamlin and Walling Tube	Sampling effort was successful; however, Hamlin sampler could not be gently lowered into place on the bed and instead was dropped from approximately 1.5 ft above the bed;	Pilot test

				it is possible, therefore, that the sampler did not lie horizontally along the bed. This sample was analyzed as a water sample.	
Meeker West	Contra Costa	1/9/2018	Walling Tube	Sampling effort was successful. This sample was analyzed as a water sample.	Pilot test
Bay Point	Contra Costa	1/15/2019	Walling Tube	Sampling effort was successful. This sample was analyzed as a water sample.	Solo deployment
Mount Diablo Creek	Contra Costa	1/15/2019	Walling Tube	Sampling effort was successful. This sample was analyzed as a water sample.	Solo deployment
Wildcat Creek	Contra Costa	1/30/2019	Walling Tube	Sampling effort was successful. This sample was analyzed as a water sample.	Solo deployment

Table 3. Laboratory analysis methods.

Analysis	Matrix	Analytical Method	Lab[14]	Filtered	Field Preservation	Contract Lab / Preservation Hold Time
PCBs (40)[15]-Total	Water	EPA 1668	SGS AXYS	No	NA	NA
PCBs (40)[8]-Dissolved	Water	EPA 1668	SGS AXYS	Yes	NA	NA
PCBs (40)[8]	Sediment	EPA 1668	SGS AXYS	NA	NA	NA
Mercury-Total	Water	EPA 1631E	BAL	No	NA	BRL preservation with BrCl within 28 days
Mercury-Dissolved	Water	EPA 1631E	BAL	Yes	Na	BRL preservation with BrCl within 28 days
Mercury	Sediment	EPA 1631E, Appendix	BAL	NA	NA	7 days
Metals-Total (As, Cd, Pb, Cu, Zn)	Water	EPA 1638 mod	BAL	No	HNO_3	BRL preservation with Nitric acid within 14 days
SSC	Water	ASTM D3977	USGS	No	NA	NA
Grain size	Water	USGS GS method	USGS	No	NA	NA
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 2016-2018)	Water	EPA 9060A	ALS	No	HCL	NA
Organic carbon-Dissolved (WY 2016, 2017)	Water	EPA 9060A	ALS	Yes	HCL	NA
Organic carbon (WY 2016, 2017)	Particulate	EPA 440.0	ALS	NA	NA	NA

concentration (EPC; ratio of mass of a given pollutant of concern to mass of suspended sediment) has been demonstrated to have less inter-storm variability than whole water concentrations, and therefore the EPC is likely a better characterization of water quality at a site than water concentration alone, and is also a better metric for comparison between sites (McKee et al., 2012; Rügner et al., 2013; McKee et al., 2015). EPCs were used as the primary index to compare sites without regard to climate or rainfall intensity. For each analyte at each site the EPC was computed for each composite water sample (Equation 1):

$$EPC\ (ng/mg) = \ (pollutant\ concentration\ (ng/L))/(SSC\ (mg/L)\ ) \quad (1)$$

[14] Labs and locations: SGS AXYS, British Columbia, Canada; Brooks Applied Labs (formerly Brooks Rand Laboratories), Bothell, WA; USGS, Santa Cruz, CA; East Bay Municipal Utilities District, Oakland, CA, ALS Environmental, Kelso, WA.

[15] Samples were analyzed for 40 PCB congeners (PCB-8, PCB-18, PCB-28, PCB-31, PCB-33, PCB-44, PCB-49, PCB-52, PCB-56, PCB-60, PCB-66, PCB-70, PCB-74, PCB-87, PCB-95, PCB-97, PCB-99, PCB-101, PCB-105, PCB-110, PCB-118, PCB-128, PCB-132, PCB-138, PCB-141, PCB-149, PCB-151, PCB-153, PCB-156, PCB-158, PCB-170, PCB-174, PCB-177, PCB-180, PCB-183, PCB-187, PCB-194, PCB-195, PCB-201, PCB-203).

Although normalizing PCB and Hg concentrations to SSC provides an improved metric for comparing sites, climatic conditions can nonetheless influence relative ranking based on EPCs. The nature of that influence may differ between watershed locations depending on source characteristics. For example, a higher proportion of polluted sediment may be triggered during dry years when there is little dilution by sediment erosion from rural parts of the watershed. This scenario is most likely to occur in mixed land-use watersheds with large amounts of pervious area. In contrast, a small patch of polluted soil in a highly impervious watershed may be eroded and transported any time rainfall intensity reaches some threshold. In this instance, a false negative could occur if sampling only occurs during rain events that do not meet that intensity threshold. Such processes can only be identified when data are collected for a single site during many types of storms.

Because of concerns regarding inter-storm variability, relative ranking of sites based on EPC from only one or two storms is always interpreted with caution and added to a broad set of evidence. Such comparisons may be sufficient for providing evidence to differentiate a group of sites with higher pollutant concentrations from a contrasting group with lower pollutant concentrations (acknowledging the risk that some data for watersheds/catchments in this group will be false negatives). However, to generate information on the absolute relative ranking between individual sites, a more rigorous sampling campaign targeting many storms over many years would be required (c.f. the Guadalupe River study: McKee et al., 2017; McKee et al., 2018, or the Zone 4 Line A study: Gilbreath and McKee, 2015; McKee and Gilbreath, 2015). Alternatively, more advanced interpretive methods could be used that take into account a variety of parameters (PCB and suspended sediment sources and mobilization processes, PCB congeners, rainfall intensity, rainfall antecedence, flow production and volume) in the normalization and ranking procedure. As mentioned above, the RMP has funded a project in CYs 2018 and 2019 to develop advanced data analysis methods (McKee et al., 2019; Davis and Gilbreath, 2019) and these methods are now being applied to the entire data set (McKee and Gilbreath, 2021) to identify sites of high, medium, and low management interest and sites where data are insufficient to make that determination such that resampling is recommended.

Derivations of central tendency for comparisons with past data

A mean, median, geometric mean, time-weighted mean, or flow-weighted mean have all been used to summarize the central tendency of data from RMP studies with discrete stormwater samples, and depending on the circumstance, any can be considered the right way. However, to compare the composite sample concentrations (comprised of multiple individual grab samples composited into a single bottle) collected in WYs 2015-20 with discrete grab samples collected at several time points in a storm in previous studies, the average of the discrete grab sample concentrations for the pollutant of interest for an event at a site was divided by the average of the SSC discrete grab sample concentrations. In this case, this is the only right way of computing the average that provides directly comparable data between sites. Because of the use of this alternative method, EPCs reported here differ slightly from those reported previously for some sites (McKee et al., 2012; McKee et al., 2014; Wu et al., 2016).

3. Results and Discussion

This report presents all available stormwater data[16] collected since WY 2003 when stormwater studies first began through SFEI contracts or RMP projects, including data collected in intensive loading studies from WYs 2003-2010 and 2012-2014, a similar reconnaissance study done in WY 2011, and studies of green stormwater infrastructure by SFEI have been done intermittently since WY 2009 with funding from outside of BASMAA and the RMP[17]. The data are presented in the context of three key questions.

a) What are the concentrations and EPCs observed at each of the sites based on the composite water samples? (related to MQs 1 and 2; see page 1)
b) How do the EPCs measured at each of the sites for composite water samples compare to EPCs derived from samples collected by the remote suspended-sediment samplers? (influences collection of data to address MQs 1 & 2. The analysis related to this question is presented in Gilbreath et al., 2019)
c) How do concentrations and EPCs for PCBs and Hg relate to other trace contaminant concentrations and land use? (related to MQs 1 & 2)

These data contribute to a broad effort to identify potential management areas, and the rankings based on either stormwater concentration or EPCs are part of a weight-of-evidence approach for locating and prioritizing areas that may be disproportionately impacting downstream water quality. As the number of sample sites has increased, the relative rankings of particular sites have changed, but the highest-ranking sites have generally remained high. As mentioned previously, a parallel data interpretation effort funded by the RMP will also provide further insights into which sites may warrant higher, medium or low management effort or resampling in the cases where data are insufficient for determination (McKee and Gilbreath, 2021).

3.1 Stormwater SSC concentrations

Suspended sediment concentrations from the 91[18] sampling locations ranged from 16 to 1,354 mg/L, with a median of 96 mg/L. About 30% of the watersheds included in these statistics have greater than 5% agricultural and uncompacted open spaces. If those watersheds/catchments are removed, the 66 remaining are nearly wholly urban (maximum agricultural plus uncompacted open space of 2.1%). The urban, impervious watersheds/catchments have low SSC (relative to the watersheds with greater than 5% open and uncompacted area). Summary statistics for SSC for these 66 urban watersheds/catchments are given in Table 4[19].

[16] Similar data collected by BASMAA in Santa Clara and San Mateo Counties are not included in this report.
[17] Note that BASMAA agencies have also collaborated on performance studies of green stormwater infrastructure. Data from these studies are not included in this report but have been summarized recently (Gilbreath et al., 2018)
[18] This count excludes the sites in which only a remote suspended sediment sampler was deployed. Because those samplers are intended to concentrate suspended sediment, the measurement of SSC is not comparable to the composite sampling. There are 91 total sampling locations. Of these, 70 were sampled during WYs 2015-2019, 87 had water concentrations for PCBs, and 88 had water concentrations for HgT.
[19] At sites where more than one sample has been collected, the SSC has been averaged.

Table 4. Summary statistics (count, minimum, maximum and percentiles) of SSC (in mg/L) for urban watersheds/catchments largely without agricultural and uncompacted open space (functionally <2.1%[20]).

	All Counties	Alameda	Contra Costa	San Mateo	Santa Clara
Number of sampled (n)	66	19	7	18	21
Minimum	16	55	57	16	27
10th Percentile	27	69	NA	21	34
25th Percentile	46	83	58	26	46
50th Percentile	79	164	96	44	73
75th Percentile	148	297	151	83	118
90th Percentile	275	357	NA	160	148
Maximum	671	671	344	265	250

3.2 PCBs stormwater concentrations and estimated particle concentrations

Total PCB concentrations from 90 sampling sites[21] ranged from 533 to 448,000 pg/L (840-fold variation), excluding one sample that had a large number of individual congeners below the method detection limit (<MDL; Table 5). Based on water composite concentrations for all available data, the 10 highest ranking sites for PCBs were (from high to low): Pulgas Pump Station-South, Line 12H at Coliseum Way, Santa Fe Channel, Industrial Rd Ditch, Line 12H at Coliseum Way, Sunnyvale East Channel, Line 12M at Coliseum Way, Pulgas Pump Station-North, Ridder Park Dr Storm Drain and Lind 12A at Shellmound (Table 5, Figure 3). Old industrial land use and PCB concentration were not well correlated (r = 0.19); old industrial land use for these 10 sites ranges from 3-79% (mean 30%, median 16%), illustrating that land use alone is insufficient to identify high leverage areas and is a loose and imperfect regional scale proxy only. Rather, localized sources (e.g., former transformer manufacturing locations, locations of transformer spills, properties that used PCBs where the soils have been contaminated but not remediated to TMDL levels) are likely the most important factor controlling PCB concentrations, although these sources frequently are located in old industrial areas.

For PCBs, EPCs ranged between 2 and 8,222 (4,111-fold variation). Based on EPCs, the 10 highest-ranking sites for PCBs were: Pulgas Pump Station-South, Industrial Rd Ditch, Line 12H at Coliseum Way, Santa Fe Channel, Gull Dr SD, Pulgas Pump Station-North, Outfall to Colma Ck on service road near Littlefield Ave., Outfall to Lower Silver Creek, South Linden Ave. SD and Gull Dr. Outfall. Sites ranked highest based on stormwater concentrations and those ranked highest based on EPCs corresponded moderately well. Five sampling sites were among the 10 highest-ranking sites for both metrics (Figure 4); most sites in the top 10 for either concentrations or EPCs were within the top 20 of the other list, while only one site (South Linden Ave. SD) was ranked high (10th) in EPCs but low on water concentration (38th) because of very low SSC.

[20] Sites were selected based on having less than 5% agricultural and open space, and functionally all of the sites meeting this criterion were in fact less than 2.1% in these land uses.
[21] There are 94 sites in Table 5 but one site, San Pedro Storm drain, only analyzed samples for Hg, not PCBs, and three samples were measured using suspended sediment samplers for which only the particle ratio is comparable to the other manually collected data. The bioretention unit studies are also excluded from these statistics.

Table 5. PCB and total mercury (HgT) water concentrations and estimated particle concentrations (EPCs) measured in Bay Area tributaries based on all RMP data collected in stormwater since water year 2003. The data are sorted from high-to-low for PCB EPC to provide preliminary information on potential leverage. Note: Ranks with a half number (.5) indicate two watersheds/catchments with the same rank. NR = not ranked because concentration was below the MDL or because the study was part of a bioretention study and data is based on a relatively very small watershed.

Watershed/ Catchment	County	Water Year sampled	Area (km^2)	Impervious cover (%)	Old Industrial land use (%)	Polychlorinated biphenyls (PCBs)				Total Mercury (HgT)				Suspended Sediment Concentration (SSC)	
						Estimated Particle Concentration		Composite /mean water concentration		Estimated Particle Concentration		Composite /mean water concentration		Composite /mean water concentration	
						(ng/g)	Rank	(ng/L)	Rank	(ng/g)	Rank	(ng/L)	Rank	(mg/L)	Rank
Pulgas Pump Station-South	San Mateo	2011-2014	0.58	87%	54%	8222	1	448	1	350	46.5	19	64	54	66
Industrial Rd Ditch	San Mateo	2016	0.23	85%	79%	6139	2	160	4	535	27	14	74	26	83
Line 12H at Coliseum Way	Alameda	2017 & 2020	0.97	71%	10%	1936	3	417	2	602	19	36	47	297	15
Santa Fe Channel	Contra Costa	2011	3.3	69%	3%	1295	4	198	3	570	22.5	86	13.5	151	27
Gull Dr SD	San Mateo	2016 & 2018	0.30	78%	54%	903	5	39.8	15	320	53	5.4	86	43	74
Pulgas Pump Station-North	San Mateo	2011	0.55	84%	52%	893	6	60.3	8	400	40	24	58.5	60	59
Outfall to Colma Ck on service rd nr Littlefield Ave. (359)	San Mateo	2017	0.09	88%	87%	788	7	33.9	18	210	70	9	83	43	72.5
Outfall to Lower Silver Creek	Santa Clara	2015	0.17	79%	78%	783	8	44.6	14	420	37	24	58.5	57	63
S Linden Ave SD (291)	San Mateo	2017	0.78	88%	57%	736	9	11.8	38	775	10	12	80	16	87
Gull Dr Outfall	San Mateo	2016 & 2018	0.43	75%	42%	599	10	49.5	12	180	75.5	7.6	84	62	57
Ettie Street Pump Station	Alameda	2011 & 2019 & 2020	4.0	75%	22%	581.3	11	50.7	11	690	14	55	27.5	93	47
Austin Ck at Hwy 37	Solano	2017	4.9	61%	2%	573	12	11.5	40	640	17	13	78.5	20	86
Ridder Park Dr Storm Drain	Santa Clara	2015	0.50	72%	57%	488	13	55.5	9	330	51	37	46	114	37.5
MeekerWest	Contra Costa	2018	0.41	70%	69%	458	14	28.0	25	530	29	32	50	61	58

WYs 2015 through 2020 POC Reconnaissance Monitoring

Watershed/ Catchment	County	Water Year sampled	Area (km²)	Impervious cover (%)	Old Industrial land use (%)	Polychlorinated biphenyls (PCBs)				Total Mercury (HgT)				Suspended Sediment Concentration (SSC)	
						Estimated Particle Concentration		Composite /mean water concentration		Estimated Particle Concentration		Composite /mean water concentration		Composite /mean water concentration	
						(ng/g)	Rank	(ng/L)	Rank	(ng/g)	Rank	(ng/L)	Rank	(mg/L)	Rank
Outfall at Gilman St.	Alameda	2016 & 2018 & 2020	0.84	76%	32%	366	15	29.0	23	2201	3	176	5	76	52
Sunnyvale East Channel	Santa Clara	2011	15	59%	4%	343	16	96.6	6	200	72	50	31	250	18
Line 3A-M at 3A-D	Alameda	2015	0.88	73%	12%	337	17	24.8	26	1170	5	86	13.5	74	53
SMBUR85A	San Mateo	2019	0.42	81%	44%	334	18	31.1	20	440	34	41	42	93	46
Line 12I at Coliseum Way	Alameda	2017	3.4	63%	9%	330	19	97.4	5	170	77.5	71	20	347	13
Line 12M at Coliseum Way	Alameda	2017, 2019	5.3	69%	22%	280	20	82.7	7	348	48	89	12	263	17
North Richmond Pump Station	Contra Costa	2011-2014	2.0	62%	18%	241	21	13.2	36	810	9	47	32.5	58	61
Seabord Ave Storm Drain SC-050GAC580	Santa Clara	2015	1.4	81%	68%	236	22	19.9	30	550	25	47	32.5	85	48
Line 4-E	Alameda	2015	2.0	81%	27%	219	23	37.4	16	350	46.5	59	24	170	24
Kirker Ck at Pittsburg Antioch Hwy and Verne Roberts Cir	Contra Costa	2017 & 2018	36.67	18%	5%	219	24	5.64	60	540	26	16	68	27	81.5
Santa Fe Channel East	Contra Costa	2020	0.87	61%	28%	211	25	31.0	22	1184	4	174	6	147	30
Glen Echo Creek	Alameda	2011	5.5	39%	0%	191	26	31.1	21	210	71	73	18	348	12
Seabord Ave Storm Drain SC-050GAC600	Santa Clara	2015	2.8	62%	18%	186	27	13.5	35	530	28	38	44.5	73	54
Line 12F below PG&E station	Alameda	2017	10	56%	3%	184	28	21.0	29	373	42	43	39	114	37.5
South Linden Pump Station	San Mateo	2015	0.14	83%	22%	182	29	7.81	52	680	15	29	54	43	72.5
Taylor Way SD	San Mateo	2016	0.27	67%	11%	169	30	4.23	65	1156	6	29	55	25	84
Line 9-D	Alameda	2015	3.6	78%	46%	153	31	10.5	43	240	64.5	17	66.5	69	56

WYs 2015 through 2020 POC Reconnaissance Monitoring

Watershed/ Catchment	County	Water Year sampled	Area (km^2)	Impervious cover (%)	Old Industrial land use (%)	Polychlorinated biphenyls (PCBs)				Total Mercury (HgT)				Suspended Sediment Concentration (SSC)	
						Estimated Particle Concentration		Composite /mean water concentration		Estimated Particle Concentration		Composite /mean water concentration		Composite /mean water concentration	
						(ng/g)	Rank	(ng/L)	Rank	(ng/g)	Rank	(ng/L)	Rank	(mg/L)	Rank
Meeker Slough	Contra Costa	2015 & 2018	7.3	64%	6%	140	32	7.91	51	770	11	45	35	57	64
Santa Fe Channel West	Contra Costa	2020	0.66	58%	21%	131	33	45.2	13	287	58	99	10	344	14
North Emeryville Crescent	Alameda	2020	3.71	71%	9%	131	34	7.22	54	No data	No data	No data	No data	55	65
Rock Springs Dr Storm Drain	Santa Clara	2015	0.83	80%	10%	128	35	5.25	61	930	7	38	44.5	41	75.5
GR outfall 066GAC900	Santa Clara	2018	0.17	66%	1%	125	36	3.36	71	644	16	17	65	27	81.5
Charcot Ave Storm Drain	Santa Clara	2015	1.8	79%	24%	123	37	14.9	33	560	24	67	21	121	36
Veterans Pump Station	San Mateo	2015	0.52	67%	7%	121	38	3.52	70	470	32	14	73	29	80
Gateway Ave Storm Drain	San Mateo	2015	0.36	69%	52%	117	39	5.24	62	440	33	20	63	45	70.5
Guadalupe River at Hwy 101	Santa Clara	2003-2006, 2010, 2012-2014, 2017	233	39%	3%	115	40	23.7	27	3600	2	603	1	560	6
Line 9D1 PS at outfall to Line 9D	Alameda	2016	0.48	88%	62%	110	41	18.1	32	720	13	118	7.5	164	25
Tunnel Ave Ditch	San Mateo	2016	3.0	47%	8%	109	42	10.5	41	760	12	73	19	96	43.5
Valley Dr SD	San Mateo	2016	5.2	21%	7%	109	43	10.4	44	276	62	27	57	96	43.5
Runnymede Ditch	San Mateo	2015	2.1	53%	2%	108	44	28.5	24	190	74	52	30	265	16
E Gish Rd Storm Drain	Santa Clara	2015	0.45	84%	70%	99	45	14.4	34	590	21	85	15	145	31
Line 3A-M-1 at Industrial Pump Station	Alameda	2015	3.4	78%	26%	96	46	8.92	46	340	49	31	51	93	45

WYs 2015 through 2020 POC Reconnaissance Monitoring

Watershed/ Catchment	County	Water Year sampled	Area (km^2)	Impervious cover (%)	Old Industrial land use (%)	Polychlorinated biphenyls (PCBs)				Total Mercury (HgT)				Suspended Sediment Concentration (SSC)	
						Estimated Particle Concentration		Composite /mean water concentration		Estimated Particle Concentration		Composite /mean water concentration		Composite /mean water concentration	
						(ng/g)	Rank	(ng/L)	Rank	(ng/g)	Rank	(ng/L)	Rank	(mg/L)	Rank
Line 13A at end of slough	Alameda	2016	0.83	84%	68%	96	47	34.3	17	331	50	118	7.5	357	10
Line 12A at Shellmound	Alameda	2018 & 2019	10.48	41%	6%	74	56	51.6	10	406	38	46	34	817	4
SC100CTC500A	Santa Clara	2019	3.01	54%	7%	94	48	10.5	42	386	41	43	38	111	39.5
Rosemary St SD 066GAC550C	Santa Clara	2017	3.7	64%	11%	89	49	4.11	67	591	20	27	56	46	69
North Fourth St SD 066GAC550B	Santa Clara	2017	1.0	68%	27%	87	50	4.17	66	477	31	23	61	48	67.5
Zone 4 Line A	Alameda	2007-2010	4.2	68%	12%	82	51	18.4	31	170	77.5	30	53	176	23
Forbes Blvd Outfall	San Mateo	2016	0.40	79%	0%	80	52	1.84	80	637	18	15	72	23	85
Storm Drain near Cooley Landing	San Mateo	2015	0.11	73%	39%	79	53	6.47	58	430	35	35	48	82	49
Lawrence & Central Expwys SD	Santa Clara	2016	1.2	66%	1%	78	54	4.51	64	226	66	13	75.5	58	62
Condensa St SD	Santa Clara	2016	0.24	70%	32%	74	55	2.60	78	329	52	12	82	35	78
San Leandro Creek	Alameda	2011-2014	8.9	38%	0%	66	57	8.61	49	860	8	117	9	136	34
Oddstad Pump Station	San Mateo	2015	0.28	74%	11%	62	58	9.20	45	370	43	55	27.5	148	29
Line 4-B-1	Alameda	2015	1.0	85%	28%	57	59	8.67	48	280	59.5	43	37	152	26
Line 12A under Temescal Ck Park	Alameda	2016	9.4	42%	1%	54	60	7.80	53	290	57	42	40	143	32
Victor Nelo PS Outfall	Santa Clara	2016	0.58	87%	4%	51	61	2.29	79	351	44	16	70	45	70.5
SMBUR164A	San Mateo	2019	0.98	71%	37%	48	62	3.87	68	276	61	22	62	80	50
Line 12K at Coliseum Entrance	Alameda	2017	16	31%	1%	48	63	32.0	19	429	36	288	4	671	5
GR outfall 066GAC850	Santa Clara	2018	3.35	61%	6%	45	64	6.63	56	107	86	16	69	149	28

WYs 2015 through 2020 POC Reconnaissance Monitoring

Watershed/ Catchment	County	Water Year sampled	Area (km^2)	Impervious cover (%)	Old Industrial land use (%)	Polychlorinated biphenyls (PCBs)				Total Mercury (HgT)				Suspended Sediment Concentration (SSC)	
						Estimated Particle Concentration		Composite /mean water concentration		Estimated Particle Concentration		Composite /mean water concentration		Composite /mean water concentration	
						(ng/g)	Rank	(ng/L)	Rank	(ng/g)	Rank	(ng/L)	Rank	(mg/L)	Rank
Haig St SD	Santa Clara	2016	2.1	72%	10%	43	65	1.45	82	194	73	7	85	34	79
SC100CTC400A	Santa Clara	2019	1.38	63%	8%	38	66	2.92	74	303	56	23	60	77	51
Colma Ck at S. Linden Blvd	San Mateo	2017	35	41%	3%	37	67	2.65	77	215	69	15	71	71	55
Line 12J at mouth to 12K	Alameda	2017	8.8	30%	2%	35	68	6.48	57	401	39	73	17	183	22
Wildcat Creek	Contra Costa	2019	23.44	53%	1%	32	69	NA	NA	No data	No data	No data	No data	NA	NA
S Spruce Ave SD at Mayfair Ave (296)	San Mateo	2017	5.1	39%	1%	30	70	3.36	72	350	45	39	43	111	39.5
Lower Coyote Creek	Santa Clara	2005	327	22%	1%	30	71	4.58	63	240	64.5	34	49	142	33
Calabazas Creek	Santa Clara	2011	50	44%	3%	29	72	11.5	39	150	82	59	24	393	8
E Outfall to San Tomas at Scott Blvd	Santa Clara	2016	0.67	66%	31%	27	73	2.80	76	127	84	13	75.5	103	42
San Lorenzo Creek	Alameda	2011	125	13%	0%	25	74	12.9	37	180	75.5	41	41	228	20
Stevens Creek	Santa Clara	2011	26	38%	1%	23	75	8.16	50	220	67.5	77	16	350	11
Guadalupe River at Foxworthy Road/ Almaden Expressway	Santa Clara	2010	107	22%	0%	19	76	3.12	73	4090	1	529	2	129	35
Duane Ct and Ave Triangle SD	Santa Clara	2016	1.0	79%	23%	17	77	0.832	84	268	63	13	77	48	67.5
Lower Penitencia Creek	Santa Clara	2011, 2015	12	65%	2%	16	78	1.59	81	160	79.5	17	66.5	106	41
Borel Creek	San Mateo	2011	3.2	31%	0%	15	79	6.13	59	160	79.5	58	26	363	9
San Tomas Creek	Santa Clara	2011	108	33%	0%	14	80	2.83	75	280	59.5	59	24	211	21

WYs 2015 through 2020 POC Reconnaissance Monitoring

Watershed/ Catchment	County	Water Year sampled	Area (km^2)	Impervious cover (%)	Old Industrial land use (%)	Polychlorinated biphenyls (PCBs)				Total Mercury (HgT)				Suspended Sediment Concentration (SSC)	
						Estimated Particle Concentration		Composite /mean water concentration		Estimated Particle Concentration		Composite /mean water concentration		Composite /mean water concentration	
						(ng/g)	Rank	(ng/L)	Rank	(ng/g)	Rank	(ng/L)	Rank	(mg/L)	Rank
Little Bull Valley	Contra Costa	2018	0.02	67%	2%	13	81	0.543	85	312	55	13	78.5	41	75.5
Zone 5 Line M	Alameda	2011	8.1	34%	5%	13	82.5	21.1	28	570	22.5	505	3	886	3
Belmont Creek	San Mateo	2011	7.2	27%	0%	13	82.5	3.60	69	220	67.5	53	29	241	19
BayPoint	Contra Costa	2019	4.35	21%	0%	12	84	NA	NA	140	83	NA	NA	NA	NA
Refugio Ck at Tsushima St	Contra Costa	2017	11	23%	0%	9	85	0.533	86	509	30	30	52	59	60
Walnut Creek	Contra Costa	2011	232	15%	0%	7	86	8.83	47	70	88	94	11	1343	2
Rodeo Creek at Seacliff Ct. Pedestrian Br.	Contra Costa	2017 & 2019	23.41	2%	1%	6	87	7.21	55	93	87	65	22	1354	1
Lower Marsh Creek	Contra Costa	2011-2014	84	10%	0%	3	88	1.45	83	110	85	44	36	400	7
Mount Diablo Creek	Contra Costa	2019	75.56	9%	0%	2	89	NA	NA	157	81	NA	NA	NA	NA
East Antioch nr Trembath	Contra Costa	2017	5.3	26%	3%	NR[a]	NR[a]	<MDL	NR[a]	313	54	12	81	39	77
Gellert Park Daly City Library Bioretention Influent	San Mateo	2009	0.02	40%	0%	36	NR[a]	0.725	NR[a]	1010	NR[a]	22	NR[a]	22	86
El Cerrito Bioretention Influent	Contra Costa	2012, 2014-15, 2017	0.00	74%	0%	310	NR[a]	29.7	NR[a]	196	NR[a]	19	NR[a]	96	42
Fremont Osgood Road Bioretention Influent	Alameda	2012, 2013	0.00	76%	0%	45	NR[a]	2.91	NR[a]	120	NR[a]	10	NR[a]	83	47
San Pedro Storm Drain	Santa Clara	2006	1.3	72%	16%	No data	No data	No data	No data	1120	6	160	6	143	28

NR[a] = site not included in ranking. These are very small catchments with unique sampling designs for evaluation of green stormwater infrastructure.

** Collection was done using a suspended sediment sampler, which concentrates suspended sediment and therefore is not comparable to the samples collected using manual compositing techniques of whole water.

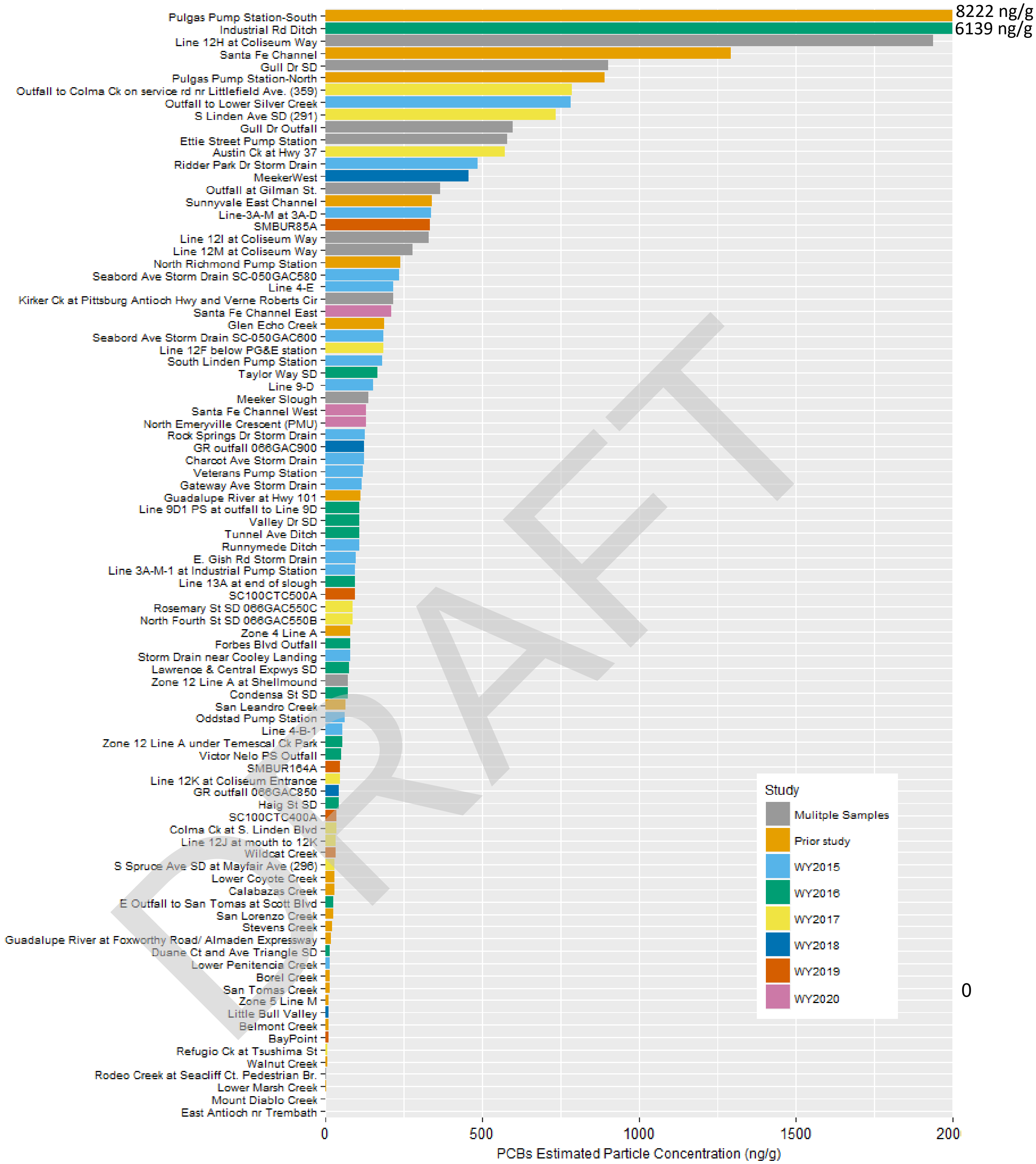

Figure 3. PCB estimated particle concentrations (EPCs) for watershed and catchment sampling sites measured in water years 2003-2020 (where more than one storm was sampled at a site, the reported concentration is the average of the storm composite samples). Note that PCB EPCs for Pulgas Pump Station-South (8,222 ng/g) and Industrial Road Ditch (6,139 ng/g) extend beyond upper bound of the graph. The sample count represented by each bar in the graph is provided in Appendix D.

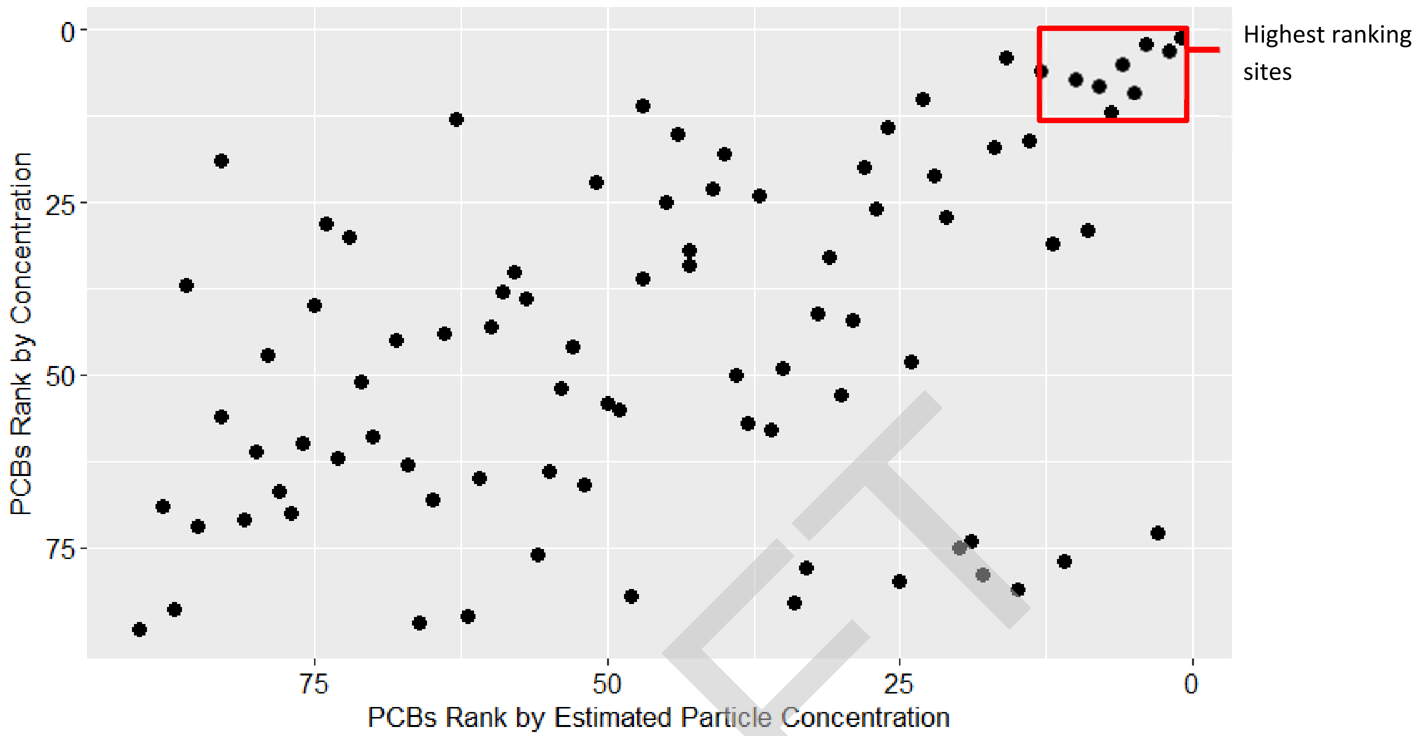

Figure 4. Comparison of site rankings for PCBs based on estimated particle concentrations (EPCs) and on water concentrations. 1 = highest rank; 87[22] = lowest rank.

A high rank in water concentration and a low rank in EPC indicates the presence of PCB sources but dilution by relatively high loading of clean sediment (e.g., >75th percentile of SSC, Table 5). Examples include Line 13A at end of slough (357 mg SS/L) and Line 12K at Coliseum Entrance (671 mg SS/L). Conversely, a high rank in EPC and low rank in water concentration indicates that mobilization of PCB-contaminated sediment is high relative to mobilization of cleaner sediment; these samples often have a relatively low SSC. Examples include South Linden Ave. SD (16 mg SS/L), Austin Ck at Hwy 37 (20 mg SS/L) and Kirker Ck at Pittsburg Antioch Hwy and Verne Roberts Circle (27 mg SS/L). This latter scenario is more likely to occur in watersheds/catchments that are highly impervious with little erosion and transport of clean sediment from undeveloped areas. These ideas are discussed in more detail in the coming RMP report (McKee and Gilbreath, 2021).

Most of the sites investigated had PCB EPCs that were higher than those needed for attainment of the TMDL. The PCB load allocation of 2 kg from the TMDL (SFBRWQCB 2008) translates to a mean water concentration of 1,330 pg/L and a mean particle concentration of 1.4 ng/g. These calculations assume an annual average flow from small tributaries of 1.5 km^3 (Wu et al., 2017) and an average annual suspended sediment load of 1.4 million metric tons (McKee et al., 2013). Only five sampling locations investigated to date (Gellert Park bioretention influent stormwater, Duane Ct. and Triangle Ave., East Antioch nr Trembath, Refugio Ck at Tsushima St. and Little Bull Valley) had a composite averaged PCB

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[22] Includes only sites with PCB concentrations and PCB EPCs.

water concentration of <1,330 pg/L (Table 5) and none of the 90 sampling locations had composite averaged PCB EPCs of <1.4 ng/g (Table 5; Figure 3). The lowest PCB EPC measured to date was for Mount Diablo Creek (1.8 ng/g).

3.3 Mercury stormwater concentrations and estimated particle concentrations

Total mercury concentrations in composite water samples ranged 112-fold from 5.4 to 603 ng/L among the 91[23] sites sampled to date (Table 4). Based on water concentrations, the 10 highest ranking sites for HgT are the Guadalupe River at Hwy 101 (3% old industrial and the legacy New Almaden Mining District upstream), Guadalupe River at Foxworthy Road/ Almaden Expressway (0% old industrial and the legacy New Almaden Mining District upstream), Zone 5 Line M (5% old industrial), Line 12K at the Coliseum Entrance (1% old industrial), Outfall at Gilman St. (32% old industrial), Santa Fe Channel East (28% old industrial), San Pedro Storm Drain (16% old industrial), Line 13-A at end of slough (68% old industrial), Line 9-D-1 PS at outfall to Line 9-D (62% old industrial) and San Leandro Creek at San Leandro Blvd. (0% old industrial) (Table 5). There is a weak and positive relationship between mercury concentrations and old industrial land use. None of the top 10 sites for Hg concentrations were among the top 10 for PCB concentrations, also suggesting there is no direct relationship between mercury and PCBs in stormwater runoff in the Bay Area.

There are several watersheds/catchments with relatively low Hg concentrations. The HgT load allocation of 82 kg from the TMDL (SFBRWQCB, 2006) translates to a mean water concentration of 53 ng/L, based on an annual average flow from small tributaries of 1.5 km^3 (Wu et al., 2017). Sixty-one of 90 sampling locations have composite HgT water concentrations below this concentration (Table 4). There are likely few Hg sources in these watersheds/catchments besides atmospheric deposition[24] and/or low concentrations in atmospheric deposition dilute out any higher concentrations that result from release from the few urban sources that occur.

Estimated particle concentrations of HgT ranged between 70 and 4,090 ng/g (58-fold). The 10 most polluted sites for HgT based on EPCs were Guadalupe River at Foxworthy Road/ Almaden Expressway, Guadalupe River at Hwy 101, Outfall at Gilman St., Santa Fe Channel East, Line 3A-M at 3A-D, Taylor Way SD, San Pedro Storm Drain, Rock Springs Dr. Storm Drain, San Leandro Creek and North Richmond Pump Station (Table 4; Figure 5). None of these 10 sites were among the 10 most highly-ranked sites for PCBs , but 6 additional watersheds/catchments rank in the 20 most highly-ranked sites for both pollutants (Figure 6), providing the opportunity to address both PCBs and HgT. Twenty-seven sites sampled to date have EPCs <250 ng/g, which, given a reasonable expectation of error of 25% around the measurements, could be considered equivalent to or less than 200 ng/g of Hg on suspended solids, the particulate Hg

[23] Includes the 94 sites excluding the 3 sites sampled using the remote samplers and therefore only reporting EPCs, not water concentrations.

[24] Multiple studies in the Bay Area on atmospheric deposition rates for HgT reported 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), and Tsai and Hoenicke reported a total (wet + dry) deposition rate of 18-21 µg/m^2/y. Tsai and Hoenicke computed volume-weighted mean mercury concentrations in precipitation based on 59 samples collected across the Bay Area of 8.0 ng/L. They reported that wet deposition contributed 18% of total annual deposition; scaled to volume of runoff, an equivalent stormwater concentration is 44 ng/L (8 ng/L/0.18 = 44 ng/L).

concentration specified in the Bay and Guadalupe River TMDLs (SFBRWQCB, 2006; 2008). Unlike PCBs, there is no relation between water concentration and EPC for HgT (Figure 7). Therefore, ranking of sites for HgT should be approached more cautiously than for PCBs.

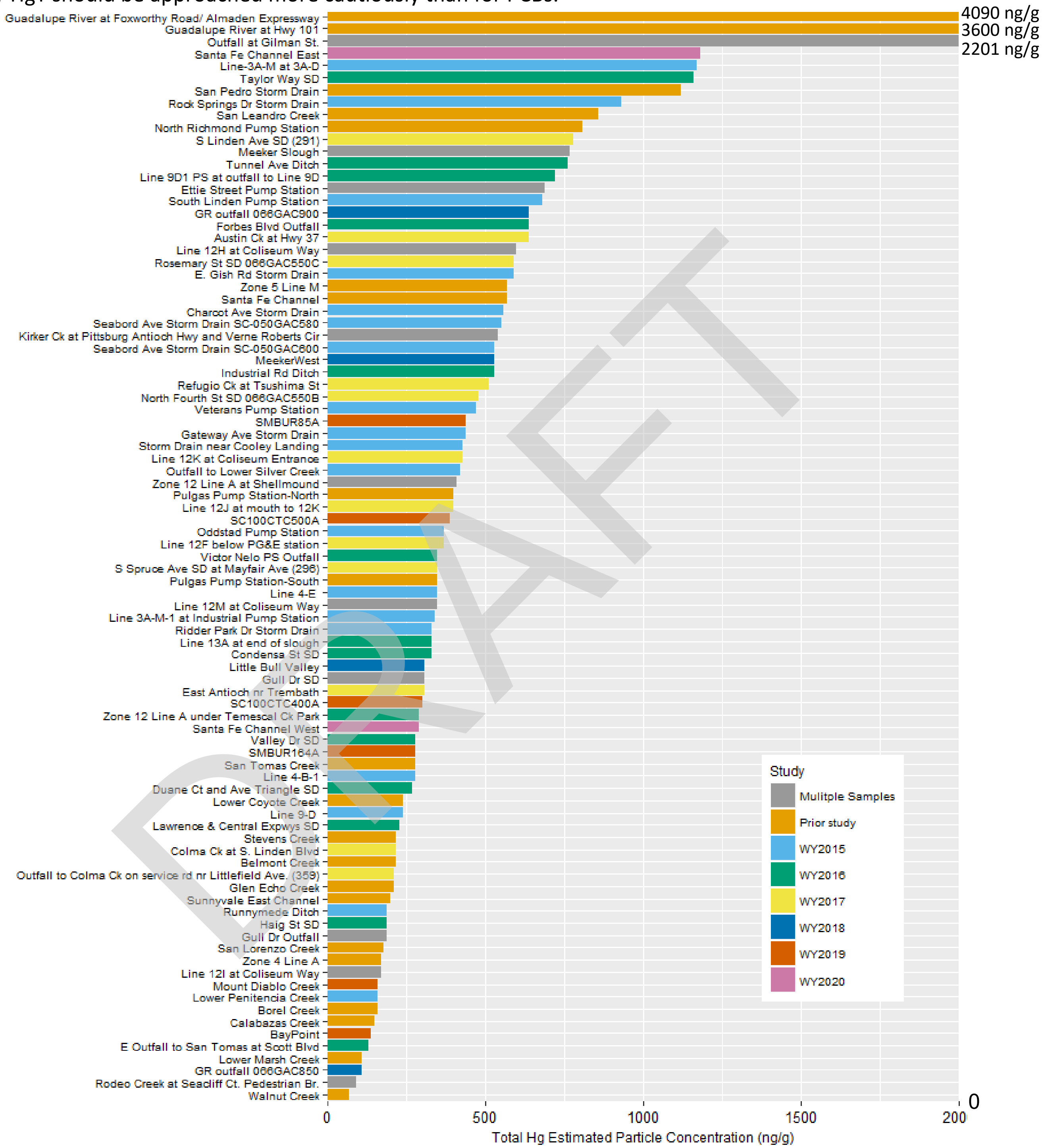

Figure 5. All sampling locations measured to date (water years 2003-2020) ranked by total mercury (HgT) estimated particle concentrations (EPCs). The sample count represented by each bar in the graph is provided in Appendix D.

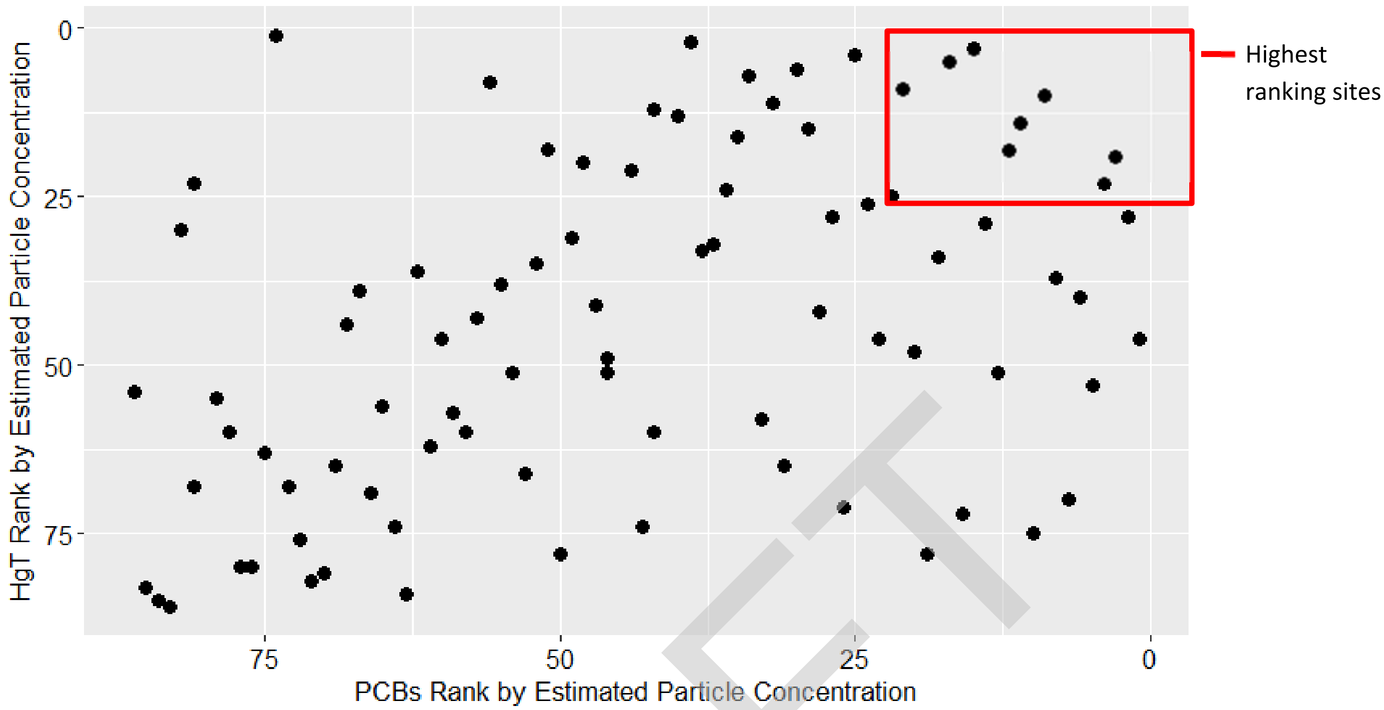

Figure 6. Comparison of site rankings for PCB and total mercury (HgT) estimated particle concentrations (EPCs). 1 = highest rank; 86 = lowest rank. Nine watersheds rank in the top 25 for both PCBs and HgT (in the solid red box).

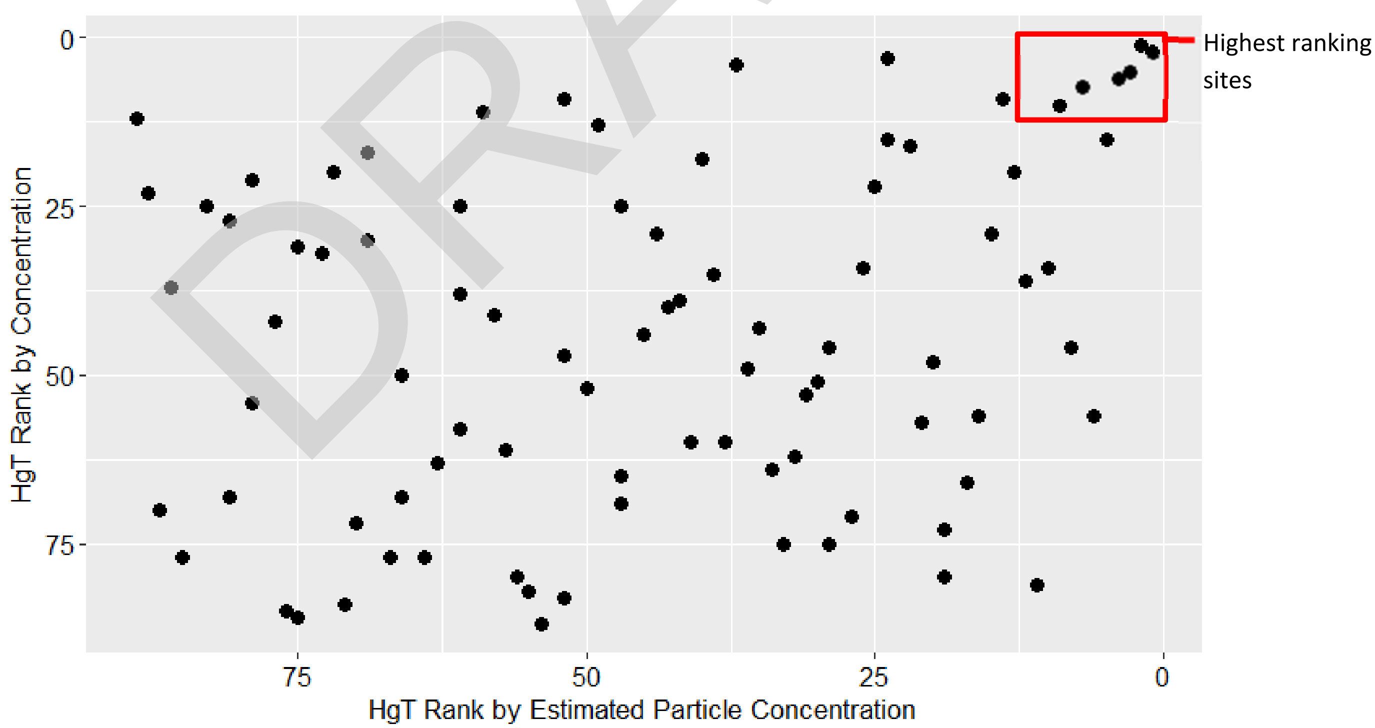

Figure 7. Comparison of site rankings for total mercury (HgT) estimated particle concentrations and water concentrations. 1 = highest rank; 87 = lowest rank.

3.4 Trace element (As, Cd, Cu, Mg, Pb, Se and Zn) concentrations

Trace metal (As, Cd, Cu, Pb and Zn) concentrations measured in selected watersheds during WYs 2015, 2016, and 2017[25] were similar in range to those previously measured in the Bay Area.

- Arsenic (As): Concentrations ranged from less than the MDL (0.34 µg/L for that sample) to 2.66 µg/L (Table 6). Similar total As concentrations have been measured previously (Guadalupe River at Hwy 101: mean=1.9 µg/L; Zone 4 Line A: mean=1.6 µg/L) and are lower than measured at North Richmond Pump Station (mean=11 µg/L) (Appendix A3 in McKee et al., 2015).
- Cadmium (Cd): Concentrations ranged from 0.023-0.55 µg/L (Table 6), similar to mean concentrations measured at Guadalupe River at Hwy 101 (0.23 µg/L), North Richmond Pump Station (mean = 0.32 µg/L), and Zone 4 Line A (mean = 0.25 µg/L) (Appendix A3 in McKee et al., 2015).
- Copper (Cu): Concentrations ranged from 3.63 to 52.7 µg/L (Table 6). These concentrations are typical of those measured in other Bay Area watersheds (mean concentrations for all of the following: Guadalupe River at Hwy 101: 19 µg/L; Lower Marsh Creek: 14 µg/L; North Richmond Pump Station: Cu 16 µg/L; Pulgas Pump Station-South: Cu 44 µg/L; San Leandro Creek: Cu 16 µg/L; Sunnyvale East Channel: Cu 18 µg/L; and Zone 4 Line A: Cu 16 µg/L) (Appendix A3 in McKee et al., 2015).
- Lead (Pb): Concentrations ranged from 0.910 to 21.3 µg/L (Table 6). Total Pb concentrations of this magnitude have been measured in the Bay Area previously (mean concentrations for all of the following: Guadalupe River at Hwy 101: 14 µg/L; North Richmond Pump Station: Pb 1.8 µg/L; and Zone 4 Line A: 12 µg/L) (Appendix A3 in McKee et al., 2015).
- Zinc (Zn): Concentrations ranged from 39.4-337 µg/L (Table 6). Zinc were comparable to mean concentrations measured in the Bay Area previously (Zone 4 Line A: 105 µg/L; Guadalupe River at Hwy 101: 72 µg/L) (see Appendix A3 in McKee et al., 2015).

In WY 2016, magnesium (Mg; 528-7350 µg/L) and selenium (Se; <MDL-0.39 µg/L) were added to the list of analytes. Both Mg and Se largely reflect geologic sources in watersheds. No measurements of Mg have been previously reported in the Bay Area. The measured concentrations of Se are on the lower end of previously reported concentrations (North Richmond Pump Station: 2.7 µg/L; Walnut Creek: 2.7 µg/L; Lower Marsh Creek: 1.5 µg/L; Guadalupe River at Hwy 101: 1.3 µg/L; Pulgas Creek Pump Station - South: 0.93 µg/L; Sunnyvale East Channel: 0.62 µg/L; Zone 4 Line A: 0.48 µg/L; Mallard Island: 0.46 µg/L; Santa Fe Channel - Richmond: 0.28 µg/L; San Leandro Creek: 0.22 µg/L) (Table A3: McKee et al., 2015). Given the high proportion of Se transported in the dissolved phase and the inverse correlation with flow (David et al., 2015; McKee and Gilbreath, 2015; McKee et al., 2017), Se concentrations measured with the current sampling protocol, with a focus on high flow, were likely biased low relative to those measured with sampling designs that included low 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/). Care, therefore, should be taken if Se concentrations reported here were used to estimate regional loads.

[25] Trace elements were not measured in WYs 2018-2020.

Table 6. Concentrations of selected trace elements measured during water years 2015, 2016, and 2017. The highest and lowest concentration for each trace element is in bold.

Watershed/Catchment	Sample Date	As (µg/L)	Cd (µg/L)	Cu (µg/L)	Pb (µg/L)	Mg (µg/L)	Se (µg/L)	Zn (µg/L)
Charcot Ave SD	4/7/2015	0.623	0.0825	16.1	2.02			115
Condensa St SD	1/19/2016	1.07	0.055	6.66	3.37	3,650	0.39	54.3
E. Gish Rd SD	12/11/2014	1.52	**0.552**	23.3	19.4			152
East Antioch nr Trembath	1/8/2017	1.57	0.119	**3.53**	1.68	5,363	0.53	**36.3**
Forbes Blvd Outfall	3/5/2016	1.5	0.093	31.7	3.22	7,350	**<MDL**	246
Gateway Ave SD	2/6/2015	1.18	0.053	24.3	1.04			78.8
Gull Dr SD	3/5/2016	**<MDL**	**0.023**	3.63	1.18	**528**	**<MDL**	39.4
Line 9-D-1 PS at outfall to Line 9-D	1/5/2016	1.07	0.524	22.5	20.9	2,822	0.2	217
Line 3A-M at 3A-D	12/11/2014	2.08	0.423	19.9	17.3			118
Line 3A-M-1 at Industrial PS	12/11/2014	1.07	0.176	14.8	7.78			105
Line 4-B-1	12/16/2014	1.46	0.225	17.7	8.95			108
Line 4-E	12/16/2014	2.12	0.246	20.6	13.3			144
Line 9-D	4/7/2015	0.47	0.053	6.24	**0.91**			67
Lower Penitencia Ck	12/11/2014	2.39	0.113	16.4	4.71			64.6
Meeker Slough	12/3/2014	1.75	0.152	13.6	14.0			85.1
North Fourth St SD 066GAC550B	1/8/2017	1.15	0.125	14.0	5.70	**11,100**	**0.67**	75.7
Oddstad PS	12/2/2014	2.45	0.205	23.8	5.65			117
Outfall to Lower Silver Ck	2/6/2015	2.11	0.267	21.8	5.43			**337**
Ridder Park Dr SD	12/15/2014	**2.66**	0.335	19.6	11.0			116
Rock Springs Dr SD	2/6/2015	0.749	0.096	20.4	2.14			99.2
Runnymede Ditch	2/6/2015	1.84	0.202	**52.7**	**21.3**			128
S Spruce Ave SD at Mayfair Ave (296)	1/8/2017	2.2	0.079	9.87	5.31	3,850	0.13	54.8
SD near Cooley Landing	2/6/2015	1.74	0.100	9.66	1.94			48.4
Seabord Ave SD SC-050GAC580	12/11/2014	1.29	0.295	27.6	10.2			168
Seabord Ave SD SC-050GAC600	12/11/2014	1.11	0.187	21	8.76			132
South Linden PS	2/6/2015	0.792	0.145	16.7	3.98			141
Taylor Way SD	3/11/2016	1.47	0.0955	10.0	4.19	5,482	**<MDL**	61.6
Veterans PS	12/15/2014	1.32	0.093	8.83	3.86			41.7
Victor Nelo PS Outfall	1/19/2016	0.83	0.140	16.3	3.63	1,110	0.04	118
Minimum		<MDL	0.023	3.53	0.91	528	<MDL	36.3
Maximum		2.66	0.552	52.7	21.3	11,100	0.67	337

3.5 Relationships between PCBs and Hg and other trace elements and land-cover attributes

Spearman rank correlations were analyzed to identify potential relationships between PCBs, HgT, trace elements, and land use variables[26] (Table 7). Beginning in WY 2003, numerous sites have been evaluated for selected trace elements in addition to HgT. These sites include the fixed loads monitoring sites on Guadalupe River at Hwy 101 (McKee et al., 2017, Zone 4 Line A (Gilbreath and McKee, 2015; McKee and Gilbreath, 2015), North Richmond Pump Station (Hunt et al., 2012) and four sites at which only Cu was measured (Lower Marsh Creek, San Leandro Creek, Pulgas Pump Station-South, and Sunnyvale East Channel) (Gilbreath et al., 2015a). Copper data were also collected at the inlets to multiple pilot performance studies for bioretention (El Cerrito: Gilbreath et al., 2012; Fremont: Gilbreath et al., 2015b), and Cu, Cd, Pb, and Zn data were collected at the Daly City Library Gellert Park demonstration bioretention site (David et al., 2015). During WYs 2015, 2016, and 2017, trace element data were collected at an additional 29 locations (Table 6). The pooled data comprise 39 sites for Cu; 33 for Cd, Pb, and Zn; and 32 for As. Data for Mg and Se were not included because of small sample size. Organic carbon was collected at 28 locations in this study and at an additional 21 locations in previous studies.

PCBs correlate positively with impervious cover and old industrial land use, and inversely with watershed area (Table 7), on the basis of Spearman rank correlation analysis[27]. The highest PCB concentrations were measured in small watersheds with a high proportion of impervious cover and old industrial area (Figure 8). However, the lack of a stronger correlation between PCBs and these geospatial variables indicates that not all small, highly impervious watersheds have high PCB concentrations. The data also indicate the presence of outliers that may be worth exploring with additional sampling. PCBs did not correlate with any of the trace elements with the exception of an inverse relationship with arsenic. Arsenic is often associated with non-urban sources and agricultural uses which may explain this result but a thorough literature review would be needed to explore this fully.

These general observations are consistent with previous analysis (McKee et al., 2012), and with the concept that larger watersheds tend to have mixed land use and thus a lower proportional amount of PCB source areas relative to smaller watersheds that are more urbanized and more industrialized. There was also a positive but relatively weak relationship between PCBs and HgT, consistent with the general relationships between impervious cover and both PCBs and HgT. This observation contrasts with conclusions drawn from the WY 2011 dataset, for which there was a stronger relationship between PCBs and HgT (McKee et al., 2012). This difference might reflect a stronger focus on PCBs during the WY 2015-2020 sampling campaigns, which included more drainage-line outfalls to creeks with higher imperviousness and old industrial land use, or it might be an artifact of sampling frame without full

[26] HgT data associated with the main channel of the Guadalupe River were removed from the analysis because of historic mining influence in the watershed. Historic mining in the Guadalupe River watershed caused a unique positive relationship between Hg, Cr, and Ni, and unique inverse correlations between Hg and other typically urban metals such as Cu and Pb (McKee et al., 2017).

[27] The rank correlation was preferred because it makes no assumption of the type of relationship (linear or other) or the data distribution (normal data distribution is a requirement of a Pearson Product Moment correlation); in the Spearman correlation, every data pair has an equal influence on the coefficient.

Table 7. Spearman Rank correlation matrix based on estimated particle concentrations (EPCs) of stormwater samples collected in the Bay Area since water year 2003 (see text for data sources and exclusions). Sample size in correlations ranged from 28 to 95. Correlation coefficients (r) shaded in light blue have a *p*-value <0.05.

	PCBs (pg/mg)	*HgT (ng/mg)*	*Arsenic (ug/mg)*	*Cadmium (ug/mg)*	*Copper (ug/mg)*	*Lead (ug/mg)*	*Zinc (ug/mg)*	*Area (sq km)*	*% Imperviousness*	*% Old Industrial*	*% Clay (<0.0039 mm)*	*% Silt (0.0039 to <0.0625 mm)*	*% Sands (0.0625 to <2.0 mm)*
HgT (ng/mg)	0.38												
Arsenic (ug/mg)	-0.60	-0.06											
Cadmium (ug/mg)	-0.27	0.22	0.67										
Copper (ug/mg)	-0.08	0.16	0.56	0.74									
Lead (ug/mg)	-0.25	0.17	0.58	0.86	0.71								
Zinc (ug/mg)	-0.25	0.26	0.50	0.80	0.89	0.69							
Area (sq km)	-0.43	-0.29	0.01	-0.23	-0.43	-0.08	-0.41						
% Imperviousness	0.56	0.28	-0.36	-0.01	0.17	-0.11	0.16	-0.74					
% Old Industrial	0.53	0.23	-0.46	-0.21	-0.14	-0.26	-0.09	-0.57	0.73				
% Clay (<0.0039 mm)	0.29	0.12	-0.12	0.04	-0.24	-0.03	-0.17	-0.18	-0.03	-0.01			
% Silt (0.0039 to <0.0625 mm)	-0.11	0.13	-0.13	-0.15	0.28	0.01	0.18	0.15	0.06	0.07	-0.39		
% Sands (0.0625 to <2.0 mm)	-0.17	-0.23	0.09	0.00	-0.03	0.10	-0.03	0.28	-0.08	-0.03	-0.83	-0.04	
TOC (mg/mg)	0.21	0.39	0.70	0.60	0.87	0.47	0.76	-0.46	0.41	0.21	-0.21	0.21	-0.02

p-value <0.05

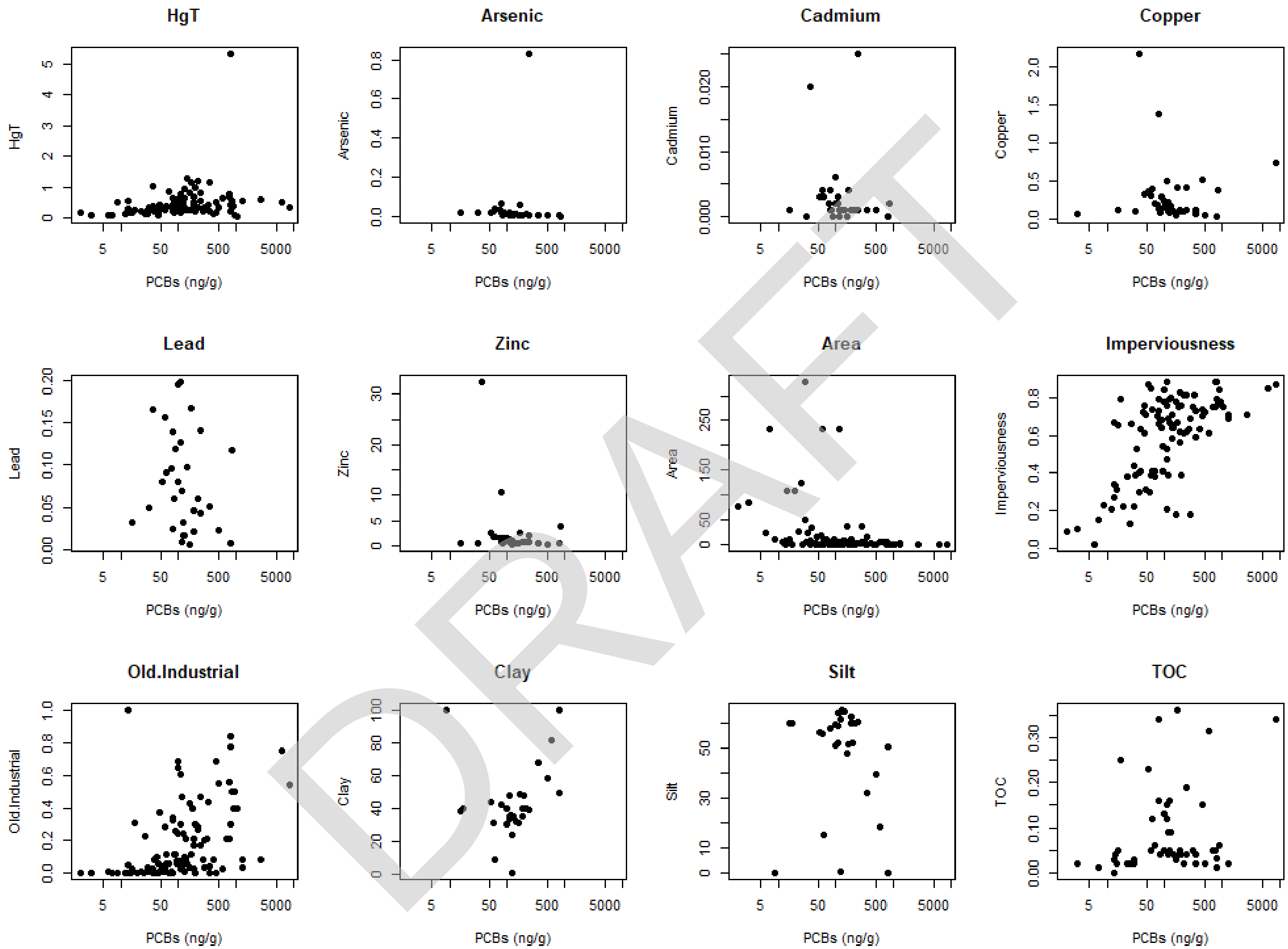

Figure 8. Relationships between observed estimated particle concentrations (EPCs) of PCBs and total mercury (HgT), trace elements, and impervious land cover, old industrial land use, grainsize (clay and silt), and total organic carbon (TOC).

representation of all environmental gradients. Additionally, or alternatively, the weakness of the relationship between PCBs and HgT may partly be associated with the larger role of atmospheric recirculation in the mercury cycle than the PCB cycle and with large differences between the use history of each pollutant. Correlations between HgT and impervious cover, old industrial land use, and watershed area were similar to but weaker than those for PCBs and these geospatial variables. Neither PCBs nor Hg were strongly correlated with other trace metals. Based on the available pooled data, there is no support for the use of trace metals as a surrogate investigative tool for either PCB or HgT pollution sources.

3.7 Sampling progress in relation to data uses

It has been argued that old industrial land use and the specific source areas found within or in association with older industrial areas are likely to have properties that exhibit higher concentrations and loads of PCBs and HgT (McKee et al., 2012; McKee et al., 2015) and indeed this current report, while illustrating there is a lot a variability and that old industrial land use is not a perfect proxy for predicting higher concentrations, continues to generally support this premise. RMP sampling for PCBs and HgT since WY 2003 has included 34% of the old industrial land use in the region. The best coverage to date has occurred in Santa Clara County (78% of old industrial land use in the county is in watersheds that have been sampled), followed by San Mateo County (36%) and Alameda County (32%). In Contra Costa County, only 16%[28] of old industrial land use is in watersheds that have been sampled, and just 1% in Solano County. The disproportional coverage in Santa Clara County is a result of sampling several large watersheds (Lower Penitencia Creek, Lower Coyote Creek, Guadalupe River at Hwy 101, Sunnyvale East Channel, Stevens Creek and San Tomas Creek) that have relatively large proportions of older industrial land use upstream from their sampling points. Of the remaining older industrial land use yet to be sampled across all the counties, 48% of it lies within 1 km and 74% within 2 km of the Bay. These areas are more likely to be tidal and are likely to include heavy industrial areas that were historically serviced by rail and ship-based transport, and military areas, but are often very difficult to sample because of a lack of public rights-of-way and tidal conditions. A different sampling strategy may be required to effectively assess what pollution might be associated with these areas and to better identify sources for potential management.

4. Summary and Recommendations

This report presents all available stormwater data[29] collected since WY 2003 when stormwater studies first began through SFEI contracts or RMP projects, not just the data collected for this WY 2015-2020 reconnaissance monitoring study (total of 94 sites). Prior to WY 2015, studies mostly employed Method 1, whereas beginning in WY 2015, with the exception of green stormwater infrastructure studies, sampling employed Methods 2 and 3.

[28] This result is largely due to the fact that fewer samples have been collected in Contra Costa County than the Alameda, San Mateo and Santa Clara Counties.

[29] Similar data collected by Santa Clara and San Mateo County stormwater programs are not included in this report.

Method 1. Fixed location multi-year turbidity-based sampling protocol for accurate loads estimation

Method 2. Water based composite sampling protocol for single storm reconnaissance characterization and relative site comparisons to support management prioritization

Method 3. Remotely deployable sedimentation sampling protocol for preliminary screening to support further field sampling using our water based composite sampling protocol

During WYs 2015-2020, composite water samples were collected at 70[30] sites during at least one storm event and analyzed for PCBs, HgT, and SSC, and, for a subset of samples, trace metals, organic carbon, and grain size[31]. Sampling efficiency was increased, when possible, by sampling two nearby sites during a single storm. At three of these sites in WY 2019, collection was done using a remote sampler only – a method that was pilot tested during WYs 2015-2018 and approved for use in spring 2018. Several sites with elevated PCB and HgT concentrations and EPCs were identified, in part because of an improved site selection process that focused on older industrial landscapes. The following recommendations are based on the WY 2015-2020 results.

- Continue to select sites based on the four main selection objectives (Section 2.2). Most of the sampling effort should be devoted to identifying potential high leverage areas with high unit area loads (yields) or concentrations/EPCs. Selecting sites by focusing on older industrial and highly impervious landscapes appears to be successful in identifying high leverage areas for PCBs.
- Continue to use the composite sampling field protocol as developed and applied during WYs 2015-2020 without further modifications. In the event of a higher rainfall wet season, when there is a greater likelihood that more storm events will fall within the required tidal windows, it may be possible to sample tidally influenced sites.
- Results from the remote sampler pilot study indicated reasonable comparability to manually collected sample concentrations. It is recommended that future sampling continue to include the use of remote samplers as a low-cost screening tool to identify sites for further sampling using the reconnaissance characterization monitoring protocol.
- Apply the advanced data analysis method for identifying and ranking watersheds of management interest for most if not all watersheds ranked in this report (pending report: McKee and Gilbreath, 2021). The results once peer-reviewed could contribute to site selection in WY 2022.
- Develop a procedure for identifying sites that return lower-than-expected concentrations or EPCs and consider re-sampling those sites. This method is being developed as part of the advanced data analysis project (pending report: McKee and Gilbreath, 2021).

[30] Includes samples collected for this POC reconnaissance study as well as for the Priority Margin Unit Study.
[31] Another 24 sites were sampled prior to WY 2015.

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6. Appendices

Appendix A: Characteristics of Larger Watersheds

Characteristics of larger watersheds to be monitored, proposed sampling location, and proposed sampling trigger criteria. In WY 2017, the sampling trigger criteria for flow and rainfall were met but large watershed sampling was focused on the Guadalupe River rather than the watersheds on this list due to a piggybacking opportunity associated with Hg.

Proposed sampling location							Relevant USGS gauge for 1st order loads computations	
Watershed system	Watershed Area (km^2)	Impervious Surface (%)	Industrial (%)	Sampling Objective	Commentary	Proposed Sampling Triggers	Gauge number	Area at USGS Gauge (sq^2
Alameda Creek at EBRPD Bridge at Quarry Lakes	913	8.5	2.3	2, 4	Operating flow and sediment gauge at Niles just upstream will allow the computation of 1st order loads to support the calibration of the RWSM for a large, urbanizing type watershed.	7" of antecedent rainfall in Livermore (reliable web published rain gauge), after at least an annual storm has already occurred (~2000 cfs at the Niles gauge), and a forecast for the East Bay interior valleys of 2-3" over 12 hrs.	11179000	906
Dry Creek at Arizona Street (purposely downstream from historic industrial influences)	25.3	3.5	0.3	2, 4	Operating flow gauge at Union City just upstream will allow the computation of 1st order loads to support the calibration of the RWSM for mostly undeveloped land use type watersheds.	7" of antecedent rainfall in Union City, after at least a common annual storm has already occurred (~200 cfs at the Union City gauge), and a forecast for the East Bay Hills of 2-3" over 12 hrs.	11180500	24.3
San Francisquito Creek at University Avenue (as far down as possible to capture urban influence upstream from tide)	81.8	11.9	0.5	2, 4	Operating flow gauge at Stanford upstream will allow the computation of 1st order loads to support the calibration of the RWSM for larger mixed land use type watersheds. Sample pair with Matadero Ck.	7" of antecedent rainfall in Palo Alto, after at least a common annual storm has already occurred (~1000 cfs at the Stanford gauge), and a forecast for the Peninsula Hills of 3-4" over 12 hrs.	11164500	61.1
Matadero Creek at Waverly Street (purposely downstream from the railroad)	25.3	22.4	3.7	2, 4	Operating flow gauge at Palo Alto upstream will allow the computation of 1st order loads to support the calibration of the RWSM for mixed land use type watersheds. Sample pair with San Francisquito Ck.	7" of antecedent rainfall in Palo Alto, after at least a common annual storm has already occurred (~200 cfs at the Palo Alto gauge), and a forecast for the Peninsula Hills of 3-4" over 12 hrs.	11166000	18.8
Colma Creek at West Orange Avenue or further downstream (as far down as possible to capture urban and historic influence upstream from tide)	27.5	38	0.8	2, 4 (possibly 1)	Historic flow gauge (ending 1996) in the park a few hundred feet upstream will allow the computation of 1st order loads estimates to support the calibration of the RWSM for mixed land use type watersheds.	Since this is a very urban watershed, precursor conditions are more relaxed: 4" of antecedent rainfall, and a forecast for South San Francisco of 2-3" over 12 hrs. Measurement of discharge and manual staff plate readings during sampling will verify the historic rating.	11162720	27.5

Appendix B – Sampling Method Development

The monitoring protocol implemented in WYs 2015-2020 was based on a previous monitoring design that was trialed in WY 2011 when multiple sites were visited during one or two storm events. In that study, multiple discrete stormwater samples were collected at each site and analyzed for a number of pollutants of concern (POCs) (McKee et al., 2012). At the 2014 SPLWG meeting, an analysis of previously collected stormwater sample data from both reconnaissance and fixed station monitoring was presented (SPLWG et al. 2014). A comparison of three sampling designs for Guadalupe River at Hwy 101 (sampling 1, 2, or 4 storms, respectively: functionally 4, 8, and 16 discrete samples) showed that PCB estimated particle concentrations (EPC) at this site can vary from 45-287 ng/g (1 storm design), 59-257 ng/g (2 storm design), and 74-183 ng/g (4 storm design) between designs, suggesting that the number of storms sampled for a given watershed has big impacts on the EPCs and therefore the potential relative ranking among sites. A similar analysis that explores the relative ranking based on a random 1-storm composite or 2-storm composite design was also presented for other monitoring sites (Pulgas Pump Station-South, Sunnyvale East Channel, North Richmond Pump Station, San Leandro Creek, Zone 4 Line A, and Lower Marsh Creek). This analysis showed that the potential for a false negative could occur due to a low number of sampled storms, especially in smaller and more urbanized watersheds where transport events can be more acute due to lack of channel storage. The analysis further highlighted the trade-off between gathering information at fewer sites with more certainty versus at more sites with less certainty. Based on these analyses, the SPLWG recommended a 1-storm composite per site design with allowances that a site could be revisited if the measured concentrations were lower than expected, either because a low-intensity storm was sampled or other information suggested that potential sources exist.

In addition to composite sampling, a pilot study was designed and implemented to test remote suspended sediment samplers based on enhanced water column settling. Four sampler types were considered: the single-stage siphon sampler, the CLAM sampler, the Hamlin sampler, and the Walling Tube. The SPLWG recommended the single-stage siphon sampler be dropped because it allowed for collection of only a single stormwater sample at a single time point, and therefore offers no advantage over manual sampling but requires more effort and expense to deploy. The CLAM sampler was also dropped as it had limitations affecting the interpretation of the data; primarily its inability to estimate the volume of water passing through the filters and the lack of performance tests in high turbidity environments. As a result, the remaining two samplers (Hamlin sampler and Walling Tube) were selected for the pilot study as previous studies showed the promise of using these devices in similar systems (Phillips et al., 2000; Lubliner, 2012). The SPLWG recommended piloting these samplers at 12 locations where manual water composites would be collected in parallel to test the comparability between sampling methods.

Appendix C – Quality assurance

The sections below report quality assurance reviews on WYs 2015-20 data only. The data were reviewed using the quality assurance program plan (QAPP) developed for the San Francisco Bay Regional Monitoring Program for Water Quality (Yee et al., 2017). That QAPP describes how RMP data are reviewed for possible issues with hold times, sensitivity, blank contamination, precision, accuracy, comparison of dissolved and total phases, magnitude of concentrations versus concentrations from previous years, other similar local studies or studies described from elsewhere in peer-reviewed literature and PCB (or other organics) fingerprinting. Data handling procedures and acceptance criteria can differ among monitoring protocols, however, for the RMP the underlying data were never discarded. Because the results for “censored” data were maintained, the effects of applying different QA protocols can be assessed by a future analyst if desired.

Suspended Sediment Concentration and Particle Size Distribution

In WY 2015, the SSC and particle size distribution (PSD)[32] 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; the USGS hold time is 100 days); hold times are not specified in the RMP QAPP for PSD. Minimum detection limits (MDLs) were generally sufficient, with <20% non-detects (NDs) reported for SSC and the more abundant Clay and Silt fractions. Extensive NDs (>50%) were generally reported for the sand fractions starting as fine as 0.125 mm and larger, with 100% NDs for the coarsest (Granule + Pebble/2.0 to <64 mm) fraction. Method blanks and spiked samples are not typically reported for SSC and PSD. Blind field replicates were used to evaluate precision in the absence of any other replicates. The relative standard deviation (RSD) for two field blind replicates of SSC were well below the 10% target. Particle size fractions had average RSDs ranging from 12% for silt to 62% for fine sand. Although some individual fractions had average relative percent difference (RPD) or RSDs >40%, suspended sediment in runoff (and particle size distributions within that SSC) can be highly variable, even when collected by minutes, so results were flagged as estimated concentrations rather than rejected. Fines (clay and silt) represented the largest proportion (~89% average) of the mass.

In 2016 samples, SSC and PSD was analyzed beyond the specified 7-day hold time (between 20 and 93 days after collection) and qualified for holding-time violation but not censored. No hold time is specified for grain-size analysis. Method detection limits were sufficient to have some reportable results for nearly all the finer fractions, with extensive NDs (> 50%) for many of the coarser fractions. No method blanks or spiked samples were analyzed/reported, common with SSC and PSD. Precision for PSD could not be evaluated as no replicates were analyzed for 2016. Precision of the SSC analysis was evaluated using the field blind replicates and the average RSD of 2.12% was well within the 10% target Method Quality Objective (MQO). PSD results were similar to other years, dominated by around 80% Fines. Average SSC for whole-water samples (excluding those from passive samplers) was in a reasonable range of a few hundred mg/L.

In 2017, method detection limits were sufficient to have at least one reportable result for all analyte/fraction combinations. Extensive non-detects (NDs > 50%) were reported for only Granule + Pebble/2.0 to <64 mm (90%). The analyte/fraction combinations Silt/0.0039 to <0.0625 mm;

[32] Particle size data were captured for % Clay (<0.0039 mm), % Silt (0.0039 to <0.0625 mm), % V. Fine Sand (0.0625 to <0.125 mm), % Fine Sand (0.125 to <0.25 mm), % Medium Sand (0.25 to <0.5 mm), % Coarse Sand (0.5 to <1.0 mm), % V. Coarse Sand (1.0 to <2.0 mm), and % Granule + Pebble (>2.0 mm).

Sand/Medium 0.25 to <0.5 mm; Sand/Coarse 0.5 to <1.0 mm; Sand/V. Coarse 1.0 to <2.0 mm all had 20% (2 out of 10) non-detects. No method blanks were analyzed for grain size analysis. SSC was found in one of the five method blanks at a concentration of 1 mg/L. The average SSC concentration for the three method blanks in that batch was 0.33 mg/L, less than the average method blank method detection limit of 0.5 mg/L. No blank contamination qualifiers were added. No spiked samples were analyzed/reported. Precision for grain size could not be evaluated as there was insufficient amount of sample for analysis of the field blind replicate. Precision of the SSC analysis was examined using the field blind replicates with the average RSD of 29.24% being well above the 10% target MQO, therefore they were flagged with the non-censoring qualifier "VIL" as an indication of possible uncertainty in precision.

In WY 2018, the SSC and particle size distribution (PSD)[33] data from USGS-PCMSC were acceptable, aside from failing hold-time targets. SSC samples were all analyzed outside of hold time (between 25 and 62 days after collection, exceeding the 7-day hold time specified in the RMP QAPP); hold times are not specified in the RMP QAPP for PSD. Minimum detection limits (MDLs) were generally sufficient, with zero non-detects (NDs) reported for SSC and the more abundant clay and silt fractions. Extensive NDs (>50%) were generally reported for the sand fractions starting as fine as 0.125 mm and larger, with 100% NDs for the coarsest (Granule + Pebble/2.0 to <64 mm) fraction. Method blanks and spiked samples are not typically reported for SSC and PSD. Blind field replicates were used to evaluate precision in the absence of any other replicates. The relative standard deviation (RSD) for the field blind replicate of SSC was 8.22%, below the 10% target. Particle size fractions had average RSDs ranging from 10.6% - 10.7% for Fine, Clay and Silt fractions.

In WY 2019, the SSC data from USGS-PCMSC were acceptable, aside from failing hold-time targets. SSC samples were all analyzed outside of hold time (between 98 and 175 days after collection, exceeding the 7-day hold time specified in the RMP QAPP). Minimum detection limits (MDLs) were generally sufficient, with zero non-detects (NDs) reported. Two method blanks were analyzed and both were below the MDL. Spiked samples are not typically reported for SSC. Blind field replicates were used to evaluate precision in the absence of any other replicates. The relative standard deviation (RSD) for the field blind replicate of SSC was 0%, below the 10% target.

No samples for PSD analysis were collected in WY 2019.

In WY 2020, the SSC data from USGS-PCMSC were acceptable, aside from failing hold-time targets. SSC samples were all analyzed outside of hold time (exceeding the 7-day hold time specified in the RMP QAPP). Minimum detection limits (MDLs) were generally sufficient, with zero non-detects (NDs) reported. Two method blanks were analyzed. Of the two blanks, one was ND and the other only slightly above MDL, but their average was not >MDL. Therefore, only the individual detected lab blank was flagged for blank contamination, but all the associated field samples were not. Concentrations in field samples were well over 20x higher, so blank contamination would have minor impact on reported values. Spiked samples are not typically reported for SSC. Blind field replicates were not collected in

[33] Particle size data were captured for % Clay (<0.0039 mm), % Silt (0.0039 to <0.0625 mm), % V. Fine Sand (0.0625 to <0.125 mm), % Fine Sand (0.125 to <0.25 mm), % Medium Sand (0.25 to <0.5 mm), % Coarse Sand (0.5 to <1.0 mm), % V. Coarse Sand (1.0 to <2.0 mm), and % Granule + Pebble (>2.0 mm).

2020 and therefore the relative standard deviation (RSD) for the field blind replicate could not be assessed.

No samples for PSD analysis were collected in WY 2020.

Organic Carbon in Water

Reported TOC and DOC data from EBMUD and ALS were acceptable. In 2015, TOC samples were field acidified on collection, DOC samples were field or lab filtered as soon as practical (usually within a day) and acidified after, so were generally within the recommended 24-hour holding time. MDLs were sufficient with no NDs reported for any field samples. TOC was detected in only one method blank (0.026 mg/L), just above the MDL (0.024 mg/L), but the average blank concentration (0.013 mg/L) was still below the MDL, so results were not flagged. Matrix spike samples were used to evaluate accuracy, although many samples were not spiked high enough for adequate evaluation (must be at least two times the parent sample concentration). Recovery errors in the remaining DOC matrix spikes were all below the 10% target MQO. TOC errors in WY 2015 averaged 14%, above the 10% MQO, and TOC was therefore qualified but not censored. Laboratory replicate samples evaluated for precision had an average RSD of <2% for DOC and TOC, and 5.5% for POC, within the 10% target MQO. RSDs for field replicates were also within the target MQO of 10% (3% for DOC and 9% for TOC), so no precision qualifiers were needed.

POC and DOC were also analyzed by ALS in 2016. One POC sample was flagged for a holding time of 104 days (past the specified 100 days). All OC analytes were detected in all field samples and were not detected in method blanks, but DOC was detected in filter blanks at 1.6% of the average field sample and 5% of the lowest field sample. The average recovery error was 4% for POC evaluated in LCS samples, and 2% for DOC and TOC in matrix spikes, within the target MQO of 10%. Precision on POC LCS replicates averaged 5.5% RSD, and 2% for DOC and TOC field sample lab replicates, well within the 10% target MQO. No recovery or precision qualifiers were needed. The average 2016 POC was about three times higher than 2014 results. DOC and TOC were 55% and 117% of 2016 results, respectively.

In 2017, method detection limits were sufficient with no non-detects (NDs) reported except for method blanks. DOC and TOC were found in one method blank in one lab batch for both analytes. Four DOC and eight TOC results were flagged with the non-censoring qualifier “VIP”. TOC was found in the field blank and it’s three lab replicates at an average concentration of 0.5375 mg/L which is 8.6% of the average concentration found in the field and lab replicate samples (6.24 mg/L). Accuracy was evaluated using the matrix spikes except for POC which was evaluated using the laboratory control samples. The average %error was less than the target MQO of 10% for all three analytes; DOC (5.2%), POC (1.96%), and TOC (6.5%). The laboratory control samples were also examined for DOC and TOC and the average %error was once again less than the 10% target MQO. No qualifying flags were needed. Precision was evaluated using the lab replicates with the average RSD being well below the 10% target MQO for all three analytes; DOC (1.85%), POC (0.97%), and TOC (1.89%). The average RSD for TOC including the blind field replicate and its lab replicates was 2.32% less than the target MQO of 10%. The laboratory control sample replicates were examined and the average RSD was once again well below the 10% target MQO. No qualifying flags were added.

In WY 2018, all TOC samples were censored. Accuracy was evaluated using the matrix spikes. The average %error for TOC in the matrix spikes of 47.68% (average recovery 147.68%) was above the 10% target MQO.

No samples for TOC analysis were collected in WY 2019 or WY 2020.

PCBs in Water and Sediment

PCBs samples were analyzed for 40 PCB congeners (PCB-8, PCB-18, PCB-28, PCB-31, PCB-33, PCB-44, PCB-49, PCB-52, PCB-56, PCB-60, PCB-66, PCB-70, PCB-74, PCB-87, PCB-95, PCB-97, PCB-99, PCB-101, PCB-105, PCB-110, PCB-118, PCB-128, PCB-132, PCB-138, PCB-141, PCB-149, PCB-151, PCB-153, PCB-156, PCB-158, PCB-170, PCB-174, PCB-177, PCB-180, PCB-183, PCB-187, PCB-194, PCB-195, PCB-201, PCB-203). Water (whole water and dissolved) and sediment (separately analyzed particulate) PCB data from SGS AXYS were acceptable. EPA 1668 methods for PCBs recommend analysis within a year, and all samples were analyzed well within that time (maximum 64 days). MDLs were sufficient with no NDs reported for any of the PCB congeners measured. Some blank contamination was detected in method blanks for about 20 of the more abundant congeners, with only two PCB 008 field sample results censored for blank contamination exceeding one-third the concentration of PCB 008 in those field samples. Many of the same congeners detected in the method blank also were detected in the field blank, but at concentrations <1% the average measured in the field samples and (per RMP data quality guidelines) always less than one-third the lowest measured field concentration in the batch. Three target analytes (part of the "RMP 40 congeners"), PCBs 105, 118, and 156, and numerous other congeners were reported in laboratory control samples (LCS) to evaluate accuracy, with good recovery (average error on target compounds always <16%, well within the target MQO of 35%). A laboratory control material (modified NIST 1493) was also reported, with average error 22% or better for all congeners. Average RSDs for congeners in the field replicate were all <18%, within the MQO target of 35%, and LCS RSDs were ~2% or better. PCB concentrations have not been analyzed in remote sediment sampler sediment for previous POC studies, so no inter-annual comparisons could be made. PCBs in water samples were similar to those measured in previous years (2012-2014), ranging from 0.25 to 3 times previous averages, depending on the congener. Ratios of congeners generally followed expected abundances in the environment.

SGS AXYS analyzed PCBs in dissolved, particulate, and total fraction water samples for 2016. Numerous congeners had several NDs, but extensive NDs (>50%) were reported for only PCBs 099 and 201 (both 60% NDs). Some blank contamination was detected in method blanks, with results for some congeners in field samples censored due to concentrations that were less than 3 times higher than the highest concentration measured in a blank. This was especially true for dissolved-fraction field samples with low concentrations. Accuracy was evaluated using the laboratory control samples. Again, only three of the PCBs (PCB 105, PCB 118, and PCB 156) reported in the field samples were included in LCS samples (most being non-target congeners), with average recovery errors for those of <10%, well below the target MQO of 35%. Precision on LCS and blind field replicates was also good, with average RSDs <5% and <15%, respectively, well below the 35% target MQO. Average PCB concentrations in total fraction water samples were similar to those measured to previous years, but total fraction samples were around 1% of those measured in 2015, possibly due to differences in the stations sampled.

SGS AXYS also analyzed PCBs in dissolved, particulate, and total fraction water samples for 2017. Numerous congeners had several NDs but none extensively. Some blank contamination was detected in method blanks, with results for some congeners in field samples censored due to concentrations that were less than 3 times higher than the highest concentration measured in a blank. This was especially true for dissolved-fraction field samples with low concentrations. Accuracy was evaluated using the laboratory control samples. Again, only three of the PCBs (PCB 105, PCB 118, and PCB 156) reported in the field samples were included in LCS samples (most being non-target congeners), with average recovery errors for those of <10%, well below the target MQO of 35%. Precision on LCS replicates was also good, with average RSDs <5%, well below the 35% target MQO.

In WY 2018, SGS AXYS analyzed total water samples for PCBs (no samples for dissolved or particulate fractions were submitted for analysis). Method detection limits were acceptable with non-detects (NDs) reported for a single PCB 170 result (7.14%; 1 out of 14 PCB 170 results). PCB 008, PCB 018, PCB 028, PCB 031, PCB 033, PCB 044, PCB 049, PCB 052, PCB 056, PCB 066, PCB 070, PCB 087, PCB 095, PCB 099, PCB 101, PCB 105, PCB 110, PCB 118, PCB 138, PCB 149, PCB 151, and PCB 174 were found in at least one and often both method blanks at concentrations above the method detection limits. Two PCB 008 results (14.29%; 2 out of 14 results) were flagged with the censoring qualifier VRIP; other blank contaminated results were flagged by the laboratory and did not need to be censored. Contamination was found in the field blank for PCB 008, PCB 018, PCB 028, PCB 031, PCB 033, PCB 044, PCB 049, PCB 052, PCB 056, PCB 060, PCB 066, PCB 070, PCB 087, PCB 095, PCB 099, PCB 101, PCB 110, PCB 118, PCB 138, PCB 151, PCB 153, and PCB187 at concentrations generally less than 1% of the average concentrations found in the field samples (the only exception was PCB 008 which was found in the field blank at a concentration representing ~2% of the average field sample concentration). Accuracy was evaluated using the laboratory control samples (LCSs); the only spiked samples reported. PCB 105, PCB 118, and PCB 156 were the only target congeners included in the LCS samples with an average %error of 8.35%, 9.25%, and 13.63%, respectively, all well below the 35% target MQO. No qualifiers were needed. Precision was evaluated using the blind field replicates. The average RSD ranged from 0.10% to 17.99% for the 40 target PCB congeners; all below the target MQO of 35% target. Laboratory control sample replicates were examined, but not used in the evaluation. The respective RSD's for PCB 105, PCB 118, and PCB 156 were 11.07%, 12.25%, and 3.27%, respectively. No qualification was necessary.

In WY 2019, SGS AXYS analyzed total water samples for PCBs (no samples for dissolved or particulate fractions were submitted for analysis). Method detection limits (MDLs) were satisfactory for the PCBs with only four non-detects reported (one for PCB008, PCB019, PCB049 and PCB15). PCB concentrations above the MDL were reported for the one method blank for PCB 028, PCB 031, PCB 033, PCB 044, PCB 049, PCB 052, PCB 066, PCB 070, PCB 105, PCB 110, PCB 149, PCB 153, and PCB 180. As a consequence, one PCB 049 result was flagged with the censoring QA code of "VRIP" (Data rejected - Analyte detected in field or lab generated blank, flagged by QAO) for blank contamination. The other blank contaminated results were flagged by the analyzing laboratory so no additional flags had to be added.

PCB concentrations above the MDL were reported in the field blanks for PCB 018, PCB 028, PCB 031, PCB 033, PCB 044, PCB 049, PCB 052, PCB 066, PCB 070, PCB 095, PCB 132, PCB 138, and PCB 149. But the average concentrations in the field blanks were less than 1% of the average field sample concentrations. No certified reference material samples, and no matrix spike samples were analyzed/reported. The percent error for the three PCBs included in the single laboratory control sample (PCB 105, PCB 118, and PCB 156) were 2%, 3%, and 3%, respectively (recoveries were 102%, 103%, and 97%) all well below the 35% target MQO. No qualifiers were added. Lab replicates were not analyzed/reported so blind field replicates were used to decide whether precision flags were needed for the PCB results. The RPDs were all below the MQO target of 35%, ranging from 1.87% to 29.58%. No qualifiers were needed.

In WY 2020, SGS AXYS analyzed total water samples for PCBs (no samples for dissolved or particulate fractions were submitted for analysis). The dataset included 7 field samples, and 1 each of a lab blank, lab rep, MS, and LCS sample. Nearly all of the data were quantitative, aside from a handful of congeners in a few samples of the same concentration range as blank contamination (<3x higher), which were flagged as estimated despite being above MDL and RL. Method detection limits (MDLs) were sufficiently sensitive that most of the dominant congeners in Aroclors were detected in all samples. Only PCB 201 was ND in one sample. Twenty-two of the congeners were found in the lab blank, but most at concentrations less than ⅓ those in field samples. Only PCB 008, 033, and 044 were found to have blank concentrations within ⅓ of those in the lowest concentration field samples. Lab reps had RPDs ranging 38-95% for the various congeners, with one of the replicates consistently higher than the other. Due to the systematic nature of the bias between samples, it may be an issue of subsampling or composite creation leading to the bias rather than measurement precision (which would tend to be randomly higher, not always in the same replicate). The entire batch was flagged with a “VIL” QACode indicating this uncertain precision for all the congeners reported in replicates, as all had RPDs > the target 35%. Recovery of congeners in the LCS was very good, with 2-19% deviation from target expected values. No added recovery flags were needed.

Trace Elements in Water

Overall, the 2015 water trace elements (As, Cd, Pb, Cu, Zn, Hg) data from Brooks Rand Labs (BRL) were acceptable. MDLs were sufficient with no NDs reported for any field samples. Arsenic was detected in one method blank, and mercury in four method blanks; the results were blank corrected, and blank variation was <MDL. No analytes were detected in the field blank. Recoveries in certified reference materials (CRMs) were good, averaging 2% error for mercury to 5% for zinc, all well below the target MQOs (35% for arsenic and mercury; 25% for all others). Matrix spike and LCS recovery errors all averaged below 10%, well within the accuracy MQOs. Precision was evaluated in laboratory replicates, except for mercury, which was evaluated in certified reference material replicates (no mercury lab replicates were analyzed). RSDs on lab replicates ranged from <1% for zinc to 4% for arsenic, well within target MQOs (35% for arsenic and mercury; 25% for all the other analytes). Mercury CRM replicate RSD was 1%, also well within the target MQO. Matrix spike and laboratory control sample replicates similarly had average RSDs well within their respective target MQOs. Even including the field heterogeneity from blind field replicates, precision MQOs were easily met. Average concentrations were up to 12 times higher than the average concentrations of 2012-2014 POC water samples, but whole water composite samples were in a similar range those measured in as previous years.

For 2016 the quality assurance for trace elements in water reported by Brooks Applied Lab (BRL's name post-merger) was good. Blank corrected results were reported for all elements (As, Cd, Ca, Cu, Hardness (as $CaCO_3$), Pb, Mg, Hg, Se, and Zn). MDLs were sufficient for the water samples with no NDs reported for Cd, Cu, Pb, Hg, and Zn. Around 20% NDs were reported for As, Ca, Hardness, and Mg, and 56% for Se. Mercury was detected in a filter blank, and in one of the three field blanks, but at concentrations <4% of the average in field samples and (per RMP data quality guidelines) always less than one-third the lowest measured field concentration in the batch. Accuracy on certified reference materials was good, with average %error for the CRMs ranging from 2 to 18%, well within target MQOs (25% for Cd, Ca, Cu, Pb, Mg, Zn; 35% for As, Hg, and Se). Recovery errors on matrix spike and LCS results on these compounds was also good, with the average errors all below 9%, well within target MQOs. The average error of 4.8% on a Hardness LCS was within the target MQO of 5%. Precision was evaluated for field sample replicates, except for Hg, where matrix spike replicates were used. Average RSDs were all < 8%, and all below their relevant target MQOs (5% for Hardness; 25% for Cd, Ca, Cu, Pb, Mg, Zn; 35% for As, Hg, and Se). Blind field replicates were also consistent, with average RSDs ranging from 1% to 17%, all within target MQOs. Precision on matrix spike and LCS replicates was also good. No qualifiers were added. Average concentrations in the 2016 water samples were in a similar range of POC samples from previous years (2003-2015), with averages ranging 0.1x to 2x previous years' averages.

In 2017, the data was overall good and all field samples were usable. Blank corrected results were reported for all elements (As, Cd, Ca, Cu, Hardness (as $CaCO_3$), Pb, Mg, Hg, Se, and Zn). MDLs were sufficient for the water samples with no NDs reported. The Hg was also not detected. Accuracy on certified reference materials was good, with average % error for the CRMs within 12%, well within target MQOs (25% for Cd, Ca, Cu, Pb, Mg, Zn; 35% for As, Hg, and Se). Recovery errors on matrix spike and LCS results on these compounds were also all within target MQOs. Precision was evaluated for field sample replicates. Average RSDs were all < 8%, and all below their relevant target MQOs (5% for Hardness; 25% for Cd, Ca, Cu, Pb, Mg, Zn; 35% for As, Hg, and Se).

In WY 2018, samples were only analyzed for mercury. Samples were all measured well within hold time. Method detection limits were acceptable as no non-detects (NDs) were reported for mercury. Mercury was not found in the method blanks at concentrations above the method detection limits. All method blank results were NDs. The single field blank contained mercury at a low concentration (0.00015 ug/L) equal to ~0.1% of the average mercury concentration measured in the field samples. Accuracy was evaluated using the matrix spikes. The average % error for mercury in the matrix spikes of 4% was well below the 35% target MQO. Laboratory control material samples were examined, but not used in the evaluation. The average % error of 6% was also well below the target MQO of 35%. No qualifiers were needed. Precision was evaluated using the lab replicates. The average RSD for Mercury was 3% well below the target MQO of 35% target (average RSD for lab replicates and field replicates combined was 6%). Matrix spike replicates were examined, but not used in the evaluation. The average

RSD of 2% was also below the 35% target MQO. The laboratory control materials were not used because they had different though similar target concentrations. No additional qualifiers were added.

In WY 2019, samples were only analyzed for mercury. Samples were all measured well within hold time. Method detection limits were acceptable as no non-detects (NDs) were reported for mercury. Total mercury was measured/reported at concentrations above the MDL for two lab blanks in one of the lab batches, and as a consequence four sample concentrations were flagged with the QACode “VIP” (Analyte detected in field or lab generated blank, flagged by QAO) for blank contamination. The average percent error for total mercury in the certified reference materials was 1.21% (average recovery 101.21%) well below the target MQO of 35%. No qualifiers were added. The average percent error for total mercury in the matrix spike samples was 8.32% (average recovery 91.68%) below the target MQO listed in the 2018 RMP QAPP of 35%. The percent error for total mercury in the single laboratory control samples was 3.35% (recovery 96.65%) below the 35% target MQO. Lab replicates were used to decide whether precision flags were needed for the total mercury results. The average RPD of 0.76% was below the MQO target of 35%. No qualifiers were needed. The average certified reference material samples RPD was 1.39% below the 35% MQO target. The average RPD for the matrix spike replicates of 2.21% was likewise below the target MQO of 35%. No field replicates were analyzed/reported.

In WY 2020, samples were only analyzed for mercury. The dataset includes 4 field samples, analyzed in 2 batches, with multiple blanks, and a lab rep, LCS, CRM, and MS/MSD pair in each batch. All samples were analyzed within 90-day hold time for all samples (1-32 days). All (100% of) the data are usable with no added qualifiers needed. The method is sufficiently sensitive with no NDs reported. Results are reported blank corrected, and the variation (stdev) in the blank is <MDL, so no qualifiers are needed. Lab rep precision RPD was 1% (maximum 2%), well within the target 35%. Recovery on CRMs was 102-107% of target, averaging 104%. MS recoveries ranged 87-100%, and LCS 92-98%, also well within the target ±35% MQO.

Trace Elements in Sediment

A single sediment sample was obtained in 2015 from fractionating one Hamlin sampler and analyzing for As, Cd, Pb, Cu, Zn, and Hg concentration on sediment. Overall the data were acceptable. MDLs were sufficient with no NDs for any analytes in field samples. Arsenic was detected in one method blank (0.08 mg/kg dw) just above the MDL (0.06 mg/kg dw), but results were blank corrected and the blank standard deviation was less than the MDL so results were not blank flagged. All other analytes were not detected in method blanks. CRM recoveries showed average errors ranging from 1% for copper to 24% for mercury, all within their target MQOs (35% for arsenic and mercury; 25% for others). Matrix spike and LCS average recoveries were also within target MQOs when spiked at least 2 times the native concentrations. Laboratory replicate RSDs were good, averaging from <1% for zinc to 5% for arsenic, all well within the target MQOs (35% for arsenic and mercury; 25% for others). Matrix spike RSDs were all 5% or less, also well within target MQOs. Average results ranged from 1 to 14 times higher than the average concentrations for the RMP Status and Trend sediment samples (2009-2014). Results were reported for Mercury and Total Solids in one sediment sample analyzed in two laboratory batches. Other client samples (including lab replicates and Matrix Spike/Matrix Spike replicates), a certified reference material (CRM), and method blanks were also analyzed. Mercury results were reported blank corrected.

In 2016, a single sediment sample was obtained from a Hamlin sampler, which was analyzed for total Hg by BAL. MDLs were sufficient with no NDs reported, and no target analytes were detected in the method blanks. Accuracy for mercury was evaluated in a CRM sample (NRC MESS-4). The average recovery error for mercury was 13%, well within the target MQO of 35%. Precision was evaluated using the laboratory replicates of the other client samples concurrently analyzed by BAL. Average RSDs for Hg and Total Solids were 3% and 0.14%, respectively, well below the 35% target MQO. Other client sample matrix spike replicates also had RSDs well below the target MQO, so no qualifiers were needed for recovery or precision issues. The Hg concentration was 30% lower than the 2015 POC sediment sample.

Appendix D – Figures 7 and 10 Supplementary Info

Sample counts for data displayed in Figures 7 and 10 bar graphs. For samples with a count of two or more, the central tendency was used which was calculated as the sum of the pollutant water concentrations divided by the sum of the SSC data.

Catchment	Year Sampled	Discrete Grabs	Composite Samples	Number of Aliquots per composite sample	Remote Sample
Belmont Creek	Prior to WY2015	4	0	NA	0
Borel Creek	Prior to WY2015	5	0	NA	0
Calabazas Creek	Prior to WY2015	5	0	NA	0
Ettie Street Pump Station	Prior to WY2015	4	0	NA	0
Glen Echo Creek	Prior to WY2015	4	0	NA	0
Guadalupe River at Foxworthy Road/ Almaden Expressway	Prior to WY2015	14 PCB; 46 Hg	0	NA	0
Guadalupe River at Hwy 101	Prior to WY2015	119 PCB; 261 Hg	0	NA	0
Lower Coyote Creek	Prior to WY2015	5 PCB; 6 Hg	0	NA	0
Lower Marsh Creek	Prior to WY2015	28 PCB; 31 Hg	0	NA	0
Lower Penitencia Creek	Prior to WY2015	4	0	NA	0
North Richmond Pump Station	Prior to WY2015	38	0	NA	0
Pulgas Pump Station-North	Prior to WY2015	4	0	NA	0
Pulgas Pump Station-South	Prior to WY2015	29 PCB; 26 Hg	0	NA	0
San Leandro Creek	Prior to WY2015	39 PCB; 38 Hg	0	NA	0
San Lorenzo Creek	Prior to WY2015	5 PCB; 6 Hg	0	NA	0
San Pedro Storm Drain	Prior to WY2015	0 PCB; 3 Hg	0	NA	0
San Tomas Creek	Prior to WY2015	5	0	NA	0
Santa Fe Channel	Prior to WY2015	5	0	NA	0
Stevens Creek	Prior to WY2015	6	0	NA	0
Sunnyvale East Channel	Prior to WY2015	42 PCB; 41 Hg	0	NA	0
Walnut Creek	Prior to WY2015	6 PCB; 5 Hg	0	NA	0
Zone 4 Line A	Prior to WY2015	69 PCB; 94 Hg	0	NA	0
Zone 5 Line M	Prior to WY2015	4	0	NA	0
Charcot Ave Storm Drain	WY2015	0	1	6	1
E. Gish Rd Storm Drain	WY2015	0	1	5	0
Gateway Ave Storm Drain	WY2015	0	1	6	0
Line 3A-M-1 at Industrial Pump Station	WY2015	0	1	6	0
Line 4-B-1	WY2015	0	1	5	0
Line 9-D	WY2015	0	1	8	0
Line-3A-M at 3A-D	WY2015	0	1	5	0
Line4-E	WY2015	0	1	6	0
Lower Penitencia Creek	WY2015	0	1	7	0
Meeker Slough	WY2015	0	1	6	0
Oddstad Pump Station	WY2015	0	1	6	0
Outfall to Lower Silver Creek	WY2015	0	1	5	1
Ridder Park Dr Storm Drain	WY2015	0	1	5	0
Rock Springs Dr Storm Drain	WY2015	0	1	5	0
Runnymede Ditch	WY2015	0	1	6	0
Seabord Ave Storm Drain SC-050GAC580	WY2015	0	1	5	0
Seabord Ave Storm Drain SC-050GAC600	WY2015	0	1	5	0
South Linden Pump Station	WY2015	0	1	5	0
Storm Drain near Cooley Landing	WY2015	0	1	6	1

WYs 2015 through 2020 POC Reconnaissance Monitoring

Catchment	Year Sampled	Discrete Grabs	Composite Samples	Number of Aliquots per composite sample	Remote Sample
Veterans Pump Station	WY2015	0	1	5	0
Condensa St SD	WY2016	0	1	6	0
Duane Ct and Ave Triangle SD	WY2016	0	1	5	0
Duane Ct and Ave Triangle SD	WY2016	0	1	3	1
E Outfall to San Tomas at Scott Blvd	WY2016	0	1	6	0
Forbes Blvd Outfall	WY2016	0	1	5	1
Gull Dr Outfall	WY2016	0	1	5	0
Gull Dr SD	WY2016	0	1	5	0
Haig St SD	WY2016	0	1	6	0
Industrial Rd Ditch	WY2016	0	1	4	0
Lawrence & Central Expwys SD	WY2016	0	1	3	0
Line 13A at end of slough	WY2016	0	1	7	0
Line 9D1 PS at outfall to Line 9D	WY2016	0	1	8	0
Outfall at Gilman St.	WY2016	0	1	9	0
Taylor Way SD	WY2016	0	1	5	1
Tunnel Ave Ditch	WY2016	0	1	6	1
Valley Dr SD	WY2016	0	1	6	0
Victor Nelo PS Outfall	WY2016	0	1	9	1
Zone 12 Line A under Temescal Ck Park	WY2016	0	1	8	0
Line 12H at Coliseum Way	WY2017	0	1	3	0
Outfall to Colma Ck on service rd nr Littlefield Ave. (359)	WY2017	0	1	2	1
S Linden Ave SD (291)	WY2017	0	1	7	0
Austin Ck at Hwy 37	WY2017	0	1	6	1
Line 12I at Coliseum Way	WY2017	0	1	3	0
Kirker Ck at Pittsburg Antioch Hwy and Verne Roberts Cir	WY2017	0	1	4	0
Line 12M at Coliseum Way	WY2017	0	1	4	0
Line 12F below PG&E station	WY2017	0	1	3	0
Rosemary St SD 066GAC550C	WY2017	0	1	5	0
North Fourth St SD 066GAC550B	WY2017	0	1	5	0
Line 12K at Coliseum Entrance	WY2017	0	1	4	0
Colma Ck at S. Linden Blvd	WY2017	0	1	5	0
Line 12J at mouth to 12K	WY2017	0	1	3	0
S Spruce Ave SD at Mayfair Ave (296)	WY2017	0	1	8	0
Guadalupe River at Hwy 101	WY2017	0	0	7	0
Refugio Ck at Tsushima St	WY2017	0	1	6	1
Rodeo Creek at Seacliff Ct. Pedestrian Br.	WY2017	0	1	7	1
East Antioch nr Trembath	WY2017	0	1	6	0
Outfall at Gilman St.	WY2018	0	1	5	1
Zone 12 Line A at Shellmound	WY2018	0	1	6	0
Meeker Slough	WY2018	0	1	5	0
MeekerWest	WY2018	0	1	5	1
Little Bull Valley	WY2018	0	1	2	0
Kirker Ck at Pittsburg Antioch Hwy and Verne Roberts Cir	WY2018	0	1	5	0
Gull Dr Outfall	WY2018	0	1	6	0
Gull Dr SD	WY2018	0	1	5	0
GR outfall 066GAC850	WY2018	0	1	4	0
GR outfall 066GAC900	WY2018	0	1	4	0
SC100CTC400A	WY2019	0	1	5	0

WYs 2015 through 2020 POC Reconnaissance Monitoring

Catchment	Year Sampled	Discrete Grabs	Composite Samples	Number of Aliquots per composite sample	Remote Sample
SC100CTC500A	WY2019	0	1	5	0
Line 12M at Coliseum Way	WY2019	0	1	4	0
Rodeo Creek	WY2019	0	1	5	0
SMBUR164A	WY2019	0	1	4	0
SMBUR85A	WY2019	0	1	4	0
Bay Point	WY2019	0	0	NA	1
Mount Diablo Creek	WY2019	0	0	NA	1
Wildcat Creek	WY2019	0	0	NA	1
Santa Fe Channel East	WY2020	0	1	4	0
Santa Fe Channel West	WY2020	0	1	4	0
North Emeryville Crescent	WY2020	0	1	4	0
Outfall at Gilman St.	WY2020	0	1	3	0
Line 12H at Coliseum Way	WY2020	0	1	3	0
Line 12I at Coliseum Way	WY2020	0	1	3	0

Attachment A

Electronic Data Transmittal Letter dated March 31, 2021 with attached file list

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REPLACE WITH LETTER FROM CCCWP to SFBRWQCB and CVRWQB

RE: SUBMITTAL OF ELECTRONIC STATUS MONITORING DATA REPORT IN ACCORDANCE WITH MRP 2.0 PERMIT PROVISION C.8.h.ii AND CENTRAL VALLEY PERMIT PROVISION C.8.g.ii

Attachment B

BASMAA Regional Monitoring Coalition: Status of Regional Stressor/Source Identification (SSID) Projects (updated March 2021)

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SSID Project ID	Date Updated	Program	Creek/ Channel Name	Site Code(s) or Other Site ID	Project Title	Primary Indicator(s) Triggering Stressor/Source ID Project									Indicator Result Summary	Rationale for Proposing / Selecting Project	Current Status of SSID Project or Date Completed	EO Concurrence of Project Completion (per C.8.e.iii.(3)(b)
						Bioassess	General WQ	Chlorine	Temp	Water Tox	Sed Tox	Sed Chem	Bacteria	Other				
AL-1	02/04/21	ACCWP	Palo Seco Creek		Exploring Unexpected CSCI Results and the Impacts of Restoration Activities	X									Sites where there is a substantial difference in CSCI score observed at a location relative to upstream or downstream sites, including sites on Palo Seco Creek upstream of the Sausal Creek restoration-related sites, that had substantial and unexpected differences in CSCI scores.	The project will provide additional data to aid consideration of unexpected and unexplained CSCI results from previous water year sampling on Palo Seco Creek, enable a more focused study of monitoring data collected over many years in a single watershed, and allow analysis of before and after data at sites upstream and downstream of previously completed restoration activities.	In WY 2019, nutrient sampling, bioassessment, and additional DO and temperature monitoring were conducted. The final SSID progress report is included in ACCWP's March 2020 IMR, recommending project completion.	
AL-2	02/04/21	ACCWP	Arroyo Las Positas		Arroyo Las Positas Stressor Source Identification Project	X	X							X	Creek Status Monitoring has identified multiple instances of benthic macroinvertebrate assemblages within the "Very Likely Altered" condition category, exceedances of the Basin Plan objective for pH, and multiple instances of nitrate concentrations above guidelines for nuisance algal growth and nitrate toxicity.	The Water Board is conducting sampling in the watershed as part of their TMDL development efforts and an SSID project will supplement those efforts and generate a better overall picture of stressors impacting the waterbody.	In WY 2019, ACCWP conducted bioassessments, nutrient sampling, and continuous monitoring at multiple locations within the watershed over the course of spring and summer months. The first SSID progress report was included in ACCWP's March 2020 IMR. The planned second year's efforts were mostly precluded by the Covid-19 pandemic restrictions. ACCWP will investigate alternative monitoring techniques in WY 2021 to better understand causal factors.	
CC-1	02/04/21	CCCWP	Lower Marsh Creek		Marsh Creek Stressor Source Identification Study									X	10 fish kills have been documented in Marsh Creek between September 2005 and September 2019. Low dissolved oxygen was proved to be the cause in the most recent (9/17/19) event; circumstances indicate low DO was a likely cause in many if not all of the prior events.	This SSID study addresses the root causes of fish kills in Marsh Creek. Monitoring data collected by CCCWP and other parties are being used to investigate multiple potential causes, including low dissolved oxygen, warm temperatures, daily pH swings, fluctuating flows, physical stranding, and pesticide exposure. During year 2 a pilot test of water storage and night-time flow augmentation was conducted by the City of Brentwood Wastewater Treatment Plant (WWTP).	The CCCWP SSID work plan was submitted in 2018. The Year 2 Status Report is included in CCCWP's March 2020 IMR. The study successfully concluded in Year 2. The final report recommended project completion. Flow augmentation appears to be a viable means of avoiding lethally low DO in portions of the creek downstream of the WWTP. Permittees are voluntarily implementing flow augmentation and monitoring during WY2021 and WY 2022.	Final report submitted. Waiting for EO concurrence.
SC-1	02/17/21	SCVURPPP	Coyote Creek	NA	Coyote Creek Toxicity SSID Project						X				The SWRCB recently added Coyote Creek to the 303(d) list for toxicity.	This SSID study investigated the extent and magnitude of toxicity in an urban reach of Coyote Creek. Sediment samples (n=8) were collected during the dry season of 2018 and 2019. Samples were generally not toxic, except for one sample with low levels of toxicity (subsequent re-test of sample was not toxic). Sediment chemistry results were inconclusive (i.e., pesticide concentrations were not at levels suspected of causing toxicity). SSID Project results support similar findings from long term monitoring conducted by the SWAMP SPoT Program of reduced acute toxicity in Coyote Creek over the past 10 years.	The work plan was submitted with SCVURPPP's WY 2017 UCMR. A project report describing the results of the WY 2018 and WY 2019 monitoring and recommending project completion was submitted with the WY 2019 IMR.	Final report submitted. Waiting for EO concurrence.
SC-2	02/04/21	SCVURPPP	Lower Silver-Thompson Creek	NA	Lower Silver SSID Project	X								X	Low CSCI scores and high nutrient concentrations at a majority of bioassessment locations.	Evaluate potential causes of reduced biological conditions in Lower Silver-Thompson Creek. The SSID Project is investigating sources of nutrients and assessing the range and extent of eutrophic conditions (if present). The Project will evaluate association between stressor data (e.g., water chemistry, dissolved oxygen, and physical habitat) and biological condition indicators (i.e., CSCI and ASCI scores).	The work plan was submitted with SCVURPPP's FY 18-19 Annual Report and the WY 2019 IMR. A project report describing the results of the WY 2019 and WY 2020 monitoring and recommending project completion will be submitted by mid-2021.	

SSID Project ID	Date Updated	Program	Creek/ Channel Name	Site Code(s) or Other Site ID	Project Title	Primary Indicator(s) Triggering Stressor/Source ID Project									Indicator Result Summary	Rationale for Proposing / Selecting Project	Current Status of SSID Project or Date Completed	EO Concurrence of Project Completion (per C.8.e.iii.(3)(b)
						Bioassess	General WQ	Chlorine	Temp	Water Tox	Sed Tox	Sed Chem	Bacteria	Other				
SM-1	02/04/21	SMCWPPP	Pillar Point/ Deer Creek/ Denniston Creek	NA	Pillar Point Harbor Bacteria SSID Project								X		FIB samples from 2008 and 2011-2012 exceeded WQOs.	A grant-funded Pillar Point Harbor MST study conducted by the RCD and UC Davis in 2008, 2011-2012 pointed to urban runoff as a primary contributor to bacteria at Capistrano Beach and Pillar Point Harbor. The study, however, did not identify the specific urban locations or types of bacteria. This SSID project investigated bacteria contributions from the urban areas within the watershed. In WY 2018, Pathogen indicator and MST monitoring was conducted at 14 freshwater sites during 2 wet and 2 dry events. Very few samples contained "controllable" source markers (i.e., human and dog). Additional field studies were conducted in WY 2019 to understand hydrology and specific source areas.	The work plan was submitted with SMCWPPP's WY 2017 UCMR. A project report describing the results of the WY 2018 and WY 2019 investigations was submitted on Oct 28, 2019. On Feb 7, 2020, RWQCB staff requested minor report changes prior to Executive Officer concurrence regarding project completion. The Revised Final Report was submitted Jun 30, 2020. A TMDL addressing bacteria in Pillar Point Harbor is currently under development.	Yes (per letter dated 02/07/20)
FSV-1	02/20/21	City of Vallejo in Association with FSURMP	Rindler Creek	207R03504	Rindler Creek Bacteria and Nitrogen Study								X		E. coli result of 2800 MPN/100mL in Sept. 2017.	A source identification study is warranted in Rindler Creek due to the elevated FIB result, other (non-RMC) monitoring indicating elevated ammonia levels, and the presence of a suspected pollutant source upstream of the data collection point. Rindler Creek is a highly urbanized and modified creek that originates in open space northeast of the City of Vallejo. Monitoring is conducted just downstream of the creek crossing under Columbus Parkway; upstream of this site there is City-owned land that is grazed by cattle roughly from December-June.	A Project Outline was submitted with the IMR in March 2020. The project has been approved by RB staff. Fencing to exclude cattle from Rindler Creek will be installed in Fall 2021 and subsequent monitoring will commence in spring 2022 to monitor project efficacy.	
RMC-1	02/17/21	RMC/ Regional	NA (entire RMC area)	NA	Regional SSID Project: Electrical Utilities as a Potential PCBs Source to Stormwater in the San Francisco Bay Area									X	Fish tissue monitoring in San Francisco Bay led to the Bay being designated as impaired on the CWA 303(d) list and the adoption of a TMDL for PCBs in 2008. POC monitoring suggests diffuse PCBs sources throughout region.	PCBs were historically used in electrical utility equipment, some of which still contain PCBs. Although much of the equipment has been removed from services, ongoing releases and spills may be occurring at levels approaching the TMDL waste load allocation. This regional SSID project is investigating opportunities for BASMAA RMC partners to work with RWQCB staff to: 1) improve knowledge about the extent and magnitude of PCB releases and spills, 2) improve the flow of information from utility companies, and 3) compel cooperation from utility companies to implement improved control measures.	The work plan was submitted with each Program's WY 2018 UCMR and implementation began in WY 2019. The work plan outlined a process for BASMAA RMC partners to work with RWQCB staff to better understand PCB releases from electrical utility equipment owned by PG&E and to propose a source control framework. Ongoing bankruptcy proceedings at PG&E stalled the process. Therefore, BASMAA, with RWQCB staff concurrence, developed a revised approach to implement the work plan but with a focus on municipally owned utilities. The SSID project was completed in June 2020.	Final report submitted. Waiting for EO concurrence.

SSID Project ID Descriptors:

AC	Clean Water Program of Alameda County (ACCWP)
CC	Contra Costa Clean Water Program (CCCWP)
SC	Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP)
SM	San Mateo Countywide Water Pollution Prevention Program (SMCWPPP)
FSV	Solano County Permittees
RMC	Bay Area Stormwater Management Agencies Association (BASMAA) Regional Monitoring Coalition (RMC)