Santa Clara Valley
Urban Runoff
Pollution Prevention Program

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Electronically submitted to SF Bay Water Board ftp Site (c/o Zachary Rokeach) and to the Regional Data Center (Moss Landing) on 3/31/2020

March 31, 2020

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

Subject: Submittal of SCVURPPP Integrated Monitoring Report and Electronic Monitoring Data for Water Year 2019

Dear Mr. Montgomery:

At the direction of the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP) Management Committee, I am pleased to submit SCVURPPP's Integrated Monitoring Report (IMR) for water quality monitoring conducted in Water Years (WY) 2014 through 2019 (i.e., October 1, 2013 through September 30, 2019) and Electronic Monitoring Data for water quality monitoring conducted in WY 2019. The IMR is submitted in compliance with provision C.8.h.v of the 2015 Municipal Regional Stormwater Permit (MRP, NPDES # CAS612008, Order R2-2015-0049) and pursuant to provision C.8 of the MRP. The SCVURPPP IMR is submitted in five parts, which are listed below and summarized in the IMR Executive Summary.

- Part A – San Francisco Estuary Receiving Water Monitoring (C.8.c)
- Part B – Creek Status (C.8.d) and Pesticides & Toxicity (C.8.g) Monitoring
- Part C – Stressor Source Identification (SSID) Projects (C.8.e)
- Part D – Pollutants of Concern Monitoring (C.8.f)
- Part E – Budget Summary (C.8.h.v(4))

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

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

Project	Date Range	MRP Provision
Creek Status Monitoring	April - September 2019	C.8.d
Stressor/Source Identification Study	August - September 2019	C.8.e
Pollutants of Concern Monitoring	January – August 2019	C.8.f
Pesticides and Toxicity Monitoring	July 2019	C.8.g

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

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

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

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

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

Certification Regarding SCVURPPP Program Urban Creeks Monitoring Report

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

Very truly yours,



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

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

Attachments: SCVURPPP IMR Water Year 2014 through Water Year 2019 (uploaded to ftp site)
Electronic Data Report for Water Year 2019 Creek Status and Pesticides & Toxicity Monitoring Data, Stressor/Source Identification Data, and Pollutants of Concern Monitoring Data (uploaded to ftp site)
Third Party Monitoring Statement

Third Party Monitoring Statement

Please note that consistent with provision C.8.a.iii of the MRP, one water quality monitoring requirement was partially fulfilled by third party monitoring in Water Year 2019:

- The Regional Monitoring Program for Water Quality in the San Francisco Estuary (RMP) supplements SCVURPPP data collection from Water Year 2018, pursuant to MRP provision C.8.f – Pollutants of Concern Loads Monitoring. The results of monitoring conducted through the RMP are summarized in Section 5 of the attached UCMR. Data collected from stations monitored by the RMP will be submitted to the California Environmental Data Exchange Network directly by the RMP following completion of their quality assurance review.
- Data collected by the State of California's Surface Water Ambient Monitoring Program (SWAMP) through its Stream Pollutant Trend (SPoT) Monitoring Program supplements SCVURPPP data collection associated with MRP Provision C.8.f - Pollutants of Concern Monitoring requirements. These SPoT data address the pollutants trends management question. Data collected from stations monitored by the SPoT Program will be submitted directly to the California Environmental Data Exchange Network according to the SWAMP schedule for review and reporting of data, which may not occur for several years.

Santa Clara Valley
Urban Runoff
Pollution Prevention Program

Watershed Monitoring and Assessment Program



Integrated Monitoring Report Executive Summary

Waters 2014 - 2019

Submitted in compliance with Provision C.8.h.v of NPDES Permit No. CAS612008, Order No. R2-2015-049

March 31, 2020

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Table E.1. Water Year 2019 Creek Status Monitoring Station Summary Table

In compliance with provision C.8.h.v(1), this table of all Creek Status Monitoring stations sampled by SCVURPPP in Water Year 2019 is provided immediately following the Table of Contents.

Map ID [1]	Station ID	Watershed	Creek Name	Land Use	Latitude	Longitude	Probabilistic	Targeted				
							Bioassess, Nutrients, General WQ	Chlorine	Pesticides & Toxicity	Temp [2]	Cont WQ [3]	Pathogen Indicators
60	205GUA060	Guadalupe River	Los Gatos Creek	U	37.29092	-121.93516	X	X				
251	205GUA251	Guadalupe River	Alamitos Creek	U	37.23306	-121.87054	X	X				
4378	205R04378	Guadalupe River	Los Gatos Creek	U	37.21641	121.98787	X	X				
4395	205R04395	Lower Penitencia Cr	Arroyo de los Coches	U	37.27497	-122.74731	X	X				
4418	205R04418	Coyote Creek	Thompson Creek	U	37.29241	-121.76800	X	X				
4530	205R04530	Coyote Creek	Upper Silver Creek	U	37.29709	-121.79408	X	X				
4537	205R04537	Coyote Creek	Thompson Creek	U	37.274966	-121.74731	X	X				
4591	205R04591	San Tomas Aquino	San Tomas Aquino	U	37.39046	-121.96851	X	X				
4602	205R04602	San Tomas Aquino	Wildcat Creek	U	37.26485	-122.01930	X	X				
4614	205R04614	San Tomas Aquino	San Tomas Aquino	U	37.27361	-121.98240	X	X				
4638	205R04638	Guadalupe River	Guadalupe Creek	U	37.228257	-121.90358	X	X				
4670	205R04670	San Thomas Aquino	Saratoga Creek	U	37.25077	-122.05510	X	X				
455	205COY455	Coyote Creek	Coyote Creek	U	37.166314	-121.64775	X	X				
4274	205R04247	Stevens Creek	Stevens Creek	U	37.325439	-122.06068	X	X				
4271	205R04271	Stevens Creek	Stevens Creek	NU	37.3051	-122.15480	X	X				
4317	205R04317	Coyote Creek	Coyote Creek	U	37.16628	-121.63747	X	X				
4359	205R04359	Adobe Creek	Adobe Creek	U	37.42889	-122.10522	X	X				
4383	205R04383	San Francisquito Cr	San Francisquito Cr	U	37.45462	-122.16078	X	X				
4479	205R04479	San Tomas Aquino	Saratoga Creek	U	37.35448	-121.97338	X	X				
70	205STE070	Stevens Creek	Stevens Creek	U	37.30275	-122.07486	X	X				
033	205LGA033	Guadalupe River	Los Gatos Creek	U	37.29516	-121.93337						X
400	205LGA400	Guadalupe River	Los Gatos Creek	U	37.23869	-121.97088						X
450	205LGA420	Guadalupe River	Los Gatos Creek	U	37.22024	-121.98303						X
330	205COY330	Coyote Creek	Coyote Creek	U	37.29027	-121.81831						X
392	205COY392	Coyote Creek	Coyote Creek	U	37.23504	-121.76105						X
190	205GUA190	Guadalupe River	Guadalupe Creek	U	37.24373	-121.87561				X		
202	205GUA202	Guadalupe River	Guadalupe Creek	U	37.23291	-121.89795				X		
210	205GUA210	Guadalupe River	Guadalupe Creek	U	37.21746	-121.91039				X		
218	205GUA218	Guadalupe River	Guadalupe Creek	U	37.2028	-121.88845				X		

Map ID [1]	Station ID	Watershed	Creek Name	Land Use	Latitude	Longitude	Probabilistic	Targeted				
							Bioassess, Nutrients, General WQ	Chlorine	Pesticides & Toxicity	Temp [2]	Cont WQ [3]	Pathogen Indicators
250	205GUA250	Guadalupe River	Alamitos Creek	U	37.23363	-121.87058				X		
255	205GUA255	Guadalupe River	Alamitos Creek	U	37.22607	-121.85842				X		
262	205GUA262	Guadalupe River	Alamitos Creek	U	37.22041	-121.84516				X		
270	205GUA270	Guadalupe River	Alamitos Creek	U	37.20129	-121.82891				X		
279	205GUA279	Guadalupe River	Alamitos Creek	U	37.17409	-121.82409				X		
235	205COY235	Coyote Creek	Coyote Creek	U	37.3536	-121.87417					X	
236	205COY236	Coyote Creek	Coyote Creek	U	37.35098	-121.87378					X	
239	205COY239	Coyote Creek	Coyote Creek	U	37.33722	-121.86953					X	
021	205STE021	San Tomas Aquino	Stevens Creek	U	37.40982	-122.06905			X			
010	205STQ010	San Tomas Aquino	San Tomas Aquino	U	37.38863	-121.96853			X			

U = urban, NU = non-urban

[1] Map ID applies to Figure 1.2. of Part B of this Integrated Monitoring Report.

[2] Temperature monitoring was conducted continuously (i.e., hourly) April through September.

[3] Continuous water quality monitoring (temperature, dissolved oxygen, pH, specific conductivity) was conducted during two 2-week periods (spring and late summer).

EXECUTIVE SUMMARY

This Integrated Monitoring Report (IMR) was prepared by the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP or Program), on behalf of its 15 member agencies (13 cities/towns, the County of Santa Clara, and the Santa Clara Valley Water District) SCVURPPP member agencies are subject to the National Pollutant Discharge Elimination System (NPDES) stormwater permit for Bay Area municipalities referred to as the Municipal Regional Permit (MRP). The MRP was first adopted by the San Francisco Regional Water Quality Control Board (SFRWQCB or Regional Water Board) on October 14, 2009 as Order R2-2009-0074 (SFRWQCB 2009; referred to as MRP 1.0). On November 19, 2015, the Regional Water Board updated and reissued the MRP as Order R2-2015-0049 (SFRWQCB 2015; referred to as MRP 2.0).

This IMR fulfills the requirements of provision C.8.h.v of MRP 2.0 for comprehensively interpreting and reporting all monitoring data collected since the previous IMR - Water Years[1] (WYs) 2014 through 2019. The previous IMR included data collected during WYs 2012 and 2013 (SCVURPPP 2014). Data presented in this report were also submitted in electronic SWAMP-comparable formats by SCVURPPP to the Regional Water Board on behalf of SCVURPPP Permittees and pursuant to Provision C.8.h.ii of MRP 2.0.

Provision C.8.a (Compliance Options) of the MRP allows Permittees to address monitoring requirements through a "regional collaborative effort," their countywide stormwater program, and/or individually. On behalf of Co-permittees, SMCWPPP conducts creek water quality monitoring and monitoring projects in in collaboration with the Bay Area Stormwater Management Agency Association (BASMAA) Regional Monitoring Coalition (RMC), and actively participates in the Regional Monitoring Program for Water Quality in San Francisco Bay (RMP), which focuses on assessing Bay water quality and associated impacts.

Monitoring data were collected in accordance with the BASMAA RMC Quality Assurance Project Plan (QAPP; BASMAA 2016a) and the BASMAA RMC Standard Operating Procedures (SOPs; BASMAA 2016b). Where applicable, and in compliance with Provision C.8.b of MRP 2.0, methods described in the QAPP and SOP are comparable with methods specified by the California Surface Water Ambient Monitoring Program (SWAMP) Quality Assurance Program Plan (QAPrP).

The IMR consists of five "Parts" (A-E) that address the various sub-provisions of MRP Provision C.8 (Water Quality Monitoring). Monitoring results and recommendations for future monitoring, which are fully described in IMR Parts A-D, are summarized in this Executive Summary. Additionally, a summary of the costs and benefits of monitoring conducted in compliance with provision C.8 is also provided.

- Part A: San Francisco Estuary Receiving Water Monitoring
- Part B: Creek Status and Pesticides & Toxicity Monitoring
- Part C: Stressor/Source Identification Projects
- Part D: Pollutants of Concern Monitoring
- Part E: Monitoring Costs and Benefits Summary

[1] Most hydrologic monitoring occurs for a period defined as a Water Year, which begins on October 1 and ends on September 30 of the named year. For example, Water Year 2019 (WY 2019) began on October 1, 2018 and concluded on September 30, 2019.

Part A: San Francisco Estuary Receiving Water Monitoring

In accordance with Provision C.8.b of MRP 1.0 and Provision C.8.c of MRP 2.0, Permittees are required to provide financial contributions towards implementing an San Francisco Bay Estuary receiving water monitoring program on an annual basis that, at a minimum, is equivalent to the monitoring conducted via the Regional Monitoring Program for Water Quality in San Francisco Bay (RMP). SCVURPPP Permittees comply with this provision by making financial contributions to the RMP. Additionally, SCVURPPP Permittee and Program staff actively participate in RMP committees, workgroups, and strategy teams, such as the Small Tributaries Loading Strategy (STLS), to help oversee RMP activities and provide input, consistent with MRP Permittee interests.

RMP activities conducted between WY 2014 and WY 2019, included:

- On-going implementation of the long-term **Status and Trends Monitoring Program**, which monitors contaminants in water, sediment, bird eggs, sport fish, and bivalves, and conducts long-term suspended sediment, nutrients, and phytoplankton monitoring.
- Pilot and Special Studies, conducted in support of the:
    - Sources, Pathways and Loadings Work Group (SPLWG);
    - Emerging Contaminants Work Group;
    - Nutrients Management Strategy;
    - Microplastics Strategy;
    - PCBs Work Group;
    - Sediment Work Group; and
    - Selenium Work Group.

Part B: Creek Status and Pesticides & Toxicity Monitoring

Part B of the IMR comprehensively interprets and reports all Creek Status and Pesticides & Toxicity monitoring data collected since the previous IMR (SCVURPPP 2014). As such, Part B includes data collected during WY 2014 through WY 2019, with bioassessment and chlorine data also inclusive of WYs 2012 and 2013.

The RMC's creek status monitoring strategy includes both a regional ambient/probabilistic monitoring design and a local targeted monitoring design. The probabilistic monitoring design was developed to remove bias from site selection such that ecosystem conditions can be objectively assessed on local (i.e., Santa Clara Basin) and regional (i.e., RMC) scales. The targeted monitoring design focuses on sites selected based on the presence of significant fish and wildlife resources, as well as historical and/or recent indications of water quality concerns. Monitoring results are compared to "triggers" listed in the MRP. Some triggers are equivalent to regulatory Water Quality Objectives (WQOs), while others are thresholds above (or below) which potential impacts to aquatic life or other beneficial uses may occur. Sites where triggers are exceeded (or not met) are considered for future stressor/source identification (SSID) projects.

B.1 Bioassessment

During WYs 2012 – 2019, SCUVRPPP conducted biological assessments at 160 stream sites. An additional 12 sites were monitored by the Regional Water Board during that timeframe, for a total of 172 sites. Of these sites, 168 were selected using the probabilistic design and 4 were targeted. Bioassessments include the collection of benthic macroinvertebrate and algae samples, physical habitat measurements, water chemistry (i.e., nutrient analyses) and general water quality. The California Stream Condition Index (CSCI), a statewide tool that translates benthic macroinvertebrate data into an overall measure of stream health, was used to assess biological condition.

- Of the 172 (74%) bioassessment sites, 128 (74%; including four targeted sites) received CSCI scores that were below the MRP trigger (0.795), which corresponds to the two lower condition categories *(likely altered* and *very likely altered)*. Of the 128 low--scoring sites, 113 were classified as urban. The proportion of good and very good sites varies by watershed. Figure E.1 illustrates the CSCI condition category scores for the 172 sites.

- Cumulative distribution function (CDF) curves indicate there is a 65% probability that a random stream site in Santa Clara County will have a CSCI score below the MRP trigger (i.e., *likely altered* or *very likely altered* categories). There is a 80% probability that a random *urban* site in Santa Clara County will have a CSCI score below the MRP trigger and there is a 48% probability that a random *non-urban* site will have a CSCI score below the trigger.

Ancillary parameters collected during bioassessments, such as physical habitat, nutrient concentrations, and general water quality measurements, along with watershed grouping based on land use data, were analyzed using Spearman's rank correlation and random forest models to identify stressors that likely to pose the greatest risk to stream health.

- The random forest model for CSCI scores indicates that watershed grouping along with physical habitat, and several landscape and water-quality stressors were the best predictors of condition scores. The high ranking of the watershed variable means that biological conditions stratify spatially, as well as being correlated to specific stressors.

- Results of the Santa Clara stressor assessment were similar to the RMC regional assessment. Both Santa Clara and regional CSCI scores are strongly influenced by physical habitat variables such as imperviousness in the contributing area (BASMAA 2019).

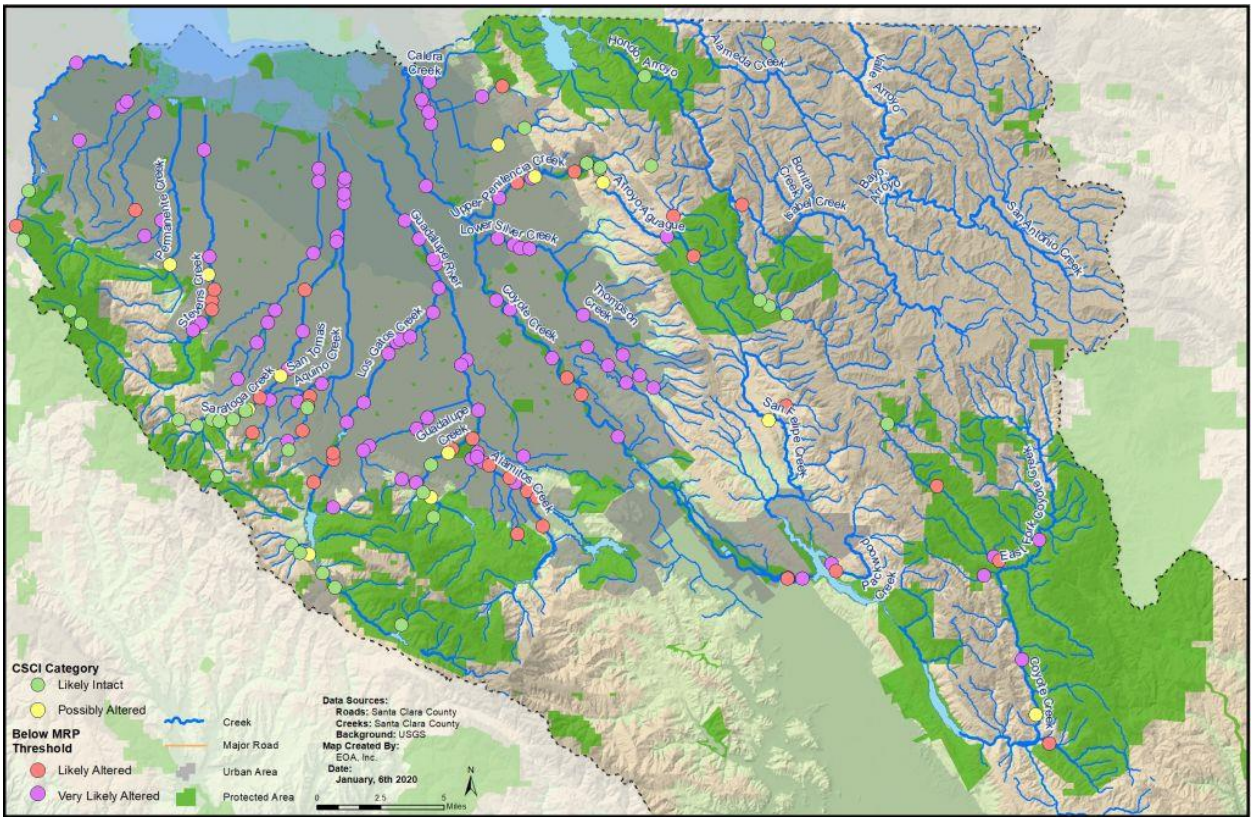


Figure E.1. CSCI condition categories observed at 172 bioassessments in Santa Clara County, WYs 2012 – 2019.

B.2 Continuous Temperature and Water Quality Monitoring

Continuous monitoring of water temperature and general water quality parameters in WY 2014 through WY 2019 was conducted in compliance with Provisions C.8.c of MRP 1.0 and C.8.d.iii – iv of MRP 2.0. Hourly temperature measurements were recorded at a minimum of eight (8) sites each year from April through September. Continuous (15-minute) general water quality measurements (pH, DO, specific conductance, temperature) were recorded at three sites each year during two, two-week periods in the spring (Event 1) and the summer (Event 2). Monitoring sites were selected based on the presence of significant fish and wildlife resources as well as historical and/or recent indications of water quality concerns. The same sites were often monitored for multiple years to gain a better understanding of the range of water quality conditions that may occur over time. In some years, continuous monitoring data were used to support or follow-up on SSID investigations (Figure E.2).

Overall, continuous monitoring results indicate that temperature and specific conductivity typically increase in the downstream direction, which is also characterized by increasing urbanization in Santa Clara County watersheds. The MRP maximum weekly average temperature (MWAT) trigger threshold of 17°C is often exceeded. These temperature exceedances resulted in sites being placed on the list of candidate SSID projects, but may not be of concern in Santa Clara County because the MWAT threshold was developed for streams of the Pacific Northwest, a cooler region with inherently lower water temperatures. Other locations where the MWAT trigger was exceeded are in reaches where cold-water fish migrate, rather than reside or rear.

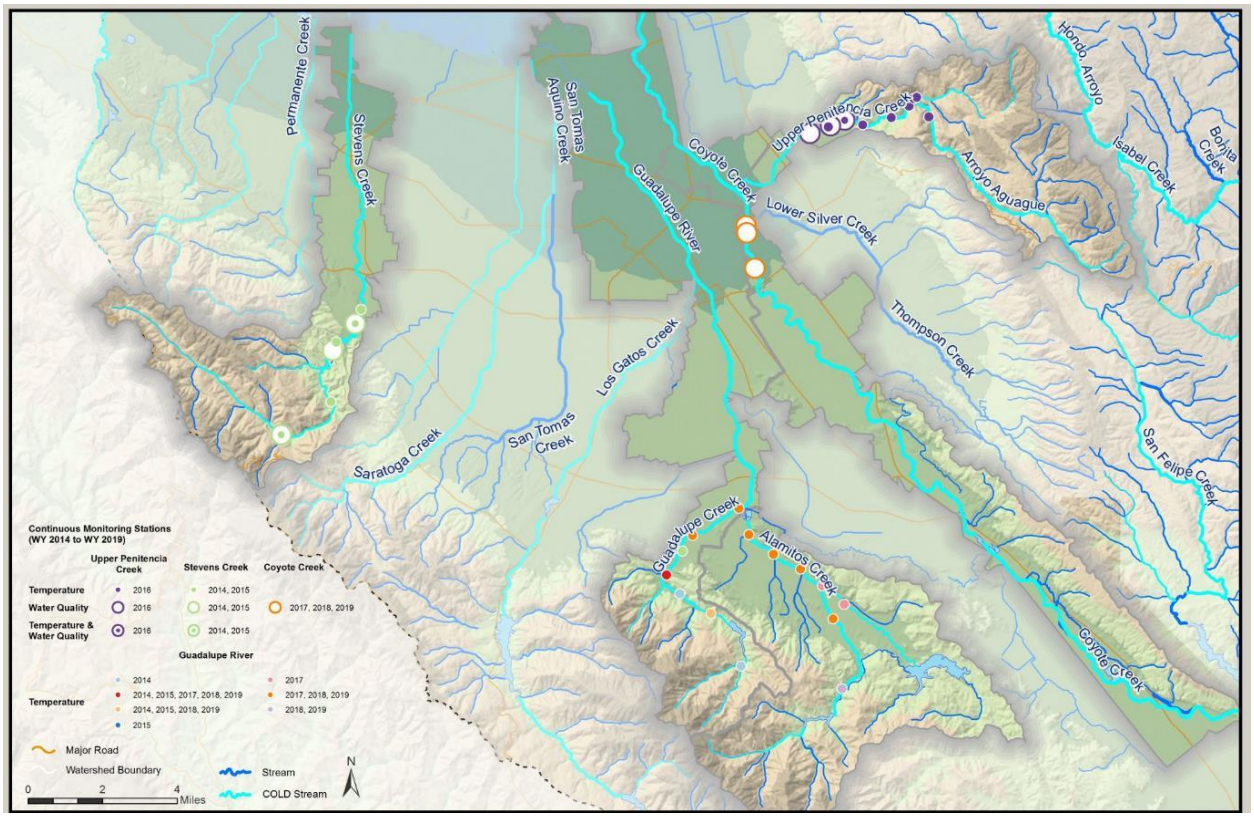


Figure E.2. Continuous temperature and water quality monitoring stations in Santa Clara Basin, WYs 2014 – 2019.

B.3 Pathogen Indicator Monitoring

From WY 2014 through WY 2019, in compliance with Provisions C.8.c of MRP 1.0 and C.8.d.v of MRP 2.0, SCVURPPP collected five grab samples per year for pathogen indicator bacteria analysis. Monitoring was generally conducted at sites that, while generally could not be considered “bathing beaches,” were located within creekside parks or along trails that were considered to exhibit potential for public access to streams. Some stations were sampled in multiple years. The overall goal of pathogen indicator monitoring is to assess whether WQOs are being met and whether creeks are supportive of water contact recreation (REC-1) Beneficial Uses.

Although WQO exceedances were found in two of the six watersheds targeted, there is no evidence for large scale spatial patterns of elevated bacteria concentrations. The results suggest that pathogen indicator densities at the monitoring stations are variable. It is important to recognize that pathogen indicators do not directly represent actual pathogen concentrations and do not distinguish among sources of bacteria. Sources of pathogen indicator bacteria include homeless encampments, wildlife, livestock, pets, leaking septic systems/sanitary sewers, and regrowth of bacteria within biofilms. It is the human sources of bacteria that are associated with REC-1 health risks. As a result, the comparison of pathogen indicator results to pathogen indicator thresholds may not be appropriate and should be interpreted cautiously.

B.4 Chlorine Monitoring

From WY 2012 through WY 2019, in compliance with Provision C.8.c of MRP 1.0 and Provision C.8.d.ii of MRP 2.0, SCVURPPP collected field measurements of total and free chlorine residual in creeks where bioassessments were conducted. While chlorine residual is generally not a concern in Santa Clara Valley urban creeks, WY 2019 and prior monitoring results suggest there are occasional free chlorine and/or total chlorine residual exceedances in the Santa Clara Basin. Trigger exceedances may be the result of a one-time potable water discharges that are difficult to trace. Furthermore, chlorine in surface waters can dissipate from volatilization and reaction with sediment and organic matter. Over the past eight years of monitoring (WY 2012 – WY 2019), there have been a total of 17 (out of 160) sites with chlorine trigger exceedances (none in WY 2019 after immediate re-sampling).

B.5 Pesticides and Toxicity Monitoring

Toxicity testing, sediment chemistry monitoring, and water column pesticides monitoring, collectively referred to as pesticides and toxicity monitoring, was conducted during WY 2014 through WY 2019 in compliance with Provisions C.8.c of MRP 1.0 and C.8.g of MRP 2.0. There were slight differences between the two permit terms with regard to the required number of samples, toxicity test organisms, chemical constituents, and MRP triggers.

The results of pesticides and toxicity monitoring conducted from WY 2014 through WY 2019 were analyzed to identify trends at sampling locations in Santa Clara County watersheds. During this period, there were two sediment samples and four water samples with toxicity relative to the laboratory control *and* a Percent Effect exceeding the MRP evaluation criterion. There were an additional 20 test results that had significant toxicity, but with a Percent Effect that did not exceed the MRP trigger thresholds. A majority of these toxicity results were found in water samples and were associated with either *C. dubia* reproduction (10 samples), a chronic toxicity endpoint, or *H. azteca* survival (7 samples), an acute toxicity endpoint. Six of the seven water samples with toxicity to *H. azteca* were collected during wet season sampling events suggesting that stormwater runoff is affecting *H. azteca*. The water samples with toxicity to *C. dubia* were more evenly divided between wet and dry season sampling events.

Between WY 2014 and WY 2019, there was just one sediment sample with a probabe effects concentration (PEC) quotient calculated that was ≥ 1.0 for and analyte other than chromium and nickel (mercury in Alamitos Creek downstream of the former New Almaden Mercury Mining District). Excluding the naturally occurring chromium and nickel, there were eight samples with threshold effects concentration (TEC) quotients ≥ 1.0; the more conservative of the two evaluation criteria. These included legacy insecticide DDT compounds in San Tomas Aquino Creek and Lower Silver Creek; copper in Adobe Creek, San Tomas Aquino Creek, and Stevens Creek, and total PAHs in Stevens Creek. Overall, detection frequencies for bifenthrin and fipronil were on par with results from the DPR Northern California study (Ensminger 2019) and *H. azteca* toxicity responses were similar to SWAMP Stream Pollution Trend (SPoT) monitoring results in Coyote Creek and Guadalupe River (Phillips et al. 2014).

The pesticides and toxicity data collected from WYs 2014 through 2019 provide a reference to inform management decisions regarding water quality improvement in Santa Clara County watersheds and guide the planning of future monitoring in the area.

B.6 Recommendations

Impacts to urban streams identified through creek status monitoring are likely the result of long-term changes in stream hydrology, channel geomorphology, in-stream habitat complexity, and other modifications associated with the urban development, along with pollutant discharges typically found in urban watersheds. SCVURPPP Co-permittees are actively implementing many stormwater management programs to address these and other stressors and associated sources of water quality conditions observed in local creeks, with the goal of protecting these natural resources. Through the continued implementation of MRP-associated and other watershed management programs (e.g., stream restoration and flow augmentation), SCVURPPP anticipates that stream conditions and water quality in local creeks will continue to improve over time.

Recommendations presented in Part B are directed towards the next iteration of the MRP (i.e., MRP 3.0) that is currently under development and will likely become effective in WY 2022.

- The Program recommends transitioning from the current ambient probabilistic Biological Condition Assessment monitoring design to a targeted design that would focus on specific watersheds or reaches of interest. It is anticipated that a watershed approach would provide stormwater programs more flexibility to evaluate priority areas that stakeholders want to improve, protect, and/or evaluate.

- Continuous monitoring for temperature and general water quality has been an effective tool in supporting SSID studies and evaluating cold water habitat. It can also complement targeted Biological Condition Assessments. The Program recommends continued implementation of this approach in MRP 3.0.

- Pathogen indicator monitoring is generally not informative due to the prevalence of uncontrollable sources, such as wildlife, and sources outside the scope of stormwater programs such as homelessness. Monitoring efforts for pathogen indicators should instead be used to support bacteria Total Maximum Daily Load (TMDL) action plans in the county.

- Although chlorine monitoring can be an important tool in investigating fish kills, continued chlorine monitoring is not recommended in the next MRP. Exceedances are not prevalent, and sources are generally transient and challenging to trace. Additionally, the most common source, discharges of drinking water, is already addressed by MRP Provisions C.5 (IDDE) and C.15 (Exempted and Conditionally Exempted Discharges) and the NPDES General Permit for Drinking Water Systems (Order WQ 2014-0194-DWQ), and available field equipment does not provide reliable results at the MRP threshold.

- The Program recommends no changes to the current Pesticides and Toxicity monitoring requirements until the statewide coordinated monitoring program, currently under development by the State Water Board, is in place.

Part C: Stressor/Source Identification (SSID) Projects

In compliance with the MRP, Permittees must initiate a minimum number of SSID projects during the permit term. SSID projects are intended to identify and isolate potential sources and/or stressors associated with observed water quality concerns. These projects are intended lead to action(s) that alleviate stressors and reduce sources of pollutants. During MRP 1.0 (WYs 2012 – 2015), SCVURPPP as part of a regional collaborative, initiated three SSID projects. Two of the MRP 1.0 SSID projects were completed in WY 2013 and results were included in the previous IMR (SCVURPPP 2014). These projects addressed fish kills in Guadalupe River and reduced dissolved oxygen in Coyote Creek. The third project under MRP 1.0, Upper Penitencia Creek low CSCI scores, was completed in 2015 and is described below.

- In WY 2013, SCVURPPP initiated the Upper Penitencia Creek SSID Project by developing a work plan to investigate low creek condition scores[2] and temperature trigger exceedances. The monitoring design followed the CADDIS framework developed by the USEPA (2010). Monitoring parameters were selected to evaluate a range of potential stressors to biological condition at the two locations. One site (the "test site") is potentially affected by discharges from the Robert Gross Percolation Ponds and the second site (the "comparator site") is located upstream of the test site above the pond's outfall. Based on results of the monitoring, the reduced biological integrity observed in Upper Penitencia creek was believed to be associated with episodic streamflow due to percolation of surface flow into the underlying groundwater basin rather than operation of the percolation ponds. Therefore, the sources of stressors identified as causing poor biological condition in the study area cannot be mitigated through stormwater management.

During MRP 2.0 (WYs 2016 – 2019), SCVURPPP initiated two SSID projects and participated in one regional project. These SSID projects are briefly summarized below:

- The Coyote Creek Toxicity SSID Project was triggered by the recommended listing of Coyote Creek for toxicity in sediment in the 2016 Integrated Report (303(d) List/305(b) Report for the San Francisco Bay Region. The Coyote Toxicity SSID monitoring design included an evaluation of sediment chemistry and toxicity testing during the dry season over a two-year period (WY 2018 and WY 2019). The results of this SSID Study and review of toxicity data collected over the past 14 years suggest that sediment toxicity is generally not present in Coyote Creek. Based on these results and analyses, the Coyote Creek Toxicity SSID Project is considered complete.

- The Lower Silver SSID project was triggered by creek status/condition data suggesting that Lower Silver-Thompson Creek watershed has reduced biological integrity and relatively high nutrient concentrations. In WY 2019, SCVURPPP developed a work plan designed to investigate nutrient sources, the relationship between nutrients and biological condition, and the extent of eutrophic conditions. The project was initiated in the summer of 2019 with multiple nutrient monitoring events and will continue through WY 2020.

[2] Creek condition was assessed using the California Stream Condition Index (CSCI) and the Southern California Index of Biological Integrity (SoCal IBI). Both indices translate benthic macroinvertebrate (BMI) data into an overall assessment of stream health.

- The Regional SSID Project - Electrical Utilities as a Potential PCBs Source to Stormwater in the San Francisco Bay Area – was triggered by fish tissue monitoring in the Bay that led to the Bay being designated as impaired on the Clean Water Act (CWA) Section 303(d) list and the adoption of a TMDL for PCBs in 2008. Subsequent PCBs monitoring by the BASMAA RMC partners and the RMP suggests that diffuse sources of PCBs are present throughout the region, with one potential source being releases and spills from electrical utility equipment. The work plan, developed in WY 2018, presents a framework to investigate electrical utility equipment as a source of PCBs to urban stormwater runoff and identify appropriate actions and control measures to reduce the water quality impacts of this source. The RMC partners are currently gathering information from municipally-owned electrical utilities in the MRP area to improve current estimates of PCBs loadings to MS4s and identify opportunities to develop improved spill response and reporting procedures.

Overall, Permittees find that SSID monitoring provides valuable information. Although the SSID studies have found that the primary stressor sources are unrelated to municipal stormwater runoff and/or are inconclusive, they have resulted in a greater understanding of hydrology, water quality, and land use in the targeted watersheds, and the findings inform other aspects of stormwater management. Continuation of SSID monitoring in the next permit should be considered, with the level-of-effort determined in a manner mindful of the overall costs of Provision C.8 monitoring.

Part D: Pollutants of Concern Monitoring

Part D of the IMR comprehensively reports and interprets all Pollutants of Concern (POC) monitoring data collected since the previous IMR (SCVURPPP 2014). This includes all POC monitoring data collected during WY 2014 through WY 2019. POC monitoring is intended to assess inputs of POCs to the Bay from local tributaries and urban runoff, provide information to support implementation of Total Maximum Daily Load (TMDL) water quality restoration plans and other pollutant control strategies, assess progress toward achieving wasteload allocations (WLAs) for TMDLs, and help resolve uncertainties associated with loading estimates for POCs. Under both MRP 1.0 and MRP 2.0, Permittees are required to monitor a number of POCs including PCBs, mercury, copper, nutrients, and other parameters of interest (e.g., pesticides, toxicity, emerging contaminants, etc.). POC monitoring under MRP 1.0 focused primarily on loads monitoring stations, while POC monitoring under MPR 2.0 focuses primarily on source identification.

POC Monitoring in the Santa Clara Valley is conducted by SCVURPPP and its water quality partners, which include the RMP and the State of California's Surface Water Ambient Monitoring Program (SWAMP) Stream Pollution Trend (SPoT) monitoring program. Figure E.3 illustrates locations of monitoring stations associated with POC monitoring conducted by SCVURPPP and its water quality partners in compliance with MRP provision C.8 in WYs 2014-2019. This figure illustrates the geographic extent of POC monitoring conducted in Santa Clara County since the previous IMR.

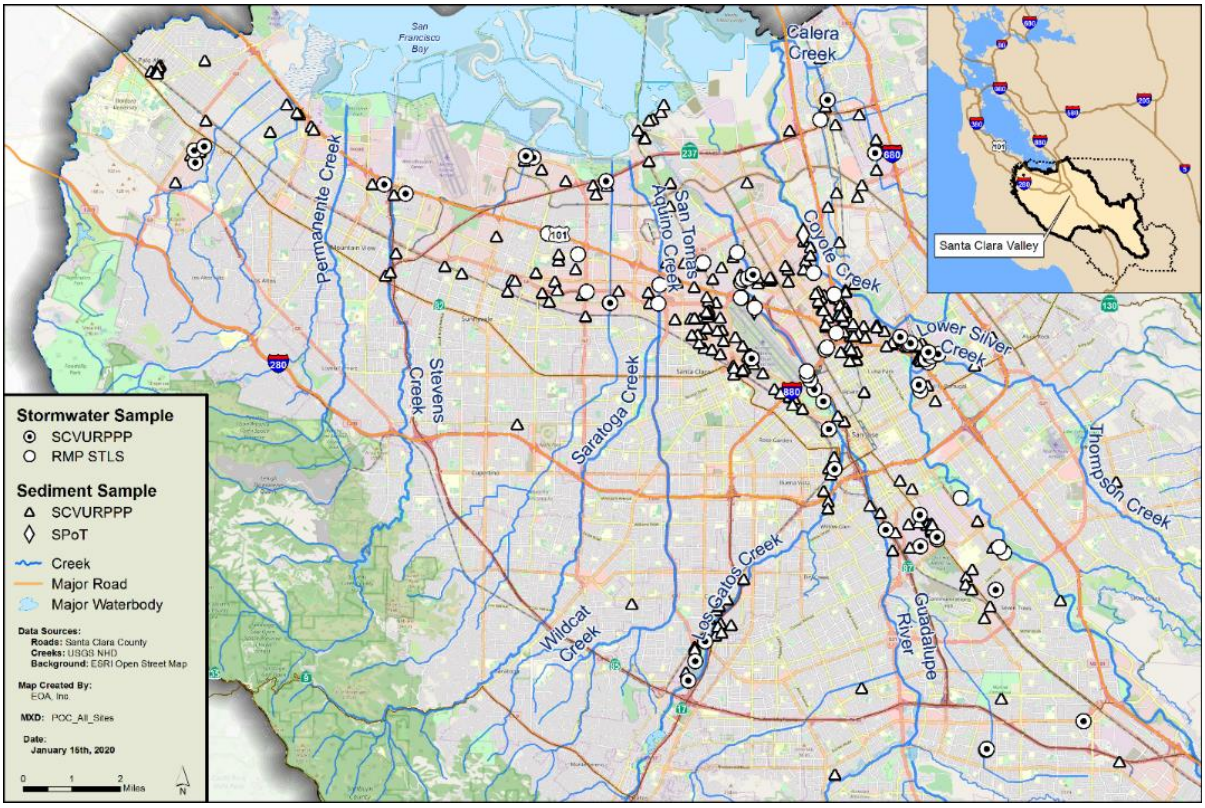


Figure E.3. POC monitoring stations in the Santa Clara Valley, WYs 2014-2019.

D.1 POC Loads Monitoring Stations

Under MRP 1.0, Permittees complied with POC loads monitoring requirements through a collaboration with the BASMA RMC and RMP Small Tributaries Loading Strategy team with the establishment of “bottom-of-the watershed” stormwater monitoring stations across Bay Area Counties. Two POC loads monitoring stations were located in the Santa Clara Valley, including the Guadalupe River station and the Sunnyvale East Channel. Monitoring conducted in WY 2014 included four storms at the Guadalupe River Station, and six storms at the Sunnyvale East Channel Station. Complete results of all monitoring at the POC Loads Monitoring Stations from WY2012 through WY 2014 are presented in Gilbreath et al., (2016). The POC loads monitoring stations were mostly discontinued after WY 2014, with the exception of a single, high-intensity storm event at the Guadalupe River Station in WY 2017. McKee et al. (2018) estimated the mercury loads during this rare event represented more than half of the previously estimated average annual baseline load for the Guadalupe River. SCVURPPP will continue to support mercury monitoring at the Guadalupe River loading stations which is now conducted through the Coordinated Monitoring Program for the Guadalupe River watershed, a collaboration of entities subject to the Guadalupe River Mercury TMDL. The Program is currently working with BASMAA and the RMP STLS to determine if additional POC loading station monitoring is needed in the future to provide additional data for estimating loads to the Bay and to support evaluation and modeling of trends in POC loads to the Bay from urban stormwater runoff.

D.2 PCBs and Mercury

Stormwater Load Estimates

Provisions C.11.c and C.12.c require that Permittees submit a Reasonable Assurance Analysis (RAA) to demonstrate quantitatively that mercury reductions of at least 10 kg/yr and PCBs reductions of at least 3 kg/yr will be realized by 2040 through implementation of green infrastructure projects. As part of this RAA, the Program estimated the loading for PCBs and mercury in urban stormwater runoff from the Santa Clara Valley to the Bay. These estimates were developed by Paradigm Environmental as Phase I (baseline modeling) for the RAA. The final RAA for the Santa Clara Valley will be submitted in September 2020 with the Program's Fiscal Year 2019/20 Annual Report to the Regional Water Board.

POC Monitoring to Identify Sources and Source Areas

Beginning in WY 2015, SCVURPPP and the RMP STLS began implementing an approach to POC monitoring for PCBs and mercury that focuses on screening monitoring to identify sources and source areas that contribute elevated concentrations of PCBs and/or mercury to the MS4. These areas are designated as Watershed Management Areas (WMAs), where new PCBs and mercury control measures will be implemented to reduce stormwater loads to the Bay. Starting in WY 2015 and continuing through WY 2019, both SCVURPPP and the RMP STLS have conducted screening monitoring in catchments of interest, and targeted source property investigations in catchments with elevated PCBs in street dirt, MS4 sediment, or stormwater samples. A sediment sample or stormwater particle ratio is considered elevated if it has a PCBs concentration over 0.5 mg/kg, moderately elevated from 0.2 to 0.5 mg/kg, and low or urban background below 0.2 mg/kg. PCBs concentrations above 1 mg/kg are considered confirmation of a source.

Figure E.4 presents sediment concentrations and/or particle ratios for all PCBs data collected for source identification by the Program and the RMP STLS between WY 2015 and WY 2019. These data include 332 sediment samples and 70 stormwater samples collected during both screening monitoring and during targeted source property investigations.

Overall, identifying PCBs and mercury source areas and source properties is challenging and often a multi-year process. Since WY 2015, the Program has used the screening monitoring data to identify 21 high and moderate priority WMAs. Eighteen of these priority WMAs have been targeted for source investigations, which have resulted in 11 confirmed source properties. Two of these source properties were referred to the Regional Water Board for follow-up investigation and abatement during this permit term. The remaining 9 confirmed source properties are currently under evaluation by the Program and the associated municipal jurisdictions to determine next steps. Of the 18 WMAs targeted for source property investigations, investigations were completed in 2 WMAs, and are currently ongoing in 16 WMAs. There remain 47 catchments of interest that have not yet been screened for elevated PCBs or mercury concentrations. Given the outcomes of screening monitoring and source investigations to date, the Program recommends maintaining the same yearly minimum PCBs monitoring requirements (8 samples per year) in the next MRP in order to continue to screen catchments, prioritize WMAs and conduct source property investigations as warranted. In contrast, because the baseline loading estimate for mercury indicates that the Santa Clara Valley is already achieving the San Francisco Bay TMDL WLA for mercury in urban stormwater, the Program recommends reducing mercury monitoring requirements in the next MRP.

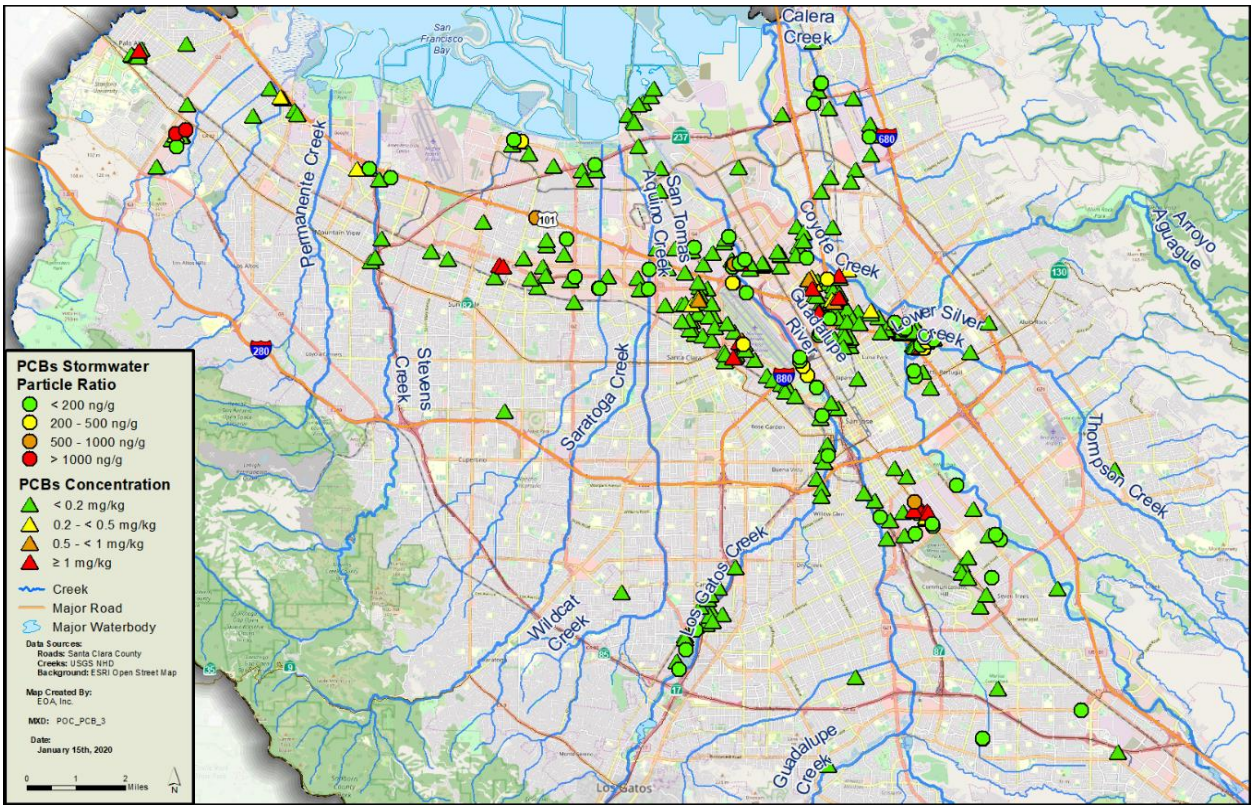


Figure E.4. Locations and relative concentrations of PCBs measured in sediment and stormwater in the Santa Clara Valley by SCVURPPP and the RMP STLS, WYs 2015 – 2019.

Other PCBs and Mercury Studies

The Program also completed other POC Monitoring studies per MRP 2.0 requirements through participation in the following BASMAA Regional Projects:

- PCBs in Infrastructure Caulk. This project collected 20 composite samples (region-wide) of the caulks and sealants used in storm drains or roadway infrastructure in public ROWs and analyzed them for PCBs. The results found PCBs concentrations of concern to stormwater (i.e., > 50 ppm) in only one type of sample: black, pliable joint fillers from concrete bridges or roadway overpasses. All other samples were well below the 50-ppm threshold that has been established to identify caulking in building materials that require special handling during building demolition because of PCBs. The Program recommends that any further activities related to PCBs in roadway and storm drain infrastructure caulk focus on caulks and sealants found on concrete bridges and roadway overpasses.
- BMP Effectiveness Studies. This project evaluated the effectiveness of 2 types of BMPs, including (1) biochar-enhanced bioretention soil media, and (2) maintenance practices for large trash full capture devices (i.e., Hydrodynamic Separator Units, or HDS units). The results suggest that (1) biochar may increase PCBs removal in bioretention facilities, and (2) regular maintenance of HDS units increases the PCBs and mercury load reductions from stormwater catchments where these units are located. These results are currently being considered in the update to the Interim Accounting Methodology (BASMAA 2017) that is being conducted as part of a separate BASMAA regional project.

D.3 Copper

From WY 2016 through WY 2019, in compliance with MRP 2.0 provision C.8.f, SCVURPPP collected at least two samples per year for copper analysis to address Management Question No. 4 (Loads and Status) and Management Question No. 5 (Trends). A review of the WY 2016 through WY 2019 copper dataset suggests that relatively low levels of copper are being conveyed to receiving waters from urban areas during stormwater runoff events. These data provide a relatively cost-effective check on copper discharges to tributaries to the Bay. However, copper data collected under MRP 2.0 have generally been of limited value to the Program. Copper data collected in San Francisco Bay through the RMP Status and Trends Program are more useful in tracking the effectiveness of the copper control measures required by provision C.13 of MRP 2.0 and, more importantly, the success of the Brake Pad Partnership and Senate Bill (SB) 346 which addresses the largest source of copper by requiring brake pad manufacturers to reduce the use of copper in brake pads sold in California. The Program recommends maintaining the same overall copper monitoring requirements (i.e., 20 total samples) in the next MRP, but an elimination of the yearly minimums could result in a more effective monitoring design.

D.4 Nutrients

Nutrients were included in the MRP 2.0 POC monitoring requirements to support Regional Water Board efforts to develop nutrient numeric endpoints (NNE) for the San Francisco Bay Estuary. In WY 2016 through WY 2019, in compliance with provision C.8.f of MRP 2.0, the Program collected at least two samples per year for nutrient analysis. This monitoring addressed Management Question No. 4 (Loads and Status). A review of the WY 2016 through WY 2019 nutrient dataset suggests that nutrient concentrations are highest during storm events and generally higher at stations lower in the watershed. Nutrient data collected in compliance with provision C.8.f have been used to support Stressor/Source Identification studies investigating causes of low biological condition identified in creeks through provision C.8.c/d Creek Status Monitoring. An ongoing SSID study is being conducted in Lower Silver Creek where some of the highest nutrient concentrations have been measured. However, although nutrient samples provide a useful tool in some types of SSID projects, the Program recommends that the requirement for nutrient monitoring be removed from the POC Monitoring provision under the next MRP. The original need for nutrient sampling in tributaries to the Bay to support Regional Water Board efforts to develop NNEs for the San Francisco Bay Estuary no longer exists. This effort has now been captured and superseded by the State Water Board Biostimulatory Substances and Biological Integrity Project, which is proposing to adopt a statewide water quality objective for biostimulatory substances (such as nitrogen and phosphorus) along with a program of implementation as an amendment to the Water Quality Control Plan for Inland Surface Water, Enclosed Bays and Estuaries of California (ISWEBE Plan).

D.5 Emerging Contaminants

Provision C.8.f of MRP 2.0 identifies three emerging contaminants that at a minimum must be addressed through POC monitoring: Perflourooctane Sulfonate Substances (PFOS), Perfluoroalkyl and Polyfluoroalkyl Sulfonate Substances (PFAS), and Alternative Flame Retardants (AFRs). POC monitoring for these emerging contaminants is being addressed through SCVURPPP's participation in the RMP. The RMP has investigated Contaminants of Emerging Concern since 2001 and established the RMP Emerging Contaminants Work Group (ECWG) in 2006. The purpose of the ECWG is to identify CECs that might impact beneficial

uses in the Bay and to develop cost-effective strategies to identify, monitor, and minimize impacts. In 2018, the RMP's ECWG initiated a multi-year special study to analyze stormwater samples collected from urban watersheds for a large suite of CECs intended to target urban runoff constituents rather than those found in wastewater (e.g., pharmaceuticals). Pilot sampling began in 2019. Under the next MRP, SCVURPPP recommends continuing support of RMP special studies that address data gaps and the scientific understanding of fate and transport of stormwater-related CECs in the Bay. In particular, the Program is supportive of continued coordination through the STLS to identify the appropriate watersheds and sampling sites for monitoring CECs through RMP special studies. The Program is also supportive of further developing conceptual and empirical models to better evaluate the distribution and sources of CECs of interest within a stormwater and watershed context.

D.6 SPoT Program

The SWAMP SPoT program currently collects annual dry season sediments for POCs (subject to funding constraints) at two long-term monitoring sites in Santa Clara County (Coyote Creek and Guadalupe River). The goal is to monitor trends in sediment toxicity and sediment contaminant concentrations in selected large rivers throughout California, and relate contaminant concentrations and toxicity to watershed land uses. The SPoT Monitoring Program data support the investigation of long-term trends in water quality (Management Question #5 – Trends). The most recent technical report prepared by SPoT program staff was published in 2016 and describes seven-year trends from the initiation of the program in 2008 through 2014 (Phillips et al. 2016). An update to the report is anticipated in the near future. During the next MRP, the Program recommends continuing to work with the SPoT Program to conduct long-term trends monitoring.

Part E: Monitoring Costs and Benefits Summary

MRP 2.0 Provision C.8.h.v(4) requires that Permittees include a budget summary for each monitoring requirement in the IMR. Costs expended by SCVURPPP member agencies, through contributions to the Program, from WY 2014 through WY 2019 to comply with MRP provision C.8 requirements are associated with the following:

- Monitoring program coordination and management,
- Program/project planning,
- Sample and data collection,
- Laboratory analyses,
- Quality assurance/quality control (QA/QC),
- Data evaluation and analysis,
- Data interpretation and reporting, and
- Information management.

Additionally, direct financial contributions to the RMP by SCVURPPP on behalf of Permittees and NPDES permit fee surcharges that were paid by Co-permittees during that time fame and used by the State and/or Regional Water Board to fund its State's Surface Water Ambient Monitoring Program (SWAMP) are costs expended by SCVURPPP Permittees.

Resources spent by SCVURPPP Permittees complying with water quality monitoring requirements between WY 2014 and WY 2019 were considerable (~$6.8 M over 6 years). Average annual monitoring costs during this timeframe were roughly $1.1M/year.

Monitoring activities that are funded by SCVURPPP Permittees, consistent with Provision C.8, generate information designed to answer core management questions outlined in the MRP. The Program conducted a qualitative cost-benefit evaluation of these activities based on the ability of the Program to answer these questions using the data collected between WY 2014 and WY 2019. The results of the evaluation are presented in Table E.2

Table E.2. Qualitative cost-benefit evaluation of water quality monitoring conducted under MRP 2.0 provision C.8.

MRP 2.0 Subprovision		Relative Costs of Implementing ($ - $$$$)[3]	Relative Benefit Towards Answering Core Management Questions (★ - ★★★★)	Evaluation Summary
C.8.c	San Francisco Bay Estuary Receiving Water Monitoring (RMP)	$$$$	★★★	Contributions to the RMP provided useful information on the status and trends of water quality in the Bay and provided supplemental information to help SCVURPPP identify PCBs and mercury source areas for management actions. Attempts to focus RMP-led monitoring on high priority issues remains an on-going challenge due to competing interests and information needs. Overall, the RMP provides useful information to track water quality conditions in the Bay and help inform broad-scale management and policy directions based on science, but at a relatively high cost.
C.8.d	Creek Status Monitoring	$$$$	★★★	Creek status monitoring continued to provide useful information on the status of water quality in urban creeks that receive stormwater discharges, and the biological condition of those creeks. Many parameters were monitored, however, the utility of the data that the MRP requires to be collected is variable between parameters. Some parameters have provided valuable, baseline data or helped identify concerns that should be addressed. Other parameters were less useful and did not directly assist stormwater managers in validating, refining, or adjusting current practices. The high relative costs and the variability in the usefulness of data collected via this provision suggest that refinements are needed to improve the cost-effectiveness of Creek Status Monitoring during MRP 3.0.
C.8.e	Stressor/Source Identification (SSID) Projects	$$	★★★	SSID studies have provided useful information that is needed to help better define potential water quality concerns and identify sources of pollutants or environmental stress occurring in Santa Clara Valley streams. SSID projects have been challenging due to the lack of methods available to differentiate the causes stress and sources of pollutants/stress due to the complex and overlapping watershed/runoff processes observed in streams. The relatively moderate costs and moderate/high benefits of data collected via this provision suggest that SSID projects are cost-effective endeavors, but that refinements are needed to the methods and expectations for these studies to improve the utility of the data collected via provision C.8.e during MRP 3.0.

[3] Qualitative categories for costs are based on the relative percentage of costs associated with each monitoring component. Costs for data management/QA and reporting were not included in the evaluation because their costs are functions of the other monitoring requirements/components. Qualitative categories are as follows:$ = 1-5%, $$ = 5-10%; $$$ = 10-15%; $$$$ = >15%.

MRP 2.0 Subprovision		Relative Costs of Implementing ($ - $$$$)[3]	Relative Benefit Towards Answering Core Management Questions (★ - ★★★★)	Evaluation Summary
C.8.f	Pollutants of Concern (POC) Monitoring	$$$$	★★★	Monitoring conducted under provision C.8.f provided valuable data on potential sources of POCs in Watershed Management Areas (WMAs) and helped prioritize land areas for further source property evaluations. Additionally, the data collected under this provision helped further understand the geographical distribution of POCs in the urban portion of the Santa Clara Basin. Although there were high relative costs associated with POC monitoring, there was a high level of benefit associated with the data collected during MRP 2.0. Nutrient and copper monitoring were less useful in answering monitoring questions associated with these pollutants. Considerations of whether similar POC data collection efforts are predicted to be useful during MRP 3.0 should be taken before MRP 3.0 POC monitoring requirements are finalized. As source property identification efforts become less fruitful, it may be helpful to shift POC monitoring resources away from source characterization and towards other priority monitoring questions (e.g., trends and control measure effectiveness).
C.8.g	Pesticides and Toxicity Monitoring	$	★★	There were relatively low costs expended by the Program for Pesticides and Toxicity Monitoring during MRP 2.0. Data collected via the statewide SPoT program provides important information on trends in pesticides and toxicity in stream sediments over time and helps supplement important data needs. Low costs and low/moderate benefits suggest that refinements are needed to improve the cost-benefits of the data collected via provision C.8.g during MRP 3.0. Currently a statewide effort to develop an Urban Pesticide Coordinated Monitoring Program is underway, and the Program is actively participating in this process. For SCVURPPP, the goal is to stabilize costs for pesticide/toxicity monitoring, while improving and enhancing coordination of data collection efforts on a statewide basis with the California Department of Pesticide Regulation (DRP) to fill important information gaps that will improve the regulation of pesticides that effect stormwater quality.
NA	NPDES Surcharge - Surface Water Ambient Monitoring Program (SWAMP)	$$	★	Provided limited usefulness to local programs and stormwater managers. Benefits are not readily apparent. Moderate costs, with limited benefits.

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Santa Clara Valley
Urban Runoff
Pollution Prevention Program

Watershed Monitoring and Assessment Program



Integrated Monitoring Report
Part A: San Francisco Estuary Receiving Water Monitoring

Water Years 2014-2019

Submitted in compliance with Provision C.8.h.v of NPDES Permit No. CAS612008,
Order No. R2-2015-049

March 31, 2020

LIST OF ACRONYMS

AFR	Alternative Flame Retardant
BAHM	Bay Area Hydrological Model
BASMAA	Bay Area Stormwater Management Agency Association
BOD	Board of Directors
CEC	Contaminant of Emerging Concern
ECWG	Emerging Contaminant Workgroup
IMR	Integrated Monitoring Report
MPC	Monitoring and Pollutants of Concern Committee
MRP	Municipal Regional Permit
MS4	Municipal Separate Stormwater Sewer System
NPDES	National Pollution Discharge Elimination System
PBDE	Polybrominated Diphenyl Ether
PCBs	Polychlorinated Biphenyls
PFAS	Polyfluoroalkyl Sulfonate Substances
POC	Pollutant of Concern
RAA	Reasonable Assurance Analysis
RMC	Regional Monitoring Coalition
RMP	Regional Monitoring Program for Water Quality in the San Francisco Bay
RWSM	Regional Watershed Spreadsheet Model
S&T	Status and Trends
SCVURPPP	Santa Clara Valley Urban Runoff Pollution Prevention Program
SFEI	San Francisco Estuary Institute
SFRWQCB	San Francisco Bay Regional Water Quality Control Board
SPLWG	Sources, Pathways and Loadings Workgroup
SSC	Suspended Sediment Concentration
STLS	Small Tributary Loading Strategy
TMDL	Total Maximum Daily Load
TRC	Technical Review Committee
USGS	United States Geologic Service
WMA	Watershed Management Area
WY	Water Year

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Table 1.1. RMP Status and Trends Monitoring Schedule. 2

1.0 INTRODUCTION

This Integrated Monitoring Report (IMR) Part A: San Francisco Estuary Receiving Water Monitoring, Water Year[1] (WY) 2014 through WY 2019 was prepared by the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP or Program), on behalf of its 15 member agencies (13 cities/towns, the unincorporated County of Santa Clara, and the Santa Clara Valley Water District), which are subject to the National Pollutant Discharge Elimination System (NPDES) stormwater permit for Bay Area municipalities referred to as the Municipal Regional Permit (MRP). The MRP was first adopted by the San Francisco Bay Regional Water Quality Control Board (SFRWQCB or Regional Water Board) on October 14, 2009 as Order R2-2009-0074 (SFRWQCB 2009; referred to as MRP 1.0). On November 19, 2015, the Regional Water Board updated and reissued the MRP as Order R2-2015-0049 (SFRWQCB 2015; referred to as MRP 2.0).

This report fulfills the requirements of provision C.8.h.v of MRP 2.0 for comprehensively interpreting and reporting all monitoring data collected since the previous IMR. As such, this report describes monitoring activities conducted during WY 2014 through WY 2019. The previous IMR submitted to the Regional Water Board in 2014 described monitoring conducted during MRP 1.0 (SCVURPPP 2014).

As described in provision C.8.c of MRP 2.0 and provision C.8.b of MRP 1.0, Permittees are required to provide annual financial contributions towards implementing an Estuary receiving water monitoring program that at a minimum is equivalent to the Regional Monitoring Program for Water Quality in the San Francisco Bay (RMP). Since the adoption of the 2009 MRP, SCVURPPP has complied with this provision by making financial contributions to the RMP. Additionally, SCVURPPP and member agency staff actively participate in RMP committees, workgroups, and strategy teams as described in the following sections.

The RMP is a long-term (1993 – present) discharger-funded monitoring program that shares direction and participation by regulatory agencies and the regulated community with the goal of assessing water quality in the San Francisco Bay. The regulated community includes municipal separate stormwater sewer systems (MS4s), publicly owned treatment works, dredgers, flood control districts, and industrial dischargers. The San Francisco Estuary Institute (SFEI) implements the RMP and is the fiduciary agent for RMP stakeholder funds. SFEI does not provide direct oversight of the RMP but does help identify stakeholder information needs, develop workplans that address these needs, and implement the workplans.

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

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

[1] Most hydrologic monitoring occurs for a period defined as a Water Year, which begins on October 1 and ends on September 30 of the named year. For example, Water Year 2019 (WY 2019) began on October 1, 2018 and concluded on September 30, 2019.

5. *What are the projected concentrations, masses, and associated impacts of contaminants in the Estuary?*

The RMP budget is generally divided between two major program elements: Status and Trends and Pilot/Special Studies. The following sections provide a brief overview of these programs. The *2019 Annual Update to the RMP Multi-year Plan*[2] provides more details and establishes deliverables for each component of the current RMP budget. The RMP publishes annual summary reports. In odd years, the *Pulse of the Bay Report* focuses on Bay water quality and summarizes information from all sources. In even years, the *RMP Update Report* has a narrower and specific focus. The *2019 Pulse of the Bay*[3] includes: an overview of the various pollutant sources and pathways to the Bay with feature articles on four sources/pathways (municipal and industrial wastewater, stormwater, dredging and dredged sediment disposal) and updates on priority pollutants, such as nutrients, contaminants of emerging concern, mercury, Polychlorinated Biphenyls (PCBs), selenium, bacteria, and copper. Program staff actively participated as a co-author to the stormwater pathway article in the *2019 Pulse of the Estuary*.

2.0 RMP STATUS AND TRENDS MONITORING PROGRAM

The Status and Trends Monitoring Program (S&T Program) is the long-term contaminant-monitoring component of the RMP. The S&T Program was initiated as a pilot study in 1989, implemented thereafter, and was redesigned in 2007 based on a more rigorous statistical design that enables the detection of trends. The RMP Technical Review Committee (TRC), in which SCVURPPP participates, continues to assess the efficacy and value of the various elements of the S&T Program and to recommend modifications to S&T Program activities based on ongoing findings. The current S&T sampling schedule, established in 2014, is listed in Table 2.1 with 2014 - 2019 accomplishments and 2020 goals. A redesign of the S&T Program is anticipated in 2020/21 reflecting on 20 years of monitoring, continued need for legacy contaminant monitoring, on-ramping of contaminants of emerging concern (CECs), and future collaboration with the United States Geological Survey (USGS).

Table 1.1. RMP Status and Trends Monitoring Schedule.

Program Element	Schedule	2014	2015	2016	2017	2018	2019	2020 (Plan)
Water	Every 2 years		X		X		X	
Bird Eggs	Every 3 years			X		X		
Sediment	Every 4 years	X				X		
Bay Margin Sediments	Random		X		X			X
Sport Fish	Every 5 years	X					X	
Bivalves	Every 2 years	X		X		X		X
Support to the USGS for suspended sediment, nutrients, and phytoplankton monitoring	Every year	X	X	X	X	X	X	X

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

[2] https://www.sfei.org/sites/default/files/biblio_files/2019%20Multi-Year%20Plan%20-%20SC%20Approved%2020190430%20-%20050119.pdf

[3] https://www.sfei.org/documents/2019-pulse-bay-pollutant-pathways

3.0 RMP PILOT AND SPECIAL STUDIES

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

In 2019, Pilot and Special Studies focused on the following topics:

- Small Tributary Loading Strategy (see Section 5.0 below and IMR Part D: Pollutants of Concern Monitoring for more details)
    - Watershed characterization reconnaissance monitoring for pollutants of concern
    - Advanced analysis of PCBs data
    - Development of a trends strategy
- Emerging Contaminant Strategy (see IMR Part D: Pollutants of Concern Monitoring for more information)
    - Ongoing review and update of the RMP's Tiered Risk and Management Action Framework
    - Contaminants of emerging concern (CECs) monitoring (imidacloprid, fragrance ingredients, Polyfluoroalkyl Sulfonate Substances (PFAS), nonionic surfactants, pharmaceuticals) in water, sediment, and/or wastewater
    - Non-targeted analysis of Bay sediment to help identify new CECs
    - Increased focus on studying CECs in stormwater runoff
- Nutrients Management Strategy
    - Continued coordination with USGS for monitoring of nutrients, phytoplankton biomass, and dissolved oxygen at moored sensors in the Bay
    - Ship-based nutrient sampling
    - Study of harmful algae and toxin accumulation in small fish and mussels using Supplemental Environmental Project (SEP) funds
- Microplastics
    - Review and update of the RMP's Microplastic Strategy
    - Monitoring of microplastics in sport fish
    - Development of several documents synthesizing microplastic research, including a factsheet and a draft manuscript on microplastics in urban stormwater runoff (Werbowski et al. *in review*)
- Development of conceptual PCB models for prioritized Bay margin units
- Sediment
    - Development of the Sediment Monitoring Strategy

  - Review of beneficial reuse and strategic placement projects
  - Bathymetric change studies
  - Hosting and support for Dredged Material Management Office database
- Selenium monitoring in sturgeon plugs and North Bay clams and water

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

During WYs 2014 to 2019, a considerable amount of RMP and Stormwater Program staff time was spent overseeing and implementing Special Studies associated with the RMP's Small Tributary Loading Strategy (STLS). Pilot and Special Studies associated with the STLS are intended to fill data gaps associated with loadings of Pollutants of Concern (POC) from relatively small tributaries to the San Francisco Bay. Additional information on STLS-related studies is included in Section 5.0 of this report (IMR Part A) and in IMR Part D: POC Monitoring.

4.0 PARTICIPATION IN COMMITTEES, WORKGROUPS AND STRATEGY TEAMS

SCVURPPP and the BASMAA RMC partners actively participated in the following RMP committees, workgroups, and strategy teams during WYs 2014 - 2019:

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

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

5.0 SMALL TRIBUTARIES LOADING STRATEGY

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

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

Work conducted by the STLS in WYs 2014-2019 is framed by the same five priority POC management information needs identified in MRP 2.0.

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

The sections below describe the tasks implemented by the RMP STLS in WYs 2014-2019 to address the relevant management policies.

5.1 Wet Weather Reconnaissance Monitoring

With a goal of identifying watershed sources of PCBs and mercury, STLS field monitoring in WYs 2015-2019 focused on collection of storm composite samples in the downstream reaches of catchments located throughout the Bay Area. A total of 66 sites (21 in Santa Clara County) were sampled during at least one storm event. The contributing areas for these sites range in size from 0.02 km^2 to 233 km^2 and typically represent small engineered MS4 drainage areas (75% were smaller than 5.2 km^2). Storm composite water samples were analyzed for concentrations of PCBs (i.e., RMP 40 congeners), total mercury, and suspended sediment concentration (SSC). In addition, a pilot study was continued at a subset of locations (two stations) to collect fine sediments using specialized settling chambers. A full description of the methods and results from WYs 2015-2018 monitoring is included in Gilbreath et al. (2020), which is provided as Attachment D.3 to IMR Part D: POC Monitoring Report. Data generated through STLS reconnaissance monitoring are used by SCVURPPP to prioritize Watershed Management Areas (WMAs) for PCB source investigations. Reconnaissance monitoring by the STLS is planned to continue in WY 2020 and possibly into future years.

As a result of STLS (RMP and Permittee) POC monitoring, 88 sites regionwide have been sampled during wet weather events for PCBs, mercury, and SSC since 2003. Some stations have also been sampled for a larger suite of constituents. Prior to WY 2015, most of the stations were located in natural creeks. Since that time, most of the stations were located in small MS4 catchments draining primarily old industrial land uses. At three of these sites, collection was

conducted using a remote sediment sampler only – a method that was pilot-tested during WYs 2015-2018 and approved by the SPLWG in spring 2018 for use in reconnaissance monitoring.

Acknowledging that dynamic climatic conditions and individual storm characteristics may affect data interpretation, the following broad conclusions and recommendations were identified as a result of wet weather reconnaissance monitoring conducted via the STLS (Gilbreat et al. 2020):

- PCBs positively correlate with impervious cover, old industrial land use, and mercury. They inversely correlate with watershed area. Although mercury and PCBs positively correlate, the relationship is relatively weak, probably due to the larger role of atmospheric recirculation in the mercury cycle and the differences in use history of each POC.
- Neither PCBs nor mercury have strong correlations with other trace metals (As, Cu, Cd, Pb, and Zn). Therefore, there is no support for the use of trace metals as surrogate investigative tools for either PCBs or mercury sources.
- Continued focus on resampling of some stations (i.e., those that return lower than expected concentrations) is recommended to test for false negatives.

5.2 STLS Trends Strategy

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

The Trends Strategy document (and Technical Appendix), initially drafted in WY 2016, serves as a foundation for this team. The main document summarizes the background, management questions, and guiding principles of the Trends Strategy. It also describes coordination between the RMP and BASMAA within the context of the MRP, proposed tasks to answer management questions, anticipated deliverables, and the overall timeline. The current priority POCs are PCBs and mercury and trend indicators under consideration (i.e., PCB concentrations and particle-ratios) were identified within the context of existing datasets (e.g., POC loading stations) and TMDL timelines. However, the Strategy recognizes that priorities can change in the future. The Technical Appendix (Melwani et al. 2016) presents an evaluation of variability and statistical power[4] for detecting trends based on POC loading station PCBs data. It presents sample size and revisit frequency scenarios needed to detect declining trends in PCBs in 25 years with > 80% statistical power. Due to high variability in baseline PCB concentrations, the modeled sampling scenarios would likely not be practical to implement. Therefore, the Technical Appendix recommends additional analyses and monitoring that should be considered prior to developing a trends monitoring design.

In 2018, the STLS Trends Strategy team followed up on some of the recommendations from the Technical Appendix. A statistical model for trends in PCB loads in the Guadalupe River (as a case study) was finalized. The model incorporates the significant turbidity-PCB relationships that exist and evaluates climatic, seasonal, and inter-annual factors as potential drivers of PCB

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

loads. More intensive review of the Guadalupe River dataset resulted in two main findings: 1) No trends in PCB loads were apparent for the period of 2003 through 2014: 2) A monitoring design that includes sampling at least two storms in 13 out of 20 years (with 4 to 6 grab samples per storm) would detect inter-annual trends of 25% or more over 20 years with > 80% power (Melwani et al. 2018). Results of the statistical analyses were presented at key stages in the analysis to USGS technical advisors with expertise in trends analysis of water data. It is uncertain how the Guadalupe River model and analysis could be applied to other watersheds which have distinct characteristics.

In 2018, the Trends Strategy team updated the Trends Strategy document to include an evaluation of how various tasks to date have and could be used to address the five POC information needs from the MRP (Wu et al. 2018). This review included empirical data collection (i.e., loading stations, wet weather reconnaissance monitoring, BASMAA source identification and BMP effectiveness monitoring, SPoT monitoring) and modeling approaches (i.e., RWSM, the Guadalupe River statistical analysis, Reasonable Assurance Analysis). The 2018 Trends Strategy describes the pros and cons of various methods available to identify and predict trends. Due to concerns about the limitations of extrapolating monitoring results from a relatively small number of watersheds to the entire region, regional modeling was proposed as the most efficient tool to estimate POC loading over time and space for trends evaluation at the desired spatial scales. The 2018 Trends Strategy reviews and compares currently available models and modeling platforms relative to their ability to answer key management questions, including Countywide Reasonable Assurance Analysis (RAA) modeling efforts, the Bay Area Hydrological Model (BAHM), the Regional Watershed Spreadsheet Model (RWSM), and HSPF and SWMM platforms. Based on the goals of the STLS Trends Strategy team, the BAHM, which is based on the HSPF platform, was recommended as the most suitable starting point to develop a regional POC trends model. This recommendation was documented in the Modeling Implementation Plan (Wu and McKee 2019).

Beyond questions about PCBs and mercury, the new regional model will also be used to support other RMP workgroups that have similar management questions. For example, the model could be used to estimate sediment and CEC loads to the Bay.

In 2020, the STLS plans to develop a regional model for hydrology following procedures outlined in the Modeling Implementation Plan. The hydrology model, once established, will be used as a basis for modeling sediment, PCBs, CECs, and other POCs in subsequent years.

5.3 Advanced Data Analysis

In 2018, the STLS began a new task to provide a deeper analysis of the growing set of PCBs data collected by BASMAA and the RMP. The Advanced Data Analysis task includes two parallel lines of investigation: site inter-comparison methodologies and PCB congener profile comparisons.

5.3.1 Site Inter-Comparison Methodologies

Most of the wet weather characterization data used by the Program and other BASMAA RMC partners to identify and prioritize WMAs where PCB source investigations will be conducted are based on composite samples collected during a single storm event. See IMR Part D for more information on the wet weather sampling programs implemented by the Program and the WMA characterization process. While cost effective, interpretation of the data collected through these sampling techniques has been challenging. Since only one storm was sampled at most sites, differing storm characteristics (intensity, duration, antecedent rainfall conditions) interplay with

differing PCB source characteristics to confound comparisons between watersheds. For example, if the targeted storm was relatively small, it is possible that measured PCB concentrations (and/or PCB particle ratios) will be lower than they would be in a sample collected at the same station during a larger storm. The main goal of this investigation was to develop a method to account for the differences in targeted storm characteristics at the various sampled stations.

In 2019, the STLS developed a method to generate comparable yield estimates for small industrial watersheds where only a single storm has been sampled. The method includes four steps:

1. Estimate storm runoff volume in the sampled watershed.
2. Compute estimates of storm load for the sampled storm.
3. Adjust estimates of storm load to a standard sized storm.
4. Normalize standardized storm loads to the watershed area of interest to generate storm yields.

This stepwise method was developed using Santa Clara County as a case study and pilot tested with a focus on nested sites within the Guadalupe River watershed. McKee et al. (2019) describes the loads-based site inter-comparison method.Further development and testing in a great number of areas with a wider range of conditions is recommended for 2020.

5.3.2 PCB Congener Profile Comparisons

PCB samples collected by BASMAA and the STLS are routinely analyzed for 40 individual PCB congeners (i.e., the “RMP 40”). Although most data analyses are conducted using the sum of those congeners, BASMAA and the STLS recognize the value of generating the more robust RMP 40-based dataset and the potential for future data exploration possibilities. For example, PCB congener profiles can be used to help identify source areas that contribute most to the PCB mass exported from the watershed via stormwater, and to illustrate variability in PCB mobilization from source areas over time.

In 2018, the STLS began development of a method to estimate the contributions of different Aroclor[5] mixtures to the congener profiles of samples of stormwater and sediment. The method is based on the use of indicator congeners that are representative of each of the four most commonly used Aroclors. Data from the Pulgas Pump Station watershed in the City of San Carlos were used to pilot test the method. At this station, stormwater and sediment had high concentrations with a relatively unique pattern, dominated by congeners indicative of a combination of Aroclors 1242 and 1260. The concentrations and congener profiles in sediment suggest that there are two distinct source areas in the watershed that combine to create the mix of 1242 and 1260 that is dominant in stormwater at the Pump Station (Figure 5.1). The data suggest that if PCB flux from one of these areas could be eliminated, loads from the watershed would be reduced by 50% or more. For the Coyote Creek watershed in Santa Clara County, the similarity in congener profiles between the highest concentration sediment samples and the

[5] PCBs were manufactured and used as complex mixtures of individual PCBs (referred to as PCB congeners). In North America, the only producer was the Monsanto Company, which marketed PCBs under the trade name Aroclor from 1930 to 1977. A series of different Aroclor mixtures was produced, with varying degrees of overall chlorine content, and these different mixtures were used for different purposes. The congener composition of the various Aroclor mixtures has been reported in the literature (e.g., Schulz et al. 1989, Frame et al. 1996a,b). As a consequence of the use of Aroclor mixtures, PCBs are also present in the environment as complex mixtures of congeners.

stormwater samples suggest that the important source areas in the watershed have been identified, and that reduction of loading from an area at the south end of the Charcot Avenue Storm Drain watershed would yield the greatest reduction in export at the Coyote Creek station. The concentrations and congener profiles in stormwater and sediment from the Guadalupe River watershed indicate the presence of one source area that is likely a significant contributor to PCB export from the watershed, but suggest that all of the significant sources areas may not yet have been identified.

A report describing the PCB congener profile comparison method was published in 2019 (Davis and Gilbreath 2019).

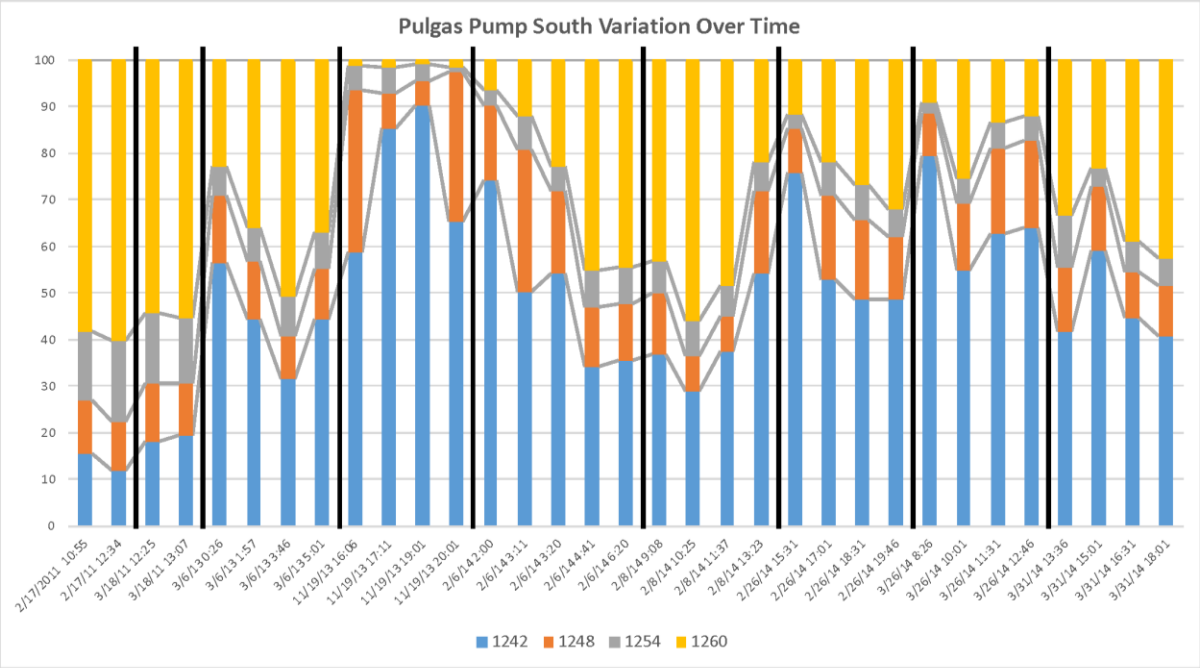


Figure 5.1. Aroclor fractions in stormwater at the outlet of Pulgas Pump Station South over time (SFEI, 2018).

5.4 Alternative Flame Retardant Conceptual Model

Alternative flame retardants (AFRs) came into use following state bans and nationwide phase-outs of polybrominated diphenyl ether (PBDE) flame retardants in the early 2000's. They include many categories of compounds, including organophosphate esters. In 2018 the RMP STLS and the Emerging Contaminant Workgroup worked together to conduct a special study to inform ECWG's planning activities related to AFRs. The special study compiled and reviewed available data and previously developed conceptual models for PBDE to support a stormwater-related AFR conceptual model being developed by the ECWG. Organophosphate esters were prioritized for further investigation due to their increasing use, persistent character, and ubiquitous detections at concentrations exceeding PBDE concentrations in the Bay. Limited stormwater data from two watersheds in Richmond and Sunnyvale suggest that urban runoff may be an important source of these compounds. Additional monitoring and modeling were recommended in the AFR Technical Report (Lin and Sutton 2018).

5.5 Regional Watershed Spreadsheet Model

The Regional Watershed Spreadsheet Model is a land use based planning tool for estimation of annual POC loads from small tributaries to San Francisco Bay at a regional scale. Development of the RWSM began in 2010 and the RWSM tool-kit that was published in 2017. The RWSM is based on the idea that to accurately assess total contaminant loads entering San Francisco Bay, it is necessary to estimate loads from local watersheds. “Spreadsheet models” of stormwater quality provide a useful and relatively inexpensive means of estimating regional scale watershed loads. Spreadsheet models have advantages over mechanistic models because the data for many of the input parameters required by mechanistic models may not currently exist. Mechanistic models also require large calibration datasets which take money and time to collect.

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

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

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

As described in Section 5.2, a more sophisticated dynamic simulation model (i.e., SWMM, HSPF) is currently under development.

6.0 RECOMMENDATIONS

Overall, the Program finds value in the work being conducted through the RMP and is supportive of continuing to provide annual financial contributions to the RMP at the current funding level. SCVURPPP would like to see ongoing RMP funding be directed towards the following high priority topics:

- Bay status and trends monitoring focused on current and emerging pollutants;
- Wet weather monitoring in small tributaries for high priority pollutants; and
- Conceptual and quantative modeling to further understand the sources, transport, and fates of current and emerging pollutants.

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Santa Clara Valley
Urban Runoff
Pollution Prevention Program

Watershed Monitoring and Assessment Program



Integrated Monitoring Report
Part B: Creek Status Monitoring

Water Years 2014-2019

Submitted in compliance with Provision C.8.h.v of NPDES Permit No. CAS612008,
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March 31, 2020

PREFACE

In early 2010, several members of the Bay Area Stormwater Agencies Association (BASMAA) joined together to form the Regional Monitoring Coalition (RMC), to coordinate and oversee water quality monitoring required by the Municipal Regional National Pollutant Discharge Elimination System (NPDES) Stormwater Permit (in this document the permit is referred to as the MRP).[1] The RMC includes the following participants:

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

This Integrated Creek Status Monitoring Report complies with provision C.8.h.v of the MRP for reporting of all data collected since the previous Integrated Monitoring Report which was submitted on March 31, 2014. It includes data collected in Water Year 2014 through Water Year 2019 (October 1, 2013 through September 30, 2019). Data were collected pursuant to Creek Status Monitoring and Pesticides & Toxicity Monitoring requirements of MRP provision C.8. Data presented in this report were produced under the direction of the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP or Program) and in collaboration with the RMC, using probabilistic and targeted monitoring designs as described herein.

Consistent with the Creek Status and Long-Term Trends Monitoring Plan (BASMAA 2012), monitoring data were collected in accordance with the most recent versions of the BASMAA RMC Quality Assurance Project Plan (QAPP; BASMAA, 2016a) and the BASMAA RMC Standard Operating Procedures (SOPs; BASMAA, 2016b). Where applicable, monitoring data were derived using methods comparable with methods specified by the California Surface Water Ambient Monitoring Program (SWAMP) Quality Assurance Program Plan (QAPrP).[2] Data presented in this report were submitted in electronic SWAMP-comparable formats by SCVURPPP to the San Francisco Bay Regional Water Quality Control Board on behalf of SCVURPPP Co-permittees and pursuant to provision C.8.h.ii of the MRP.

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

[2] The current SWAMP QAPrP is available at: https://www.waterboards.ca.gov/water_issues/programs/swamp/qapp/swamp_QAPrP_2017_Final.pdf

LIST OF ACRONYMS

ACCWP	Alameda Countywide Clean Water Program
AFDM	Ash Free Dry Mass
AFS	American Fisheries Society
ASCI	Algae Stream Condition Index
BASMAA	Bay Area Stormwater Management Agency Association
BMI	Benthic Macroinvertebrate
BMP	Best Management Practice
CCCWP	Contra Costa Clean Water Program
CDF	Cumulative Distribution Function
CEDEN	California Environmental Data Exchange Network
COLD	Cold Freshwater Habitat
CSBP	California Stream Bioassessment Protocol
CSCI	California Stream Condition Index
DF	Detection Frequency
DO	Dissolved Oxygen
DPR	Department of Pesticide Regulation
EMAP	Environmental Monitoring and Assessment Program
FSURMP	Fairfield Suisun Urban Runoff Management Program
GIS	Geographic Information Systems
GM	Geometric Mean
GRTS	Generalized Random Tessellation Stratified
GSI	Green Stormwater Infrastructure
IBI	Indices of Biotic Integrity
IDDE	Illicit Discharge Detection and Elimination
IMR	Integrated Monitoring Report
IPI	Index Physical Habitat Integrity
IPM	Integrated Pest Management
IWRMP	Integrated Water Resources Management Plan
LID	Low Impact Development
MDL	Method Detection Limit
MIGR	Fish Migration
MMI	Multimetric Index
MPC	Monitoring and Pollutants of Concern Committee
MPN	Most Probable Number
MRP	Municipal Regional Permit
MS4	Municipal Separate Storm Sewer System
MUN	Municipal and Domestic Water Supply Beneficial Use
MWAT	Maximum Weekly Average Temperature
MWMT	Maximum Weekly Maximum Temperature
NMFS	National Marine and Fisheries Services
NPDES	National Pollution Discharge Elimination System
O/E	Observed to Expected
PAH	Polycyclic Aromatic Hydrocarbons
PCBs	Polychlorinated Biphenyls
PEC	Probable Effects Concentrations
PHAB	Physical Habitat Assessment

pMMI	Predictive Multimetric Index
PSA	Perennial Streams Assessment
QAPP	Quality Assurance Project Plan
QAPrP	Quality Assurance Program Plan
QA/QC	Quality Assurance/Quality Control
RARE	Preservation of Rare and Endangered Species
RM	Reporting Module
RMC	Regional Monitoring Coalition
RWB	Reachwide Benthos
RWQC	Recreation Water Quality Criteria
SAFIT	Southwest Association of Freshwater Invertebrate Taxonomists
SCAPE	Stream Classification and Priority Explorer
SCCWRP	Southern California Coastal Water Research Project
SCVURPPP	Santa Clara Valley Urban Runoff Pollution Prevention Program
SCVWD	Santa Clara Valley Water District
SFRWQCB	San Francisco Bay Regional Water Quality Control Board
SMC	Southern California Monitoring Coalition
SMCWPPP	San Mateo County Water Pollution Prevention Program
SOP	Standard Operating Protocol
SPoT	Stream Pollution Trends
SPWN	Fish Spawning
SSID	Stressor/Source Identification
STORMS	Strategy to Optimize Resource Management of Storm Water
STV	Statistical Threshold Value
SURF	Surface Water Database
SWAMP	Surface Water Ambient Monitoring Program
SWPP	Surface Water Protection Program
TEC	Threshold Effects Concentrations
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TOC	Total Organic Carbon
TST	Test of Significant Toxicity
TU	Toxicity Unit
UCMR	Urban Creeks Monitoring Report
USEPA	Environmental Protection Agency
WARM	Warm Freshwater Habitat
WQO	Water Quality Objective
WY	Water Year

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1.0 INTRODUCTION

This *Integrated Monitoring Report (IMR) Part B: Creek Status Monitoring*, *Water Year*[3] *(WY) 2014 through WY 2019* was prepared by the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP or Program), on behalf of its 15 member agencies (13 cities/towns, the County of Santa Clara, and the Santa Clara Valley Water District), which are subject to the National Pollutant Discharge Elimination System (NPDES) stormwater permit for Bay Area municipalities referred to as the Municipal Regional Permit (MRP). The MRP was first adopted by the San Francisco Regional Water Quality Control Board (SFRWQCB or Regional Water Board) on October 14, 2009 as Order R2-2009-0074 (SFRWQCB 2009; referred to as MRP 1.0). On November 19, 2015, the Regional Water Board updated and reissued the MRP as Order R2-2015-0049 (SFRWQCB 2015; referred to as MRP 2.0).

This report fulfills the requirements of provision C.8.h.v of MRP 2.0 for comprehensively interpreting and reporting all Creek Status and Pesticides & Toxicity monitoring data collected since the previous IMR. As such, this report includes data collected during WY 2014 through WY 2019.[4] The previous IMR included data collected during WY 2012 and WY 2013 (SCVURPPP 2014). Data presented in this report from WY 2014 and WY 2015 were collected pursuant to water quality monitoring requirements in provisions C.8.c (Creek Status Monitoring) of MRP 1.0 and provisions C.8.d (Creek Status Monitoring) and C.8.g (Pesticides & Toxicity Monitoring) of MRP 2.0.[5] Data presented in this report were submitted electronically to the Regional Water Board by SCVURPPP and may be obtained via the California Environmental Data Exchange Network (CEDEN).

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

- **Section 1.0** – Introduction including overview of the Program goals, background, monitoring approach, and statement of data quality
- **Section 2.0** – Biological condition assessment and stressor analysis at probabilistic sites
- **Section 3.0** – Continuous water quality monitoring (temperature, general water quality)
- **Section 4.0** – Pathogen indicators
- **Section 5.0** – Chlorine monitoring
- **Section 6.0** – Pesticides & Toxicity monitoring
- **Section 7.0** – Conclusions and recommendations

[3] Most hydrologic monitoring occurs for a period defined as a Water Year, which begins on October 1 and ends on September 30 of the named year. For example, Water Year 2019 (WY 2019) began on October 1, 2018 and concluded on September 30, 2019.

[4] The exception is biological condition data which are reported for the WY 2012 through WY 2019 period of record.

[5] Monitoring data collected pursuant to other C.8 provisions (e.g., Pollutants of Concern Monitoring, Stressor/Source Identification Monitoring Projects) are reported in the SCVURPPP Integrated Monitoring Report (IMR) for WY 2014 through WY 2019 to which this Integrated Creek Status Monitoring Report is appended.

1.1 Monitoring Objectives

Provision C.8.d of MRP 2.0 (and provision C.8.c of MRP 1.0) requires Permittees to conduct creek status monitoring that is intended to answer the following management questions:

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

The first management question is addressed primarily through the evaluation of probabilistic and targeted monitoring data with respect to the triggers defined in the MRP. Sites where triggers are exceeded may indicate potential impacts to aquatic life or other beneficial uses and consideration for future Stressor/Source identification (SSID) projects.

The second management question is addressed by assessing indicators of beneficial uses. For example, the indices of biological integrity based on benthic macroinvertebrate and algae data are direct measures of the condition of aquatic life beneficial uses. Continuous monitoring data (temperature, dissolved oxygen, pH, and specific conductance) are evaluated with respect to COLD and WARM Beneficial Uses. Pathogen indicator data are used to assess REC-1 (water contact recreation) Beneficial Uses.

Creek Status and Pesticides & Toxicity monitoring parameters, methods, occurrences, durations and minimum number of sampling sites are described in provisions C.8.d and C.8.g of the MRP, respectively.

The monitoring requirements in MRP 2.0 (SFRWQCB 2015) are similar to MRP 1.0 (SFRWQCB 2009) requirements (which began implementation on October 1, 2011) and build upon earlier monitoring conducted by SCVURPPP between 2002 and 2009. Creek Status and Pesticides & Toxicity monitoring is coordinated through the Bay Area Stormwater Agencies Association (BASMAA) Regional Monitoring Coalition (RMC). Monitoring results are evaluated to determine whether triggers are met and further investigation is warranted as a potential Stressor/Source Identification (SSID) Project, as described in provision C.8.e of the MRP. Results of Creek Status and Pesticides & Toxicity Monitoring conducted in Water Years 2012 through 2018 are summarized in this report and were detailed in prior reports (SCVURPPP 2019, SCVURPPP 2018, SCVURPPP 2017, SCVURPPP 2016, SCVURPPP 2015, SCVURPPP 2014). Water Year 2019 data are reported for the first time in this IMR.

1.2 Regional Monitoring Coalition

Provision C.8.a (Compliance Options) of the MRP allows Permitees to address monitoring requirements through a regional collaborative effort, their Stormwater Program, and/or individually. The RMC was formed in early 2010 as a collaboration among a number of the BASMAA members and MRP Permittees (Table 1.1) to develop and implement a regionally coordinated water quality monitoring program to improve stormwater management in the region and address water quality monitoring required by the MRP.[6] Implementation of the RMC's

[6] The Regional Water Board issued the first five-year MRP to 76 cities, counties and flood control districts (i.e., Permittees) in the Bay Area on October 14, 2009 (MRP 1.0; SFRWQCB 2009). On November 19, 2015, the Regional Water Board updated and reissued the MRP (MRP 2.0; SFRWQCB 2015). The BASMAA programs supporting MRP

Creek Status and Long-Term Trends Monitoring Plan (BASMAA 2012) allows Permittees and the Regional Water Board to improve their ability to collectively answer core management questions in a cost-effective and scientifically rigorous way. Participation in the RMC is facilitated through the BASMAA Monitoring and Pollutants of Concern (MPC) Committee.

Table 1.1. Regional Monitoring Coalition (RMC) participants.

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

The goals of the RMC are to:

1. Assist Permittees in complying with requirements in provision C.8 (Water Quality Monitoring) of the MRP;
2. Develop and implement regionally consistent creek monitoring approaches and designs in the Bay Area, through the improved coordination among RMC participants and other agencies (e.g., Regional Water Board) that share common goals; and
3. Stabilize the costs of creek monitoring by reducing duplication of effort and streamlining reporting.

The RMC's monitoring strategy for complying with Creek Status Monitoring is described in the RMC Creek Status and Long-Term Trends Monitoring Plan (BASMAA 2012). The strategy includes regional ambient/probabilistic monitoring and local "targeted" monitoring. The combination of these two components allows each individual RMC participating program to assess the status of beneficial uses in local creeks within its jurisdictional area, while also contributing data to answer management questions at the regional scale (e.g., differences between aquatic life condition in urban and non-urban creeks). The current MRP, updated and reissued in 2015, specifically prescribes the probabilistic/targeted approach and most of the

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.

other details of the RMC Creek Status and Long-Term Trends Monitoring Plan. Table 1.2 provides a list of which monitoring parameters are included in the probabilistic and targeted programs in MRP 2.0. This report includes data collected in Santa Clara County under both monitoring components. Data are organized into report Sections that reflect the format of monitoring requirements in the MRP.

Table 1.2. Monitoring parameters of MRP 2.0 provisions C.8.d (Creek Status Monitoring) and C.8.g (Pesticides & Toxicity Monitoring) and associated monitoring component.

Monitoring Elements	Monitoring Component		Report Section
	Regional Ambient (Probabilistic)	Local (Targeted)	
Creek Status Monitoring (C.8.d)			
Bioassessment & Physical Habitat Assessment	X	X[1]	2.0
Nutrients	X	X[1]	2.0
General Water Quality (Continuous)		X	3.0
Temperature (Continuous)		X	3.0
Pathogen Indicators		X	4.0
Chlorine	X	X[2]	5.0
Pesticides & Toxicity Monitoring (C.8.g)			
Water Toxicity		X	6.0
Sediment Toxicity		X	6.0
Sediment Chemistry		X	6.0

Notes:
[1] Provision C.8.d.i.(6) allows for up to 20% of sample locations to be selected on a targeted basis.
[2] Provision C.8.d.ii.(2) provides options for probabilistic or targeted site selection. In WY 2018, chlorine was measured at probabilistic sites.

1.3 Monitoring and Data Assessment Methods

1.3.1 Monitoring Methods

Water quality data were collected in accordance with California Surface Water Ambient Monitoring Program (SWAMP) comparable methods and procedures described in the BASMAA RMC Standard Operating Procedures (SOPs; BASMAA 2016a) and the associated Quality Assurance Project Plan (QAPP; BASMAA 2016b). These documents are updated as needed to maintain their currency and optimal applicability. Where applicable, monitoring data were collected using methods comparable to those specified by the SWAMP Quality Assurance Program Plan (QAPrP)[7], and were submitted in SWAMP-compatible format to the SFRWQCB. The SOPs were developed using a standard format that describes health and safety cautions and considerations, relevant training, site selection, and sampling methods/procedures, including pre-fieldwork mobilization activities to prepare equipment, sample collection, and de-mobilization activities to preserve and transport samples.

[7] The current SWAMP QAPrP is available at:
https://www.waterboards.ca.gov/water_issues/programs/swamp/qapp/swamp_QAPrP_2017_Final.pdf

1.3.2 Laboratory Analysis Methods

RMC participants, including SCVURPPP, agreed to use the same laboratories for individual parameters (except pathogen indicators), developed standards for contracting with the labs, and coordinated quality assurance samples. All samples collected by RMC participants that were sent to laboratories for analysis were analyzed and reported per SWAMP-comparable methods as described in the RMC QAPP (BASMAA 2016b). Analytical laboratory methods, reporting limits and holding times for chemical water quality parameters are also described in BASMAA (2016a). Analytical laboratory contractors in WY 2019 included:

- BioAssessment Services, Inc. – Benthic macroinvertebrate (BMI) identification
- EcoAnalysts, Inc. – Algae identification
- CalTest, Inc. – Sediment chemistry, nutrients, chlorophyll a, ash free dry mass
- Pacific EcoRisk, Inc. - Water and sediment toxicity
- Alpha Analytical – Pathogen indicators

1.3.3 Data Analysis Methods

Monitoring data generated during WY 2014 through WY 2019 were analyzed and evaluated to identify potential stressors that may be contributing to degraded or impacted biological conditions, including exceedances of water quality objectives (WQOs). Creek Status Monitoring and Pesticides & Toxicity Monitoring data are evaluated with respect to numeric thresholds (i.e., triggers) specified in the MRP (SFRWQCB 2015, SFRWQCB 2009). Sites with monitoring data that do not meet WQOs and/or MRP trigger thresholds require consideration for further evaluation as part of a Stressor/Source Identification project. SSID projects are intended to be oriented toward taking action(s) to alleviate stressors and reduce sources of pollutants. A stepwise process for conducting SSID projects is described in Provision C.8.e.iii of MRP 2.0.

In compliance with Provision C.8.e.i of MRP 2.0, all monitoring results exceeding trigger thresholds are added to a list of candidate SSID projects that will be maintained throughout the permit term. Follow-up SSID projects are selected from this list.

1.4 Setting

1.4.1 Watersheds Monitored by SCVURPPP

There are 13 major watersheds within the SCVURPPP jurisdictional boundaries and these watersheds comprise most of the Santa Clara Basin. The watersheds are illustrated in Figure 1.1 and their major characteristics are listed in Table 1.3. The Santa Clara Basin, which drains to the Lower South San Francisco Bay, is 840 square miles and bounded by the Diablo Mountains on the east and the Santa Cruz Mountains on the west and south. Elevations range from sea level at the Bay to almost 4,000 feet in the Santa Cruz Mountains. There is a distinct transition in geography and land use at elevations of 600 to 800 feet. Areas above this elevation generally have steeper slopes and are largely forest, rangeland, or open space. Below this elevation threshold, an urbanized landscape dominates. The headwaters of most watersheds begin in the undeveloped mountains and drain north through urbanized areas and into the Lower South Bay. Flows in the lower reaches of most watersheds are controlled by the presence of water supply reservoirs that are managed by Valley Water (formerly Santa Clara Valley Water District) and other agencies. Many of the reservoirs are constructed at the transition between the Santa Clara Valley and the surrounding foothills. Water is captured

during the winter rainy season and released in the spring at managed rates to allow for percolation through the stream bed to groundwater aquifers and to protect fish habitat downstream of the reservoirs. To varying degrees, portions of all watersheds within the urban zone have been engineered or placed within underground culverts. The Sunnyvale East and West Channel watersheds contain no natural creek bed at all, as they were constructed in the 1960s strictly for flood control purposes.

Table 1.3. Characteristics of major watersheds within SCVURPPP boundary.

Watershed	Area (miles^2)	# of Tributary Creeks	Natural Creek Bed (Miles)	Engineered Channel (Miles)	Underground Culvert or Stormdrain (Miles)	Impervious Area	Land Use				
							Residential	Industrial/ Commercial	Forest	Rangeland	Other
Adobe	11.0	7	18.8	2.3	12.0	45%	47%	12%	36%	3%	3%
Barron	15.6	5	15.1	7.9	28.6	60%	61%	20%	7%	7%	5%
Calabazas	20.3	6	12.9	14.1	55.5	NA	55%	29%	9%	5%	2%
Coyote	321	53	670	36.4	146	11%	9%	4%	50%	30%	8%
Guadalupe	171	50	207	45.5	265	37%	30%	14%	35%	16%	7%
Lower Penitencia	28.6	13	29.2	20.8	61.6	43%	31%	19%	1%	39%	11%
Matadero	14.0	3	18	NA	NA	60%	57%	6%	9%	8%	20%
Permanente	17.3	7	NA	NA	NA	44%	46%	13%	35%	3%	3%
San Francisquito	42.8	25	90.6	4.8	15.3	21%	30%	5%	45%	15%	6%
San Tomas Aquino	44.8	15	50.5	15.5	79.3	60%	54%	19%	24%	1%	3%
Stevens	29.2	12	54.2	1.1	30.0	29%	25%	9%	49%	13%	5%
Sunnyvale East	7.1	0	0	6.2	26.6	82%	65%	32%	0%	0%	3%
Sunnyvale West	7.6	0	0	6.7	18.7	72%	21%	65%	0%	0%	14%
Totals	**730.3**	**196**	**1166.3**	**161.3**	**738.6**	**27%**	**25%**	**10%**	**38%**	**20%**	**7%**

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

1.4.2 WY 2019 Creek Status and Pesticides & Toxicity Monitoring Stations

The complete list of probabilistic and targeted monitoring sites sampled by SCVURPPP in WY 2019 in compliance with provisions C.8.d (Creek Status Monitoring) and C.8.g (Pesticides and Toxicity Monitoring) is presented in Table 1.4. Station ID's for probabilistic sites, generated from the RMC Sample Frame, and station ID's for targeted sites, based on SWAMP station numbering methods (BASMAA 2016a), are provided. Monitoring locations from WY 2019 with monitoring parameter(s) are illustrated in Figure 1.2. Monitoring locations from WY 2014 through WY 2018 are illlustrated in the various parameter-specific sections of this report.

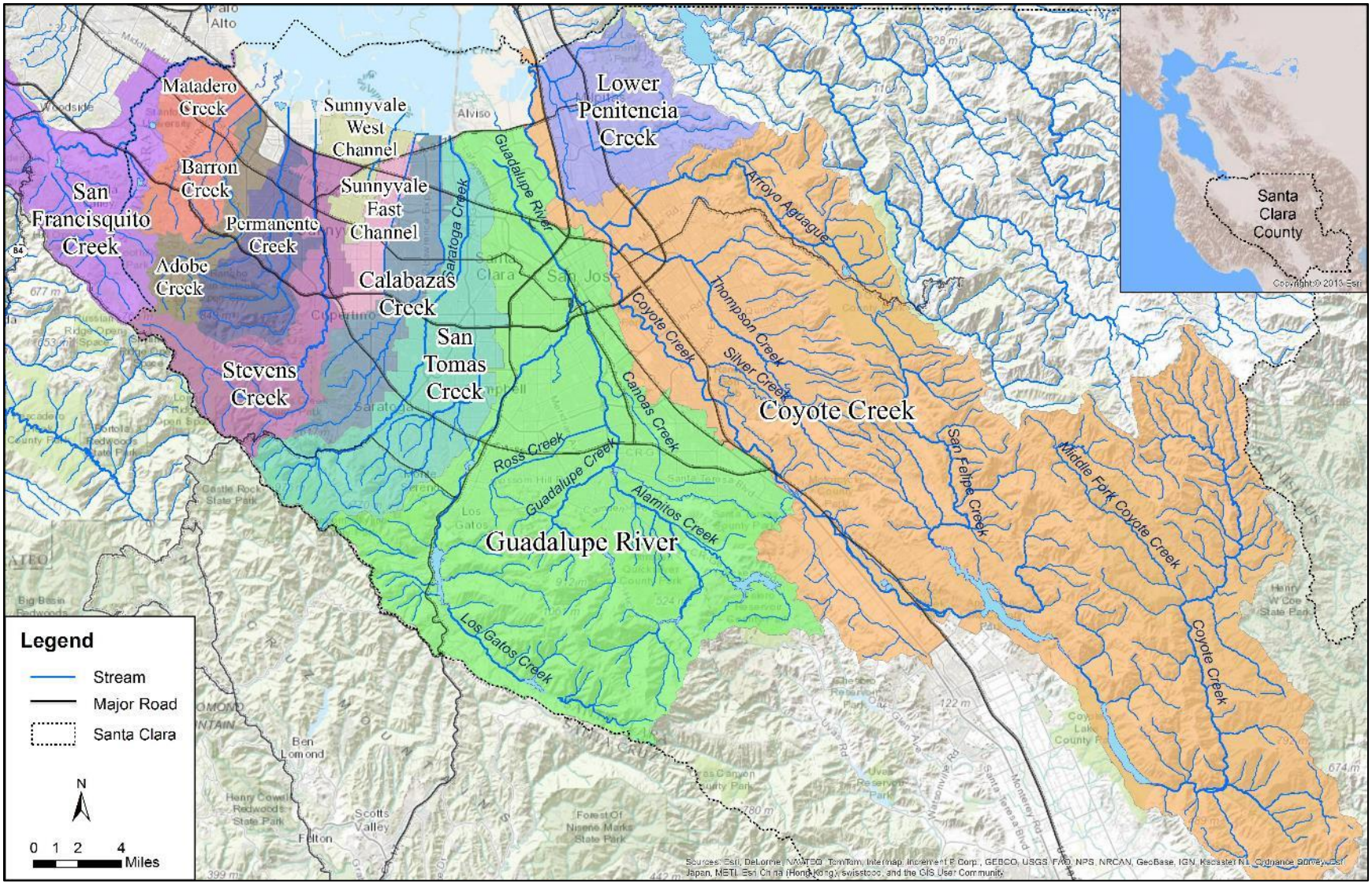


Figure 1.1. Watersheds within SCVURPPP jurisdictional boundaries.

Table 1.4. Sites and parameters monitored in WY 2019 in Santa Clara County.

Map ID [1]	Station ID	Watershed	Creek Name	Land Use	Latitude	Longitude	Probabilistic	Targeted				
							Bioassessment, Nutrients, General WQ	Chlorine	Pesticides & Toxicity	Temp [2]	Cont WQ [3]	Pathogen Indicators
60	205GUA060	Guadalupe River	Los Gatos Creek	U	37.29092	-121.93516	X	X				
251	205GUA251	Guadalupe River	Alamitos Creek	U	37.23306	-121.87054	X	X				
4378	205R04378	Guadalupe River	Los Gatos Creek	U	37.21641	121.98787	X	X				
4395	205R04395	Lower Penitencia Cr	Arroyo de los Coches	U	37.27497	-122.74731	X	X				
4418	205R04418	Coyote Creek	Thompson Creek	U	37.29241	-121.76800	X	X				
4530	205R04530	Coyote Creek	Upper Silver Creek	U	37.29709	-121.79408	X	X				
4537	205R04537	Coyote Creek	Thompson Creek	U	37.274966	-121.74731	X	X				
4591	205R04591	San Tomas Aquino	San Tomas Aquino	U	37.39046	-121.96851	X	X				
4602	205R04602	San Tomas Aquino	Wildcat Creek	U	37.26485	-122.01930	X	X				
4614	205R04614	San Tomas Aquino	San Tomas Aquino	U	37.27361	-121.98240	X	X				
4638	205R04638	Guadalupe River	Guadalupe Creek	U	37.228257	-121.90358	X	X				
4670	205R04670	San Thomas Aquino	Saratoga Creek	U	37.25077	-122.05510	X	X				
455	205COY455	Coyote Creek	Coyote Creek	U	37.166314	-121.64775	X	X				
4274	205R04247	Stevens Creek	Stevens Creek	U	37.325439	-122.06068	X	X				
4271	205R04271	Stevens Creek	Stevens Creek	NU	37.3051	-122.15480	X	X				
4317	205R04317	Coyote Creek	Coyote Creek	U	37.16628	-121.63747	X	X				
4359	205R04359	Adobe Creek	Adobe Creek	U	37.42889	-122.10522	X	X				
4383	205R04383	San Francisquito Cr	San Francisquito Cr	U	37.45462	-122.16078	X	X				
4479	205R04479	San Tomas Aquino	Saratoga Creek	U	37.35448	-121.97338	X	X				
70	205STE070	Stevens Creek	Stevens Creek	U	37.30275	-122.07486	X	X				
033	205LGA033	Guadalupe River	Los Gatos Creek	U	37.29516	-121.93337						X
400	205LGA400	Guadalupe River	Los Gatos Creek	U	37.23869	-121.97088						X
450	205LGA420	Guadalupe River	Los Gatos Creek	U	37.22024	-121.98303						X
330	205COY330	Coyote Creek	Coyote Creek	U	37.29027	-121.81831						X
392	205COY392	Coyote Creek	Coyote Creek	U	37.23504	-121.76105						X
190	205GUA190	Guadalupe River	Guadalupe Creek	U	37.24373	-121.87561				X		
202	205GUA202	Guadalupe River	Guadalupe Creek	U	37.23291	-121.89795				X		
210	205GUA210	Guadalupe River	Guadalupe Creek	U	37.21746	-121.91039				X		
218	205GUA218	Guadalupe River	Guadalupe Creek	U	37.2028	-121.88845				X		
250	205GUA250	Guadalupe River	Alamitos Creek	U	37.23363	-121.87058				X		
255	205GUA255	Guadalupe River	Alamitos Creek	U	37.22607	-121.85842				X		
262	205GUA262	Guadalupe River	Alamitos Creek	U	37.22041	-121.84516				X		
270	205GUA270	Guadalupe River	Alamitos Creek	U	37.20129	-121.82891				X		

Map ID [1]	Station ID	Watershed	Creek Name	Land Use	Latitude	Longitude	Probabilistic	Targeted				
							Bioassessment, Nutrients, General WQ	Chlorine	Pesticides & Toxicity	Temp [2]	Cont WQ [3]	Pathogen Indicators
279	205GUA279	Guadalupe River	Alamitos Creek	U	37.17409	-121.82409				X		
235	205COY235	Coyote Creek	Coyote Creek	U	37.3536	-121.87417					X	
236	205COY236	Coyote Creek	Coyote Creek	U	37.35098	-121.87378					X	
239	205COY239	Coyote Creek	Coyote Creek	U	37.33722	-121.86953					X	
021	205STE021	San Tomas Aquino	Stevens Creek	U	37.40982	-122.06905			X			
010	205STQ010	San Tomas Aquino	San Tomas Aquino	U	37.38863	-121.96853			X			

U = urban, NU = non-urban

[1] Map ID applies to Figure 1.2.

[2] Temperature monitoring was conducted continuously (i.e., hourly) April through September.

[3] Continuous water quality monitoring (temperature, dissolved oxygen, pH, specific conductivity) was conducted during two 2-week periods (spring and late summer).

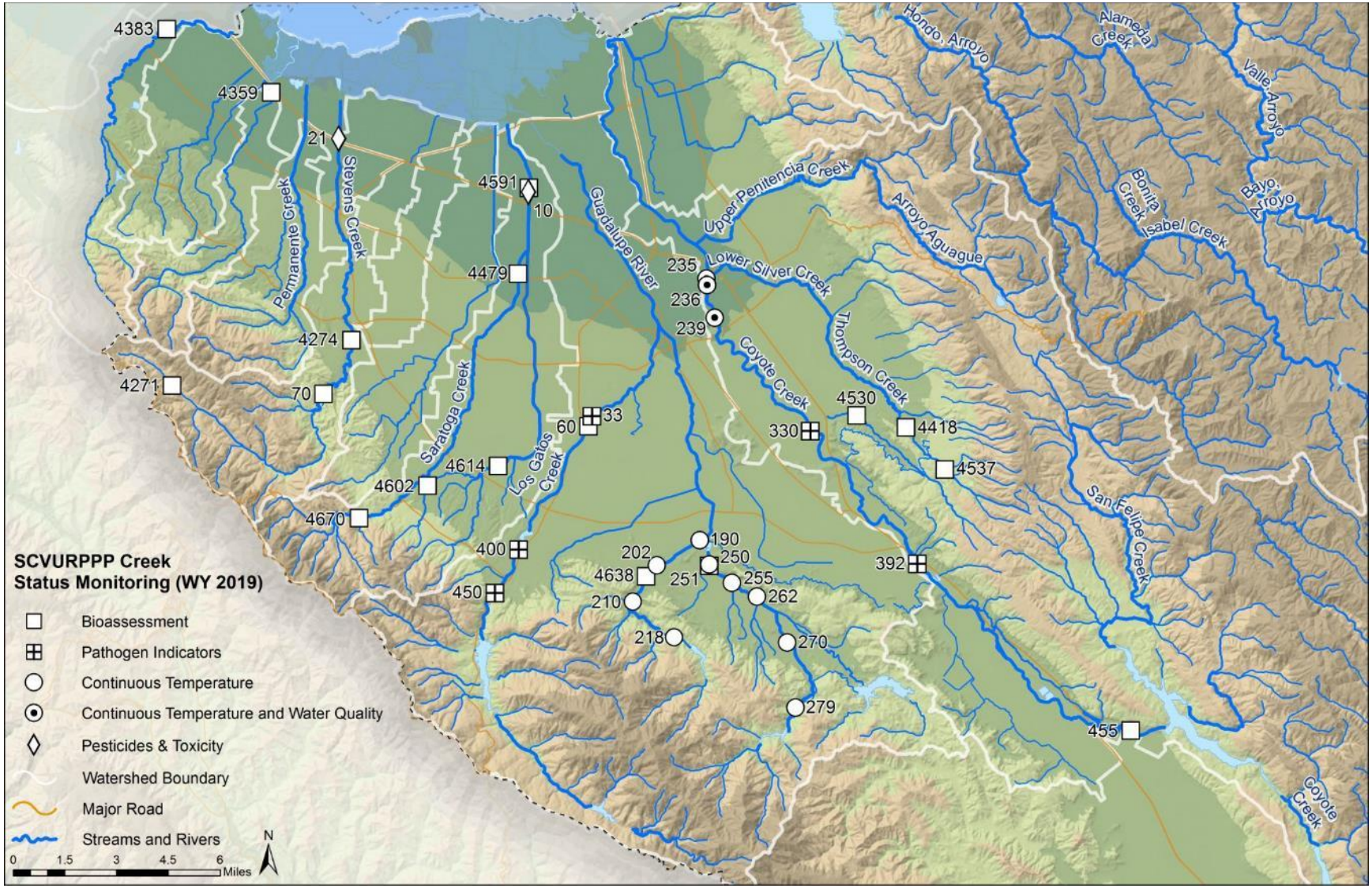


Figure 1.2. Map of SCVURPPP Program Area, major creeks, and sites monitored in WY 2019.

1.4.3 Designated Beneficial Uses

Beneficial Uses in Santa Clara Valley creeks are designated by the SFBRWQCB for specific water bodies and serve as the basis for establishing applicable WQOs designed to protect those uses (SFBRWQCB 2017). All creeks in the Santa Clara Basin are designated as having warm freshwater habitat (WARM) Beneficial Uses. Most creeks, with the exception of Lower Silver Creek, Lower Penitencia Creek, and a few small tributaries, are designated as having cold freshwater habitat (COLD) Beneficial Uses in the Santa Clara Basin, meaning that they either historically or currently a belived to support trout, anadromous salmon, and/or steelhead fisheries. Dissolved oxygen WQOs are more stringent in creeks with COLD Beneficial Uses because these species are relatively intolerant to environmental stresses. Virtually all creeks in the region are designated as having water contact recreation (REC-1) Beneficial Uses such as swimming and wading where ingestion of water is considered reasonably possible. Fecal indicator bacteria WQOs are identified to protect REC-1 Beneficial Uses. Los Gatos Creek is designated as having municipal and domestic supply (MUN) Beneficial Uses. The Basin Plan identifies WQOs for several constituents of concern that apply only to waters with MUN Beneficial Uses.

1.4.4 Climate

The Santa Clara Valley experiences a Mediterranean-type climate with cool, wet winters and hot, dry summers. The area is characterized by microclimates created by topography, ocean currents, fog exposure, and onshore winds. The wet season typically extends from October through April with local long-term, mean annual precipitation ranging from 15 inches near the Bay to over 55 inches along the highest ridges in the Santa Cruz Mountains (PRISM Climate Group 30-year normals, 1981-2010[8]). Figure 1.3 illustrates the geographic variability of mean annual precipitation in the area. It is important to understand that mean annual precipitation depths are statistically calculated or modeled; actual measured precipitation in a given year rarely equals the statistical average. Figure 1.4 illustrates the temporal variability in annual precipitation measured at the Mineta San José International Airport from WY 1946 to WY 2018. Creek Status Monitoring in compliance with the MRP began in WY 2012 which was the first year of a severe statewide drought that persisted through WY 2016. In WY 2018, rainfall was below average but was preceded by a relatively wet year in WY 2017.

The overall Bay Area climate and the specific conditions within any given year are influenced by global climate change. The Climate Change Assessment report for the Bay Area highlights several impacts of climate change that are already being felt: the Bay Area's average annual maximum temperature increased by nearly 1°C from 1950 – 2005, coastal fog along the coast may be less frequent, sea level in the Bay Area has risen over 8 inches (Ackerly et al. 2018). These changes are projected to increase significantly in the coming decades. As a consequence, heat extremes, high year-to-year variability in precipitation, droughts, intense storms, and other events are also predcted to increase.

Climate patterns (e.g., extended droughts) and individual weather events (e.g., extreme storms, hot summers) influence biological communities (i.e., vegetation, wildlife) and their surrounding physical habitat and water quality. They should therefore be considered when evaluating the type of data collected by the Creek Status Monitoring Program. For example, periods of drought (rather than individual dry years) can result in changes in riparian and upland vegetation communities. Long drought periods are associated with increased streambed sedimentation which can persist directly or indirectly for many years, depending on the occurrence and

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

magnitude of flushing flow events. Furthermore, in response to prolonged drought, the relative proportion of pool habitat can increase at the expense of riffle habitat. In addition, during severe droughts, water management agencies (such as the SCVWD) may also decrease the magnitude and duration of reservoir releases.

It is currently uncertain what effect these climatic factors have on biological indices that are calculated using data collected by the Creek Status Monitoring Program, such as benthic macroinvertebrates or algae. A study evaluating 20 years of bioassessment data collected in northern California showed that, although benthic macroinvertebrate taxa with certain traits may be affected by dry (and wet) years and/or warm (and cool) years, indices based on these organisms appear to be resilient (Mazor et al. 2009, Lawrence et al. 2010). However, this study did not specifically examine the impact of *longer periods* of extended drought or heat on biological indices, which would require analysis of a dataset with a much longer period of record. The Herbst Lab at the Sierra Nevada Aquatic Research Laboratory, University of California Santa Barbara recently completed a study exploring how flooding and droughts vary taxa metrics in the Sierra Nevada streams. While species diversity and density remained relatively unchanged during flooding, extreme dry weather conditions significantly impacted benthic macroinvertebrate population structure. These differences were exacerbated with continued exposure to drought (Herbst et al. 2019). Similar changes to the benthic macroinvertebrate community in Santa Clara County streams may have occurred during the WY 2012 – WY 2016 drought, but have not been evaluated.

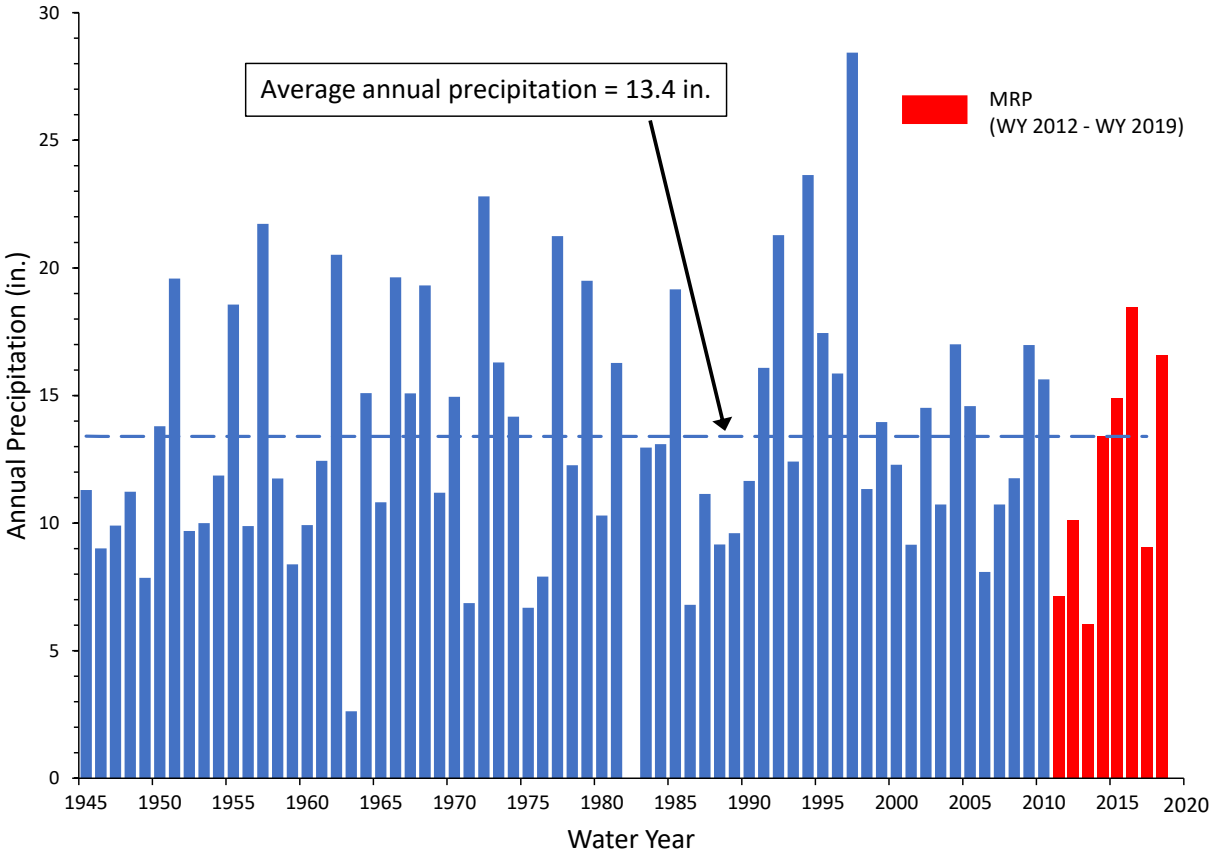


Figure 1.4. Annual rainfall recorded at the San José Airport, WY 1946 – WY 2018.

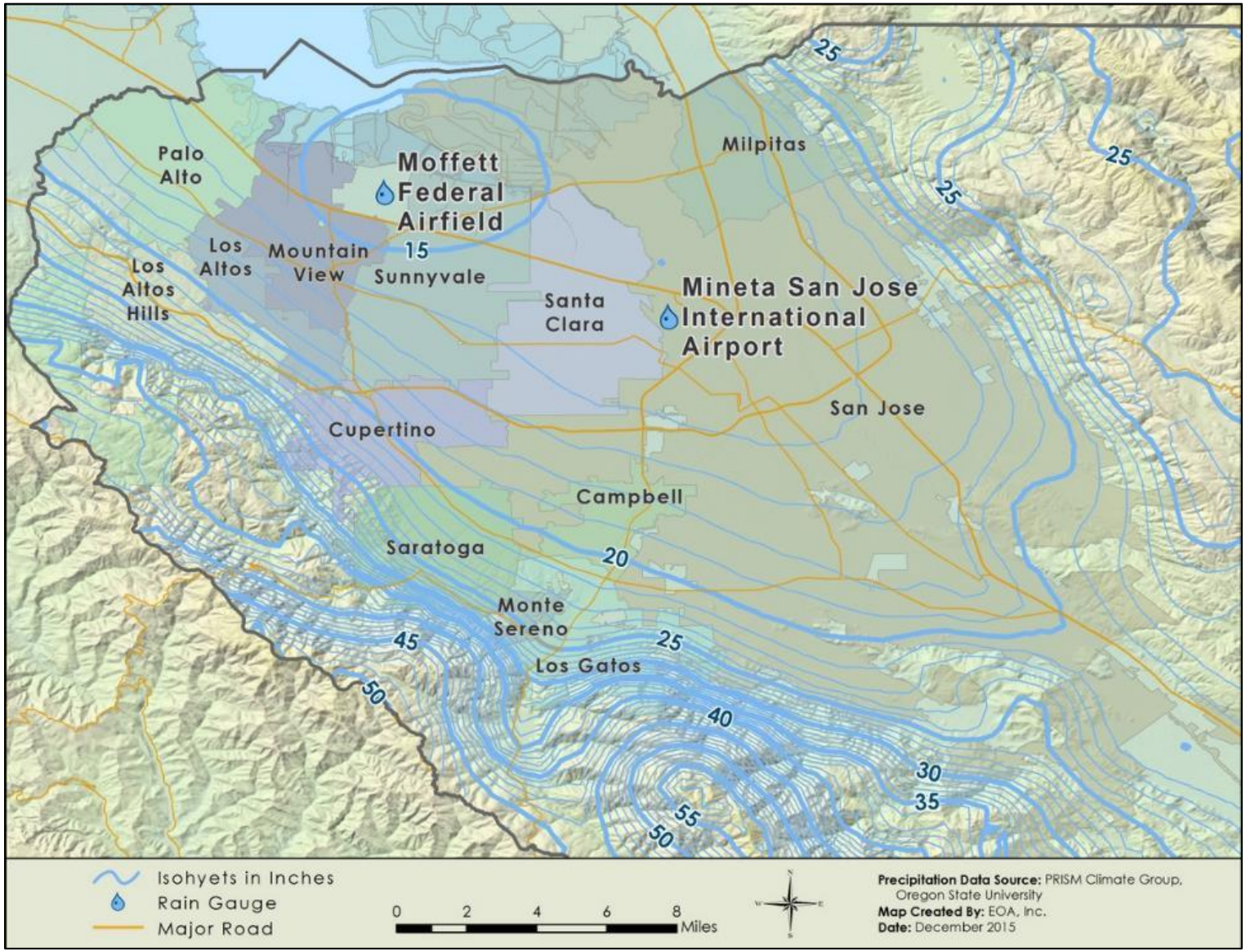


Figure 1.3. Average annual precipitation in Santa Clara Valley, as modeled by the PRISM Climate Group for the period of 1981-2010.

1.5 Statement of Data Quality

A comprehensive Quality Assurance/Quality Control (QA/QC) program was implemented by SCVURPPP covering all aspects of the probabilistic and targeted monitoring. In general, QA/QC procedures were implemented as specified in the BASMAA RMC QAPP (BASMAA, 2016a), which was adapted from the methods detailed by the SWAMP QAPrP[9]. The QAPP was revised twice – once in 2014 and again in 2016 – to conform to changes in the MRP reissuance and changes made to the SWAMP QAPrP. Changes made were minor, and overall methods and protocols remain similar. Each year's monitoring data were compared against objectives in the governing QAPP. Monitoring was performed according to protocols specified in the BASMAA RMC SOPs (BASMAA 2016b), which were also revised with the QAPP.

Overall, the results of the QA/QC reviews suggest that the Creek Status Monitoring data generated during WY 2012 through WY 2019 were of sufficient quality, in comparison to objectives outlined in the QAPP. However, some data were flagged in accordance with quality assurance/quality control protocols, and the following data collected during these Water Years were rejected:

- All of the continuous pH data collected at station 205COY235 during the June 2019 deployment, some of the continuous pH data collected at this site during the September 2019 deployment.
- All continuous pH data collected at site 205COY236 during May/June 2018
- Oxygen field measurements collected at sites 205R02947, 205R02693, 205R03386, 205R00570 in WY 2017.
- Some of the continuous dissolved oxygen data collected at site 205COY114 during April 2016.

A detailed QA/QC report for WY 2019 data is included as Attachment 1. Detailed QA/QC reports for past data are included with their respective water year reports.

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

2.0 BIOLOGICAL CONDITION ASSESSMENT

2.1 Introduction

The Program has conducted bioassessment monitoring since WY 2012 in compliance with Creek Status Monitoring provisions C.8.c of MRP 1.0 and C.8.d.i of MRP 2.0. Nearly all bioassessment monitoring has been performed at sites selected randomly using the probabilistic monitoring design. The probabilistic monitoring design allows each individual RMC participating program to objectively assess overall stream ecosystem conditions within its program area (e.g., County boundary) while contributing data to answer regional management questions about water quality and Beneficial Use condition in San Francisco Bay Area creeks. The survey design provides an unbiased framework for condition assessment of ambient aquatic life uses within known estimates of precision. The monitoring design was developed to address management questions for RMC participating counties and the overall RMC area:

1. *What is the condition of aquatic life in creeks in the RMC area; are water quality objectives met and are Beneficial Uses supported?*
    i. *What is the condition of aquatic life in the urbanized portion of the RMC area; are water quality objectives met and are Beneficial Uses supported?*
    ii. *What is the condition of aquatic life in RMC participant counties; are water quality objectives met and are Beneficial Uses supported?*
    iii. *To what extent does the condition of aquatic life in urban and non-urban creeks differ in the RMC area?*
    iv. *To what extent does the condition of aquatic life in urban and non-urban creeks differ in each of the RMC participating counties?*
2. *What are major stressors to aquatic life in the RMC area?*
    i. *What are major stressors to aquatic life in the urbanized portion of the RMC area?*
3. *What are the long-term trends in water quality in creeks over time?*

The first question (i.e., *What is the condition of aquatic life in creeks in the RMC area?*) is addressed by assessing indicators of aquatic biological health at probabilistic sampling locations. Once a sufficient number of samples have been collected, ambient biological condition can be estimated for streams at a regional (or countywide) scale. Over the past eight years (WY 2012 through WY 2019), SCVURPPP and Regional Water Board have sampled 168 probabilistic sites in the Santa Clara Valley, providing a sufficient sample size to estimate ambient biological condition for both urban and non-urban streams.[10] There is still an insufficient number of samples to accurately assess the biological condition for many watersheds and smaller jurisdictional areas (i.e., cities).

The second question (i.e., *What are major stressors to aquatic life in the RMC area?*) is addressed by evaluation of physical habitat and water chemistry data collected at the probabilistic sites, as potential stressors to biological health. The stressor levels can be compared to biological indicator data through correlation and random forest models. Assessing

[10] For each of the strata, it is necessary to obtain a sample size of at least 30 in order to evaluate the condition of aquatic life within known estimates of precision. This estimate is defined by a power curve from a binomial distribution (BASMAA 2012).

the extent and relative importance of stressors in predicting biological condition can help prioritize stressors at a regional scale and inform local management decisions.

The third question (i.e., *What are the long-term trends in water quality in creeks over time?*) is addressed by assessing the change in biological condition over several years. Changes in biological condition over time can help evaluate the effectiveness of management actions. Although, long-term trend analysis for the RMC probabilistic survey will require more than eight years of data collection, preliminary trend analysis of biological condition may be possible for some stream reaches using a combination of historical targeted data with the probabilistic data.

MRP 2.0 allows for up to 20% of bioassessment surveys at targeted sites to address other types of management questions, provided a statistically representative dataset (i.e., 30 samples) has already been collected. In WY 2019, SCVURPPP conducted bioassessment surveys at four targeted sites. All four sites were located in creek reaches where in-stream habitat improvement projects were recently completed or planned by Valley Water.

This section of the report presents bioassessment results from WY 2019, as well as a comprehensive evaluation of the probabilistic bioassessment data collected in the Santa Clara Valley from WY 2012 through WY 2019. In addition, in compliance with Provision C.8.d.i.(8) of MRP 2.0, WY 2019 data are compared to triggers and water quality objectives identified in the MRP. Sites with results exceeding trigger thresholds are added to the list of candidate SSID projects.

2.2 Methods

2.2.1 Probabilistic Survey Design

The RMC probabilistic design was created using the Generalized Random Tessellation Stratified (GRTS) approach developed by the United States Environmental Protection Agency (USEPA) and Oregon State University (Stevens and Olsen 2004). GRTS offers multiple benefits for coordinating among monitoring entities, including the ability to develop a spatially balanced design that produces statistically representative data with known confidence intervals. The GRTS approach has been implemented in California by several agencies including the statewide Perennial Streams Assessment (PSA) conducted by Surface Water Ambient Monitoring Program (Ode et al. 2011) and the Southern California Stormwater Monitoring Coalition's (SMC) regional monitoring program conducted by municipal stormwater programs in Southern California (SCCWRP 2007).

Sample sites were selected using the GRTS approach from a sample frame consisting of a creek network geographic information system (GIS) data set within the 3,407-square mile RMC area (BASMAA 2012). The sample frame includes non-tidally influenced perennial and non-perennial creeks within five management units representing areas managed by the stormwater programs associated with the RMC (listed in Table 1.1). There is approximately one site for every stream kilometer in the sample frame. The National Hydrography Plus Dataset (1:100,000) was selected as the creek network data layer to provide consistency with both the Statewide PSA and the SMC, and the opportunity for data coordination with these programs.

Once the master draw was performed, the list of sites was classified by county and land use (i.e., urban and non-urban) to allow for comparisons between these strata. Urban areas were delineated by combining urban area boundaries and city boundaries defined by the U.S. Census (2000). Non-urban areas were defined as the remainder of the RMC area. Some sites classified

as urban fall near the non-urban edge of the city boundaries and have little upstream development. For the purposes of consistency, these urban sites were not re-classified. Therefore, data values within the urban classification represent a wide range of conditions.

The RMC participants decided to partition their annual sampling efforts so that approximately 80% are in urban areas and 20% in non-urban areas. In addition, between WY 2012 and WY 2015, the SFRWQCB SWAMP conducted 34 bioassessments throughout the RMC region at non-urban sites selected from the sample frame, including 12 sites in Santa Clara County.[11]

2.2.2 Site Evaluations

Sites identified in the regional sample draw are evaluated by each RMC participant in chronological order using the process described in RMC Standard Operating Procedure FS-12 (BASMAA 2016a) which is consistent with the procedure described by Southern California Coastal Water Research Project (SCCWRP 2012). Each site is evaluated to determine if it meets RMC sampling location criteria (e.g., not tidally influenced, sufficient flow, safe accessibility, landowner permission to access site). Site evaluation information is stored in a database and analyzed to determine the statistical significance of average ambient conditions calculated from the multi-year dataset.

2.2.3 Field Sampling Methods

Bioassessment survey methods were consistent with the BASMAA RMC QAPP (BASMAA 2016b) and SOPs (BASMAA 2016a). In accordance with the RMC QAPP (BASMAA 2016b) bioassessments were planned during the spring index period (approximately April 15 – July 15) with the goal to sample a minimum of 30 days after any significant storm (defined as at least 0.5-inch of rainfall within a 24-hour period). The 30-day grace period allows diatom and soft algae communities to recover from peak flows that may scour benthic algae from the bottom of the stream channel.[12]

Over the eight-year monitoring period, one or two small but significant storms (i.e., 0.5 inches in 24-hour period) typically occurred during the first two weeks of April. Generally, bioassessment sampling was conducted 20-30 days following the storm event to allow recovery time for the algal community. However, due to drought or below average rainfall conditions that characterized the WY 2012 – WY 2016 period, bioassessments at selected sites (i.e., small streams less impacted by storm) were conducted approximately 10 days after the significant storm event to ensure that flow would still be present. During WY 2019, a significant storm occurred late in the season (May 20, 2019). Bioassessment sampling was paused until June 3, 2019 (approximately two weeks after the storm). All algae data collected prior to the 30-day grace period were flagged.

Each bioassessment sampling site consisted of an approximately 150-meter stream reach that was divided into 11 equidistant transects placed perpendicular to the direction of flow. Benthic macroinvertebrate (BMI) and algae samples were collected at 11 evenly spaced transects using the Reachwide Benthos (RWB) method described in the SWAMP SOP (Ode et al. 2016). The most recent SWAMP SOP (i.e., Ode et al. 2016) combines the BMI and algae methods

[11] As of WY 2016, the SFRWQCB SWAMP is no longer conducting RMC-related bioassessment monitoring at probabilistic sites.

[12] The BASMAA 30-day grace period is more conservative than the 21-day grace period described in the SWAMP SOP (Ode et al. 2016).

referenced in the MRP (Ode 2007, Fetscher et al. 2009), provides additional guidance, and adds two new physical habitat analytes (assess scour and engineered channels). The full suite of physical habitat data was collected within the sample reach using methods described in Ode et al. (2016).

Immediately prior to biological and physical habitat data collection, water samples were collected for nutrients, conventional analytes, ash free dry mass, and chlorophyll a analysis using the Standard Grab Sample Collection Method as described in SOP FS-2 (BASMAA 2016a). Water samples were also collected and analyzed in the field for free chlorine and total chlorine residual using a Pocket Colorimeter™ II and DPD Powder Pillows according to SOP FS-3 (BASMAA 2016a) (see Section 5.0 for chlorine monitoring results). In addition, general water quality parameters (dissolved oxygen, pH, specific conductance and temperature) were measured at or near the centroid of the stream flow using a pre-calibrated multi-parameter probe.

Biological and water samples were sent to laboratories for analysis. The laboratory analytical methods used for BMIs followed Woodard et al. (2012), using the Southwest Association of Freshwater Invertebrate Taxonomists (SAFIT) Level 1 Standard Taxonomic Level of Effort, with the additional effort of identifying chironomids (midges) to subfamily/tribe instead of family (Chironomidae). Soft algae and diatom samples were analyzed following SWAMP protocols (Stancheva et al. 2015). The taxonomic resolution for all data was compared SWAMP master taxonomic list. All BMI and algal taxa identified in samples collected over the eight-year monitoring period were consistent with the taxa listed on the SWAMP Master List, which was then included in the data submittal each year.

2.2.4 Data Analysis

Biological condition indicator and stressor data for all bioassessment sites surveyed in WY 2012 – WY 2019 were compiled into a master spreadsheet for data analyses. The master spreadsheet is included with this report as Attachment 2. BMI and algae data were analyzed to assess the biological condition (i.e., aquatic life Beneficial Uses) of the sampled reaches using condition index scores. Physical habitat data were used to assess biological condition and were evaluated as potential stressors. Water chemistry data were evaluated as potential stressors to biological health using triggers and water quality objectives identified in the MRP (see Stressor Variable section below). Data analysis methods for biological indicators and stressors are described below.

2.2.4.1 Biological Indicators

<u>Benthic Macroinvertebrates</u>

Benthic (i.e., bottom-dwelling) macroinvertebrates are organisms that live on, under, and around the rocks and sediment in the stream bed. Examples include dragonfly and stonefly larvae, snails, worms, and beetles (Figure 2.1). Each BMI species has a unique response to water chemistry and physical habitat condition. Some are relatively sensitive to poor habitat and pollution; others are more tolerant. Therefore, the abundance and variety of BMIs in a stream indicates the biological condition of the stream.

The California Stream Condition Index (CSCI) is an assessment tool that was developed by the State Water Resources Control Board (State Water Board) to support the development of

California's statewide Biological Integrity Plan[13]. The CSCI translates benthic macroinvertebrate data into an overall measure of stream health. The CSCI was developed using a large reference data set that represents the full range of natural conditions in California and site-specific models for predicting biological communities. The CSCI combines two types of indices: 1) taxonomic completeness, as measured by the ratio of observed-to-expected taxa (O/E); and 2) ecological structure and function, measured as a predictive multimetric index (pMMI) that is based on reference conditions. The CSCI score is computed as the average of the sum of the O/E and pMMI.

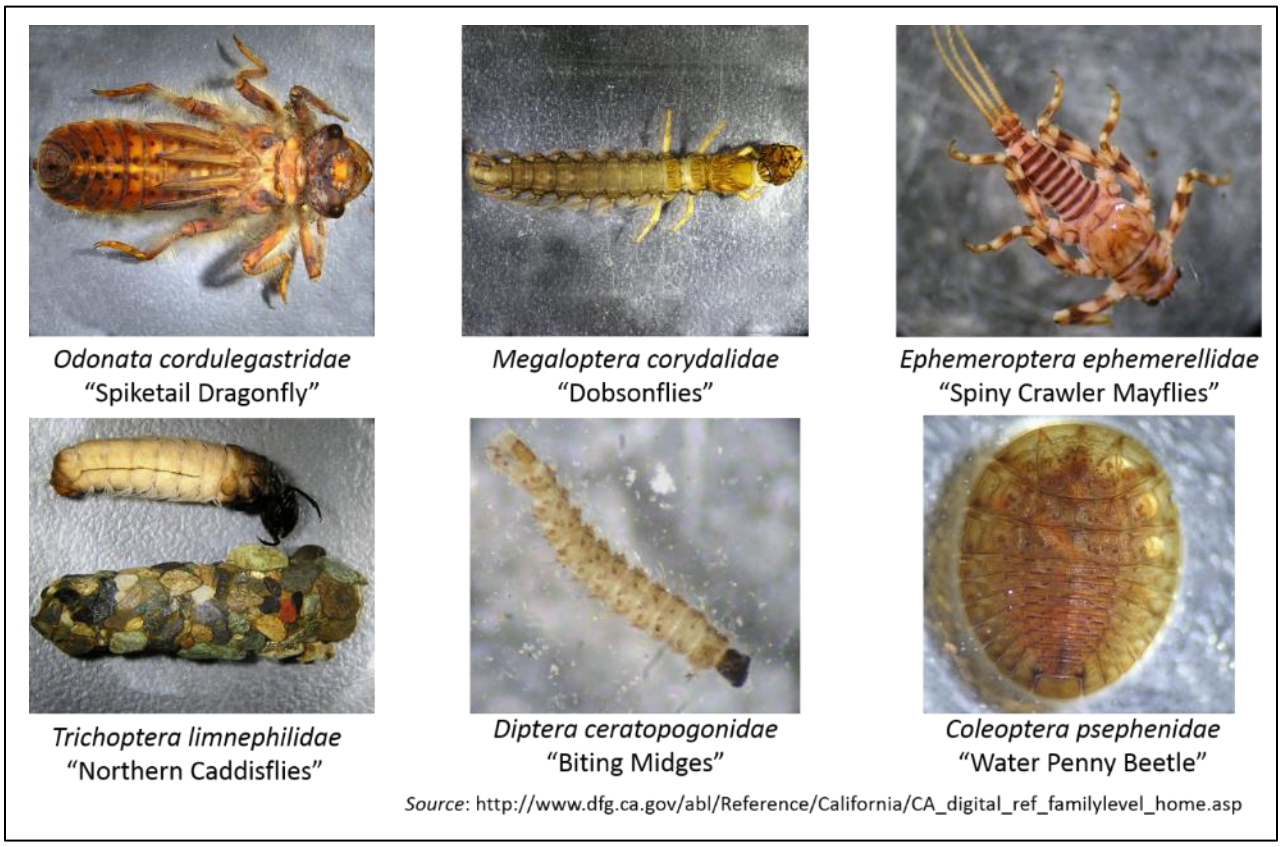


Figure 2.1. Examples of benthic macroinvertebrates.

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

[13] The Biological Integrity Assessment Implementation Plan has been combined with the Biostimulatory Substances Amendment project. The State Water Board is proposing to adopt a statewide water quality objective for biostimulatory substances (e.g., nitrate) along with a program of implementation. A draft policy document for public review is anticipated in late 2019.

The State Water Board is continuing to evaluate the performance of CSCI in a regulatory context. In Provision C.8.d of MRP 2.0, the Regional Water Board defines a CSCI score of 0.795 as a trigger threshold for identifying sites with potentially degraded biological condition that may be considered as candidates for a Stressor/Source Identification project.

Benthic Algae

Similar to BMI's, the abundance and type of benthic algae species living on a streambed can indicate stream health. When evaluated with the CSCI, biological indices based on benthic algae can provide a more complete picture of the stream's biological condition because algae respond more directly to nutrients and water chemistry. In contrast, BMIs are more responsive to physical habitat. Figure 2.2 shows examples of benthic algae common in Bay Area streams.

The State Water Board and SCCWRP recently developed the draft Algae Stream Condition Index (ASCI) which uses benthic algae data as a measure of biological condition for streams in California (Theroux et al. *in prep.).* The ASCI includes both predictive[14] and non-predictive multimetric indices (MMI) used to evaluate ecological conditions. There are three versions of the ASCI MMI: an index for diatoms, one for soft-bodied algae and a hybrid index using both assemblages. Using a statewide data set, all three indices were evaluated by the State Water Board for precision, accuracy, responsiveness, and regional bias The hybrid ASCI was found to be the most sensitive to anthropogenic stressor gradients, emphasizing the value of combining multiple algal assemblages (diatoms and soft bodied algae) to provide a more comprehensive assessment of biological condition (Theroux et al. in prep).

Additional study is needed to determine the best approach to apply the ASCI tools to evaluate bioassessment data. For example, it is not clear if the ASCI should be used as a second line of evidence to understand CSCI scoring results, or if it would be more effective as an independent indicator to evaluate different types of stressors (e.g., nutrients) to which BMIs are not very responsive. The ASCI is currently under review by the Biostimulatory-Biointegrity Policy Science Advisory Panel and the State Water Board.

The algae data collected at 172 sites in Santa Clara Valley creeks/channels during WYs 2012 to 2019 were evaluated using the three ASCI MMIs (diatom, soft algae and hybrid). ASCI scores were generated using the beta version reporting module developed by SCCWRP. These ASCI scores should be considered provisional until the ASCI has been fully evaluated and finalized.

[14] Predictive indices utilize environmental variables that characterize immutable natural gradients as predictors for biological conditions. A predictive algal O/E model was developed and tested, but ultimately not recommended due to low precision and accuracy. Predictive metrics were used for both diatom and hybrid MMIs, but the soft body algae MMI did not incorporate predictive metrics.

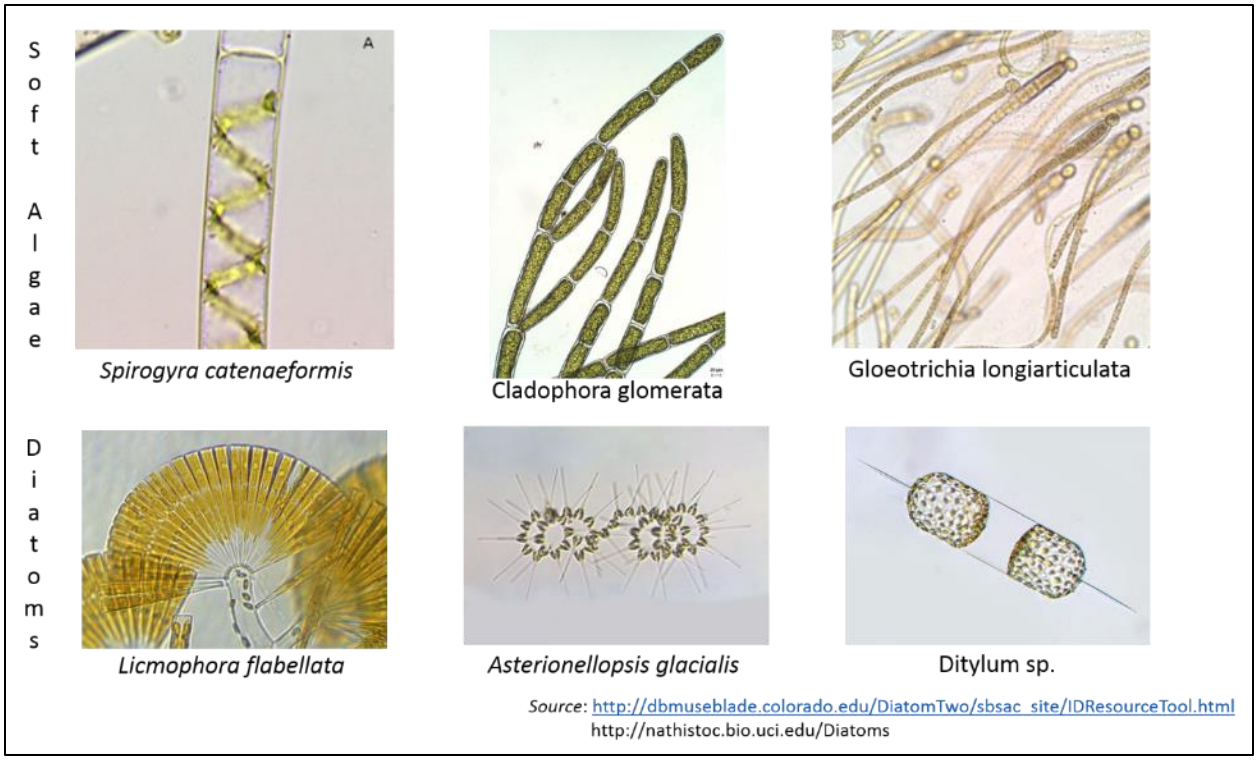


Figure 2.2. Examples of soft algae and diatoms.

2.2.4.2 Physical Habitat Indicators

The condition of physical habitat is a major contributor to stream ecosystem health. Physical habitat components such as streambed substrate, channel morphology, microhabitat complexity, in-stream cover-type complexity, and riparian vegetation cover contribute to the overall physical and biological integrity of a stream. The physical characteristics of a stream reach are affected by both natural factors (e.g., climate, slope, geology) and human disturbance (e.g., channelization, development, stream crossings, hydromodification).

Physical habitat conditions are generally evaluated using endpoint variables, or metrics, which are calculated using reach-scale averages of transect-based measurements and observations. The State Water Board has developed a SWAMP Bioassessment Reporting Module (SWAMP RM), a custom Microsoft Access™ application, that produces approximately 170 different metrics that are based on physical habitat measurements collected using both USEPA's Environmental Monitoring and Assessment Program (EMAP) for freshwater wadeable streams (Kaufmann et al. 1999) and the SWAMP "Full" habitat protocol (Ode 2007) that was implemented by SCVURPPP at bioassessment stations. The metrics are classified into five thematic groups representing different physical attributes: substrate, riparian vegetation (including structure and shading), flow habitat variability, in-channel cover, and channel morphology.

The State Water Board recently developed the Index of Physical Habitat Integrity (IPI) as an overall measure of physical habitat condition. Similar to the CSCI, the IPI is calculated using a combination of physical habitat data collected in the field and environmental data generated in GIS following the methods described in Rehn et al. (2018). The IPI is based on five of the

metrics generated by the SWAMP RM. The metrics were selected for their ability to discriminate between reference and stressed sites and provide unbiased representation of waterbodies across the different ecoregions of California. Scoring for these metrics were then calibrated using environmental variables that were associated with drainage areas for each sampling location.

2.2.4.3 Biological and Physical Habitat Condition Thresholds

Existing thresholds for CSCI scores (Mazor 2015) and ASCI scores (Theroux et al. in review) were used to evaluate the BMI and algae data collected in Santa Clara County and analyzed in this report (Table 2.1). Provisional thresholds for IPI scores (Rehn et al 2018) were used to evaluate physical habitat conditions. The thresholds for all three indices were based on the distribution of scores for data collected at reference calibration sites located throughout California. Four condition categories are defined by these thresholds: "likely intact" (greater than 30th percentile of reference site scores); "possibly intact" (between the 10th and the 30th percentiles); "likely altered" (between the 1st and 10th percentiles); and "very likely altered" (less than the 1st percentile).

Table 2.1. Condition categories used to evaluate CSCI, ASCI, and IPI scores.

Biological Indicator	Tool	Likely Intact	Possibly Intact	Likely Altered	Very Likely Altered
BMI	CSCI	≥ 0.92	≥ 0.79 to < 0.92	≥ 0.63 to < 0.79	< 0.63
Diatoms	ASCI	≥ 0.92	≥ 0.81 to < 0.92	≥ 0.66 to < 0.81	< 0.66
Soft Algae		≥ 0.92	≥ 0.80 to < 0.92	≥ 0.65 to < 0.80	< 0.65
Hybrid		≥ 0.95	≥ 0.88 to < 0.95	≥ 0.78 to < 0.88	< 0.78
Physical Habitat	IPI	≥ 0.94	≥ 0.84 to < 0.94	≥ 0.71 to < 0.83	< 0.70

A CSCI score below 0.795 is referenced in the MRP as a threshold indicating a potentially degraded biological community, and thus should be considered for a SSID Project. The MRP threshold is the division between the "possibly intact" and "likely altered" condition categories described in Mazor (2015). Further investigation is needed to evaluate the applicability of this threshold to sites in highly urban watersheds and/or modified channels that are frequent throughout the SCVURPPP study area.

2.2.4.4 Stressor Variables

Physical habitat, landscape characteristics, general water quality, and water chemistry data collected during the bioassessment surveys were compiled and evaluated as potential stressor variables affecting biological condition.

Physical habitat stressor variables include 11 of the metrics developed by the SWAMP RM (described above) that were selected based on their ability to discriminate between reference and stressed sites and also showed little bias among ecoregions (Andy Rehn, personal communication, 2017) (Table 2.2). Additional physical habitat variables include the reachwide qualitative assessment (PHAB) that consists of three separate attributes: channel alteration,

epifaunal substrate, and sediment deposition. Each attribute is individually scored on a scale of 0 to 20, with a score of 20 representing good condition. The total PHAB score is the sum of three individual attribute scores with a score of 60 representing the highest possible score.

Table 2.2. Physical habitat metrics used to assess physical habitat data collected at bioassessment sites in Santa Clara County, WY 2012 - WY 2019. The five metrics used to calculate IPI scores are also shown.

Type	Variable Name	Variables used for IPI Score
Channel Morphology	Evenness of Flow Habitat Types	x
	Percent Fast Water of Reach	
Habitat Complexity and Cover	Mean Filamentous Algae Cover	
	Natural Shelter cover - SWAMP	
	Shannon Diversity (H) of Aquatic Habitat Types	x
	Riparian Cover Sum of Three Layers	x
Human Disturbance	Combined Riparian Human Disturbance Index - SWAMP	
Substrate Size and Composition	Evenness of Natural Substrate Types	
	Percent Gravel - coarse	
	Percent Substrate Smaller than Sand (<2 mm)	x
	Shannon Diversity (H) of Natural Substrate Types	x

Landscape variables were generated in GIS using three different scales of drainage area upstream of each sampling location: 1 km, 5 km, and entire watershed. Land use and transportation data layers were overlayed with the drainage areas to calculate landscape variables, including percent urban area, percent impervious area, total number of road crossings, and road density.

Water quality stressor variables include the general parameters measured in the field with sondes (i.e., dissolved oxygen, pH, temperature and specific conductivity), free chlorine and total chlorine residual, and water chemistry analyzed at laboratories (nutrients and anions). Additional water quality variables included chlorophyll a and ash free dry mass, both measured from filtration of the benthic algae composite samples.

Some of the water quality stressor variables used in the analysis were calculated or converted from other analytes or units of measurement:

- Conversion of measured total ammonia to the more toxic form of unionized ammonia was calculated to compare with the 0.025 mg/L annual median standard provided in the San Francisco Basin Water Quality Control Plan (Basin Plan) (SFRWQCB 2017). The conversion was based on a formula provided by the American Fisheries Society (AFS; https://fisheries.org/wp-content/uploads/2016/03/Copy-of-pub_ammonia_fwc.xls). The calculation requires total ammonia and field-measured values of pH, temperature, and specific conductance.
- Total nitrogen concentration was calculated by summing nitrate, nitrite, and Total Kjeldahl Nitrogen concentrations.
- The volumetric concentrations (mass/volume) for ash free dry mass and chlorophyll a (as measured by the laboratory) were converted to an area concentration (mass/area). Calculations required using both algae sampling grab size and composite volume.

Another potential stressor is climate. During the first five years of probabilistic sampling (WY 2012 – WY 2016), average precipitation was lower than average. During the drought, low base flow conditions were further impacted by minimal or complete absence of water releases from upstream reservoirs and diversion pipes bringing imported water from other parts of the State. Drought conditions changed with an above average wet season in WY 2017, followed by average season in WY 2018 and above average in WY 2019. Comparison of sampling results from recent wet years will provide useful information to evaluate the impacts of drought on biological integrity of the streams.

2.2.4.5 Trigger Thresholds

In compliance with Provision C.8.h.iii.(4) of MRP 2.0, water chemistry data collected at the bioassessment sites during WY 2019 were compared to MRP trigger thresholds and applicable water quality standards (Table 2.3). Thresholds for pH, specific conductance, dissolved oxygen (DO), and temperature (for waters with COLD Beneficial Use only) are listed in Provision C.8.d.iv of MRP 2.0. With the exception of temperature and specific conductance, these conform to Water Quality Objectives (WQOs) in the Basin Plan (SFRWQCB 2017). Of the eleven nutrients analyzed synoptically with bioassessments, WQOs only exist for three: ammonia (unionized form), and chloride and nitrate (for waters with MUN Beneficial Use only).

Table 2.3. MRP trigger thresholds for nutrient and general water quality variables.

	Units	Threshold	Direction	Source
Nutrients and Ions				
Nitrate as N [a]	mg/L	10	Increase	Basin Plan
Un-ionized Ammonia [b]	mg/L	0.025	Increase	Basin Plan
Chloride [a]	mg/L	250	Increase	Basin Plan
General Water Quality				
Oxygen, Dissolved	mg/L	5.0 or 7.0	Decrease	Basin Plan
pH		6.5 to 8.5		Basin Plan
Temperature, instantaneous maximum [c]	°C	24	Increase	MRP
Specific Conductance [c]	µS/cm	2000	Increase	MRP

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

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

[c] The MRP thresholds (or triggers) for temperature and specific conductance apply when 20 percent of instantaneous results are in exceedance. Application to individual samples is provisional.

2.2.4.6 Stressor Assessment

The association of stressors (physical habitat, landscape, chemistry) with biological indicator scores (CSCI and ASCI) was evaluated using eight years (WY 2012 – 2019) of bioassessment data collected in San Mateo County. Spearman's rank correlation analyses and random forest statistical models were applied to the dataset. A summary of these analyses is provided in Section 2.3.2.

2.2.4.7 SCAPE Modeling to Assess CSCI Scores

Biological conditions, based on CSCI scores, for the 90 bioassessment sampling locations in the Santa Clara Basin were compared to a landscape model developed for streams in California that estimates ranges of likely scores for CSCI scores based on the level of landscape alteration

contributing to the sampling reach (Beck et al. 2020). The landscape model was created using data from StreamCat, which is a national dataset that includes attributes characterizing watershed development (Hill at al. 2015).

The predictive model was developed to support management decisions, such as identifying reaches for restoration or enhanced protection based on how observed scores relate to the model expectation. It has been integrated into a publicly available web-based application called the Stream Classification and Priority Explorer (SCAPE). The SCAPE tool can be used to compare measured/calculated CSCI scores with the predictive scores produced by the model (https://sccwrp.shinyapps.io/scape/).

The SCAPE model was obtained from SCCWRP as a GIS shapefile. Stream/channel attributes in the shapefile include stream classifications using three thresholds for CSCI (1st, 10th, and 30th percentile of reference sites) and a prediction interval (ranging from the 10th to the 90th percentiles of the quantile predictions). There are four possible stream classifications in the model: “likely unconstrained”, “possibly constrained”, “possibly unconstrained” and “likely unconstrained”. The model predicts a range of CSCI scores for each stream reach and an expected median score. Observed CSCI scores at a site are compared to the model expectations and characterized as over-scoring, expected or under-scoring. See section 2.3.4 for application of the SCAPE model to CSCI scores at bioassessment sites in Santa Clara County.

2.3 Results and Discussion

The results for bioassessment monitoring in WY 2019, as well as the previous eight years of bioassessment data (WY 2012 – WY 2019), are presented in the section below.

- **Section 2.3.1** presents overall results of biological assessments conducted at twenty sites in Santa Clara County during WY 2019. This section also includes description of purpose and selection of sites for targeted monitoring.

- **Section 2.3.2** provides an overall summary of biological conditions (CSCI and ASCI scores) and exceedances of stressor thresholds for the 172 bioassessment sites sampled in Santa Clara County between WY 2012 and WY 2019. The association between biological conditions and stressor data (land use, water chemistry, physical habitat) for 168 probabilistic sites is evaluated using statistical analyses. The evaluation of bioassessment data is consistent with the approach used in the RMC 5-year Bioassessment Report (BASMAA 2019).

- **Section 2.3.3** presents a comparison of historical BMI data (Pre-MRP; WY 2003 – WY 2009) and BMI data collected in compliance with the MRP (WY 2012 – WY 2019), based on CSCI scores, as one approach using existing data sources to evaluate trends in biological conditions. The Program conducted bioassessments in eight watersheds in Santa Clara County between 2003 and 2009.

- **Section 2.3.4** provides potential approaches to consider for future monitoring design to address requirements for Provision C.8 of the next MRP (i.e., MRP 3.0) that is currently under development and will likely become effective in WY 2022. One approach would be to conduct targeted monitoring at specific watershed/reaches that have identified water quality problems or reduced biological conditions and high potential to mitigate

stressor impacts through management actions. Another approach is to identify healthy stream reaches and focus efforts on protecting those resources.

Conclusions and recommendations for this section are presented in Section 7.0.

2.3.1 Bioassessment Results (WY 2019)

This section documents the biological condition and stressor data collected in WY 2019. In WY 2019, the Program conducted bioassessments at 4 targeted sites and 16 probabilistic sites[15] in Santa Clara County. The WY 2019 bioassessment sites are listed in Table 2.4 and mapped in Figure 2.3. The probabilistic sites were derived from the RMC Sample Frame and the four targeted sites were located in creek reaches where in-stream habitat improvement projects were recently completed or planned by Valley Water. Bioassessment data at targeted sites are intended to provide baseline data to evaluate changes in conditions over time. A description of targeted monitoring study is provided in Section 2.3.1.3.

Table 2.4. Bioassessment sampling dates and locations in Santa Clara County in WY 2019.

Station Code	Creek	Sample Date	Elevation (m)	Latitude	Longitude	Probabilistic	Targeted
205COY455	Coyote Creek	04-Jun-19	116	37.16631	-121.64776		x
205GUA060	Los Gatos Creek	08-May-19	49	37.29109	-121.93488		x
205GUA251	Alamitos Creek	29-Apr-19	63	37.23306	-121.87054		x
205STE070	Stevens Creek	05-Jun-19	127	37.30275	-122.07486		x
205R04247	Stevens Creek	05-Jun-19	86	37.32635	-122.06019	x	
205R04271	Stevens Creek	03-Jun-19	457	37.30551	-122.15517	x	
205R04317	Coyote Creek	04-Jun-19	124	37.16628	-121.63747	x	
205R04359	Adobe Creek	12-Jun-19	2	37.42669	-122.10509	x	
205R04378	Los Gatos Creek	08-May-19	110	37.21733	-121.98670	x	
205R04383	San Francisquito Cr	06-Jun-19	15	37.45383	-122.16170	x	
205R04395	Arroyo De Los Coches	02-May-19	126	37.44464	-121.85645	x	
205R04418	Thompson Creek	30-Apr-19	120	37.29217	-121.76741	x	
205R04479	Saratoga Creek	12-Jun-19	19	37.35436	-121.97327	x	
205R04530	Upper Silver Creek	01-May-19	66	37.29639	-121.79295	x	
205R04537	Thompson Creek	30-Apr-19	181	37.27378	-121.74535	x	
205R04591	San Tomas Aquino Cr	07-May-19	5	37.39086	-121.96797	x	
205R04602	Wildcat Creek	01-May-19	123	37.26359	-122.01925	x	
205R04614	San Tomas Aquino Cr	07-May-19	75	37.27327	-121.98247	x	
205R04638	Guadalupe Creek	06-May-19	84	37.22823	-121.90335	x	
205R04670	Saratoga Creek	09-May-19	194	37.25116	-122.05508	x	

2.3.1.1 Biological and Physical Habitat Conditions

Biological condition, as represented by CSCI and ASCI (diatom, soft algae, and hybrid) scores, for the 20 bioassessment sites sampled by SCVURPPP in WY 2019 are listed in Table 2.5. Physical habitat conditions, as represented as IPI Scores, are shown in Table 2.6. All sites

[15] MRP 2.0 allows for up to 20% of bioassessment locations (4 sites) to be targeted; the remaining sites are probabilistic.

were classified as urban land use. Scores in the two higher condition categories (i.e., above the 10th percentile of reference sites) for each indicator are highlighted and bold.

CSCI Scores

The CSCI scores ranged from 0.32 to 1.08 across the 20 bioassessment sites sampled in WY 2019 (Table 2.5). Three of the 20 bioassessment sites (15%) had CSCI scores in the two higher condition categories: "possibly intact" and "likely intact" condition. These combined classifications are above the MRP trigger threshold value of 0.795. Although these three sites are classified as urban in the RMC sample frame, impervious area in their contributing watersheds is relatively low, < 3%.

Three sites (15%) were ranked as "likely altered" (CSCI score 0.63 – 0.795). The remaining 14 sites were ranked as "very likely altered" (CSCI score < 0.63), indicating highly degraded conditions. Nine of these sites were predominantly urban (11% - 38% impervious watershed area). he remaining low scoring sites were either downstream of dams, or in small watersheds with low or no flow conditions during the late summer. Sites with CSCI scores below 0.795 will be considered as candidates for SSID projects.

ASCI Scores

The benthic algae taxa identified in the samples collected in Santa Clara County were used to calculate scores for the provisional statewide ASCI. Scores for three ASCI indices (diatoms, soft algae and hybrid) are shown in Table 2.5. There is no MRP trigger for any of the ASCI index scores.

The diatom and hybrid ASCI scores exhibited similar patterns, with majority of the scores in the top two condition categories occurring at sites with minimal development. Nine of the ten higher scoring sites for ASCI-H ($\geq$ 0.88 score) occurred in watersheds that were $\leq$ 3% impervious area (Table 2.5). All seven sites with high scores for diatom index were at sites with low development (< 3% impervious area). The ASCI-SB index exhibited high scores at sites with both low and high levels of urbanization. Two sites below dams on Coyote Creek (201COY455 and 205R04318) and Stevens Creek (205R04247 and 205STE070) had very high scores for the soft algae index; 3 of the 4 sites has scores > 1.0.

Table 2.5. Biological condition scores, presented as CSCI and ASCI (diatom, soft algae and hybrid) for 20 probabilistic sites sampled in Santa Clara during WY 2019. Site characteristics related to percent impervious watershed area and flow condition are also presented. Bolded/shaded values indicate scores in the two higher condition categories.

Station Code	Creek	Impervious Watershed Area	Flow[1]	CSCI Score	ASCI Score		
					Diatom	Soft Algae	Hybrid
205R04247	Stevens Creek	3%	P	0.65	**0.97**	**0.87**	**1.01**
205R04271	Stevens Creek	3%	P	**1.08**	**1.09**	**1.28**	**1.10**
205R04317	Coyote Creek	1%	P	0.54	**0.95**	**1.10**	**1.13**
205R04359	Adobe Creek	25%	P	0.32	0.61	0.53	0.68
205R04378	Los Gatos Creek	3%	P	0.64	0.48	**0.96**	**0.96**
205R04383	San Francisquito Cr	13%	NP	0.47	0.79	**0.90**	0.86
205R04395	Arroyo De Los Coches	2%	P	0.67	**0.91**	**1.28**	0.72
205R04418	Thompson Creek	11%	P	0.38	0.62	**0.86**	0.62
205R04479	Saratoga Creek	25%	P	0.58	0.53	0.53	0.80
205R04530	Upper Silver Creek	18%	P	0.53	0.72	0.37	0.65
205R04537	Thompson Creek	3%	NP	0.51	0.46	**1.28**	**0.90**
205R04591	San Tomas Aquino Cr	38%	P	0.50	0.62	0.24	0.52
205R04602	Wildcat Creek	16%	NP	0.50	0.73	**0.96**	0.83
205R04614	San Tomas Aquino Cr	21%	P	0.63	0.62	**0.81**	0.72
205R04638	Guadalupe Creek	3%	P	**0.97**	**0.96**	**0.87**	**0.95**
205R04670	Saratoga Creek	2%	P	**0.99**	**0.94**	0.69	**1.13**
205COY455	Coyote Creek	1%	P	0.58	**0.84**	**0.95**	**1.00**
205GUA060	Los Gatos Creek	12%	P	0.57	0.77	**0.82**	**0.97**
205GUA251	Alamitos Creek	7%	P	0.62	0.69	**0.81**	0.86
205STE070	Stevens Creek	2%	P	0.44	0.66	**1.02**	**1.11**

[1] Flow: P=Perennial, NP=Non-perennial (no flow during dry season)

IPI Scores

Physical habitat conditions, as represented by IPI scores, are listed in Table 2.6 along with CSCI scores and hybrid ASCI scores. The two higher condition categories for all three indices (i.e., above the 10th percentile of reference sites) are shown in shaded cells with bold text. Sixteen of the twenty sites had IPI scores that were in the top two condition categories (> 0.83). The lowest score (0.13) occurred at site 205R04359, which was located within concrete channel section of Adobe Creek.

The qualitative habitat (PHAB) scores, including individual scores for channelization, epifaunal substrate and sedimentation attributes[16], and total PHAB (sum of the three attributes scores)

[16] Channelization is measure of extent of reach that is armored/modified; Epifaunal substrate is measure of quantity and quality of physical habitat features (substrate, wood) that provides structure for colonization of biological communities; Sedimentation is a measure of the amount of sediment that has accumulated in the reach.

are also presented in the table. There appears to be no relationship between IPI and PHAB scores. Biological condition scores for CSCI and the hybrid ASCI are included in the table for comparison.

Table 2.6. IPI scores for 20 probabilistic sites in Santa Clara County sampled in WY 2019. Qualitative PHAB scores are also listed. CSCI and hybrid ASCI scores are provided for comparison. Bolded/shaded values indicate scores in the two higher condition categories.

Station Code	Creek Name	CSCI Score	Hybrid ASCI Score	IPI Score	Channel Alteration	Epifaunal Substrate	Sediment Deposition	Total PHAB
205R04247	Stevens Creek	0.65	**1.01**	**1.10**	11	12	7	30
205R04271	Stevens Creek	**1.08**	**1.10**	**1.17**	20	18	12	50
205R04317	Coyote Creek	0.54	**1.13**	**1.06**	12	13	15	40
205R04359	Adobe Creek	0.32	0.68	0.13	0	1	2	3
205R04378	Los Gatos Creek	0.64	**0.96**	**1.18**	16	16	16	48
205R04383	San Francisquito Cr	0.47	0.86	0.79	2	6	2	10
205R04395	Arroyo De Los Coches	0.67	0.72	**0.85**	17	18	5	40
205R04418	Thompson Creek	0.38	0.62	**0.88**	14	10	8	32
205R04479	Saratoga Creek	0.58	0.80	0.75	4	4	11	19
205R04530	Upper Silver Creek	0.53	0.65	**0.99**	15	9	7	31
205R04537	Thompson Creek	0.51	**0.90**	**0.92**	16	8	8	32
205R04591	San Tomas Aquino Cr	0.50	0.52	0.77	7	2	1	10
205R04602	Wildcat Creek	0.50	0.83	**0.90**	8	10	8	26
205R04614	San Tomas Aquino Cr	0.63	0.72	**0.91**	7	7	10	24
205R04638	Guadalupe Creek	**0.97**	**0.95**	**1.02**	16	15	12	43
205R04670	Saratoga Creek	**0.99**	**1.13**	**1.04**	20	18	17	55
205COY455	Coyote Creek	0.58	**1.00**	**1.13**	15	15	16	46
205GUA060	Los Gatos Creek	0.57	**0.97**	**1.1**	11	10	12	33
205GUA251	Alamitos Creek	0.62	0.86	**1.12**	13	13	12	38
205STE070	Stevens Creek	0.44	**1.11**	**1.00**	18	7	13	38

Overall Condition

The condition categories for each site based on two of the biological indicators (CSCI and hybrid ASCI) and physical habitat indicator (IPI) are listed in Table 2.6 and illustrated in Figure 2.3. There were three sites with scores in the two higher condition categories for all three indices: CSCI, hybrid ASCI and IPI (green and yellow symbols in Figure 2.3). Two of the sites are located in upper reaches of Saratoga Creek (site 205R04670) and Stevens Creek (205R04271). The remaining site is located at the urban boundary of Guadalupe Creek, just downstream of Coleman Av (site 205R04638).

In contrast, there were four sites with scores in the two lower condition categories for all three indices. Two sites were in the highly urban reaches of San Tomas Aquino Creek (site 205R04591) and Saratoga Creek (site 205R04479). The third site was located in concrete channel reach of Adobe Creek (site 205R04359) and the fourth site was located in an intermittent section of San Franciscquito Creek (site 205R04383).

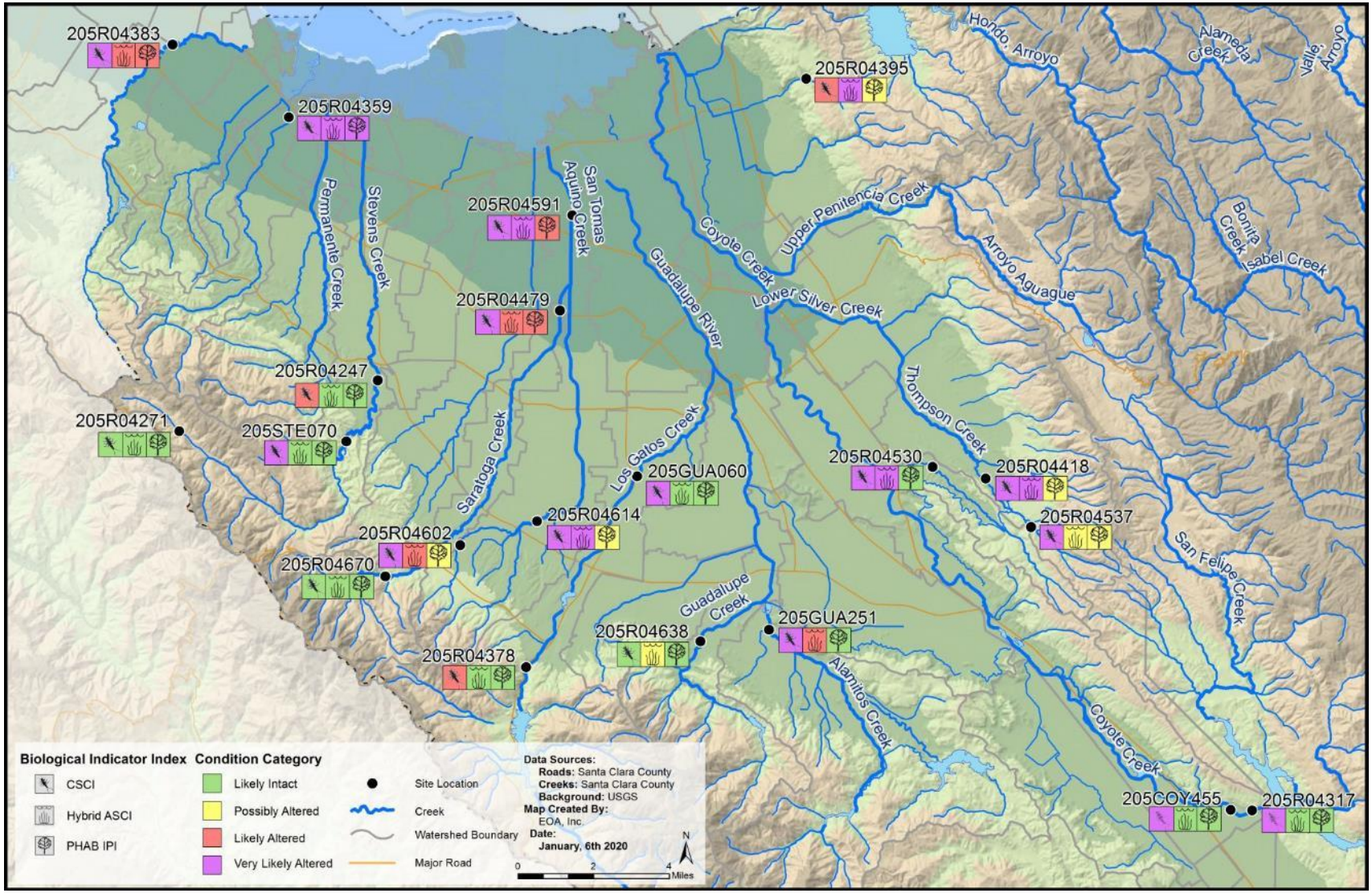


Figure 2.3. Condition category as represented by CSCI, ASCI Hybrid, and IPI scores for 20 probabilistic sites sampled in Santa Clara County during WY 2019.

2.3.1.2 Stressor Assessment (WY 2019)

This section lists results for stressor data collected at the 20 bioassessment sites in WY 2019. The comparison of WY 2019 stressor data to associated MRP triggers and/or WQOs is also documented for the purposes of maintaining the list of sites with trigger exceedances for SSID project consideration.

General Water Chemistry

General water quality measurements sampled at the twenty bioassessment sites in WY 2019 are listed in Table 2.7. None of the water quality measurements exceeded water quality objectives or MRP trigger thresholds.

Table 2.7. General water quality measurements for twenty probabilistic sites in Santa Clara County sampled in WY 2019.

Station Code	Creek Name	Sample Date	DO (mg/L)	Temp (Deg C)	Specific Cond (uS/cm)	pH
205R04247	Stevens Creek	05-Jun-19	12.0	17.2	495	8.3
205R04271	Stevens Creek	03-Jun-19	10.0	12.6	547	8.3
205R04317	Coyote Creek	04-Jun-19	9.2	11.6	315	7.7
205R04359	Adobe Creek	12-Jun-19	8.2	21.2	989	8.1
205R04378	Los Gatos Creek	08-May-19	10.7	11.9	753	8.1
205R04383	San Francisquito Cr	06-Jun-19	6.3	18.1	796	8.3
205R04395	Arroyo De Los Coches	02-May-19	11.0	11.9	908	8.3
205R04418	Thompson Creek	30-Apr-19	10.3	15.1	750	8.3
205R04479	Saratoga Creek	12-Jun-19	10.8	23	1093	7.9
205R04530	Upper Silver Creek	01-May-19	11.5	12.9	1252	8.3
205R04537	Thompson Creek	30-Apr-19	8.4	14	977	7.8
205R04591	San Tomas Aquino Cr	07-May-19	20.5	25.4	1064	8.4
205R04602	Wildcat Creek	01-May-19	9.7	17.4	604	7.8
205R04614	San Tomas Aquino Cr	07-May-19	10.0	13.8	607	8.3
205R04638	Guadalupe Creek	06-May-19	10.8	12.2	370	8.2
205R04670	Saratoga Creek	09-May-19	11.1	12.5	415	8.4
205COY455	Coyote Creek	04-Jun-19	10.7	13.7	314	7.9
205GUA060	Los Gatos Creek	08-May-19	8.5	20	367	8.2
205GUA251	Alamitos Creek	29-Apr-19	9.8	14.8	509	8.1
205STE070	Stevens Creek	05-Jun-19	8.3	15.2	471	7.8

Water Chemistry (Nutrients)

Nutrient and conventional analyte concentrations measured in water samples collected at twenty bioassessment sites in Santa Clara County during WY 2019 are listed in Table 2.8. There were four sites that exceeded Water Quality Objectives for unionized ammonia. Two sites were in Stevens Creek, one site in Arroyo de las Coches and one site in San Tomas Aquino.

Table 2.8. Nutrient and conventional constituent concentrations in water samples collected at 20 sites in Santa Clara County during WY 2019. Bolded values are above water quality objectives.

Station Code	Creek Name	Ammonia as N	Unionized Ammonia (as N)	Chloride	Nitrate as N	Nitrite as N	Total Kjeldahl as N	Total Nitrogen	Ortho-Phosphate as P	Phosphorus as P	Silica	AFDM	Chlorophyll a
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	g/m2	mg/m2
	Water Quality Objective	***NA***	***0.025*** [b]	***250*** [a]	***10*** [a]	***NA***	***NA***	***NA***	***NA***	***NA***	***NA***	***NA***	***NA***
205R04247	Stevens Creek	0.92	**0.056**	19	0.1	0.001 J	0.28	0.4	0.04	0.07	20	106.4	153.5
205R04271	Stevens Creek	0.78	**0.030**	14	0.033 J	<0.001	< 0.07	0.1	0.03	0.03	16	200.1	7.7
205R04317	Coyote Creek	0.83	0.008	15	0.33	0.001 J	0.22	0.6	0.02	0.04	12	48.0	91.8
205R04359	Adobe Creek	0.20	0.009	73	2.2	0.072	0.63	2.9	0.03	0.06	25	135.0	64.3
205R04378	Los Gatos Creek	0.25	0.006	7.1	0.19	0.003 J	0.11	0.3	0.02	0.03	21	10.3	92.9
205R04383	San Francisquito Cr	0.06	0.004	56	0.3	0.006	0.28	0.6	0.02	0.03	11	46.8	110.4
205R04395	Arroyo De Los Coches	0.33	**0.033**	71	2.1	0.006	0.83	2.9	0.23	0.36	47	427.4	20.5
205R04418	Thompson Creek	0.33	0.024	130	0.071	0.001 J	0.77	0.8	0.10	0.10	25	133.2	17.1
205R04479	Saratoga Creek	0.06	0.002	95	1.6	0.019	0.19	1.8	0.02	0.03	19	42.2	35.7
205R04530	Upper Silver Creek	0.33	0.015	150	1.4	0.004 J	0.61	2.0	0.15	0.15	47	133.2	13.9
205R04537	Thompson Creek	0.33	0.008	65	1	0.008	0.77	1.8	0.11	0.11	31	78.4	8.8
205R04591	San Tomas Aquino Cr	0.34	**0.039**	81	0.45	0.028	0.8	1.3	0.007 J	0.04	21	223.8	184.2
205R04602	Wildcat Creek	0.33	0.006	73	0.65	0.004 J	0.25	0.9	0.15	0.03	30	133.2	2.0
205R04614	San Tomas Aquino Cr	0.14	0.006	56	0.11	0.002 J	0.25	0.4	0.02	0.02	21	25.5	184.2
205R04638	Guadalupe Creek	0.41	0.012	10	0.095	0.002 J	0.14	0.2	0.02	0.03	19	12.7	184.2
205R04670	Saratoga Creek	0.28	0.014	13	0.16	0.001 J	< 0.07	0.2	0.06	0.08	21	113.3	184.2
205COY455	Coyote Creek	0.76	0.014	15	0.3	0.001 J	0.33	0.6	0.02	0.04	12	15.7	73.6
205GUA060	Los Gatos Creek	0.27	0.015	7.1	0.067	0.003 J	0.11	0.2	0.02	0.03	21	56.7	62.5
205GUA251	Alamitos Creek	0.33	0.009	28	0.32	0.0025 J	0.77	1.1	0.02	0.03	21	133.2	184.2
205STE070	Stevens Creek	0.79	0.013	15	0.029 J	<0.001	0.19	0.2	0.04	0.08	20	37.8	153.1
Number of exceedances		NA	4	0	0	NA	NA	NA	NA	NA	NA	NA	NA

NA = Not Applicable, NR = Not Reported

J = The reported result is an estimate.

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

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

Total nitrogen concentrations ranged from 0.2 to 2.9 mg/L. The two highest nitrogen concentrations were measured at site 205R04359 in Adobe Creek (2.9 mg/L) and site 205R04395 (2.9 mg/L) on Arroyo Los Coches. Total phosphorus concentrations ranged from <0.03 to 0.36 mg/L. The highest phosphorus concentration was measured at site 205R04395 on Arroyo Los Coches.

2.3.1.3 Targeted Sites (WY 2019)

In WY 2019, SCVURPPP conducted bioassessments at four targeted sites located near recently constructed or planned stream restoration projects (Table 2.9 and Figure 2.4). Planned or completed stream restoration work entailed placement of gravel and wood into the channel for the purpose of increasing the amount of spawning habitat and high flow refugia on the floodplain for salmonid fish populations. The selected monitoring locations were at 4 of the 20 sites identified for potential gravel and wood augmentation projects in Santa Clara County watersheds managed by Valley Water (Rubin et al. 2017).

Table 2.9. Bioassessment site locations during WY 2019.

Station Code	Location	Project data for Gravel/wood placement	Bioassessment sampling dates
205COY455	Coyote Creek at Stream Gage near Boys Ranch	TBD	2015, 2019
205GUA060	Los Gatos Creek at Creekside Way	August 2019	2009, 2019
205GUA251	Alamitos Creek upstream Golf Creek Confluence (upstream Mazzone Dr)	August 2018	2019
205STE070	Stevens Creek at Stevens Creek Park below dam	August 2018	2006, 2014, 2019

The purpose of the bioassessment monitoring conducted at targeted sites in WY 2019 was to establish a baseline dataset on biological conditions at the beginning phase of the restoration projects. Bioassessments would then be repeated at these sites after channel conditions have stabilized to measure changes in biological conditions. Three of the four targeted sites were previously sampled by SCVURPPP before the 2019 sampling event (Table 2.9).

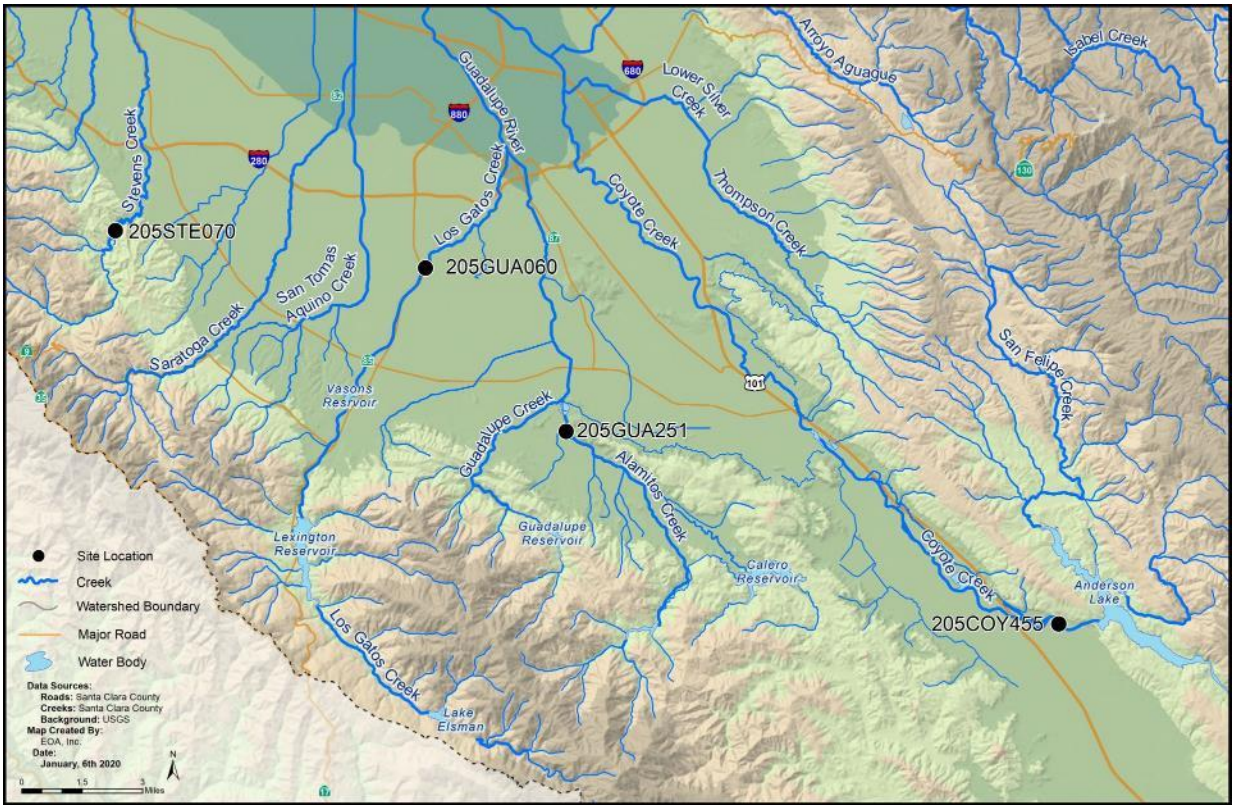


Figure 2.4. Targeted bioassessment sites during WY 2019.

2.3.2 Evaluation of Countywide Bioassessment Results (WY 2012 – 2019)

This section addresses the first two bioassessment monitoring management questions presented at the beginning of Section 2.0 by summarizing WY 2012 through WY 2019 biological condition data and comparing scores to synoptically collected stressor data.

The first bioassessment management question (i.e., *What is the condition of aquatic life in creeks in the RMC?*) is addressed by assessing indicators of aquatic biological health at probabilistic sampling locations. As part of the RMC Bioassessment Monitoring Program, 172 sites were sampled by SCVURPPP (n=160) and SWAMP (n=12) in Santa Clara County between WY 2012 and WY 2019. SCVURPPP sampled 140 urban and 20 non-urban sites and SWAMP sampled 12 non-urban sites. All monitoring sites were derived from the RMC sample frame, except four targeted sites that were sampled during WY 2019.

The bioassessment data collected at probabilistic sites (n=168) were evaluated to assess the current condition of water bodies in the County and identify stressors likely to pose the greatest risk to the health of those streams. The methods used to evaluate bioassessment data were consistent with the approach used to develop the RMC Five-Year Bioassessment Report (BASMAA 2019). A summary of the methods and results is presented below.

The overall range of biological conditions in Santa Clara County streams was estimated using cumulative distribution functions (CDFs). CDF sample weights were calculated as the total stream length in the RMC sample frame divided by the stream length evaluated in each land use category (urban and non-urban). The adjusted sample weights were used to estimate the

proportion of stream length (average and 95% confidence interval) represented by CSCI and ASCI scores for all SCVURPPP sites combined, as well as urban sites only. All calculations were conducted using the R-package *spsurvey* (Kincaid and Olsen 2016).

The second bioassessment monitoring management question (i.e., *What are major stressors to aquatic life in the RMC area?*) is addressed by evaluation of physical habitat, land use, and water chemistry data collected at the probabilistic sites, as potential stressors to biological health. Potential stressors to biological condition were evaluated using Spearman's rank correlation analysis and random forest statistical models. The stressor variable list consisted of 50 quantitative environmental variables, related to water quality, physical habitat, and land use factors that could potentially influence biological condition scores. In addition, two categorical factors (Land Use and Strata) were used to evaluate condition scores for different types of streams. Watershed/Sub-watershed Area was used as the strata to evaluate regional differences in biological conditions.

2.3.2.1 Site Evaluations

A total of 514 randomly selected monitoring sites were sampled in the RMC region between 2012 and 2019. Of these, 168 (33%) were located in the Santa Clara Basin, representing a total stream length of 176.9 km. The majority (137 of 168, 81%) were classified as urban streams/channels. A total of 624 sites were initially evaluated to obtain the 168 probabilistic Santa Clara Basin sites that were ultimately sampled. This equates to a rejection rate of about 73%, largely due to lack of flow, tidal influence, or lack of accessibility.

As of the beginning of WY 2020, there are 1,294 sites remaining in the RMC sample draw for the Santa Clara Basin. Of these, 1,191 are non-urban . Assuming a rejection rate of 75%, the sample draw will likely only be sufficient to provide new sites through WY 2020.

2.3.2.2 Countywide Biological Conditions (WY 2012 – WY 2019)

A summary of CSCI and three ASCI index scores from bioassessment sites in Santa Clara County sampled between WYs 2012 and 2019 is presented in Table 2.10 and figure 2.5. A total of 128 of the 172 (74%) bioassessment sites (includes 4 targeted sites) received CSCI scores below the MRP trigger (0.795), which corresponds to the "likely altered" and "very likely altered" categories. Of these 128 sites, 113 (81%) were in streams classified as urban. As a reminder, urban areas were delineated by combining urban area boundaries and city boundaries defined by the U.S. Census (2000). Non-urban areas were defined as the remainder of the RMC area. Some sites classified as urban fall near the non-urban edge of the city boundaries and have little upstream development.

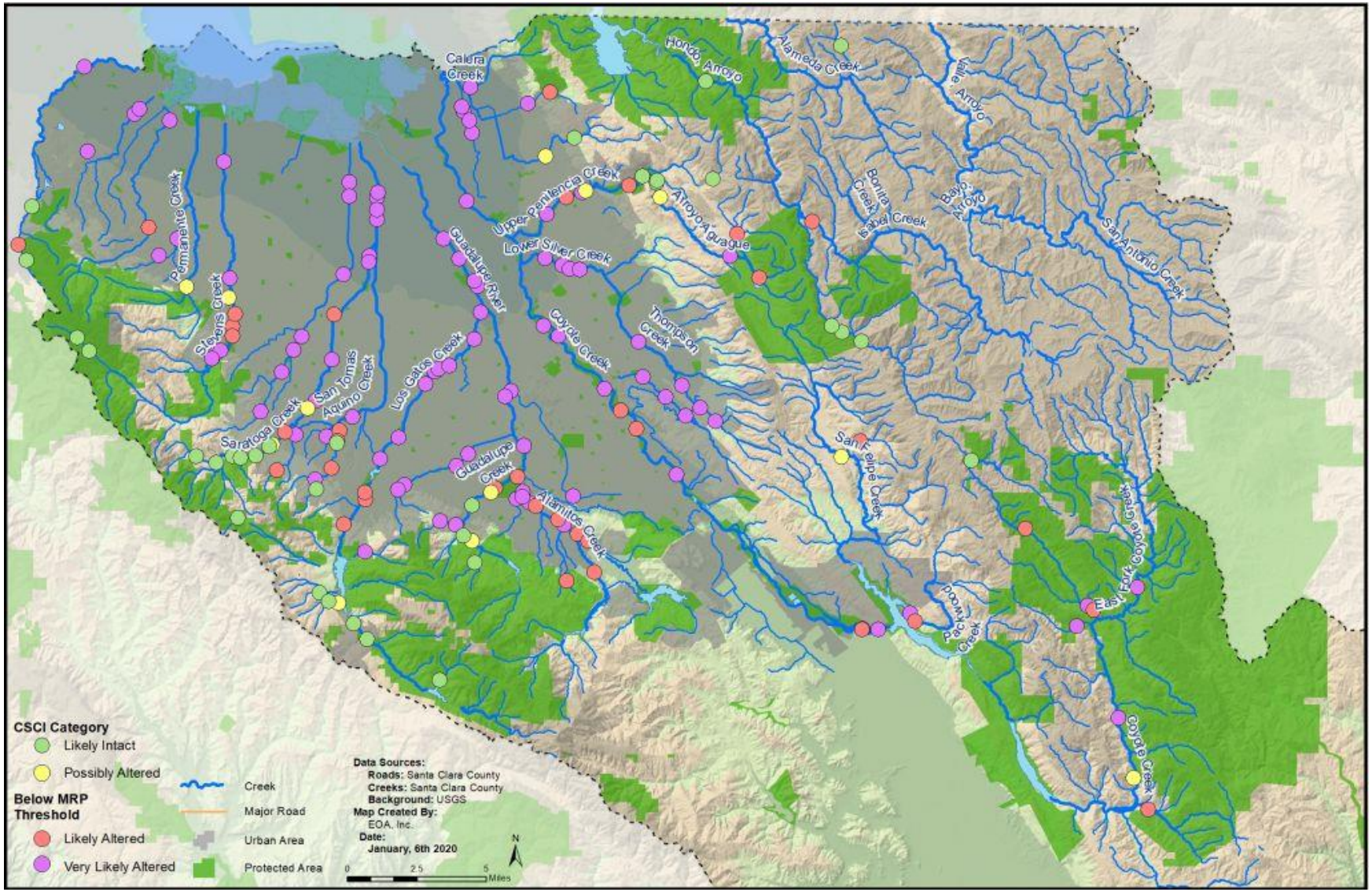


Figure 2.5. Condition categories for CSCI scores at 172 bioassessment sites in Santa Clara County sampled between WY 2012 and WY 2019.

Table 2.10. Number of sites sampled between WYs 2012 and 2019 within each condition category for the four biological indices.

Index[1]	Sites with index score[2]	Land Use	Likely Intact	Possibly Altered	Likely Altered	Very Likely Altered
CSCI	172	Urban	18	9	30	83
		Non-Urban	14	3	9	6
ASCI-D	172	Urban	17	23	46	54
		Non-Urban	17	8	6	1
ASCI-SB	165	Urban	50	34	21	29
		Non-Urban	20	5	6	0
ASCI-H	165	Urban	21	13	24	76
		Non-Urban	22	4	4	1

[1] Indices: CSCI = California Stream Condition Index; ASCI-D = Diatom Algae Stream Condition Index; ASCI-SB = Soft Bodied Algae Stream Condition Index; ASCI-H = Hybrid Algae Stream Condition Index.
[2] Index scores for ASCI-SB and ASCI-H were not calculated for 7 bioassessment sites due to insufficient soft algae taxa needed to calculate score.

The number of sites receiving scores within the lower two condition categories (*likely altered* and *very likely altered*) for the diatom and hybrid ASCI indices was very similar to each other, with 107 and 105 sites, respectively. The number of sites in the two lower condition categories for the soft-bodied algae ASCI was substantially less (56) than the other three indices (Table 2.10). Proportionally, there were more urban sites that had ASCI-SB index scores in the two higher condition categories (63%), compared to the other three indices (ranged 19-29%), indicating that the soft-bodied algae index may not respond well to urban disturbance gradients.

Figure 2.6 includes four plots showing cumulative distribution functions for the four biological condition indicators (CSCI, ASCI-D, ASCI-SB, and ASCI-H). Each plot shows CDFs for urban sites (n=136) all sites (n=168[17]), and non-urban sites (n=32). The CDFs can be used to determine the probability that a random observation will be less than or equal to a certain value. The dashed lines show the uncertainty around these estimates. For example, there is a 65% probability that a random site in the Santa Clara Basin will have a CSCI score below 0.79 (i.e., *likely altered* or *very likely altered*). There is a 80% probability that a random *urban* site in the Santa Clara Basin will have a CSCI score below 0.79 and there is a 48% probability that a random *non-urban* site will have a CSCI score below 0.79.

The CDFs for the various indicators are shaped differently, illustrating the differences in scores in the Santa Clara Basin dataset. The responsiveness or lack of responsiveness of the indicator to urban land uses is illustrated by the separation of the “urban” line from the “all sites” and “non-urban” lines. The CSCI CDFs have the greatest degree of separation between the urban line and the others; whereas, the ASCI-SB CDFs have the smallest degree of separation. As stated previously, the ASCI-SB may not respond to urban disturbance gradients in Santa Clara Basin streams.

[17] CDFs were developed using only the 168 probabilistic sites.

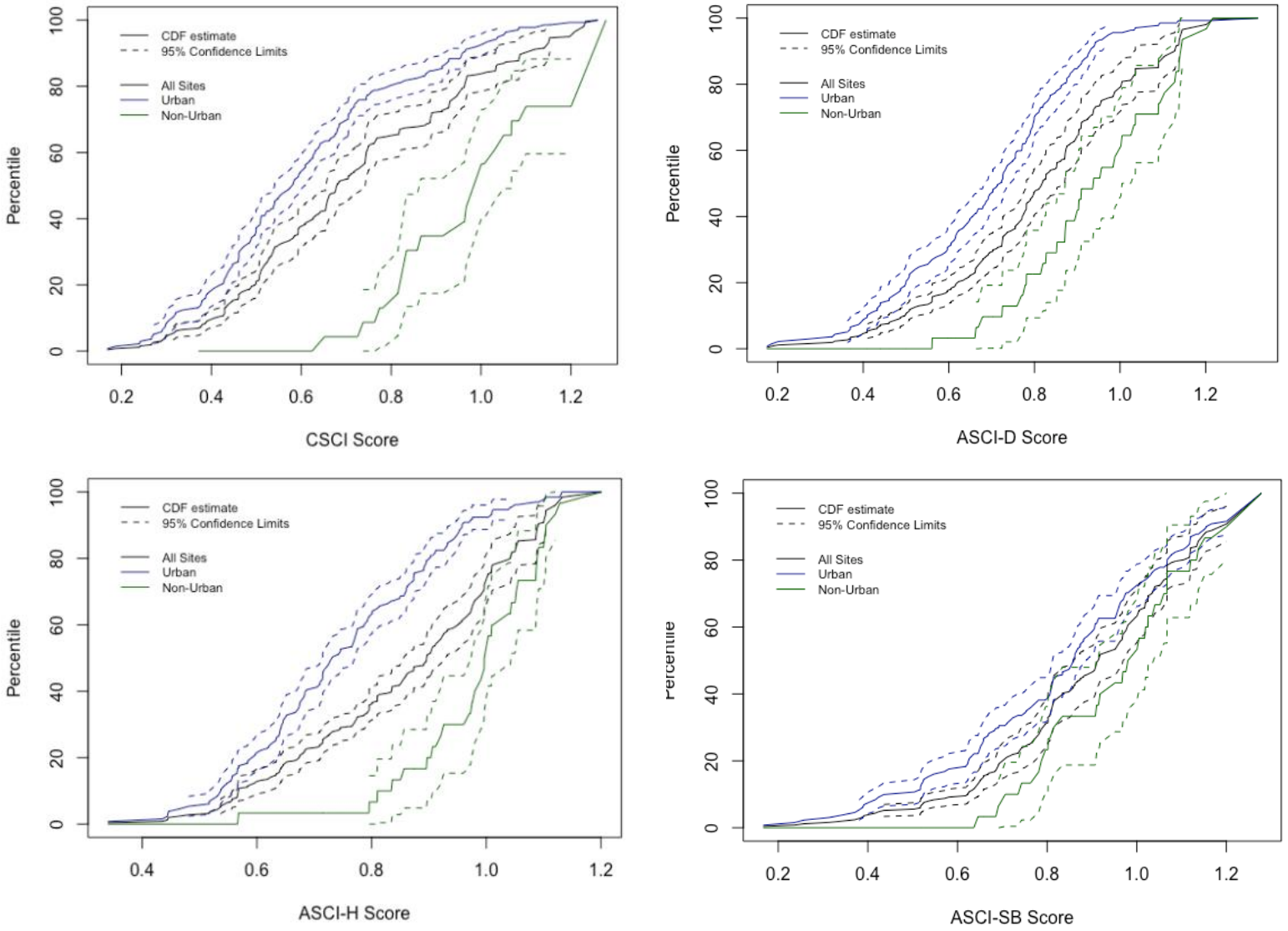


Figure 2.6. Cumulative distribution functions of CSCI, ASCI-D, ASCI-H and ASCI-SB scores in Santa Clara County (n = 168) based on WYs 2012-2019 data.

To further evaluate biological conditions on the watershed and subwatershed scales, biological condition scores were grouped into thirteen different hydrological areas, including major watershed (e.g., Stevens Creek), subwatershed (e.g., Upper Penitencia Creek), combination of subwatersheds (e.g., Silver, which is a combination of Upper Silver and Lower Silver Creeks including Thompson Creek) or portion of major watershed (e.g., Upper Coyote). Several watersheds were not included due to a low number of sampling sites (e.g., Adobe Creek, Permanente Creek). The distribution of CSCI and ASCI-H scores are presented for each of the thirteen hydrological areas in Figures 2.7 and 2.8, respectively. Figure 2.9 shows the proportion of each condition category for the four biological indices (CSCI, ASCI-D, ASCI-SB, ASCI-H) in each of the watershed areas.

The highest median CSCI scores occurred in Upper Penitencia, Guadalupe Creek and Saratoga Creek. The lowest CSCI scores occurred in Lower Penitencia, Guadalupe River, Coyote Creek, Lower and Upper Silver Creeks, and Calabazas Creek. There was very low variability in scores in larger creeks (Coyote Creek and Guadalupe River) and highly urban watersheds (Upper/Lower Silver Creek and Calabazas Creek).

ASCI-H scores grouped by watersheds showed similar patterns to the CSCI scores. Some notable differences were consistently high scores in Saratoga Creek, and generally higher scores compared to CSCI at Los Gatos Creek, Alamitos Creek and Stevens Creek, all of which have impoundments in the upper watershed.

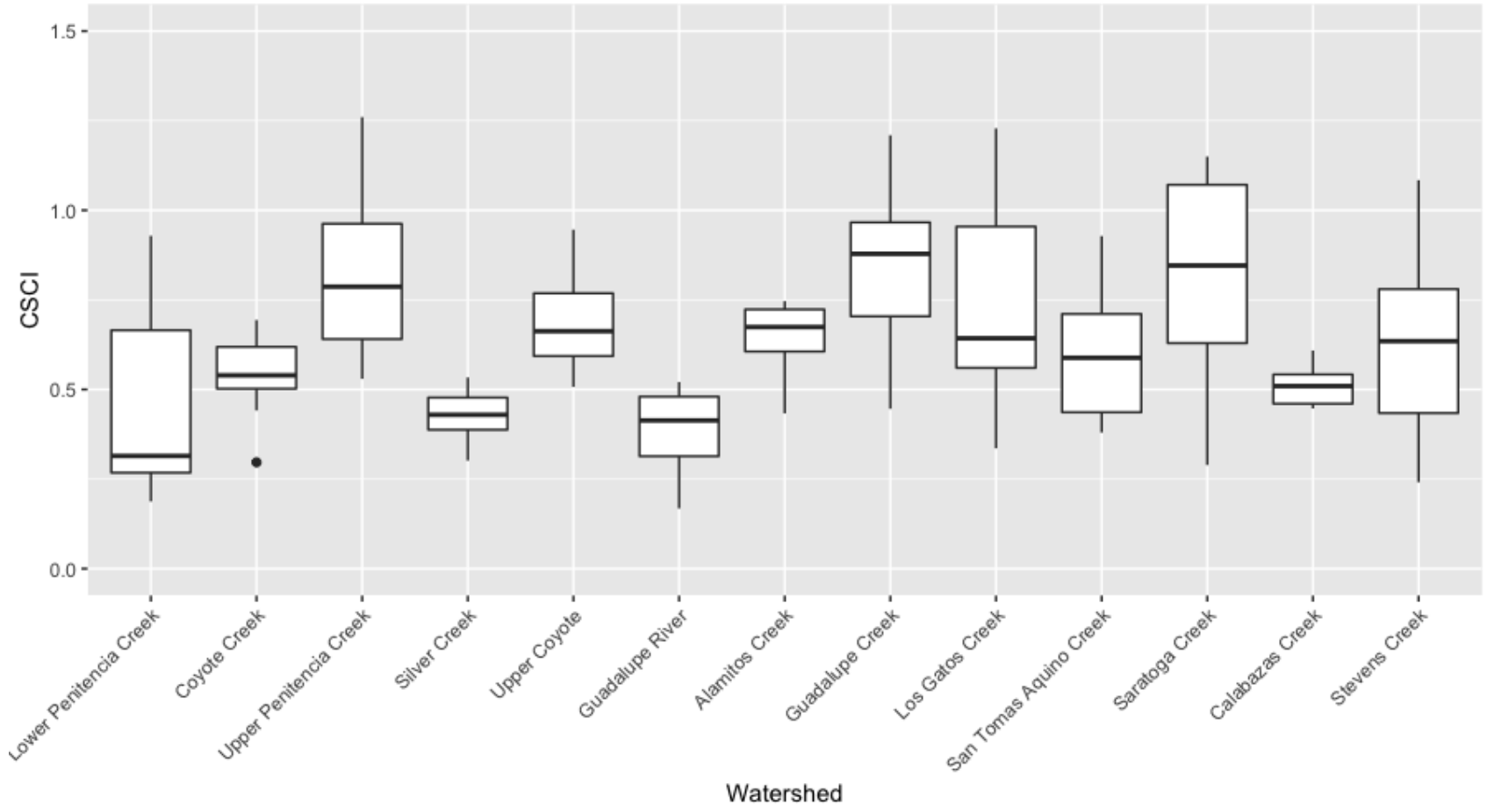


Figure 2.7. Boxplot of CSCI Scores from WY 2012-2019 data, grouped by Watershed.

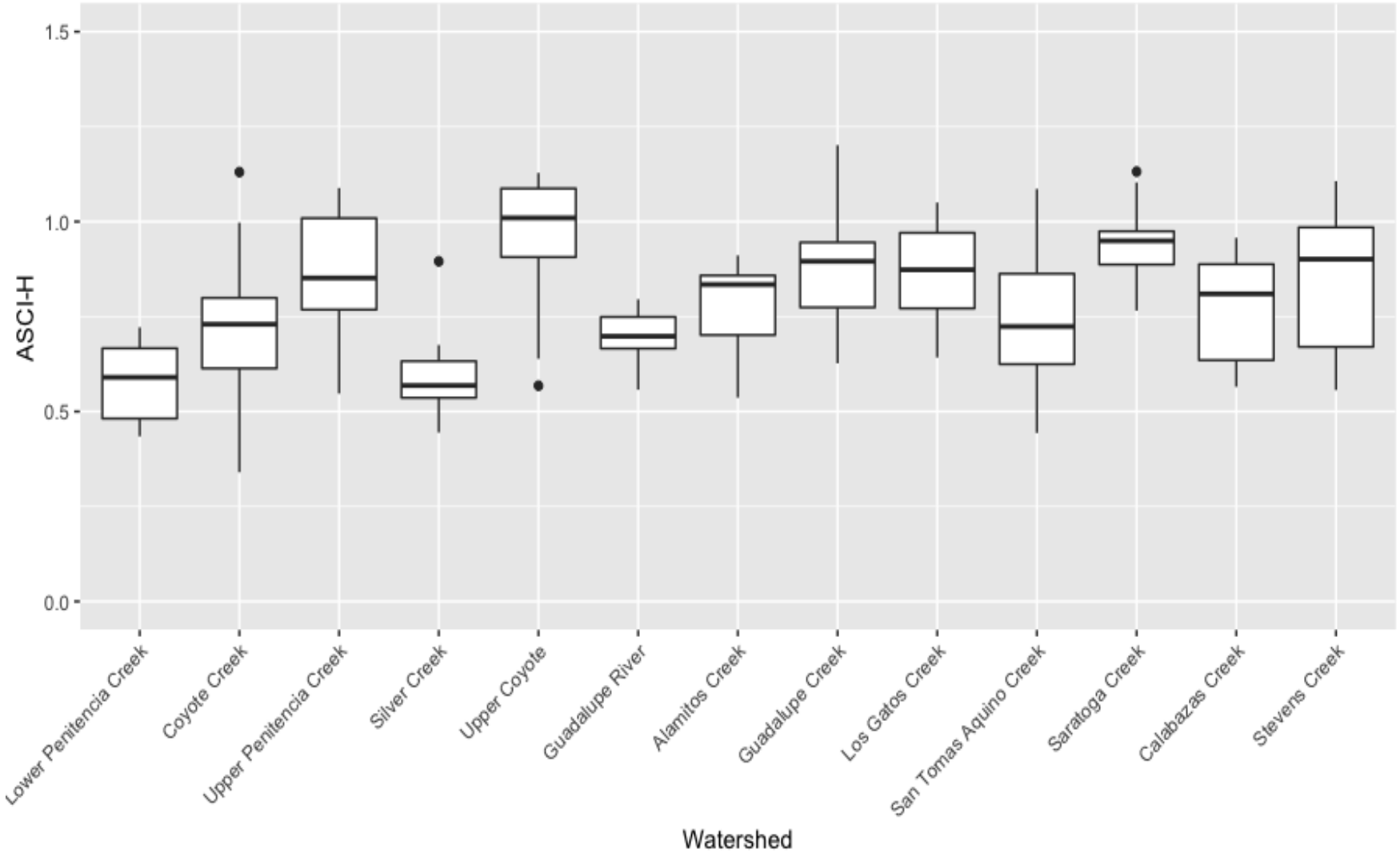


Figure 2.8. Boxplot of ASCI-H Scores from WY 2012-2019 data, grouped by Watershed.



Figure 2.9. All Santa Clara County biological condition scores (WY 2012 – WY 2019) grouped by condition category and watershed (including 4 targeted sites).

2.3.2.3 Stressor Association with Biological Conditions (WY 2012 – WY 2019)

To evaluate the association of stressors with biological condition, Spearman's rank correlation analyses and random forest modeling was performed. The correlation was conducted first to prune the list of 50 potential stressor variables. Twenty-three of the 50 variables exhibited a statistically significant correlation with at least one of the four biological indices (CSCI, ASCI-D, ASCI-SB, ASCI-H). Many of the correlated variables were representative of land use (i.e., road density and urban area). Six variables were related to water quality (e.g., specific conductivity and chloride); and six variables were representative of physical habitat (e.g., boulder density, percent reach smaller than sand, and combined human disturbance index)

Spearman's rank correlation analyses were also performed to evaluate stressors that may differ on a watershed scale. CSCI and the ASCI-H were prioritized for this comparison because they exhibited the best correlation statistics when data were pooled. The results of this analysis suggest that correlations vary greatly among watersheds:

- Biological condition in Coyote Creek, San Tomas Aquino Creek, Saratoga Creek, and Lower/Upper Penitencia Creek was most closely associated with several physical habitat and landscape factors.
- Biological condition in Stevens Creek and Upper Coyote was associated with water quality variables but not with landscape factors. Stevens Creek exhibited one of the highest correlation coefficients between ASCI-H scores and total nitrogen concentration.
- Biological condition in Guadalupe River, Los Gatos Creek, and Silver Creek did not exhibit strong correlations (> 0.8) with any variables.
- Total nitrogen and Total Kjeldahl Nitrogen (TKN) never correlated with CSCI scores at any of the watershed groupings.

The prioritized list of 23 variables was used in random forest model development for CSCI and ASCI-H. Random forest model results indicated similar predictor variables associated with CSCI and ASCI-H index scores. The random forest models showed that 70% of the variability in CSCI scores could be explained with eight predictor (stressor) variables; whereas, only 65% of the variability ASCI-H scores could be explained with the same number of predictors.

The CSCI random forest model indicated that percent boulders and watershed grouping[18] were the two largest contributors to the variance in CSCI scores, followed by a combination of land use and general water quality variables (Table 2.11). The ASCI-H random forest model indicated that three landscape variables, one habitat variable, and three water quality variables (AFDM, total nitrogen and chloride) were the largest contributors to variance in ASCI-H scores (Table 2.12). Overall, landscape variables (e.g., percent impervious in 5k area) were the most important stressor variables for both CSCI and ASCI-H (see Section 2.3.2.4 or more discussion on urban influence on biological conditions).

[18] Indicates that the relationship of index scores to stressors is not independent of watershed (i.e. they would have different slopes/intercept).

Table 2.11. Summary statistics for the CSCI random forest model. Ranking of top eight most influential predictor variables are colored according to: physical habitat (green), land use (orange), and water quality (blue).

Stressor Variable	% Increase MSE	Increase Node Purity
Percent Boulders (> 0.25m)	16.9	0.50
Watershed Strata	15.4	0.65
Chloride	14.8	0.61
Percent Impervious Areas in 5km (PctImp_5K)	14.5	0.47
Specific Conductivity	13.6	0.35
Road Density in Watershed (RdDen_W)	13.3	0.41
Percent Impervious Area of Reach (PctImp)	12.2	0.41
Percent Urban Area of Reach (PctUrb)	12.1	0.41

Table 2.12. Summary statistics for the ASCI-H random forest model. Ranking of top eight most influential predictor variables are colored according to: physical habitat (green), land use (orange), and water quality (blue).

Stressor Variable	% Increase MSE	Increase Node Purity
Road Density in Watershed (RdDen_W)	16.6	0.45
Ash Free Dry Mass (AFDM)	14.9	0.30
Total Nitrogen (TotalN)	14.7	0.30
Chloride	13.7	0.35
Percent Smaller than Sand (PctSmallSand)	13.0	0.27
Percent Impervious Area in 5km (PctImp_5K)	12.7	0.30
Percent Urban Area in 5km (PctUrb_5K)	11.7	0.30
Watershed Strata	9.5	0.42

The stressor analysis of biological condition in Santa Clara County streams using BMIs (CSCI scores) and algae (ASCI scores) has shown that both types of assemblages correlate with landscape factors, as well as unique sets of water quality and habitat stressors. It should be acknowledged that despite these apparent relationships to stressors, these analyses do not determine causation, particularly as stressors from habitat/landscape factors are often present at the same sites that exhibit water quality impairment.

Comparison of Santa Clara Stressor Assessment to RMC Regional Assessment

The analyses of stressor data association for Santa Clara bioassessment sites was similar to findings in the RMC Five-Year Bioassessment Report (BASMAA 2019). Regional biological condition, based on CSCI scores, was strongly associated with physical habitat variables and land use within the vicinity of the site. The percent of the land area within a 5 km radius of a site that is impervious appears to have the strongest relationship to CSCI scores based on the regional random forest model results. Regional biological condition, based on an algae diatom index, was moderately correlated with water quality variables, and less associated with physical habitat or landscape variables (note: the algae index used for the RMC report was different than the ASCI index used in this report).

However, the RMC report showed that nutrient variables (e.g., nitrate, total nitrogen, orthophosphate, phosphorus) did not correlate strongly with any of the biological indicator scores in the Bay Area, nor were nutrients ranked as important variables via the random forest model. These results are in contrast to the Santa Clara stressor data analyses which found that total nitrogen did significantly correlate to ASCI-H scores.

2.3.2.4 Biological Conditions in Urban Landscapes

The previous section shows that biological indicator scores appear highly sensitive to urbanization. The Spearman's rank correlation and random forest analyses of stressor association with biological conditions indicated that percent impervious area has the strongest relationship with both CSCI and ASCI-H scores. (Figure 2.10).

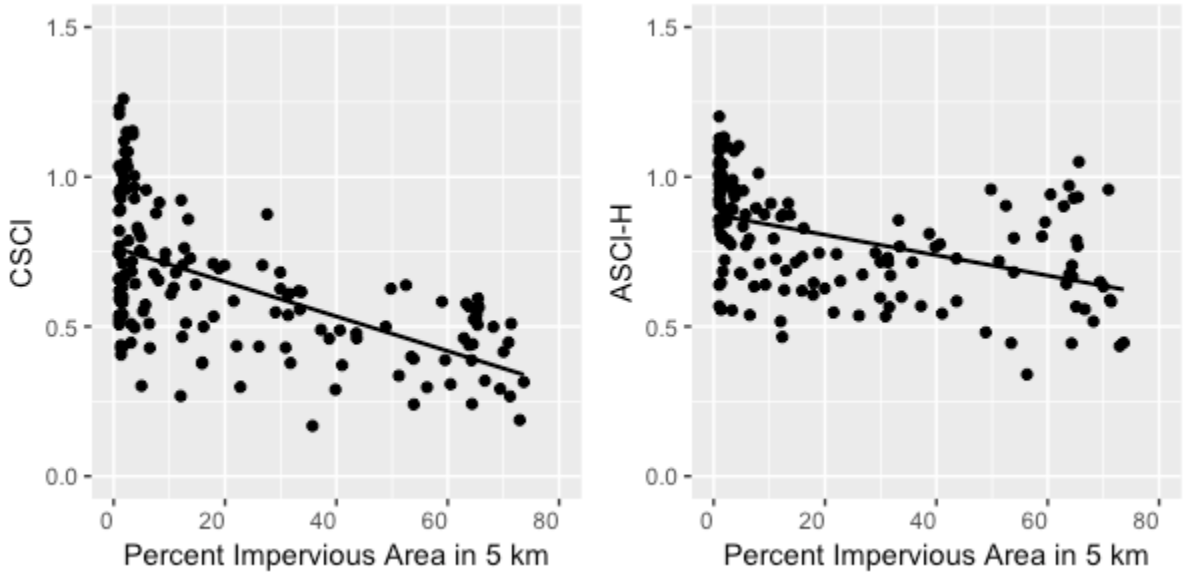


Figure 2.10. Percent Impervious Area in 5 km vs. CSCI and ASCI-H scores.

The distribution of CSCI and ASCI-H scores for the 172 bioassessment sites in the Santa Clara Basin, presented as box plots, is shown for three classes of urbanization, represented by percent watershed imperviousness (Figure 2.11). For highly developed watersheds (>10% impervious area), the median CSCI score was about 0.5 and all but three sites were below the MRP trigger (0.795). The variability in CSCI scores was lower at sites in highly developed watersheds, indicating that BMI communities are consistently impacted by stressors associated with urbanization.

Sites with a moderate level of urbanization (3-10%) had a median CSCI score of about 0.7. These sites ranged 0.3 to 1.2 in CSCI scores, indicating a much wider range of stressor impacts associated with urbanization (and other factors). Sites with a low level of urbanization (<3% impervious area) were generally in good biological conditions, with a median CSCI score of about 0.75. However, there were some low scoring sites, indicating non-urban stressors were impacting those sites.

Although, ASCI-H scores were generally higher compared to CSCI scores, they showed similar patterns with urbanization. The median ASCI-H score for highly developed watersheds was 0.68; for moderate levels of urbanization (0.77); and for lower levels of urbanization (0.97). The ASCI-H scores ranged 0.55 to 1.2 at sites in low urbanized watersheds, indicating that non-urban stressors impact biological conditions at some sites.

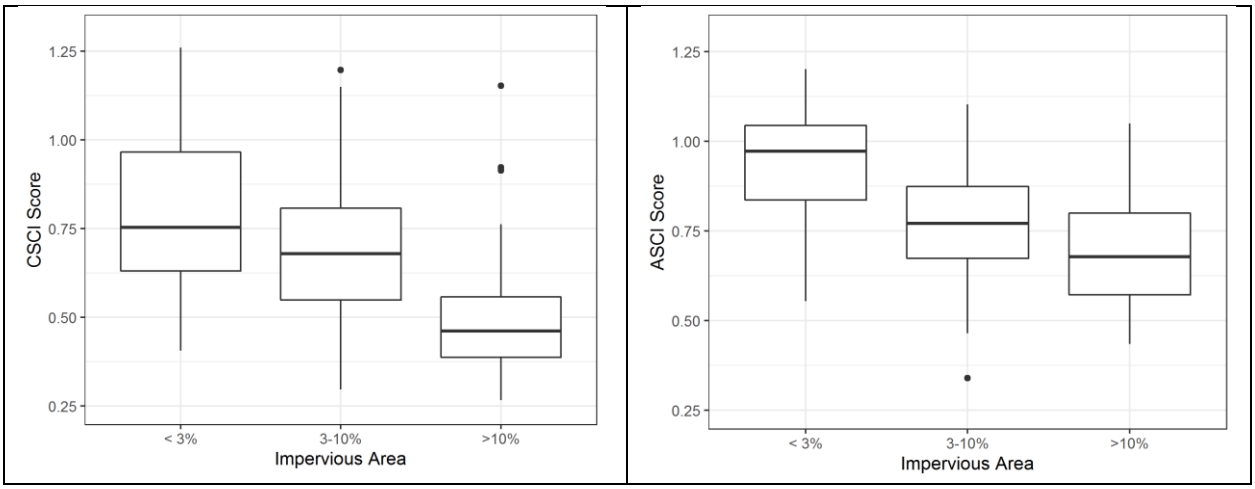


Figure 2.11. Box plots showing the distribution of CSCI and ASCI-H scores for 90 bioassessment sites in the Santa Clara Basin, grouped by three classes of percent watershed imperviousness.

2.3.3 Trend Analysis

This section addresses the third bioassessment monitoring management question presented at the beginning of Section 2.0 (i.e., *What are the long-term trends in water quality in creeks over time?*) by assessing the change in biological condition over several years. Changes in biological condition over time can help evaluate the effectiveness of management actions. For example, control measures, such as green stormwater infrastructure (GSI), implemented to disconnect impervious areas, should result in improved stream condition and water quality. Many of these measures are still in the planning phase and it may take decades to see their benefits. Therefore, more than eight years of data will be required to evaluate trends. In the interim, a preliminary trend analysis is presented using more recent probabilistic data and historic data collected at targeted sites prior to adoption of MRP 1.0.

Figure 2.12 shows the distribution of CSCI scores calculated for urban sites for each year of MRP monitoring (WY 2012 – WY 2019). Over the eight-year monitoring period, biological conditions, based on CSCI scores, have been highly variable at urban sites (median scores ranging 0.4 to 0.7). These results suggest that there is wide range of biological conditions at urban sites, as well as potential variation in conditions due to changes in environmental conditions from year to year (e.g., precipitation, temperature).

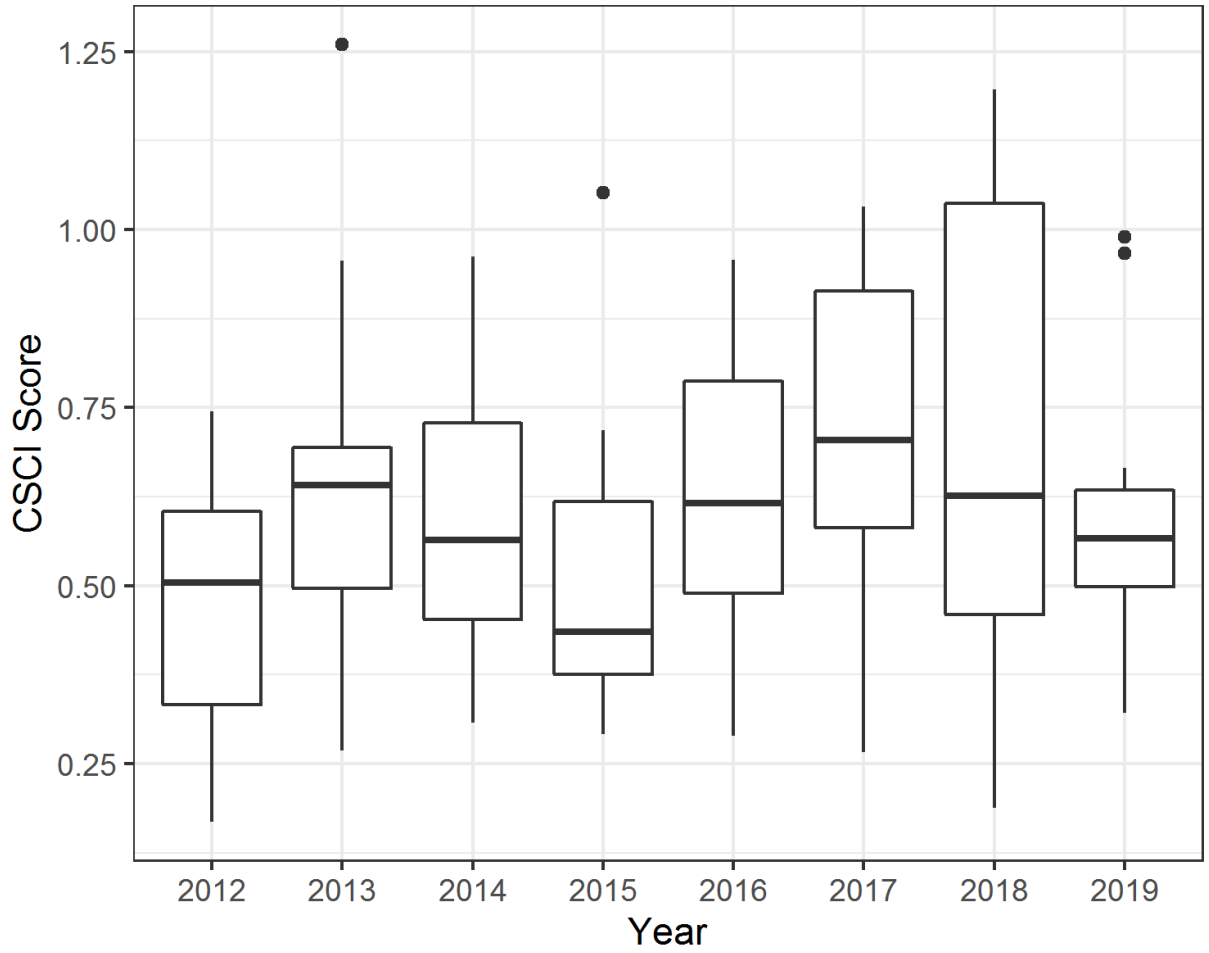


Figure 2.12. Box plots showing the distribution of CSCI scores at urban sites in Santa Clara County, WY 2012 – WY 2019.

Comparison of MRP Data to Historic Data

The Program conducted bioassessments in nine watersheds between 2003 and 2009 as part of watershed assessment and monitoring requirements in its municipal stormwater NPDES Permit (Pre-MRP). There were 76 bioassessment surveys completed in Santa Clara County watersheds during the Pre-MRP time period. The number of sites within each watershed for both Pre-MRP and MRP time periods are shown in Table 2.13.

Bioassessment sampling during the Pre-MRP time period was conducted using the California Stream Bioassessment Protocol (CSBP), a different methodology than the SWAMP Bioassessment Reachwide Protocol which was implemented during the MRP. The CSBP was the standardized methodology developed by California Department Fish and Wildlife for bioassessments conducted in streams throughout California. BMI samples collected using the CSBP method have been shown to produce taxonomic metric scores similar to the SWAMP protocol. In addition, the level of taxonomic identification (SAFIT Level 1+) is consistent for samples collected and analyzed during Pre-MRP and MRP, which allows for a consistent and standard approach to calculate CSCI scores.

Biological conditions based on CSCI scores during the Pre-MRP and MRP time periods were compared for six Santa Clara County watersheds/subwatersheds. The sample time frames were approximately 7-10 years apart. During the Pre-MRP monitoring period, several sites were sampled two consecutive years; the average CSCI score was used for these sites. The distribution of CSCI scores for each watershed, grouped by the Pre-MRP and MRP time periods is shown in Figure 2.13. Median CSCI scores were similar for majority of the watersheds between the two sampling periods, with the exception of Saratoga Creek, with had overall much higher scores during the Pre-MRP sample period. The difference in scores for Saratoga Creek could be explained by different sampling locations in the watershed; the majority of sampling locations in Saratoga Creek during the Pre-MRP were located in the upper reaches, where CSCI scores are expected to be higher.

Table 2.13. Total number of bioassessment surveys conducted by SCVURPPP, grouped by watershed, during Pre-MRP and MRP time periods.

Watershed	Subwatershed Area	Pre-MRP	MRP
Alameda Creek	Upper Alameda Creek	0	6
Lower Penitencia Cr	Lower Penitencia Creek	4	9
Coyote Creek	Coyote Creek Mainstem	12	9
	Upper Penitencia Creek	7	13
	Silver Cr/Thompson Cr	7	11
	Upper Coyote Watershed	0	14
Guadalupe River	Guadalupe River	8	12
	Alamitos Creek	4	11
	Guadalupe Creek	4	9
	Los Gatos Creek	5	19
San Tomas Aquino	San Tomas Aquino	1	14
	Saratoga Creek	7	14
Calabazas Creek	Calabazas Creek	4	7
Permanente Creek	Permanente Creek	6	3
Stevens Creek	Stevens Creek	7	12
Adobe Creek	Adobe Creek	4	3
Matadero Creek	Matadero Creek	4	2
San Francisquito Cr	San Francisquito Creek	0	4
	Total Sites	76	172

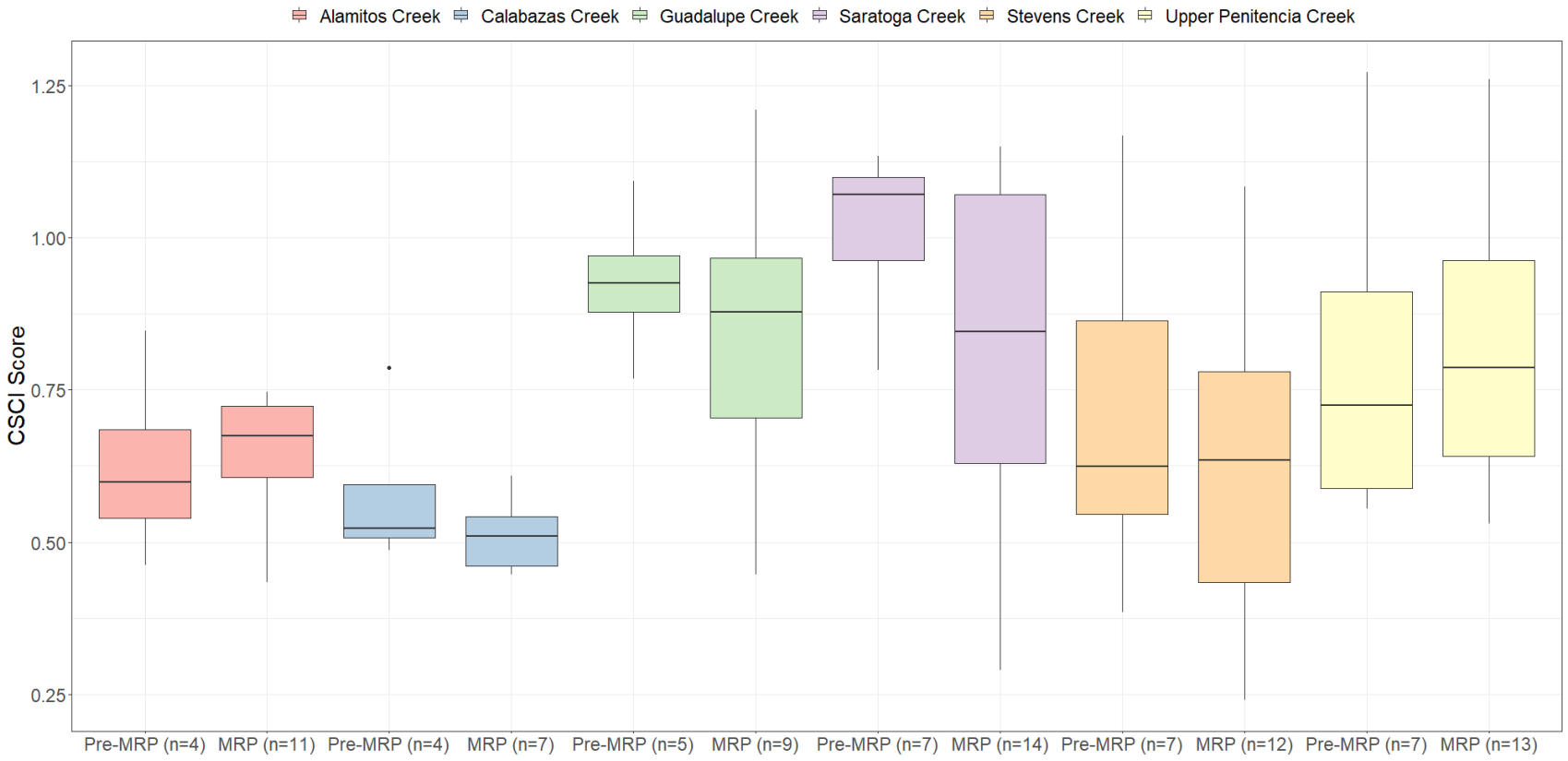


Figure 2.13. Distribution of CSCI scores at sites in six Santa Clara County watersheds that were sampled during Pre-MRP (WYs) and MRP (WYs 2012-2019) time periods.

A comparison of CSCI scores at nine individual sites sampled during the two sampling periods is shown in Table 2.14. Site IDs for pre-MRP and MRP sites vary, but the sites compared for this analysis were generally less than 100 feet apart from each other. Five of the nine sites had very similar scores (< 0.06 points difference). The remaining sites had differences that ranged 0.13 to 0.25 points; of these three sites had lower scores during MRP sampling event and one site had a higher score.

It is important to note that biological condition, based on CSCI scores, can be influenced by many factors that were not evaluated as stressor data. These factors may include the following: timing and magnitude of storm events during sampling index period, variable antecedent conditions (e.g., precipitation, temperature) and changes in management actions (e.g., operations related to water releases from reservoirs or diversions). It is not clear, especially with such a small sample size, what factors might be associated with general temporal trends of improved or reduced biological conditions at these watersheds/sites.

Table 2.14. CSCI scores for bioassessments conducted at nine Santa Clara County sites during two different monitoring periods: Pre-MRP and MRP.

Site	Creek	Date	CSCI
205STE060	Stevens Creek downstream I-680	2006	0.61
205R03235		2017	0.86
205STE070	Stevens Creek at Stevens County Park (below dam)	2006	0.49
205R01187		2014	0.43
205STE070		2019	0.44
205GUA060	Los Gatos Creek at Creekside Way	2009	0.60
205GUA060		2019	0.57
205GUA050	Los Gatos Creek downstream Lincoln Ave	2009	0.57
205R01539		2014	0.58
205GUA330	Arroyo Calero upstream confluence with Alamitos Cr	2009	0.85
205R02422		2016	0.72
205GUA180	Guadalupe River downstream Blossom Hill	2009	0.64
205R00346		2012	0.48
205COY140	Upper Penitencia Creek in Alum Rock Park	2003	1.27
205R00787		2013	1.26
205COY184	Lower Silver Creek at Kammerer Ave	2008	0.54
205R01747		2015	0.37
205COY330	Coyote Creek in Hellyer County Park	2007	0.60
205R00218		2012	0.54

2.4 Considerations for Future Bioassessment Monitoring

The RMC bioassessment dataset provides a comprehensive survey of stream health throughout the San Francisco Bay Area. The probabilistic design allows for an evaluation of ambient stream conditions using biological indicators and stressor data at regional and countywide scales. These data provide stormwater programs with an understanding of existing stream conditions that can assist in the decision-making process for future management actions, as well as baseline conditions that can be re-evaluated over time to assess trends.

The urban sites for most counties within the RMC sample frame will be exhausted (i.e., either sampled or evaluated) following Creek Status Monitoring during WY 2020. As result, the RMC is currently evaluating options for revising the monitoring design to address the Creek Status Monitoring requirements anticipated under MRP 3.0. One of the options under consideration by the RMC is to implement a targeted monitoring design that would focus on specific watersheds or reaches of interest. A watershed approach would provide stormwater programs more flexibility to evaluate priority areas that stakeholders want to improve, protect, or learn more about. The following objectives could be used to guide the monitoring design:

- Address existing problems (e.g., poor biological conditions, water quality issues) at locations where implementation of potential management actions is practical and feasible.
- Evaluate changes in biological conditions and/or water quality at locations that are likely affected by planned management activities.
- Actively monitor and manage areas that are in good condition.

Examples for each of these approaches are provided in section below:

2.4.1 Investigate Sites with Reduced Biological Conditions

The RMC dataset indicates a majority of urban streams are in poor condition. Biological conditions were poor (i.e., lowest two condition categories) at 80% and 75% of the bioassessment sites classified as urban, based on CSCI and ASCI-H scores, respectively. This finding suggests that stressors associated with urban streams (e.g., poor physical habitat, hydromodification) may result in too many constraints to achieve biological conditions that are targeted in the MRP (i.e., greater than CSCI score 0.79). Therefore, stormwater programs may want to focus future monitoring resources on better understanding the biological conditions of urban sites/reaches that have a higher potential for improved conditions due to management actions.

The SCAPE tool (discussed in Section 2.2.4.7) provides a context for evaluating stream health by estimating an expectation of biological condition at a given stream reach relative to landscape constraints. Biological condition, based on CSCI scores, can be compared to the reach expectation. As an example, CSCI scores for 16 sites sampled in Stevens Creek watershed over an eight-year period were compared to the range of scores predicted by the landscape model (Figure 2.14). The predicted range of CSCI scores for these sites fall into three stream classifications: likely constrained (dark red), possibly unconstrained (light blue), likely unconstrained (dark blue). The CSCI scores for bioassessment sites (i.e., Relative Site Score) are represented by either circles or triangles superimposed over the predicted range of CSCI scores estimated by the model. Sites that have CSCI scores higher than model

predictions are depicted by an up-pointing triangle symbol (i.e., “over scoring”); sites with CSCI scores lower than model predictions were depicted by an inverted triangle (i.e., under scoring”).

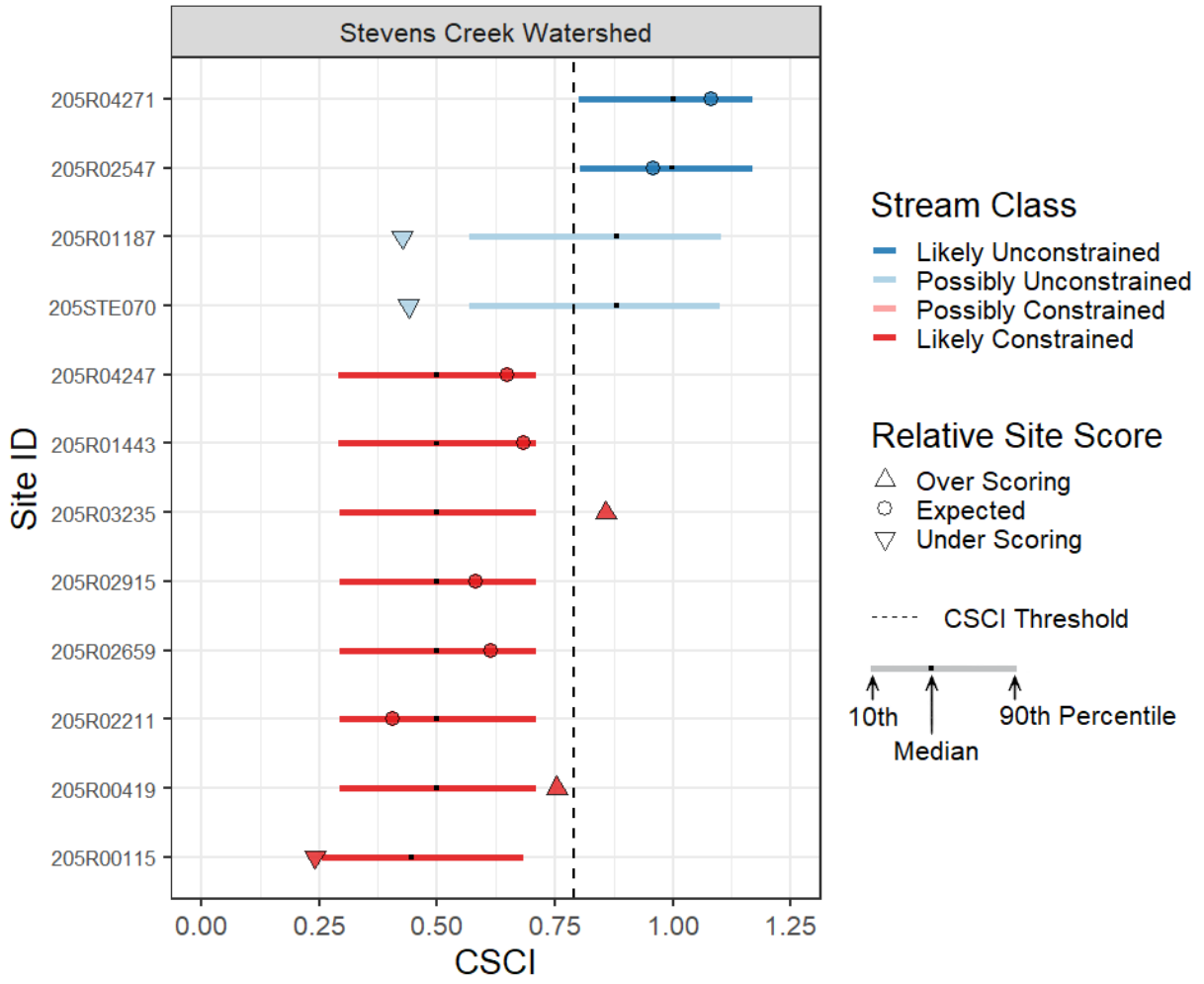


Figure 2.14. Comparison of CSCI scores for 12 sites in the Stevens Creek watershed with predicted model of CSCI scores based on developed landscapes (Beck et al. 2020)

There were three “under scoring” sites in Stevens Creek watershed. Two sites (205R01187 and 205STE070) were below the expected CSCI scores for possibly constrained channel (Figure 2.12). Both of these sites were about half mile downstream of the Stevens Creek dam in Stevens County Park. The third site (205R00115), located upstream of Highway 101, was below the expected score for likely constrained channel. These three sites indicate biological conditions that may have impacts beyond what is predicted from the developed landscape model. These impacts may be associated with physical habitat and water quality issues related to water releases from the reservoir or other factors not associated characteristics included in the model. Follow-up monitoring could be implemented at these sites to evaluate important stressors impacting conditions, and further illuminate management actions that could improve bioligcal condition at these sites.

In addition to the "under scoring" sites, two of the sampling locations in Stevens Creek scored above the expected CSCI score for a likely constrained channel. One site (205R00419) was located at Blackberry Farm (Cupertino), a reach that has recently been restored. The second site (205R03235) was located in highly modified reach downstream of Interstate 280. The highest scoring sites were in likely unconstrained channel within the upper reaches of Stevens Creek in the Monte Bello Open Space District land. Continued monitoring at these sites may provide additional information the importance of restoration projects and other factors when evaluating biological conditions.

2.4.2 Evaluate Sources and Impacts of Potential Stressors

Targeted monitoring design could also focus on sites where bioassessment data exceeded stressor thresholds or water quality objectives. Although not currently a Water Quality Objective or listed as a MRP trigger, nutrient concentrations (e.g., total nitrogen, total phosphorus) and algal biomass indicators (e.g., chlorophyll a) are potential water quality stressors that may impact biological conditions (Sutula et al 2018).

Comparisons of total nitrogen concentrations to CSCI and ASCI-H scores for 172 bioassessment sites sampled in Santa Clara County are presented in Figure 2.15. The random forest model results indicated that total nitrogen was an important stressor contributing to the variability in ASCI-H scores.

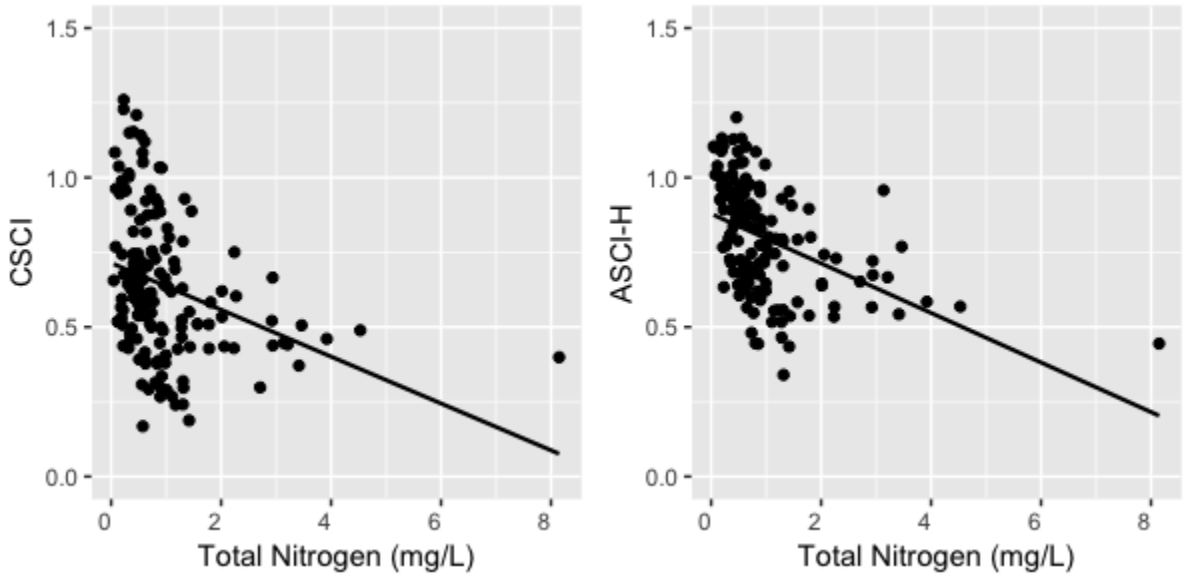


Figure 2.15. Total Nitrogen vs. CSCI and ASCI-H scores for 172 sites in Santa Clara County.

Follow-up monitoring could be conducted to evaluate sites with elevated concentrations of nutrients. Total nitrogen concentrations for 172 bioassessment sites in Santa Clara County are shown in Figure 2.16. There were ten sites that had concentrations of total nitrogen greater than 3.0 mg/L (red symbol on map). Four of the ten sites were in Lower Silver Creek, tributary to Coyote Creek. The Program is currently evaluating sources of nutrients in Lower Silver Creek as part of Stressor Source Identification Project (see Part C of the IMR). Additional studies like the SSID project in Lower Silver Creek may assist with identifying and addressing key water quality stressors via targeted monitoring.

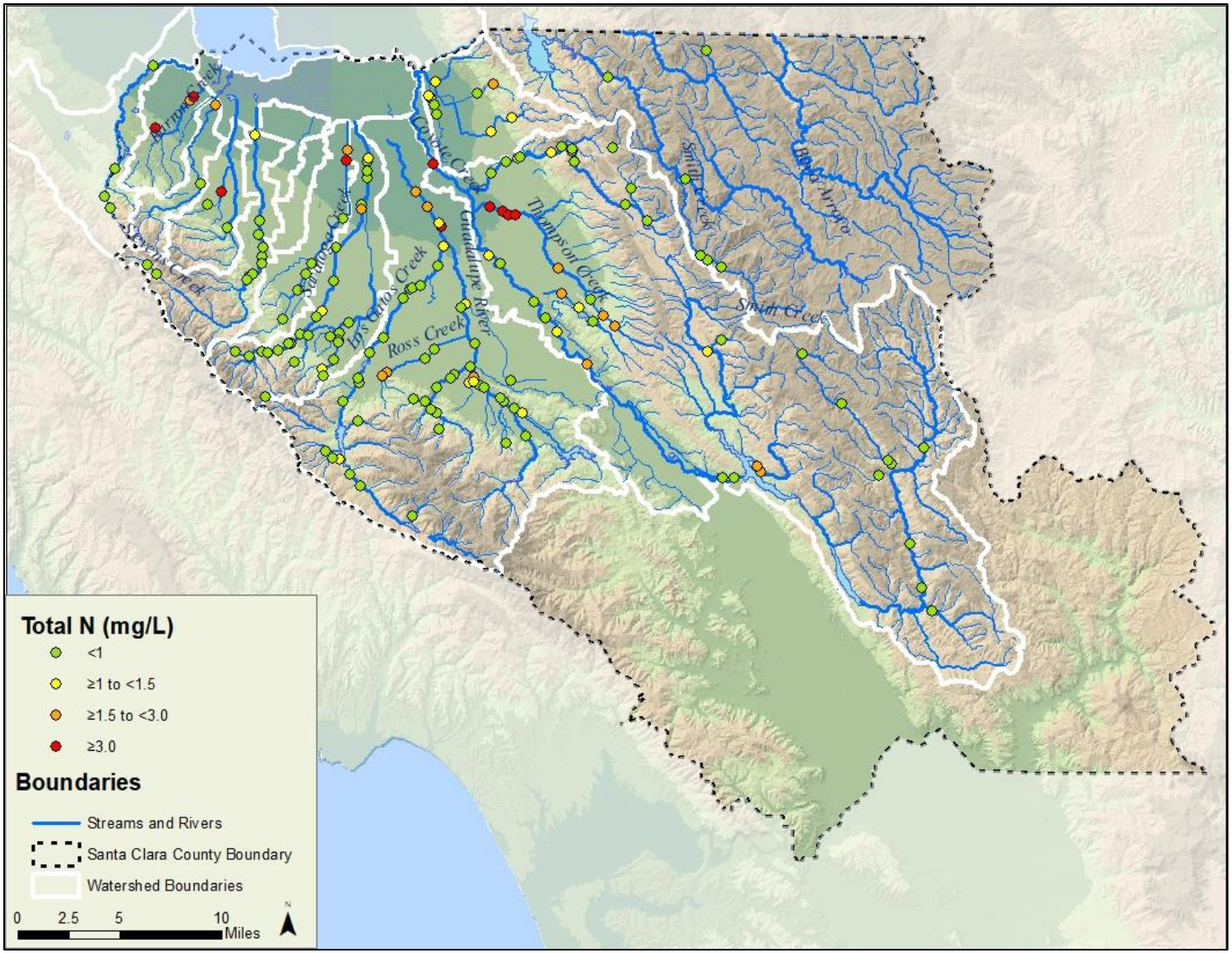


Figure 2.16. Total nitrogen concentrations measured at 172 bioassessment sites in Santa Clara County sampled between WY 2012 and WY 2019.

2.4.3 Evaluate Effectiveness of BMP/Restoration Projects

Bioassessment monitoring could be conducted at stream locations that may be impacted by stream restoration or best management practices (BMPs), such as Green Stormwater Infrastructure (GSI) projects. Benthic macroinvertebrate indicators are often used to evaluate the success of stream restoration projects (Rubin et al. 2017). BMIs can be good indicators that show response to changes in physical habitat, as well as water quality. The CSCI score provides an overall measure of biological conditions, however, individual BMI metrics can provide useful information related to presence or absence of specific stressors (e.g., fine sediment).

The RMC dataset may provide information on baseline conditions at locations where projects are currently planned or recently constructed (see Section 2.3.1.3). Stormwater programs could conduct future bioassessments following the completion of restoration or GSI projects to evaluate if conditions have improved. Effectiveness monitoring should be considered in all restoration projects as one measure of success.

2.4.4 Evaluate Sites in Good Condition

Many of the bioassessment sites sampled by SCVURPP and SWAMP are located in publicly protected lands that have limited or no urban development. Of the 172 bioassessment sites sampled in the Santa Clara Basin between WY 2012 and 2019, 28 received high biological condition scores for both BMI (CSCI > 0.79) and algae (ASCI-H > 0.88) (Figure 2.17). Six of these sites were located on privately-owned lands.[19] The remaining 22 sites were in public lands, including State Parks, County Parks, City Parks, Open Space Districts, and watersheds protected by water utility agencies (e.g., Valley Water, San Francisco Public Utilities Commission,San Jose Water Company).

Stormwater programs should ensure that information on high quality sites is made available to park and land managers so that these areas can be managed in a way that protects stream health and water quality. Follow-up monitoring may also be conducted to evaluate whether biological conditions are changing over time. Trends monitoring at minimally disturbed sites may also provide useful information related to climate change, and its effects on biological conditions in Santa Clara Basin streams.

[19] Field crews obtained permission to access private property to conduct bioassessment sampling.

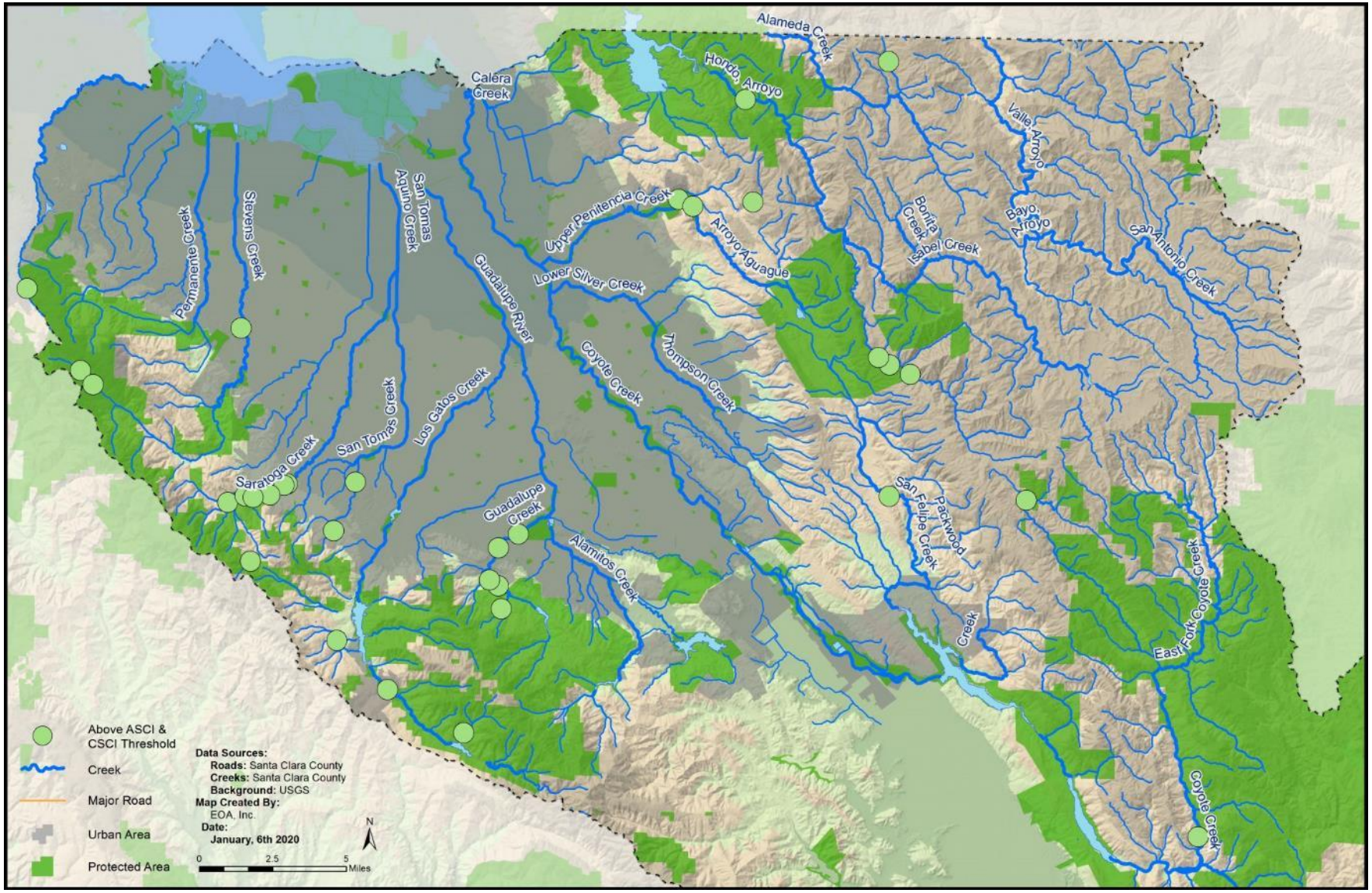


Figure 2.17. Protected areas in Santa Clara County and bioassessment sites with scores in the top two condition categories for CSCI and ASCI-H.

3.0 CONTINUOUS WATER QUALITY MONITORING

3.1 Introduction

This section describes continuous water temperature and general water quality data that were collected during WY 2014 through WY 2019. These parameters were monitored in compliance with Creek Status Monitoring Provisions C.8.c of MRP 1.0 and C.8.d.iii – iv of MRP 2.0. Monitoring was conducted at selected sites using a targeted design based on the directed principle[20] to address the following management questions:

1. *What is the spatial and temporal variability in water quality conditions during the spring and summer season?*
2. *Do general water quality measurements indicate potential impacts to aquatic life?*

The first management question is addressed primarily through evaluation of water quality results in the context of existing aquatic life uses. Temperature and general water quality data were evaluated for potential impacts to different life stages and overall population of fish community present within monitored reaches.

The second management question is addressed primarily through the evaluation of targeted data with respect to water quality objectives and thresholds from published literature. Sites where exceedances occur may indicate potential impacts to aquatic life or other Beneficial Uses and are considered as candidates for future Stressor/Source Identification projects.

The sections below summarize methods and results from continuous temperature and water quality monitoring conducted in WY 2014 – WY 2019. Conclusions and recommendations for continuous monitoring are presented in Section 7.0.

3.2 Methods

In compliance with MRP 1.0 and MRP 2.0, temperature was monitored at a minimum of eight sites each year, and general water quality was monitored at three sites each year. Continuous temperature and water quality data were collected in accordance with SWAMP-comparable methods and procedures described in the BASMAA RMC SOPs (current version is BASMAA 2016a) and associated QAPP (current version is BASMAA 2016b). Data were evaluated with respect to MRP 1.0 provision C.8.c and MRP 2.0 provision C.8.d triggers for each parameter.

3.2.1 Continuous Temperature

Digital temperature loggers (Onset HOBO Water Temp Pro V2) were programmed to record data at 60-minute intervals. The loggers were deployed at targeted sites from April through September. Procedures used for calibrating, deploying, programming and downloading data are described in RMC SOP FS-5 (BASMAA 2016a). SCVURPPP typically deploys temperature loggers at more than the minimum number of sites in anticipation of field equipment being stolen or washed downstream.

[20] 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."

3.2.2 Continuous General Water Quality

Water quality monitoring equipment recording dissolved oxygen, temperature, conductivity, and pH (YSI 6600 data sondes) were programmed to record data at 15-minute intervals. The sondes were deployed at targeted sites for two 1 to 2-week events each year: spring season (Event 1) and late-summer season (Event 2). Procedures for calibrating, deploying, programming and downloading data are described in RMC SOP FS-4 (BASMAA 2016a).

3.2.3 Data Evaluation

Continuous temperature and water quality data are analyzed and evaluated to identify potential stressors that may be contributing to degraded or impacted biological conditions, including exceedances of WQOs. The relevant trigger criteria for continuous temperature and water quality data are listed in Table 3.1. Sites with continuous monitoring results exceeding the trigger criteria are identified as candidate SSID projects.

Table 3.1. Water Quality Objectives and trigger thresholds used for evaluation of continuous temperature and water quality data.

Monitoring Parameter	Objective/Trigger Threshold	Units	Source
Temperature	Two or more weekly average temperatures exceed the MWAT threshold of 17.0°C for a Steelhead stream, or when 20% of the results at one sampling station exceed the instantaneous maximum of 24°C.	^{o}C	MRP 2.0 provision C.8.d.iii Sullivan et al. 2000
General Water Quality Parameters	20% of results at each monitoring site exceed one or more established standard or threshold - applies individually to each parameter		
Conductivity	2000	µS/cm	MRP 2.0 provision C.8.d.iii
Dissolved Oxygen	WARM < 5.0, COLD < 7.0	mg/L	SF Bay Basin Plan Ch. 3, p. 3-4
pH	> 6.5, < 8.5 [1]	pH	SF Bay Basin Plan Ch. 3, p. 3-4
Temperature	Same as Temperature (See Above)		

[1]. Special consideration will be used at sites where imported water is naturally causing higher pH in receiving waters.

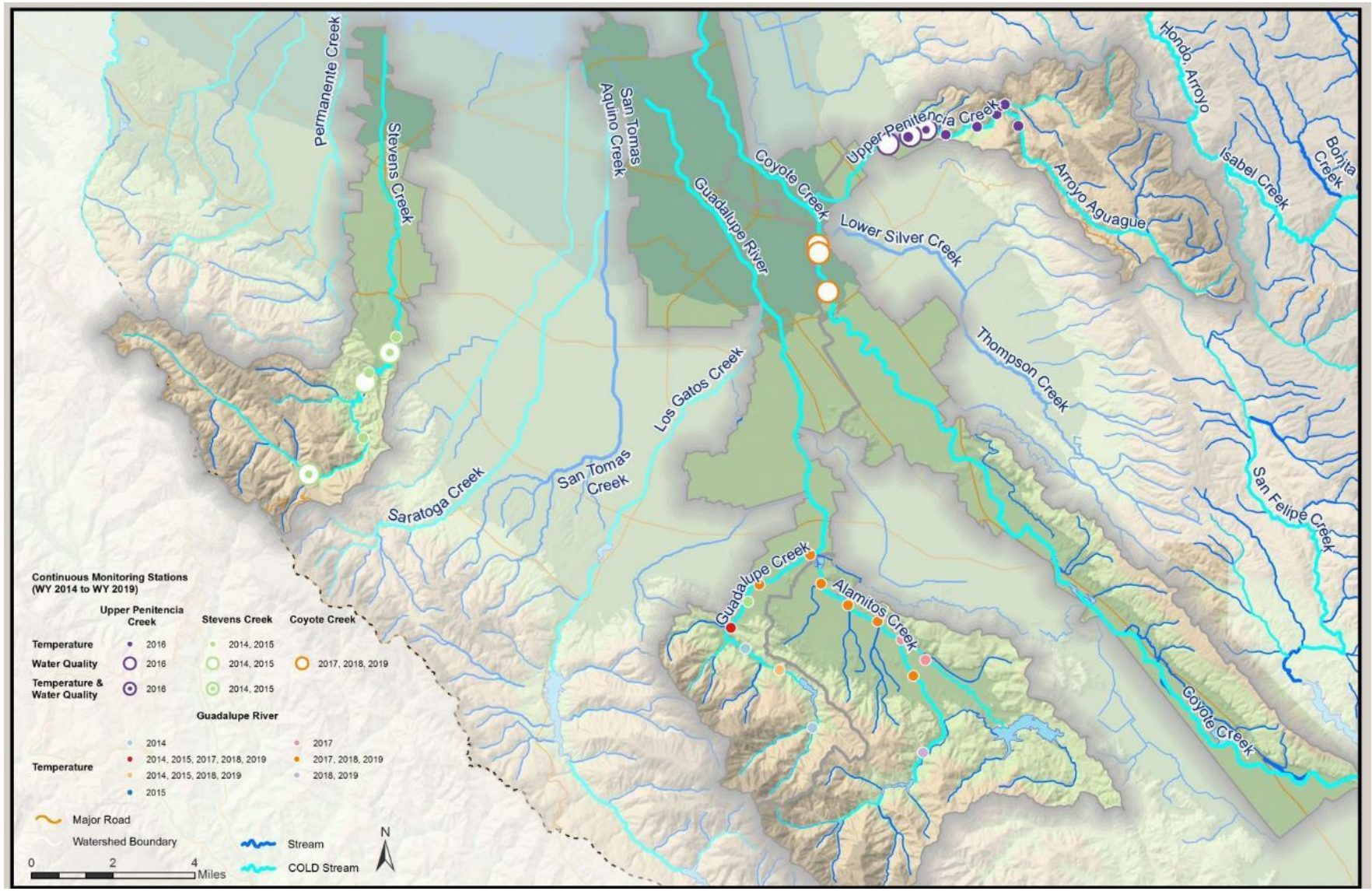


Figure 3.1. Continuous temperature and water quality monitoring stations, Santa Clara Basin, WY 2014 – WY 2019.

3.3 WY 2014 – WY 2019 Overview

Continuous temperature and water quality monitoring sites were selected based on the presence of significant fish and wildlife resources as well as historical and/or recent indications of water quality concerns. The same sites were often monitored for multiple years to gain a better understanding of the range of water quality conditions that may occur over time. In some years, continuous monitoring data were used to support or follow-up on SSID investigations.

Figure 3.1 illustrates the stations and watersheds where continuous temperature and water quality monitoring was conducted during WY 2014 through WY 2019. For reference, Figure 3.1 shows which creeks are designated in the Basin Plan as having COLD Beneficial Uses. Continuous monitoring stations were focused at stream reaches within Stevens Creek Watershed (WY 2014 – WY 2015), Upper Penitencia Creek Watershed (WY 2016), Coyote Creek Watershed (WY 2017 – WY 2019; water quality sondes only), and Guadalupe River Watershed (WY 2014 – WY 2015 and WY 2017 – WY 2019; temperature only).

The sections below summarize monitoring results from WY 2014 – WY 2018. Details are available in the respective UCMRs (SCVURPPP 2015, 2016, 2017, 2018, and 2019). Results from WY 2019 continuous monitoring are detailed in this IMR in Section 3.4.

3.3.1 Stevens Creek Watershed (WY 2014 – WY 2015)

Continuous general water quality data (dissolved oxygen, specific conductance, pH, and temperature) were recorded at three locations in the Stevens Creek watershed (Figure 3.1). during two two-week deployments in WY 2014 and WY 2015 (four total events) (SCVURPPP 2015 and SCVURPPP 2016). Two of the sampling stations were located at WY 2014 probabilistic bioassessment sampling locations within the urban area below Stevens Creek Reservoir. These locations were selected to provide water quality data in a reach that supports both rearing and spawning habitat for the existing steelhead population. The third sampling location was established near the urban boundary approximately three miles upstream of the Stevens Creek Reservoir. The upper station was selected to provide water quality data in a perennial reach of the creek upstream of reservoir influence.

Overall, general water quality conditions measured in Stevens Creek during the four monitoring events were supportive of COLD Beneficial Uses. No triggers for specific conductance or pH were exceeded during the spring and late-summer monitoring events in either year. In WY 2014, dissolved oxygen concentrations were notably lower at the stations below the reservoir compared to the station above the reservoir and the trigger was exceeded (> 20% of results were below 7 mg/L). However, in WY 2015, no dissolved oxygen triggers were exceeded, suggesting that low dissolved oxygen conditions below the reservoir do not occur every year and may be associated with, climatic variations, reservoir operations, or ambient water quality conditions in the reservoir. In general, dissolved oxygen was higher in the spring compared to late summer when water temperatures were warmer. Temperatures rarely exceeded the 24°C acute threshold for salmonids; however, the maximum weekly average temperature (MWAT) threshold of 17°C was exceeded at the stations below the reservoir during the late summer event in both years.

3.3.2 Stevens Creek/Guadalupe Creek Temperature Comparison (WY 2014 – WY 2015)

In WY 2014 and WY 2015, temperature logging devices were deployed from April through September at five stations in the Stevens Creek Watershed (two above and three below the reservoir) and five stations in the Guadalupe Creek Watershed (one above and four below the

reservoir) (SCVURPPP 2015 and SCVURPPP 2016). The logger installed above the Guadalupe Reservoir was not found or retrieved in WY 2015. Median water temperatures were generally coolest at the sites directly below the reservoirs, gradually increasing at each site in the downstream direction. The maximum instantaneous trigger threshed of 24°C was not exceed at any station in either year. However, the MWAT trigger of 17°C was exceeded at multiple stations downstream of the reservoirs in both creeks.

3.3.2 Upper Penitencia Creek Watershed (WY 2016)

In WY 2016, all continuous monitoring was conducted in the Upper Penitencia Creek watershed. Reaches within Alum Rock Park, in the upper watershed, are perennial and support both rearing and spawning habitat for steelhead, as well as other native fishes (Stillwater 2006). The lower watershed is characterized by urban development, unconfined geology conducive to infiltration, and seasonal flows that are supplemented by releases of imported water from the Robert Gross Percolation Ponds, operated by Valley Water. Pond releases typically begin after the lower watershed has ceased flowing in the spring and persist through late July. The WY 2016 continuous monitoring data were used to support an SSID project in Upper Penitencia Creek by evaluating a range of potential stressors that may cause reduced biological condition. Results from the SSID study are presented in SCVURPPP (2017) and summarized in Part C of this IMR.

Monitoring results from WY 2016 indicate that the upper reaches of Upper Penitencia Creek in Alum Rock Park have temperatures that support juvenile steelhead populations through the dry season. The MWAT (17°C) threshold for steelhead was generally not exceeded at the four upper elevation sites. However, temperatures at the four lower elevation sites do not appear to be optimal for juvenile steelhead rearing habitat.

Continuous water quality data were collected at three locations within Upper Penitencia Creek during a two-week event in April 2016 and a two-week event in June in 2016. Dissolved oxygen and specific conductivity results were generally within ranges supportive of aquatic life. Dissolved oxygen concentrations, however, dropped below WQOs for WARM freshwater habitat at the lowest elevation station, possibly in response to low flow conditions. The MRP trigger for pH was exceeded at two monitoring stations, possibly as a result of water releases from upstream percolation ponds into the creek.

3.4 WY 2017 - WY 2019 Results

3.4.1 Continuous Temperature Study Area (Guadalupe River Watershed)

In WY 2017 – WY 2019, continuous (hourly) water temperature measurements were collected from April through September at locations in the Guadalupe River watershed. In WY 2017, monitoring was conducted in three creeks: Alamitos Creek, Arroyo Calero, and Guadalupe Creek (Figure 3.2). All three creeks are impounded by large dams located at the base of the Santa Cruz Mountains. The temperature monitoring locations were downstream of the reservoirs in reaches flowing through the Santa Clara Valley. The upper watershed areas for these creeks include rangeland and forested land uses within Almaden Quicksilver County Park and the Sierra Azul Open Space Preserve. The lower watershed areas are primarily residential land uses within the City of San José. Guadalupe Creek and Alamitos Creek support spawning and rearing habitat for steelhead, although fish are less abundant in the unshaded, warm section of Guadalupe Creek downstream of Camden Avenue (Smith 2013).

In WY 2018, monitoring in Arroyo Calero at stations 205GUA225 and 205GUA340 was eliminated and two stations, closer to the reservoirs on Guadalupe Creek and Alamitos Creek, were added. These new sites were selected to evaluate water temperatures in reaches closer to the reservoirs. Both reservoirs are owned and operated by Valley Water and are primarily used for water supply, although they also provide some flood protection by containing runoff during the wet season. Releases during the late summer also improve water quality and aquatic habitat conditions in lower reaches of the creeks that would otherwise go dry.

In WY 2019, temperature loggers were deployed at nine sites in the Guadalupe River watershed (Figure 3.2) on April 9, 2019, checked and downloaded on July 3, 2019, and removed on September 19, 2019 (24 weeks).

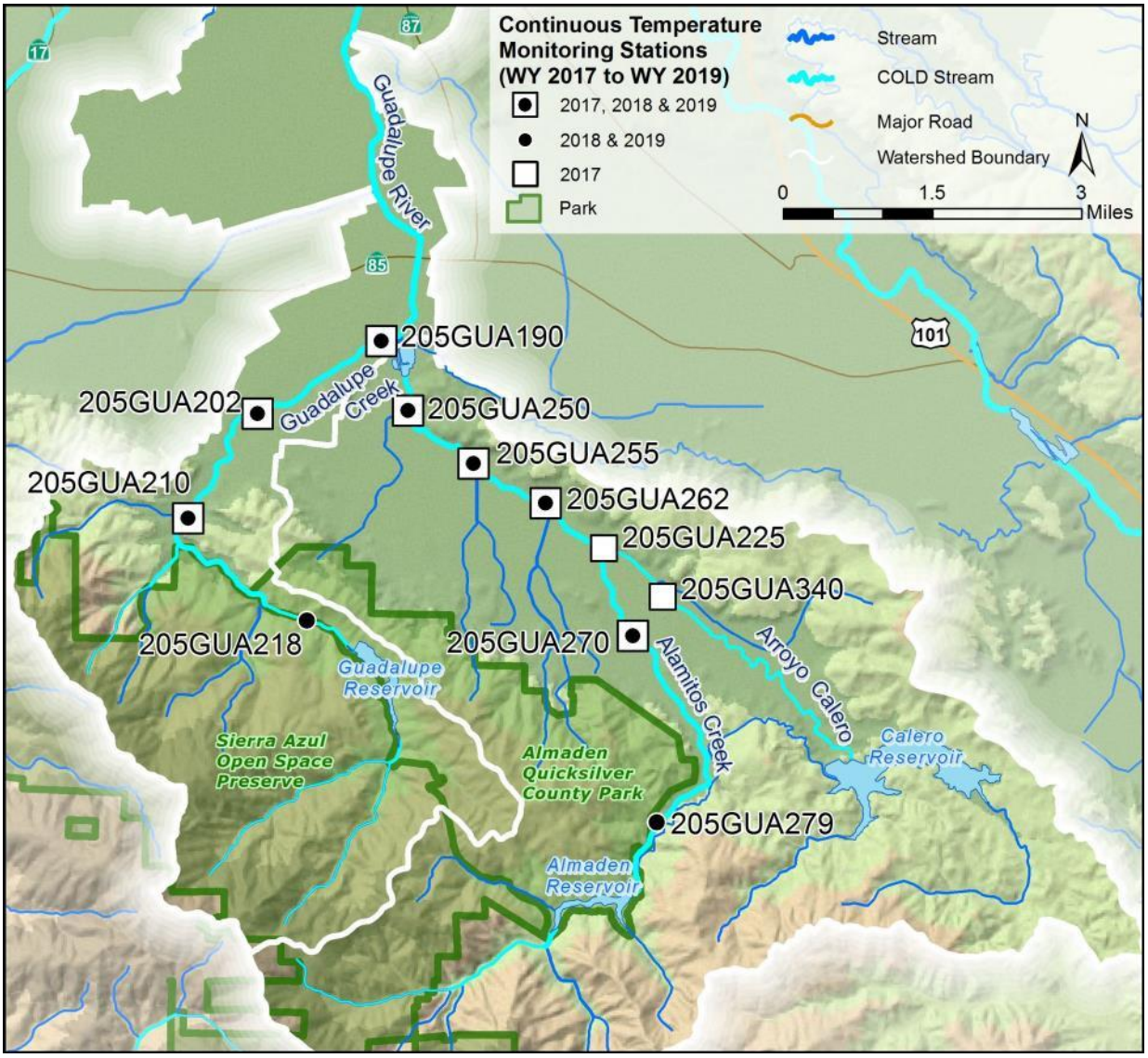


Figure 3.2. Continuous temperature stations in the Guadalupe River watershed, WY 2017 - WY 2019.

3.4.2 Continuous Temperature Results and Discussion

Summary statistics for continuous water temperature data collected at the nine sites monitored in WY 2019 are listed in Table 3.2. The number and percent of measurements from each site that exceed the instantaneous maximum temperature trigger of 24°C is shown in the table. Temperatures greater than 24°C were recorded in Guadalupe Creek at station 205GUA190 (in July and August) and in Alamitos Creek at station 205GUA250 (during the month of August). However, these temperatures comprised <1% of the total measurements recorded. Therefore, the trigger threshold for instantaneous maximum temperature at these sites was not exceeded.

Weekly average temperature values calculated for each of the nine WY 2019 monitoring sites are listed in Table 3.3. Consistent with MRP 2.0 requirements, the values were calculated for non-overlapping, seven-day periods. Weekly average temperatures across all the sites ranged from lows of 11.7°C (205GUA218) to 15.7°C (205GUA250) recorded during the month of April to highs of 20.3°C (205GUA210) to 22.4°C (205GUA218) recorded during the month of September. Similar to the results from WY 2017 and 2018, the MWAT trigger was exceeded in two or more weeks at all sampling locations in WY 2019. As a result, all nine sites were added to the list of potential sites considered for SSID projects.

WY 2017 – WY 2019 instantaneous temperature data (hourly) for monitoring sites in Guadalupe Creek and Alamitos Creek are shown in Figures 3.3 and 3.4, respectively. WY 2019 weekly average temperature values for sites in Guadalupe Creek and Alamitos Creek are shown in Figures 3.5 and 3.6, respectively. These time series figures illustrate how water temperatures generally increase throughout the summer months of June through August followed by a slow decline by mid/late September. Figures 3.3 and 3.4 show the same general pattern for all three years. Minor differences in the general pattern appear to be explained by large fluctuations in air temperature that differ from year to year. For example, the higher water temperatures recorded in September 2017 coincide with a heatwave that exhibited some of the highest air temperatures for that month on record.

Water temperatures were relatively consistent for all three Water Years, with the exception of the station closest to Guadalupe Reservoir (205GUA218) (Figures 3.3 and 3.4). In WY 2019, median temperatures increased in the downstream direction (Table 3.2). Increasing temperatures are likely associated with a reduction of stream shading within the riparian corridor with increasing urbanization. In addition, the influence of groundwater on the valley floor is also likely to cause increases to stream temperature. However, in WY 2018, the upstream-most sites (205GUA218 on Guadalupe Creek and 205GUA279 on Alamitos Creek) had a higher median temperature than stations farther downstream. A possible explanation for the WY 2018 pattern was that that reservoir releases were warmed by solar radiation, but gradually cooled along the shaded riparian corridor before warming again due to urbanization. It is unknown why the pattern differed from WY 2018 to WY 2019.

Table 3.2. Descriptive statistics for continuous water temperature measured from April through September in 2017, 2018, and 2019 at 11 sites in the Guadalupe River watershed, Santa Clara County. N is number of individual measurements.

WY	Creek		Guadalupe Creek (downstream ---------- upstream)				Alamitos Creek (downstream ---------- upstream)					Arroyo Calero (downstream – upstream)	
	Site ID		205GUA190	205GUA202	205GUA210	205GUA218	205GUA250	205GUA255	205GUA262	205GUA270	205GUA279	205GUA225	205GUA340
2017	Start Date		4/3/2017	4/3/2017	4/3/2017		4/3/2017	4/3/2017	4/3/2017	4/3/2017		4/3/2017	4/3/2017
	End Date		9/26/2017	9/26/2017	9/26/2017		9/26/2017	9/26/2017	9/26/2017	9/26/2017		9/26/2017	9/26/2017
	Temperature (ºC)	Min	10.6	10.2	10.2		12	11.6	12.4	11.5		11.6	11.6
		Median	18.8	17.7	17		19.2	19.1	18.5	18.9		18.9	19.2
		Mean	18	17.2	16.7		18.8	18.6	18.4	18.3		18.3	18.5
		Max	26.2	23.8	24.1		24.8	24.6	23.7	24.3		23.4	23.2
		Max 7-day mean	21.1	21.3	21.1		21.2	21.4	21.2	21.9		21.1	21.4
	N		4220	4220	4220		4220	4220	4220	4220		4220	4220
	#/% Measurements		36	0	2		18	6	0	13		0	0
	> 24°C		**1%**	**0%**	**0%**		**0%**	**0%**	**0%**	**0%**		**0%**	**0%**
2018	Start Date		4/5/2018	4/5/2018	4/5/2018	4/5/2018	4/5/2018	4/5/2018	4/5/2018	4/5/2018	4/5/2018	--	--
	End Date		9/27/2018	9/27/2018	9/27/2018	9/27/2018	9/27/2018	9/27/2018	6/25/2018	9/27/2018	9/27/2018	--	--
	Temperature (ºC)	Min	12.3	9.7	8.7	9.6	12.7	11.9	12.0	10.7	--	--	--
		Median	19.0	17.8	17.1	19.1	19.1	18.6	16.6	17.9	--	--	--
		Mean	18.4	17.2	16.7	18.1	18.7	18.5	16.7	17.5	--	--	--
		Max	23.4	22.6	22.6	24.9	23.4	23.4	22.2	22.0	--	--	--
		Max 7-day mean	21.0	21.1	20.4	22.7	21.4	21.3	19.2	20.6	--	--	--
	N		4196	3451	4196	4197	4195	4194	1939	4195	4195	--	--
	#/% Measurements		0	0	0	52	0	0	0	0	0	--	--
	> 24°C		**0%**	**0%**	**0%**	**1%**	**0%**	**0%**	**0%**	**0%**	**0%**	--	--
2019	Start Date		4/9/2019	4/9/2019	4/9/2019	4/9/2019	4/9/2019	4/9/2019	4/9/2019	4/9/2019	4/9/2019	--	--
	End Date		9/19/2019	9/19/2019	9/19/2019	9/19/2019	9/19/2019	9/19/2019	9/19/2019	9/19/2019	9/19/2019	--	--
	Temperature (ºC)	Min	11	10.6	10.3	10.9	13.5	13	12.8	11.7	--	--	--
		Median	18.3	17.3	16.3	15.1	19.5	19.2	18.9	18.4	--	--	--
		Mean	18	17	16.4	16	19.2	18.9	18.6	18	--	--	--
		Max	25.1	22.8	23.1	23.7	24.3	23.7	23.6	22.9	--	--	--
		Max 7-day mean	21	20.4	20.3	22.4	21.4	21.3	21.1	20.6	--	--	--
	N		3913	3911	3911	3911	3910	3911	3910	3911	3912	--	--
	#/% Measurements		23	0	0	0	7	0	0	0	0	--	--
	> 24°C		**1%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	--	--

Table 3.3. Weekly average temperature values for water temperature data collected at nine stations in the Guadalupe River watershed in WY 2019, with summary MRP trigger exceedance results from WY 2017 and WY 2018. Values that exceed MRP trigger (17°C) are indicated in bold.

	Guadalupe Creek (downstream ---------- upstream)				Alamitos Creek (downstream ---------- upstream)				
Station	**205GUA190**	**205GUA202**	**205GUA210**	**205GUA218**	**205GUA250**	**205GUA255**	**205GUA262**	**205GUA270**	**205GUA279**
Date	**Weekly Average Temperature (°C)**								
4/9/2019	13.5	12.8	12.2	11.7	15.7	15.3	15.0	13.9	13.2
4/16/2019	14.4	13.5	12.8	11.9	16.6	16.2	15.8	14.6	13.7
4/23/2019	16.0	14.8	13.8	12.2	**17.9**	**17.5**	16.9	15.7	14.3
4/30/2019	14.8	13.7	12.9	12.0	16.8	16.3	15.9	14.9	14.3
5/7/2019	15.9	14.7	13.8	12.3	**17.7**	**17.3**	16.8	15.8	15.0
5/14/2019	13.7	13.1	12.6	12.0	15.8	15.4	15.3	14.8	15.0
5/21/2019	14.7	13.7	13.1	12.2	16.9	16.5	16.2	15.8	15.7
5/28/2019	16.8	15.4	14.4	12.7	**18.6**	**18.2**	**17.7**	**17.1**	16.3
6/4/2019	**17.6**	15.9	14.6	12.8	**19.2**	**18.6**	**18.1**	**17.9**	16.8
6/11/2019	**18.8**	**17.0**	15.6	13.5	**19.6**	**19.0**	**18.5**	**18.9**	**17.4**
6/18/2019	**18.8**	**17.0**	15.8	14.3	**19.7**	**19.2**	**18.8**	**18.7**	**17.5**
6/25/2019	**17.8**	16.4	15.5	14.9	**19.0**	**18.6**	**18.3**	**17.9**	**17.5**
7/2/2019	**18.3**	16.9	16.2	15.7	**19.5**	**19.0**	**18.8**	**18.3**	**17.9**
7/9/2019	**19.6**	**18.2**	**17.4**	16.8	**20.2**	**19.8**	**19.6**	**19.2**	**18.6**
7/16/2019	**20.0**	**18.6**	**17.9**	**17.6**	**20.4**	**20.1**	**19.8**	**19.4**	**18.9**
7/23/2019	**20.8**	**19.4**	**18.5**	**18.2**	**21.0**	**20.7**	**20.4**	**20.1**	**19.4**
7/30/2019	**19.7**	**19.0**	**18.5**	**18.6**	**20.7**	**20.5**	**20.3**	**19.7**	**19.6**
8/6/2019	**19.8**	**19.2**	**18.8**	**19.4**	**20.8**	**20.6**	**20.5**	**19.7**	**19.9**
8/13/2019	**20.5**	**20.0**	**19.6**	**20.2**	**21.3**	**21.1**	**21.0**	**20.3**	**20.2**
8/20/2019	**21.0**	**20.4**	**20.2**	**20.8**	**21.4**	**21.3**	**21.1**	**20.6**	**20.6**
8/27/2019	**20.9**	**20.3**	**20.3**	**21.5**	**21.3**	**21.2**	**21.0**	**20.4**	**20.8**
9/3/2019	**20.0**	**19.9**	**20.3**	**22.2**	**20.7**	**20.7**	**20.6**	**19.8**	**20.8**
9/10/2019	**19.9**	**19.8**	**20.3**	**22.4**	**20.6**	**20.5**	**20.5**	**19.7**	**21.1**
9/17/2019	**18.3**	**18.5**	**19.2**	**21.8**	**19.5**	**19.5**	**19.6**	**18.6**	**20.7**
2019 Total Weeks	24	24	24	24	24	24	24	24	24
Number >17°C	16	13	11	10	19	19	17	17	15
% Exceed	67%	54%	46%	42%	79%	79%	71%	71%	63%
> MRP Trigger	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
WY 2018 > 17°C	18	11	12	17	19	19	5	16	15
% Exceed	69%	52%	46%	65%	73%	73%	42%	62%	58%
WY 2017 > 17°C	17	15	15	18	20	19	19	18	18
% Exceed	65%	58%	58%	69%	77%	73%	73%	69%	69%

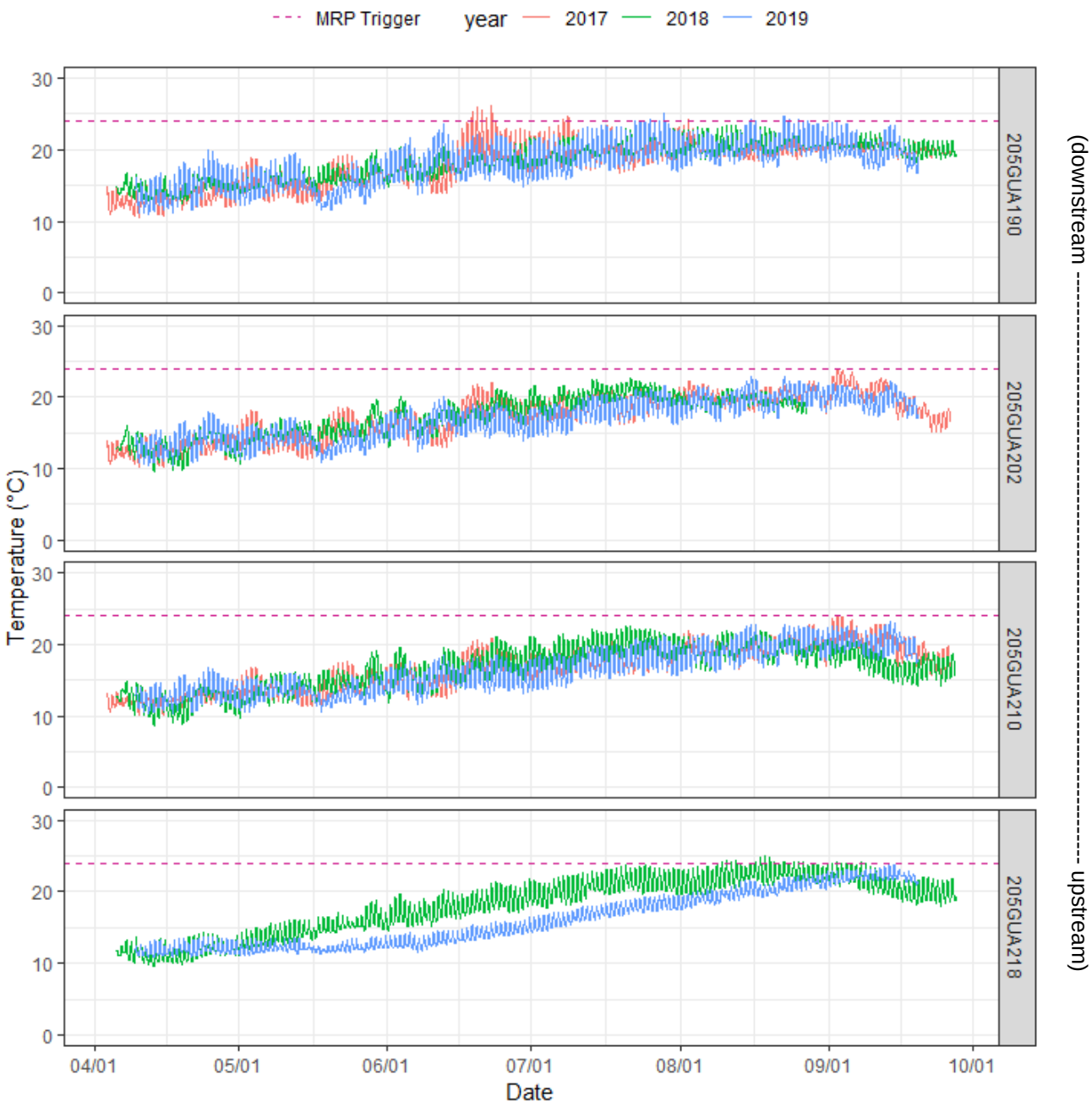


Figure 3.3. Continuous water temperature collected between April and September at four sites in Guadalupe Creek during WY 2017, WY 2018 and WY 2019.[21]

[21] Datalogger at site 205GUA202 malfunctioned at the end of August 2018 with an abrupt jump in temperature from approximately 17 to 20°C with no diurnal variability; these records were excluded. Site 205GUA218 was not monitored in WY 2017.

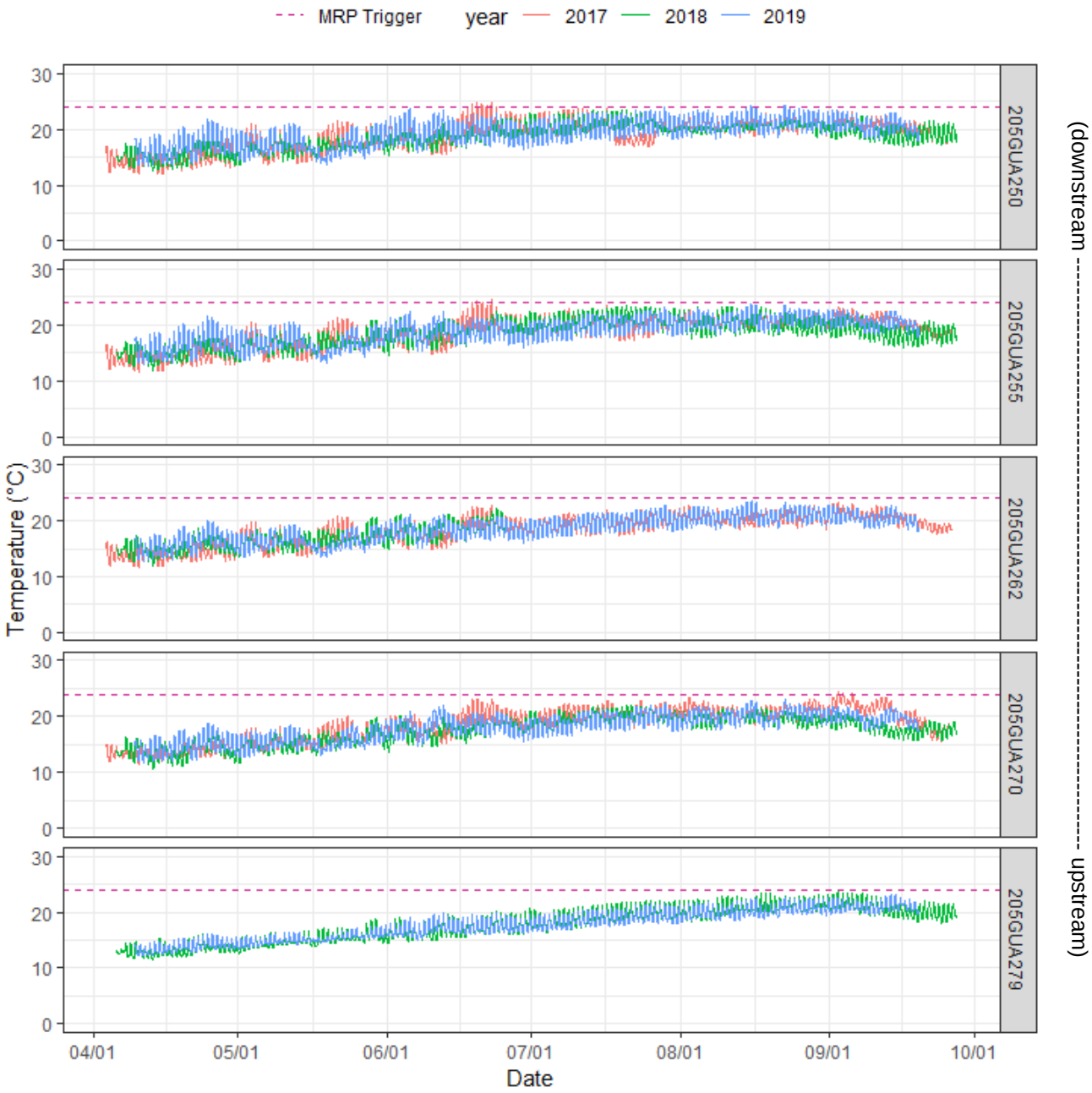


Figure 3.4. Continuous water temperature collected between April and September at five sites in Alamitos Creek during WY 2017, WY 2018 and WY 2019.

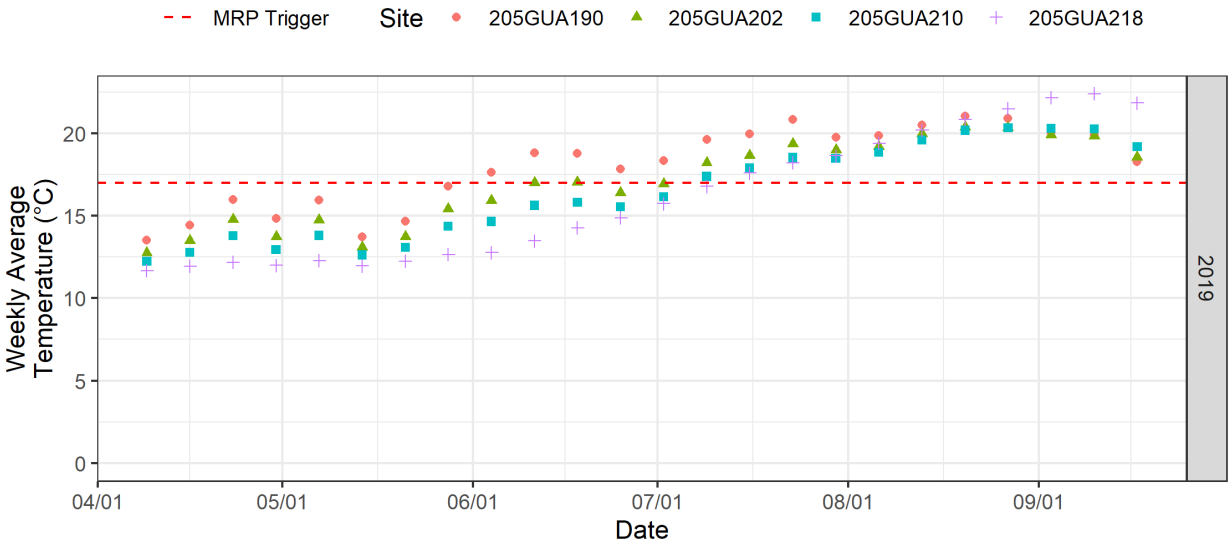


Figure 3.5. Weekly average temperature values calculated for water temperature collected at four sites in Guadalupe Creek over 24 weeks of monitoring in WY 2019. The MRP trigger (17°C) is shown for comparison.

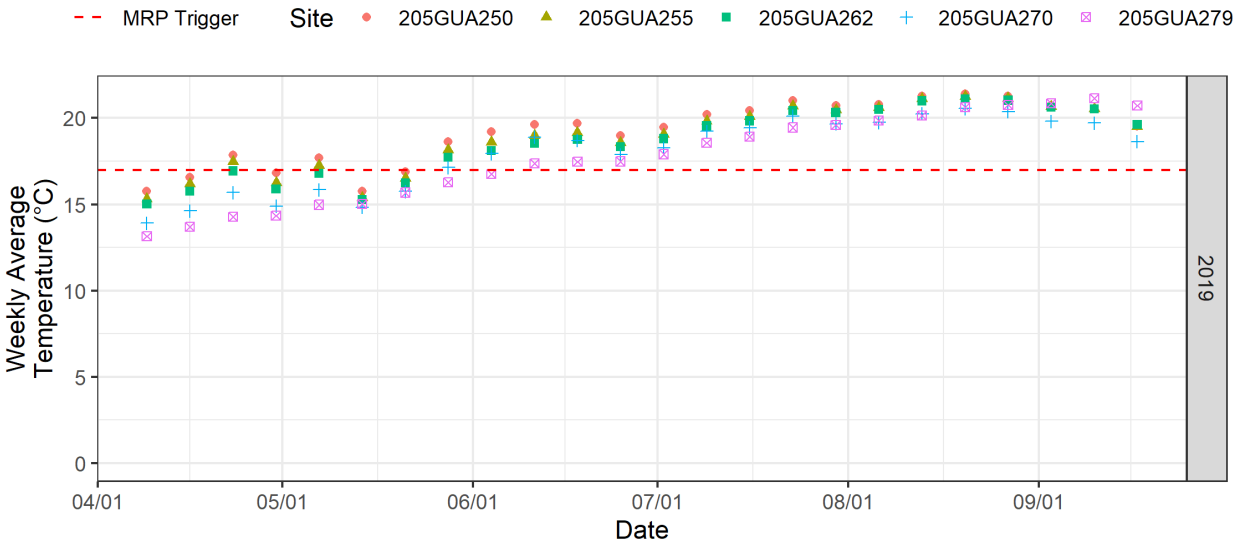


Figure 3.6. Weekly average temperature values calculated for water temperature collected at five sites in Alamitos Creek over 26 weeks of monitoring in WY 2019. The MRP trigger (17°C) is shown for comparison.

Temperature Trigger Considerations

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

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

Annual fall monitoring conducted by Valley Water since 2004 indicates juvenile steelhead are typically present in Guadalupe Creek (SCVWD et al. 2016). The only exception is 2015, when no steelhead were encountered due to extreme drought conditions. However, in 2016 two steelhead individuals were documented, which was the lowest count on record but showed recovery after the 2015 drought. Monitoring in 2017 and 2018 recorded 30 and 66 steelhead in Guadalupe Creek, respectively, confirming that Guadalupe Creek continues to provide summer refugia for steelhead (SCVWD 2019). In Alamitos Creek, steelhead were historically found (Leidy et al. 2005, Smith 2013), and 32 individuals were recorded by Valley Water in 2018 (SCVWD 2019). In addition, in 2018, Valley Water recorded 17 individual steelhead in Calero Creek (SCVWD 2019).

Providing continuous flow during the dry season would allow steelhead to migrate to more optimal habitat conditions, including reaches with cooler water temperatures. In addition, longitudinal connectivity to areas where food is available can allow juvenile steelhead to increase feeding behavior and maintain optimal body weight to survive periods of warmer temperatures (Smith 2013). Thus, flow in the lower reaches is critically important for sustaining steelhead populations, as well as other Aquatic Life Beneficial Uses.

Although the MRP trigger for temperature (i.e., MWAT >17°C for two or more weeks) was exceeded at all nine stations in WY 2017 – WY 2019, it is important to keep in mind that different water temperature thresholds exist that may be more relevant to Santa Clara County streams. NOAA's National Marine Fisheries Service (NMFS) has developed recovery plans for Central Coast steelhead (which includes the Guadalupe River watershed) using the Maximum Weekly Maximum Temperature (MWMT) of 20°C to evaluate water quality conditions potentially impacting steelhead. The MWMT is calculated using the maximum, not the average, weekly temperatures of non-overlapping weeks. The MWMT is suggested to better reflect transient water temperature peaks and any acute effects of the single point maximum temperature.[22]

[22] http://krisweb.com/stream/temp_standards.htm

3.4.3 General Water Quality Study Area (Coyote Creek Watershed)

In WY 2017 – WY 2019, continuous (15-minute) general water quality measurements (DO, specific conductance, pH, and temperature) were recorded at three locations on the mainstem of Coyote Creek during two 7 to 14-day sampling events each year (Figure 3.7). The stations include site 205COY235 (Watson Park), site 205COY236 (Julian Street) and site 205COY239 (Williams). The first event of each year (Event 1) began in late-May or early-June and the second event of each year (Event 2) began in late-August or early-September. Table 3.4 shows the start and end dates for all events in the record.

All three monitoring stations were previously sampled for continuous water quality in WY 2013 as part of the Coyote Creek Dissolved Oxygen Stressor/Source Identification (Coyote Creek SSID) Project (SCVURPPP 2014). The Coyote Creek SSID Project evaluated a range of potential stressors and sources that may cause low dissolved oxygen in the section of Coyote Creek between Watson Park and Williams Park. The Coyote Creek SSID Project measured continuous water quality at six locations between June and September 2013.

The WY 2017 monitoring was conducted following an extremely wet winter that resulted in widespread flooding in the urban reaches of Coyote Creek including the reach with the three monitoring stations. One of the objectives for sampling these locations was to assess whether the high flow events in 2017 flushed out the fine sediment and organic matter that was identified as a potentially important factor causing reduced dissolved oxygen levels in the Coyote Creek SSID Project study area. Monitoring results from WY 2017 indicated that dissolved oxygen levels during the September sampling event were generally higher compared to levels measured in WY 2013. To evaluate inter-annual variability, the same sites were monitored in WY 2018 and WY 2019. Data was used to assess overall variability in water quality conditions between a year with high rainfall and flooding (WY 2017), a year with average rainfall (WY 2018), and a year with above average rainfall (WY 2019).

Table 3.4. Start and end dates of continuous general water quality monitoring events, WY 2013 and WY 2017 – WY 2019.

	Event 1		Event 2	
Year	begin	end	begin	end
WY 2013 [a]	Jun 26	Jul 10	Aug 29	Sep 13
WY 2017	Jun 14	Jun 29	Sep 8	Sep 19
WY 2018	May 21	Jun 4	Sep 10	Sep 19
WY 2019	Jun 3	Jun 17	Aug 20	Sep 3

[a] WY 2013 sondes were deployed continuously from June 26 through September 13, 2013 or later. This IMR uses a subset of the 2013 data, as indicated in dates listed above, to compare with the other years.



Figure 3.7. Continuous water quality stations in Coyote Creek, WY 2017 – WY 2019.

3.4.4 General Water Quality Results and Discussion

Summary statistics for general water quality measurements collected at the three sites in Coyote Creek during the two sampling events in WY 2019 are listed in Table 3.5. Monitoring was conducted from June 3 through June 17, 2019 (Event 1) and from August 20 through September 3, 2019 (Event 2). Sampling locations are mapped in Figure 3.7. Plots for all water quality parameters collected during Event 1 are shown in Figure 3.8 and for Event 2 in Figure 3.9. Results discussed below are organized according to parameter (i.e., temperature, dissolved oxygen, specific conductance, and pH).

Table 3.5. Descriptive statistics for continuous water temperature, dissolved oxygen, pH, and specific conductance measured at three Coyote Creek sites in Santa Clara County during WY 2019. Data were collected every 15 minutes over two 2-week time periods during June (Event 1) and September (Event 2).

Parameter	Data Type	205COY235		205COY236		205COY239	
		Event 1	Event 2	Event 1	Event 2	Event 1	Event 2
Temperature (°C)	Minimum	19.2	20.2	19.3	19.7	18.7	19.1
	Median	21.5	21.8	21.2	21.6	21.2	21.4
	Mean	21.6	21.8	21.3	21.6	21.3	21.5
	Maximum	24.9	22.9	24.3	22.8	25.0	23.4
	% > 24	4%	0%	2%	0%	4%	0%
Dissolved Oxygen (mg/L)	Minimum	1.9	2.8	2.4	3.0	4.4	5.3
	Median	3.5	3.7	3.5	3.7	5.6	5.8
	Mean	3.3	3.7	3.4	3.7	5.6	6.0
	Maximum	4.8	4.6	5.3	4.6	6.8	7.2
	% < 7.0	**100%**	**100%**	**100%**	**100%**	**100%**	**98%**
pH [a]	Minimum	NA	7.4	7.1	7.5	7.6	7.6
	Median	NA	8.1	7.8	7.8	7.7	7.7
	Mean	NA	8.1	7.7	7.8	7.7	7.7
	Maximum	NA	8.5	7.8	8.1	7.7	7.8
	% < 6.5 or > 8.5	NA	0%	0%	0%	0%	0%
Specific Conductivity (µS/cm)	Minimum	952	933	948	889	890	880
	Median	1072	970	1063	960	1014	913
	Mean	1054	970	1041	961	990	915
	Maximum	1137	1015	1108	1009	1060	957
	% > 2000	0%	0%	0%	0%	0%	0%
Total number of data points (N)		1338	1345	1340	1343	1341	1341

[a] The pH sensors did not meet data quality objectives at site 205COY235 during Event 1. The data were rejected and not used in the analyses. The sensor was replaced for Event 2.

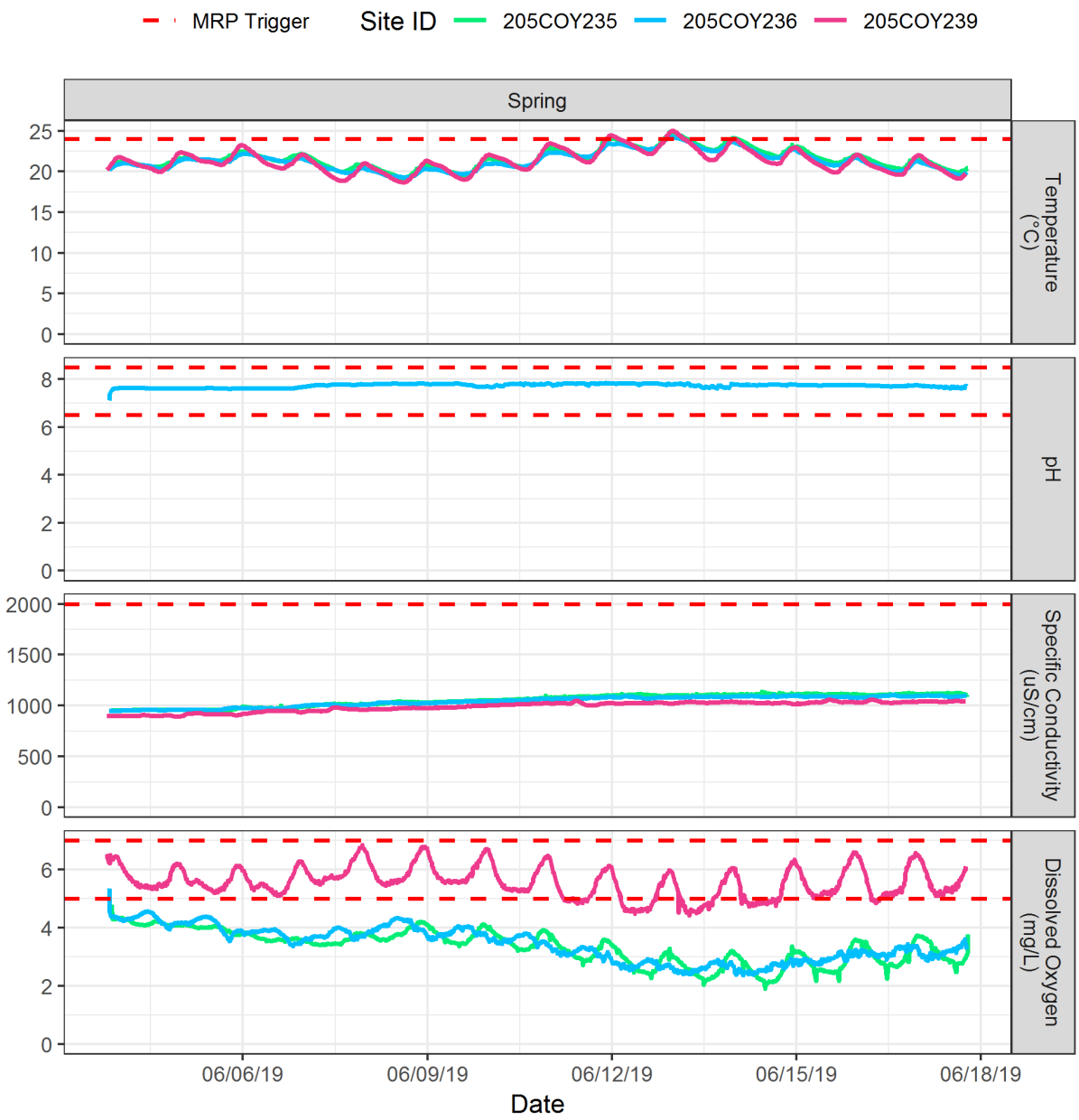


Figure 3.8. Continuous water quality data (temperature, specific conductance, pH[23], and dissolved oxygen) collected at three sites in Coyote Creek in June 2019 (Event 1).

[23] The pH sensor did not meet data quality objectives for pre- and post-calibration for site 205COY235; data were not used for analyses. These pH sensor was replaced for Event 2.

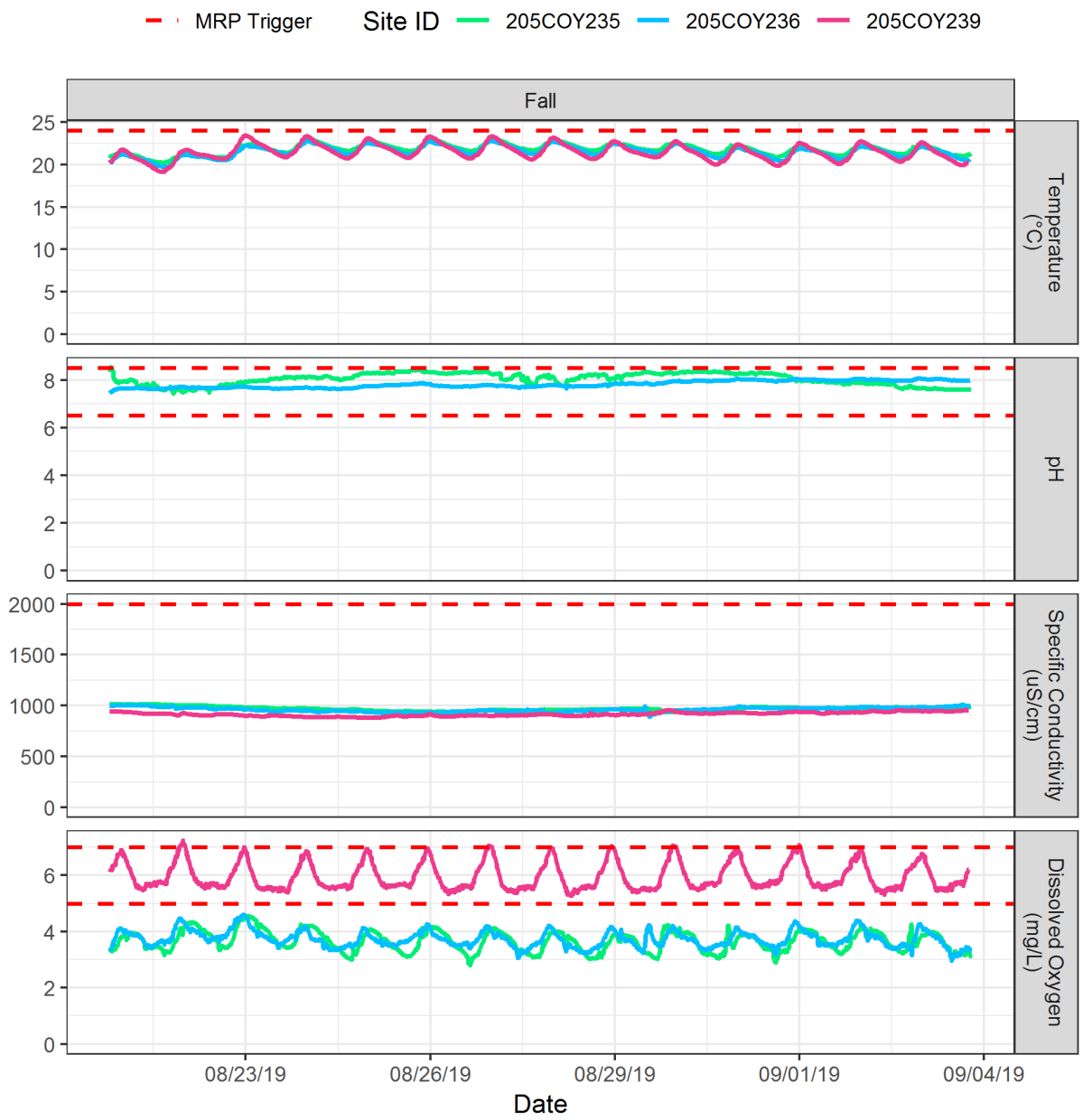


Figure 3.9. Continuous water quality data (temperature, specific conductance, pH, and dissolved oxygen) collected at three sites in Coyote Creek in August/September 2019 (Event 2).

Temperature

The water temperature data collected at the three sites in Coyote Creek show a similar pattern during both events. In general, water temperatures showed little variability between sites during each event (Figures 3.8 and 3.9). Daily patterns are evident in the record with cooler temperatures recorded at night and warmer temperatures in the afternoon. During the June sampling event (Event 1), water temperatures showed both cooling and warming trends (Figure 3.8). During the August-September event (Event 2) water temperatures were more stable (other than diurnal variation) (Figure 3.9). In WY 2018, there were also cooling and warming trends during Event 1 but not during Event 2 (SCVURPPP 2019). The cause of the differences is unknown but is likely related to air temperatures, groundwater inflow, and upstream reservoir operations.

In WY 2019, during Event 1, water temperatures at all stations occasionally exceeded the instantaneous maximum threshold of 24°C; however, this only applies to 2-4% of the record (Table 3.5); therefore, the MRP trigger was not exceeded. The 24°C threshold was not exceeded at any of the three sites during Event 2. In previous water years, the MRP trigger for instantaneous maximum temperature was also not exceeded at any of the sites for either sampling event.

Weekly average temperatures were calculated for both monitoring events (Table 3.6). The MWAT threshold (17°C) was exceeded at all three stations during both weeks of both events. The MWAT trigger was also exceeded during both monitoring events in WY 2017 and WY 2018. Therefore, all three sites were added to the list of candidate SSID projects.

Table 3.6. Weekly average temperature (°C) values for water temperature data collected at three stations monitored in Coyote Creek, WYs 2017, 2018, and 2019.

		Station	205COY235	205COY236	205COY239
Water Year	**Month**	**Week**	**Weekly Average Temperature (°C)**		
2017	May/June	Week 1	21.0	20.7	21.2
		Week 2	22.5	22.2	21.4
	September	Week 1	22.3	22.0	22.2
		Week 2	20.3	20.0	19.9
2018	May/June	Week 1	18.1	18.2	18.5
		Week 2	18.0	18.2	18.1
	September	Week 1	19.3	19.1	19.2
		Week 2	19.1	18.8	18.8
2019	June	Week 1	21.0	20.8	20.9
		Week 2	22.2	21.9	21.9
	August/ September	Week 1	21.8	21.6	21.6
		Week 2	21.8	21.5	21.3

Box and whisker plots are useful in understanding the distribution of data and in comparing data from different years. Each “box” represents the upper quartile, median, and lower quartile of the dataset. The “whiskers” represent the smallest and largest values within 1.5 times the interquartile range and points represent values outside the box and whiskers.

Box and whisker plots comparing temperature and dissolved oxygen data collected during Event 1 and Event 2 of WY 2013, WY 2017, WY 2018, and WY 2019 are shown in Figures 3.10 and 3.11. During the Event 1 time period, temperatures were similar in all years except WY 2018, when they were lower (Figure 3.10). This difference may be explained by differences in timing of Event 1; the WY 2018 deployment was earlier in the season (May 21 – June 4, 2018) compared to the other years when deployments did not start until sometime in June (Table 3.4). During the Event 2 time period, the Coyote Creek sites also had lower water temperatures in 2018 compared to 2019, 2017 and 2013 (Figure 3.11). In this case, the differences cannot be explained by event timing, as the WY 2018 and WY 2017 deployments were nearly identical (Table 3.4).

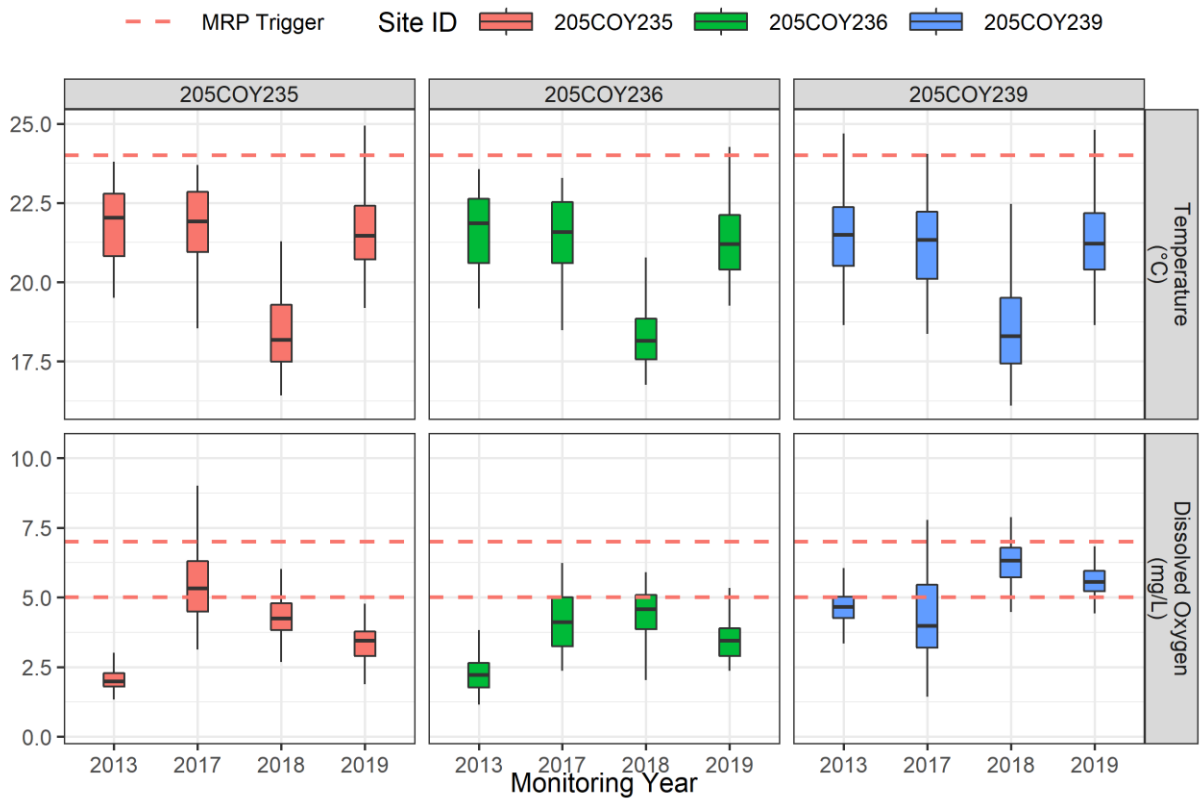


Figure 3.10. Comparison of temperature and dissolved oxygen data collected during Event 1 (May/June) in WYs 2013, 2017, 2018, and 2019 at three stations in Coyote Creek.



Figure 3.11. Comparison of temperature and dissolved oxygen data collected during Event 2 (August/September) in WYs 2013, 2017, 2018, and 2019 at three stations in Coyote Creek.

Dissolved Oxygen

Similar to previous years, the dissolved oxygen data showed a consistent pattern for both sampling events in WY 2019, with median DO levels about 2.0 mg/L lower at the two downstream sites (205COY235, 205COY236) compared to the upstream site (205COY239) (Figures 3.8 and 3.9). The two lower elevation sites also had less diurnal variability compared to the upstream site.

Dissolved oxygen concentrations decreased across all the sites during second week of Event 1 (Figure 3.8). The decrease may be associated with the observed increase in water temperatures that occurred during the same period. In previous years, a similar drop was observed in the Event 1 datasets and attributed to thermal stratification in the water column, which was documented in the WY 2013 Coyote Creek SSID Project (SCVURPPP 2014). In 2019, the drop in dissolved oxygen may also have been associated with above average air temperatures from June 10 to June 12. During these dates, the City of San José experienced three consecutive days of air temperatures reaching 95-100°F, which is 20 °F warmer than average high temperatures for these dates.[24] As water temperatures rise, oxygen solubility decreases. In addition, higher temperatures could lead to a spike in photosynthesis followed by an algae die-off, promoting decomposition and oxygen-consuming processes.

[24] https://www.accuweather.com/en/us/san-jose/95110/june-weather/347630?year=2019

Box and whisker plots of dissolved oxygen and temperature data collected during Event 1 and Event 2 of WYs 2013, 2017, 2018, and 2019 are shown in Figures 3.10 and 3.11. In general, dissolved oxygen concentrations have increased since WY 2013 during both the Event 1 and Event 2 time periods. One hypothesis for the observed increase is the high stream flows that occurred in Coyote Creek during the winter season of WY 2017. These high flows may have caused an overall reduction in the amount of organic material and sediment present in the channel at the sites. One of the conclusions of the Coyote Creek SSID project was that accumulated organic material and sediment coupled with slow velocity and low gradient of the channel are likely important factors in the low DO concentrations and the low potential for re-aeriation of the water column (SCVURPPP 2014). If high flows in WY 2017 reduced the amount of organic material in this reach of Coyote Creek, it is unknown how long the effects will last without subsequent high flow events to scour sediment from the channel.

The dissolved oxygen concentrations in WY 2019, 2018 and 2017 were below 7.0 mg\L (MRP trigger for cold water fishery stream) at all three sites (Table 3.6); therefore, these sites will remain on the list of candidate SSID sites. However, these results should be interpreted cautiously. Although Coyote Creek is designated as having COLD Habitat, Aquatic Life Beneficial Uses associated with a cold water fishery are generally not supported in the reach where water quality sampling was conducted. The sampling reach of Coyote Creek mainstem may support a WARM water fishery; however, existing habitat and water quality conditions currently do not support a cold water fishery beyond serving as a migration corridor to colder, upstream reaches.

Specific Conductance

Specific conductance during WY 2019 was approximately 900 to 1000 µS /cm at all three sites during both sampling events, and thus, never exceeded the MRP trigger threshold (2000 µS/cm). Specific conductance levels followed a similar pattern at all three sites during both events, with very little variability in the record. The same pattern is true of WY 2017 and 2018 monitoring results.

pH

The pH data was generally consistent between sites, ranging between 7.5 and 8.2 for both sampling events, and thus never exceeded the MRP trigger. Calibration checks of the sondes that were deployed at station 205COY235 during Event 1 showed a drift in the pH sensor of over 0.2 units, which was not consistent with Measurement Quality Objectives in the project QAPP (BASMAA 2016b). Thus, those pH data were rejected and not used in the analyses. The pH probe was replaced prior to the September 2019 sampling event.

Continuous Water Quality Trigger Summary

The MRP trigger summary for the continuous water quality data is shown in Table 3.6. All three sites exceeded triggers for temperature MWAT and dissolved oxygen, and therefore these sites were added to the SSID list.

Table 3.6. Exceedances of MRP triggers at three continuous monitoring sites in Coyote Creek, Santa Clara County, WY 2019.

Data Type	MRP Trigger	205COY235	205COY236	205COY239	205COY235	205COY236	205COY239
		Event 1 (June) WY 2019			Event 2 (August/September) WY 2019		
Temperature	20% results > 24°C	No	No	No	No	No	No
MWAT	2 weeks > 17°C	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Dissolved Oxygen	20% results < 7 mg/L	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Specific Conductivity	20% results > 2000 µS/cm	No	No	No	No	No	No
pH	20% results > 6.5, < 8.5	NA	No	No	No	No	No

4.0 PATHOGEN INDICATORS

4.1 Introduction

This section describes the results of pathogen indicator monitoring that was conducted during WY 2014 through WY 2019 in compliance with Creek Status Monitoring Provisions C.8.c of MRP 1.0 and C.8.d.v of MRP 2.0. Monitoring was conducted at selected sites using a targeted design based on the directed principle[25] to address the following management question:

1. *What are the pathogen indicator concentrations at creek sites where there is potential for water contact recreation to occur?*

This management question is addressed primarily through the evaluation of data with respect to trigger thresholds identified in the MRP and WQOs adopted by the State Water Board. Sites where exceedances occur may indicate potential impacts to water contact recreation (REC-1) or other Beneficial Uses and are considered as candidates for future Stressor Source Identification projects.

In compliance with MPR 1.0 and 2.0, five samples were collected each year for a cumulative total of 30 samples for the WY 2014 through WY 2019 IMR reporting period. The sections below summarize methods results from pathogen indicator monitoring conducted during WY 2014 through WY 2019. Conclusion and recommendations for this section are presented in Section 7.0.

4.2 Methods

4.2.1 Sample Collection

Pathogen indicator samples were collected during the dry season in accordance with SWAMP-comparable methods and procedures described in the BASMAA RMC SOPs (BASMAA 2016b) and associated QAPP (BASMAA 2016a). Sampling techniques for pathogen indicators (*E. coli*, enterococci and fecal coliform) include direct filling of sterile containers and transfer of samples to the analytical laboratory within specified holding time requirements. Procedures for sampling and transporting samples are described in RMC SOP FS-2 (BASMAA 2016b).

4.2.2 Data Evaluation

During MRP 1.0 (WY 2014 and WY 2015) *E. coli* and fecal coliform were monitored as pathogen indicators. During MRP 2.0 (WY 2016 – WY 2019), *E. coli* and enterococcus were monitored as pathogen indicators. Pathogen indicator data were evaluated with respect to trigger thresholds identified in the MRP and WQOs adopted by the State Water Board on August 7, 2018 and approved by the USEPA on March 22, 2019. Pathogen indicator trigger thresholds and WQOs are listed in Table 4.1.

The MRP triggers and adopted WQOs are both based on the 2012 USEPA recommended recreational water quality criteria (RWQC). The 2012 RWQC offer two sets of numeric concentration thresholds for *E. coli* and enterococci designed to protect all types of water

[25] 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."

contact recreation in freshwaters where immersion and ingestion are likely. The two sets of criteria are based on estimated rates of gastrointestinal illness (estimated illness rate of 36 per 1,000 recreators and estimated illness rate of 32 per 1,000 recreators). MPR 2.0 specified the illness rate of 36/1000 as a trigger threshold; whereas, the State Water Board adopted the more conservative set of criteria based on the illness rate of 32/1000 in 2015.

The 2012 RWQC consists of both a geometric mean (GM) and a Statistical Threshold Value (STV). The GM criteria are applied when there are at least five samples distributed over a six-week period. According to the RWQC, the STV criteria should not be exceeded by more than 10 percent of the samples taken in a month, and therefore approximate a single sample maximum. Because pathogen indicator samples collected in compliance with the MRP are not repeated, results are compared to the STV criteria. Also, in this evaluation, the Most Probable Number (MPN) of bacteria colonies given by the analytical method is compared directly with the Colony Forming Units (CFU) of the USEPA recommendations.

The 2012 RWQC do not recommend using fecal coliform as a pathogen indicator. Therefore, fecal coliform data collected during MRP 1.0 were compared to WQOs listed in the Basin Plan (2017).

Table 4.1. Bacteriological trigger thresholds and water quality objectives for water contact recreation in freshwater.

Pathogen Indicator	State Water Board WQO (Estimated Illness Rate 32/1,000)		MRP 2.0 Trigger Threshold (Estimated Illness Rate 36/1,000)		Basin Plan WQO	
	GM	STV	GM	STV	GM	STV
Fecal Coliform (MPN/100 mL)	NA	NA	NA	NA	200	400
E. coli (cfu/100 mL)	100	320	125	410	NA	NA
Enterococci (cfu/100 mL)	30	110	35	130	NA	NA

4.3 Study Area

In compliance with the MRP, five pathogen indicator samples are collected during one sampling event per year at sites located in municipal parks with good public access to creeks and the potential for recreational water contact. In WY 2019, three sites were located on Los Gatos Creek; Novitiate Park (205LGA420), Vasona Park (205LGA400), and along the Los Gatos Creek Trail behind the Pruneyard Shopping Center (205LGAS033). Two sites were located on Coyote Creek; Metcalf Park (205COY392) and Hellyer Park (205COY330). All pathogen indicator monitoring stations sampled from WY 2014 through WY 2019 are mapped in Figure 4.1 with WY 2019 station symbols outlined in black. Figure 4.1 shows that some stations have been sampled more than one time during the WY 2014 through WY 2019 period of record. For example, Alamitos Creek at Singer park has been sampled four times.

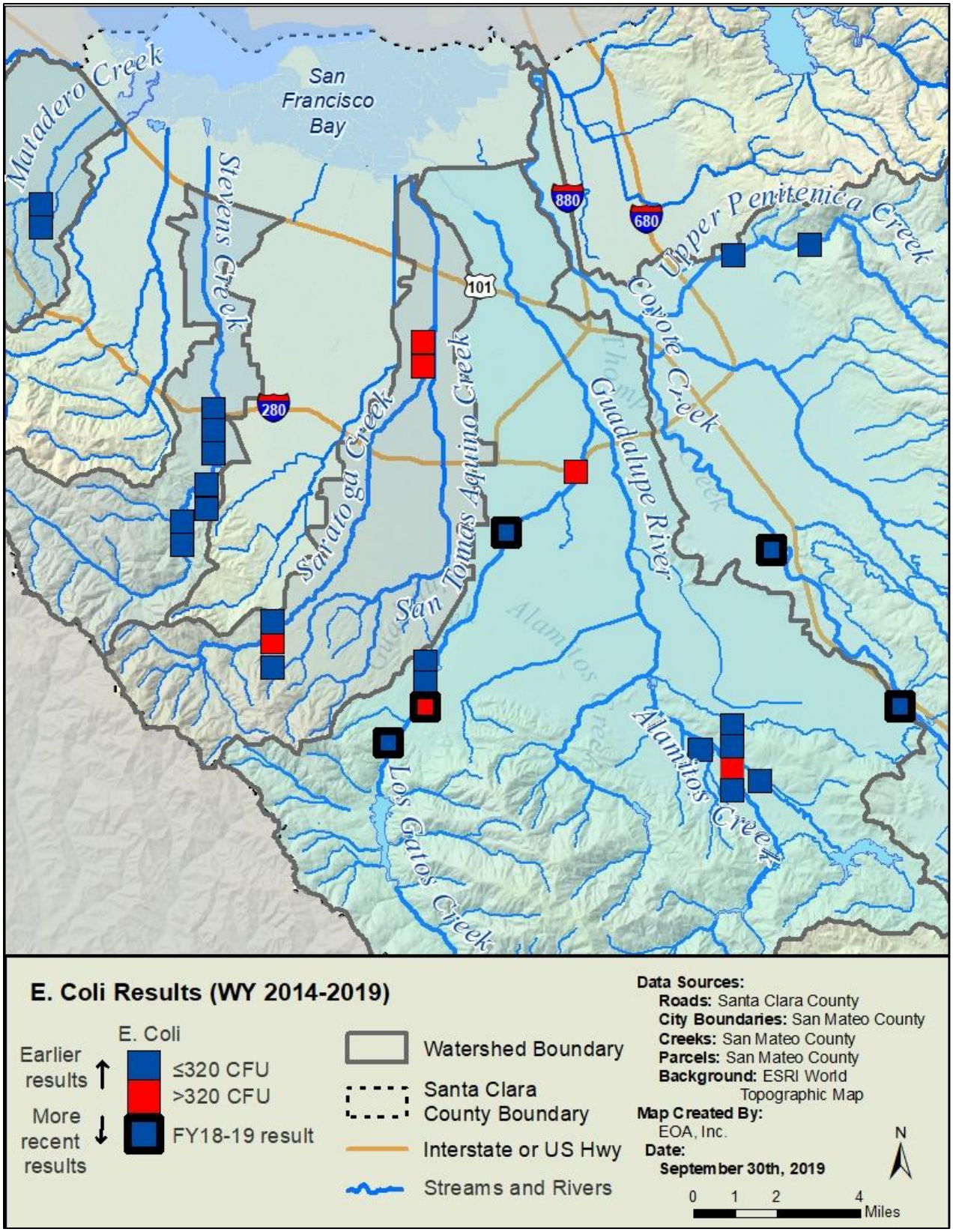


Figure 4.1. Pathogen indicator monitoring sites sampled in Santa Clara County during WY 2014 – WY 2019. Concentrations exceeding the WQO threshold for *E. coli*.

4.4 Results and Discussion

Pathogen indicator (*E. coli* and enterococci) densities measured in grab samples collected in WY 2019 on August 1, 2019 are listed in Table 4.2. Stations are mapped in Figure 4.1. In WY 2019, one sample (205COY330) exceeded the MRP 2.0 trigger and the State Water Board WQO for enterococci. A different sample, 205LGA400, exceeded the WQO for *E. Coli* and did not exceed the MRP 2.0 trigger. Both sites will be considered for future SSID projects.

Table 4.2. Enterococci and *E. coli* levels measured in Santa Clara County during WY 2019 (August 1, 2019). Results exceeding the MRP 2.0 trigger are bold. Results exceeding the WQO are highlighted

Site ID	Creek Name	Site Name	*Enterococci (cfu/100ml) (MPN/100ml)*[1]	*E. Coli (cfu/100ml) (MPN/100ml)*[1]
205LGA420	Los Gatos Creek	Los Gatos Creek at Novitiate Park	15	7.5
205LGA400	Los Gatos Creek	Los Gatos at Vasona Park	17	326
205LGA033	Los Gatos Creek	Los Gatos at Pruneyard	12	102
205COY392	Coyote Creek	Coyote Creek at Metcalf Park	7	27
205COY330	Coyote Creek	Coyote Creek at Hellyer Park	**157**	70
State Water Board WQO (based on 32 per 1000 recreators)			110	320
MRP 2.0 Trigger Threshold (USEPA 2012; 36 per 1000 recreators)			**130**	**410**

All monitoring data collected between WY 2014 and WY 2019 were evaluated for this IMR. The results for *E. coli* from WY 2014 through WY 2109 are shown in Figure 4.1 as compared to the WQO of 320 cfu/100 mL. In WY 2019, there was one *E. coli* exceedance in one of three locations sampled on Los Gatos Creek at site 205LGA400. The reason for this exceedance is unknown, but likely caused by a local source, as this is located between two sites that had results below the threshold. Potential sources of fecal indicator bacteria at 205LGA400 include local wildlife and homeless encampments. The WY 2019 *E. coli* exceedance is the smallest exceedance observed within the WY 2014 – WY 2019 period of record; it was 2% above the WQO compared to the highest result measured at the lower station on Saratoga Creek (205SAR005) in WY 2015 which was 218% above the threshold. Saratoga Creek collectively had the most exceedances with exceedances at both the downstream (205SAR005) and upstream (205SAR045) sites. Between WY 2014 and WY 2019 there were a total of six exceedances in two watersheds: Saratoga Creek watershed and Guadalupe River watershed. The Guadalupe River watershed had exceedances in the Los Gatos Creek tributary (WY 2019 and WY 2014) and the Alamitos Creek tributary (WY 2017). Although WQO exceedances are found in two of the six watersheds targeted, there is no evidence for large scale spatial patterns of bacteria concentrations. The results suggest that pathogen indicator densities at the monitoring stations are highly variable and generally below RWQC and WQOs during dry weather.

It is important to recognize that pathogen indicators do not directly represent actual pathogen concentrations and do not distinguish among sources of bacteria. Testing water samples for specific pathogens is generally not practical for a number of reasons (e.g., concentrations of pathogens from fecal contamination may be small and difficult to detect but still of concern, laboratory analysis is often difficult and expensive, the number of possible pathogens is large).

Therefore, the presence of pathogens is inferred by testing for “pathogen indicator” organisms. The USEPA recommends using *E. coli* and enterococci as indicators of fecal contamination based on historical and recent epidemiological studies (USEPA 2012). The USEPA pathogen indicator thresholds were derived based on human recreation at beaches receiving bacteriological contamination from human wastewater, and may not be applicable to conditions in urban creeks which do not receive wastewater treatment plant discharges. Furthermore, although animal fecal waste contributes to the pathogen indicator load, it is much less likely to contain pathogens of concern to human health than human sources. In most cases, it is the human sources that are associated with REC-1 health risks rather than wildlife or domestic animal sources (USEPA 2012). As a result, the comparison of pathogen indicator results to pathogen indicator thresholds may not be appropriate and should be interpreted cautiously.

5.0 CHLORINE MONITORING

5.1 Introduction

Chlorine is added to potable water supplies and wastewater to kill microorganisms that cause waterborne diseases. However, the same chlorine can be toxic to the aquatic species. Chlorinated water may be inadvertently discharged to the MS4s and/or urban creeks from residential activities, such as pool dewatering, car washing, and over-watering landscaping, or from municipal activities, such as hydrant flushing and water main breaks.

From WY 2012 through WY 2019, in compliance with provision C.8.c of MRP 1.0 and provision C.8.d.ii of MRP 2.0, and to assess whether the chlorine in receiving waters is present at concentrations potentially toxic to the aquatic life living there, SCVURPPP field staff measured free chlorine and total chlorine residual in creeks where bioassessments were conducted. Total chlorine residual is comprised of “combined” chlorine and free chlorine, and should always be greater than or equal to the free chlorine residual. Combined chlorine is the chlorine that has reacted with ammonia or organic nitrogen to form chloramines, while free chlorine is the chlorine that remains unbound. Both can be toxic to aquatic life, but chlorine dissipates into the atmosphere more quickly than chloramine.

5.2 Methods

In accordance with the BASMAA RMC Creek Status and Long-Term Trends Monitoring Plan (BASMAA 2012), field testing for free chlorine and total chlorine residual was conducted at twenty sites each year concurrent with spring bioassessment sampling (April - May). From WY 2012 through WY 2018, all sites were selected using the probabilistic design described in Section 2.0. In WY 2019, three of the twenty sites were selected on a targeted basis to address bioassessment management questions Probabilistic and targeted site selection methods are described in Section 2.0.

Field testing for free chlorine and total chlorine residual conformed to methods and procedures described in the BASMAA RMC SOPs (BASMAA 2016a), which are comparable to those specified in the SWAMP QAPP. Per SOP FS-3 (BASMAAS 201ab), water samples were collected and analyzed for free and total chlorine using a Pocket Colorimeter™ II and DPD Powder Pillows, which has a manufacturer reported method detection limit of 0.02 mg/L. If concentrations exceeded the MRP trigger criteria of 0.1 mg/L, the site was immediately resampled. The MRP 1.0 trigger criterion, implemented in WY 2012 through WY 2015, was 0.08 mg/L. The MRP 2.0 trigger criterion, implemented in WY 2016 through WY 2019, was 0.1 mg/L. If the resample also exceeds the trigger, the site is added to the list of candidate SSID projects. Provision C.8.d.ii(4) of the MRP 2.0 also specifies that “Permittees report the observation to the appropriate Permittee central contact point for illicit discharges to that the illicit discharge staff can investigate and abate the associated discharge in accordance with its provision C.5.e – Spill and Dumping Complaint Response Program.”

5.3 Results and Discussion

The section below summarizes results from chlorine monitoring conducted during WY 2012 through 2018 and details results from WY 2019. Conclusion and recommendations are presented in Section 7.0.

In WY 2019, SCVURPPP monitored 20 sties for free chlorine and total chlorine residual. The measurements were compared to the MRP 2.0 trigger threshold of 0.1 mg/L.[26] Results are listed in Table 5.1. The trigger thresholds for free chlorine and total chlorine residual were three times; however, in each case, the immediate resample results were lower than the trigger thresholds. These findings illustrate the transient nature of chlorine and/or the unreliability in field measurement equipment at these small quantities. Overall, the results indicate that chlorine levels in the sampled creeks were not of concern during the monitoring time frame.

In WY 2019, the free chlorine result was greater than the total residual chlorine result at two stations (Table 5.1). Inverted results such as these have been occasionally noted through the WY 2012 – WY 2019 monitoring program. Potential causes for these inverted results include matrix interferences, colorimeter user error, and concentrations near the detection limit. According to Hach, the supplier of the equipment and reagents, the free chlorine could have false positive results due to a pH exceedance of 7.6 and/or an alkalinity exceedance of 250 mg/L. The pH was measured concurrently with the chlorine samples, but alkalinity was not measured. At all twenty stations, the pH exceeded 7.6. It is unlikely that the higher free chlorine readings were caused by user error. The field crew is well trained and aware of potential problems with this testing method, such as wait times between adding reagents and taking the readings and keeping the free chlorine and total residual chlorine samples separate. At more than one station, the field crew immediately resampled the creek in response to the inverted readings; with the second set of samples having identical results. The cause of the inverted free chlorine and total chlorine residual results (compared to expected) is unknown. However, it should be noted that colorimetric field instruments are generally not considered capable of providing accurate measurements of free chlorine and total chlorine residual below 0.13 mg/L, regardless of the method detection limit provided by the manufacturer. For this reason, the Statewide General Permit for drinking Water Discharges (Order WQ 2014-0194-DWQ) uses 0.1 mg/L as a reporting limit for field measurements of total chlorine residual.

[26] For reference, the Statewide General Permit for Drinking Water Discharges (Order WQ 2014-0194-DWQ) uses 0.1 mg/L as a reporting limit (minimum level) for field measurements of total residual chlorine.

Table 5.1. Summary of SCVURPPP chlorine testing results compared to MRP trigger of 0.1 mg/L, WY 2019.

Station Code	Date	Creek	Free Chlorine (mg/L) [1,2]	Total Chlorine Residual (mg/L) [1,2]	Exceeds Trigger Threshold (0.1 mg/L)[2]
205COY455	06/04/19	Coyote Creek	0.02	0.03	No
205GUA060	05/08/19	Los Gatos Creek	<0.02	0.04	No
205GUA251	04/29/19	Alamitos Creek	0.03	0.03	No
205R04247	06/05/19	Stevens Creek	0.04	0.04	No
205R04271	06/03/19	Stevens Creek	<0.02	<0.02	No
205R04317	06/04/19	Coyote Creek	<0.02	<0.02	No
205R04359	06/12/19	Adobe Creek	0.03	0.05	No
205R04378	05/08/19	Los Gatos Creek	0.02	0.02	No
205R04383	06/06/19	San Francisquito	0.02	0.05	No
205R04395	05/02/19	Arroyo de Los Coches	0.01	0.01	No
205R04418	04/30/19	Thompson Creek	0.09	0.05	No
205R04479	06/12/19	Saratoga Creek	0.01	0.03	No
205R04530	05/01/19	Upper Silver Creek	0.01	0.02	No
205R04537	04/30/19	Thompson Creek	0.00	0.02	No
205R04591	05/07/19	San Thomas Aquino Creek	0.55 / 0.04	0.07	No
205R04602	05/01/19	Wildcat Creek	0.03	0.02	No
205R04614	05/07/19	San Thomas Aquino	0.21 / 0.08	0.03	No
205R04638	05/06/19	Guadalupe Creek	<0.02	0.11 / 0.01	No
205R04670	05/09/19	Saratoga Creek	<0.02	<0.02	No
205STE070	06/05/19	Stevens Creek	<0.02	0.04	No

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

A total of 144 stations have been monitored by SCVURPPP for free chlorine and total chlorine residual between WY 2012 and WY 2019 in compliance with MRP 1.0 and MRP 2.0. Occasional exceedances were recorded throughout the years and addressed by the appropriate follow-up process. Figure 5.1 maps of all the samples stations with their associated results. Each sample station has two symbols; free chlorine in the left square and total chlorine residual on the right. Larger symbols are used to represent WY 2019 results. The results exceeding the MRP 2.0 trigger threshold of 0.1 mg/L are shown in red. The results exceeding MRP 1.0 trigger threshold of 0.08 mg/L but below the MRP 2.0 trigger are shown in orange. All results equal to or below 0.08 mg/L are shown in green.

Since WY 2012, 17 of the 144 stations had exceedances of either the free chlorine or total chlorine residual trigger. Trigger exceedances tend to occur in high order streams that have traveled through highly populated areas towards the Bay, such as Lower Penitencia Creek. The values range from non-detectable levels of chlorine to 0.4 mg/L with one outlier of 0.91 mg/L (Lower Silver Creek in WY 2016). All stations with exceedances have been included on the SSID table for potential follow up projects.

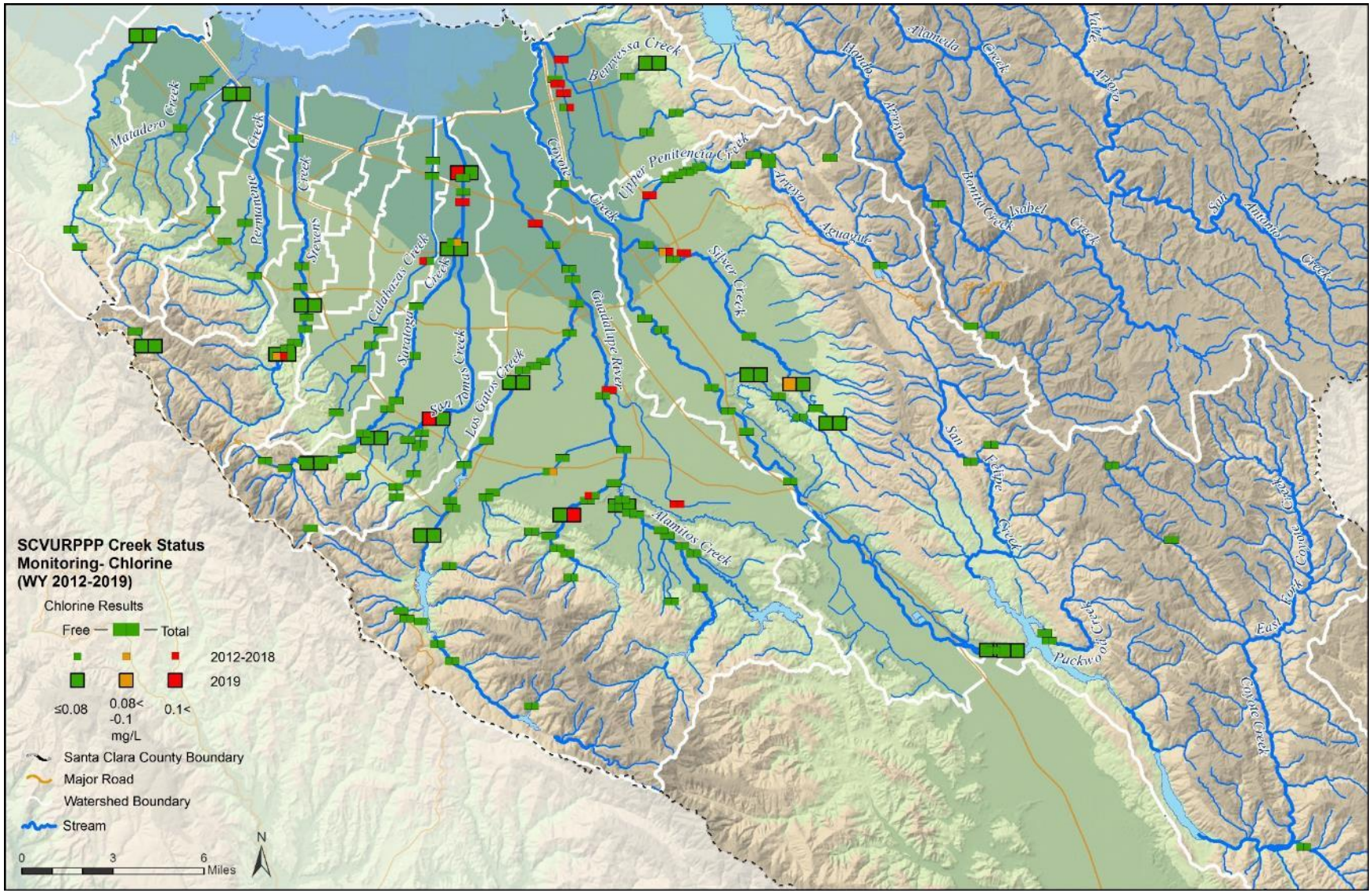


Figure 5.1 Chlorine sample stations and results WY 2012 – WY 2019 in Santa Clara County.

6.0 TOXICITY AND SEDIMENT CHEMISTRY MONITORING

6.1 Introduction

This section describes the results of toxicity testing, sediment chemistry monitoring, and water column pesticides monitoring (collectively referred to as pesticides and toxicity monitoring) conducted during WY 2014 through WY 2019 in compliance with Provisions C.8.c of MRP 1.0 and C.8.g of MRP 2.0. Pesticide and toxicity monitoring results and data from SCVURPPP monitoring and projects external to the RMC are discussed, to inform management efforts for Santa Clara Basin urban creeks with respect to achievement of water quality objectives and support of Beneficial Uses.

Toxicity testing provides a tool for assessing the toxic effects (acute and chronic) of all chemicals in receiving waters or sediments on aquatic organisms, and allows the cumulative effect of these chemicals to be evaluated. Because different test organisms are sensitive to different classes of chemicals and pollutants, several different organisms are used when assessing the toxicity of water or sediment in receiving waters. Sediment and water chemistry monitoring for a variety of potential pollutants is conducted synoptically with toxicity monitoring to provide preliminary insight into the possible causes of toxicity, should it be observed.

Pesticide and toxicity monitoring in urban creeks during wet and dry weather were required by both MRP 1.0 and MRP 2.0. There were slight differences, however, between the requirements included in the two permits, including the required number of samples, types test organisms, and chemical constituents. These differences are outlined in the following sections.

6.1.1 Dry Weather

Provision C.8.c of MRP 1.0 required that three stream sites be sampled during the dry weather period for pesticides and toxicity during WYs 2014 and 2015. The Program selected sites from the list of twenty probabilistic sites where bioassessment was conducted during the same WY. The MRP 1.0 dry weather monitoring included:

- Toxicity testing in water using four species: *Ceriodaphnia dubia* (chronic survival and reproduction), *Pimephales promelas* (larval survival and growth), *Selenastrum capricornutum* (growth), and *Hyalella azteca* (survival);
- Toxicity testing of bedded sediment using one species: *Hyalella azteca* (survival);[27]
- Sediment chemistry analysis for pyrethroids, chlordane, dieldrin, endrin, heptachlor epoxide, lindane, dichlorodiphenyltrichloroethanes (DDT), metals, polycyclic aromatic hydrocarbons (PAHs), total organic carbon (TOC), and sediment grain size.

Provision C.8.g of MRP 2.0 required the Program to sample two stream sites each year during the dry season for pesticides and toxicity during WY 2016 through WY 2019. MRP 2.0 provides examples of possible monitoring location types, including sites with suspected or past toxicity results, existing bioassessment sites, or creek restoration sites. Dry weather pesticides and toxicity monitoring required by MRP 2.0 included:

[27] Although the chronic (growth) endpoint for *Hyalella azteca* was not required by the MRP, it was provided by the laboratory and reported in the UCMRs.

- Toxicity testing in water using five species: *Ceriodaphnia* dubia (chronic survival and reproduction), *Pimephales promelas* (larval survival and growth), *Selenastrum capricornutum* (growth), *Hyalella azteca* (survival) and *Chironomus dilutus* (survival).
- Toxicity testing of bedded sediment using two species: *Hyalella azteca* (survival) and *Chironomus dilutus* (survival).
- Sediment chemistry analysis for pyrethroids, fipronil, carbaryl, polycyclic aromatic hydrocarbons (PAHs), metals, total organic carbon (TOC), and sediment grain size.

6.1.2 Wet Weather

MRP 1.0 required wet weather toxicity testing in WYs 2014 and 2015 at the same three sites where dry weather toxicity and sediment chemistry monitoring was conducted. The wet weather toxicity monitoring was based on the same four species that were used in dry season monitoring. No wet weather water chemistry monitoring for pesticides or other potential pollutants was required during MRP 1.0.

Provision C.8.g.iii.(3) of MRP 2.0, covering WY 2016 through WY 2019, requires MRP Permittees to collectively test a total of 10 wet weather samples for toxicity and water chemistry if the wet weather monitoring is coordinated via the RMC on behalf of all MRP Permittees. MRP 2.0 states that the monitoring locations should be representative of urban watersheds (i.e., at the bottom of watersheds). At the RMC Monitoring Workgroup meeting on January 25, 2016, RMC members agreed to collaborate on implementation of the wet weather monitoring requirements. MRP 2.0 wet weather monitoring requirements include collection of water column samples during storm events for toxicity testing using the same five organisms required for dry weather testing and analysis of pyrethroids, fipronil, imidacloprid, and indoxacarb.[28] All 10 wet weather samples were collected in WY 2018 during a single storm event on January 8, 2018. SCVURPPP and ACCWP each collected three samples, and SMCWPPP and CCCWP each collected two samples.

6.2 Methods

6.2.1 Site Selection

Under MRP 1.0, the three annual pesticides and toxicity monitoring sites were selected from the list of 20 probabilistic sites where bioassessment surveys were conducted. See Section 2.2 of this report for a description of the probabilistic survey design. Sites were identified based on the likelihood that they would be safe to access during storm events and that fine depositional sediments would be present to sample during the dry season.

Under MRP 2.0, water and sediment toxicity and sediment chemistry samples were collected from two sites during dry weather: Stevens Creek and San Tomas Aquino Creek (see Figure 6.1). Sites were selected to represent urban watersheds that were not already being monitored for toxicity or pesticides by other programs, such as the SWAMP Stream Pollution Trends (SPoT) program or the California Department of Pesticide Regulation (DPR) Surface Water Protection Program Monitoring (SWPP). Specific stations within the watersheds were identified based on the likelihood that they would contain fine depositional sediments during dry season sampling and would be safe to access during wet weather sampling. It is anticipated that

[28] Standard analytical methods for indoxacarb are not currently available. Indoxacarb analysis will not be required until the water year following notification by the Executive Officer that a method is available.

SCVURPPP will continue to sample these same two stations throughout the permit term of MRP 2.0, with the goal of building a long-term dataset that complements data being gathered through SWAMP SPoT and DPR SWPP.

In WY 2018, in compliance with Provision C.8.g.iii of MRP 2.0, water toxicity and pesticides samples were collected from three sites during wet weather: Stevens Creek, San Tomas Aquino Creek, and Calabazas Creek (see Figure 6.1). The sites on Stevens Creek and San Tomas Aquino Creek were selected because they were the focus of MRP 2.0 dry weather monitoring. The station on Calabazas Creek was selected because it is located at the bottom of a large urban watershed that may be representive of other urban watersheds in the Santa Clara Basin.

All stations monitored by SCVURPPP for wet and dry weather pesticides and toxicity during WY 2014 through WY 2019 are illustrated in Figure 6.1. SPoT and DPR stations are also included in the figure.

6.2.2 Sample Collection

Water and sediment samples for pesticides and toxicity monitoring were collected in accordance with SWAMP-comparable methods and procedures described in the BASMAA RMC SOPs (BASMAA 2016a) and the associated QAPP (BASMAA 2016b). Before sampling, field personnel conduct a qualitative assessment of the proposed sampling site to identify appropriate sampling locations. This is particularly necessary for sediment sampling, which requires the presence of fine-sediment depositional areas that can support at least five sub-sites within a 100 meter reach.

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

Sediment samples were collected after any water samples were collected. Sediment samples were collected from the top 2 cm at each sub-site beginning at the downstream-most location and continuing upstream. Field staff walk in an upstream direction, carefully avoiding disturbance of sediment at collection sub-sites. Sediment samples were placed in a compositing container, thoroughly homogenized, and then aliquoted into separate jars for chemical or toxicological analysis using standard clean sampling techniques (see SOP FS-6, BASMAA 2016a).

Samples were submitted to respective laboratories under RMC SOP FS-9 Chain of Custody procedures and field data sheets were reviewed per SOP FS-13 (BASMAA 2016a).

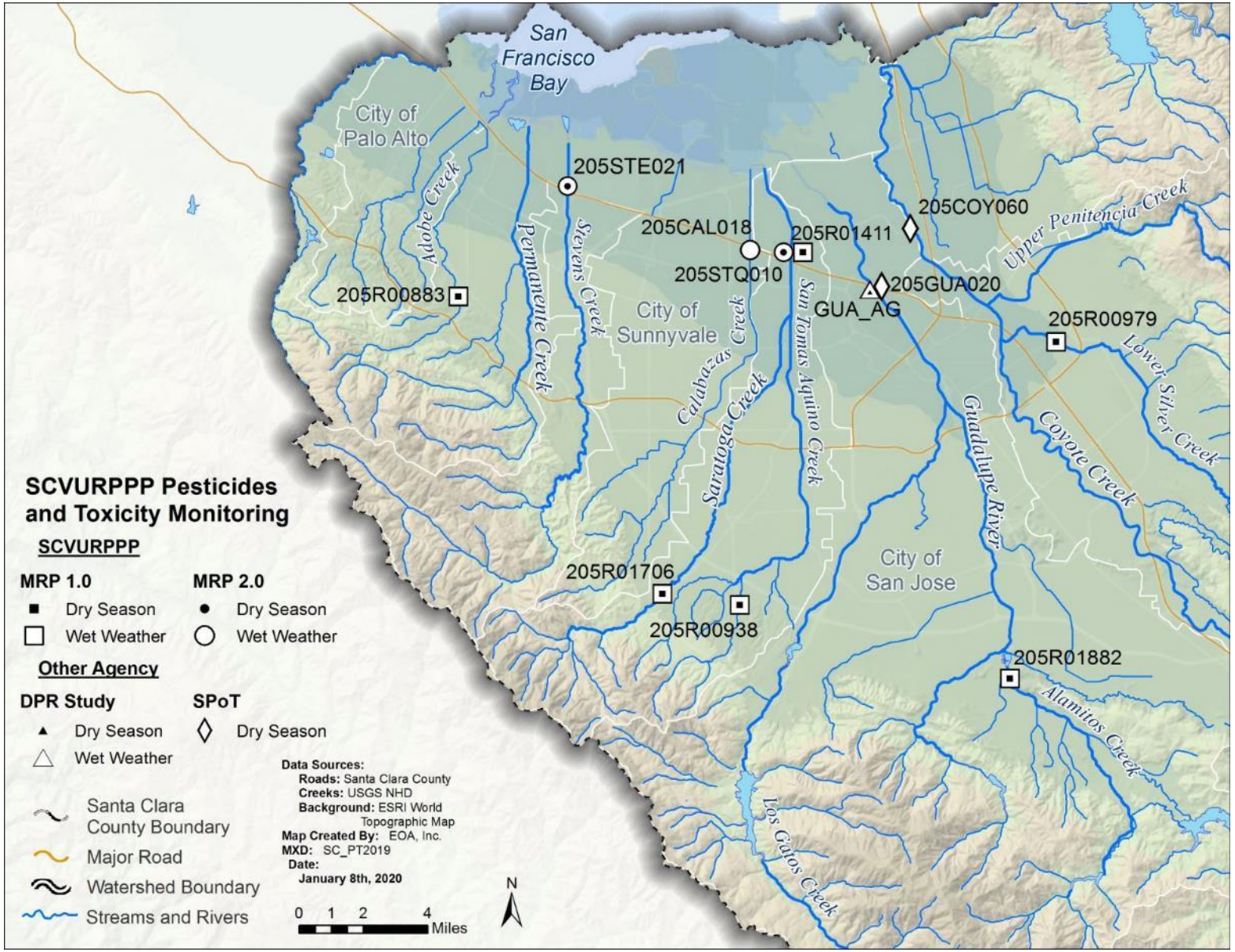


Figure 6.1. Pesticides and toxicity sampling stations in the Santa Clara Basin during WYs 2014 through 2019.

6.2.3 Data Evaluation

Water and Sediment Toxicity

Toxicity data evaluation required by MRP 1.0 and MRP 2.0 involves first assessing whether the samples are toxic to the test organisms relative to the laboratory control treatment via statistical comparison. MRP 2.0 specifies using the Test of Significant Toxicity (TST) statistical approach to compare the sample to the laboratory control. For samples with toxicity (i.e., those that "failed" the TST), the Percent Effect is evaluated. The Percent Effect compares sample endpoints (survival, reproduction, growth) to the laboratory control endpoints. Both the statistical comparison (e.g., TST) and the comparison of the sample results to the laboratory control (e.g., Percent Effect) are determined by the laboratory.

For WY 2014 and WY 2015 data, Table 8.1 of MRP 1.0 identified toxicity results of less than 50% of the laboratory control as requiring follow-up action for water toxicity tests. For sediment toxicity tests conducted during these years, Table H-1 identified toxicity results of greater than 20% less than the control as requiring follow-up action. Follow-up actions for MRP 1.0 include resampling sites where water toxicity tests exceeded the thresholds defined in the MRP. Failure of sediment toxisty tests did not require resampling. Based on the results of initial and/or resampling events, sites with observed toxicity above these thresholds onto a list for consideration of Stressor/Source Identification (SSID) projects, consistent with the MRP.

For WY 2016 through WY 2019 data, Provision C.8.g of MRP 2.0 identified toxicity results reported as "fail" via the TST approach and a Percent Effect of ≥ 50% as requiring follow-up action for water and sediment tests. Follow-up actions include the resampling of a site if any toxicity test result exceeds the threshold defined in MRP 2.0. If both the initial and follow-up sample exceed the threshold, the site is added to the list of candidate SSID projects.

Sediment Chemistry

Sediment chemistry results were evaluated using three criteria: Probable Effects Concentration (PEC) quotients, Treshold Effects Concentration (TEC) quotients and Toxicity Unit (TU) equivalents. PEC and TEC quotients are calculated as the ratio of the measured concentration to the respective PEC and TEC values from MacDonald et al. (2000). TU equivalents are calculated for individual pyrethroid pesticide results based on available LC50[29], values from the literature. Because organic carbon mitigates the toxicity of pyrethoid pesticides and the LC50 values are derived on the basis of TOC-normalized concentrations, the pyrethroid concentrations as reported by the lab were divided by the measured TOC concentration at each site, and the TOC-normalized concentrations were then used to compute TU equivalents for each pyrethroid.

Under MRP 1.0 (WY 2014 and WY 2015), sites were added to the list of candidate SSID projects if three or more TEC quotients were ≥ 1.0, if the site had a mean PEC quotient ≥ 0.5, or if the sum of TU equivalents for all measured pyrethroids was ≥ 1.0.

MRP 2.0 requires that all sites where a PEC or TEC quotient is ≥ 1.0 are added to the list of candidate SSID projects. MRP 2.0 does not require consideration of pyrethroid, fipronil, or carbaryl[30] sediment chemistry data for follow-up SSID projects, perhaps because pyrethroids

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

[30] No LC50 is published for carbaryl in sediment.

are ubiquitous in the urban environment and little is known about fipronil and carbaryl distribution.

Evaluation of sediment chemistry data and calculation of PEC/TEC quotients and TU equivalents is based in several assumptions and considerations, including:

- For PAHs in sediment, the laboratory reports concentrations for 24 individual PAHs; whereas, PECs and TECs are listed in MacDonald et al. (2000) for total PAHs. Total PAH concentrations were calculated by summing the concentrations of 24 individual PAHs.
- Concentrations equal to one-half of the respective laboratory method detection limits were substituted for non-detect data so that calculations and statistics could be computed. Therefore, some of the TEC and PEC quotients and TU equivalents may be artificially elevated (and contribute to trigger exceedances) due to the method used to account for non-detect data.
- The TECs for bedded sediments are very conservative values that do not consider site specific background conditions, and are therefore not very useful in identifying real water quality concerns in receiving waters in Santa Clara County. All sites in the County are likely to have at least one TEC quotient equal to or greater than 1.0. This is due to high levels of naturally-occurring chromium and nickel in geologic formations (i.e., serpentine) and soils that contribute to TEC and PEC quotients.

Water Chemistry

Water chemistry analysis was not part of pesticides and toxicity monitoring under MRP 1.0. Provision C.8.g.iv of MRP 2.0 requires that chemical pollutant data from water and sediment monitoring is compared to the corresponding water quality objectives in the SF Bay Water Quality Control Plan (i.e., Basin Plan) for each analyte sampled. If concentrations in the samples exceed the associated water quality objectives, then the site at which the exceedances were observed will be added to the list of candidate SSID projects. The Basin Plan, however, the does not contain numeric water quality objectives for the chemical analytes that are required to be monitored as part of MRP wet weather pesticide monitoring.

6.3 Results and Discussion

In WY 2014 and WY 2015, a total of six sites (three sites per year) were monitored for water and sediment toxicity and sediment chemistry during the wet and dry seasons within the watersheds of Adobe Creek, San Tomas Aquino Creek, and Lower Silver Creek. Sites were selected at locations where bioassessment surveys were conducted. The results of these monitoring efforts were compared to MRP 1.0 trigger thresholds.

In WY 2016 through WY 2019, dry weather water and sediment toxicity and sediment chemistry monitoring was conducted to satisfy the requirements specified in MRP 2.0. This monitoring took place at the same two sites in Stevens Creek and San Tomas Aquino Creek over all three years. In WY 2018, wet weather toxicity and water chemistry monitoring was conducted at three sites to satisfy Provision C.8.g.iii of MRP 2.0. Two of these sites were the same sites in Stevens Creek and San Tomas Aquino Creek where the dry weather monitoring took place, while the third site was located in Calabasas Creek.

Toxicity and pesticides monitoring results are described in the sections below. Conclusions are provided in Section 7.0.

6.3.1 Toxicity

WY 2019 Results

Table 6.1 provides a summary of toxicity testing results for water and sediment samples collected during dry weather in WY 2019. Due to MRP threshold exceedances associated with the samples taken at station 205STE021 on Stevens Creek, as described below, this site was added to the list of potential SSID project locations.

- **Stevens Creek (205STE021).** The dry weather sediment sample at this sites was not toxic to either of the test organisms utilized. The water sample was significantly toxic to two of the five test organisms (*C. dubia* and *C. dilutus*). The Percent Effect did not exceed the 50% threshold for follow-up for *C. dilutus* (survival), but the threshold for follow-up was exceeded for *C. dubia* (reproduction). The follow-up water sample was significantly toxic, but the 50% threshold for follow-up was not exceeded. The cause of the water toxicity to this test organism that is sensitive to a broad range of aquatic contaminants is unknown. Chronic (reproduction) toxicity to *C. dubia*, however, has been observed in some prior samples collected by SCUVRPPP (Table 6.2) in Stevens Creek. Regional Water Board staff have also observed toxicity in Stevens Creek in previous years. A preliminary study of Stevens Creek toxicity conducted by the Regional Water Board was inconclusive and additional investigation is currently considered a low priority (Jan O'Hara, *personal communication*, Dec. 9, 2019).

- **San Tomas Aquino Creek (205STQ010).** The water sample taken from this site was significantly toxic to one of the five test organisms (*C. dubia*), however, the Percent Effect did not exceed the 50% threshold for follow-up. The cause of the water toxicity is unknown. The sediment sample from this site was significantly toxic to one of the two test organisms (*C. dilutus*) and the Percent Effect exceeded the 50% threshold for follow-up. The follow-up sediment sample was not toxic to *C. dilutus*. The cause of the sediment toxicity is unknown. *C. dilutus* is known to be sensitive to noenicitinoid pesticides, such as fipronil, however, the concentration of fipronil and its degradates at the sites were all below the method detection limit (MDL) in the sediment sample collected concurrently with the initial toxicity sample.

Table 6.1. Summary of SCVURPPP dry weather toxicity results for WY 2019.

Site	Organism	Test Type	Unit	Results		% Effect	TST Value	Follow up needed
				Lab Control	Organism Test			
205STQ010 San Tomas Aquino Creek July 23, 2019	**Water**							
	Ceriodaphnia dubia	Survival	%	100	100	0%	NA[1]	No
		Reproduction	Num/Rep	32	22	31.3%	Fail	No
	Pimephales promelas	Survival	%	100	97.5	2.5%	Pass	No
		Growth	mg/ind	0.767	0.805	-4.99%	Pass	No
	Chironomus dilutus	Survival	%	100	87.5	13%	Pass	No
	Hyalella azteca	Survival	%	100	100	0.00%	Pass	No
	Selenastrum capricornutum	Growth	cells/ml	3560000	5220000	-46.5%	Pass	No
	Sediment							
	Chironomus dilutus	Survival	%	80	35	**56.3%**	**Fail**	**Yes**
	Hyalella azteca	Survival	%	96.2	96.2	0.00%	Pass	No
205STQ010 San Tomas Aquino Creek August 28, 2019	**Sediment – Resample**							
	Chironomus dilutus	Survival	%	92.5	81.2	12.16%	Pass	No
205STE021 Stevens Creek July 23, 2019	**Water**							
	Ceriodaphnia dubia	Survival	%	100	90	10%	NA[1]	No
		Reproduction	Num/Rep	32	8.6	**73.1%**	**Fail**	**Yes**
	Pimephales promelas	Survival	%	100	90	10.0%	Pass	No
		Growth	mg/ind	0.767	0.71	6.85%	Pass	No
	Chironomus dilutus	Survival	%	100	82.5	18%	Fail	No
	Hyalella azteca	Survival	%	100	98	2.00%	Pass	No
	Selenastrum capricornutum	Growth	cells/ml	3560000	3390000	4.7%	Pass	No
	Sediment							
	Chironomus dilutus	Survival	%	80	83.8	-4.69%	Pass	No
	Hyalella azteca	Survival	%	96.2	98.8	-2.60%	Pass	No
205STE021 Stevens Creek September 18, 2019	**Water - Resample**							
	Ceriodaphnia dubia	Survival	%	90	100	0.00%	NA[1]	No
	Ceriodaphnia dubia	Young/female	Num/Rep	32.3	17.2	46.8%	Fail	No

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

WY 2014 – WY 2019 Results Summary

Toxicity results for the IMR reporting period (WY 2014 through WY 2019) are summarized in Table 6.2. Details of the WY 2014 to WY 2018 toxicity tests can be found in the Urban Creeks Monitoring Reports for each associated year (SCVURPPP 2019, SCVURPPP 2018, SCVURPPP 2017, SCVURPPP 2016, SCVURPPP 2015).

During WY 2014 through WY 2019, two sediment samples and four water samples had observed toxicity relative to the laboratory control *and* a Percent Effect exceeding the MRP evaluation criteria (see Section 6.2.3 for an explanation of MRP 1.0 and 2.0 triggers). There were an additional 20 test results where significant toxicity was observed, but the Percent Effect did not exceed the MRP trigger threshold. There is no clear pattern to these observations of toxicity. The samples were collected from a variety of creeks under both wet and dry season conditions and a variety of test organisms were affected. In all but one case, the six events with observed toxicity and a Percent Effect over the MRP threshold were resampled for the same test organism within the same season, and the follow-up tests did not exceed the MRP toxicity trigger thresholds. Of the 26 samples where significant toxicity was observed, a majority were water samples and associated with either *C. dubia* reproduction (10 samples) or *H. azteca* survival (7 samples). Six of the seven water samples with toxicity to *H. azteca* survival were collected during wet season sampling events, suggesting that stormwater runoff may be adversely affecting *H. azteca*. The water samples with toxicity to *C. dubia* were more evenly dispersed between wet and dry season sampling events.

With the adoption of MRP 2.0, SCVURPPP initiated annual monitoring of toxicity and pesticides in San Tomas Aquino Creek and Stevens Creek with the goal of building a long-term dataset. A review of the toxicity summary in Table 6.2 suggests that toxicity to *H. azteca*, a test organism known to be sensitive to pyrethroid pesticides is less prevalent in these creeks than toxicity to *C. dilutus*, a test organism known to be sensitive to neonicotinoids (e.g., imidacloprid). This finding is consistent with monitoring results reported by DPR which show that imidacloprid is being detected more frequently throughout Northern California streams (Ensminger 2017). Based on these limited results, it appears plausible that the water quality impacts associated with pyrethroid pesticides may be decreasing, while impacts associated with their replacements (i.e., neonicotinoids) may be increasing as these types of pesitides gain market share.

Table 6.2. Toxicity test result summary, WY 2014 – WY 2019. The Percent Effect is indicated for test results with toxicity relative to the lab control. Test results with toxicity exceeding the MRP 1.0 and MRP 2.0 trigger thresholds are highlighted.

					Sediment			Water						
					C. dilutus [2]	*H. azteca*		*C. dubia*		*P. promelas*		*C. dilutus* [2]	*H. azteca*	*S. capricornutum*
Station ID	Creek	Date	Water Year	Season	Survival	Survival	Growth [2]	Survival	Reproduction	Survival	Growth	Survival	Survival	Growth
MRP 1.0														
205R00883	Adobe Cr	2/24/2014	WY 2014	Wet	--	--	--	No	No	No	No	--	No	No
205R00883	Adobe Cr	6/4/2014	WY 2014	Dry	--	**Yes** (9%)	No	No	**Yes** (25%)	No	No	--	No	No
205R00938	San Tomas Aquino Cr	2/24/2014	WY 2014	Wet	--	--	--	No	**Yes** (26%)	No	No	--	No	No
205R00938	San Tomas Aquino Cr	6/4/2014	WY 2014	Dry	--	No	No	No	**Yes** (45%) [1]	No	No		No	No
205R00979	Lower Silver Cr	2/24/2014	WY 2014	Wet	--	--	--	No	No	No	No	--	**Yes** (29%)	No
205R00979	Lower Silver Cr	6/4/2014	WY 2014	Dry	--	No	No	No	No	No	No	--	No	No
205R01411	San Tomas Aquino Cr	2/26/2015	WY 2015	Wet	--	--	--	No	**Yes** (17%)	No	No	--	**Yes** (16%)	No
205R01411	San Tomas Aquino Cr	7/7/2015	WY 2015	Dry	--	No	No	No	No	No	No	--	No	No
205R01706	Saratoga Cr	2/26/2015	WY 2015	Wet	--	--	--	No	No	No	No	--	**Yes** (45%)	No
205R01706	Saratoga Cr	7/7/2015	WY 2015	Dry	--	No	No	No	No	No	No	--	No	No
205R01882	Alamitos Cr	2/26/2015	WY 2015	Wet	--	--	--	No	**Yes** (17%)	No	No	--	**Yes** (35%)	No
205R01882	Alamitos Cr	7/7/2015	WY 2015	Dry	--	**Yes** (100%)	**Yes** (100%)	No	No	No	No	--	No	No
MRP 2.0														
205STQ010	San Tomas Aquino Cr	7/11/2016	WY 2016	Dry	**Yes** (18%)	No	--	No	No	No	No	No	No	No
205STQ010	San Tomas Aquino Cr	7/13/2017	WY 2017	Dry	No	No	--	No	**Yes** (30%)	No	No	**Yes** (11%)	No	No
205STQ010	San Tomas Aquino Cr	1/8/2018	WY 2018	Wet	--	--	--	No	No	No	No	No	**Yes** (56%)	No
205STQ010	San Tomas Aquino Cr	3/1/2018	WY 2018	Wet [3]	--	--	--	No	--	--	--	**--**	No	--
205STQ010	San Tomas Aquino Cr	7/17/2018	WY 2018	Dry	No	No	--	No	No	No	No	No	No	No
205STQ010	San Tomas Aquino Cr	7/23/2019	WY 2019	Dry	**Yes** (56%)	No	--	No	**Yes** (31%)	No	No	No	No	No
205STQ010	San Tomas Aquino Cr	8/28/2019	WY 2019	Dry [3]	No	--	--	No	--	--	--	--	--	--
205STE021	Stevens Cr	7/11/2016	WY 2016	Dry	No	No	--	No	No	**Yes** (27%)	No	No	No	No
205STE021	Stevens Cr	7/13/2017	WY 2017	Dry	No	No	--	No	**Yes** (80%)	No	No	No	No	No
205STE021	Stevens Cr	8/15/2017	WY 2017	Dry [3]	--	--	--	No	No	--	--	--	--	--
205STE021	Stevens Cr	1/8/2018	WY 2018	Wet	--	--	--	No	No	No	No	No	**Yes** (28%)	No
205STE021	Stevens Cr	7/17/2018	WY 2018	Dry	No	No	--	No	No	No	No	**Yes** (24%)	No	No
205STE021	Stevens Cr	7/23/2019	WY 2019	Dry	No	No	--	No	**Yes** (73%)	No	No	**Yes** (18%)	No	No
205STE021	Stevens Cr	9/18/2019	WY 2019	Dry [3]	--	--	--	No	**Yes** (47%)	--	--	--	--	--
205CAL018	Calabazas Cr	1/8/2018	WY 2018	Wet	--	--	--	No	No	No	No	No	**Yes** (60%)	No
205CAL018	Calabazas Cr	3/1/2018	WY 2018	Wet [3]	--	--	--	No	--	--	--	--	**Yes** (12%)	--

1 - The test response in one of the replicates for this test treatment was determined to be a statistical outlier; the results reported above are for the analysis of the data excluding the outlier.
2 - *Chironomus dilutus* testing was not required by MRP 1.0. *Hyalella azteca* growth was not required by either permit but is included here when reported by the lab.
3- Resample.

6.3.2 Sediment Chemistry

Sediment chemistry results are evaluated as potential stressors based on TEC quotients and PEC quotients according to trigger thresholds listed in MRP 1.0 and MRP 2.0 (see Section 6.2.3). Evaluation of TU equivalents was required under MRP 1.0 and, although not required under MRP 2.0, used to inform stormwater management.

WY 2019 Results

Table 6.3 lists concentrations and TEC quotients for sediment chemistry constituents (metals and total PAHs) collected in WY 2019 from Stevens Creek and San Tomas Aquino Creek. TEC quotients are calculated as the measured concentration divided by the highly conservative TEC value, per MacDonald et al. (2000)[31]. TECs are extremely conservative and are intended to identify concentrations below which harmful effects on sediment-dwelling organisms are unlikely to be observed. Both sites exceeded the trigger threshold from MRP 2.0 of having at least one result exceeding the TEC and will be added to the list of potential SSID projects. However, the constituents with TEC quotients ≥ 1.0 were limited to nickel and chromium which are expected in watersheds draining hillsides underlain by serpentine formations.

Table 6.4 lists concentrations and PEC quotients for sediment chemistry constituents (metals and total PAHs) collected in WY 2019. PECs are intended to identify concentrations above which toxicity to benthic-dwelling organisms are predicted to be probable. No PEC quotients were greater than 1.0 in San Tomas Aquino Creek. The PEC quotient for nickel, a serpentine-related metal) in Stevens Creek was equal to 1.2.

Table 6.3. Threshold Effect Concentration (TEC) quotients for WY 2019 sediment chemistry constituents. Bolded and shaded values indicate TEC quotient ≥ 1.0.

Analyte	TEC	205STE021 Stevens Creek		205STQ010 San Tomas Aquino Creek	
Metals (mg/kg DW)		**Concentration**	**Quotient**	**Concentration**	**Quotient**
Arsenic	9.79	2.8	0.29	2.1	0.21
Cadmium	0.99	0.19	0.19	0.09	0.09
Chromium	43.4	65	**1.5**	37	0.85
Copper	31.6	27	0.85	18	0.57
Lead	35.8	11	0.31	6.7	0.19
Nickel	22.7	57	**2.5**	36	**1.6**
Zinc	121	84	0.69	58	0.48
PAHs (ug/kg DW)					
Total PAHs	1610	227	0.14[a]	106	0.07[a]

[a] Total calculated using 1/2 MDLs for some individual PAHs.

[31] MacDonald et al. (2000) does not provide TEC or PEC values for pyrethroids, fipronil, or carbaryl. Pesticides are compared to LC50 values in Table 6.5.

Table 6.4. Probable Effect Concentration (PEC) quotients for WY 2019 sediment chemistry constituents. Bolded and shaded values indicate PEC quotient ≥ 1.0.

Analyte	PEC	205STE021 Stevens Creek		205STQ010 San Tomas Aquino Creek	
Metals (mg/kg DW)		**Concentration**	**Quotient**	**Concentration**	**Quotient**
Arsenic	33.0	2.8	0.08	2.1	0.06
Cadmium	4.98	0.19	0.04	0.09	0.02
Chromium	111	65	0.59	37	0.33
Copper	149	27	0.18	18	0.12
Lead	128	11	0.09	6.7	0.05
Nickel	48.6	57	**1.2**	36	0.7
Zinc	459	84	0.18	58	0.13
PAHs (ug/kg DW)					
Total PAHs	22,800	227.3	0.01[a]	106.15	0.005[a]

[a] Total calculated using 1/2 MDLs for some individual PAHs.

Table 6.5 lists the concentrations of pesticides measured in sediment samples taken in WY 2019, TOC-normalized concentrations, and TU equivalents for the pesticides for which there are published LC50 values in the literature. Many of the pesticides measured were below MDLs and the TU equivalents were calculated using ½ the MDL concentration. No TU equivalents exceeded 1.0. The highest TU equivalent in the Stevens Creek sample was for fipronil sulfone (0.21), however, this calculation was based on ½ the MDL and therefore is an estimate. The TU equivalent for bifenthrin, which is considered to be the leading cause of pyrethroid-related toxicity in urban areas (Ruby 2013) and the most-commonly detected insecticide monitored by the DPR SWPP (Ensminger 2017), was 0.15. The highest TU equivalent in the WY 2019 San Tomas Aquino Creek sediment sample was for cypermethrin (0.12).

Table 6.5. Pesticide concentrations and calculated toxic unit (TU) equivalents, WY 2019.

Analyte	Unit	LC50 [c]	205STE021 Stevens Creek			205STQ010 San Tomas Aquino Creek		
			Concentration	Normalized to TOC	TU Equivalent	Concentration	Normalized to TOC	TU Equivalent
Total Organic Carbon	%	NA	0.79	NA	NA	0.58	NA	NA
Pyrethroid								
Bifenthrin	µg/g dw	0.52	0.0006 [b]	0.08	0.15	0.0003 [a]	0.04	0.09
Cyfluthrin, total	µg/g dw	1.08	0.0003 [a]	0.04	0.03	0.0003 [a]	0.05	0.05
Cypermethrin, total	µg/g dw	0.38	0.0003 [a]	0.03	0.09	0.0003 [a]	0.04	0.12
Deltamethrin/ Tralomethrin	µg/g dw	0.79	0.0003 [a]	0.04	0.05	0.0003 [a]	0.05	0.07
Esfenvalerate /Fenvalerate, total	µg/g dw	1.54	0.0003 [a]	0.04	0.03	0.0003 [a]	0.06	0.04
Cyhalothrin, Total lambda-	µg/g dw	0.45	0.0002 [a]	0.02	0.04	0.0003 [a]	0.03	0.06
Permethrin, Total	µg/g dw	10.83	0.0003 [a]	0.04	0.003	0.0003 [a]	0.05	0.004
			Sum of TU Equivalents		0.4	Sum of TU Equivalents		0.4
Other MRP Pesticides of Concern								
Carbaryl	mg/Kg dw	NA [d]	0.01 [a]	1.3	NA	0.01 [a]	1.7	NA
Fipronil	ng/g dw	306	0.26 [a]	32.9	0.11	0.26 [a]	44.0	0.14
Fipronil Desulfinyl	ng/g dw	NA [d]	0.26 [a]	32.9	NA	0.26 [a]	44.0	NA
Fipronil Sulfide	ng/g dw	435	0.26 [a]	32.9	0.08	0.26 [a]	44.0	0.10
Fipronil Sulfone	ng/g dw	158	0.26 [a]	32.9	0.21	0.26 [a]	44.0	0.28

a. Concentration was below the method detection limit (MDL). TU equivalents calculated using 1/2 MDL.
b. TU equivalents calculated from concentration below the reporting limit (J-flagged).
c. Sources: Amweg et al. 2005 and Maund et al. 2002 for pyrethroids; Maul et al. for fipronil compounds
d. No available LC50 value for Carbaryl or Fipronil Desulfinyl.

In compliance with the MRP, a grain size analysis was conducted on both of the WY 2019 sediment samples (Table 6.6). The Stevens Creek (205STE021) sample was 10.2% fines (i.e., 3.8% clay and 6.4% silt); and the San Tomas Aquino Creek (205STQ010) sample was 5.2% fines (i.e., 0.7% clay and 4.5% silt).

Table 6.6. Summary of grain size for the two locations sampled in Santa Clara County during WY 2019.

Grain Size (%)		205STE021	205STQ010
		Stevens Creek	San Tomas Aquino Creek
Clay	<0.0039 mm	3.8%	0.7%
Silt	0.0039 to <0.0625 mm	6.4%	4.5%
Sand	V. Fine 0.0625 to <0.125 mm	12.1%	3.4%
	Fine 0.125 to <0.25 mm	8.4%	16.7%
	Medium 0.25 to <0.5 mm	31.9%	45.8%
	Coarse 0.5 to <1.0 mm	10.6%	21.6%
	V. Coarse 1.0 to <2.0 mm	9.2%	7.3%
Granule	2.0 to <4.0 mm	9.6%	2.2%
Pebble	Small 4 to <8 mm	7.5%	2.8%
	Medium 8 to <16 mm	0%	0%
	Large 16 to <32 mm	0%	0%
	V. Large 32 to <64 mm	0%	0%

Note: Sum of grain size values for both sites is greater than 100% due to the laboratory analytical methods used.

WY 2014 – WY 2019 Summary

Between WY 2014 and WY 2019, only one sediment sample had a PEC quotient that exceeded 1.0, for analytes other than chromium and nickel. Chromium and nickel are excluded from this PEC/TEC analysis because they are contributed primarily by serpentine formations present naturally in the watersheds where monitoring occurred. A total mercury PEC quotient of 10 was calculated for the sediment sample collected from Alamitos Creek (site 205R01882) in WY 2015. This sample also had complete mortality to *H. azteca*. This station on Alamitos Creek is within the Guadalupe River watershed downstream of portions of the former New Almaden Mercury Mining District, which is the likely cause of the high concentration. Mercury contamination in the Guadalupe River watershed and throughout the region is being investigated and controlled through implementation of the San Francisco Bay and Guadalupe River Watershed Mercury Total Maximum Daily Load (TMDL) water quality restoration program.

Excluding chromium and nickel, there were 8 samples in the WY 2014 through WY 2019 dataset with TEC quotients ≥ 1.0; the more conservative of the two sediment chemistry evaluation criteria. The constituents and locations with TEC quotients ≥ 1.0 included:

- Total mercury in Alamitos Creek in WY 2015.
- Legacy insecticide DDT compounds were monitored under MRP 1.0 but not under MRP 2.0. Samples with DDT (and daughter product DDE) TEC quotients ≥ 1.0 include: San Tomas Aquino Creek (WY 2014 and WY 2015) and Lower Silver Creek (WY 2014).

- Copper TEC quotients were ≥ 1.0 in sediment samples from Adobe Creek (WY 2014), San Tomas Aquino Creek (WY 2014 and WY 2015), and Stevens Creek (WY 2016 and WY 2018).
- Total PAHs TEC quotients were ≥ 1.0 in samples from Stevens Creek in WY 2017 and WY 2018.

Table 6.7 lists TU equivalents for pesticides with LC50s available in the literature and concentrations for pesticides without LC50s for sediment samples collected in WY 2014 – WY 2019. The sum-of-pyrethroids TU equivalents ranged from 0.11 (Stevens Creek in WY 2017) to 5.36 (Lower Silver Creek in WY 2014). Three samples had sum-of-pyrethroid TU equivalents that exceeded the MRP 1.0 trigger threshold of 1.0: San Tomas Aquino Creek in WY 2014, Lower Silver Creek in WY 2014, and Stevens Creek in WY 2016. Since WY 2016, no samples have had a sum-of-pyrethroids TU equivalent ≥ 1.0 suggesting that pyrethroid concentrations may be decreasing in Santa Clara Basin creek sediments.

Table 6.7. TU equivalent summary for Santa Clara County sediment samples, WY 2014 – WY 2019.

Analyte			Pyrethroids								Other MRP Pesticides of Concern				
			Bifenthrin	Cyfluthrin	Cypermethrin	Deltamethrin	Esfenvalerate	Lambda-cyhalothrin	Permethrin	**Sum Pyrethroids**	Carbaryl	Fipronil	Fipronil desulfinyl	Fipronil sulfide	Fipronil sulfone
LC50 [c]			0.52 µg/g dw	1.08 µg/g dw	0.38 µg/g dw	0.79 µg/g dw	1.54 µg/g dw	0.45 µg/g dw	10.83 µg/g dw	-	NA [d]	306 ng/g dw	NA [d]	435 ng/g dw	158 ng/g dw
Station ID	**Creek**	**Date**													
MRP 1.0															
205R00883	Adobe Creek	6/4/2014	0.33	<MDL	<MDL	<MDL	<MDL	<MDL	0.03 [b]	**0.76** [a]	-	-	-	-	-
205R00938	San Tomas Aquino	6/4/2014	2.88	0.62	<MDL	<MDL	<MDL	<MDL	0.12 [b]	**4.00** [a]	-	-	-	-	-
205R00979	Lower Silver Creek	6/4/2014	3.27	0.44	<MDL	<MDL	<MDL	<MDL	0.16 [b]	**5.36** [a]	-	-	-	-	-
205R01882	Alamitos Creek	7/7/2015	0.26	<MDL	<MDL	<MDL	<MDL	<MDL	0.01 [b]	**0.32** [a]	-	-	-	-	-
205R01411	San Tomas Aquino	7/7/2015	0.54	0.08	0.06 [b]	0.12	<MDL	0.03 [b]	0.01 [b]	**0.85** [a]	-	-	-	-	-
205R01706	Saratoga Creek	7/7/2015	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	**0.16** [a]	-	-	-	-	-
MRP 2.0															
205STQ010	San Tomas Aquino	7/11/2016	0.39	0.15	0.15 [b]	0.11 [b]	<MDL	<MDL	0.03	**0.88** [a]	<MDL	0.01 [b]	-	-	-
205STQ010	San Tomas Aquino	7/13/2017	0.07 [b]	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	**0.22** [a]	<MDL	<MDL	<MDL	<MDL	<MDL
205STQ010	San Tomas Aquino	7/17/2018	0.39	0.15	0.15 [b]	0.11 [b]	<MDL	<MDL	0.03	**0.88** [a]	<MDL	<MDL	<MDL	<MDL	<MDL
205STQ010	San Tomas Aquino	7/23/2019	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	**0.43** [a]	<MDL	<MDL	<MDL	<MDL	<MDL
205STE021	Stevens Creek	7/11/2016	0.78	0.13	0.03 [b]	0.19	0.02 [b]	0.03 [b]	0.03	**1.21** [a]	<MDL	0.01 [b]	-	-	-
205STE021	Stevens Creek	7/13/2017	0.07	<MDL	0.02 [b]	<MDL	<MDL	<MDL	0.002	**0.11** [a]	<MDL	<MDL	<MDL	<MDL	<MDL
205STE021	Stevens Creek	7/17/2018	0.12 [b]	<MDL	0.03 [b]	0.10	<MDL	<MDL	<MDL	**0.29** [a]	<MDL	<MDL	<MDL	<MDL	<MDL
205STE021	Stevens Creek	7/23/2019	0.15 [b]	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	**0.40** [a]	<MDL	<MDL	<MDL	<MDL	<MDL

a. Total calculated using 1/2 MDLs for some individual pyrethroids.
b. TU equivalents calculated from concentration below the reporting limit (J-flagged).
c. Sources: Amweg et al. 2005 and Maund et al. 2002 for pyrethroids; Maul et al. 2008 for fipronil compounds
d. No available LC50 value for Carbaryl or Fipronil Desulfinyl.

6.3.3 Pesticides in Water

During WY 2018, 10 water samples were taken during wet weather events at three sites in Calabasas Creek, San Tomas Aquino Creek, and Stevens Creek to fulfill Provision C.8.g.iii.(3) of MRP 2.0, which requires aquatic toxicity testing and monitoring of water column pesticide concentrations. Results were reported in the WY 2018 UCMR (SCVURPPP 2019). Statistically significant toxicity was observed in the water samples from all three sites (Table 6.2), and the magnitude of toxicity observed at the Calabasas and San Tomas Aquino Creek sites required the collection of follow-up samples. It was not necessary, however, to add any these sites to the list of potential SSID project locations based on the follow-up sample results where toxicity was not observed. The concentrations of most pesticides, with the exception of bifenthrin and fipronil compounds for some samples, were below the MDL, meaning that these analytes were reported as non-detects. There are no water quality objectives specified in the San Francisco Bay Basin Plan for water column pesticide analytes. As a result, no WQO or MRP trigger threshold exceedance analysis was performed on wet weather pesticide data.

6.3.4 Additional Monitoring Efforts

Throughout the monitoring period associated with the results described in this report, several additional programs external to the RMC conducted similar pesticides and toxicity monitoring studies within California. These studies provide valuable data for comparison against RMC findings to view regional water quality in a broader spatial and temporal context, ultimately providing more accurate and complete answers to the management questions set forth by the MRP.

DPR SWPP Monitoring

Mentioned previously in this document, the DPR SWPP is one of the largest pesticide monitoring and management efforts currently being undertaken in California. Pesticide studies conducted by the DPR SWPP evaluate the frequency of pesticide detections at any concentration and make use of USEPA aquatic benchmarks for many pesticide compounds. DPR provides web access to a number of their monitoring reports which contain detailed analyses of USEPA aquatic benchmark exceedance rates. DPR also maintains the Surface Water Database (SURF) to provide public access to quantitative pesticide data from a wide array of surface water monitoring studies. This database could be queried in the future to allow for the leverage of DPR monitoring data in more complex analyses of MRP pesticide data.

In WY 2017, DPR conducted two studies in Northern and Southern California that involved pesticides and toxicity monitoring at urban sites in Alameda, Contra Costa, Placer, Sacramento, Santa Clara (Guadalupe River – see Figure 6.1), Los Angeles, Orange, and San Diego Counties. Both water and sediment samples were collected and analyzed for a wide range of pesticide compounds. In both the Northern and Southern California studies, bifenthrin and fipronil were found to be among the most frequently detected pesticides. Additionally, pyrethroid concentrations were found to be above their USEPA minimum benchmarks for toxicity to aquatic life for the majority of samples with the exception of cyfluthrin. The studies also state that the detection frequencies of most pyrethroids have remained consistent over recent years. (Budd 2018 and Ensminger 2017)

In WY 2018, DPR again conducted two urban monitoring studies in Northern and Southern California that targeted watersheds in the same counties sampled during WY 2017 and involved the collection of water and sediment samples. Similar to WY 2017, bifenthrin was among the most frequently detected insecticides in water samples from both the Northern and Southern

California WY 2018 studies. In the Northern California study, bifenthrin was the most frequently detected insecticide and second most frequently detected compound in water samples with a detection frequency (DF) of 76%. In the Southern California study, bifenthrin was the most frequently detected pyrethroid insecticide and the fifth most frequently detected compound in water samples with a DF of 72%. Fipronil and its degradates were also detected at high rates in water samples from the Northern and Southern California studies. While fipronil itself only had a DF of 48% in the Northern California study, fipronil and its degradates collectively had a DF of 72%. Out of these compounds, fipronil sulfone was found at the highest rate with a DF of 70%. Fipronil was also found at a high rate during the Southern California study with a DF of 76%. Its degradates were also found in a large portion of samples, with fipronil sulfone again being the most found with a DF of 67%. Sediment samples from Northern and Southern California were collected and analyzed for bifenthrin and eight other pyrethroids, but concentrations of fipronil and its degradates were not measured. In both studies, bifenthrin was detected in all samples and was also responsible for the greatest magnitude of TUs. (Budd 2019 and Ensminger 2019)

Findings from the WY 2017 and WY 2018 DPR studies generally corroborate the results garnered from SCVURPPP pesticides monitoring. In particular, bifenthrin has been the most frequently detected pesticide in samples collected by SCVURPPP from WY 2014 through WY 2019 and responsible for the high-magnitude TU equivalents. It is of note, however, that although fipronil and its degradates were frequently detected during the DPR studies, they were seldom found at detectable levels during SCVURPPP monitoring.

SPoT Monitoring Program

The SPoT Monitoring Program conducts annual dry season monitoring (subject to funding constraints) of sediments collected from a statewide network of large rivers. The goal of the SPoT Program is to investigate long-term trends in water quality. Sites are targeted in bottom-of-the-watershed locations with slow water flow and appropriate micromorphology to allow deposition and accumulation of sediments, including stations near the mouth of Coyote Creek and the Guadalupe River (Figure 6.1). In most years, sediments are analyzed for toxicity, pesticides, metals, PCBs, mercury, and organic pollutants (Phillips et al. 2014). The most recent technical report prepared by SPoT program staff was published in 2016 and describes seven-year trends from the initiation of the program in 2008 through 2014 (Phillips et al. 2016). An update to the report is anticipated in the near future.

Toxicity testing was conducted by SPoT in Santa Clara County watersheds using *H. azteca* as the indicator organism and the TST statistical approach, similar to a subset of the toxicity testing completed by SCVURPPP. SPoT samples were characterized as highly toxic if the percent survival was lower than the threshold of 38.6% survival identified as the lower limit survival rate threshold for high toxicity (Anderson et al. 2011). SPoT reported that *H. azteca* toxicity responses have been consistent over the seven-year monitoring period with toxic and highly toxic samples accounting for an average of 18.6% of the samples tested (Phillips et al. 2014). This average aligns relatively closely with the total amount of toxicity exceedances attributed to *H. azteca* survival found during SCVURPPP monitoring from WY 2014 through WY 2019, which was approximately 14%. The SPoT study also calculated five-year rolling averages of toxicity results from 2008 to 2012 and again from 2010 to 2014 to resolve temporal trends in the data. It was found that while the total number of sites exhibiting no toxicity increased from the first averaging period to the second, the number of sites exhibiting moderate to high toxicity also increased during this time (Phillips et al. 2014).

During SPoT sediment chemistry monitoring, the average total pyrethroid concentrations were shown to have doubled from 2010 to 2013. The SPoT analysis identified urban monitoring sites as the exclusive cause of the increase in average pyrethroid concentrations, as pyrethroid concentrations in agricultural and other land use areas remained consistently low throughout the entirety of the monitoring period. The study identified bifenthrin as the primary driver of the increase in average pyrethroid concentrations with a DF of 73% throughout the extent of the monitoring period (Phillips et al. 2014). These findings contrast with the results of the most recent SCVURPPP monitoring period, which have suggested that bifenthrin and other pyrethroid loading within Santa Clara County watersheds may be decreasing. Additionally, results from SPoT testing for fipronil at urban sites in 2013 and 2014 showed that the DF of fipronil and its degradates in addition to their average and maximum concentrations increased between the two years. This trend indicates that, while rarely detected by SCVURPPP at quantifiable levels, monitoring of fipronil and its degradates may be merited in future years.

7.0 CONCLUSIONS AND RECOMMENDATIONS

This section includes conclusions and recommendations from the review of Creek Status and Pesticides & Toxicity Monitoring data collected by SCVURPPP in WYs 2014 through 2019, which were described in the previous sections of this report.

In WY 2019, in compliance with provisions C.8.d and C.8.g of MRP 2.0 and the BASMAA RMC Creek Status and Long-Term Trends Monitoring Plan (BASMAA 2012), SCVURPPP continued to implement a two-component monitoring design that was initiated in WY 2012. The strategy includes a regional ambient/"probabilistic" bioassessment monitoring component and a component based on local "targeted" monitoring for general water quality parameters and pesticides/toxicity. The combination of these monitoring designs allows each individual RMC participating program to assess the status of Beneficial Uses in local creeks within its Program (jurisdictional) area, while also contributing data to answering management questions at the regional scale (e.g., differences between aquatic life condition in urban and non-urban creeks).

Conclusions from Creek Status and Pesticides/Toxicity Monitoring conducted during WY 2014 through WY 2019 in the Santa Clara Valley are based on the management questions presented in Section 1.0 of this report:

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

The first management question is addressed primarily through the evaluation of probabilistic and targeted monitoring data with respect to WQOs and triggers defined in the MRP. A summary of trigger exceedances observed for each site in WY 2019 is presented in Table 7.2. Trigger exceedances from WY 2014 through WY 2018 are listed in prior annual monitoring reports (SCVURPPP 2019, SCVURPPP 2018, SCVURPPP 2017, SCVURPPP 2016, SCVURPPP 2015). In compliance with Provision C.8.e.i of MRP 2.0, SCVURPPP coordinates with the RMC to maintain a comprehensive list of all monitoring results from the region exceeding trigger thresholds. Sites where triggers are exceeded may indicate potential impacts to aquatic life or other Beneficial Uses and are considered for future evaluation of Stressor/Source Identification projects.

The second management question is addressed primarily by assessing indicators of aquatic biological health using benthic macroinvertebrate and algae data. The indices of biological integrity based on BMI and algae data (i.e., CSCI and ASCI) are direct measures of aquatic life Beneficial Uses. Biological condition scores were compared to physical habitat and water quality data collected synoptically with bioassessments to evaluate whether any correlations exist that may explain the variation in biological condition scores. Continuous monitoring data (temperature, dissolved oxygen, pH, and specific conductance) are evaluated with respect to COLD and WARM Beneficial Uses. Pathogen indicator data are used to assess REC-1 (water contact recreation) Beneficial Uses.

All monitoring and data validation was conducted using methods consistent with the BASMAA RMC QAPP (BASMAA 2016a) and SOPs (BASMAA 2016b).

7.1 Conclusions

7.1.1 Biological Condition Assessment

In WYs 2012 through 2019, bioassessment monitoring was conducted in compliance with Provisions C.8.c of MRP 1.0 and C.8.d.i of MRP 2.0. Nearly all bioassessment monitoring (168 of 172 sites) was performed at sites selected randomly using the regional probabilistic monitoring design. The probabilistic monitoring design allows each individual RMC participating program to objectively assess stream ecosystem conditions within its program area (e.g., county boundary) while contributing data to answer regional management questions about water quality and Beneficial Use condition in San Francisco Bay Area creeks. The monitoring design was developed to address the following management questions:

1. *What is the condition of aquatic life in creeks in the RMC area; are water quality objectives met and are Beneficial Uses supported?*
2. *What are major stressors to aquatic life in the RMC area?*
3. *What are the long-term trends in water quality in creeks over time?*

The first question (i.e., *What is the condition of aquatic life in creeks in the RMC area?*) is addressed by assessing indicators of aquatic biological health at probabilistic sampling locations. Over the past eight years (WYs 2012 through 2019), SCVURPPP and the Regional Water Board have sampled 168 probabilistic sites in Santa Clara Valley streams, providing a sufficient sample size to estimate ambient biological condition for urban streams countywide within known estimates of precision. Stream condition was assessed using three different types of indices/tools: 1) the BMI-based CSCI, 2) the draft benthic algae-based ASCI (diatom, soft algae, and hybrid), and 3) the physical habitat-based IPI. Of these three, the CSCI is the only tool with an MRP trigger threshold for follow-up SSID consideration.

The second question (i.e., *What are major stressors to aquatic life in the RMC area?*) is addressed by the evaluation of physical habitat and water chemistry data collected at the probabilistic sites, as potential stressors to biological health. Assessing the extent and relative risk of stressors can help prioritize and inform local management decisions. The stressor levels are compared to biological indicator data (i.e., CSCI and ASCI scores) through correlation and random forest models. The methods were consistent with the approach used in the RMC Five-Year Bioassessment Report (BASMAA 2019) which analyzed the first five years (WY 2012 – WY 2016) of regional bioassessment data. Results from the Program assessment are compared to the regional assessment.

The third question (i.e., *What are the long-term trends in water quality in creeks over time?*) is addressed by assessing the change in biological condition over several years. Changes in biological condition over time can help evaluate the effectiveness of management actions and the effects of changes in factors affecting biological community composition (e.g., climate change).

7.1.1.1 Bioassessment Data (WY 2019)

In WY 2019, 20 sites were sampled for benthic macroinvertebrates, benthic algae, and nutrients. Physical habitat and general water quality parameters were also measured at each site. Sixteen of the twenty sites were randomly selected using the probabilistic monitoring design and four were targeted sites.

CSCI scores and water quality data were compared to applicable WQOs and triggers identified in the MRP. Sites with results that exceed WQOs and triggers are considered as candidates for SSID projects, consistent with Provision C.8.e of MRP 2.0.

- Fourteen of the probabilistic sites and all four targeted sites had CSCI scores below the MRP trigger threshold of 0.795. These seventeen sites were all classified as within urban segments of these streams.
- Four sites had un-unionized ammonia concentrations that exceeded WQOs. No other nutrient or general water quality parameters were measured at concentrations exceeding WQOs or MPR trigger thresholds.

Bioassessment data collected at the four targeted sites during WY 2019 were in creek reaches with planned or recently completed stream restoration work that entailed placement of gravel and wood into the channel for the purpose of increasing the amount of spawning habitat and high flow refugia on the floodplain for salmonid fish populations. Bioassessment data are intended to provide baseline dataset to compare changes in biological conditions at these sites over time.

7.1.1.2 Countywide Bioassessment Data (WY 2012 – WY 2019)

The bioassessment data collected at probabilistic sites (n=168) over the 8-year timeframe were evaluated to assess the current condition of streams in the County and to identify stressors that are likely to pose the greatest risk to stream health. The methods used to evaluate bioassessment data were consistent with the approach used to develop the RMC Five-Year Bioassessment Report (BASMAA 2019).

<u>Biological Condition Assessment</u>

Four biological indicators (CSCI and ASCI-D, ASCI-SB, ASCI-H) were used to assess stream conditions. Results of the analysis indicate that much of the stream length in Santa Clara County is in poor biological condition. Aquatic life uses may not be fully supported at a majority of sites sampled by SCVURPPP. These findings should be interpreted with the understanding that the survey focused on urban segments of streams. Approximately 81% of the assessments (140 of 172) were conducted at urban sites, while only 19% (32 of 172) were conducted at non-urban sites. Although the low number of non-urban sample size precludes making any definitive comparisons, bioassessment scores at non-urban sites were generally higher than scores at urban sites.

- A total of 128 of the 172 (74%) bioassessment sites (including four targeted sites) received CSCI scores that were below the MRP trigger (0.795), corresponding to the two lower condition categories *(likely altered* and *very likely altered)*. Of the 128 low-scoring sites, 113 were classified as urban. The proportion of high-scoring sites varies by watershed. Cumulative distribution frequency functions (CDFs) for CSCI scores indicate there is a 65% probability that a random site in Santa Clara County will have a CSCI score below 0.79 (i.e., *likely altered* or *very likely altered*). There is an 80% probability that a random *urban* site in Santa Clara County will have a CSCI score below 0.79 and there is a 48% probability that a random *non-urban* site will have a CSCI score below 0.79.

- Biological conditions based on algae data (ASCI) differ from those based on BMI data (CSCI). The ASCI-D tool applies diatom data, the ASCI-SB tool applies soft bodied

algae data, and the ASCI-H tool applies both. Table 7.1 summarizes the percentages of sites in each condition category for each of the four indices. The percentage of sites in each category based on ASCI-D and ASCI-H was similar to the CSCI results. The ASCI-SB scores do not appear to be associated with urban disturbance gradient. A higher percentage of sites was in the *likely intact* condition category based on ASCI-SB scores and a lower percentage was in the *very likely altered* category, compared to CSCI.

Table 7.1. Percent of stream sites in Santa Clara County within each biological condition category, WY 2012 – WY 2019.

Index [1]	Sites with index score [2]	Likely Intact	Possibly Altered	Likely Altered	Very Likely Altered
Benthic Macroinvertebrates (BMI)					
CSCI	172	19%	7%	23%	52%
Benthic Algae					
ASCI-D	172	20%	18%	30%	32%
ASCI-SB	165	42%	24%	16%	18%
ASCI-H	165	26%	10%	17%	47%

[1] Indices: CSCI = California Stream Condition Index; ASCI-D = Diatom Algae Stream Condition Index; ASCI-SB = Soft Bodied Algae Stream Condition Index; ASCI-H = Hybrid Algae Stream Condition Index.

[2] Index scores for ASCI-SB and ASCI-H were not calculated for 7 bioassessment sites due to insufficient soft algae taxa needed to calculate a score.

Stressor Assessment

Relationships between biological indicators (i.e., CSCI, ASCI-D, ASCI-SB and ASCI-H) and stressor data were evaluated using Spearman's rank correlation, and random forest models utilized only CSCI and ASCI-H indices to evaluate potential relationships. The results indicate that each of the biological indicators respond to different types of stressors.

- The random forest model indicates that watershed, along with physical habitat and several landscape and water-quality stressors, were the best predictors of CSCI scores.

- In the Spearman's rank correlation analysis, nutrients (Total Nitrogen and Total Kjeldahl Nitrogen) correlated more closely with ASCI-H scores than with CSCI scores. Total Nitrogen ranked as an important variable for ASCI-H based on the random forest model results.

- The strength of the correlations between biological indices and stressors was highly variable by watershed. Nutrients did not correlate well with CSCI score for any watershed, however, Stevens Creek exhibited one of the highest correlation coefficients between ASCI score and total nitrogen concentrations.

- The ASCI-D and ASCI-H scores were similarly responsive to environmental-stressor (i.e., urban) gradients, and were particularly aligned with water quality and habitat factors. In contrast, the ASCI-SB index was high scoring at both disturbed and undisturbed sites throughout Santa Clara County, and therefore may not be a good indicator of perturbation.

- Results of the Santa Clara Valley stressor assessment were similar to the RMC regional assessment. Both Santa Clara and regional CSCI scores are strongly influenced by physical habitat variables, such as the level of imperviousness in the contributing watershed area (BASMAA 2019).

It should be acknowledged that despite these apparent relationships to stressors, these analyses do not determine causation, particularly as stressors from habitat/landscape factors are often present at the same sites that exhibit water quality impairment.

7.1.1.3 Trends Assessment

Based on a review of the probabilistic water quality and biological data collected in Santa Clara Valley streams between WYs 2012-2019, it appears that analyses of long-term trends using the probabilistic dataset will require more than eight years of monitoring. The distribution of CSCI scores at urban sites were highly variable across the eight years of monitoring suggesting there are wide range of biological conditions at urban sites, as well as potential variation in conditions due to changes in environmental conditions from year to year (e.g., precipitation, temperature).

A comparison of the probabilistic dataset with targeted data collected prior to MRP adoption (i.e., WYs 2003 -2009) allows for a semi-quantitative trends assessment. SCVURPPP conducted bioassessments in mostSanta Clara Valley watersheds between 2003 and 2009 as part of watershed assessment and monitoring requirements in its municipal stormwater NPDES Permit (Pre-MRP). Biological conditions, based on CSCI scores, during Pre-MRP and MRP time periods were compared for all sites within the six watersheds. For most watersheds, the median CSCI scores were very similar between Pre-MRP and MRP sampling events. Likewise, data collected during Pre-MRP and MRP time periods from nine individual sites in those watersheds were also compared. In general, most sites had similar CSCI scores between the two time periods.

7.1.2 Continuous Monitoring for Temperature and General Water Quality

Continuous water temperature and general water quality monitoring was conducted in WY 2014 through WY 2019 in compliance with Provisions C.8.c of MRP 1.0 and C.8.d.iii – iv of MRP 2.0. Temperature measurements were recorded hourly at a minimum of eight sites each year from April through September. Specific conductance, DO, pH, and temperature were recorded continuously (15 minute interval) at three sites each year during two 2-week periods in spring (Event 1) and summer (Event 2). Monitoring was conducted to address the following management questions:

1. *What is the spatial and temporal variability in water quality conditions during the spring and summer season?*
2. *Do general water quality measurements indicate potential impacts to aquatic life?*

Monitoring sites were selected based on the presence of significant fish and wildlife resources and historical and/or recent indications of water quality concerns. The same sites were often monitored for multiple years to gain a better understanding of the range of water quality conditions that may occur over time. In some years, continuous monitoring data were used to support or follow-up on SSID investigations.

- The Sevens Creek watershed, which supports steelhead rearing and spawning habitat, was targeted for general water quality monitoring in WY 2014 and WY 2015. Monitoring

stations were located above and below the reservoir. Overall, water quality conditions were consistent with COLD Beneficial Uses. However, in WY 2014, the number of dissolved oxygen measurements below 7 mg/L in stations below the reservoir exceeded MRP trigger threshold. Furthermore, the MRP maximum weekly average temperature trigger threshold 17°C of was exceeded in both years.

- In WY 2014 and WY 2015, temperature monitoring was conducted at a combined nine stations in the Stevens Creek and Guadalupe Creek watersheds. None of the stations exceeded the maximum instantaneous trigger threshold of 24°C. Seven of the nine stations exceeded the MWAT threshold (17°C). However, it is important to evaluate the temperature data within the context that monitoring was conducted during an extended drought period that resulted in extremely low flow conditions during the dry season.

- The Upper Penitencia Creek watershed was targeted for temperature and general water quality monitoring in WY 2016 to support and SSID study investigating reduced biological condition in a specific stream segment. The MWAT threshold (17°C) was generally not exceeded at the four upper elevation sites that were located in reaches that support juvenile steelhead populations in Alum Rock Park. However, temperatures recorded at the four lower elevation sites did exceed the MWAT threshold and are likely too high to support juvenile steelhead rearing habitat. Triggers for dissolved oxygen and pH were exceeded at the lowest elevations sites; both sites are located downstream of percolation ponds, which may impact water quality conditions in the creek following water releases from the ponds during late spring/summer season.

- The Guadalupe River watershed was targeted for temperature monitoring in WYs 2017 through 2019. Stations were located below Guadalupe Reservoir and Almaden Reservoir. Although the instantaneous maximum temperature trigger threshold was not exceeded, the MWAT trigger was exceeded at every station, each WY. In general, water temperatures were consistent from year to year and increased in the downstream direction.

- The Coyote Creek watershed was targeted for general water quality monitoring in WYs 2017 through 2019. The goal of the monitoring was to follow-up on an SSID study that was completed in 2013 and investigated low dissolved oxygen in a low-gradient reach along the mainstem. Dissolved oxygen concentrations were generally higher in WYs 2017 through 2019, compared to 2013 (but still exceeded the MRP trigger threshold). The improved dissolved oxygen concentraitons were possibly in response to high velocity flows in WY 2017 that flushed out oxygen-demanding bedded sediments that had accumulated in the reach during the WY 2012 through WY 2016 drought.

Overall, continuous monitoring results typically find that temperature and specific conductivity increase in the downstream direction Santa Clara Valley watersheds, which correlates with increased levels of urbanization. In addition, the MRP maximum weekly average temperature (MWAT) trigger threshold of 17°C is often exceeded. These temperature exceedances result in sites being placed on the list of candidate SSID projects, but may not be of concern in Santa Clara County. The MWAT threshold was developed for cooler streams of the Pacific Northwest. Fish in the Santa Clara Basin have likely adapted to warmer conditions. Some locations where the MWAT trigger was exceeded are in reaches through which cold water fish migrate, rather than segments that provide rearing habitat.

7.1.3 Pathogen Indicators

From WY 2014 through WY 2019, in compliance with Provisions C.8.c of MRP 1.0 and C.8.d.v of MRP 2.0, SCVURPPP collected five grab samples per year for pathogen indicator bacteria analyses. Monitoring was conducted at sites that, while generally not considered "bathing beaches," are located within creekside parks or along trails with a potential for public access to water. Some stations were sampled in multiple years. The overall goal of pathogen indicator monitoring is to assess whether WQOs are being met, i.e. supportive of REC-1 Beneficial Uses.

Although WQO exceedances were found in two of the six watersheds targeted, there is no evidence for large-scale spatial patterns of bacteria concentrations. The results suggest that pathogen indicator densities at the monitoring stations are highly variable. It is important to recognize that pathogen indicators do not directly represent actual pathogen concentrations and do not distinguish among sources of bacteria. Sources of pathogen indicator bacteria may include homeless encampments, wildlife, livestock, pets, leaking septic systems/sanitary sewers, and regrowth of bacteria in the environment. It is the human sources of bacteria that are of primary concern for REC-1 health risks. As a result, the comparison of pathogen indicator results to pathogen indicator thresholds may not indicate that a health risk is present, and therefore should be interpreted cautiously.

7.1.4 Chlorine Monitoring

From WY 2012 through WY 2019, in compliance with Provision C.8.c of MRP 1.0 and Provision C.8.d.ii of MRP 2.0, SCVURPPP collected field measurements of total and free chlorine residual in creeks where bioassessments were conducted.

While chlorine residual is generally not a concern in Santa Clara Valley urban creeks, WY 2019 and prior monitoring results suggest there are occasional free chlorine and/or total chlorine residual exceedances in the Santa Clara Basin. Trigger exceedances may be the result of a one-time potable water discharges that are difficult to trace. Furthermore, chlorine in surface waters can dissipate from volatilization and reaction with sediment and organic matter. Over the past eight years of monitoring (WY 2012 – WY 2019), there have been a total of 17 sites with chlorine trigger exceedances (none in WY 2019 after immediate re-sampling).

7.1.5 Pesticides and Toxicity Monitoring

Toxicity testing, sediment chemistry monitoring, and water column pesticides monitoring, collectively referred to as pesticides and toxicity monitoring, was conducted during WY 2014 through WY 2019 in compliance with Provisions C.8.c of MRP 1.0 and C.8.g of MRP 2.0. There were slight differences between the two permit terms with regard to the required number of samples, toxicity test organisms, chemical constituents, and MRP triggers.

Data Evaluation Summary

There are five toxicity test species for water samples and two test species for sediment samples. The test organism *H. azteca*, required for water and sediment is known to be sensitive to pyrethroid pesticides. The test organism *C. dilutus*, added in MRP 2.0, is known to be sensitive to neonicotinoids. A two-tiered approach is applied to assess toxicity. First, organism responses from ambient samples are compared to responses from appropriate laboratory control samples using a statistical comparison. This is followed by a comparison to a "threshold value" or "Percent Effect" that indicates the magnitude of the difference in response. The MRP 2.0 trigger threshold is 50 Percent Effect in the initial sample and a second, follow-up sample for

both water and sediment toxicity tests. The MRP 1.0 trigger threshold was 20 Percent Effect in sediment samples with no follow-up required and 50 Percent Effect in the initial and follow-up water samples.

Sediment chemistry data for metals, PAHs, and legacy pesticides (MRP 1.0 only) are compared to Threshold Effect Concentrations (TECs) and Probably Effect Concentrations (PECs) published by MacDonald et al. (2000). Most samples in Santa Clara County have chromium and nickel concentrations that exceed the TEC and PEC. These metals are naturally occurring in the serpentine formations that underly mountains and hills in the region. Sediment chemistry data for pyrethroid and fipronil (MRP 2.0 only) pesticides are compared to TOC-normalized LC50s, calculated at Toxicity Unit equivalents. Water chemistry data would be compared to WQOs, if any existed for the suite of monitored constituents.

Under MRP 1.0 (WY 2014 and WY 2015), pesticides and toxicity monitoring stations were selected from the list of bioassessment stations surveyed those years. Under MRP 2.0 (WY 2016 – WY 2019), bottom-of-the-watershed stations in different creeks were monitored each year with the goal of eventually developing geographically diverse dataset.

WY 2019 Results

In WY 2019, SCVURPPP conducted dry weather pesticides and toxicity monitoring at two stations (Stevens Creek and San Tomas Aquino Creek). Statistically significant toxicity to *C. dubia* (reproduction) and *C. dilutus* (survival) was observed in the water sample collected from Stevens Creek . The magnitude of the toxic effects in this sample did not exceed the MRP trigger criterion of 50 Percent Effect for *C. dilutus*, but this threshold was exceeded for *C. dubia*. Therefore, a follow-up sample was warranted for the latter species. The follow-up sample was found to be significantly toxic, but the follow-up threshold was not exceeded in this case. Due to the toxicity to *C. dubia* observed in the original and follow-up water samples, the Stevens Creek site will be added to a list of potential SSID project locations. The sediment sample taken at the Stevens Creek site was not toxic to either of the test organisms.

Statistically significant toxicity to *C. dubia* (reproduction) was also observed in the water sample collected from San Tomas Aquino during dry season sampling in July 2019. However, the Percent effect did not exceed the 50% threshold for follow-up. The cause of the water toxicity is unknown. The sediment sample from San Tomas Aquino was significantly toxic to one of the test organisms (*C. dilutus*), and the Percent Effect exceeded the 50% threshold for follow-up. The follow-up sediment sample was not found to be toxic to *C. dilutus.* The cause of this sediment toxicity is unknown.

Sediment chemistry results are evaluated as potential stressors based on TEC quotients and PEC quotients according to criteria in provision C.8.g.iv of the MRP. SCVURPPP also evaluated TU equivalents of pyrethroids and fipronil. TEC and PEC quotients were calculated for all metals and total PAHs measured in sediment samples from July 2019. Both sites had at least one TEC or PEC quotient exceeding 1.0. In compliance with the MRP, both stations will therefore be placed on the list of candidate SSID projects. Decisions about which SSID projects to pursue should be informed by the fact that the TEC and PEC quotient exceedances are related to naturally occurring chromium and nickel due to serpentine soils in the watersheds. No TU equivalents exceeded 1.0. The highest TU equivalent for both the Stevens Creek and San Tomas Aquino Creek samples was for fipronil sulfone.

WY 2018 Wet Weather Monitoring

During WY 2018, wet weather samples were taken at three sites in Santa Clara County (Calabasas Creek, San Tomas Aquino Creek, and Stevens Creek) to fulfill Provision C.8.g.iii.(3) of MRP 2.0, in coordination with the RMC partners. Results were reported in the WY 2018 UCMR (SCVURPPP 2019). Statistically significant toxicity was observed in the toxicity samples for all three sites, and the magnitude of toxicity observed at the Calabasas and San Tomas Aquino Creek sites required the collection of follow-up samples. However, it was not necessary to add any sites to the list of potential SSID project locations based on the follow-up sample results. The concentrations of most pesticides analyzed were below the MDL, except for bifenthrin and fipronil compounds.

WY 2014 – WY 2019 Data Summary

The results of pesticides and toxicity monitoring conducted from WYs 2014 through 2019 were analyzed to identify trends at sampling locations in Santa Clara County watersheds. During this period, there were two sediment samples and four water samples with toxicity relative to the laboratory control *and* a Percent Effect exceeding the MRP evaluation criteria. There were an additional 20 test results that had significant toxicity, but with a Percent Effect that did not exceed the MRP trigger thresholds. A majority of these toxicity results were found in water samples and were associated with either *C. dubia* reproduction (ten samples), a chronic toxicity endpoint, or *H. azteca* survival (seven samples), an acute toxicity endpoint. Six of the seven water samples with toxicity to *H. azteca* were collected during wet season sampling events suggesting that stormwater runoff is affecting *H. azteca*. The water samples with toxicity to *C.* dubia were more evenly divided between wet and dry season sampling events.

Between WY 2014 and WY 2019, only one sediment sample that had a PEC quotient ≥ 1.0 for an analyte other than chromium and nickel (mercury in Alamitos Creek downstream of the former New Almaden Mercury Mining District). Excluding the naturally-occurring chromium and nickel, there were eight samples with TEC quotients ≥ 1.0; the more conservative of the two evaluation criteria. These included legacy insecticide DDT compounds in San Tomas Aquino Creek and Lower Silver Creek; copper in Adobe Creek, San Tomas Aquino Creek, and Stevens Creek, and total PAHs in Stevens Creek. Overall, detection frequencies for bifenthrin and fipronil were on par with results from the DPR Northern California study (Ensminger 2019) and *H. azteca* toxicity responses were similar to SPoT monitoring in Coyote Creek and Guadalupe River (Phillips et al. 2014).

The pesticides and toxicity data collected from WYs 2014 through 2019 provide a reference to inform management decisions regarding water quality improvement in Santa Clara County watersheds and guide the planning of future monitoring in the area.

7.2 Trigger Assessment

The MRP requires analysis of the monitoring data to identify candidate sites for SSID projects. Trigger thresholds against which to compare the data are provided for most monitoring parameters in the MRP and are described in the foregoing sections of this report. Stream condition was assessed based on CSCI scores that were calculated using BMI data. Nutrient data were evaluated using applicable water quality standards from the Basin Plan. Water and sediment chemistry and toxicity data were evaluated using numeric trigger thresholds specified in the MRP. In compliance with provision C.8.e.i of the MRP, all monitoring results exceeding trigger thresholds are added to a list of candidate SSID projects that will be maintained throughout the permit term. Follow up SSID projects will be selected from this list. Table 7.2 lists

candidate SSID projects based on WY 2019 Creek Status and Pesticides/Toxicity monitoring data. Trigger and WQO exceedances from WY 2014 through WY 2018 were reported in the respective UCMRs (SCVURPPP 2015, 2016, 2017, 2018, and 2019).

Additional data analysis is provided in the previous sections of this report and should be considered prior to selecting and defining SSID projects. The analyses include review of physical habitat and water chemistry data to identify potential stressors that may be contributing to degraded or diminished biological conditions. Analyses in this report also include historical and spatial perspectives that help provide context and deeper understanding of the trigger exceedances.

Table 7.2. Summary of SCVURPPP Trigger Threshold Exceedance Analysis, WY 2019. "No" indicates samples were collected but did not exceed the MRP trigger; "Yes" indicates an exceedance of the MRP trigger.

Station ID	Creek	Bioassessment [1]	Nutrients [2]	Chlorine [3]	Water Toxicity [4]	Sediment Toxicity [4]	Sediment Chemistry [5]	Continuous Temperature [6]	Dissolved Oxygen [7]	pH [8]	Specific Conductance [9]	Pathogen Indicators [10]
205R04247	Stevens Creek	Yes	Yes	No	--	--	--	--	--	--	--	--
205R04271	Stevens Creek	No	Yes	No	--	--	--	--	--	--	--	--
205R04317	Coyote Creek	Yes	No	No	--	--	--	--	--	--	--	--
205R04359	Adobe Creek	Yes	No	No	--	--	--	--	--	--	--	--
205R04378	Los Gatos Creek	Yes	No	No	--	--	--	--	--	--	--	--
205R04383	San Francisquito Cr	Yes	No	No	--	--	--	--	--	--	--	--
205R04395	Arroyo De Los Coches	Yes	Yes	No	--	--	--	--	--	--	--	--
205R04418	Thompson Creek	Yes	No	No	--	--	--	--	--	--	--	--
205R04479	Saratoga Creek	Yes	No	No	--	--	--	--	--	--	--	--
205R04530	Upper Silver Creek	Yes	No	No	--	--	--	--	--	--	--	--
205R04537	Thompson Creek	Yes	No	No	--	--	--	--	--	--	--	--
205R04591	San Tomas Aquino Cr	Yes	Yes	No	--	--	--	--	--	--	--	--
205R04602	Wildcat Creek	Yes	No	No	--	--	--	--	--	--	--	--
205R04614	San Tomas Aquino Cr	Yes	No	No	--	--	--	--	--	--	--	--
205R04638	Guadalupe Creek	No	No	No	--	--	--	--	--	--	--	--
205R04670	Saratoga Creek	No	No	No	--	--	--	--	--	--	--	--
205COY455	Coyote Creek	Yes	No	No	--	--	--	--	--	--	--	--
205GUA060	Los Gatos Creek	Yes	No	No	--	--	--	--	--	--	--	--
205GUA251	Alamitos Creek	Yes	No	No	--	--	--	--	--	--	--	--
205STE070	Stevens Creek	Yes	No	No	--	--	--	--	--	--	--	--
205LGA033	Los Gatos Creek	--	--	--	--	--	--	--	--	--	--	No
205LGA400	Los Gatos Creek	--	--	--	--	--	--	--	--	--	--	Yes
205LGA420	Los Gatos Creek	--	--	--	--	--	--	--	--	--	--	No
205COY330	Coyote Creek	--	--	--	--	--	--	--	--	--	--	Yes
205COY392	Coyote Creek	--	--	--	--	--	--	--	--	--	--	No
205GUA190	Guadalupe Creek	--	--	--	--	--	--	Yes	--	--	--	--
205GUA202	Guadalupe Creek	--	--	--	--	--	--	Yes	--	--	--	--
205GUA210	Guadalupe Creek	--	--	--	--	--	--	Yes	--	--	--	--
205GUA218	Guadalupe Creek	--	--	--	--	--	--	Yes	--	--	--	--
205GUA250	Alamitos Creek	--	--	--	--	--	--	Yes	--	--	--	--
205GUA255	Alamitos Creek	--	--	--	--	--	--	Yes	--	--	--	--
205GUA262	Alamitos Creek	--	--	--	--	--	--	Yes	--	--	--	--
205GUA270	Alamitos Creek	--	--	--	--	--	--	Yes	--	--	--	--
205GUA279	Alamitos Creek	--	--	--	--	--	--	Yes	--	--	--	--
205COY235	Coyote Creek	--	--	--	--	--	--	Yes	Yes	No	No	--
205COY236	Coyote Creek	--	--	--	--	--	--	Yes	Yes	No	No	--
205COY239	Coyote Creek	--	--	--	--	--	--	Yes	Yes	No	No	--
205STE021	Stevens Creek	--	--	--	No	No	Yes	--	--	--	--	--
205STQ010	San Tomas Aquino Cr	--	--	--	No	No	Yes	--	--	--	--	--

Notes:

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

7.3 Recommendations

The recommendations presented in this section are directed towards the next iteration of the MRP (MRP 3.0) that is currently under development and will likely become effective in WY 2022. In WY 2020 and WY 2021 the Program will continue to coordinate with RMC partners on implementation of monitoring requirements in Provisions C.8.d and C.8.g of MRP 2.0.

The following recommendations are based on findings from six years (WY 2014 through WY 2019) of Creek Status and Pesticides/Toxicity monitoring conducted by SCVURPPP, as well as reflections on other monitoring, data analysis, and policy development projects being conducted in the region and statewide.

7.3.1 Biological Condition Assessment

The Program is currently working with RMC partners and Regional Water Board staff to evaluate options for revising the monitoring design for Biological Condition Assessments to address Creek Status Monitoring requirements anticipated under MRP 3.0. One of the options under consideration is a targeted monitoring design that would focus on specific watersheds or reaches of interest. A targeted watershed approach would provide stormwater programs more flexibility to evaluate priority areas that stakeholders want to improve, protect, or study. This approach was developed in response to the following findings of the SCVURPPP data analysis:

- Baseline ambient conditions in Santa Clara County urban creeks are described within known estimates of precision using probabilistic data generated through MRP 1.0 and MRP 2.0 monitoring and assessment tools such as the CSCI and ASCI. Continuing to build upon the probabilistic dataset at a countywide scale at this time is unlikely to provide additional benefits to local stormwater management programs.

- The probabilistic sample draw is only likely to provide sufficient new sites through WY 2020. A re-design of the sample draw could provide more sites and address some of the lessons learned about the current sample draw. However, this effort would only be warranted if ambient probabilistic monitoring is desired by SCVURPPP and/or its RMC partners.

- Probablisitc monitoring may inherently exclude stakeholders, such as municipal stormwater programs, land managers, creek groups, and other interested individuals and organizations, from being fully engaged in the SCVURPPP Watershed Monitoring and Assessment Program. Stakeholders may have a preference for the Program to conduct monitoring activities in targeted watersheds or creeks of high interest.

The following objectives could be used to guide future monitoring design:

- Conduct monitoring within a watershed or subwatershed of interest. The watershed could be selected based on known water quality concerns, existing aquatic and riparian resources, planned management activities, or stakeholder interest. Monitoring could be used to develop a high-resolution longitudinal profile of CSCI scores and potential stressors with the goal of identifying sources of stressors and implementing control actions. In addition to bioassessment surveys, monitoring could include creek walks using established protocols and desktop watershed mapping.

- Re-assess sites that have lower or higher biological condition than expected. Use the SCAPE model (discussed in Section 2.2.4.7) to prioritize sites for follow-up assessment. The SCAPE model that provides a context for evaluating stream health by estimating an expectation of biological condition along a given stream reach relative to landscape constraints. Biological condition, based on CSCI scores, can be compared to the reach expectation.

- Evaluate the effectiveness of BMPs or restoration projects. Conduct annual or biannual monitoring in creek reaches where biological condition and/or water quality are likely to improve due to planned management actions such as the implementation of Green Stormwater Infrastrcuture (GSI), flood control, and creek restoration projects. Baseline data generated through Pre-MRP, MRP 1.0, and MRP 2.0 monitoring can be used as baselines for comparison to future (post-implemention) conditions.

- Actively monitor and manage stream segments where monitoring data have indicated that water quality and/or biology is in good condition.

7.3.2 Continuous Monitoring for Temperature and General Water Quality

Continuous monitoring for temperature and general water quality has been an effective tool in supporting SSID studies and evaluating the condition of cold water habitat (COLD) Beneficial Uses. The Program recommends continued implementation of targeted continuous temperature and general water quality monitoring in MRP 3.0.

7.3.3 Pathogen Indicator Monitoring

Pathogen indicator monitoring is a relatively small part of the overall Creek Status and Pesticides & Toxicity monitoring program. Nonetheless, the Program recommends discontinuing this monitoring in MRP 3.0. This recommendation is based on several factors:

- Wildlife, a likely source of pathogen indicator bacteria in creeks, tend to congregate in urban creek corridors. It would be difficult and undesirable to restrict their use of creeks due to exceedances of pathogen indicator WQOs. Furthermore, bacteria from wildlife sources do not generally pose a health risk to REC-1 Beneficial Uses, compared to human sources of fecal pollution.

- Homeless encampments are another common source of bacteria in receiving waters. Although this human source of bacteria likely poses a risk to REC-1 Beneficial Uses, control options are challenging and generally not within the scope of stormwater management programs. The issue of homelessness is being addressed through a patchwork of public and private programs aimed at long-term housing, prevention, law enforcement, and other measures.[32]

- Bacteria densities in freshwater creeks are highly variable and single grab samples are not very useful in identifying problems or making decisions about stormwater management.

Monitoring efforts for pathogen indicators should instead be used to support bacteria Total Maximum Daily Load (TMDL) action plans or site-specific special studies, as applicable.

[32] https://calmatters.org/explainers/californias-homelessness-crisis-explained/

7.3.4 Chlorine Monitoring

Although chlorine monitoring can be an important tool in investigating fish kills, continued chlorine monitoring is not recommended in the next MRP. Based on the chlorine data from WY 2012 – WY 2019, little value is added to the Creek Status Monitoring program by this monitoring.

- The sources of chlorine detected through Creek Status Monitoring are generally transient, episodic, and challenging to trace.

- Discharges of drinking water are the most likely source of free chlorine and total chlorine residual. These discharges are already addressed by MRP Provisions C.5 (IDDE) and C.15 (Exempted and Conditionally Exempted Discharges) and the NPDES General Permit for Drinking Water Systems (Order WQ 2014-0194-DWQ).

- Available field equipment does not provide reliable results below 0.13 mg/L, a concentration higher than the MRP trigger resulting in uncertainty of exceedances. False positives can result in wasted efforts trying to track down non-existent sources.

7.3.5 Pesticides and Toxicity Monitoring

The Strategy to Optimize Resource Management of Storm Water (STORMS), adopted by the State Water Board in January 2016, is developing a statewide framework for urban pesticides reduction (Urban Pesticides Amendments). The primary goal of the statewide Urban Pesticides Amendments is to improve collaboration among regulators, leading to better management of pesticides in urban runoff. The Amendments will also organize coordinated pesticides and toxicity monitoring and data sharing. The Urban Pesticides Amendments team is proposing a statewide monitoring program that will substitute for pesticides and toxicity monitoring requirements in MS4 permits, such as the MRP. The goal is to generate useful data at minimal cost and standardize information at the statewide level. The Draft Amendments will likely be released for public review in early 2021 with adoption anticipated in mid-2021. At this time, the mechanism for implementing the statewide monitoring program is uncertain.

The Program recommends no changes to the current Provision C.8.g Pesticides and Toxicity monitoring requirements until the statewide monitoring program is in place.

7.4 Management Implications

The Program's Creek Status and Pesticides and Toxicity Monitoring programs (consistent with Provisions C.8.d and C.8.g of MRP 2.0, respectively) focus on assessing the water quality condition of urban creeks in the Santa Clara Valley and identifying stressors and sources of impacts observed.

This Integrated Creek Status Monitoring Report presents a comprehensive review of bioassessment and stressor data collected in WY 2012 through WY 2019. Data suggest that most urban streams have *likely altered* or *very likely altered* populations of aquatic life indicators (e.g., benthic macroinvertebrates). These poor stream conditions are likely the result of long-term changes in stream hydrology, channel geomorphology, in-stream habitat complexity, and other modifications to the watershed and riparian areas associated with the urban development that has occurred over the past 60-plus years. Additionally, episodic or site-specific increases in

temperature (particularly in lower creek reaches or reaches directly below reservoirs) may not be optimal for aquatic life in some local creeks.

The Program and its Co-permittees are actively implementing many stormwater management programs to address these and other stressors and associated sources of water quality conditions observed in local creeks, with the goal of protecting these natural resources. For example:

- In compliance with provision C.3 of MRP 2.0, new and redevelopment projects in the Bay Area are now designed to more effectively reduce water quality and hydromodification impacts associated with urban development. Low impact development (LID) methods, such as rainwater harvesting and use, infiltration, and biotreatment are required as part of development and redevelopment projects. In addition, Green Infrastructure planning is now part of all municipal projects. These LID measures are expected to reduce the impacts of urban runoff and associated impervious surfaces on stream health.
- In compliance with provision C.7 of MRP 2.0, the Program and its Co-permittees are implementing stormwater outreach activities through the Watershed Watch Campaign (Campaign) that encourage citizens and youth to make watershed-friendly choices. Pollution prevention messages are delivered at eight to ten community events per year, communicating the value and protection of creeks' natural resources to citizens both in plain non-scientific wording and multiple native languages (e.g., Spanish, Vietnamese, Chinese). Media advertising, such as the Earthquakes' and Sharks' collaborations, teach citizens how to dispose properly of litter, hazardous wastes, and car wash water. The Campaign also conducts numerous activities and sessions to educate children about watersheds and urban runoff pollution prevention through the Don Edwards San Francisco Bay National Wildlife Refuge, including watershed-focused field trips, marsh walks, gardening events, bird watching, and wildlife observation. Additionally, the Campaign supports the musical assembly program, ZunZun that engages students through music and theatre while teaching them about stormwater, watersheds, and pollution prevention topics. These efforts are expected to encourage watershed-positive behavior change in Santa Clara Valley residents.
- In compliance with provision C.9 of MRP 2.0, the Program and Co-permittees are implementing pesticide toxicity control programs that focus on source control and pollution prevention measures. The control measures include the implementation of integrated pest management (IPM) policies/ordinances, public education and outreach programs, pesticide disposal programs, and sustainable landscaping requirements for new and redevelopment projects. These efforts will eventually be supplemented by the statewide Urban Pesticides Amendments which will seek to manage pesticide usage via state and federal pesticide regulatory authorities such as DPR and USEPA. The anticipated result is a reduction in pyrethroids and other pesticides in urban stormwater runoff and a reduction in the magnitude and extent of toxicity in local creeks.
- Trash loadings to local creeks have been reduced through implementation of new control measures in compliance with provision C.10 of MRP 2.0 and other efforts by Co-permittees to reduce the impacts of illegal dumping directly into waterways. These actions include the installation and maintenance of trash capture systems, the adoption of ordinances to reduce the impacts of litter prone items, enhanced institutional controls such as street sweeping, and the on-going removal and control of direct dumping. MRP 2.0 establishes a mandatory trash load reduction schedule, minimum areas to be treated

by trash full capture systems, and requires development and implementation of receiving water monitoring programs for trash.

- In compliance with provisions C.2 (Municipal Operations), C.4 (Industrial and Commercial Site Controls), C.5 (Illicit Discharge Detection and Elimination), and C.6 (Construction Site Controls) of MRP 2.0, Co-permittees continue to implement programs that are designed to prevent non-stormwater discharges during dry weather and reduce the exposure of contaminants to stormwater and sediment in runoff during rainfall events.
- In compliance with provision C.13 of MRP 2.0, copper in stormwater runoff is reduced through implementation of controls such as architectural and site design requirements, prohibition of discharges from water features treated with copper, and industrial facility inspections.
- Mercury and polychlorinated biphenyls (PCBs) in stormwater runoff are being reduced through implementation of the respective TMDL water quality restoration plans. In compliance with provisions C.11 (mercury) and C.12 (PCBs) of MRP 2.0, the Program will continue to identify sources of these pollutants and will implement control actions designed to achieve new minimum load reduction goals. Monitoring activities conducted in WY 2014 through WY 2019 that specifically target mercury and PCBs are described in the Integrated Pollutants of Concern Monitoring Data Report that is included as Part D of this IMR.

In addition to the Program and Co-permittee controls implemented in compliance with the MRP, numerous other efforts and programs designed to improve the biological, physical and chemical condition of local creeks are underway. For example, the Valley Water's Integrated Water Resources Master Plan (IWRMP) or "One Water Plan" is an ongoing, multi-year process to develop a framework for long-term management of Santa Clara County water resources. The One Water Plan identifies, prioritizes and implements activities at a watershed scale to meet flood protection, water supply, water quality and environmental stewardship goals and objectives. Additionally, in 2019, SCVURPPP, via a Proposition 1 grant awarded to Valley Water, completed the Santa Clara Basin Stormwater Resource Plan.[33] This Plan supports the development and implementation of MRP-required Green Stormwater Infrastructure Plans and includes a prioritized list of of multi-benefit GSI project opportunities that may be eligible for future State implementation grant funds.

Through the continued implementation of MRP-associated and other watershed stewardship programs, SCVURPPP anticipates that stream conditions and water quality in local creeks will continue to improve over time. In the near term, toxicity observed in creeks should decrease as pesticide regulations better incorporate water quality concerns during the pesticide registration process. In the longer term, control measures implemented to "green" the "gray" infrastructure and disconnect impervious areas constructed over the course of the past 60-plus years will take longer to implement. Consequently, it may take several decades to observe the benefits of these important, large-scale watershed improvements in our local creeks. Long-term creek status monitoring programs designed to detect these changes over time are therefore necessary for our collective understanding of the condition, trends, and health of our local waterways.

[33] https://scvurppp.org/swrp/docs-maps/

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ATTACHMENTS

Attachment 1
QA/QC Report

Integrated Monitoring Report

Creek Status and Pesticides & Toxicity Monitoring

Quality Assurance/Quality Control Report

Water Year 2019

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Pollution Prevention Program

March 31, 2020

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LIST OF ACRONYMS

BASMAA	Bay Area Stormwater Management Agencies Association
BMI	Benthic Macroinvertebrates
CDFW	California Department of Fish and Wildlife
DPD	Diethyl-p-phenylene Diamine
DQO	Data Quality Objective
EDDs	Electronic data deliverables
EV	Expected Value
KLI	Kinnetic Laboratories, Inc.
LCS	Laboratory Control Sample
LCSD	Laboratory Control Sample Duplicate
MPN	Most Probably Number
MQO	Measurement Quality Objective
MRP	Municipal Regional Permit
MS	Matrix Spike
MSD	Matrix Spike Duplicate
MV	Measured Value
ND	Non-detect
NIST	National Institute of Standards and Technology
NPDES	National Pollution Discharge Elimination System
NV	Native Value
PAH	Polycyclic Aromatic Hydrocarbon
PR	Percent Recovery
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RL	Reporting Limit
RMC	Regional Monitoring Coalition
RPD	Relative Percent Difference
SAFIT	Southwest Association of Freshwater Invertebrate Taxonomists
SCCWRP	Southern California Coastal Water Research Project
SFRWQCB	San Francisco Regional Water Quality Control Board
SCVURPPP	Santa Clara Valley Urban Runoff Pollution Prevention Program
SOP	Standard Operating Procedures
STE	Standard Taxonomic Effort
SV	Spike Value
SWAMP	Surface Water Ambient Monitoring Program
TKN	Total Kjeldahl Nitrogen
WY	Water Year

1. INTRODUCTION

In Water Year 2019 (WY 2019; October 1, 2018 through September 30, 2019), the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP) conducted Creek Status Monitoring in compliance with provision C.8.d and Pesticide & Toxicity Monitoring in compliance with provision C.8.g of the National Pollutant Discharge Elimination System (NPDES) stormwater permit for Bay Area municipalities, referred to as the Municipal Regional Permit (MRP). The monitoring strategy includes regional ambient/probabilistic monitoring and local "targeted" monitoring as described in the Bay Area Stormwater Management Agencies Association (BASMAA) Regional Monitoring Coalition (RMC) Creek Status and Long-Term Trends Monitoring Plan (BASMAA 2012). SCVURPPP implemented a comprehensive data quality assurance and quality control (QA/QC) program, covering all aspects of the probabilistic and targeted monitoring. QA/QC for data collected was performed according to procedures detailed in the BASMAA RMC Quality Assurance Project Plan (QAPP) (BASMAA 2016a) and the BASMAA RMC Standard Operating Procedures (SOP; BASMAA 2016b), SOP FS-13 (Standard Operating Procedures for QA/QC Data Review). The BASMAA RMC QAPP and SOPs are based on the QA program developed by the California Surface Water Ambient Monitoring Program (SWAMP 2017).

Based on the QA/QC review, no WY 2019 data were rejected except for some of the continuous pH data collected in June. These data were rejected due to sensor failure. Additionally, some WY 2019 data were flagged due to issues identified in the QA/QC review. Overall, WY 2019 data met QA/QC objectives. Details are provided in the sections below.

1.1. DATA TYPES EVALUATED

During creek status monitoring (MRP Provision C.8.d), several data types were collected and evaluated for quality assurance and quality control. These data types include the following:

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

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

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

1.2. LABORATORIES

Laboratories that provided analytical and taxonomic identification support to SCVURPPP and the RMC were selected based on demonstrated capability to adhere to specified protocols. Laboratories are certified and are as follows:

- Caltest Analytical Laboratory (nutrients, chlorophyll a, ash free dry mass, sediment chemistry)
- Pacific EcoRisk, Inc. (water and sediment toxicity)

- Alpha Analytical Laboratories, Inc. (pathogen indicators)
- BioAsessment Services (benthic macroinvertebrate (BMI) identification)
- Jon Lee Consulting (BMI identification Quality Control)
- EcoAnalysts, Inc. (algae identification)

1.3. QA/QC ATTRIBUTES

The RMC SOP and QAPP identify seven data quality attributes that are used to assess data QA/QC. They include (1) Representativeness, (2) Comparability, (3) Completeness, (4) Sensitivity, (5) Precision, (6) Accuracy, and (7) Contamination. These seven attributes are compared to Data Quality Objectives (DQOs), which were established to ensure that data collected are of adequate quality and sufficient for the intended uses. DQOs address both quantitative and qualitative assessment of the acceptability of data – representativeness and comparability are qualitative while completeness, sensitivity, precision, accuracy, and contamination are quantitative assessments.

Specific DQOs are based on Measurement Quality Objectives (MQOs) for each analyte. Chemical analysis relies on repeatable physical and chemical properties of target constituents to assess accuracy and precision. Biological data are quantified by experienced taxonomists relying on organism morphological features.

1.3.1. Representativeness

Data representativeness assesses whether the data were collected so as to represent actual conditions at each monitoring location. For this project, all samples and field measurements are assumed to be representative if they are performed according to protocols specified in the RMC QAPP and SOPs.

1.3.2. Comparability

The QA/QC officer ensures that the data may be reasonably compared to data from other programs producing similar types of data. For RMC Creek Status monitoring, individual stormwater programs try to maintain comparability within the RMC. The key measure of comparability for all RMC data is the California Surface Water Ambient Monitoring Program.

1.3.3. Completeness

Completeness is the degree to which all data were produced as planned; this covers both sample collection and analysis. For chemical data and field measurements an overall completeness of greater than 90% is considered acceptable for RMC chemical data and field measurements. For bioassessment-related parameters – including BMI and algae taxonomy samples/analysis and associated field measurement – a completeness of 95% is considered acceptable.

1.3.4. Sensitivity

Sensitivity analysis determines whether the methods can identify and/or quantify results at low enough levels. For the chemical analyses in this project, sensitivity is considered to be adequate if the reporting limits (RLs) comply with the specifications in RMC QAPP Appendix E: RMC Target Method Reporting Limits. For benthic macroinvertebrate data, taxonomic identification sensitivity is acceptable provided taxonomists use standard taxonomic effort (STE) Level I as established by the Southwest Association of Freshwater Invertebrate Taxonomists (SAFIT). There is no established level of sensitivity for algae taxonomic identification.

1.3.5. Accuracy

Accuracy is assessed as the percent recovery of samples spiked with a known amount of a specific chemical constituent. Chemistry laboratories routinely analyze a series of spiked samples; the results of these analyses are reported by the laboratories and evaluated using the RMC Database QA/QC Testing Tool. Acceptable levels of accuracy are specified for chemical analytes and toxicity test parameters in

RMC QAPP Appendix A: Measurement Quality Objectives for RMC Analytes, and for biological measurements in Appendix B: Benthic Macroinvertebrate MQOs and Data Production Process.

1.3.6. Precision

Precision is nominally assessed as the degree to which replicate measurements agree, nominally determined by calculation of the relative percent difference (RPD) between duplicate measurements. Chemistry laboratories routinely analyze a series of duplicate samples that are generated internally. The RMC QAPP also requires collection and analysis of field duplicate samples at a rate of 5% of all samples for all parameters[1]. The results of the duplicate analyses are reported by the laboratories and evaluated using RMC Database QA/QC Testing Tool. Results of the Tool are confirmed manually. Acceptable levels of precision are specified for chemical analytes and toxicity test parameters in RMC QAPP Appendix A: Measurement Quality Objectives for RMC Analytes, and for biological measurements in Appendix B: Benthic Macroinvertebrate MQOs and Data Production Process.

1.3.7. Contamination

For chemical data, contamination is assessed as the presence of analytical constituents in blank samples. The RMC QAPP requires collection and analysis of field blank samples at a rate of 5% for orthophosphate.

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

2. METHODS

2.1. REPRESENTATIVENESS

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

2.2. COMPARABILITY

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

Sub-contractors collecting samples and the laboratories performing analyses received copies of the RMC SOP and QAPP and have acknowledged reviewing the documents. Data collection and analysis by these parties adhered to the RMC protocols and was included in their operating contracts.

Following completion of the field and laboratory work, the field data sheets and laboratory reports were reviewed by the SCVURPPP Program Quality Assurance staff and were compared against the methods and protocols specified in the SOPs and QAPP. Specifically, staff checked for conformance with field and laboratory methods as specified in SOPs and QAPP, including sample collection and analytical methods, sample preservation, sample holding times, etc.

Electronic data deliverables (EDDs) were submitted to the San Francisco Regional Water Quality Control Board (SFRWQCB) in Microsoft Excel templates developed by SWAMP, to ensure data comparability with the SWAMP program. In addition, data entry followed SWAMP documentation specific to each data type, including the exclusion of qualitative values that do not appear on SWAMP's look up lists[2] such as field crew member names and site IDs. Completed templates were reviewed using SWAMP's online data checker[3], further ensuring SWAMP-comparability.

2.3. COMPLETENESS

2.3.1. Data Collection

All efforts were made to collect 100% of planned samples. Upon completion of all data collection, the number of samples collected for each data type was compared to the number of samples planned and the number required by the MRP, and reasons for any missed samples were identified. When possible, SCVURPPP staff resampled sites if missing data were identified prior to the close of the monitoring period. Specifically, continuous water quality data were reviewed immediately following deployment for adherence to MQOs. If data were rejected, samplers were redeployed immediately.

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

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

2.3.2. Field Sheets

Following the completion of each sampling event, the field crew leader/local monitoring coordinator reviewed any field generated documents for completion, and any missing values were entered. Once field sheets were returned to the office, a second SCVURPPP staff member reviewed the field sheets again and noted any missing data.

2.3.3. Laboratory Results

SCVURPPP staff assessed laboratory reports and EDDs for the number and type of analysis performed to ensure all sites and samples were included in the laboratory results.

2.4. SENSITIVITY

2.4.1. Biological Data

Benthic macroinvertebrates were identified to SAFIT STE Level I, with the additional effort of identifying chironomids (midges) to subfamily/tribe instead of family (Chironomidae).

2.4.2. Chemical Analysis

The reporting limits for analytical results were compared to the target reporting limits in Appendix E (RMC Target Method Reporting Limits) of the RMC QAPP. Results with reporting limits that exceeded the target reporting limit were flagged.

2.5. ACCURACY

2.5.1. Biological Data

Ten percent of the total number of BMI samples collected was submitted to a separate taxonomic laboratory, Jon Lee Consulting, for independent assessment of taxonomic accuracy, enumeration of organisms, and conformance to standard taxonomic level. For SCVURPPP, two samples were evaluated for QC purposes. Results were compared to MQOs in Appendix B (Benthic macroinvertebrate MQOs and Data Production Process).

2.5.2. Chemical Analysis

Caltest evaluated and reported the percent recovery (PR) of laboratory control samples (LCS; in lieu of reference materials) and matrix spikes (MS), which were recalculated and compared to the applicable MQOs set by Appendix A (Measurement Quality Objectives for RMC Analytes) of the RMC QAPP MQOs. If a QA sample did not meet MQOs, all samples in that batch for that particular analyte were flagged.

For reference materials, percent recovery was calculated as:

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

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

For matrix spikes, percent recovery was calculated as:

$$PR = [(MV - NV) / SV] \times 100\%$$

Where: MV = the measured value of the spiked sample
NV = the native, unspiked result
SV = the spike concentration added

2.5.3. Water Quality Data Collection

Accuracy for continuous water quality monitoring sondes was assured via continuing calibration verification for each instrument before and after each two-week deployment. Instrument drift was calculated by comparing the instrument's measurements in standard solutions taken before and after deployment. The drift was compared to measurement quality objectives for drift listed on the SWAMP calibration form, included as an attachment to the RMC SOP FS-3.

Temperature data were checked for accuracy by comparing measurements taken by HOBO temperature loggers with NIST thermometer readings in room temperature water and ice water prior to deployment. The mean difference and standard deviation for each HOBO was calculated, and if a logger had a mean difference exceeding 0.2 ^{o}C, it was replaced.

2.6. PRECISION

2.6.1. Field Duplicates

For creek status monitoring, duplicate biological samples were collected at 10% (two) of the 20 sites and duplicate water chemistry samples were collected at 10% (two) of the sites sampled to evaluate precision of field sampling methods. The RPD for water chemistry field duplicates was calculated and compared to the MQO (RPD < 25%) set by Table 26-1 in Appendix A of the RMC QAPP. If the RPD of the two field duplicates did not meet the MQO, the results were flagged.

The RMC QAPP requires collection and analysis of duplicate sediment chemistry and toxicity samples at a rate of 5% of total samples collected for the project. Responsibility for the collection of the field duplicate rotates each year amongst Alameda County Clean Water Program (ACCWP), Contra Costa Clean Water Program (CCCWP), San Mateo County Water Pollution Prevention Program (SMCWPPP), and SCVURPPP.

The sediment sample and field duplicate were collected together using the Sediment Scoop Method described in the RMC SOP, homogenized, and then distributed to two separate containers. For sediment chemistry field duplicates, the RPD was calculated for each analyte and compared to the MQOs (RPD < 25%) set by Tables 26-7 through 26-11 in Appendix A of the RMC QAPP. For sediment and water toxicity field duplicates, the RPD of the batch mean was calculated and compared to the recommended acceptable RPD (< 20%) set by Tables 26-12 and 26-13 in Appendix A. If the RPD of the field duplicates did not meet the MQO, the results were flagged.

The RPD is calculated as:

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

Where: X1 = the first sample result
X2 = the duplicate sample result

No field duplicate is required for pathogen indicators.

2.6.2. Chemical Analysis

Caltest evaluated and reported the RPD for laboratory duplicates, laboratory control duplicates, and matrix spike duplicates. The RPDs for all duplicate samples were recalculated and compared to the applicable MQO set by Appendix A of the RMC QAPP. If a laboratory duplicate sample did not meet MQOs, all samples in that batch for that particular analyte were flagged.

2.7. CONTAMINATION

Blank samples were analyzed for contamination, and results were compared to MQOs set by Appendix A of the RMC QAPP. For creek status monitoring, the RMC QAPP requires all blanks (laboratory and field) to be less than the analyte reporting limits. If a blank sample did not meet this MQO, all samples in that batch for that particular analyte were flagged.

3. RESULTS

3.1. Overall Project Representativeness

The SCVURPPP staff and field crew members were trained in SWAMP and RMC protocols, and received significant supervision from the local monitoring coordinator and QA officer. As a result, creek status monitoring data were considered to be representative of conditions in Santa Clara County Creeks.

3.2. Overall Project Comparability

SCVURPPP creek status monitoring data were considered to be comparable to both other agencies in the RMC and to SWAMP due to a shared QAPP and SOP, trainings, use of the same electronic data templates, and close communication.

3.3. Bioassessments and Physical Habitat Assessments

In addition to algae and BMI taxonomic samples, the SCVURPPP field crew collected chlorophyll a and ash free dry mass samples during bioassessments. The BMI taxonomic laboratory, BioAssessment Services, confirmed that the laboratory QA/QC procedures aligned with the procedures in Appendices B through D of the RMC QAPP and met the BMI MQOs in Appendix B.

3.3.1. Completeness

SCVURPPP completed bioassessments and physical habitat assessments for 20 of 20 planned/required sites for a 100% sampling completion rate. However, physical habitat assessments could not be taken at several transects due to inaccessibility.

3.3.2. Sensitivity

The BMI taxonomic identification met sensitivity objectives; the taxonomy laboratory, BioAssessment Services, and QC laboratory, Jon Lee Consulting, confirmed that organisms were identified to SAFIT STE Level I, with the exception of Chironomidae which was analyzed to SAFIT level 1a.

The analytical RL for ash free dry mass analysis (8 mg/L) was much higher than the RMC QAPP target RL (2 mg/L) due to high concentrations requiring large dilutions. The results were several orders of magnitude higher than the actual and target reporting limit and were not affected by the higher RL. While the chlorophyll a analyses also required large dilutions due to high concentrations within the samples, the chlorophyll a analytical RL was below that of the RMC QAPP target RL.

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

3.3.3. Accuracy

The BMI samples that were submitted to an independent QC taxonomic laboratory had one specimen misidentification and one counting error. The specimen misidentification was speculated to be due to a sorting error or tagalong organism. The QC laboratory calculated sorting and taxonomic identification metrics, which were compared to the measurement quality objectives in Table 27-1 in Appendix B of the RMC QAPP. All MQOs were met. A comparison of the metrics with the MQOs is shown in Table 1. A copy of the QC laboratory report is available upon request.

There is currently no protocol for evaluating the accuracy of algae taxonomic identification.

Table 1. Quality control metrics for taxonomic identification of benthic macroinvertebrates collected in Santa Clara County in WY 2019 compared to measurement quality objectives.

Quality Control Metric	MQO	Sample 1		Sample 2	
		Error Rate	Exceeds MQO?	Error Rate	Exceeds MQO?
Recount Accuracy	> 95%	100%	No	99.84%	No
Taxa ID	≤ 10%	3.45%	No	0%	No
Individual ID	≤ 10%	0.16%	No	0.16%	No
Low Taxonomic Resolution Individual	≤ 10%	0%	No	0%	No
Low Taxonomic Resolution Count	≤ 10%	0%	No	0%	No
High Taxonomic Resolution Individual	≤ 10%	0%	No	0%	No
High Taxonomic Resolution Count	≤ 10%	0%	No	0%	No

3.3.4. Precision

Field blind duplicate chlorophyll a and ash free dry mass samples were collected at two sites in WY 2019 and were sent to the laboratory for analysis.

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

Again, discrepancies were expected due to the potential natural variability in algae production within the reach and the collection of field duplicates at different locations along each transect (as specified in the protocol). As a result, both parameters have frequently exceeded the field duplicate RPD MQOs during past years' monitoring efforts.

Table 2. Field duplicate water chemistry results for site 205R04638, collected on May 6, 2019 and site 205R04247, collected June 5, 2019.

Analyte	Units	205R04638 May 6, 2019				205R04247 June 5, 2019			
		Original Result	Duplicate Result	RPD	Exceeds MQO (>25%)[a]	Original Result	Duplicate Result	RPD	Exceeds MQO (>25%)[a]
Chlorophyll a	**mg/m³**	2300	320	151%	Yes	2800	2700	4%	No
Ash Free Dry Mass	**mg/L**	300	2000	148%	Yes	1940	1980	2%	No

[a]In accordance with the RMC QAPP, if the native concentration of either sample is less than the reporting limit, the RPD is not applicable

Laboratory duplicates were also collected for chlorophyll a and ash free dry mass samples. The RPD for both analytes were below the MQO limit, so it was not necessary to flag any samples.

3.3.5. Contamination

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

3.4. FIELD MEASUREMENTS

Field measurements of temperature, dissolved oxygen, pH, specific conductivity, and chlorine residual were collected concurrently with bioassessments and water chemistry samples. Chlorine residual was measured using a HACH Pocket Colorimeter™ II, which uses the DPD method. All other parameters were measured with a YSI Professional Plus or YSI 600XLM-V2-S multi-parameter instrument. All data collection was performed according to RMC SOP FS-3 (Performing Manual Field Measurements).

3.4.1. Completeness

Temperature, dissolved oxygen, pH, specific conductivity, free and total chlorine residual were collected at all 20 bioassessment sites for a 100% completeness rate.

3.4.2. Sensitivity

Free and total chlorine residual were measured using a HACH Pocket Colorimeter™ II, which uses the DPD method. For this method, the estimated detection limit for the low range measurements (0.02-2.00 mg/L) was 0.02 mg/L. There is, however, no established reporting limit. Colorimetric field instruments are generally not considered capable of providing accurate measurements of free chlorine and total chlorine residual below 0.13 mg/L (Missouri Department of Natural Resources 2004), due to analytical noise, regardless of the method detection limit provided by the manufacturer. For this reason, the Statewide General Permit for drinking Water Discharges (SWRCB 2014) and other recently issued NPDES permits, use 0.1 mg/L as a reporting limit for field measurements of total chlorine residual.

SCVURPPP also uses this threshold as a reporting limit for MRP chlorine residual monitoring. All measurements between 0.02 and 0.1 mg/L have been flagged as “detected, not quantified”. The adopted SCVURPPP reporting limit is still much lower than the target reporting limit of 0.5 mg/L listed in the RMC QAPP for free and total chlorine residual.

There are no reporting limits for temperature, dissolved oxygen, pH, and conductivity measurements, but the actual measurements are much higher than target reporting limits in the RMC QAPP, so it is assumed that the target reporting limits are met for all field measurements.

3.4.3. Accuracy

Data collection occurred Monday through Thursday, and the multi-parameter instrument was calibrated at most 12 hours prior to the first sample on Monday, with the dissolved oxygen sensor calibrated every morning to ensure accurate measurements. Calibration solutions are certified standards, whose expiration dates were noted prior to use. The chlorine kit is factory-calibrated and is sent into the manufacturer every other year to be calibrated.

Free chlorine was measured to be higher than total chlorine at three of the 20 sites sampled in WY 2019. In past years, free chlorine has also occasionally been measured as higher than total chlorine. Theoretically, the free chlorine measurement should always be less than or equal to the total chlorine measurement, as the total chlorine concentration in water encompasses the free chlorine concentration in addition to any other chlorine species. The reason for free chlorine concentrations exceeding total chlorine concentrations at a sample site has not been definitively established. Potential causes for these inverted results include matrix interferences, colorimeter user error, and uncertainty associated with low concentrations below the reporting limit. According to Hach, the manufacturer of the equipment and reagents, the free chlorine could have false positive results due to a pH exceedance of 7.6 and/or an alkalinity exceedance of 250 mg/L. It is unlikely that the higher free chlorine readings were caused by user error. The field crew is well trained and aware of potential problems with this testing method, such as wait times between adding reagents and taking the readings and separating the free chlorine and total

residual chlorine samples. When free chlorine was observed to be higher than total chlorine at a sample site, the free chlorine measurement was retaken with a new water sample and recorded on the field form. It was deemed unnecessary to flag free chlorine measurements that were higher than total chlorine measurements.

3.4.4. Precision

Precision could not be measured as no duplicate field measurements are required or were collected.

3.5. WATER CHEMISTRY

Water chemistry samples were collected by SCVURPPP staff concurrently with bioassessment samples and analyzed by Caltest Analytical Laboratory within their respective holding times. Caltest performed all internal QA/QC requirements as specified in the QAPP and reported their findings to the RMC. Key water chemistry MQOs are listed in RMC QAPP Table 26-2.

3.5.1. Completeness

SCVURPPP collected 100% of planned/required water chemistry samples at the 20 bioassessment sites including two field duplicate samples. Samples were analyzed for all requested analytes, and 100% of results were reported. Water chemistry data were flagged when necessary, but none were rejected.

3.5.2. Sensitivity

Laboratory reporting limits met or were lower than target reporting limits for all nutrients except chloride and nitrate. The reporting limit for all chloride samples exceeded the target reporting limit, but concentrations were much higher than reporting limits, and the elevated reporting limits do not decrease confidence in the measurements.

The reporting limit (0.05 mg/L) and method detection limit (0.02 mg/L) for nitrate samples were higher than the target reporting limit (0.01 mg/L). As a result, two samples were flagged as “detected, not quantified”, but they would have been quantified at the lower reporting limit. Additionally, the nitrate concentration at one other site was measured to be below the method detection limit. SCVURPPP has discussed the reporting limits with Caltest, and due the methodology, lower limits cannot currently be achieved. Target and actual reporting limits are shown in Table 3.

Table 3. Target and actual reporting limits for nutrients analyzed in SCVURPPP creek status monitoring. Data in highlighted rows exceed monitoring quality objectives in RMC QAPP.

Analyte	Target RL mg/L	Actual RL mg/L
Ammonia	0.02	0.02
Chloride	0.25	1-20
Total Kjeldahl Nitrogen	0.5	0.1
Nitrate	0.01	0.05
Nitrite	0.01	0.005
Orthophosphate	0.01	0.01
Silica	1	1
Phosphorus	0.01	0.01

3.5.3. Accuracy

The RMC QAPP lists a target range of 90-110% for nutrient laboratory control samples (LCS), and 80-120% for nutrient matrix spike and matrix spike duplicates (MS/MSD). For other conventional analytes (i.e., silica and chloride), both the LCS and MS/MSD MQO for recovery is 80-120%.

Recoveries on most LCS and MS/MSD samples were within the MQO target range. Two LCS PRs collected for silica and four MS/MSD PRs collected for total Kjeldahl nitrogen (TKN) exceeded their respective MQO ranges listed in the RMC QAPP. The QA samples affected ten sites, whose results have been assigned the appropriate SWAMP flag. Though the results were flagged, none of the analytical data were rejected due to accuracy.

The target PR ranges on laboratory reports differed from the RMC QAPP PR for several LCS and MS/MSD samples. As a result, some QA samples that exceeded RMC MQOs were flagged, but not by the laboratory and vice versa.

3.5.4. Precision

The RPD for all laboratory control sample duplicate and MS/MSD pairs were consistently below the MQO target of < 25%. Please note that the laboratory used a lower threshold of 20% for all analytes. However, all RPDs were much lower than 20% and no samples were flagged by the laboratory or the QA officer for exceeding the RPD MQO.

Water chemistry field duplicates were collected at two sites in Santa Clara County and were compared against the original samples. For WY 2019, one of the total Kjeldahl nitrogen duplicate samples exceeded the RPD MQO. In past years of sampling, total Kjeldahl nitrogen has been common among the analytes that exceed the field duplicate RPD MQOs. Field crews will continue to make an effort in subsequent years to collect the original and duplicate samples in an identical fashion.

The field duplicate water chemistry results and their RPDs are shown in Tables 4 and 5. Because of the variability in reporting limits, values less than the RL were not evaluated for RPD. For those analytes whose RPDs could be calculated and did not meet the RMC MQO, they were assigned the appropriate SWAMP flag.

Table 4. Field duplicate water chemistry results for site 205R04638, collected on May 6, 2019. Data in highlighted rows exceed measurement quality objectives in RMC QAPP.

Analyte Name	Fraction Name	Unit	Original Result	Duplicate Result	RPD	Exceeds MQO (>25%)[a]
Ammonia as N	Total	mg/L	0.41	0.34	19	No
Chloride	None	mg/L	10	10	0%	No
Nitrate as N	None	mg/L	0.095	0.093	2%	No
Nitrite as N	None	mg/L	J 0.002	J 0.002	N/A	N/A
Nitrogen, Total Kjeldahl	None	mg/L	0.14	0.25	56%	N/A
Orthophosphate as P	Dissolved	mg/L	0.018	0.017	6%	No
Phosphorus as P	Total	mg/L	0.028	0.028	0%	No
Silica as SiO2	Total	mg/L	19	20	5%	No

[a]In accordance with the RMC QAPP, if the native concentration of either sample is less than the reporting limit, the RPD is not applicable

Table 5. Field duplicate water chemistry results for site 205R04247, collected on June 5, 2019. Data in highlighted rows exceed measurement quality objectives in RMC QAPP.

Analyte Name	Fraction Name	Unit	Original Result	Duplicate Result	RPD	Exceeds MQO (>25%)[a]
Ammonia as N	Total	mg/L	0.92	0.96	4	No
Chloride	None	mg/L	19	19	0%	No
Nitrate as N	None	mg/L	0.1	0.1	0%	No
Nitrite as N	None	mg/L	J 0.001	ND	N/A	N/A
Nitrogen, Total Kjeldahl	None	mg/L	0.28	0.36	25%	Yes
Orthophosphate as P	Dissolved	mg/L	0.038	0.041	8%	No
Phosphorus as P	Total	mg/L	0.074	0.076	3%	No
Silica as SiO2	Total	mg/L	20	19	5%	No

[a]In accordance with the RMC QAPP, if the native concentration of either sample is less than the reporting limit, the RPD is not applicable

3.5.5. Contamination

None of the target analytes were detected in any of the laboratory blanks at levels above their reporting limit. All analytes were non-detect in the laboratory blanks. The RMC QAPP does not require field blanks to be collected, and possible contamination from sample collection was not assessed. However, the SCVURPPP field crew takes appropriate precautions to avoid contamination, including wearing gloves during sample collection and rinsing sample containers with stream water when preservatives are not needed.

3.6. PATHOGEN INDICATORS

Pathogen indicator samples were collected by SCVURPPP staff and were analyzed by Alpha Analytical Laboratories, Inc for *E. coli* and enterococcus. Samples were collected on August 1, 2019.

3.6.1. Completeness

All five required/planned pathogen indicator samples were collected for a 100% completeness rate. These samples and were received and incubated by the laboratory well within the 8-hour hold time.

3.6.2. Sensitivity

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

3.6.3. Accuracy

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

3.6.4. Precision

The RMC QAPP requires one laboratory duplicate to be run per 10 samples or per analytical batch, whichever is more frequent. However, determining precision for pathogen indicators requires 15 duplicate sets. Due to the small number of samples collected for this project, there were not enough laboratory duplicates to determine precision. In WY 2019, only one laboratory duplicate was run and is not sufficient to determine precision.

The RMC QAPP does not require a field duplicate to be collected for pathogen indicators. However, one field duplicate was collected in WY 2019 at 205LGA420. The RPD for *E.coli* was 0% and 113% for enterococcus. Since there is no requirement for pathogen field duplicates, there is no corresponding MQO, and the precision could not be assessed. See Table 6 for the field duplicate results.

Table 6. Lab and field duplicate pathogen results collected on August 1, 2019.

Duplicate Type	Analyte	Original Result (MPN/100mL)	Duplicate Result (MPN/100mL)	RPD
Lab Duplicate	E.coli	29.4	27.9	NA
Lab Duplicate	Enterococcus	23.1	16.0	NA
Field Duplicate	E.coli	7.5	7.5	0%
Field Duplicate	Enterococcus	14.8	4.1	113%

3.6.5. Contamination

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

3.7. CONTINUOUS WATER QUALITY

Continuous water quality measurements were recorded at three sites during the spring (June 2019), concurrent with bioassessments, and again in the summer (August/September 2019) in compliance with the MRP. Temperature, pH, dissolved oxygen, and specific conductivity were recorded once every 15 minutes for approximately two-weeks using a multi-parameter water quality sonde (YSI 6600-V2).

3.7.1. Completeness

The MRP requires one to two-week deployments, and both deployments exceeded the one week minimum. Both deployments lasted 14 days. Sondes collected data for 100% of the planned deployments. However, the pH sensor for the sonde deployed at station 205COY235 failed during the spring deployment, and all of the pH data were rejected for that deployment. The sensor was subsequently replaced; however, during the summer deployment, the pH sensor for the sonde deployed at the same site failed periodically, and some data were rejected for this deployment as well.

3.7.2. Sensitivity

There are no method reporting limits for temperature, dissolved oxygen, pH, and conductivity measurements, but the actual measurements are much higher than target reporting limits in the RMC QAPP, so it is assumed that target reporting limits are met for all field measurements.

3.7.3. Accuracy

The SCVURPPP staff conduct pre- and post-deployment sonde calibrations for the three sondes used during monitoring events and calculate the drift during the deployments. During the first monitoring event, the sondes deployed at both 205COY235 and 205COY236 exceeded both the pH 7 and pH 10 MQOs. During the second deployment, sonde at 205COY235 failed the pH 10 drift check and the sonde at 205COY236 failed the pH 7 drift check. The pH results at these sites were subsequently flagged for both deployments. Though some pH data for site 205COY235 were rejected for both deployments due to sensor malfunctions, none were rejected for drift check exceedances. A summary of the drift measurements is shown in Table 7.

Table 7. Drift measurements for two continuous water quality monitoring events in Santa Clara Valley urban creeks during WY 2019. Bold and highlighted values exceeded measurement quality objectives.

Parameter	Measurement Quality Objectives	205COY235		205COY236		205COY239	
		Event 1	Event 2	Event 1	Event 2	Event 1	Event 2
Dissolved Oxygen (mg/l)	± 0.5 mg/L or 10%	-0.09	0.09	-0.07	0.07	-0.29	0.29
pH 7.0	± 0.2	-0.79	0.02	0.18	0.28	0.02	0.02
pH 10.0	± 0.2	-0.22	-0.77	-0.38	0.19	0.02	0.02
Specific Conductance (uS/cm)	± 10%	0.2%	3.4%	0.3%	1.7%	0.0%	0.0%

3.7.4. Precision

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

3.8. Continuous Temperature Monitoring

Continuous temperature monitoring was conducted from April through September 2019 at nine sites in Santa Clara County. Onset HOBO Water Temperature data loggers recorded one measurement per hour.

3.8.1. Completeness

The MRP requires SCVURPPP to monitor eight stream reaches for temperature each year but anticipating the potential for a HOBO temperature logger to be lost during such a long deployment, SCVURPPP deployed one extra temperature logger, for a total of nine loggers. In the middle of the deployment, SCVURPPP staff checked the loggers to ensure that they were still present and recording. If a logger was missing during the mid-deployment field check, it would be replaced with a new logger. During the field check, staff also downloaded the existing data and redeployed the loggers. All temperature loggers were recovered at the end of the deployment, resulting in a completion rate of over 100%.

3.8.2. Sensitivity

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

3.8.3. Accuracy

A pre-deployment accuracy check was run on the temperature loggers in March 2019. None of the deployed loggers exceeded the 0.2 ºC mean difference threshold for either the room temperature bath or the ice bath. The loggers were subsequently deployed, and no flagging of the data was necessary.

3.8.4. Precision

There are no precision protocols for continuous temperature monitoring.

3.9. Sediment Chemistry

The dry season sediment chemistry samples were collected by Kinnetic Laboratories, Inc (KLI) concurrently with the dry season toxicity sample on July 23, 2019. Inorganic and synthetic organic compounds were analyzed by Caltest and grain size distribution was analyzed by Soil Control Laboratories, a subcontractor laboratory. Caltest conducted all QA/QC requirements as specified in the

RMC QAPP and reported their findings to the RMC. Key sediment chemistry MQOs are listed in RMC QAPP Tables 26-9 through 26-11. Sediment chemistry data were flagged when necessary, but none were rejected.

3.9.1. Completeness

The MRP requires a sediment chemistry sample to be collected at two locations each year. In WY 2019, SCVURPPP collected the sediment chemistry sample at 205STE021 and 205STQ010. The laboratories analyzed within the one year holding time for analytes in sediment, set by the RMC SOP, and reported 100% of the required analytes.

3.9.2. Sensitivity

A comparison of target and actual reporting limits for those parameters is shown in Table 8. For sediment chemistry analysis conducted in WY 2019, laboratory reporting limits were higher than RMC QAPP target reporting limits for 20 analytes. Since reporting limits for a sample are dependent on the percent solids of that sample, it is likely that the amount of solids in the sample resulted in these exceedances.

Table 8. Comparison of target and actual reporting limits for sediment analytes where reporting limits exceeded target limits. Sediment samples were collected in Santa Clara County creeks in WY 2019.

Analyte	Target RL	Actual RL	Unit
Arsenic	0.3	0.51	mg/Kg
Cadmium	0.01	0.08	mg/Kg
Chromium	0.1	1.0	mg/Kg
Copper	0.01	0.41	mg/Kg
Lead	0.01	0.08	mg/Kg
Nickel	0.02	0.08	mg/Kg
Zinc	0.1	0.8	mg/Kg
Bifenthrin	0.33	1.3	ng/g
Cyfluthrin	0.33	1.3	ng/g
Total Lambda-cyhalothrin	0.33	1.3	ng/g
Total Cypermethrin	0.33	1.3	ng/g
Total Deltamethrin	0.33	1.3	ng/g
Total Esfenvalerate/Fenvalerate	0.33	1.3	ng/g
Permethrin	0.33	1.3	ng/g
Carbaryl	30	31	ng/g
Fipronil	0.33	1.3	ng/g
Fipronil Desulfinyl	0.33	1.3	ng/g
Fipronil Sulfide	0.33	1.3	ng/g
Fipronil Sulfone	0.33	1.3	ng/g
Total Organic Carbon	0.01	0.051	% dw

3.9.3. Accuracy

Inorganic Analytes

No QA samples exceeded the QAPP MQO for LCS percent recovery (PR) for inorganic analytes (75-125%), but the MS samples for arsenic and lead exceeded the PR MQO. These sample were flagged but not rejected.

Synthetic Organic Compounds

The RMC QAPP lists the percent recovery MQO for pyrethroids and other synthetic organic compounds in sediment as 50-150%. However, the PR MQOs listed in the laboratory reports for synthetic organic compounds varied by analyte and were much larger than PR ranges listed in the QAPP. The MQOs ranged from 1 to 275% in certain cases. As a result, several analytes were flagged by the local QA officers, but not by the laboratory.

None of the LCS PRs exceeded the RMC MQO range. However, the MS/MSD PRs exceeded the RMC MQO range for seven PAHs in addition to fipronil, fipronil sulfide, and fipronil sulfone. The PAH MS/MSD samples that exceeded the PR MQO include benzo(a)pyrene, benzo(g,h,i)perylene, fluoranthene, indeno(1,2,3-c,d)pyrene, naphthalene, perylene, and pyrene.

3.9.4. Precision

Inorganic Analytes

The RMC QAPP lists the maximum RPD for inorganic analytes (metals) as 25%. All MS/MSD sets for metals were well below the RMC RPD MQO of 25%.

Synthetic Organic Compounds

The maximum RPD for synthetic organics listed in the sediment laboratory report lists ranges from 30 to 50% for most analytes. However, the RMC QAPP lists the MQO as < 25% RPD for most synthetic organics, < 35% for pyrethroids and fipronil, and < 40% for carbaryl. None of the MS/MSD pairs or LCS duplicates exceeded the RPD MQO.

Field Duplicates

A sediment sample field duplicate was collected in Contra Costa County on July 23, 2019 and evaluated for precision. The field duplicate sample and corresponding RPDs are shown in Table 9. Because of the variability in reporting limits, values less than the RL were not evaluated for RPD. The measured concentrations of a majority of analytes from the original and duplicate samples were below the method detection limit and therefore reported as “ND”. As a result, the RPDs were non-calculable. All calculable RPDs were below the MQO limits. Analytes that exceeded the MQO of RPD < 25% were medium sand (0.25 to <0.5 mm); total cyfluthrin; total lambda-cyhalothrin; deltamethrin/tralomethrin.

Given the inherent variability associated with sediment sample field duplicates, the number of analytes with RPDs outside of the MQO limits is acceptable. The method used to collect sediment field duplicates provides more insight to laboratory precision than precision of field methods; however, the results do suggest that field methods are precise.

Table 9. Sediment chemistry duplicate field results for site 544MSH045, collected on July 23, 2019 in Contra Costa County. Data in highlighted rows exceed monitoring quality objectives in RMC QAPP.

Analyte		Unit	Original	Duplicate	RPD	Exceeds MQO? (<25%)[a]
Grain Size Distribution	Clay: <0.0039 mm	%	25.14	23.22	7.9%	No
	Silt: 0.0039 to <0.0625 mm	%	60.97	60.13	1.4%	No
	Sand: V. Fine 0.0625 to <0.125 mm	%	7.36	8.39	13.1%	No
	Sand: Fine 0.125 to <0.25 mm	%	3.4	4.19	20.8%	No
	Sand: Medium 0.25 to <0.5 mm	%	1.54	2.37	42.5%	Yes
	Sand: Coarse 0.5 to <1.0 mm	%	0.8	1	22.2%	No
	Sand: V. Coarse 1.0 to <2.0 mm	%	0.8	0.7	13.3%	No
	Granule: 2.0 to <4.0 mm	%	0.38	0.36	5.4%	No
	Pebble: Small 4 to <8 mm	%	0.09	ND	N/A	N/A
	Pebble: Medium 8 to <16 mm	%	1.68	ND	N/A	N/A
	Pebble: Large 16 to <32 mm	%	ND	ND	N/A	N/A
	Pebble: V. Large 32 to <64 mm	%	ND	ND	N/A	N/A
Metals	Arsenic	mg/Kg dw	6.4	6.1	4.8%	No
	Cadmium	mg/Kg dw	0.14	0.17	19.4%	No
	Chromium	mg/Kg dw	31	32	3.2%	No
	Copper	mg/Kg dw	34	34	0%	No
	Lead	mg/Kg dw	9.3	10	7.3%	No
	Nickel	mg/Kg dw	43	45	4.5%	No
	Zinc	mg/Kg dw	130	140	7.4%	No
Pyrethroids (MQO <35%)	Bifenthrin	ng/g dw	18	17	5.7%	No
	Cyfluthrin	ng/g dw	2.5	1.7	38.1%	Yes
	Lambda-Cyhalothrin	ng/g dw	1	1.3	26.1%	No
	Cypermethrin	ng/g dw	ND	ND	N/A	ND
	Deltamethrin/Tralomethrin	ng/g dw	6.8	4.8	34.5%	No
	Esfenvalerate/Fenvalerate	ng/g dw	ND	ND	N/A	N/A
	Permethrin	ng/g dw	0.77	0.83	7.5%	No
	Total Organic Carbon	%	2.6	2.4	8.0%	No
	Carbaryl	mg/Kg dw	ND	ND	N/A	N/A
Fipronil	Fipronil	ng/g dw	ND	ND	N/A	N/A
	Fipronil Desulfinyl	ng/g dw	ND	ND	N/A	N/A
	Fipronil Sulfide	ng/g dw	ND	ND	N/A	N/A
	Fipronil Sulfone	ng/g dw	ND	ND	N/A	N/A
Polycyclic Aromatic Hydrocarbons	Acenaphthene	ng/g dw	ND	ND	N/A	N/A
	Acenaphthylene	ng/g dw	ND	ND	N/A	N/A
	Anthracene	ng/g dw	ND	ND	N/A	N/A
	Benz(a)anthracene	ng/g dw	ND	ND	N/A	N/A
	Benzo(a)pyrene	ng/g dw	ND	ND	N/A	N/A
	Benzo(b)fluoranthene	ng/g dw	ND	ND	N/A	N/A
	Benzo(e)pyrene	ng/g dw	ND	ND	N/A	N/A
	Benzo(g,h,i)perylene	ng/g dw	ND	ND	N/A	N/A
	Benzo(k)fluoranthene	ng/g dw	ND	ND	N/A	N/A
	Biphenyl	ng/g dw	ND	ND	N/A	N/A
	Chrysene	ng/g dw	ND	ND	N/A	N/A

Table 9. Sediment chemistry duplicate field results for site 544MSH045, collected on July 23, 2019 in Contra Costa County. Data in highlighted rows exceed monitoring quality objectives in RMC QAPP.

Analyte		Unit	Original	Duplicate	RPD	Exceeds MQO? (<25%)[a]
	Dibenz(a,h)anthracene	ng/g dw	ND	ND	N/A	N/A
	Dibenzothiophene	ng/g dw	ND	ND	N/A	N/A
	Dimethylnaphthalene, 2,6-	ng/g dw	11	11	0%	No
	Fluoranthene	ng/g dw	ND	ND	N/A	N/A
	Fluorene	ng/g dw	ND	ND	N/A	N/A
	Indeno(1,2,3-c,d)pyrene	ng/g dw	ND	ND	N/A	N/A
	Methylnaphthalene, 1-	ng/g dw	ND	ND	N/A	N/A
	Methylnaphthalene, 2-	ng/g dw	ND	ND	N/A	N/A
	Methylphenanthrene, 1-	ng/g dw	ND	ND	N/A	N/A
	Naphthalene	ng/g dw	ND	ND	N/A	N/A
	Perylene	ng/g dw	ND	ND	N/A	N/A
	Phenanthrene	ng/g dw	ND	ND	N/A	N/A
	Pyrene	ng/g dw	ND	ND	N/A	N/A

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

Laboratory Duplicates

Laboratory duplicates were collected and analyzed for grain sizes and total organic carbon. All RPDs were below the MQO limits except for medium (8 to <16 mm) pebbles in addition to granules (2.0 to <4.0 mm). As a result, the associated samples were flagged.

3.9.5. Contamination

All instrument (lab) blanks had concentrations below the reporting limit, and no data were flagged or rejected.

3.10. TOXICITY TESTING

Dry season water and sediment toxicity samples were collected by KLI concurrently with dry season sediment chemistry samples at two Santa Clara County sites on July 23, 2019. All toxicity tests were performed by Pacific EcoRisk. The water samples were analyzed for toxicity to five organisms (*Selenastrum capricornutum, Ceriodaphnia dubia, Pimephales promelas, Hyalella azteca, and Chronomus dilutus*) and the sediment samples were analyzed for toxicity to *Hyalella azteca* and *Chironomus dilutus.*

3.10.1. Completeness

The MRP requires the collection of dry season water and sediment toxicity samples at two sites per year in Santa Clara County. Pacific EcoRisk tested the required organisms for toxicity, and 100% of results were reported.

3.10.2. Sensitivity and Accuracy

Internal laboratory procedures that align with the RMC QAPP, including water and sediment quality testing and reference toxicant testing, were performed and submitted to SCVURPPP. The laboratory data QC checks found that all conditions and responses were acceptable. A copy of the laboratory QC report is available upon request.

3.10.3. Precision

Field duplicates for sediment toxicity were not taken during the dry weather sampling. This oversight was the result of a misunderstanding of the conflict between the 2016 version of the RMC QAPP (V3.0) and

the SWAMP requirements for toxicity sample field duplicates that were revised in 2018. As such, 2019 RMC toxicity data are SWAMP comparable, but were flagged with the “VQCP” qualifier to indicate a discrepancy with the RMC QAPP. The RMC QAPP has been updated to reflect the recent revisions to the SWAMP MQOs.

3.10.4. Contamination

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

4. CONCLUSIONS

Sample collection and analysis followed MRP and RMC QAPP requirements and data that exceeded measurement quality objectives were flagged. Additionally, all continuous pH data collected in June and several data points in September were rejected due to instrument failure.

5. REFERENCES

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Attachment 2

SCVURPPP Bioassessment Data, WY 2012 – WY 2019

Attachment 2: Eight years of bioassessment data (WY 2012- WY 2019) used for analyses in the Integrated Monitoring Report

Site Information						Water Quality						Water Chemistry (nutrients)																Biological and Physical Habitat Indicator Scores					Physical Habitat									Land Use Variables		
Station Code	Creek Name	Latitude	Longitude	Land Use	Sample Date	Dissolved Oxygen (mg/L)	Spec Conductance (uS/cm)	Temperature (Deg C)	pH	Chloride (mg/L)	Silica (mg/L)	Ash Free Dry Mass (g/m2)	Chlorophyll a (mg/m2)	QA Flag	Ammonia (mg/L)	QA Flag	UIA (ug/L)	Nitrate as N (mg/L)	QA Flag	Nitrite as N (mg/L)	QA Flag	TKN as N (mg/L)	QA Flag	Ortho Phosphate as P (mg/L)	QA Flag	Total Phosphorus as P (mg/L)	QA Flag	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)	CSCI	ASCI_D	ASCI_SB	ASCI_H	IPI	Channel Alteration	Epifaunal Substrate	Sediment Deposition	Human Disturbance Index	Evenness Flow Habitat	% Substrate <2 mm	Shannon Diversity Habitat	Sum Riparian Cover	Shannon Diversity Substrate	% Impervious (wat)	% Urban (wat)	Road Density (wat)
205R00026	Los Gatos Creek	37.23057	-121.97317	U	5/14/12	9.8	439	13.6	7.0	16	14.1	34	28	=	0.077	DNQ	0.2	0.19	=	-0.002	ND	0.34	=	0.016	=	-0.007	ND	0.5	0.004	0.68	0.73	0.62	0.72	NR	15	10	8	1.6	0.8	34	1.7	NR	1.9	6%	11%	2.9
205R00234	San Tomas Aquino	37.26620	-121.99081	U	5/15/12	8.3	632	18.5	8.1	59	24.6	258	18	=	0.055	DNQ	2.0	0.18	=	-0.002	ND	0.33	=	0.018	=	0.023	=	0.5	0.023	0.71	0.66	0.40	0.61	NR	3	5	6	1.9	0.5	30	0.9	NR	1.4	13%	54%	5.6
205R00058	Saratoga Creek	37.25170	-122.08407	NU	5/15/12	10.5	410	10.9	7.1	10	22.3	199	28	=	0.044	DNQ	0.1	0.10	=	-0.002	ND	0.23	=	0.110	=	0.100	=	0.3	0.100	1.15	0.85	NA	NA	NR	20	17	10	0.9	0.8	15	1.6	NR	1.9	3%	3%	0.9
205R00021	MF Coyote Creek	37.25513	-121.57811	NU	5/16/12	6.1	366	12.3	7.4	8	9.2	35	-6	ND	0.088	DNQ	0.4	0.03	DNQ	-0.002	ND	0.13	=	0.010	DNQ	0.012	=	0.2	0.012	0.95	0.87	0.80	0.93	NR	20	15	17	0.0	0.9	5	1.6	NR	1.5	1%	0%	0.4
205R00099	Calabazas Creek	37.30773	-122.02170	U	5/17/12	9.8	456	16.6	7.8	58	11.7	31	-7	ND	-0.040	ND	0.4	0.42	=	-0.002	ND	0.23	=	0.070	=	0.090	=	0.7	0.090	0.61	0.47	0.44	0.56	NR	13	6	6	1.5	0.8	24	1.8	NR	1.4	25%	63%	8.0
205R00042	Coyote Creek	37.24578	-121.77020	U	5/21/12	7.6	510	23.0	8.2	43	12.7	491	-50	ND	0.066	DNQ	4.1	0.81	=	0.003	DNQ	0.76	=	0.012	=	0.032	=	1.6	0.032	0.51	0.83	0.66	0.79	NR	19	8	5	2.0	1.0	64	1.6	NR	1.5	3%	1%	0.8
205R00241	Upper Silver Creek	37.27642	-121.76496	U	5/21/12	7.3	1014	14.1	7.6	87	49.6	743	-50	ND	0.550	=	5.0	0.32	=	-0.002	ND	0.56	=	0.170	=	0.180	=	0.9	0.180	0.30	0.65	0.86	0.68	NR	18	13	3	2.6	0.7	50	1.8	NR	1.6	5%	8%	1.4
205R00154	Canoas Creek	37.23400	-121.83759	U	5/22/12	4.2	1087	20.3	7.6	79	21.3	237	133	=	-0.040	ND	0.3	-0.01	ND	-0.002	ND	0.57	=	0.085	=	0.130	=	0.6	0.130	0.17	0.76	0.38	0.71	NR	3	1	2	4.7	0.0	37	0.6	NR	0.4	36%	61%	8.8
205R00282	Guadalupe Creek	37.23760	-121.88840	U	5/22/12	8.9	403	16.8	7.2	30	16.2	415	-56	ND	-0.040	ND	0.1	0.20	=	-0.002	ND	0.29	=	0.034	=	0.055	=	0.5	0.055	0.74	0.79	0.66	0.64	NR	15	16	10	2.9	0.9	29	1.6	NR	1.8	4%	8%	2.4
205R00090	Canoas Creek	37.28807	-121.87920	U	5/23/12	6.0	952	18.4	8.2	87	29.4	68	40	=	0.120	=	5.8	0.10	=	0.080	=	0.99	=	-0.006	ND	0.024	=	1.2	0.024	0.24	0.88	0.17	0.80	NR	0	1	19	5.4	0.0	0	0.3	NR	0.0	46%	76%	11.8
205R00218	Coyote Creek	37.29000	-121.81804	U	5/23/12	6.4	490	19.1	7.2	42	12.4	271	-52	ND	0.150	=	0.7	0.20	=	-0.002	ND	0.43	=	0.034	=	0.055	=	0.6	0.055	0.54	0.87	0.63	0.71	NR	19	14	7	2.9	0.9	35	1.7	NR	1.6	4%	3%	0.9
205R00035	Upper Penitencia Cr	37.38105	-121.85735	U	5/24/12	9.3	361	18.0	7.7	46	10.9	213	69	=	0.120	=	2.1	0.33	=	-0.002	ND	0.44	=	0.072	=	0.087	=	0.8	0.087	0.59	0.52	0.42	0.55	NR	14	12	14	4.1	1.0	30	1.8	NR	1.7	4%	9%	1.1
205R00131	Lower Penitencia Cr	37.43404	-121.91280	U	6/3/12	4.8	1253	18.1	8.0	100	13.8	1555	65	DNQ	0.330	=	8.8	0.14	=	0.014	DNQ	0.65	=	0.020	=	0.038	=	0.8	0.038	0.31	0.49	0.68	0.45	NR	1	1	1	4.1	0.0	96	1.4	NR	0.9	69%	96%	12.4
205R00067	San Tomas Aquino	37.37693	-121.96857	U	6/3/12	16.1	1093	25.0	8.2	71	10.4	141	112	=	0.150	=	10.0	0.25	=	0.012	DNQ	0.36	=	0.008	DNQ	-0.007	ND	0.6	0.004	0.39	0.83	0.31	0.85	NR	1	2	2	4.6	1.0	15	0.7	NR	1.3	37%	70%	9.1
205R00227	Matadero Creek	37.40990	-122.15831	U	6/5/12	5.0	977	13.8	7.2	100	20.7	89	133	=	0.430	=	1.4	0.58	=	0.073	=	3.20	=	0.150	=	0.230	=	3.9	0.230	0.59	0.33	0.76	0.57	NR	2	7	9	3.4	0.3	15	1.3	NR	1.3	17%	51%	4.9
205R00115	Stevens Creek	37.40586	-122.06906	U	6/5/12	5.8	789	16.6	6.8	27	19.2	60	61	=	0.120	=	0.2	0.55	=	0.035	=	0.72	=	0.018	=	0.055	=	1.3	0.055	0.24	0.89	0.55	0.70	NR	11	8	9	2.9	0.5	37	1.9	NR	1.5	20%	34%	5.5
205R00066	Trib to Arroyo Aguague	37.37189	-121.73289	NU	6/5/12	9.4	471	11.6	8.0	16	NR	20	15	=	0.105	=	1.8	0.18	=	-0.001	ND	0.40	=	0.075	=	0.019	=	0.6	0.019	0.66	0.82	1.02	1.05	NR	19	15	15	0.0	0.5	13	1.7	NR	1.7	1%	0%	0.2
205R00291	Coyote Creek	37.31718	-121.84857	U	6/13/12	4.8	748	18.5	7.0	69	17.5	358	11	DNQ	0.120	=	0.4	0.26	=	0.003	DNQ	0.47	=	0.091	=	0.120	=	0.7	0.120	0.50	0.52	1.11	0.48	NR	19	10	10	2.4	1.0	31	1.7	NR	1.5	5%	5%	1.2
205R00355	Saratoga Creek	37.32668	-121.99539	U	6/13/12	9.0	438	20.7	8.1	56	10.9	24	-52	ND	0.099	DNQ	4.6	0.27	=	-0.002	ND	0.22	=	0.074	=	0.088	=	0.5	0.088	0.64	0.51	0.65	0.90	NR	5	7	5	3.5	0.5	22	1.5	NR	1.5	20%	39%	5.8
205R00259	Guadalupe River	37.36723	-121.92477	U	6/14/12	9.8	894	20.1	7.5	56	20.2	71	19	=	-0.040	ND	0.2	2.60	=	0.010	DNQ	0.33	=	0.046	=	0.062	=	2.9	0.062	0.44	0.64	1.09	0.67	NR	10	13	15	2.9	0.6	31	1.8	NR	1.5	25%	43%	6.8
205R00346	Guadalupe River	37.25973	-121.87010	U	6/14/12	6.1	531	19.7	7.8	42	14.2	42	14	DNQ	0.055	DNQ	1.1	0.02	DNQ	0.005	DNQ	0.32	=	0.017	=	0.040	=	0.3	0.040	0.48	0.67	0.91	0.73	NR	16	14	12	3.0	0.8	31	1.7	NR	1.6	10%	19%	3.3
204R00189	Smith Creek	37.32117	-121.66358	NU	5/6/13	9.4	306	12.6	8.2	7	15	35	65	=	-0.040	ND	0.6	-0.10	ND	-0.002	ND	0.22	=	0.011	=	0.012	=	0.3	0.012	0.93	1.09	1.12	0.90	NR	19	16	17	0.3	0.8	10	1.7	NR	1.7	1%	0%	0.5
205R00337	EF Coyote Creek	37.18975	-121.46888	NU	5/7/13	11.3	582	21.7	8.2	12	NR	15	14	=	0.030	DNQ	1.7	0.00	ND	-0.001	ND	0.48	=	-0.004	ND	0.014	=	0.5	0.014	0.59	1.03	1.15	1.09	NR	19	7	5	0.1	0.0	9	1.4	NR	1.4	3%	0%	0.1
205R00182	Randol Creek	37.18947	-121.84108	NU	5/7/13	9.2	1131	13.3	8.6	16	21	65	9	=	0.055	DNQ	3.9	0.05	=	-0.002	ND	0.35	=	0.058	=	0.051	=	0.4	0.051	0.74	0.91	0.65	0.84	NR	20	18	13	0.7	0.7	12	1.0	NR	1.7	1%	0%	1.5
205R00538	Shannon Creek	37.21801	-121.91376	U	5/8/13	6.8	855	14.5	7.5	61	26	130	13	=	-0.040	ND	0.1	-0.01	ND	-0.002	ND	0.37	=	0.062	=	0.060	=	0.4	0.060	0.50	0.84	0.91	0.93	NR	16	8	10	2.3	0.6	17	1.5	NR	1.5	4%	21%	4.5
205R00666	Coyote Creek	37.26930	-121.79683	U	5/9/13	6.6	474	18.3	8.4	62	8.2	81	256	=	0.066	DNQ	4.5	0.48	=	-0.002	ND	0.68	=	0.007	DNQ	0.020	=	1.2	0.020	0.69	0.80	0.90	0.75	NR	15	6	8	2.1	0.8	34	1.8	NR	1.6	4%	2%	0.8
205R00474	Coyote Creek	37.27891	-121.80733	U	5/9/13	7.8	486	18.0	8.1	64	9	90	27	=	0.055	DNQ	1.9	0.36	=	0.002	DNQ	0.53	=	0.018	=	0.026	=	0.9	0.026	0.68	0.77	1.04	0.60	NR	16	8	13	2.8	0.7	29	1.4	NR	1.7	4%	2%	0.9
205R00289	Coyote Creek	37.09003	-121.46985	NU	5/28/13	10.1	571	20.7	7.7	22	NR	18	30	=	-0.003	ND	-0.1	0.00	ND	-0.001	ND	0.40	=	-0.004	ND	*0.007*	DNQ	0.4	*0.007*	0.82	1.14	1.07	1.13	NR	15	13	13	0.5	0.2	23	1.6	NR	1.7	2%	0%	0.2
205R00554	San Tomas Aquino	37.24656	-121.99543	U	5/29/13	11.2	527	14.3	7.6	13	29	216	71	=	0.055	DNQ	0.5	0.03	DNQ	-0.002	ND	0.20	=	0.089	=	0.010	=	0.2	0.010	0.68	0.81	0.87	0.63	NR	13	10	18	2.2	0.6	18	1.7	NR	1.5	7%	38%	4.2
205R00170	Saratoga Creek	37.24845	-122.07081	NU	5/29/13	10.4	477	12.8	7.8	33	21	8	5	=	0.044	DNQ	0.6	0.57	=	-0.002	ND	0.31	=	0.016	=	0.082	=	0.9	0.082	1.03	0.66	1.04	0.97	NR	19	16	19	1.3	0.6	7	1.4	NR	1.6	3%	4%	0.8
205R00602	Alamitos Creek	37.23019	-121.86591	U	6/3/13	11.8	513	19.0	8.4	36	21	198	107	=	0.066	DNQ	5.5	0.16	=	-0.002	ND	0.57	=	0.039	=	0.041	=	0.7	0.041	0.55	0.79	1.08	0.75	NR	14	12	7	2.5	0.9	47	1.6	NR	1.6	7%	15%	2.6
205R00374	Alamitos Creek	37.19420	-121.82315	U	6/3/13	9.9	444	15.5	8.2	9	19	152	83	=	0.066	DNQ	2.3	0.05	=	-0.002	ND	0.40	=	0.065	=	0.062	=	0.5	0.062	0.67	0.85	0.86	0.86	NR	15	11	13	3.0	0.9	33	1.9	NR	1.8	3%	2%	1.2
205R00627	Calabazas Creek	37.39597	-121.98683	U	6/4/13	18.7	952	25.0	8.7	66	23	355	354	=	0.044	DNQ	8.6	0.56	=	0.010	DNQ	1.00	=	0.010	=	0.120	=	1.6	0.120	0.51	0.66	0.39	0.58	NR	19	16	16	2.7	0.8	61	1.0	NR	1.3	49%	84%	10.5
205R00547	Calabazas Creek	37.34769	-121.98985	U	6/4/13	16.3	578	25.2	9.0	66	23	43	41	=	-0.040	ND	7.1	-0.01	ND	0.002	DNQ	0.46	=	-0.006	ND	-0.007	ND	0.5	0.004	0.46	0.50	0.67	0.90	NR	0	0	19	3.5	1.0	3	0.0	NR	0.6	40%	78%	9.9
205R00451	Coyote Creek	37.38717	-121.90979	U	6/5/13	7.8	1203	19.0	8.0	94	19	396	22	=	0.190	=	5.9	1.70	=	0.009	DNQ	1.50	=	0.086	=	0.150	=	3.2	0.150	0.44	0.62	1.28	0.67	NR	15	12	3	3.2	0.8	68	1.4	NR	1.5	10%	15%	2.5
205R00707	Upper Penitencia Cr	37.38984	-121.84495	U	6/5/13	8.8	439	22.4	8.3	54	9.8	127	70	=	0.120	=	8.7	0.37	=	0.002	DNQ	0.59	=	0.100	=	0.110	=	1.0	0.110	0.64	0.57	1.03	0.71	NR	15	16	18	2.7	0.5	22	1.5	NR	1.9	3%	8%	1.0
205R00387	Calera Creek	37.44631	-121.90844	U	6/6/13	12.6	1113	31.6	8.2	47	25	2526	65	=	-0.040	ND	2.2	-0.01	ND	0.003	DNQ	1.10	=	0.015	=	0.052	=	1.1	0.052	0.27	0.63	0.72	0.52	NR	1	12	3	5.5	0.0	99	0.7	NR	0.2	10%	18%	3.1
205R00771	Guadalupe River	37.34260	-121.90206	U	6/6/13	8.6	805	18.4	7.8	61	19	140	193	=	-0.040	ND	0.4	3.00	=	0.004	DNQ	0.46	=	0.032	=	0.045	=	3.5	0.045	0.51	0.68	0.98	0.77	NR	10	11	11	3.3	0.8	27	1.9	NR	1.7	23%	40%	6.5
205R00714	Los Gatos Creek	37.23407	-121.97355	U	6/10/13	10.4	396	16.2	8.1	14	13	109	97	=	-0.040	ND	0.6	0.07	=	-0.002	ND	0.57	=	0.028	=	0.036	=	0.6	0.036	0.71	0.75	1.02	0.87	NR	13	12	16	1.9	0.6	25	1.9	NR	1.8	6%	11%	2.9
205R00586	Los Gatos Creek	37.16565	-121.97938	U	6/10/13	9.8	410	14.2	8.0	9	19	332	29	=	-0.040	ND	0.5	-0.01	ND	-0.002	ND	0.26	=	0.039	=	0.034	=	0.3	0.034	0.96	0.73	1.00	0.77	NR	18	18	14	0.6	0.7	23	1.7	NR	1.6	5%	7%	2.3
205R00739	Matadero Creek	37.42984	-122.12799	U	6/11/13	13.6	1020	19.2	8.5	78	28	538	39	=	0.044	DNQ	4.0	1.50	=	0.003	DNQ	0.77	=	0.044	=	0.078	=	2.3	0.078	0.27	0.68	0.52	0.77	NR	0	3	14	4.6	0.8	3	0.2	NR	0.6	30%	65%	7.0
205R00419	Stevens Creek	37.31979	-122.06175	U	6/11/13	9.9	537	17.5	8.1	22	18	202	126	=	-0.040	ND	0.7	0.21	=	-0.002	ND	0.53	=	0.027	=	0.048	=	0.7	0.048	0.75	0.70	0.75	0.68	NR	15	13	8	1.9	0.8	25	1.8	NR	1.5	3%	4%	1.4
205R00275	Arroyo Aguague	37.39043	-121.78352	NU	6/12/13	8.9	760	14.7	8.1	19	NR	17	12	=	-0.003	ND	-0.1	0.09	=	-0.001	ND	0.27	=	0.040	=	0.047	=	0.4	0.047	0.89	0.90	0.83	0.81	NR	20	18	19	0.0	0.1	7	1.3	NR	1.6	1%	0%	0.4
205R00787	Upper Penitencia Cr	37.40139	-121.79528	U	6/12/13	9.8	569	15.1	8.0	16	15	40	6	=	0.044	DNQ	1.1	0.10	=	-0.002	ND	0.13	=	0.034	=	0.027	=	0.2	0.027	1.26	0.94	0.88	0.89	NR	18	18	15	1.3	0.7	4	0.9	NR	1.6	1%	2%	0.4
205R00851	Arroyo de las Coches	37.43828	-121.87107	U	4/21/14	9.2	750	14.9	8.0	94	31	1387	54	=	-0.040	ND	0.5	-0.01	ND	-0.005	ND	0.40	=	0.170	=	0.180	=	0.4	0.180	0.60	0.50	0.89	0.68	NR	10	7	5	2.6	1.0	61	1.3	NR	1.4	2%	3%	2.2
205R01578	San Tomas Aquino	37.24047	-122.00595	U	4/22/14	7.0	657	14.8	6.8	49	26	88	51	=	-0.040	ND	0.0	1.20	=	-0.005	ND	0.22	=	-0.006	ND	0.014	=	1.4	0.014	0.55	0.93	1.12	0.95	NR	10	10	12	2.8	1.0	16	1.7	NR	1.6	5%	25%	3.0
205R00938	San Tomas Aquino	37.26078	-121.99184	U	4/22/14	9.5	303	14.6	7.7	90	26	87	49	=	-0.040	ND	0.2	0.37	=	-0.005	ND	0.62	=	0.044	=	0.046	=	1.0	0.046	0.76	0.69	0.83	0.62	NR	8	12	10	2.8	0.7	31	1.5	NR	1.7	11%	51%	5.1
205R00266	Limekiln Creek	37.20320	-121.97296	NU	4/23/14	6.6	689	12.5	7.1	34	22	4	19	=	0.055	DNQ	0.1	-0.01	ND	-0.005	ND	0.31	=	-0.006	ND	-0.007	ND	0.3	0.004	0.43	0.56	1.01	0.80	NR	16	14	15	1.2	0.8	3	1.4	NR	1.4	2%	2%	1.5
205R01306	Ross Creek	37.24887	-121.91393	U	4/23/14	8.6	959	14.0	8.9	150	12	85	119	=	-0.040	ND	2.8	-0.01	ND	-0.005	ND	0.62	=	0.140	=	0.180	=	0.6	0.180	0.38	0.50	0.57	0.67	NR	2	2	1	3.3	0.1	22	1.2	NR	1.4	31%	73%	8.9
205R00979	Lower Silver Creek	37.35432	-121.84674	U	4/24/14	13.3	950	18.3	8.1	130	16	1034	137	=	0.088	DNQ	3.2	2.90	=	0.052	=	0.97	=	0.013	=	0.091	=	3.9	0.091	0.46	0.17	1.05	0.58	NR	4	2	16	3.2	0.5	7	1.7	NR	1.1	24%	47%	6.8
205R00915	Thompson Creek	37.31470	-121.79623	U	4/24/14	7.2	2	14.9	8.1	340	26	224	47	=	0.077	DNQ	2.4	1.70	=	-0.005	ND	0.53	=	0.200	=	0.200	=	2.2	0.200	0.43	0.27	0.86	0.53	NR	9	4	3	2.8	0.4	26	1.9	NR	1.5	16%	30%	4.5
205R01098	Guadalupe Creek	37.20961	-121.90311	U	4/30/14	9.6	675	16.0	8.0	18	13	405	49	=	0.055	DNQ	1.5	0.19	=	-0.005	ND	0.70	=	0.023	=	0.033	=	0.9	0.033	0.89	0.80	0.91	0.95	NR	2	2	2	3.0	0.4	20	1.8	NR	1.5	1%	0%	1.3
205R00330	Hicks Creek	37.19830	-121.90095	NU	4/30/14	9.7	437	13.2	8.0	9	17	35	27	=	-0.040	ND	0.4	0.06	=	-0.005	ND	0.40	=	0.022	=	0.026	=	0.5	0.026	1.21	1.00	1.14	1.20	NR	15	16	15	0.7	1.0	1	1.4	NR	1.4	1%	0%	0.5
205R00362	Lyndon Canyon Creek	37.21976	-122.05622	NU	5/1/14	9.7	356	12.2	7.6	10	25	37	14	=	-0.040	ND	0.2	0.09	=	-0.005	ND	0.31	=	0.160	=	0.180	=	0.4	0.180	1.15	1.22	1.20	0.99	NR	20	19	16	0.3	0.8	7	1.1	NR	1.7	12%	2%	1.1
205R01027	Guadalupe River	37.35694	-121.91432	U	5/5/14	6.4	907	17.7	7.2	58	21	59	-3	ND	0.130	=	0.7	2.30	=	-0.005	ND	0.62	=	0.038	=	0.051	=	2.9	0.051	0.52	0.64	0.97	0.57	NR	10	10	10	2.1	0.8	46	1.8	NR	1.3	25%	42%	6.7
205R01091	Saratoga Creek	37.35755	-121.97317	U	5/5/14	19.4	123	19.9	7.8	85	15	440	170	=	0.055	DNQ	1.2	0.08	=	-0.005	ND	0.48	=	0.008	DNQ	0.021	=	0.6	0.021	0.31	0.73	0.52	0.94	NR	9	3	2	3.0	0.0	33	0.9	NR	1.4	25%	47%	6.6
205R00394	Austrian Gulch	37.13670	-121.92300	NU	5/12/14	10.4	286	10.9	7.8	5	20	191	20	=	-0.040	ND	0.2	-0.01	ND	-0.005	ND	0.22	=	0.010	=	0.007	DNQ	0.2	0.007	1.23	1.13	1.00	0.98	NR	20	18	11	0.7	0.7	10	1.1	NR	1.9	1%	0%	2.0
205R00883	Adobe Creek	37.37074	-122.11770	U	5/13/14	9.3	601	17.7	7.9	72	25	95	32	=	-0.040	ND	0.4	0.44	=	-0.005	ND	0.44	=	0.066	=	0.074	=	0.9	0.074	0.72	0.67	1.00	0.64	NR	16	8	5	2.5	0.4	31	1.8	NR	1.4	8%	29%	3.1
205R00322	Arroyo Aguague	37.36018	-121.73720	NU	5/14/14	8.5	508	16.6	7.9	19	15.6	19	14	=	-0.002	ND	-0.1	-0.01	ND	-0.002	ND	0.18	=	0.028	=	0.020	=	0.2	0.020	0.53	1.00	0.97	1.09	NR	19	14	15	0.3	0.3	12	1.8	NR	1.7	1%	0%	0.2
205R01187	Stevens Creek	37.30299	-122.07446	U	5/14/14	7.7	756	13.8	7.4	25	18	183	32	=	0.190	=	1.1	0.62	=	0.019	DNQ	0.57	=	0.020	=	0.073	=	1.2	0.073	0.43	0.41	1.28	0.56	NR	19	12	1	0.9	0.8	38	2.1	NR	1.8	2%	2%	1.2
205R01443	Stevens Creek	37.31477	-122.06168	U	5/14/14	8.8	752	17.8	7.8	27	13	439	98	=	-0.040	ND	0.3	0.12	=	-0.005	ND	0.26	=	0.032	=	0.044	=	0.4	0.044	0.68	0.80	1.20	0.89	NR	15	12	4	2.9	0.7	40	1.8	NR	1.8	2%	4%	1.3
205R01299	Arroyo Aguague	37.39816	-121.78614	U	5/15/14	8.6	779	13.3	7.7	18	11	115	156	=	-0.040	ND	0.2	0.05	DNQ	-0.005	ND	-0.07	ND	0.051	=	0.058	=	0.1	0.058	0.96	1.32	0.98	1.01	NR	20	18	13	0.6	0.6	6	1.6	NR	1.7	1%	1%	0.3
204R00221	Valpe Creek	37.47092	-121.66640	NU	5/19/14	10.2	343	11.0	8.1	9	15.2	25	15	=	-0.002	ND	-0.1	0.01	DNQ	-0.002	ND	0.17	=	0.022	=	0.023	=	0.2	0.023	0.96	1.13	0.95	1.00	NR	19	17	16	0.0	0.6	10	1.7	NR	1.7	2%	0%	0.4
205R01539	Los Gatos Creek	37.31488	-121.90380	U	5/20/14	9.4	392	19.2	7.9	16	11	483	43	=	-0.040	ND	0.5	0.01	DNQ	-0.005	ND	0.48	=	0.016	=	0.033	=	0.5	0.033	0.58	0.60	1.13	0.64	NR	10	10	8	3.0	0.5	17	1.7	NR	1.4	17%	29%	5.1
205R01226	Los Gatos Creek	37.29782	-121.92913	U	5/20/14	8.7	505	19.2	8.1	15	11	121	101	=	-0.040	ND	0.8	-0.01

Site Information						Water Quality						Water Chemistry (nutrients)																								Biological and Physical Habitat Indicator Scores					Physical Habitat									Land Use Variables		
Station Code	Creek Name	Latitude	Longitude	Land Use	Sample Date	Dissolved Oxygen (mg/L)	Spec Conductance (uS/cm)	Temperature (Deg C)	pH	Chloride (mg/L)	Silica (mg/L)	Ash Free Dry Mass (g/m2)	Chlorophyll a (mg/m2)	QA Flag	Ammonia (mg/L)	QA Flag	UIA (ug/L)	Nitrate as N (mg/L)	QA Flag	Nitrite as N (mg/L)	QA Flag	TKN as N (mg/L)	QA Flag	Ortho Phosphate as P (mg/L)	QA Flag	Total Phosphorus as P (mg/L)	QA Flag	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)	CSCI	ASCI_D	ASCI_SB	ASCI_H	IPI	Channel Alteration	Epifaunal Substrate	Sediment Deposition	Human Disturbance Index	Evenness Flow Habitat	% Substrate <2 mm	Shannon Diversity Habitat	Sum Riparian Cover	Shannon Diversity Substrate	% Impervious (wat)	% Urban (wat)	Road Density (wat)
205R01562	Shannon Creek	37.21995	-121.92418	U	4/16/15	7.6	793	12.9	7.6	45	26	229	11	=	-0.040	ND	0.2	-0.01	ND	-0.005	ND	0.88	=	0.024	=	0.023	=	0.9	0.023	0.45	0.88	1.08	0.77	NR	16	12	13	2.4	1.0	21	1.6	NR	1.4	3%	14%	4.0
205R02154	Wildcat Creek	37.24502	-122.03136	U	4/16/15	9.4	520	13.3	8.2	15	24	148	5	=	-0.040	ND	0.6	-0.01	ND	-0.005	ND	0.40	=	0.022	=	0.016	=	0.4	0.016	0.71	0.77	1.12	1.04	NR	15	15	9	1.3	0.7	29	1.6	NR	1.9	2%	7%	1.3
204R00253	Isabel Creek	37.37893	-121.68361	NU	4/20/15	9.6	430	16.8	8.1	9	12	16	6	=	0.130	=	4.3	-0.01	ND	-0.005	ND	0.62	=	-0.006	ND	0.018	=	0.6	0.018	0.68	1.15	1.06	1.12	NR	20	17	18	0.4	0.8	14	1.7	NR	1.8	1%	0%	0.4
205R02074	Golf Creek	37.23195	-121.87455	U	4/21/15	14.8	1434	23.2	8.8	150	24	99	26	=	0.140	=	27.2	0.43	=	-0.005	ND	1.00	=	0.058	=	0.084	=	1.4	0.084	0.43	0.33	0.81	0.54	NR	3	3	6	5.0	0.1	17	1.1	NR	1.2	26%	54%	7.9
205R01962	Sobey Creek	37.26295	-121.99919	U	4/21/15	8.6	1240	13.8	8.0	210	35	61	7	=	0.140	=	2.8	0.36	=	-0.005	ND	0.62	=	0.071	=	0.085	=	1.0	0.085	0.38	0.70	1.15	0.73	NR	11	7	9	3.5	0.8	33	1.8	NR	1.5	16%	100%	6.6
205R01882	Alamitos Creek	37.23577	-121.87047	U	4/27/15	5.9	867	16.6	7.3	78	26	38	183	=	0.044	DNQ	0.2	1.70	=	-0.005	ND	0.57	=	0.012	=	0.013	=	2.3	0.013	0.60	0.69	0.62	0.73	NR	12	13	11	2.1	0.8	23	1.2	NR	1.9	9%	19%	3.2
205R01738	Ross Creek	37.23844	-121.94789	U	4/27/15	8.5	1162	16.7	8.1	85	36	17	40	=	-0.040	ND	0.6	0.95	=	0.006	DNQ	1.10	=	0.230	=	0.230	=	2.1	0.230	0.44	0.43	0.83	0.74	NR	6	15	6	4.9	0.8	20	1.8	NR	1.8	22%	62%	7.5
205R01610	Los Gatos Creek	37.15754	-121.97052	U	4/28/15	10.2	403	12.3	8.0	8	17	150	9	=	0.055	DNQ	1.0	0.05	DNQ	-0.005	ND	0.53	=	0.016	=	0.017	=	0.6	0.017	1.05	0.94	1.28	0.85	NR	18	17	8	0.8	0.6	31	1.5	NR	1.9	3%	4%	1.5
205R01706	Saratoga Creek	37.26485	-122.02638	U	4/28/15	10.2	597	16.6	8.2	32	23	48	84	=	0.044	DNQ	1.7	0.12	=	-0.005	ND	0.44	=	0.043	=	0.040	=	0.6	0.040	0.72	0.80	0.98	0.87	NR	12	13	14	2.9	0.9	20	1.7	NR	1.7	6%	13%	2.2
205R01715	Hale Creek	37.35606	-122.11071	U	4/29/15	7.0	1406	14.1	7.8	110	30	672	101	=	0.150	=	1.9	-0.01	ND	-0.005	ND	0.97	=	0.061	=	0.064	=	1.0	0.064	0.46	0.56	0.74	0.64	NR	18	6	3	1.9	0.0	49	1.8	NR	1.2	11%	59%	5.5
205R02119	Los Trancos Creek	37.36044	-122.20276	U	4/29/15	8.0	590	16.4	8.0	29	18	63	7	=	-0.040	ND	0.5	-0.01	ND	-0.005	ND	0.20	=	0.009	DNQ	0.012	=	0.2	0.012	0.68	0.37	1.07	0.81	NR	14	11	7	2.4	0.7	9	1.1	NR	1.7	4%	13%	1.5
205R02211	Stevens Creek	37.30555	-122.07191	U	5/14/15	10.3	481	12.7	7.9	17	18	762	73	=	0.160	=	2.5	0.33	=	-0.005	ND	0.66	=	0.029	=	0.052	=	1.0	0.052	0.41	0.76	1.16	0.65	NR	16	11	5	1.9	0.9	36	1.7	NR	1.5	2%	2%	1.2
205R01315	Coyote Creek	37.32263	-121.85837	U	5/18/15	3.3	1236	15.7	7.6	83	19	302	15	=	0.200	=	1.9	0.29	=	0.025	DNQ	1.00	=	0.210	=	0.230	=	1.3	0.230	0.30	0.36	0.87	0.34	NR	13	7	8	2.4	0.4	20	1.9	NR	1.6	6%	6%	1.4
205R01747	Lower Silver Creek	37.35223	-121.84211	U	5/18/15	9.9	1320	17.1	8.2	110	27	350	-7	ND	0.220	=	8.3	2.80	=	0.045	=	0.57	=	0.050	=	0.130	=	3.4	0.130	0.37	0.39	1.02	0.54	NR	11	9	13	3.6	0.6	66	1.9	NR	1.4	23%	46%	6.7
205R02051	Guadalupe River	37.34548	-121.90422	U	5/19/15	3.1	1360	16.2	7.8	180	20	217	16	=	0.220	=	3.2	0.67	=	0.016	DNQ	0.62	=	0.200	=	0.220	=	1.3	0.220	0.32	0.71	0.72	0.56	NR	8	9	12	2.3	0.6	16	1.9	NR	1.7	24%	41%	6.5
205R01411	San Tomas Aquino	37.38842	-121.96863	U	5/19/15	11.7	967	18.6	8.3	59	15	87	108	=	0.180	=	11.2	0.17	=	-0.005	ND	0.44	=	0.046	=	0.056	=	0.6	0.056	0.42	0.55	0.42	0.63	NR	5	3	1	4.6	0.4	23	1.1	NR	1.5	39%	72%	9.2
205R01669	Coyote Creek	37.16628	-121.64787	U	5/20/15	9.6	643	15.2	8.1	100	16	175	56	=	0.044	DNQ	1.2	0.64	=	-0.005	ND	0.40	=	0.088	=	0.096	=	1.0	0.096	0.63	0.84	0.85	0.80	NR	13	16	13	3.1	0.8	28	1.9	NR	1.8	3%	0%	0.5
205R01923	Lower Penitencia Cr	37.42266	-121.90707	U	5/21/15	10.4	1467	18.7	8.2	110	14	199	50	=	0.099	DNQ	5.1	0.15	=	-0.005	ND	0.53	=	0.015	=	0.021	=	0.7	0.021	0.29	0.44	0.88	0.65	NR	2	1	1	4.0	0.1	40	1.4	NR	1.4	69%	96%	12.5
205R01930	Los Gatos Creek	37.26308	-121.95209	U	5/26/15	8.2	479	18.3	7.8	21	12	63	45	=	0.044	DNQ	1.0	0.04	DNQ	-0.005	ND	0.88	=	0.020	=	0.035	=	0.9	0.035	0.34	0.69	0.69	0.72	NR	14	16	9	1.7	0.9	33	1.8	NR	1.6	8%	15%	3.4
205R02307	Los Gatos Creek	37.29904	-121.92683	U	5/26/15	10.2	495	20.7	8.2	20	7.5	44	87	=	-0.040	ND	1.2	-0.01	ND	-0.005	ND	0.53	=	0.026	=	0.051	=	0.5	0.051	0.56	0.82	1.03	1.05	NR	13	17	11	3.1	0.6	17	1.6	NR	1.7	13%	22%	4.2
205R00593	Soda Springs Canyon	37.16919	-121.50815	NU	5/28/15	9.0	922	13.4	7.9	19	20.4	46	12	=	-0.002	ND	0.0	-0.01	ND	-0.002	ND	0.11	=	0.046	=	0.026	=	0.1	0.026	0.52	0.78	1.03	1.04	NR	17	16	15	0.9	0.6	8	1.8	NR	1.8	1%	0%	1.1
205R00657	MF Coyote Creek	37.17992	-121.50095	NU	6/2/15	8.3	502	20.7	7.7	11	12.9	15	17	=	0.005	DNQ	0.1	-0.01	ND	0.003	DNQ	0.20	=	0.011	=	0.007	DNQ	0.2	0.007	0.51	1.04	0.79	1.00	NR	16	13	15	0.9	0.5	19	1.8	NR	1.8	1%	0%	0.2
204R00893	Smith Creek	37.32471	-121.67017	NU	6/10/15	9.2	386	16.6	8.0	7	19.6	26	101	=	0.012	DNQ	0.4	0.05	=	-0.002	ND	0.18	=	0.028	=	0.024	=	0.2	0.024	0.97	0.73	0.92	1.06	NR	15	16	17	1.3	0.8	5	1.9	NR	1.3	1%	0%	0.5
205R00578	Arroyo Aguague	37.34925	-121.71812	NU	4/26/16	7.9	305	13.9	7.6	13	13	72	9	=	-0.015	ND	0.1	-0.02	ND	-0.001	ND	0.40	=	0.030	=	0.044	=	0.4	0.044	0.74	0.87	1.28	0.92	1.03	17	10	10	1.0	0.4	17	1.7	172	1.5	1%	0%	0.0
205R00213	Cow Creek	37.26445	-121.65039	NU	4/27/16	10.5	492	10.7	8.2	16	16	14	1	=	-0.015	ND	0.2	-0.02	ND	-0.001	ND	-0.07	ND	0.006	DNQ	0.018	=	0.0	0.018	0.66	0.94	1.28	1.10	1.06	20	17	16	0.0	0.6	6	1.5	139	1.6	1%	0%	0.8
205R00305	San Felipe Creek	37.25626	-121.66266	NU	4/27/16	10.7	555	13.4	8.4	18	14	83	87	=	-0.015	ND	0.4	1.20	=	0.002	DNQ	0.26	=	0.024	=	0.040	=	1.5	0.040	0.89	0.68	0.98	0.91	1.19	16	7	5	0.2	0.7	18	1.9	166	1.6	1%	0%	0.9
205R02618	Aldercroft Creek	37.17623	-121.98942	U	5/2/16	10.9	575	11.7	8.0	15	23	10	4	=	0.015	DNQ	0.3	0.54	=	0.001	DNQ	0.48	=	0.081	=	0.087	=	1.0	0.087	0.83	0.93	NA	NA	1	17	15	10	1.3	0.7	16	1.7	138	1.7	4%	11%	2.5
205R01114	Guadalupe River	37.28534	-121.88298	U	5/3/16	9.4	547	18.9	8.3	41	8.8	224	47	=	0.022	=	1.3	0.03	DNQ	0.002	DNQ	0.48	=	0.016	=	0.086	=	0.5	0.086	0.39	0.72	0.66	0.68	0.92	6	12	15	2.9	0.8	29	1.1	106	1.5	17%	34%	5.2
205R02330	Ross Creek	37.25520	-121.90656	U	5/3/16	16.0	2848	25.2	9.1	670	16	22	66	=	0.025	=	9.3	0.15	=	0.001	DNQ	0.79	=	0.060	=	0.084	=	0.9	0.084	0.49	0.44	0.80	0.78	0.47	2	4	15	6.2	0.1	3	0.9	30	1.3	37%	79%	10.2
205R02422	Arroyo Calero	37.21059	-121.82717	U	5/4/16	8.8	489	15.8	7.7	37	17	421	75	=	0.024	=	0.3	0.26	=	0.004	DNQ	0.88	=	0.039	=	0.049	=	1.1	0.049	0.72	1.03	0.71	0.55	1	14	13	9	2.7	0.8	51	1.7	152	1.5	3%	5%	1.9
205R02458	Alamitos Creek	37.21897	-121.84321	U	5/4/16	10.4	472	16.7	8.1	28	18	34	35	=	0.033	=	1.2	0.14	=	0.003	DNQ	0.57	=	0.030	=	0.037	=	0.7	0.037	0.61	0.92	0.91	0.91	1.05	14	10	7	3.1	0.7	38	1.9	128	1.7	4%	8%	1.9
205R01731	Upper Penitencia Cr	37.39265	-121.83477	U	5/5/16	10.3	876	15.7	8.7	50	15	55	-4	ND	0.027	=	2.8	0.19	=	0.004	DNQ	1.10	=	0.020	=	0.026	=	1.3	0.026	0.63	0.60	0.64	0.79	0.91	11	10	15	3.9	0.7	17	1.7	72	1.5	2%	4%	0.9
205R02835	Upper Penitencia Cr	37.39658	-121.80390	U	5/5/16	10.0	794	13.8	8.2	37	15	248	74	=	0.170	=	6.2	0.30	=	0.035	=	0.97	=	0.030	=	0.042	=	1.3	0.042	0.79	0.76	1.01	0.79	0.98	7	17	13	2.8	0.9	27	1.5	95	1.9	2%	2%	0.7
205R02474	Saratoga Creek	37.25819	-122.03437	U	5/18/16	9.9	526	14.6	8.0	20	20	30	14	=	-0.015	ND	0.2	0.06	=	0.002	DNQ	0.57	=	0.042	=	0.044	=	0.6	0.044	0.82	0.77	0.81	1.10	1.07	15	16	14	3.6	0.6	16	1.9	149	1.7	5%	10%	2.0
205R02538	Calabazas Creek	37.27538	-122.04225	U	5/18/16	8.7	1108	20.1	8.0	96	16	63	13	=	-0.015	ND	0.2	-0.02	ND	0.001	DNQ	0.53	=	0.032	=	0.019	=	0.5	0.019	0.57	0.61	0.81	0.87	0.88	13	7	8	2.4	0.6	19	1.5	120	1.4	6%	33%	4.2
205R02563	Los Gatos Creek	37.32924	-121.89960	U	5/19/16	12.1	498	21.4	8.8	43	10	39	145	=	-0.015	ND	1.4	0.66	=	0.003	DNQ	0.62	=	0.021	=	0.033	=	1.3	0.033	0.52	0.80	0.86	0.93	0.9	13	12	9	3.7	0.9	26	1.1	87	1.7	18%	30%	5.3
205R02659	Stevens Creek	37.34474	-122.06417	U	5/19/16	9.6	467	15.7	8.4	17	18	72	10	=	0.390	=	21.8	0.09	=	0.014	=	0.62	=	0.028	=	0.072	=	0.7	0.072	0.62	0.43	0.81	0.60	1.03	12	10	9	1.8	0.8	22	1.8	125	1.6	8%	13%	2.5
205R02650	Alamitos Creek	37.22150	-121.84700	U	5/31/16	9.0	492	16.4	7.9	38	18	186	71	=	0.021	=	0.5	0.18	=	0.002	DNQ	0.62	=	0.034	=	0.037	=	0.8	0.037	0.73	0.78	1.15	0.87	1.1	15	15	12	2.7	0.8	35	1.8	136	1.8	5%	10%	2.1
205R02547	Stevens Creek	37.31243	-122.16309	U	6/1/16	10.2	534	12.6	8.2	12	18	14	15	=	0.029	=	0.8	-0.02	ND	-0.001	ND	0.70	=	0.025	=	0.024	=	0.7	0.024	0.96	0.98	1.12	0.98	1.18	20	17	6	0.1	0.8	7	1.7	171	1.7	2%	1%	1.0
205R02730	Saratoga Creek	37.28141	-122.00642	U	6/1/16	10.3	501	20.1	8.4	71	10	158	96	=	0.069	=	5.2	0.22	=	-0.001	ND	0.79	=	0.098	=	0.110	=	1.0	0.110	0.29	0.76	0.52	0.77	1	11	11	10	3.1	0.8	23	1.7	124	1.5	11%	22%	3.4
205R02602	Unnamned Tributary	37.23547	-122.00528	U	6/2/16	8.9	468	15.8	7.6	18	23	195	12	=	0.028	=	0.3	0.41	=	-0.001	ND	0.40	=	0.200	=	0.017	=	0.8	0.017	0.93	1.09	1.28	1.09	0.95	13	15	11	3.4	0.7	8	1.9	103	1.4	4%	20%	3.1
205R02762	Ross Creek	37.23593	-121.95184	U	6/2/16	11.7	1013	18.7	8.3	96	35	63	223	=	0.036	=	2.1	1.60	=	0.009	=	1.10	=	0.036	=	0.200	=	2.7	0.200	0.30	0.20	0.85	0.65	0.64	11	8	11	4.1	0.1	32	1.6	73	1.6	23%	64%	7.6
205R02771	Lower Silver Creek	37.35228	-121.83543	U	6/3/16	9.0	1364	20.9	8.1	120	24	736	123	=	0.098	=	4.1	3.40	=	0.031	=	1.10	=	0.200	=	0.082	=	4.5	0.082	0.49	0.50	1.12	0.57	0.68	5	9	10	4.0	0.6	39	1.6	25	1.9	21%	43%	6.2
205R02755	Berryessa Creek	37.42093	-121.84015	U	5/8/17	11.1	590	10.9	8.5	25	31	290	16	=	0.220	=	11.7	0.71	=	0.007	=	0.62	=	0.180	=	0.210	=	1.3	0.210	0.93	0.41	NA	NA	0.98	20	12	13	0.5	1.0	28	1.4	112	1.9	1%	3%	0.7
205R03011	Berryessa Creek	37.41123	-121.85857	U	5/8/17	8.1	614	20.4	8.7	27	30	260	5	=	0.270	=	42.9	0.43	=	0.005	=	0.62	=	0.130	=	0.180	=	1.1	0.180	0.80	0.86	NA	NA	0.89	11	8	10	3.0	1.0	41	1.7	110	1.5	4%	8%	1.5
205R03306	Saratoga Creek	37.27739	-122.01172	U	5/9/17	11.5	458	12.6	8.3	21	24	90	17	=	0.049	=	1.8	0.18	=	0.001	DNQ	0.48	=	0.047	=	0.065	=	0.7	0.065	0.87	0.65	NA	NA	1.04	14	14	10	3.1	1.0	49	1.7	134	1.6	8%	17%	2.7
205R00609	Hunting Hollow	37.07372	-121.46027	NU	5/10/17	9.1	618	15.1	8.0	28	17	21	12	=	0.058	=	1.4	-0.02	ND	-0.001	ND	0.97	=	0.010	=	0.015	=	1.0	0.015	0.66	0.83	0.81	1.04	0.87	20	16	9	0.8	0.5	33	1.2	108	1.8	2%	0%	0.3
205R02947	Lower Penitencia Cr	37.42918	-121.90895	U	5/11/17	1.9	1386	23.3	8.4	120	16	218	52	=	0.047	=	4.4	0.22	=	0.013	=	0.66	=	0.013	=	0.012	=	0.9	0.012	0.27	0.42	0.58	0.59	0.23	4	3	2	3.5	0.0	94	0.8	36	0.9	69%	96%	12.3
205R03523	Upper Penitencia Cr	37.39339	-121.83237	U	5/11/17	7.2	788	13.8	8.5	41	17	44	42	=	0.038	=	2.5	0.19	=	0.007	=	0.66	=	0.036	=	0.043	=	0.9	0.043	0.91	0.40	0.78	0.71	0.99	12	14	15	2.5	1.0	42	1.9	104	1.7	3%	6%	0.8
205R00645	Packwood Creek	37.17072	-121.61339	NU	5/15/17	10.8	576	11.7	8.4	19	17	173	21	=	-0.015	ND	0.4	1.80	=	0.002	DNQ	0.44	=	0.015	=	0.019	=	2.2	0.019	0.75	0.77	0.78	0.57	1.12	20	16	13	0.1	1.0	22	1.4	141	1.7	1%	0%	0.4
205R02693	Packwood Creek	37.17479	-121.61669	U	5/15/17	4.9	579	15.6	8.5	19	17	62	12	=	-0.015	ND	0.5	1.70	=	0.003	DNQ	0.31	=	0.015	=	0.024	=	2.0	0.024	0.62	0.46	1.07	0.64	0.76	20	9	4	1.3	0.8	49	1.3	60	1.5	1%	0%	0.4
205R03386	Aldercroft Creek	37.17676	-121.99588	U	5/16/17	3.6	320	11.4	8.1	16	26	49	4	=	0.068	=	1.4	0.10	=	0.003	DNQ	0.22	=	0.110	=	0.140	=	0.3	0.140	1.00	0.71	NA	NA	0.99	19	14	10	1.4	0.9	24	1.7	126	1.6	4%	5%	0.8
205R00570	Trib to Aldercroft Creek	37.18146	-122.00217	NU	5/16/17	5.7	738	10.6	8.0	14	27	278	9	=	0.054	=	1.0	0.06	=	0.003	DNQ	0.13	=	0.120	=	0.140	=	0.2	0.140	0.95	0.99	1.28	1.00	0.83	14	13	4	2.7	0.7	43	1.9	103	1.5	1%	0%	3.3
205R03091	Arroyo Aguague	37.39925	-121.78563	U	5/18/17	10.7	670	10.5	8.5	22	16	2	5	=	0.017	DNQ	0.8	-0.02	ND	0.001	DNQ	0.31	=	0.033	=	0.033	=	0.3	0.033	1.01	0.88	NA	NA	0.91	19	17	14	0.1	0.6	14	0.8	119	1.8	1%	1%	0.3
205R03443	Calabazas Creek	37.38864	-121.98684	U	6/1/17	19.6	703	30.4	9.0	83	20	136	196	=	0.110	=	45.9	1.40	=	0.035	=	1.70	=	-0.006	ND	0.014	=	3.1	0.014	0.45	0.86	0.39	0.96	0.44	0	2	14	6.0	1.0	21	0.2	22	0.8	49%	84%	10.4
205R02787	Matedero Creek	37.43220	-122.12484	U	6/1/17	12.9	1218	19.9	8.5	110	31	253	140	=	0.082	=	7.2	2.10	=	0.025	=	0.92	=	0.064	=	0.070	=	3.0	0.070	0.49	0.37	0.52	0.52	0.28	0	2	14	5.2	1.0	34	0.2	27	0.5	30%	65%	7.0
205R02915	Stevens Creek	37.30693	-122.06925	U	6/5/17	9.7	504	15.3	8.0	22	18	47	79	=	0.081	=	2.1	0.03	DNQ	-0.001	ND	0.57	=	0.024	=	0.066	=	0.6	0.066	0.58	0.79	0.63	0.95	1.02	20	17	14	0.9	0.8	41	2.0	136	1.5	2%	2%	1.2
205R03235	Stevens Creek	37.33467	-122.06433	U	6/5/17	11.5	519	16.6	8.5	24	17	42	117	=	0.061	=	4.5	0.08	=	0.010	=	0.44	=	0.022	=	0.052	=	0.5	0.052	0.86	0.88	0.62	0.91	0.9	4	6	14	3.0	0.9	31	1.5	122	1.4	4%	7%	1.7
205R03354	Guadalupe Creek	37.21237	-121.90860	U	6/6/17	10.1	346	13.7	8.2	7	16	30	19	=	0.056	=	1.9	0.04	DNQ	0.002	DNQ	0.88	=	0.011	=	0.015	=	0.9	0.015	1.03	0.89	1.28	0.86	0.96	14	17	16	2.8	0.6	23	1.7	110	1.7	1%	0%	1.3
205R03098	Guadalupe Creek	37.24366	-121.87407	U	6/6/17	10.5	393	17.8	8.3	17	16	371	54	=	0.073	=	3.8	0.09	=	0.002	DNQ	0.53	=	0.011	=	0.025	=	0.6	0.025	0.70	0.74	0.65	0.63	0.98	16	15	11	1.9	1.0	25	1.5	110	1.5	6%	11%	2.7
205R03530	Los Gatos Creek	37.25194	-121.96387	U	6/7/17	9.4	331	18.5	8.2	9	17	209	152	=	0.140	=	6.5	0.03	DNQ	0.006	=	0.18	=	0.012	=	0.027	=	0.2	0.027	0.56	0.74	0.65	0.77	1.13	16	15	11	2.5	1.0	45	1.8	134	1.7	8%	14%	3.2
205R03331	Los Gatos Creek	37.30089	-121.91970	U	6/7/17	9.9	332	21.0	8.4	11	14	41	163	=	0.120	=	10.8	-0.02	ND	0.003	DNQ	0.18	=	0.016	=	0.029	=	0.2	0.029	0.59	0.81	0.67	0.93	1.03	14	15	16	3.3	0.7	15	1.4	124	1.6	14%	23%	4.4
205R03418	Alamitos Creek	37.22855	-121.86176	U	6/8/17	10.2	461	16.5	8.3	19	20	74	219	=	0.110	=	5.2	0.09	=	0.002	DNQ	0.57	=	0.022	=	0.033	=	0.7	0.033	0.70	0.73	0.75	0.67	0.91	11	14	9	3.8	0.8	28	1.0	90	1.8	7%	14%	2.6
205R03699	Hale Creek	37.36503	-122.09869	U	4/30/18	9.0	1959	12.0	8.1	200	32	74	18	=	0.099	DNQ	2.3	2.00	=	0.012	=	1.10	=	0.210	=	0.220	=	3.1	0.220	0.46	0.59	0.96	0.53	1	13	9	9	3.7	0.5	52	1.7	159	1.7	26%	83%	8.8
205R03683	Permanente Creek	37.33985	-122.09227	U	4/30/18	9.2	1143	14.5	8.0	200	16	81	189	=	-0.040	ND	0.5	0.13	=	-0.001	ND

205R03847	Los Trancos Creek	37.38067	-122.19440	U	5/7/18	10.3	718	14.5	8.2	45	24	61	14	=	-0.040	ND	0.6	0.08	=	-0.001	ND	-0.07	ND	0.017	=	0.034	=	0.1	0.034	1.20	0.91	0.81	0.77	1.12	12	12	8	3.9	0.6	21	1.6	182	1.6	6%	20%	2.7
Site Information						**Water Quality**						**Water Chemistry (nutrients)**																			**Biological and Physical Habitat Indicator Scores**					**Physical Habitat**											**Land Use Variables**		
Station Code	**Creek Name**	**Latitude**	**Longitude**	**Land Use**	**Sample Date**	**Dissolved Oxygen (mg/L)**	**Spec Conductance (uS/cm)**	**Temperature (Deg C)**	**pH**	**Chloride (mg/L)**	**Silica (mg/L)**	**Ash Free Dry Mass (g/m2)**	**Chlorophyll a (mg/m2)**	**QA Flag**	**Ammonia (mg/L)**	**QA Flag**	**UIA (ug/L)**	**Nitrate as N (mg/L)**	**QA Flag**	**Nitrite as N (mg/L)**	**QA Flag**	**TKN as N (mg/L)**	**QA Flag**	**Ortho Phosphate as P (mg/L)**	**QA Flag**	**Total Phosphorus as P (mg/L)**	**QA Flag**	**Total Nitrogen (mg/L)**	**Total Phosphorus (mg/L)**	**CSCI**	**ASCI_D**	**ASCI_SB**	**ASCI_H**	**IPI**	**Channel Alteration**	**Epifaunal Substrate**	**Sediment Deposition**	**Human Disturbance Index**	**Evenness Flow Habitat**	**% Substrate <2 mm**	**Shannon Diversity Habitat**	**Sum Riparian Cover**	**Shannon Diversity Substrate**	**% Impervious (wat)**	**% Urban (wat)**	**Road Density (wat)**
205R03754	San Tomas Aquino	37.25953	-121.99220	U	5/8/18	9.3	626	16.5	7.6	59	28	13	7	=	-0.040	ND	0.2	0.32	=	-0.001	ND	0.31	=	0.019	=	0.020	=	0.6	0.020	0.92	0.70	1.00	0.87	1.06	NR	NR	NR	3.3	0.7	18	1.6	150	1.4	11%	51%	5.1
205R03619	Saratoga Creek	37.30297	-121.99652	U	5/8/18	11.1	447	13.8	7.8	65	14	84	14	=	-0.040	ND	0.3	0.31	=	-0.001	ND	0.18	=	0.071	=	0.077	=	0.5	0.077	0.63	0.90	0.96	0.96	0.99	9	9	10	3.5	0.4	23	1.8	126	1.5	16%	32%	4.6
204R00749	Smith Creek	37.31672	-121.65056	NU	5/9/18	10.1	310	13.1	7.8	7	13	11	54	=	0.044	DNQ	0.6	0.06	=	-0.001	ND	0.09	DNQ	0.007	DNQ	0.007	DNQ	0.2	0.007	1.23	0.90	0.69	1.09	1.14	20	18	16	0.1	0.9	7	1.7	113	1.8	1%	0%	0.4
205R00769	MF Coyote Creek	37.21997	-121.54205	NU	5/10/18	9.0	328	12.9	7.6	8	13	9			-0.040	ND	0.2	0.07	=	-0.001	ND	0.13	=	-0.006	ND	-0.007	ND	0.2	0.004	0.74	1.20	0.91	1.10	1.15	20	18	18	0.2	0.8	16	1.6	139	1.8	1%	0%	0.2
205R03562	Saratoga Creek	37.25257	-122.04499	U	5/23/18	11.9	502	12.7	8.0	21	20	61	47	=	-0.040	ND	0.4	0.17	=	-0.001	ND	0.40	=	0.066	=	0.046	=	0.6	0.046	1.08	0.93	0.81	0.97	1.14	7	16	10	5.7	0.7	20	1.6	172	1.8	2%	5%	1.3
205R03498	Saratoga Creek	37.25746	-122.03630	U	5/23/18	11.3	507	13.9	8.3	22	20	106	46	=	-0.040	ND	0.9	0.14	=	-0.001	ND	0.40	=	0.060	=	0.064	=	0.5	0.064	1.14	0.92	0.78	0.89	1.19	15	12	9	3.1	1.0	28	1.9	142	1.8	3%	9%	1.8
205R00746	Saratoga Creek	37.25201	-122.06014	NU	5/24/18	11.4	462	12.2	8.0	16	23	38	89	=	-0.040	ND	0.4	0.21	=	-0.001	ND	0.40	=	0.072	=	0.046	=	0.6	0.046	1.12	0.78	1.07	0.98	1.05	19	15	13	1.6	0.6	19	1.6	119	1.9	2%	2%	1.1
205R04190	Guadalupe Creek	37.23516	-121.89115	U	5/29/18	11.7	750	17.6	7.2	34	16	36	266	=	1.000	=	4.8	0.10	=	0.001	DNQ	0.70	=	0.020	=	-0.007	ND	0.8	0.004	0.88	1.14	1.07	0.90	1.2	17	12	8	2.9	0.9	35	1.9	169	1.6	4%	8%	2.3
205R03843	San Tomas Aquino	37.38185	-121.96842	U	5/29/18	7.2	1020	19.7	7.8	34	18	228	261	=	1.200	=	23.6	0.10	=	0.006	=	0.75	=	0.013	=	0.046	=	0.9	0.046	0.39	0.51	0.26	0.44	0.93	3	7	6	3.3	0.8	27	1.1	100	1.4	37%	71%	9.1
205R03907	Lower Penitencia Cr	37.43624	-121.91423	U	5/30/18	8.3	1342	22.6	8.0	120	20	533	62	=	1.100	=	45.6	0.77	=	0.027	=	0.62	=	0.028	=	0.043	=	1.4	0.043	0.19	0.49	0.50	0.43	0.34	3	2	1	4.6	0.1	98	1.1	86	0.1	69%	96%	12.5
205R03795	Lower Silver Creek	37.35770	-121.85819	U	5/30/18	7.7	1540	19.9	7.5	140	27	305	89	=	0.920	=	8.7	8.00	=	0.017	=	0.13	=	0.032	=	-0.007	ND	8.1	0.004	0.40	0.40	0.34	0.44	0.8	4	7	4	4.5	0.9	77	1.4	118	1.1	25%	49%	7.1
205GUA251	Alamitos Creek	37.23306	-121.87054	U	4/29/19	9.8	509	14.8	8.1	28	21	133	184	=	0.330	=	8.9	0.32	=	0.003	DNQ	0.77	=	0.017	=	0.026	=	1.1	0.026	0.62	0.69	0.81	0.86	1	13	13	12	3.3	0.9	37	1.4	119	1.7	7%	15%	2.7
205R04537	Thompson Creek	37.27378	-121.74535	U	4/30/19	8.4	977	14.0	7.8	65	31	78	9	=	0.330	=	8.1	1.00	=	0.008	=	0.77	=	0.110	=	0.110	=	1.8	0.110	0.51	0.46	1.28	0.90	0.92	16	8	8	2.8	0.9	31	1.4	126	1.4	3%	5%	1.9
205R04418	Thompson Creek	37.29217	-121.76741	U	4/30/19	10.3	750	15.1	8.3	130	25	133	17	=	0.330	=	24.4	0.07	=	0.001	DNQ	0.77	=	0.095	=	0.097	=	0.8	0.097	0.38	0.62	0.86	0.62	0.88	14	10	8	1.1	0.4	31	1.7	125	1.7	11%	20%	3.3
205R04530	Upper Silver Creek	37.29639	-121.79295	U	5/1/19	11.5	1252	12.9	8.3	150	47	133	14	=	0.330	=	14.6	1.40	=	0.004	DNQ	0.61	=	0.150	=	0.150	=	2.0	0.150	0.53	0.72	0.37	0.65	0.99	15	9	7	3.0	0.9	35	1.7	145	1.5	18%	37%	5.9
205R04602	Wildcat Creek	37.26359	-122.01925	U	5/1/19	9.7	604	17.4	7.8	73	30	133	2	=	0.330	=	6.2	0.65	=	0.004	DNQ	0.25	=	0.150	=	0.029	=	0.9	0.029	0.50	0.73	0.96	0.83	0.9	8	10	8	3.1	0.7	35	1.7	130	1.5	16%	59%	5.3
205R04395	Arroyo De Los Coches	37.44464	-121.85645	U	5/2/19	11.0	908	11.9	8.3	71	47	427	20	=	0.330	=	32.5	2.10	=	0.006	=	0.83	=	0.230	=	0.360	=	2.9	0.360	0.67	0.91	1.28	0.72	0.85	17	18	5	1.9	0.6	47	1.6	123	1.7	2%	5%	2.5
205R04638	Guadalupe Creek	37.22823	-121.90335	U	5/6/19	10.8	370	12.2	8.2	10	19	13	184	=	0.410	=	12.3	0.10	=	0.002	DNQ	0.14	=	0.018	=	0.028	=	0.2	0.028	0.97	0.96	0.87	0.95	1.02	16	15	12	2.3	0.9	36	1.7	119	1.6	3%	5%	1.9
205R04591	San Tomas Aquino	37.39086	-121.96797	U	5/7/19	20.5	1064	25.4	8.4	81	21	224	184	=	0.340	=	39.3	0.45	=	0.028	=	0.80	=	0.007	DNQ	0.043	=	1.3	0.043	0.50	0.62	0.24	0.52	0.77	7	2	1	3.3	0.3	50	1.5	105	1.3	38%	71%	9.1
205R04614	San Tomas Aquino	37.27327	-121.98247	U	5/7/19	10.0	607	13.8	8.3	56	21	25	184	=	0.140	=	6.1	0.11	=	0.002	DNQ	0.25	=	0.015	=	0.020	=	0.4	0.020	0.63	0.62	0.81	0.72	0.91	7	7	10	3.6	0.4	13	1.5	138	1.4	21%	69%	6.3
205R04378	Los Gatos Creek	37.21733	-121.98670	U	5/8/19	10.7	753	11.9	8.1	7	21	10	93	=	0.250	=	6.1	0.19	=	0.003	DNQ	0.11	=	0.018	=	0.027	=	0.3	0.027	0.64	0.48	0.96	0.96	1.18	16	16	16	3.2	0.8	25	1.9	203	1.5	3%	7%	2.4
205GUA060	Los Gatos Creek	37.29109	-121.93488	U	5/8/19	8.5	367	20.0	8.2	7	21	57	62	=	0.270	=	14.8	0.07	=	0.003	DNQ	0.11	=	0.018	=	0.034	=	0.2	0.034	0.57	0.77	0.82	0.97	1.12	11	10	12	3.9	0.8	22	1.9	137	1.6	12%	21%	4.1
205R04670	Saratoga Creek	37.25116	-122.05508	U	5/9/19	11.1	415	12.5	8.4	13	21	113	184	=	0.280	=	14.3	0.16	=	0.001	DNQ	-0.07	ND	0.064	=	0.078	=	0.2	0.078	0.99	0.94	0.69	1.13	1.04	20	18	17	1.2	0.6	20	1.4	156	1.7	2%	3%	1.1
205R04271	Stevens Creek	37.30551	-122.15517	NU	6/3/19	10.0	547	12.6	8.3	14	16	200	8	=	0.780	=	29.8	0.03	DNQ	-0.001	ND	-0.07	ND	0.029	=	0.029	=	0.1	0.029	1.08	1.09	1.28	1.10	1.17	20	18	12	0.1	0.9	20	1.9	176	1.5	3%	2%	0.9
205COY455	Coyote Creek	37.16631	-121.64776	U	6/4/19	10.7	314	13.7	7.9	15	12	16	74	=	0.760	=	13.7	0.30	=	0.001	DNQ	0.33	=	0.019	=	0.041	=	0.6	0.041	0.58	0.84	0.95	1.00	1.1	15	15	16	3.4	0.9	22	1.9	100	1.7	1%	0%	0.5
205R04317	Coyote Creek	37.16628	-121.63747	U	6/4/19	9.2	315	11.6	7.7	15	12	48	92	=	0.830	=	7.6	0.33	=	0.001	DNQ	0.22	=	0.017	=	0.042	=	0.6	0.042	0.54	0.95	1.10	1.13	1.06	12	13	15	3.8	0.9	20	1.7	126	1.3	1%	0%	0.5
205R04247	Stevens Creek	37.32635	-122.06019	U	6/5/19	12.0	495	17.2	8.3	19	20	106	154	=	0.920	=	55.7	0.10	=	0.001	DNQ	0.28	=	0.038	=	0.074	=	0.4	0.074	0.65	0.97	0.87	1.01	1.1	11	12	7	3.3	0.8	14	1.8	140	1.4	3%	6%	1.6
205STE070	Stevens Creek	37.30275	-122.07486	U	6/5/19	8.3	471	15.2	7.8	15	20	38	153	=	0.790	=	13.1	0.03	DNQ	-0.001	ND	0.19	=	0.040	=	0.082	=	0.2	0.082	0.44	0.66	1.02	1.11	1.13	18	7	13	0.5	0.8	18	1.8	157	1.5	2%	2%	1.2
205R04383	San Francisquito Cr	37.45383	-122.16170	U	6/6/19	6.3	796	18.1	8.3	56	11	47	110	=	0.058	=	3.7	0.30	=	0.006	=	0.28	=	0.018	=	0.026	=	0.6	0.026	0.47	0.79	0.90	0.86	0.79	2	6	2	3.6	0.0	23	1.4	140	1.4	13%	34%	3.8
205R04359	Adobe Creek	37.42669	-122.10509	U	6/12/19	8.2	989	21.2	8.1	73	25	135	64	=	0.200	=	8.9	2.20	=	0.072	=	0.63	=	0.030	=	0.061	=	2.9	0.061	0.32	0.61	0.53	0.68	0.13	0	1	2	7.2	0.1	95	1.0	25	0.1	25%	56%	6.6
205R04479	Saratoga Creek	37.35436	-121.97327	U	6/12/19	10.8	1093	23.0	7.9	95	19	42	36	=	0.061	=	2.1	1.60	=	0.019	=	0.19	=	0.016	=	0.026	=	1.8	0.026	0.58	0.53	0.53	0.80	0.75	4	4	11	5.0	0.1	25	1.1	111	1.4	25%	47%	6.6

Land Use: U - Urban, NU - Non-urban
QA Flag: ND - Non-detect (used ½ value of the method detection limit), DNQ - Detected Not Quantifiable (used measured value)
NR - Not Recorded
UIA- Un-ionized Ammonia
TKN - Total Kjeldahl Nitrogen
CSCI - California Stream Index
ASCI_D - Algae Stream Condition Index (Diatoms)
ASCI_H - Algae Stream Condition Index (Hybrid)
ASCI_SB - Algae Stream Condition Index (Soft Body)
IPI - Index Physical Habitat Integrity

Santa Clara Valley
Urban Runoff
Pollution Prevention Program

Watershed Monitoring and Assessment Program



Integrated Monitoring Report
Part C: Stressor/Source Identification Projects

Water Year 2014 through Water Year 2019

Submitted in compliance with Provision C.8.h.v of NPDES Permit No. CAS612008,
Order No. R2-2015-049

March 31, 2020

LIST OF ACRONYMS

ACCWP	Alameda Countywide Clean Water Program
BASMAA	Bay Area Stormwater Management Agency Association
BMI	Benthic Macroinvertebrate
CCCWP	Contra Costa Clean Water Program
CEDEN	California Environmental Data Exchange Network
CSCI	California Stream Condition Index
CWA	Clean Water Act
FSURMP	Fairfield Suisun Urban Runoff Management Program
IBI	Index of Biotic Integrity
IMR	Integrated Monitoring Report
MRP	Municipal Regional Permit
MS4	Municipal separate storm sewer system
NPDES	National Pollution Discharge Elimination System
OES	Office of Emergency Services
OFEE	Oil Filled Electrical Equipment
PCBs	Polychlorinated Biphenyls
PG&E	Pacific Gas and Electric Company
QAPP	Quality Assurance Project Plan
QAPrP	Quality Assurance Program Plan
QA/QC	Quality Assurance/Quality Control
RMC	Regional Monitoring Coalition
RMP	Regional Monitoring Program
SCVURPPP	Santa Clara Valley Urban Runoff Pollution Prevention Program
SFRWQCB	San Francisco Bay Regional Water Quality Control Board
SMCWPPP	San Mateo County Water Pollution Prevention Program
SPoT	Stream Pollution Trends
SOP	Standard Operating Protocol
SSID	Stressor/Source Identification
SWAMP	Surface Water Ambient Monitoring Program
TMDL	Total Maximum Daily Load
UCMR	Urban Creeks Monitoring Report
USEPA	Environmental Protection Agency
WY	Water Year

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1.0 INTRODUCTION

This *Integrated Monitoring Report (IMR) Part C: Stressor/Source Identification Projects, Water Year*[1] *(WY) 2014 through WY 2019* was prepared by the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP or Program), on behalf of its 15 member agencies (13 cities/towns, the County of Santa Clara, and the Santa Clara Valley Water District), which are subject to the National Pollutant Discharge Elimination System (NPDES) stormwater permit for Bay Area municipalities referred to as the Municipal Regional Permit (MRP). The MRP was first adopted by the San Francisco Regional Water Quality Control Board (SFRWQCB or Regional Water Board) on October 14, 2009 as Order R2-2009-0074 (SFRWQCB 2009; referred to as MRP 1.0). On November 19, 2015, the Regional Water Board updated and reissued the MRP as Order R2-2015-0049 (SFRWQCB 2015; referred to as MRP 2.0).

This report fulfills the requirements of provision C.8.h.v of MRP 2.0 for comprehensively interpreting and reporting all Stressor/Source Identification (SSID) monitoring data collected since the previous IMR was submitted in 2014. As such, this report includes data collected during WY 2014 through WY 2019. The previous IMR included data collected during WY 2012 and WY 2013 (SCVURPPP 2014).

Monitoring data were collected in accordance with the Bay Area Stormwater Management Agencies Association (BASMAA) Regional Monitoring Coalition (RMC) Quality Assurance Project Plan (QAPP; BASMAA 2016a) and Standard Operating Procedures (SOPs; BASMAA 2016b). Where applicable, monitoring data were derived using methods comparable with those specified by the California Surface Water Ambient Monitoring Program (SWAMP) Quality Assurance Program Plan (QAPrP)[2].

The BASMAA QAPP and SOPs were revised twice, once in 2014 and again in 2016, to conform to MRP 2.0 and changes made to the SWAMP QAPrP. The changes made were minor.

Data presented in this report were submitted electronically to the Regional Water Board by SCVURPPP and may be obtained via the California Environmental Data Exchange Network (CEDEN).

1.1 SSID Requirements

Provision C.8 of the MRP requires that Permittees evaluate Creek Status and Pesticides and Toxicity monitoring data with respect to triggers defined in the MRP. Sites where triggers are exceeded may indicate potential impacts to Aquatic Life or other Beneficial Uses and are therefore considered as candidates for SSID projects. SSID projects are selected from the list of trigger exceedances based on criteria such as magnitude of threshold exceedance, parameter, and likelihood that stormwater management action(s) could address the exceedance. Pollutants of Concern (POC) monitoring results (provision C.8.f) may be considered as appropriate.

Both MRP 1.0 (2009) and MRP 2.0 (2015) allow Permittees to comply with the SSID requirements of Provision C.8 through a regional collaborative effort, their Stormwater Program,

[1] Most hydrologic monitoring occurs for a period defined as a Water Year, which begins on October 1 and ends on September 30 of the named year. For example, Water Year 2019 (WY 2019) began on October 1, 2018 and concluded on September 30, 2019.

[2] The current SWAMP QAPrP is available at: https://www.waterboards.ca.gov/water_issues/programs/swamp/qapp/swamp_QAPrP_2017_Final.pdf

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

Table 0.1. 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
Clean Water Program of Alameda County (ACCWP)	Cities of Alameda, Albany, Berkeley, Dublin, Emeryville, Fremont, Hayward, Livermore, Newark, Oakland, Piedmont, Pleasanton, San Leandro, and Union City; Alameda County; Alameda County Flood Control and Water Conservation District; and, Zone 7
Contra Costa Clean Water Program (CCCWP)	Cities of Antioch, Brentwood, Clayton, Concord, El Cerrito, Hercules, Lafayette, Martinez, Oakley, Orinda, Pinole, Pittsburg, Pleasant Hill, Richmond, San Pablo, San Ramon, Walnut Creek, Danville, and Moraga; Contra Costa County; and, Contra Costa County Flood Control and Water Conservation District
San Mateo County Wide Water Pollution Prevention Program (SMCWPPP)	Cities of Belmont, Brisbane, Burlingame, Daly City, East Palo Alto, Foster City, Half Moon Bay, Menlo Park, Millbrae, Pacifica, Redwood City, San Bruno, San Carlos, San Mateo, South San Francisco, Atherton, Colma, Hillsborough, Portola Valley, and Woodside; San Mateo County Flood Control District; and, San Mateo County
Fairfield-Suisun Urban Runoff Management Program (FSURMP)	Cities of Fairfield and Suisun City
Vallejo Permittees	City of Vallejo and Vallejo Sanitation and Flood Control District

The MRP requires that Permittees initiate a minimum number of SSID projects during the permit term. During MRP 1.0 (WY 2012 – WY 2015), as a regional collaborative, SCVURPPP and its RMC partners were required to collectively initiate a region-wide minimum of 10 SSID projects, with a minimum of two assessing toxicity. During MRP 2.0, SCVURPPP and its RMC partners were required to collectively initiate a region-wide minimum of eight SSID projects, with a minimum of one assessing toxicity. During both permit terms, the RMC partners agreed to a population-based distribution of the required number of SSID projects among the Programs, with most projects conducted by individual Programs addressing local needs and one MRP 2.0 project conducted regionally. Through these agreements, SCVURPPP initiated three Santa Clara Basin-specific projects during MRP 1.0, two during MRP 2.0, and participated in one regional project during MRP 2.0.

Provision C.8.e.ii of MRP 2.0 requires that all SSID project reports initiated during MRP 2.0 are presented in a unified, regional-level report. As such, the BASMAA RMC Regional SSID Report is included as Attachment 1.

SSID projects must identify and isolate potential sources and/or stressors associated with observed water quality impacts. They are intended to be oriented to taking action(s) to alleviate stressors and reduce sources of pollutants. Provision C.8.e.iii of MRP 2.0 describes a stepwise process for conducting SSID projects:

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

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

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

2.0 SSID PROJECTS INITIATED BY SCVURPPP

This section summarizes the results of SSID projects initiated or completed by SCVURPPP during WY 2014 through WY 2019.

During MRP 1.0, the Program initiated three SSID projects. Two of the MRP 1.0 SSID projects were completed in WY 2013 with results included in the previous IMR (SCVURPPP 2014). These projects evaluated fish kills observed in Guadalupe River and reduced dissolved oxygen in Coyote Creek and are not described further in this report. The third MRP 1.0 SSID project addressed poor biological condition in Upper Penitencia Creek. The Upper Penitencia Creek project was initiated in WY 2013 and completed in WY 2016.

During MRP 2.0, the Program initiated two SSID projects addressing toxicity in Coyote Creek and low biological condition in Lower Silver Creek. The Program also participated in a regional project addressing releases and spills of PCBs from electrical utiity equipment (see Section 3.0).

[3] MRP 1.0 did not require that the Executive Officer concur in writing before an SSID project is determined to be completed.

2.1 Upper Penitencia Creek SSID Project

In WY 2013, SCVURPPP initiated the Upper Penitencia Creek SSID Project by developing a work plan to investigate low creek condition scores[4] and temperature trigger exceedances. Over the next two years, field work was unable to be conducted due to drought conditions that resulted in a lack of flow in the study reach during the bioassessment index period. In WY 2016, biological assessments and water and sediment quality monitoring were conducted at two locations in Upper Penitencia Creek following a relatively wet winter. The monitoring design followed the CADDIS framework developed by the USEPA (2010). Monitoring parameters were selected to evaluate a range of potential stressors to biological condition at the two locations. One site (the "test site") is potentially affected by discharges from the Robert Gross Percolation Ponds and the second site (the "comparator site") is located about one mile upstream the test site above the ponds outfall. The percolation ponds are owned and operated by Valley Water. A photograph of the outfall is shown in Figure 2.1.



Figure 2.1. Water release from Robert Gross Percolation Ponds on June 9, 2016. The channel directly upstream of the outfall is nearly dry.

Based on results of the WY 2016 monitoring, the reduced biological integrity observed in Upper Penitencia creek is believed to be associated with episodic streamflow in the segment where the reduced condition was observed. This segment has historically stopped flowing during the spring/summer season due to percolation of surface flow into the underlying groundwater basin. The impacts of this loss of flow are reflected in the aquatic biota that have adapted to abrupt, seasonal changes in flow and water quality conditions. The natural seasonal changes in habitat have further been magnified by anthropogenic activities associated with operation of the off-

[4] Creek condition was assessed using the California Stream Conditrion Index (CSCI) and the Southern California Index of Biological Integrity (SoCal IBI). Both indices translate benthic macroinvertebrate (BMI) data into an overall assessment of stream health.

stream percolation ponds. Therefore, the sources of stressors identified as causing poor biological condition in the study area cannot be mitigated through stormwater management. As a result, the Upper Penitencia Creek SSID Project was considered complete.

Project results were presented in a Final Upper Penitencia Creek SSID Report that was submitted to the Regional Water Board with the WY 2016 Urban Creeks Monitoring Report (UCMR; SCVURPPP 2017).

In effort to assist in future management of natural resources in Upper Penitencia Creek watershed, the Program identified additional follow-up actions, which are included in the report. These actions include:

- Conduct biological assessments at the SSID Project study sites in WY 2017 to evaluate potential variability in biological conditions during years with different hydrological conditions.

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

Both actions were implemented in WY 2017.

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

The management practices assessment evaluated three types of practices in Upper Penitencia Creek that may impact the Project reach, including: 1) water operations; 2) channel maintenance, and 3) sediment controls in upper watershed.

Recommended management/monitoring actions were as follows:

- Evaluate management scenarios to release water from Robert Gross Percolation Ponds that would enhance aquatic life uses in Upper Penitencia Creek. Management scenarios may include changing the timing, duration and magnitude of water releases to potentially benefit downstream migration of juvenile steelhead.
- Consider removal of non-native plant species, such as ivy, and encourage natural recruitment of native riparian vegetation at the case site to improve aquatic conditions as part of actions taken by Valley Water's Safe Clean Water and Natural Flood Protection Program, Priority D[5]. Priority D focuses on Restoring Wildlife Habitat and Providing Open Space in Santa Clara County.
- Consider installation of large woody debris to increase habitat type diversity (e.g., scour pools) to increase the diversity of aquatic biota, leveraging Valley Water's Safe Clean

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

Water and Natural Flood Protection Program, Priority D opportunities when possible. Large woody debris placement should consider habitat benefit versus flood risk.

Monitoring results and management practices assessment are summarized in the Upper Penitencia Creek SSID Project Follow-up Monitoring and Management Assessment Report that was submitted with the Program's WY 2017 UCMR (SCVURPPP 2018a).

2.2 Coyote Creek Toxicity SSID Project

The Coyote Creek Toxicity SSID Project was triggered by the Water Board staff's recommended listing of Coyote Creek for sediment toxicity via the 2016 Integrated Report (303(d) List/305(b) Report for the San Francisco Bay Region. Sediment toxicity data collected by the Water Board in 2007 and 2008 at two sites in Coyote Creek were determined to exceed the 303(d) listing evaluation guidelines. The sediment toxicity tests included survival and growth of *Hyalella azteca*.

In WY 2017, SCVURPP developed the Coyote Creek Toxicity SSID Work Plan. The work plan identified SCVURPPP's approach to determine whether sediment toxicity is present in an urban reach of Coyote Creek and, if so, evaluating the stressors and sources that may be causing the toxicity. The following monitoring objectives were identified:

1. Identify the magnitude and extent of toxicity in a reach of the Coyote Creek mainstem where sediment toxicity was observed in 2008; and
2. Identify potential causes of sediment toxicity (if observed).
3. Evaluate existing data for trends in toxicity

The Coyote Toxicity SSID monitoring design includes an evaluation of sediment chemistry and toxicity testing during the dry season over a two-year period (Water Years 2018 and 2019). In July 2018, sediment samples were collected at 5 sites within an urban reach of Coyote Creek mainstem (between Montague Exp and Story Rd). In WY 2019, sediment sampling was conducted at 3 of the 5 sites evaluated in WY 2018. Acute (survival) toxicity testing was conducted using *Hyallela azteca* and *Chironomus dilutes* test organisms. *Hyallela azteca* is an amphipod crustacean known to be sensitive to pyrethroid pesticides. *Chironomum dilutus* is an invertebrate midge known to be sensitive to neonicotinoid pesticides. Sediment samples were also analyzed for metals and pesticides, including neonicotinoids, fipronil and pyrethroids.

Overall, toxicity to *Hyalella azteca* and *Chironomum dilutus* was very low during the 2018 and 2019 monitoring period. In 2018, only one of five sediment samples had observed toxicity. Site 205COY080 at Oakland Avenue had toxicity levels for *Hylella azteca* that were slightly higher than acceptable threshold (> 20% percent effect compared to control). A subsequent Toxicity Investigation Evaluation on the same sample resulted in no significant toxicity.

One of the three WY 2019 samples exhibited toxicity: site 205COY080 had toxic levels for *Chironomus dilutes* that were just above evaluation threshold (> 20% percent effect compared to control). However, these results were ambiguous due to an identified outlier for one of the test replicates. There was no significant toxicity when the outlier was excluded from the results. Due to low levels of toxicity, a TIE was not conducted on the 2019 sample.

Evaluation of sediment chemistry results at sites where toxicity was observed were inconclusive (i.e., pesticide and metal concentrations were not at levels known to cause toxic effects). The subsequent TIE conducted in 2018 did not result in toxicity and thus, treatments to evaluate potential causes of toxicity (i.e., metals or pyrethroids) were not effective.

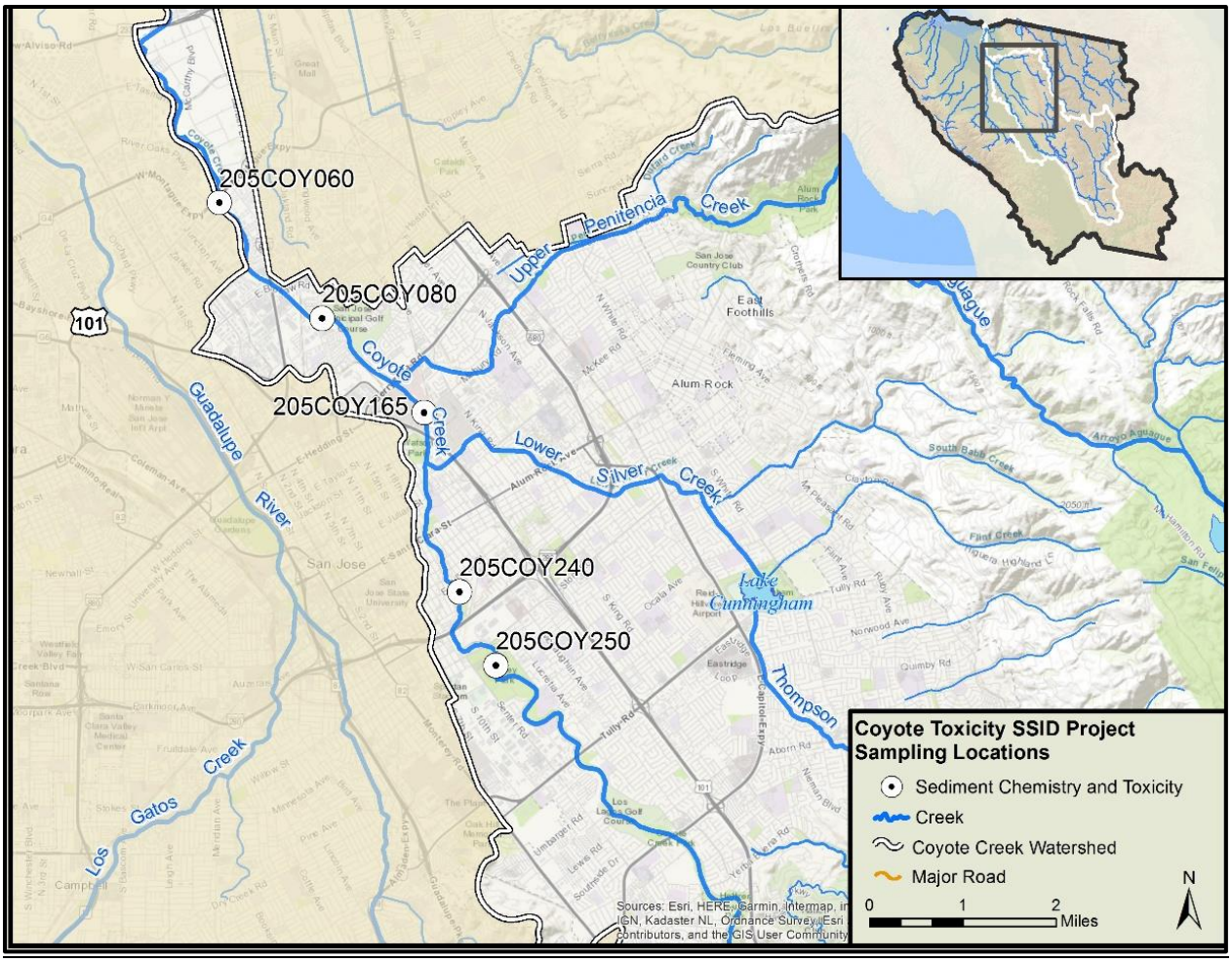


Figure 2.2. Sediment sampling locations for the Coyote Creek Toxicity SSID Project.

Long term toxicity data collected at site 205COY060 (Coyote Creek at Montague Exp) since 2008 by the SWAMP Stream Pollution Trends Monitoring Program (SPoT) were also evaluated as part of the SSID study. Over the past 12 years, there appears to be trend of decreasing *Hyalella azteca* toxicity in Coyote Creek. The decline in acute sediment toxicity at this Coyote site may reflect a decrease in pyrethroid concentrations in sediment over time since there also appears to be a general decrease in pyrethroid concentrations since 2012.

The results of this SSID Study and review of toxicity data collected over the past 14 years suggest that sediment toxicity is generally not present in Coyote Creek. Based on these results and analyses, the Coyote Creek Toxicity SSID Project is considered complete.

In Fiscal Year 2018-19, SCVURPPP conducted an evaluation of pesticide source control actions implemented by SCVURPPP and its Permittees. The results of the evaluation are described in the Pesticide Source Control Actions Effectiveness Evaluation Report (SCVURPPP 2019a) which was included in the Fiscal Year 2018-19 SCVURPPP Annual Report. As described in the Report, SCVURPPP will continue to implement the pesticide toxicity control measures described in provision C.9 of MRP 2.0.

Consistent with MRP procedures, the Program seeks approval of the completion of the Coyote Creek Sediment Toxicity SSID Study from the Water Board Executive Officer.

The Final Coyote Creek Toxicity SSID Project Report is included with this IMR as Attachment 2.

2.3 Lower Silver SSID Project

The Lower Silver SSID project was triggered by creek status/condition data suggesting that Lower Silver/Thompson Creek watershed has reduced biological integrity. Specifically, the California Stream Condition Index Scores (CSCI), based on benthic macroinvertebrate data previously collected at six bioassessment sites on Lower Silver and Thompson Creek, were below the MRP 2.0 trigger threshold for CSCI scores. In addition, water chemistry data collected during Creek Status Monitoring showed that nutrient concentrations in the water column were elevated during the spring season when biological conditions were assessed. Furthermore, algal biomass measurements at selected sites indicated the potential for eutrophication on Lower Silver/Thompson Creek. Excess nutrients may be problematic under certain conditions (e.g., sunlight exposure, high temperatures) that result in algal production. Increased algal biomass can result in poor water quality or changes in food availability, resulting in reduced biological conditions.

In WY 2019, SCVURPPP developed the Lower Silver SSID Work Plan (SCVURPPP 2019). The objective of the project is to focus on potential causes of reduced biological conditions in Lower Silver-Thompson Creek. Specifically, the study is designed to help answer the following questions:

1. What sources are contributing nutrients to the creek?
2. Are high nutrient concentrations contributing to the low biological quality in the creek?
3. Is eutrophication occurring, and if so what conditions are potential contributing factors?
4. What other conditions might contribute to the low biological quality in the creek?

The project was initiated during the WY 2019 dry season to evaluate the extent and magnitude of nutrient concentrations and the importance of nutrients in reducing bio-integrity in Lower Silver/Thompson Creek watershed. Three water sampling events were conducted at several sites between August and October 2019 to evaluate potential sources of nutrients. In addition, continuous water quality monitoring was conducted at locations that appeared to have high algal production to assess potential impacts of eutrophication on water quality.

Preliminary results suggest that nutrient concentrations in the creek are affected by flow velocity and MS4 discharges. Figure 2.3 shows creek sampling locations targeted on August 8, 2019. Follow-up monitoring in September 2019 targeted a subset of these sites and added several non-receiving water stations within the MS4. Figure 2.4 illustrates emergent vegetation and turbidity at Station LST07 on August 8, 2019.

The Lower Silver SSID project will extend to the spring and fall seasons of 2020 in an effort to gather additional information. In spring 2020, bioassessments will be conducted to evaluate biological conditions, physical habitat and water quality data. Creek walks will be conducted in fall 2020 to identify locations in the watershed that appear to have potential for eutrophic conditions. Measurements of nutrients, eutrophication indicators (e.g., chlorophyll a, ash free dry mass), and general water quality (pH, dissolved oxygen, specific conductance, temperature) will be conducted at these sites.

The Lower Silver SSID Work Plan is included with this Part C of the IMR as Attachment 3. Data collected in WY 2019 were submitted to the Regional Water Board pursuant to Provision C.8.h.ii of the MRP and may be obtained via CEDEN. Data were assessed for data quality attributes according to the BASMAA RMC QAPP (BASMAA 2016a). Results of the Quality Assurance/Quality Control (QA/QC) review suggest that the SSID data were of sufficient quality.

No data were rejected; however, some data were flagged in accordance with the QA/QC protocols.

It is anticipated that the final project report will be submitted to the Regional Water Board with the Program's WY 2020 UCMR by March 31, 2021.

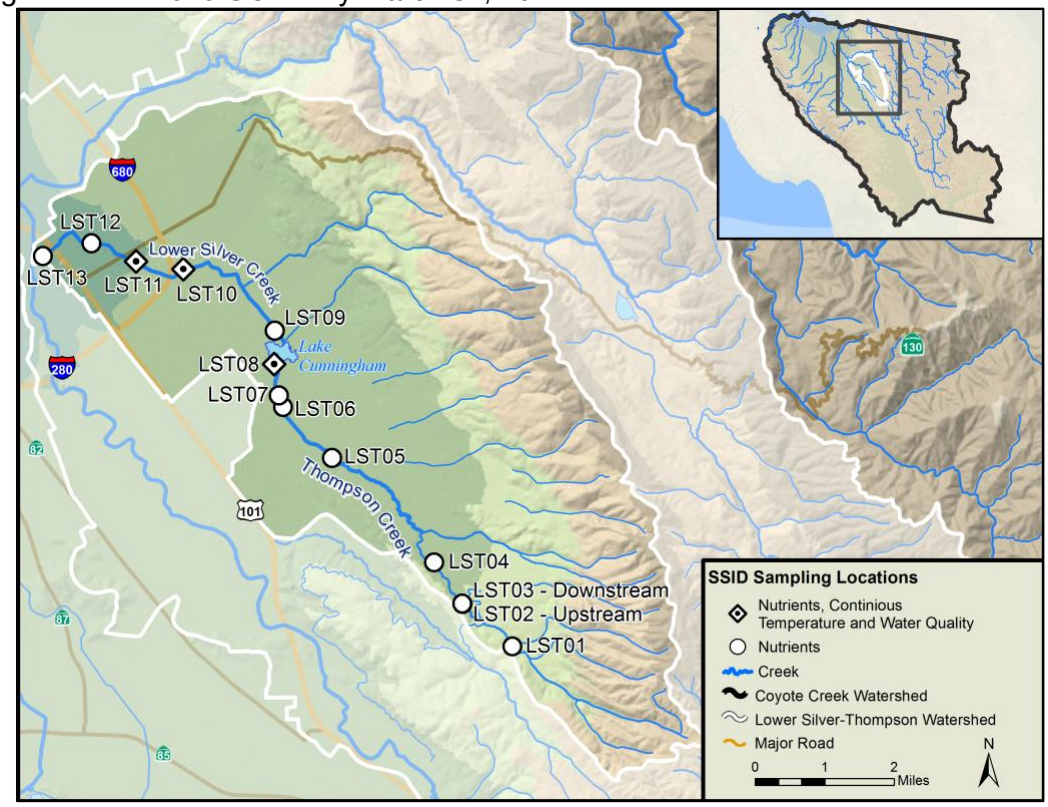


Figure 2.3. Sampling stations along Lower Silver/Thompson Creek, August 8, 2019.



Figure 2.4. Station LST07, August 8, 2019. See Figure 2.3 for location.

3.0 REGIONAL PCBS FROM ELECTRICAL UTILITY EQUIPMENT

In late-2018, BASMAA contracted with EOA, Inc. to develop a work plan for a regional SSID project addressing releases and spills of PCBs from electrical utility equipment. The Regional SSID Project - Electrical Utilities as a Potential PCBs Source to Stormwater in the San Francisco Bay Area – was triggered by fish tissue monitoring in the Bay that led to the Bay being designated as impaired on the Clean Water Act (CWA) Section 303(d) list and the adoption of a TMDL for PCBs in 2008. Subsequent PCBs monitoring by the BASMAA RMC partners and the Regional Monitoring Program for Water Quality in San Francisco Bay (RMP) suggests that diffuse sources of PCBs are present throughout the region. One potential source of PCBs to stormwater is releases and spills from electrical utility equipment.

PCBs were historically used in several types of electrical utility equipment, some of which still contain PCBs. Although much of the PCB-containing equipment has been removed from service, some remains in use, and releases and spills from the equipment may be occurring at levels approaching the TMDL waste load allocation. However, the information currently available is not adequate to fully quantify the scope and magnitude of electrical utility applications as a source of PCBs to stormwater. The information gap is partially due to state and federal regulatory levels for reporting and clean-up of PCBs spills that are higher than the PCB levels needed to comply with the PCBs TMDL requirements. Furthermore, stormwater Programs have neither the authority to compel electrical utilities to provide information about spills, equipment replacement programs, and clean-up protocols, nor the authority to require additional controls. Therefore, BASMAA identified a need to develop and implement a regional SSID work plan to further understand the magnitude and extent of this potential PCBs source, and identify controls (if necessary) that could be put into place to reduce the water quality impacts of this source.

The work plan was submitted with each countywide stormwater program's WY 2018 UCMR. It presents a framework for working with the Regional Water Board, which does have jurisdictional authority over electrical utility companies. The overall goal for the regional SSID project is to investigate electrical utility equipment as a source of PCBs to urban stormwater runoff and identify appropriate actions and control measures to reduce this source. Building on the information presented by SCVURPPP (2018b), this project is designed to achieve the following three objectives:

1. Gather information from Bay Area utilities to improve estimates of current PCBs loadings to municipal separate storm sewer systems (MS4s) from electrical utility equipment, and document current actions conducted by utilities to reduce or prevent release of PCBs from their equipment;
2. Identify opportunities to improve spill response, cleanup protocols, or other programs designed to reduce or prevent releases of PCBs from electrical utility equipment to MS4s;
3. Develop an appropriate mechanism for municipalities to ensure adequate clean-up, reporting and control measure implementation to reduce urban stormwater loadings of PCBs from electrical utility equipment.

The information gained during this project will also provide data that municipalities can use to provide better estimates of PCBs load reductions that can be achieved through implementation of a regional control measure program for electrical utilities.

3.1 Overview of the Regional SSID Work Plan

The work plan identified 4 project tasks: (1) conduct a desk top analysis; (2) propose a source control framework for electrical utility equipment to reduce ongoing PCBs loads to the Bay in stormwater runoff; (3) Develop data inputs to better estimate PCBs load reductions that can be achieved via new source controls; and (4) develop an SSID project report. Each of these tasks are described in more detail below. Progress made to date is provided in Section 3.2.

3.1.1 Task 1: Desktop Analysis

The desktop analysis is designed to gather and evaluate information on electrical utility equipment in the Bay Area to provide the foundation for development of a comprehensive regional control measure program to reduce PCBs loads from this source. The desktop analysis includes the following five sub-tasks:

- **Subtask 1.1 Request information from electrical utility companies.**
  This task will seek the assistance and support of the Regional Water Board to: obtain information from non-municipally owned utility companies that is not publicly available but is needed to better understand the extent and magnitude of PCBs releases from Oil Filled Electrical Equipment (OFEE); identify the most appropriate actions to prevent or reduce releases from this source; and develop and implement effective reporting and control measures. For this task, the Regional Water Board will be asked to assist BASMAA in compelling electrical utility companies (e.g., PG&E) to provide the necessary information. A preliminary list of information that will be requested includes the following:

  - Spill reporting and notification procedures (both region-wide and location-specific);
  - Spill records NOT reported to the California Governor's Office of Emergency Services (Cal OES);
  - SOPs and other documentation used by electrical utilities and their contractors to guide spill response and cleanup actions when releases from OFEE occur;
  - SOPs and documentation, including analytical methods for PCBs used by electrical utilities and their contractors to identify and clean up regular leaks from OFEE during regular maintenance activities;
  - Measurement data on concentrations of PCBs in OFEE;
  - Maintenance records that document when and where PCBs-containing OFEE are removed from the system and how often PCBs containing equipment is inspected for leaks or spills;
  - Documentation of past programs to voluntarily remove PCBs-containing oils or OFEE – including what equipment was removed, and the locations from which it was removed; and
  - Documentation of where PCBs-containing OFEE were located in the past, and where they are currently located across the Bay Area.

  Additional data gaps may also be identified and added to the data request based on discussions with Regional Water Board staff and/or preliminary information provided by utilities.

- **Subtask 1.2 Assess current electrical utility data.**
  This task will review, tabulate and analyze the information provided by electrical utilities as a result of the Regional Water Board's request for information, in order to document the following:

  - Measurement data on PCBs concentrations and/or mass in OFEE;
  - Locations of PCBs-containing OFEE;
  - Quantity of PCBs-containing OFEE removed from service annually;
  - Occurrences of spills or releases from OFEE;
  - Current PCBs spill and cleanup reporting requirements; and
  - Current PCBs cleanup protocols.

- **Subtask 1.3 Improve estimates of PCBs loadings.**
  This task will combine the information provided in Subtask 1.2 with all existing data in order to develop improved estimates of current PCBs loadings from electrical utility equipment to MS4s in the study area. The quality of these estimates will partly depend on the quality of the data received from the utilities.

- **Subtask 1.4 Refine PCBs reporting requirements**
  This task will review all current reporting and notification requirements to identify any improvements or clarifications that the Regional Water Board could require of electrical utilities to provide the type of data needed to better quantify the amount of PCBs released from OFEE spills, and to help ensure that adequate cleanup actions are being implemented.

- **Subtask 1.5 Evaluate PCBs cleanup protocols**
  This task will review all documented cleanup protocols that are currently used by electrical utilities in order to identify any changes or improvements that could be recommended to further reduce the discharge of PCBs to the MS4 when releases occur.

3.1.2 Task 2: Develop Source Control Framework

Based on the results of the desktop analysis, this task will propose an appropriate framework for managing and implementing control measures to reduce PCBs from electrical utility equipment. The framework should include prescribed methods and procedures for unplanned spills and releases from OFEE, as well as a plan for continued reduction of PCBs from in-use OFEE, and potentially further identification and cleanup of historic release sites. The framework will likely include the following elements:

- Summary of the outcomes of the desktop analysis results, including:
  - Summary of information provided by electrical utilities;
  - Improved estimates of current PCBs loadings from electrical utility equipment based on information received;
  - Documentation of current spill clean-up and reporting actions, and existing programs for proactive removal of PCBs-containing oils and equipment conducted by electrical utilities;
  - Recommended PCBs spill and cleanup reporting requirements that the Regional Water Board could require of electrical utilities;
  - Recommended improvements to PCBs spill cleanup protocol(s) that would reduce the discharge of PCBs to MS4s that the Regional Water Board could require of electrical utilities.

- Recommended approach to manage and control releases of PCBs from electrical utilities. The approach may include requirements the Regional Water Board could impose on electrical utilities in the Bay Area, such as new spill reporting and cleanup protocols.

3.1.3 Task 3: Develop methodologies to account for PCBs load reductions from new source control measures

BASMAA will further apply the results of the desktop analysis to develop data inputs to better account for the PCBs load reductions that can be achieved via the new clean-up and reporting protocols identified above in Task 2.

3.1.4 Task 4: Develop SSID Project Report

BASMAA will prepare a report describing the desktop analysis and outcomes. The report will summarize the information provided by electrical utilities and identify recommendations to modify or improve current control measures or management actions that will reduce PCBs released to MS4s. The Management Questions that will be addressed include:

1. What is the current magnitude and extent of PCBs stormwater loadings from electrical utility equipment and operations in the San Francisco Bay Area region?
2. Are there aspects of equipment or operational procedures that electrical utilities should be required to report to the Regional Water Board?
3. Are there additional spill and clean-up controls needed to reduce water quality impacts from the release of PCBs in electrical utility equipment?
4. Are there additional proactive activities needed to avoid releases of PCBs from electrical utility equipment?
5. What are the PCBs load reductions that can be achieved through implementation of a regional reporting and control measure program?

3.2 Current Status of the Regional SSID Project

Implementation of the regional SSID work plan began in WY 2019. The Work Plan focused on Pacific Gas and Electric Company (PG&E), the largest electrical utility operating in the MRP area, and the only utility that is not owned by a municipality. The work plan outlined a 2-step process to (1) conduct a desktop analysis using data from PG&E in order to better understand the extent and magnitude of PCBs releases from oil-filled electrical equipment (OFEE) and document current and past efforts to reduce PCBs in OFEE, and (2) propose a source control framework to potentially reduce ongoing PCBs loads to the Bay from electrical utility equipment. The project team developed a letter requesting assistance from the Regional Water Board and outlining the specific data that is needed from PG&E to complete this project. However, PG&E is currently in bankruptcy proceedings, and the outcomes of that process have not yet been determined.

Because of the current situation with PG&E, BASMAA developed a revised approach to the SSID project in early WY 2020 that focuses on municipally-owned electrical utilities in the MRP area. Although these municipally-owned electrical utilities represent a fraction of the electrical utility equipment and properties in the MRP area, BASMAA member agencies have a better opportunity to work with these utilities and gather the type of information needed to conduct the desktop analysis, albeit at a smaller scale. The revised approach will continue to implement the Regional SSID work plan but will focus exclusively on municipally-owned electrical utilities in the

Bay Area. The revised approach implements the SSID work plan objectives to develop an appropriate source control framework to inform the development of practices to potentially reduce the release of PCBs from electrical utility equipment; and to develop estimates of PCBs load reductions that could be achieved through implementation of revised management practices, such as improved clean-up and reporting procedures.

In November and December 2019, BASMAA held a series of meetings with representatives from municipally-owned electrical utilities and associated municipal staff in the MRP area to discuss the project and information needs. Based on input provided during these meetings, BASMAA developed an information request for municipally-owned electrical utilities that was similar to the request sent to the Regional Water Board for PG&E data.

BASMAA intends to continue this project during WY 2020. The new request for information will be submitted to each of the municipally-owned electrical utilities in the MRP area in the near future. The BASMAA project team will proceed with the desktop analysis upon receipt of data from these utility partners. It is anticipated that the final project report will be submitted to the Regional Water Board with the Program's WY 2020 UCMR by March 31, 2021.

4.0 RECOMMENDATIONS

Overall, Permittees find that SSID monitoring provides valuable information to assist with identifying stressors and sources of water quality impacts. Although the SSID studies have found that the primary stressor sources are unrelated to municipal stormwater runoff and/or are inconclusive, they have resulted in a greater understanding of hydrology, water quality, and land use in the targeted watersheds, and the findings inform other aspects of management to improve the condition of local receiving waters. Continuation of SSID monitoring in the next permit should be considered, with the level-of-effort determined in a manner mindful of the overall costs of implementing Provision C.8 monitoring requirements and other provisions.

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ATTACHMENTS

Attachment 1
BASMAA RMC Regional SSID Report

BASMAA Regional Monitoring Coalition
Regional Stressor/Source Identification (SSID) Report, prepared in compliance with Municipal Regional Stormwater NPDES Permit (MRP; Order No. R2-2015-0049) Provision C.8.e.iii
MRP 2.0 SSID Project Locations, Rationales, Status
Updated March 25, 2020

SSID Project ID	Date Updated	County/ Program	Creek/ Channel Name	Site Code(s) or Other Site ID	Project Title	Primary Indicator(s) Triggering Stressor/Source ID Project									Indicator Result Summary	Rationale for Proposing/Selecting Project	Current Status of SSID Project or Date Completed	EO Concurrence of project completion (per C.8.e.iii.(b))
						Bioassess	General WQ	Chlorine	Temp	Water Tox	Sed Tox	Sed Chem	Pathogen Indicators	Other				
AL-1	3/23/20	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	1/22/20	ACCWP	Arroyo Las Positas		Arroyo Las Positas Stressor Source Identification Project	X									CSCI scores below the threshold were recorded on Arroyo Las Positas in WYs 2016 and 2017. In 2017, one site exceeded the Basin Plan threshold for chloride. The creek is also listed on the 303(d) list for eutrophication and has an approved TMDL for Diazinon.	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 is included in ACCWP's March 2020 IMR.	
CC-1	1/27/20	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 will recommend project completion. Flow augmentation appears to be a viable means of avoiding lethally low DO in portions of the creek downstream of the WWTP.	

BASMAA Regional Monitoring Coalition
Regional Stressor/Source Identification (SSID) Report, prepared in compliance with Municipal Regional Stormwater NPDES Permit (MRP; Order No. R2-2015-0049) Provision C.8.e.iii
MRP 2.0 SSID Project Locations, Rationales, Status
Updated March 25, 2020

SSID Project ID	Date Updated	County/ Program	Creek/ Channel Name	Site Code(s) or Other Site ID	Project Title	Primary Indicator(s) Triggering Stressor/Source ID Project									Indicator Result Summary	Rationale for Proposing/Selecting Project	Current Status of SSID Project or Date Completed	EO Concurrence of project completion (per C.8.e.iii.(b))
						Bioassess	General WQ	Chlorine	Temp	Water Tox	Sed Tox	Sed Chem	Pathogen Indicators	Other				
SC-1	3/24/20	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, with the exception of one sample that had 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 will be submitted with the WY 2019 IMR.	
SC-2	1/29/20	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. It is anticipated to be a two-year project with the project report to be submitted with the WY 2020 UCMR.	
SM-1	3/24/20	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	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 October 28, 2019. RWQCB staff requested minor report changes prior to Executive Officer concurrence regarding project completion. A TMDL addressing bacteria in Pillar Point	

SSID Project ID	Date Updated	County/ Program	Creek/ Channel Name	Site Code(s) or Other Site ID	Project Title	Primary Indicator(s) Triggering Stressor/Source ID Project									Indicator Result Summary	Rationale for Proposing/Selecting Project	Current Status of SSID Project or Date Completed	EO Concurrence of project completion (per C.8.e.iii.(b))
						Bioassess	General WQ	Chlorine	Temp	Water Tox	Sed Tox	Sed Chem	Pathogen Indicators	Other				
																were conducted in WY 2019 to understand hydrology and specific source areas.	Harbor is currently under development.	
FSV-1	1/16/20	City of Vallejo in assoc. 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.	Additional monitoring in the spring and summer of 2019 revealed consistently high levels of E coli and enterococci when cattle are present. A Work Plan is in development and will be submitted with the IMR in March 2020.	
RMC-1	3/24/20	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 is now reaching out to municipally-owned utilities. The SSID project is anticipated to be completed in June 2020.	

Attachment 2
Final Coyote Creek Toxicity SSID Project Report

Santa Clara Valley
Urban Runoff
Pollution Prevention Program

Watershed Monitoring and Assessment Program



Coyote Creek Toxicity Stressor Source Identification Project

Final Report - Water Years 2018 - 2019

March 31, 2020

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EXECUTIVE SUMMARY

The Coyote Creek Toxicity SSID Project was triggered by the Water Board staff's recommended listing of Coyote Creek for sediment toxicity via the 2016 Integrated Report (303(d) List/305(b) Report for the San Francisco Bay Region. Sediment toxicity data collected by the Water Board in 2007 and 2008 at two sites in Coyote Creek were determined to exceed the 303(d) listing evaluation guidelines. The sediment toxicity tests included survival and growth of *Hyalella azteca*.

In WY 2017, SCVURPP developed the Coyote Creek Toxicity SSID Work Plan. The work plan identified SCVURPPP's approach to determine whether sediment toxicity is present in an urban reach of Coyote Creek and, if so, evaluating the stressors and sources that may be causing the toxicity. The following monitoring objectives were identified:

1. Identify the magnitude and extent of toxicity in a reach of the Coyote Creek mainstem where sediment toxicity was observed in 2008; and
2. Identify potential causes of sediment toxicity (if observed).
3. Evaluate existing data for trends in toxicity

The Coyote Toxicity SSID monitoring design includes an evaluation of sediment chemistry and toxicity testing during the dry season over a two-year period (Water Years 2018 and 2019). In July 2018, sediment samples were collected at 5 sites within an urban reach of Coyote Creek mainstem (between Montague Exp and Story Rd). In WY 2019, sediment sampling was conducted at 3 of the 5 sites evaluated in WY 2018. Acute (survival) toxicity testing was conducted using *Hyallela azteca* and *Chironomus dilutes* test organisms. *Hyallela azteca* is an amphipod crustacean known to be sensitive to pyrethroid pesticides. *Chironomum dilutus* is an invertebrate midge known to be sensitive to neonicotinoid pesticides. Sediment samples were also analyzed for metals and pesticides, including neonicotinoids, fipronil and pyrethroids.

Overall, toxicity to *Hyalella azteca* and *Chironomum dilutus* was very low during the 2018 and 2019 monitoring period. In 2018, only one of five sediment samples had observed toxicity. Site 205COY080 at Oakland Avenue had toxicity levels for *Hylella azteca* that were slightly higher than acceptable threshold (> 20% percent effect compared to control). A subsequent Toxicity Investigation Evaluation on the same sample resulted in no significant toxicity.

One of the three WY 2019 samples exhibited toxicity: site 205COY080 had toxic levels for *Chironomum dilutes* that were just above evaluation threshold (> 20% percent effect compared to control). However, these results were ambiguous due to an identified outlier for one of the test replicants. There was no significant toxicity when the outlier was excluded from the results. Due to low levels of toxicity, a TIE was not conducted on the 2019 sample.

Evaluation of sediment chemistry results at sites where toxicity was observed were inconclusive (i.e., pesticide and metal concentrations were not at levels known to cause toxic effects). The subsequent TIE conducted in 2018 did not result in toxicity and thus, treatments to evaluate potential causes of toxicity (i.e., metals or pyrethroids) were not effective.

Long term toxicity data collected at site 205COY060 (Coyote Creek at Montague Exp) since 2008 by the SWAMP Stream Pollution Trends Monitoring Program (SPoT) were also evaluated as part of the SSID study. Over the past 12 years, there appears to be trend of decreasing *Hyalella azteca* toxicity in Coyote Creek. The decline in acute sediment toxicity at this Coyote

site may reflect a decrease in pyrethroid concentrations in sediment over time since there also appears to be a general decrease in pyrethroid concentrations since 2012.

The results of this SSID Study and review of toxicity data collected over the past 14 years suggest that sediment toxicity is generally not present in Coyote Creek. Based on these results and analyses, the Coyote Creek Toxicity SSID Project is considered complete.

In Fiscal Year 2018-19, SCVURPPP conducted an evaluation of pesticide source control actions implemented by SCVURPPP and its Permittees. The results of the evaluation are described in the Pesticide Source Control Actions Effectiveness Evaluation Report (SCVURPPP 2019a) which was included in the Fiscal Year 2018-19 SCVURPPP Annual Report. As described in the Report, SCVURPPP will continue to implement the pesticide toxicity control measures described in provision C.9 of MRP 2.0.

Consistent with MRP procedures, the Program seeks approval of the completion of the Coyote Creek Sediment Toxicity SSID Study from the Water Board Executive Officer.

1.0 INTRODUCTION

This report presents the results of the Coyote Creek Sediment Toxicity Stressor/Source Identification Project (Coyote Creek Toxicity SSID) which was initiated in 2018 to address requirements listed under Provision C.8.e of the San Francisco Bay Region National Pollutant Discharge Elimination System (NPDES) stormwater Municipal Regional Permit (MRP) (Order R2-2015-0049). The Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP or Program) is working with Bay Area Stormwater Management Agencies Association (BASMAA) Regional Monitoring Coalition (RMC) members to collectively initiate eight Stressor/Source Identification (SSID) projects during the five-year term of the MRP (i.e., 2016 – 2020). This project satisfies the requirement that a minimum of one SSID project must address toxicity.

The Coyote Creek Toxicity SSID project is one of two SSID projects that SCVURPPP is conducting during the MRP term. Per MRP Provision C.8.e.ii, SSID projects are designed to identify and address potential sources and/or stressors associated with observed or potential impacts to aquatic life or other Beneficial Uses. SSID projects are intended to be oriented toward taking action(s) to alleviate stressors and reduce sources of pollutants.

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

This introduction (Section 1.0) provides a summary of the Coyote Creek Toxicity SSID Project Work Plan (Work Plan) (SCVURPPP 2018). Section 2.0 of this report describes methods used in the investigation. Section 3.0 presents results of the SSID project field investigations. Section 4.0 discusses the results. Section 5.0 summarizes the results and recommends management actions. References are listed in Section 6.0.

1.1 Work Plan Summary

In 2018, the Program developed the Coyote Creek Sediment Toxicity SSID Project Work Plan, which was submitted to the Water Board as an attachment to the Water Year (WY) 2017 Urban Creeks Monitoring Report on March 31, 2018. The Work Plan provides information describing the steps and process used to define the SSID Project, per Provision C.8.e.iii of the MRP. These steps include defining the problem, identifying probable causes, describing study objectives, and establishing the study design and schedule. A summary of the steps are provided below.

<u>Problem Definition</u>

This Coyote Creek Toxicity SSID Project was triggered by the recommended listing of Coyote Creek for toxicity in sediment in the 2016 Integrated Report (303(d) List/305(b) Report) for the San Francisco Bay Region. Sediment toxicity data collected by the Water Board in 2007 and 2008 at two sites in Coyote Creek were determined to exceed the 303(d) listing evaluation

guidelines. The sediment toxicity tests included survival and growth of *Hyalella azteca*. Toxicity was defined as a statistically significant effect in the sample exposure compared to the control using EPA-recommended hypothesis testing.

In 2007 and 2008, the SCVURPPP also conducted sediment chemistry and toxicity sampling in Coyote Creek as part of the Sediment Quality Triad Pilot Study (SCVURPPP 2008). Sediment data at two of the sampling locations exhibited significant acute toxicity for *Hyalella azteca* (less than 80% survival compared to control) for at least three of the four sampling events conducted over the two-year study period. Sediment samples were also analyzed for total recoverable metals and a suite of pyrethroid pesticides. The co-occurrence of pyrethroid concentrations above LC50s[1] and sediment toxicity in samples collected during the spring 2008 sampling event suggests that pyrethroids may have caused (or contributed to) the toxicity at those sites.

Candidate Causes

The toxicity data used for the 303(d) listing was collected over ten years ago. At that time, pyrethroid pesticides were identified as the predominant group of chemicals deployed for insect control in urban areas in California, and likely one of the primary cause of toxicity in urban water bodies in the state. Ruby (2013) compiled and summarized pyrethroid and fipronil pesticide data from monitoring conducted in urban areas of California , as well as related toxicity testing results, covering the ten year period from 2003-2012. Ruby (2013) concluded that pyrethroids were linked to toxicity to the amphipod *Hyalella azteca* in water and sediment samples from urban creeks in all of California's major urban areas. Bifenthrin was the most frequently detected pyrethroid (64% of water samples, 69% of sediment samples) and the greatest contributor to toxic potency in both water and sediment samples collected from urban creeks (Ruby 2013). Average concentrations for seven pyrethroids that were summarized in the study were substantially greater than the published LC50 values.

Ruby (2013) also showed that fipronil, a common pyrethroid replacement pesticide, was frequently detected in water and sediment samples. The maximum reported concentrations of fipronil and its degradates in sediment samples were generally well above published toxicity (LC50) values.

Study Objectives

The Coyote Toxicity SSID Project focuses on evaluating whether sediment toxicity is present in an urban reach of Coyote Creek and, if so, evaluating the stressors and sources that may be causing the toxicity. The study is designed to:

1. Identify the magnitude and extent of toxicity in a reach of the Coyote Creek mainstem where sediment toxicity was observed in 2008; and
2. Identify potential causes of sediment toxicity (if observed).
3. Evaluate existing data for trends in toxicity

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

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

Study Design and Schedule

The Program used an adaptive monitoring approach to investigate potential sources and causes of sediment toxicity in Coyote Creek. The approach is consistent with Section C.8.e.iii.(1)(f) of the MRP, which states:

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

The Coyote Toxicity SSID monitoring design includes an evaluation of sediment chemistry and toxicity testing during the dry season over a two-year period (Water Years 2018 and 2019). Toxicity testing was conducted using *Hyallela azteca* and *Chironomus dilutes* for acute toxicity (survival). Sediment chemistry was analyzed for metals and pesticides, including fipronil and pyrethroids. The Program evaluated sediment chemistry results for adverse effects using the analytical methods described in Section 2.4 below. The monitoring design included the following steps:

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

- If toxicity tests exhibit **significant toxicity**, **BUT the sediment chemistry results are inconclusive**, the Program will implement a **Toxicity Identification Evaluation** (TIE) consistent with guidance provided in the EPA sediment TIE manual (EPA/600/R-08/080). The TIE will consist of a series of treatments designed to identify the type of chemicals that may be causing toxicity. The Program will implement a TIE that includes three targeted tests: 1) Baseline sample (i.e., re-test of sample); 2) Activated Carbon (i.e., general organic contaminants); and 3) Cationic Resin (metals). The TIE will confirm toxicity is present (or not), and the type of contaminant (i.e., metal and/or organic) that may be causing the toxicity. TIEs are more effective when there is sufficient toxicity in the sample.

All toxicity testing, sediment chemistry results and TIE results from monitoring conducted during WY 2018 were used to inform follow-up monitoring during WY 2019. The monitoring approach described above was also followed during WY 2019.

1.2 Trend Monitoring in Coyote Creek

The Stream Pollution Trends Program (SPoT) is a core component of the California Surface Water Ambient Monitoring Program (SWAMP) that conducts statewide monitoring to provide information on the health of California waterways with respect to sediment toxicity and contamination (Phillips et al. 2016). SPoT data are used by the State and Regional Water Boards to assess the levels to which aquatic life beneficial uses are supported in California streams and rivers.

The SPoT Program has annually conducted monitoring of sediment chemistry and toxicity testing at site 205COY060 (Coyote Creek at Montague Expressway; Figure 2) since 2008. The toxicity of sediments is evaluated by exposing the amphipod, *Hyalella azteca,* to the collected sediments in a standard ten-day survival test (EPA method 600-R-99/064). Both chronic (growth) and acute (survival) toxicity tests are conducted.

Between 2008 and 2010, the SPoT Program collected one sediment sample during the dry season for toxicity testing and chemical analyses. Between 2011 and 2013, SPoT increased sampling frequency to two or three events each year, typically during the month of July and again during September/October. Between 2011 and 2016, SPoT conducted sediment toxicity tests using two different temperature treatments. Toxicity tests were conducted at the standard temperature defined in the EPA protocol (23°C) and at a lower temperature (15°C), which may be more representative of creek conditions and often results in higher toxicity to *Hyalella azteca*. In 2015, SPoT initiated use of a new test organism (i.e., *Chironomus dilutus*) to assess potential toxic effects associated with fipronil.

A summary of acute and chronic toxicity test results conducted for sediment samples collected by the SPoT Program at site 205COY060 during the dry season between 2008 and 2018 is shown in Table 1. These data do not include additional samples taken by SPoT to investigate impacts on Toxicity related to variable seasons and temperature used for laboratory testing.

- Acute toxicity. Since 2010, none of the nine sediment samples met the two criteria of being significantly toxic AND having a percent effect greater than 20% reduction in *Hyalella azteca* survival compared to the Lab Control.
- Chronic toxicity. Over the same sampling period, 2010 - 2018, two of the nine sediment samples collected (22%) were significantly toxic AND the percent effect was greater than 20% reduction in *Hyalella azteca* growth compared to the lab control.

Between 2015 and 2018, no chronic or acute toxicity was observed for *Chironomus dilutes*.

There appears to be trend of increasing amphipod (*Hyalella azteca*) survival in toxicity tests at site 205COY060. The decline in acute toxicity at the Coyote site may reflect a decrease in pyrethroid concentrations in sediment over time. Excluding one sample with a very high concentration in 2012[2], there appears to be a general decrease in pyrethroid concentrations between 2011 and 2017 (Figure 1).

[2] Pyrethroid concentration in sediment sample collected on 7/5/2012 had a concentration of cyfluthrin of 539 ng/g dw.

Table 1. Sediment toxicity testing results for *Hyalella azteca* conducted between 2008 and 2018 by the SPoT Program at Coyote Creek site 205COY060.

Year	Date	Significant Toxicity and > 20% Effect Threshold (*Hyalella azteca*)	
		Chronic (Growth)	Acute (Survival)
2008	6/17/2008	X	
2009	6/16/2009	X	X
2010	6/30/2010		
2011	7/21/11		
2012	7/5/2012		
2013	7/2/2013		
2014	6/25/2014		
2015	7/1/2015	X	
2016	7/19/2016	X	
2017	6/27/2017		
2018	6/27/2018		

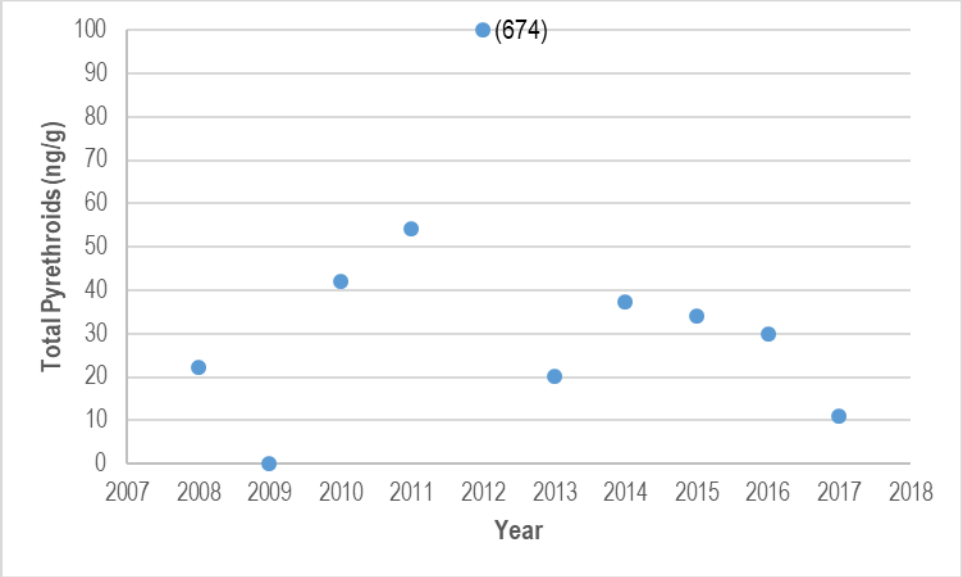


Figure 1. Total pyrethroid concentrations in sediment samples collected by the SPoT Program at Coyote Creek site 205COY060 between 2007 and 2017.

2.0 METHODS

2.1 Site Selection

The Work Plan identified five sediment sampling locations within the reach of the Coyote Creek mainstem that extends from Montague Expressway upstream to Kelley Park (south of Story Road). Three of these stations previously exhibited toxicity in 2007-2008, including two stations (205COY060 and 205COY240) used to determine the recommended 303(d) listing, and one station (205COY080) sampled by the Program as part of the Sediment Quality Triad Pilot Study in 2008. Two new stations within the study reach were added for the SSID Project. Sediment samples were collected at all five stations on July 17, 2018 and three of the five stations on July 22, 2019. Sampling location information is provided in Table 2 and illustrated in Figure 2.

Table 2. Sampling locations in WY 2018 and WY 2019 for sediment chemistry and toxicity testing in Coyote Creek mainstem as part of the Coyote Toxicity SSID Project.

Station ID	Sampling Location	Latitude	Longitude	Previous Sample Location Significant Toxicity	Sample Date	
					7/17/2018	7/22/2019
205COY060	Montague Exp	37.39540	121.91485	x	x	
205COY080	Oakland Ave	37.37778	121.89455	x	x	x
205COY165	Maybury	37.36341	121.87445		x	x
205COY240	Williams Park	37.33575	121.86707	x	x	
205COY250	Kelley Park	37.32444	-121.85983		x	x

2.2 Field Sampling

Sediment chemistry data were collected in accordance with SWAMP comparable methods and procedures described in the BASMAA Quality Assurance Project Plan (QAPP; BASMAA 2016a) and RMC Standard Operating Procedures (SOPs; BASMAA 2016b).

In accordance with the RMC SOP FS-6 (Collection of Bedded Sediment Samples for Chemical Analysis and Toxicity; BASMAA 2016b), field staff first survey the sampling location to identify appropriate fine-sediment depositional areas. Sediment samples are then collected from the top 2 cm at each sub-site beginning at the downstream-most location and continuing upstream. Field staff walk in an upstream direction, carefully avoiding to disturb the sediment at collection sub-sites. Sediment samples are placed in a compositing container, thoroughly homogenized, and then aliquoted into separate jars for chemical or toxicological analysis using standard clean sampling techniques.

Samples are submitted to respective laboratories under RMC SOP FS-9 Chain of Custody procedures and field data sheets are reviewed per SOP FS-13 Quality Assurance/Quality Control (QA/QC) Data Review procedures (BASMAA 2016b).

2.3 Laboratory Analyses

Sediment samples collected for the SSID Project were sent to Pacific EcoRisk for toxicity testing and to CalTest Laboratories for pesticide and metal analyses. Acute toxicity testing in sediment was conducted using two species: *Hyella azteca* (survival) and *Chironomus dilutus* (survival). Sediment chemistry analytes include pyrethroids, fipronil, metals, Total Organic Carbon (TOC), and sediment grain size. Analytic methods and reporting limits are shown in Table 3.

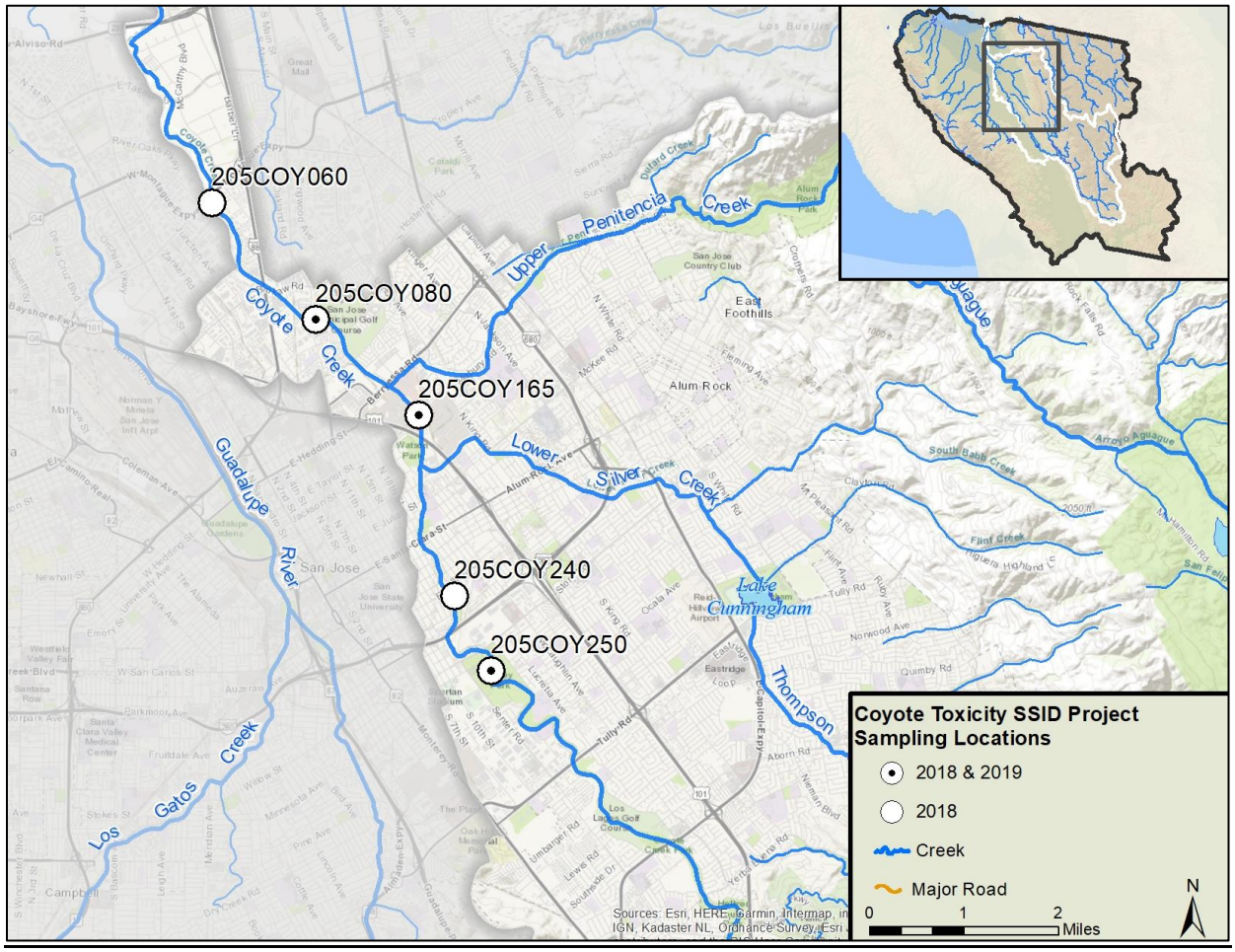


Figure 2. Sediment sampling locations for the Coyote Creek Toxicity SSID Project.

2.4 Data Evaluation

2.4.1 Sediment Toxicity

Data evaluation involves first determining whether the samples are toxic to the test organisms relative to the laboratory control treatment via statistical comparison using the Test of Significant Toxicity (TST) statistical approach. Samples are considered toxic when the TST analyses fail and the Percent Effect is greater than 20% (i.e., mortality) compared to the control sample. Both the TST result and the Percent Effect are determined by the laboratory.

2.3.2 Sediment Chemistry

The sediment sample results for metals are compared to Probable Effects Concentrations (PECs) and Threshold Effects Concentrations (TECs) as defined by MacDonald et al. (2000). PEC and TEC quotients are calculated as the ratio of the measured concentration to the respective PEC and TEC values from MacDonald et al. (2000). The TECs for bedded sediments are very conservative values that do not consider site specific background conditions, and are therefore should not be the only factor in identifying water quality concerns in receiving waters in the Santa Clara Valley. For example, all sites in Santa Clara County are likely to have at least one TEC quotient equal to or greater than 1.0 due to high levels of natural-occurring chromium and nickel in geologic formations (i.e., serpentinite) and soils.

Table 3. Analytical constituents, methods and reporting limits used for sediment samples collected for the Coyote Toxicity SSID Project.

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

** Analysis done by subcontracting lab*

Toxicity unit (TU) equivalents for individual pyrethroid and fipronil results were calculated using available literature values for pyrethroids and fipronil in sediment LC50 values. Because organic carbon mitigates the toxicity of pyrethroid pesticides in sediments, the LC50 values were derived on the basis of TOC-normalized concentrations. Therefore, the pesticide concentrations as reported by the lab were divided by the measured TOC concentration at each

site, and the TOC-normalized concentrations were then used to compute TU equivalents for each constituent. Concentrations equal to one-half of the respective laboratory method detection limits were substituted for non-detect data so that these statistics could be computed, potentially resulting in artificially elevated results.

2.5 Statement of Data Quality

Data QA/QC for the Coyote Creek Sediment Toxicity SSID Project was performed in accordance with procedures established in the BASMAA RMC QAPP (BASMAA 2016a) and BASMAA RMC SOPs (BASMAA 2016b), including SOP FS-13 (Standard Operating Proecdures for QA/QC Data Review). The BASMAA RMC SOPs and QAPP are based on the SOP and QAPP developed by SWAMP. Data collected during the SSID Project were compared to qualitative and quantitative Data Quality Objectives (DQOs) and Measurement Quality Objectives (MQOs) defined in the BASMAA RMC QAPP that determine whether collected data are of adequate quality for their intended use. Overall, it was found that data collected for the SSID Project met established QA/QC objectives. While some data were flagged based on MQO exceedances, none of the data were rejected.

3.0 RESULTS

3.1 Toxicity Testing

In 2018, one of the five sediment samples collected from Coyote Creek had significant toxicity to either of the test organisms. Site 205COY080 at Oakland Avenue failed the TST test for *Hyalella Azteca* and had a percent effect slightly greater than 20% compared to the lab control (Table 4). Evaluation of sediment chemistry results from site 205COY080 were inconclusive (i.e., pyrethroid and metal concentrations were not at levels that are known to cause toxic effects). Following the study design, the Program subsequently conducted a Toxicity Investigation Evaluation (TIE) using stored sediment from the original sample. No significant toxicity was observed for the re-test. As a result, a determination for the cause of toxicity in the initial test could not be made and the Program decided to re-sample in 2019.

In 2019, none of the three sediment samples had significant toxicity to *Hyalella azteca* (Table 4). However, the toxicity test for sediment collected at site 205COY080 was somewhat ambiguous due to a mathematical outlier (one of the eight replicant tests) that resulted in a failed TST test and a percent effect greater than 20% for *Chironomus dilutes*. There was no apparent cause for low survival in the replicate (e.g., low dissolved oxygen or foreign species present). Consistent with guidance in the EPA's freshwater sediment manual, if no explanation for the outlier can be determined, then both results (inclusion and exclusion of outlier) should be reported. The results including the outlier was a failed TST test with percent effect of 23.4%. The results excluding the outlier was a passed TST test with percent effect of 14.3%. A follow-up TIE could not be conducted because the percent effect of the results, including the outlier, was too low (23.4%) to confidently perform a TIE.

Table 4. Summary of SCVURPPP dry weather toxicity results for WYs 2018 and 2019.

Site	% Survival		% Effect	TST Value	TIE conducted (TST "Fail" and ≥ 20% Effect)
	Lab Control	Organism Test			
2018					
Hyalella azteca					
205COY060	93.8	91.3	2.7	Pass	No
205COY080	93.8	67.5	**28**	**Fail**	**Yes**
205COY165	93.8	96.2	-2.7	Pass	No
205COY240	93.8	90	4	Pass	No
205COY250	93.8	85	9.3	Pass	No
Chironomus dilutus					
205COY060	73.7	82.5	-11.9	Pass	No
205COY080	73.7	80	-8.5	Pass	No
205COY165	73.7	91.3	-23.7	Pass	No
205COY240	73.7	90	-22.0	Pass	No
205COY250	73.7	76.3	-3.4	Pass	No
2019					
Hyalella azteca					
205COY080	96.2	93.8	2.6	Pass	No
205COY165	96.2	90	6.5	Pass	No
205COY250	96.2	96.3	0	Pass	No
Chironomus dilutus					
205COY080	80	61.2	14.3/23.4	Pass/Fail[1]	No
205COY165	80	67.5	15.6	Pass	No
205COY250	80	72.5	9.4	Pass	No

[1] One of the 8 replicants was identified as an outlier. The TST analysis resulted in "pass" when outlier was excluded.

3.2 Sediment Chemistry

Table 5 lists concentrations and TEC quotients for metal constituents in sediment samples collected at Coyote sites in 2018 and 2019. Table 6 lists concentrations and PEC quotients for metal constituents in sediment samples collected at Coyote sites in 2018 and 2019.

The PEC quotient was greater than 1.0 for nickel at all the sampling locations for both years. The TEC quotient was also greater than 1.0 for nickel at all sites and for chromium in 5 of 8 samples. Both metals are typically present in watersheds that have hillsides underlain by serpentinite formations. TEC quotients greater than 1.0 were also calculated for zinc and copper at three sites. Sites 205COY240 and 205COY250 had the highest number of metals that exceeded the TEC quotient of 1.0, five and four respectively.

Tables 7 and 8 list the concentrations of pesticides measured in sediment samples collected in 2018 and 2019, respectively, and calculated TOC-normalized TU equivalents for the pesticides for which there are published LC50 values (Amweg et al. 2005, Maul et al. 2008, and Maund et al. 2002). Most of the pesticides measured were below method detection limits (MDLs) and are listed as "<MDL" in the tables. Others are J-flagged, meaning that the measured concentration was above the MDL but below the reporting limit.

No TU equivalents for individual pyrethroids exceeded 1.0. Bifenthrin and cypermethrin had the highest TU equivalent values of 0.53 and 0.6, respectively, for all sampling events. Bifenthrin was generally the highest TU equivalent across sites, with median value of 0.33 (range 0.3 to 0.63). Bifenthrin is considered to be the leading cause of pyrethroid-related toxicity in urban areas (Ruby 2013) and is the most-commonly detected insecticide monitored by the Department Pesticide Regulation Surface of Watershed Protection Program (Ensminger 2017).

The sum of pyrethroid TU equivalents are shown in Tables 7 and 8. Values over 1.0 are shown in bold. The highest sum TU equivalent value (1.6) occurred at site 205COY080 during the 2019 sampling event. Sum TU equivalent values were above 1.0 at sites 205COY165 and 205COY250 during the 2018 sampling event. Toxicity was not significant at any of the locations where sum TU equivalent values were over 1.0.

Concentrations of fipronil and its degradates were below MDLs for all sampling events, with the exception of site 205COY240 in 2018, which had detectable concentrations, but TU equivalents below 1.0.

Grain size analyses for all sediment samples collected in WY 2018 and WY 2019 are provided in Tables 9 and 10, respectively. Percent fines (clay and silt) ranged from 18% to 50% for all five sites sampled in 2018 and 26% to 41% for the three sites sampled in 2019.

Table 5. Threshold Effect Concentration (TEC) quotients for WY 2018 sediment chemistry constituents. Bolded and shaded values indicate TEC quotient ≥ 1.0.

Year	Metals	TEC	205COY060		205COY080		205COY165		205COY240		205COY250	
			Conc (mg/kg) DW	Quotient	Conc (mg/kg) DW	Quotient	Conc (mg/kg) DW	Quotient	Conc (mg/kg) DW	Quotient	Conc (mg/kg) DW	Quotient
2018	Arsenic	9.79	5.4	0.55	8.2	0.84	3.7	0.38	5.5	0.56	4.1	0.42
	Cadmium	0.99	0.27	0.27	0.24	0.24	0.3	0.30	0.5	0.51	0.25	0.25
	Chromium	43.4	41	0.94	46	**1.1**	36	0.83	70	**1.6**	61	**1.4**
	Copper	31.6	30	0.95	28	0.89	25	0.79	56	**1.8**	35	**1.1**
	Lead	35.8	15	0.42	14	0.39	22	0.61	51	**1.4**	34	0.95
	Nickel	22.7	60	**2.6**	69	**3.0**	55	**2.4**	120	**5.3**	92	**4.1**
	Zinc	121	110	0.91	96	0.79	110	0.91	320	**2.6**	180	**1.5**
2019	Arsenic	9.79	-	-	4.8	0.49	4.1	0.42	-	-	4.7	0.48
	Cadmium	0.99	-	-	0.35	0.35	0.31	0.31	-	-	0.21	0.21
	Chromium	43.4	-	-	45	**1.0**	41	0.94	-	-	67	**1.5**
	Copper	31.6	-	-	26.4	0.84	22.5	0.71	-	-	31.7	**1.0**
	Lead	35.8	-	-	25	0.70	23	0.64	-	-	35	0.98
	Nickel	22.7	-	-	68	**3.0**	61	**2.7**	-	-	100	**4.4**
	Zinc	121	-	-	130	**1.07**	110	0.91	-	-	150	**1.2**

Table 6. Probable Effect Concentration (PEC) quotients for metals in sediment collected in WY 2018 and WY 2019. Bolded and shaded values indicate PEC quotient ≥ 1.0.

Year	Metals	PEC	205COY060		205COY080		205COY165		205COY240		205COY250	
			Conc (mg/kg) DW	Quotient	Conc (mg/kg) DW	Quotient	Conc (mg/kg) DW	Quotient	Conc (mg/kg) DW	Quotient	Conc (mg/kg) DW	Quotient
2018	Arsenic	33.0	5.4	0.16	8.2	0.25	3.7	0.11	5.5	0.17	4.1	0.12
	Cadmium	4.98	0.27	0.05	0.24	0.05	0.3	0.06	0.5	0.10	0.25	0.05
	Chromium	111	41	0.37	46	0.41	36	0.32	70	0.63	61	0.55
	Copper	149	30	0.20	28	0.19	25	0.17	56	0.38	35	0.23
	Lead	128	15	0.12	14	0.11	22	0.17	51	0.40	34	0.27
	Nickel	48.6	60	**1.2**	69	**1.4**	55	**1.1**	120	**2.5**	92	**1.9**
	Zinc	459	110	0.24	96	0.21	110	0.24	320	0.70	180	0.39
2019	Arsenic	33.0	-	-	4.8	0.15	4.1	0.12	-	-	4.7	0.14
	Cadmium	4.98	-	-	0.35	0.07	0.31	0.06	-	-	0.21	0.04
	Chromium	111	-	-	45	0.41	41	0.37	-	-	67	0.60
	Copper	149	-	-	26.4	0.18	22.5	0.15	-	-	31.7	0.21
	Lead	128	-	-	25	0.20	23	0.18	-	-	35	0.27
	Nickel	48.6	-	-	68	**1.4**	61	**1.3**	-	-	100	**2.1**
	Zinc	459	-	-	130	0.28	110	0.24	-	-	150	0.33

Table 7. Pesticide concentrations and calculated toxic unit (TU) equivalents, WY 2018. Toxic Unit equivalents were not calculated (NC) for pesticide concentrations that were below Method Detection Limits (MDL)s.

Analyte	LC50 [d]	205COY060			205COY080			205COY165			205COY240			205COY250		
		Conc	TOC Normal	TU Equiv.	Conc	TOC Normal	TU Equiv.	Conc	TOC Normal	TU Equiv.	Conc	TOC Normal	TU Equiv.	Conc	TOC Normal	TU Equiv.
Total Organic Carbon (%)	--	1.5	--	--	1.2	--	--	1.3	--	--	4.7	--	--	2.1	--	--
Pyrethroid (µg/g dw)																
Bifenthrin	0.52	0.0024	0.16	0.31	0.0019	0.16	0.30	0.0036	0.28	0.53	0.0078	0.17	0.32	0.0036	0.17	0.33
Cyfluthrin	1.08	0.00085	0.057	0.05	0.00064 [a]	0.053	0.05	0.0019	0.15	0.14	0.0072	0.15	0.14	0.0026	0.12	0.11
Cypermethrin	0.38	< MDL	0.017	NC	< MDL	0.022	NC	0.00094	0.072	0.19	0.0041	0.087	0.23	0.0048	0.23	0.60
Deltamethrin	0.79	< MDL	0.021	NC	< MDL	0.026	NC	0.0012	0.092	0.12	0.00033	0.0069	0.01	0.00032	0.015	0.02
Esfenvalerate	1.54	< MDL	0.022	NC	< MDL	0.028	NC	0.00034	0.026	0.02	0.00035	0.0074	0.005	0.00034	0.016	0.01
Lambda-Cyhalothrin	0.45	< MDL	0.010	NC	< MDL	0.013	NC	0.00031	0.024	0.05	0.0013	0.028	0.06	0.00016	0.007	0.02
Permethrin	10.8	0.00120	0.08	0.01	0.0014	0.117	0.01	0.0027	0.21	0.02	0.0072	0.15	0.01	0.0055	0.26	0.02
Total				0.5			0.5			**1.1**			0.8			**1.1**
Other Pesticides of Concern (ng/g dw)																
Fipronil	306	< MDL	17.3	NC	< MDL	21.7	NC	< MDL	20.0	NC	0.27	5.7	0.019	< MDL	12.4	NC
Fipronil Desulfinyl	NA [b]	< MDL	17.3	NC	< MDL	21.7	NC	< MDL	20.0	NC	0.27	5.7	NA	< MDL	12.4	NC
Fipronil Sulfide	435	< MDL	17.3	NC	< MDL	21.7	NC	< MDL	20.0	NC	3.5	74.5	0.17	< MDL	12.4	NC
Fipronil Sulfone	158	< MDL	17.3	NC	< MDL	21.7	NC	< MDL	20.0	NC	3.1	66.0	0.42	< MDL	12.4	NC

a. TU equivalents calculated from concentration below the reporting limit (J-flagged).
b. No available LC50 value for Fipronil Desulfinyl
c. Sources: Amweg et al. 2005. Maul et al. 2008, and Maund et al. 2002

Table 8. Pesticide concentrations and calculated toxic unit (TU) equivalents, WY 2019. Toxic Unit equivalents were not calculated (NC) for pesticide concentrations that were below Method Detection Limits (MDL)s.

Analyte	LC50	205COY080			205COY165			205COY250		
		Conc	TOC Normal	TU Equiv.	Conc	TOC Normal	TU Equiv.	Conc	TOC Normal	TU Equiv.
Total Organic Carbon (%)		0.86			1.3			2.1		
Pyrethroid (µg/g dw)										
Bifenthrin	0.52	0.0028	0.33	0.63	0.0024 [a]	0.18	0.36	0.0048	0.23	0.44
Cyfluthrin	1.08	0.0011[a]	0.128	0.12	< MDL	0.04	0.04	0.0021	0.10	0.09
Cypermethrin	0.38	0.0011[a]	0.128	0.34	< MDL	0.038	0.10	0.0019	0.09	0.24
Deltamethrin/Tralomethrin	0.79	0.0026	0.302	0.38	0.0015 [a]	0.115	0.15	0.0013	0.062	0.08
Esfenvalerate/Fenvalerate	1.54	< MDL	0.00034	NC	< MDL	0.050	NC	< MDL	0.016	NC
Lambda-Cyhalothrin	0.45	< MDL	0.018	NC	< MDL	0.024	NC	< MDL	0.007	NC
Permethrin	10.83	0.0033	0.384	0.04	0.0028	0.22	0.02	0.0030	0.14	0.01
Total				**1.6**			0.8			0.9
Other Pesticides of Concern (ng/g dw)										
Fipronil	306	< MDL	29.7	NC	< MDL	38.5	NC	< MDL	12.4	NC
Fipronil Desulfinyl	NA[b]	< MDL	29.7	NC	< MDL	38.5	NC	< MDL	12.4	NC
Fipronil Sulfide	435	< MDL	29.7	NC	< MDL	38.5	NC	< MDL	12.4	NC
Fipronil Sulfone	158	< MDL	29.7	NC	< MDL	38.5	NC	< MDL	12.4	NC

a. TU equivalents calculated from concentration below the reporting limit (J-flagged).
b. No available LC50 value for Fipronil Desulfinyl
c. Sources: Amweg et al. 2005. Maul et al. 2008, and Maund et al. 2002

Table 9. Summary of grain size for the five sampling locations in Coyote Creek during WY 2018.

Grain Size (%)		205COY060	205COY080	205COY165	205COY240	205COY250
Clay	<0.0039 mm	11.2%	14.7%	9.3%	14.0%	6.6%
Silt	0.0039 to <0.0625 mm	22.7%	13.4%	16.6%	36.2%	11.6%
Sand	V. Fine 0.0625 to <0.125 mm	5.8%	2.9%	16.4%	19.3%	8.3%
	Fine 0.125 to <0.25 mm	7.8%	9.3%	37.3%	18.3%	31.3%
	Medium 0.25 to <0.5 mm	7.5%	20.8%	16.2%	8.5%	33.8%
	Coarse 0.5 to <1.0 mm	6.8%	20.7%	3.4%	2.6%	5.5%
	V. Coarse 1.0 to <2.0 mm	38.3%	18.3%	1.2%	1.1%	3.0%
Granule	2.0 to <4.0 mm	16.7%	10.9%	1.0%	0.8%	3.6%
Pebble	Small 4 to <8 mm	26.6%	22%	ND	ND	6.5%
	Medium 8 to <16 mm	38.1%	ND	ND	ND	ND
	Large 16 to <32 mm	ND	ND	ND	ND	ND
	V. Large 32 to <64 mm	ND	ND	ND	ND	ND

Note: Sum of grain size values for both sites is greater than 100% due to the laboratory analytical methods used.

Table 10. Summary of grain size for the three sampling locations in Coyote Creek during WY 2019.

Grain Size		205COY080	205COY165	205COY250
Clay	<0.0039 mm	20.4%	9.8%	7.9%
Silt	0.0039 to <0.0625 mm	20.5%	21.9%	17.6%
Sand	V. Fine 0.0625 to <0.125 mm	3.5%	11.6%	10.2%
	Fine 0.125 to <0.25 mm	10.7%	24.6%	18.5%
	Medium 0.25 to <0.5 mm	19.4%	22.0%	29.7%
	Coarse 0.5 to <1.0 mm	15.1%	6.7%	9.4%
	V. Coarse 1.0 to <2.0 mm	10.3%	3.4%	6.8%
Granule	2.0 to <4.0 mm	8.4%	1.2%	7.0%
Pebble	Small 4 to <8 mm	21.0%	ND	11.8%
	Medium 8 to <16 mm	29.0%	ND	ND
	Large 16 to <32 mm	ND	ND	21.9%
	V. Large 32 to <64 mm	ND	ND	ND

Note: Sum of grain size values for both sites is greater than 100% due to the laboratory analytical methods used.

4.0 DISCUSSION

The monitoring results from Coyote Creek Toxicity SSID Project are discussed below in the context of each monitoring objective identified in the Work Plan.

What is the magnitude and extent of toxicity at SSID monitoring sites?

Overall, acute toxicity to *Hyalella azteca* and *Chironomum dilutus* organisms was very low during the 2018 and 2019 monitoring period. In 2018, only one of five sediment samples had toxicity. A subsequent TIE on the same sample resulted in no observation of acute toxicity.

Three of the five sites sampled in 2018 were resampled in 2019. Only one of the three samples exhibited acute toxicity. However, the results are ambiguous due to an identified outlier for one of the test replicants. There was no significant toxicity when the outlier was excluded from the results. Due to low levels of toxicity, a TIE was not conducted on the 2019 sample.

What are the potential causes of toxicity?

Hyalella azteca and *Chironomus dilutus* are typically the only organisms used to evaluate toxicity in sediments from freshwater creeks. *Hyalella azteca* is highly sensitive to pyrethroid pesticides. *Chironomus dilutus* (a midge) is sensitive to fipronil, its degradates, and neonicotinoids (i.e., imidacloprid).

Evaluation of 2018 sediment chemistry results from site 205COY080 (where toxicity was observed) were inconclusive (i.e., pyrethroid or metal concentrations were not at levels that are known to cause toxic effects). The subsequent TIE conducted in 2018 did not result in toxicity and thus, treatments to evaluate potential causes of toxicity (i.e., metals or pyrethroids) were not effective.

Sediment chemistry results from 2019 at site 205COY080 did indicate pyrethroid concentrations were at levels that may cause toxicity (TU for sum of pyrethroids > 1.0). However, acute toxicity did not occur with *Hyalella azteca*, which is the test organism most sensitive to pyrethroids. Although there may have been toxic effects to *Chironomum dilutes* (when outlier replicant test was included in results), fipronil concentrations were all below method detection limits. Overall, toxicity results were too inconclusive to identify potential contaminants that may be causing toxicity.

Is toxicity declining in Coyote Creek?

Evaluation of sediment toxicity data collected during the dry season at site 205COY060 in Coyote Creek by the SPoT Program between 2008 and 2018 (summarized in Section 1.2 of this report) indicates that acute toxicity has declined over the 11 year time period. Sediment data collected over a wider range of seasons and across multiple sites within the Coyote Creek mainstem (not including sampling locations in tributaries to Coyote Creek) between 2006 and 2019 shows similar results (Table 11). These data were generated by the following programs:

- SCVURPPP has been collecting sediment chemistry data and conducting toxicity testing in Coyote Creek since 2006. Between 2006 and 2008, SCVURPPP collected sediment data at several sites in Coyote Creek as part of the Sediment Quality Triad Pilot Study (SCVURPPP 2008). In 2012 and 2013, SCVURPPP conducted sediment sampling at

three locations in Coyote Creek to satisfy MRP Provision C.8 monitoring requirements (SCVURPPP 2014).

- SWAMP's SPoT program has conducted monitoring at site 205COY060 every year since 2008. SWAMP also conducted monitoring in 2007 at two locations in Coyote Creek as part of the Statewide Urban Pyrethroid Study.

Table 11. Sediment data collected in Coyote Creek mainstem by SCVURPP and SWAMP between 2006 and 2019. These data include samples collected by SPoT over variable seasonal time periods.

Year	SCVURPPP Monitoring Program			Surface Water Ambient Monitoring Program (SWAMP)		Total # Samples
	Pre-MRP Monitoring	RMC Monitoring (MRP)	SSID Project	Urban Pyrethroid Status Monitoring	Stream Pollution Trends (SPoT) Program[1]	
2006	6	-	-	-	-	6
2007	10	-	-	2	-	12
2008	4	-	-	-	1	5
2009	-	-	-	-	1	1
2010	-	-	-	-	1	1
2011	-	-	-	-	6	6
2012	-	1	-	-	9	10
2013	-	2	-	-	4	6
2014	-	-	-	-	1	1
2015	-	-	-	-	1	1
2016	-	-	-	-	1	1
2017	-	-	-	-	1	1
2018	-	-	5	-	1	6
2019	-	-	3	-	1	4

[1] Includes toxicity testing results for variable season and temperature treatments.

Figure 3 illustrates the number of samples collected in Coyote Creek mainstem over the span of 14 years (Table 11) that had acute toxicity[3] for the test organism *Hyalella azteca.* Between 2010 and 2019, only 4 of 36 (11%) samples were toxic. More recently, only 1 of 13 (8%) samples collected between 2014 to 2019 had observed acute sediment toxicity. Based on these data, it appears that toxicity for *Hyalella azteca* in Coyote Creek may have declined over the past 10 years.

The SPoT Program also conducted chronic (growth) toxicity tests using the *Hyalella azteca* test organism. Chronic toxicity was relatively infrequent over the 14 year monitoring period. Figure 4 shows the number of sediment samples collected in Coyote Creek (Table 11) that exhibited chronic (growth) toxicity[4]. Between 2010 and 2019, only 2 of 28 (7%) samples exhibited chronic toxicity to *Hyalella azteca*.

[3] Does not include SWAMP results of toxicity tests conducted using the temperature treatment (15 C).
[4] Chronic toxicity tests were not conducted for the SSID project.

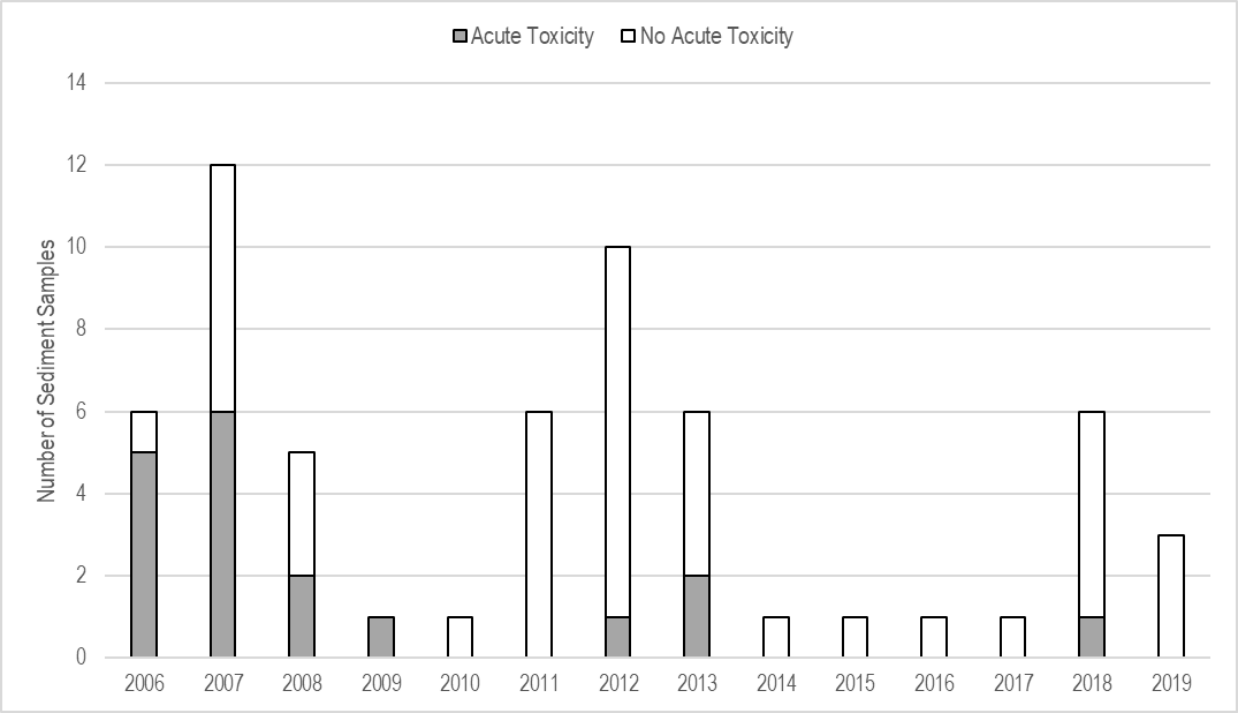


Figure 3. Number of sediment samples collected in Coyote Creek with acute toxicity to *Hyalella azteca*.

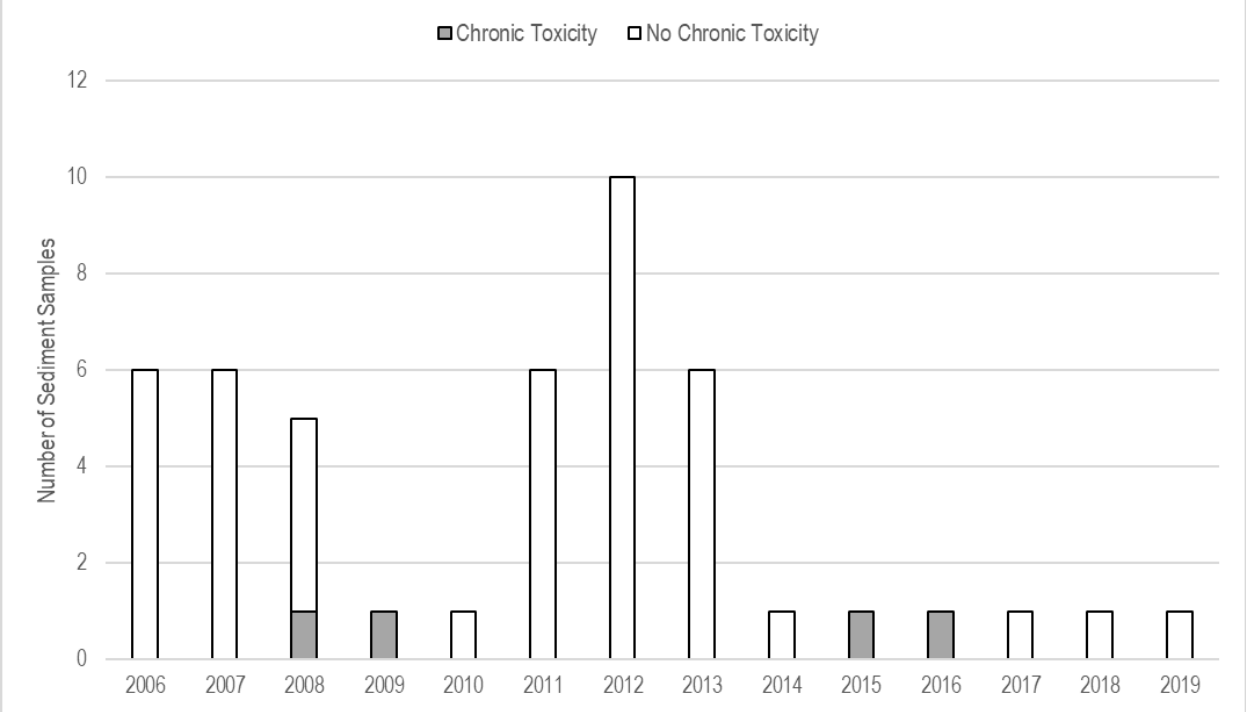


Figure 4. Number of sediment samples collected in Coyote Creek with chronic toxicity to *Hyalella azteca*.

A decline in overall toxicity to *Hyalella azteca* may be associated with reduction in pyrethroid pesticide concentrations in bedded stream sediments. Overall, there appears to be a decline in pyrethroid concentrations in samples collected by SPoT at site 205COY060 since 2012 (Figure 1 in Section 1.2). Pyrethroid concentrations also appear to be declining for sediment samples collected over the wider range of sites shown in Table 11. Figure 5 shows the concentrations for two pyrethroids, bifenthrin and cypermethrin, in samples collected between 2007 and 2019. Concentrations in samples collected at site 205COY060 at Montague Expressway are called out to show trends at a single sampling location over time. Both pesticides had concentrations that were consistently below the LC50 threshold for all samples collected in Coyote Creek after 2013.

A reduction in pyrethroid concentrations observed in Coyote Creek may reflect an overall reduction in the amount of pyrethroid used in the landscape (SCVURPPP 2019). However, sediment chemistry results for sediment samples collected in Coyote Creek since 2013 indicate minimal changes in fipronil concentrations over time. Fipronil degradates (sulfite and sulfone) concentrations in sediment samples between 2013 and 2018 are shown in Figure 6. Furthermore, acute toxicity tests over the monitoring period showed no significant mortality for *Chironomum* dilutes, an organism sensitive to fipronil.

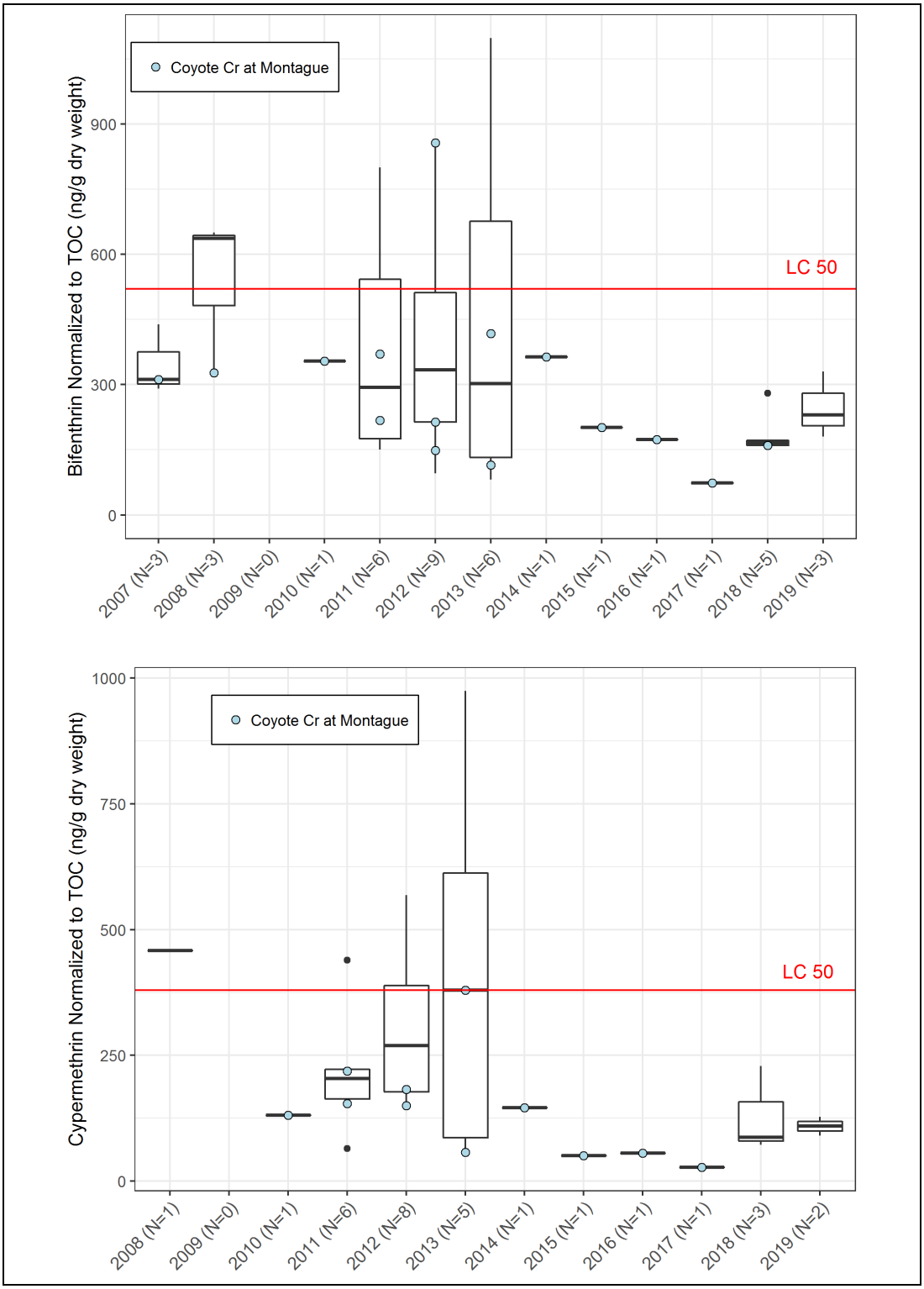


Figure 5. Pyrethroid pesticide concentrations (bifenthrin and cypermethrin) in sediment samples collected in Coyote Creek between 2008 and 2019. Sediment data collected by SWAMP SPoT program in 2018 and 2019 was not available for this analyses.

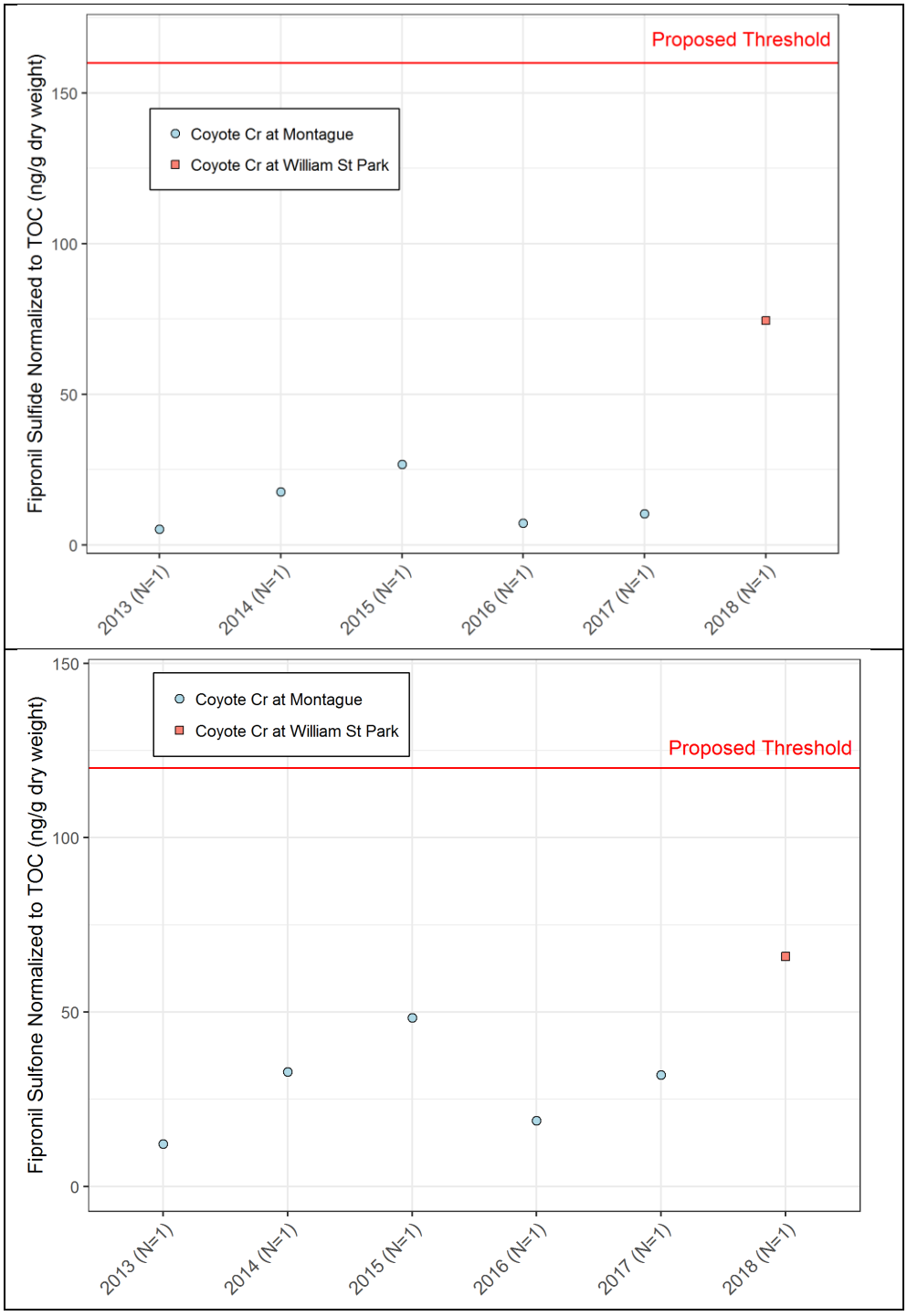


Figure 6. Fipronil degradate concentrations in sediment samples collected in Coyote Creek between 2013 and 2019. Sediment data collected by SWAMP SPoT program in 2018 and 2019 was not available for this analyses.

5.0 CONCLUSIONS AND RECOMMENDATIONS

The Coyote Creek Toxicity SSID Project was designed to identify the cause(s) of sediment toxicity to *Hyalella azteca* measured in samples collected in 2008 and 2009, which was the evidence used by the Water Board to add Coyote Creek to the 303(d) list. Because *Hyalella azteca* is particularly sensitive to pyrethroid pesticides, this study focused on pyrethroids as a potential cause of *Hyalella azteca* toxicity. However, there was an overall lack of toxicity observed in the Coyote Creek Toxicity SSID study samples (collected 2018 – 2019). Furthermore, review of toxicity data from Coyote Creek for the 2006 – 2019 period of record suggests a declining trend in toxicity to *Hyalella azteca*. The reduction in toxicity may be explained by the gradual decline over time in pyrethroid concentrations in sediment samples.

This study also explored sediment toxicity to *Chironomum dilutus*, a test organism that is sensitive to fipronil. A low level of toxicity was observed in one sample during the two year study. However, these results were ambiguous due to an outlier (no significant toxicity occurred when outlier was excluded). Concentrations of fipronil and its degradates were at low concentrations that were generally below method detection limits.

The results of this SSID Study and review of toxicity data collected over the past 14 years suggest that sediment toxicity is generally not present in Coyote Creek. Based on these results and analyses, the Coyote Creek Toxicity SSID Project is considered complete.

In FY 2018-19, SCVURPPP conducted an evaluation of pesticide source control actions implemented by SCVURPPP and its Permittees. The results of the evaluation are described in the Pesticide Source Control Actions Effectiveness Evaluation Report which was included in the FY 2018-19 SCVURPPP Annual Report. As described in the Report, SCVURPPP will continue to implement the pesticide toxicity control measures described in MRP Provision C.9. These include:

- Implement Integrated Pest Management (IPM) policies/ordinances and established pesticide application SOPs. All SCVURPPP Permittees have adopted IPM policies/ordinances requiring the use of IPM techniques on municipal properties.
- Train all municipal staff that apply pesticides on the IPM policy and SOPs.
- Require contractors to follow the IPM Policy and implement IPM.
- Collaborate with the County Household Hazardous Waste (HHW) Program to ensure that adequate pesticide disposal services are available to all residents.
- Implement the Our Water Our World (OWOW) Program in local retail stores and nurseries to provide less toxic pest control information to residents at the point of purchase. Conduct trainings for store employees to educate them on the availability of less-toxic pesticide products.
- Educate residents about pesticides and IPM, using media advertising, website and social media postings, and distribution of outreach materials at events.
- Conduct the Santa Clara Valley Green Gardener training to educate professional landscapers on other sustainable landscaping practices, including IPM.
- Educate pest control professionals on IPM and water quality issues by sending them informational letters and publishing articles in the Santa Clara County Department of Agriculture’s newsletter.

- Encourage new development and redevelopment sites to use “beneficial landscaping” techniques that minimize pesticides, fertilizers, irrigation, and runoff.
- Work with the California Stormwater Quality Association (CASQA) to communicate to the USEPA Office of Pesticide Programs and the California Department of Pesticide Regulation the need to fully consider the impact on water quality during the pesticide approval and registration process.

Consistent with MRP procedures, the Program seeks approval of the completion of the Coyote Creek Sediment Toxicity SSID Study from the Water Board Executive Officer.

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Attachment 3
Lower Silver SSID Project Work Plan

Santa Clara Valley
Urban Runoff
Pollution Prevention Program

Watershed Monitoring and Assessment Program



Lower Silver-Thompson Creek Watershed Stressor Source Identification Project

Work Plan - Water Year 2019 - 2020

July 30, 2019

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1 INTRODUCTION

The purpose of this work plan is to describe the design and tasks to complete a Stressor/Source Identification (SSID) project required by Provision C.8.e.iii of the San Francisco Bay Region Municipal Regional Stormwater National Pollutant Discharge Elimination System (NPDES) Stormwater Permit (MRP) (Order No. R2-2015-0049). The Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP or Program) is working with the Bay Area Stormwater Management Agencies Association (BASMAA) Regional Monitoring Coalition (RMC) to collectively initiate eight new SSID projects during the five-year term of the MRP (i.e., 2016 – 2020).

SSID projects typically follow-up on monitoring conducted in compliance with MRP Provision C.8 (or monitoring conducted through other programs) with results that exceed trigger thresholds identified in the MRP. Trigger thresholds are not necessarily equivalent to Water Quality Objectives (WQOs) established in the San Francisco Bay Basin (Region 2) Water Quality Control Plan (Basin Plan, SFRWQCB 2017) by the San Francisco Bay Regional Water Quality Control Board (Water Board); however, sites where triggers are exceeded may indicate potential impacts to aquatic life or other Beneficial Uses.

The Program will conduct two SSID projects during MRP 2.0. The Coyote Toxicity SSID Project was initiated during WY 2018 and will continue through WY 2019. The project entails an investigation of the magnitude and extent of potential sediment related toxicity in an urban reach of the Coyote Creek mainstem. In addition, the project will evaluate potential causes and sources of toxicity (if found). A final report will be submitted to the Water Board by March 31, 2020.

In WY 2019, the Program will initiate the second and final SSID project for MRP 2.0. The Lower Silver-Thompson Creek SSID Project was triggered by creek status/condition data suggesting Lower Silver Creek and Thompson Creek have reduced biological integrity. In addition, existing water chemistry data collected during bioassessments indicate elevated nutrient concentrations at most of the monitoring locations. Nutrients are biostimulatory substances that may cause eutrophic conditions that can influence biological conditions.

The Lower Silver – Thompson Creek SSID work plan (this document) describes the steps that will be taken during WY 2019 and WY 2020 to investigate potential causes of low biological integrity in Lower Silver-Thompson Creek, San Jose, California.

1.1 SSID Regulatory Background

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

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

- Define the problem (e.g., magnitude and temporal and geographic extent) to the extent known;
- Describe the SSID project objectives, including the management context within which the results of the investigation will be used;
- Consider the problem within a watershed context and look at multiple types of related indicators, where possible (e.g., basic water quality data and biological assessment results);
- List candidate causes of the problem (e.g., biological stressors, pollutant sources, and physical stressors);

- Establish a schedule for investigating the cause(s) of the trigger stressor/source to begin upon completion of the work plan. Investigations may include evaluation of existing data and/or collection of new data.
- Conduct a site specific study (or non-site specific if the problem is wide-spread) in a stepwise process to identify and isolate the cause(s) of the trigger stressor/source. Study approaches are listed depending on the stressor being investigated.

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

Step 3: Follow-up actions:

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

1.2 SSID Work Plan Organization

This work plan fulfills **Step 1** of the SSID process presented in Section 1.1 and describes the steps that will be conducted to investigate potential sources and impacts to biological integrity in Lower Silver-Thompson Creek. The work plan is organized according to the work plan elements required by MRP Provision C.8.e.iii as described in Step 1.

Section 2.0 Problem Definition and Study Objectives

Section 4.0 Study Area, Existing Data, and Candidate Causes

Section 5.0 SSID Monitoring Approach and Schedule

Section 6.0 References

2 PROBLEM DEFINITION AND STUDY OBJECTIVES

2.1 Problem Definition

This SSID project was triggered by creek status/condition data suggesting Lower Silver-Thompson Creek watershed has reduced biological integrity. Specifically, the California Stream Condition Scores (CSCI), based on benthic macroinvertebrate data collected at six bioassessment sites on Lower Silver and Thompson Creek, were below the MRP threshold for CSCI scores. In addition, existing water chemistry data show that nutrient concentrations in the water column were elevated during the spring season when biological conditions were assessed. Furthermore, algal biomass measurements at selected sites indicate the potential for eutrophication. Excess nutrients may be problematic under certain conditions (e.g., sunlight exposure, high temperatures) that result in algal production. Increase in algal biomass can result in poor water quality or changes in food availability, resulting in reduced biological conditions.

An evaluation of bioassessment data collected in California stream and rivers suggests potential correlation between nutrients (i.e., total nitrogen and total phosphorus) and biological condition index scores (Mazor, *et al*. in prep). However, these associations are highly variable, indicating that confounding stressors may co-occur, especially in urban streams. Thus, the linkage between nutrients and biological conditions is not always clear.

An evaluation of five years of bioassessment data collected in San Francisco Bay watersheds (BASMAA 2019) identified physical habitat and landscape variables as the primary factors affecting variability of CSCI scores. In contrast, indices measuring health of benthic algae were more correlated to water quality variables.

Existing bioassessment data indicate that sampling locations in Lower Silver – Thompson Creek are likely impacted by multiple urban stressors. The majority of locations were modified channels with poor physical habitat conditions. In addition, five of the six sampling locations were in highly urban watersheds, with percent imperviousness in the surrounding landuse ranging from 31% to 53%.

2.2 Study Objectives

The objective of this SSID project is to focus on potential causes of reduced biological conditions in Lower Silver-Thompson Creek. Specifically, the study is designed to help answer the following questions:

1. What sources are contributing nutrients to the creek?
2. Are high nutrient concentrations contributing to the low biological quality in the creek?
3. Is euthropication occurring, and if so what conditions are potential contributing factors?
4. What other conditions might contribute to the low biological quality in the creek?

The data collected during this study will be combined with existing data (Section 3.2) to support a more robust characterization and evaluation of conditions and potential stressors and sources in the subwatershed.

3 STUDY AREA, EXISTING DATA, CANDIDATE CAUSES

3.1 Study Area

The Lower Silver – Thompson Creek subwatershed is the largest tributary (approximately 42 square miles) within the Coyote Creek watershed area below Anderson Dam. Thompson Creek originates in the Diablo Range foothills at an elevation of about 2,300 feet and flows northerly to its confluence with Lower Silver Creek at the eastern edge of the Santa Clara Valley.The transition from Thompson Creek to Lower Silver Creek orrurs just upstream of Lake Cunningham. There is no hydrological connection between the creek and the lake. Historically, with its gentle slopes and poorly drained soils, Lower Silver Creek flowed in an ill-defined channel; most of the flatter areas were swampy and prone to ponding and frequent floods. In the early 1950s, prior to urbanization, Lower Silver Creek was placed in an earthen channel and diverted to its present alignment (SCVURPPP 2003) to flow within an earthen levee around the western edge of Lake Cunningham. From there, it continues to flow in a northwesterly direction in a flood control channel to its confluence with Coyote Creek.

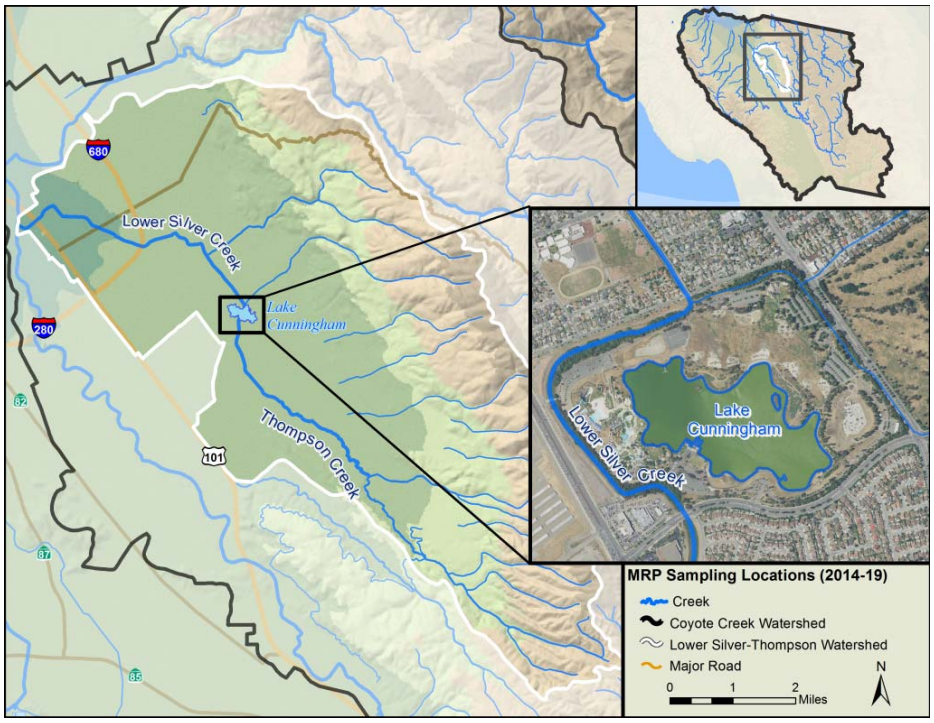


Figure 1. Lower Silver – Thompson Creek watershed, San Jose, California.

Existing land uses in the Lower Silver - Thompson Creek subwatershed are predominantly urban. The upland areas are devoted to uses ranging from rangelands to wildlife habitat, and are largely located outside of the City of San Jose's Urban Service Area boundary and in unincorporated areas of Santa Clara County. Two drop structures are present upstream and downstream of Quimby Road along Thompson Creek. Further upstream, the channel includes levees, rock slope protection, box culverts, and storm drain outfalls. Stream flow is typically intermittent throughout Thompson Creek and perennial in Lower Silver Creek (below Lake Cunningham).

The Lower Silver Creek Flood Protection Project, initiated by Valley Water[1] in early 2000, has resulted in major changes to the channel and physical habitat in the Lower Silver Creek. The primary goal of the

[1] Formerly known as Santa Clara Valley Water District.

project was to reduce potential flooding in the area by removing sediments from the channel to increase conveyance of flow during flood events. Sediment removal in the reach between Coyote Creek confluence and I-680 was completed in 2005. Sediment removal from the remaining section of creek, between I-680 and Lake Cunningham, was completed in 2017. The flood control project also included new levee walls, wider flood plain areas and vegetated banks. In addition, Valley Water has been working on a project to increase the capacity of Lake Cunningham to capture excess water during peak flow events by building a flood wall adjacent to Cunningham Avenue and White Road. Valley Water has also been working on bank stabilization projects in Thompson Creek to reduce erosion and sediment supply to the lower reaches.

3.2 Existing Data

Since 2014, the Program has conducted Creek Status Monitoring (CSM) and Pollutants of Concern (POC) Monitoring in Lower Silver-Thompson Creek to meet requirements under the MRP.

As part of the CSM, the Program conducted bioassessments at six locations in the watershed between 2014 and 2018 (Table 1 and Figure 2). The majority of the bioassessment sites were in low-gradient channels with adjacent urban/suburban land uses. All sites in Lower Silver Creek were within the channelized flood control channel, bordered by earthen levees. Due to recent channel construction associated with the Lower Silver Creek Flood Protection Project (see Section 3.1), riparian vegetation was relatively immature and provided minimal stream shading. Thompson Creek sites consisted of smaller channels with mature riparian forest providing shade and habitat complexity. Reach photos for each bioassessment site are provided in Attachment A.

The Program also collected nutrient samples at three locations in the Lower Silver-Thompson Creek watershed as part of the POC Monitoring (Table 1 and Figure 2). As shown on the map, two of the sample sites were co-located with a CSM site.

CSM and POC results are summarized below.

Table 1. Sampling locations in Lower Silver-Thompson Creek associated with Creek Status and Pollutant of Concern Monitoring.

Program	Creek Name	Station ID	Map ID	Site Location Description	Latitude	Longitude
Creek Status Monitoring	Thompson	205R03825	3825	Flowering Meadow Ln	37.28070	-121.75540
		205R00915	915	Aborn Rd	37.31470	-121.79620
	Lower Silver	205R02771	2771	S. Jackson Rd	37.35228	-121.83543
		205R01747	1747	Kammerer	37.35200	-121.84200
		205R00979	979	Lausett Ave	37.35400	-121.84660
		205R03795	3795	Plata Arroyo Park	37.35770	-121.85820
Pollutants of Concern Monitoring	Thompson	205COY205	205	Aborn Rd	37.31376	-121.79468
	Lower Silver	205COY185	185	S. Jackson Ave	37.35186	-121.83600
		205COY180	180	Wooster Av	37.35544	-121.87083

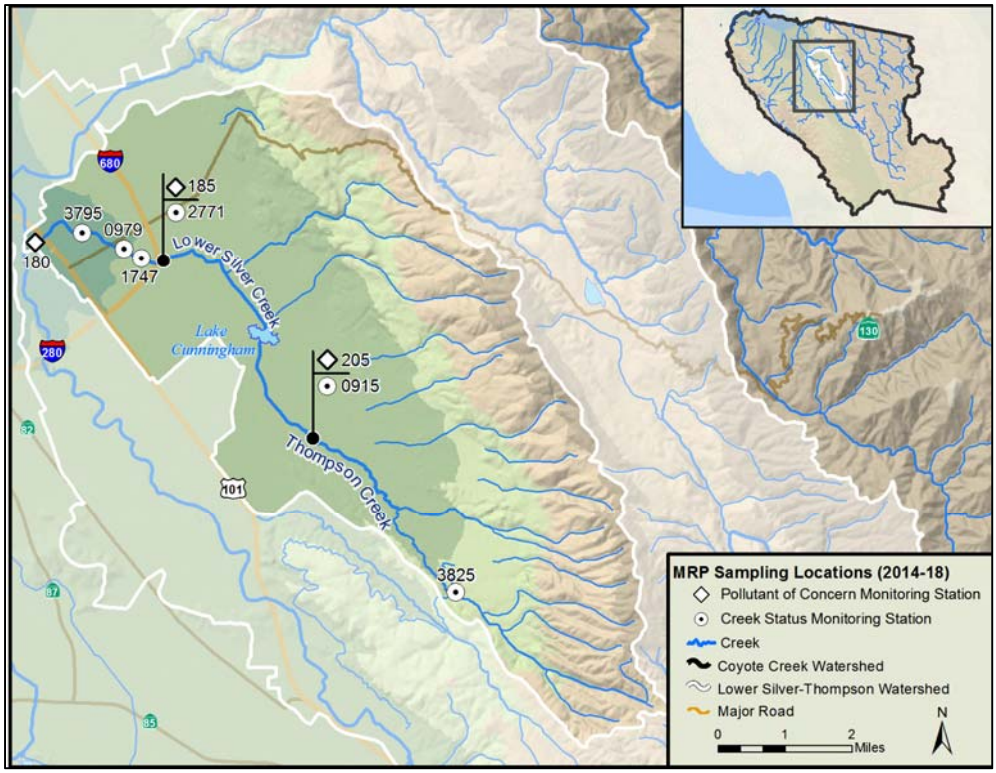


Figure 2. CSM and POCM monitoring stations in Lower Silver-Thompson Creek (2014 through 2018).

3.2.1 Biological and Physical Habitat Conditions

Benthic macroinvertebrate (BMI) and algae samples were collected during the spring season and evaluated as indicators for biological condition. BMI results were interpreted using the California Stream Condition Index (CSCI) (Mazor 2015). Algae results were interpreted using the hybrid Algae Stream Condition Index (ASCI), which integrates soft-bodied algae and diatom metrics (Theroux et al. in prep). The CSCI, ASCI and qualitative score for physical habitat condition (PHAB) at each site are presented in Table 2. Methods for calculating both indices for biological condition and Total PHAB are described in SCVURPPP 2019.

Table 2. Biological condition scores for bioassessment sites sampled in Lower Silver-Thompson Creek (2014 – 2018). Sites are ordered in upstream to downstream direction (from top to bottom of the table).

Station ID	Sampling Date	Elev. (m)	Flow Regime[1]	Benthic Macroinvertebrates		Algae	
				CSCI Score[2]	Condition Category	ASCI Hybrid Score	Condition Category
205R03825	5/1/2018	157	I	0.43	Very Likely Altered	0.64	Very Likely Altered
205R00915	4/24/2014	59	I	0.43	Very Likely Altered	0.68	Very Likely Altered
205R02771	6/3/2016	34	P	0.49	Very Likely Altered	0.49	Very Likely Altered
205R01747	5/18/2015	31	P	0.37	Very Likely Altered	0.56	Very Likely Altered
205R00979	4/24/2014	30	P	0.46	Very Likely Altered	0.78	Likely Altered
205R03795	5/30/2018	25	P	0.40	Very Likely Altered	0.61	Very Likely Altered

[1] Flow Regime: I = Intermittent; P = Perennial

[2] A CSCI score below 0.795 is appropriate for a Stressor Source Identification project as defined in MRP Provision C.8.e.

As shown in Table 2, the CSCI scores were relatively consistent across sites, ranging from 0.37 to 0.49. The ASCI hybrid score varied more, ranging from 0.49 to 0.78. All six bioassessment sites were in the Very Likely Altered or Likely Altered condition category for both CSCI and ASCI Hybrid Indices. Furthermore, all sites had a CSCI score below 0.795. MRP Provision C.8.d(8) states that sites with a CSCI score below 0.795 are considered appropriate for a SSID project.

Selected physical habitat variables measured at the six bioassessments sites in Lower Silver – Thompson Creek are summarized in Table 3. The Physical Habitat (PHAB) Assessment score consists of three attributes that are assessed for the entire bioassessment reach. These include channel alteration, epifaunal substrate, and sediment deposition. Each attribute is individually scored on a scale of 0 to 20, with a score of 20 representing good condition. The total PHAB score is the sum of three individual attribute scores with a score of 60 representing the highest possible score. The most highest elevation site had a total score of 41. The five remaining monitoring sites had PHAB scores ranging from 15 to 27.

Physical habitat endpoints (or metrics) were obtained using the SWAMP Bioassessment Reporting Module (SWAMP RM), which calculates metrics using reach-scale averages of transect-based measurements and observations. Three of the calculated metrics are shown in Table 3. The habitat metric scores indicate that most of the sites are deep with slow moving habitat (e.g, pools and glides), resulting in relatively high depsotion of sand and fine substrate.

Table 3. Physical habitat and landscape data for bioassessment sites sampled in Lower Silver-Thompson Creek (2014 – 2018). Sites are ordered in upstream to downstream direction (from top to bottom of the table

Station ID	Qualitative Physical Habitat Assessment				Quantitative Habitat Metric Score			Landscape
	Channel Alteration Score	Epifaunal Substrate Score	Sediment Deposition Score	Total Score[1]	Wetted Width to Depth Ratio	Slow Water Habitat (%)	Substrate Smaller than Sand (%)	Watershed Impervious area (%)
205R03825	18	10	13	41	34	60	50	6
205R00915	9	4	3	16	52	90	26	16
205R02771	5	9	10	24	29	86	39	21
205R01747	5	9	13	27	26	98	66	23
205R00979	4	2	16	22	29	88	7	24
205R03795	4	7	4	15	16	100	77	25

[1] Total PHAB score is the sum of three individual attribute scores.

Land use and transportation data layers were overlayed with the drainage areas to calculate landscape variables, such as percent impervious area in the area draining to the bioassessment location. With the exception of the highest elevation site (205R03825) which had a 6% impervious area, the bioassessment locations had relatively high percent impervious area, ranging from 16% to 25% (Table 3).

3.2.2 Nutrient Data

Water samples were collected during spring season at all CSM bioassessment locations and analyzed for nutrients. The total nitrogen and total phosphorus concentrations ranged from 1.8 to 8.2 mg/L and <.001 to 0.2 mg/L, respectively, across all sites (Table 4). Un-ionized ammonia concentrations are also presented in Table 34

Table 4. Nutrient concentrations measured at six bioassessment sites.

Project	Station ID	Sampling Date	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)	Un-ionized Ammonia (ug/L)
Creek Status Monitoring	205R03825	5/1/2018	1.8	0.05	0.6
	205R00915	4/24/2014	2.2	0.20	2.4
	205R02771	6/3/2016	4.5	0.08	4.1
	205R01747	5/18/2015	3.4	0.13	8.3
	205R00979	4/24/2014	3.9	0.09	3.2
	205R03795	5/30/2018	8.2	< 0.01	8.7

Water samples collected as part of POC monitoring during wet and spring seasons at three locations in Lower Silver-Thompson Creek were also analyzed for nutrients. Two of the POC stations were located at previously sampled CSM bioassessment stations. The total nitrogen and total phosphorus concentrations ranged from 3.3 to 5.8 mg/L and .051 to 0.88 mg/L, respectively, across all sites and samples (Table 5). Total nitrogen concentrations in samples collected in the spring season were slightly higher than concentrations in samples collected in the wet season. In contrast, total phosphorus concentrations in the "wet season" samples were higher than those in the "spring season" samples.

Table 5. Nutrient concentrations measured at POC sites.

Project	POCM Station ID	CSM Station ID	Sampling Date	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)	Unionized Ammonia (ug/L)
Pollutant of Concern Monitoring	205COY205[1]	205R00915	1/09/2017	4.6	0.43	2.2
	205COY185	205R02771	1/09/2017	3.4	0.87	1.6
			6/01/2017	4.9	0.1	7.3
	205COY180	NA	1/09/2017	3.3	0.88	1.6
			6/01/2017	5.6	.051	6.7

[1] Sample was not collected during the dry season due to no flow.

An evaluation of existing nutrient concentration data collected in rivers and streams at different trophic states within the United States identified threshold concentrations for total nitrogen and total phosphorus in eutrophic conditions to be 1.5 mg/L and 0.75 mg/L, respectively (Dobbs and Smith 2016). All Lower Silver-Thompson Creek total nitrogen concentrations exceeded the threshold. Phosporus concentrations were below the threshold except two samples from separate POC locations collected during the wet season (See Table 5).

The data evaluation by Dobbs and Smith (2016) also found a strong statistical link between total nitrogen and total phosphorus and benthic algal biomass. Furthermore, they found strong evidence that anthropogenic sources of nitrogen and phosphorus have a large influence on eutrophication-related water quality in rivers and streams.

3.2.3 Eutrophication Indicator Data

The benthic algae samples collected during the spring CSM bioassessments were analyzed for biomass indicators, including ash free dry mass (AFDM) and chlorophyll a (Table 6). In addition, the relative amount of macroalgae cover at each site was estimated during pebble counts as part of the physical habitat condition assessment. These measurements are used as indicators of organic matter accumulation, which is one of the symptoms of eutrophication.

Temperature, dissolved oxygen, and pH readings were also taken from water quality grab samples collected during the bioassessments (Table 6). Reduced concentrations of dissolved oxygen (DO) are another indicator of eutrophication. While the grab sample results are presented in Table 6, it's important to mention that continuous water quality readings are more suitable to understand diurnal fluctuations in temperature and dissolved oxygen and therefore necessary for understanding eutrophication.

Table 6. Eutrophication indicator data measured at CSM bioassessment sites in Lower Silver-Thompson Creek between 2014 and 2018.

Station ID	Sampling Date	Water Temperature C	Dissolved Oxygen (mg/L)	pH	Ash Free Dry Mass (g/m^2)	Chlorophyll a (mg/m^2)	Macroalgae Cover (%)
205R03825	5/1/2018	14	8.5	8.12	135	96	33
205R00915	4/24/2014	15	7.2	8.07	224	47	10
205R02771	6/3/2016	21	9.0	8.08	736	123	34
205R01747	5/18/2015	17	9.9	8.15	350	3	28
205R00979	4/24/2014	18	13.3	8.09	1034	137	32
205R03795	5/30/2018	20	7.7	7.45	305	89	50

The data in Table 6 do not show a consistent pattern between the various eutrophication indicators. For example, there was no association between chlorophyll a or AFDM with percent macroalgae cover. The data also do not indicate a consistent pattern along the creek (upstream to downstream) (Figure 3).

Dobbs and Smith (2016) identified mean and maximum threshold levels for benthic chlorophyll a concentrations for rivers and streams in eutrophic conditions as 70 mg/m^2 and 200 mg/m^2, respectively. Chlorophyl a concentrations in samples from four of the six CSM bioassessment sites in Lower Silver-Thompson Creek exceeded the mean threshold concentration but all concentrations were below the maximum threshold for chlorophyll a. It is important to note, however, that biomass concentrations were measured during spring season and not during the dry season, when sunlight, temperature and flow conditions may be more conducive to the development of eutrophic conditions.

3.2.4 Association between Eutrophication Indicator Data and Biological Conditions

The biological indicator scores for BMI (CSCI) and algae (ASCI) are plotted for the six bioassessment sites sampled in Lower Silver-Thompson Creek in Figure 3. The sites are organized from left to right along the x-axis by decreasing elevation (i.e. from upstream on the left of the x-axis to downstream on the right). The nutrient concentrations and indicators of organic matter accumulation are also presented to allow visual comparison with the biological condition scores.

The CSCI and ASCI hybrid scores for six bioassessment sites are plotted with nutrient concentrations and biomass indicators in Figures 4 and 5. Due to the small number of samples, statistical tests for significance were not conducted. The ASCI hybrid scores show negative association with increasing concentrations of total nitrogen and ammonia, but a positive relationship with total phosphorus. The CSCI scores show very little response to changes in nutrient concentrations. Both the CSCI and ASCI hybrid indices show positive increase with both AFDM and Chl-a as biomass indicators. These data

analyses should be interpreted with caution due to the small sample size and the number of factors (e.g., water quality, hydromorphology, etc) that may have confounding influence on biological conditions.

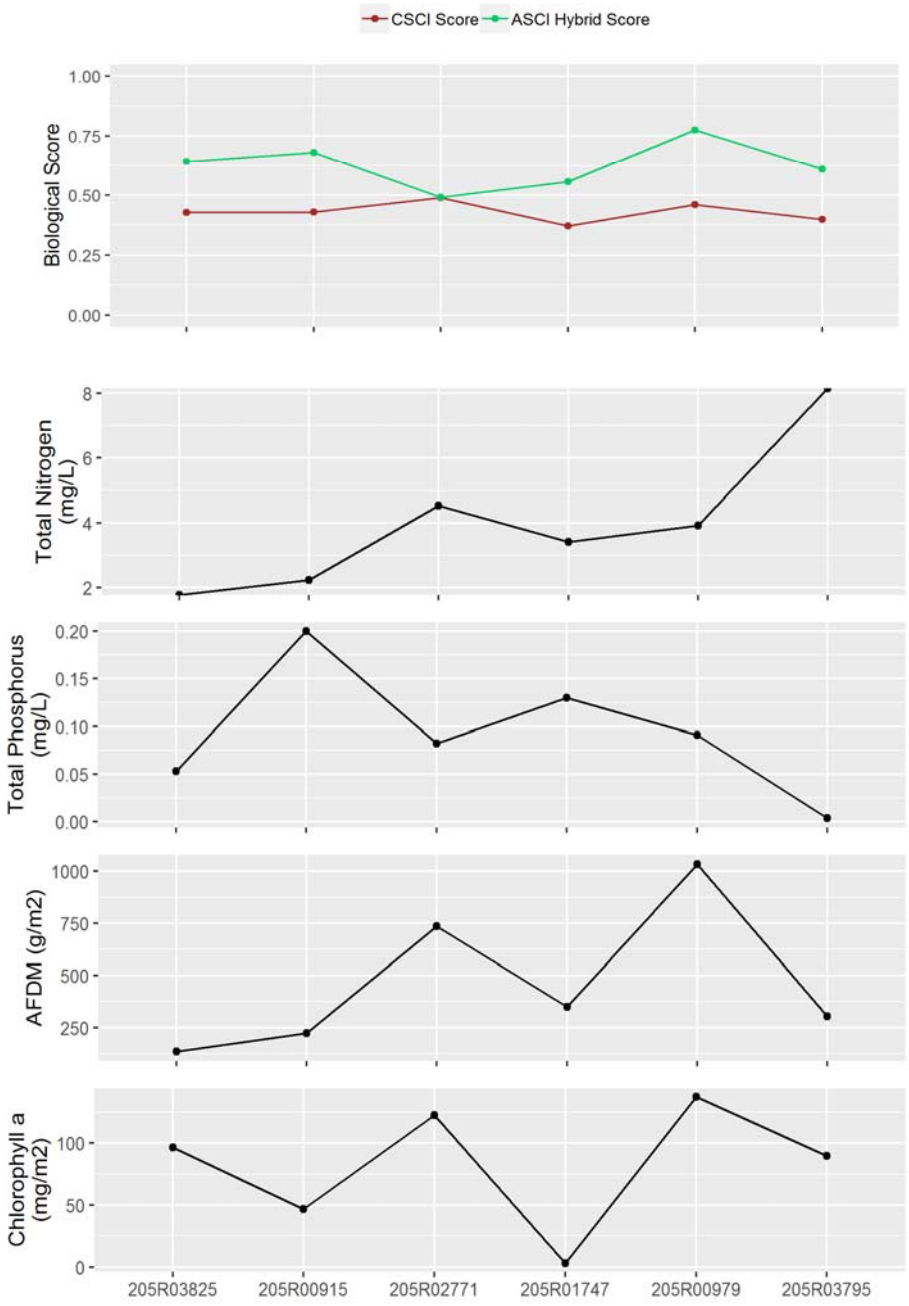


Figure 3. Biological indicator scores, nutrients and biomass indicators for six bioassessment sites in Lower Silver-Thompson Creek (2014-2018). Sites are orders upstream to downstream (right to left).

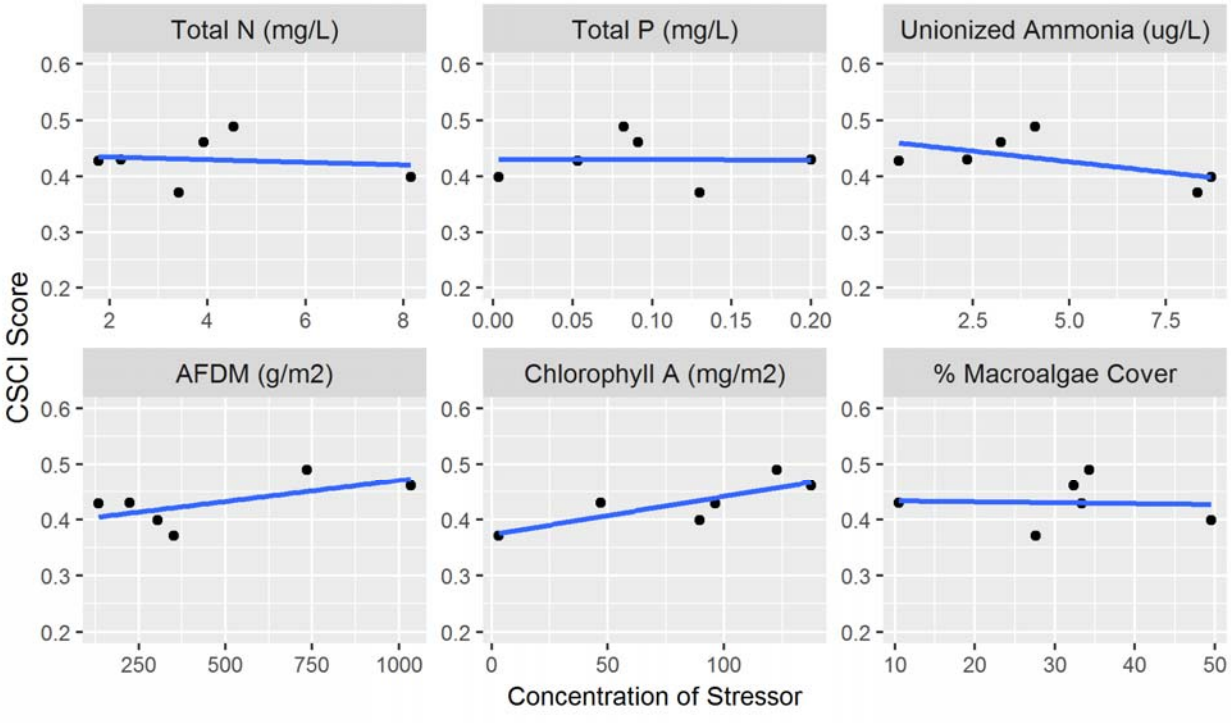


Figure 4. Scatter plots comparing CSCI score with nutrient concentrations (top three plots) and biomass indicators (bottom three plots). Trend lines are indicated, however due to small sample size, statistical test for significance was not conducted.

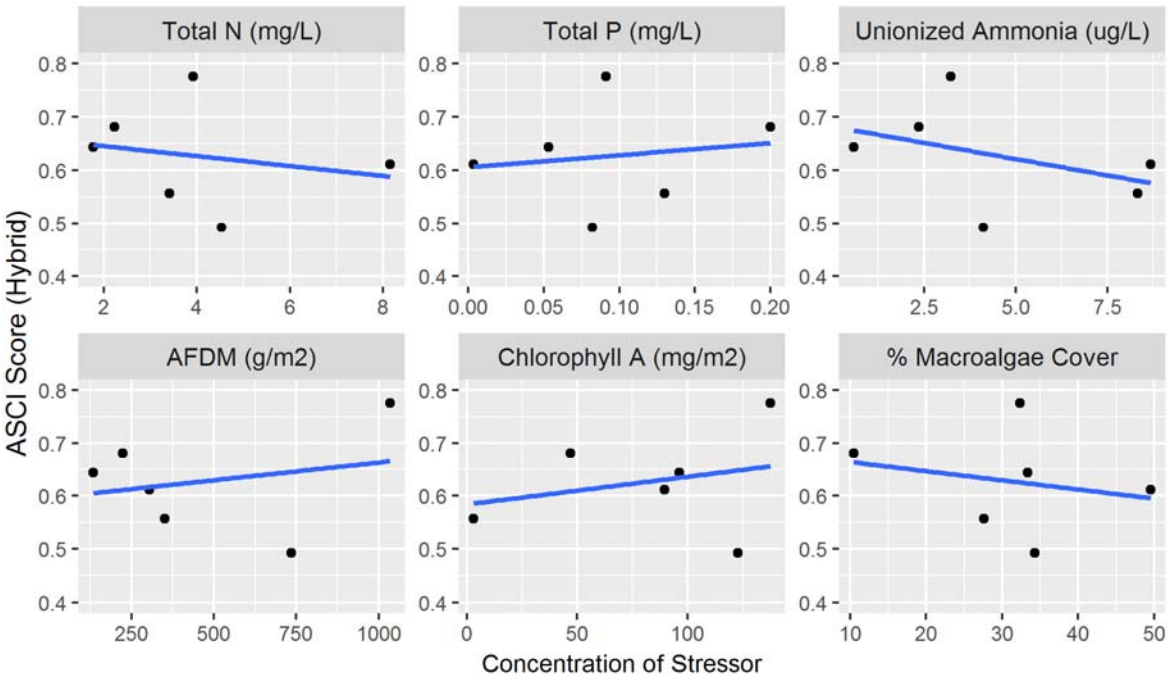


Figure 5. Scatter plots comparing ASCI hybrid score with nutrient concentrations (top three plots) and biomass indicators (bottom three plots). Trend lines are indicated, however due to small sample size, statistical test for significance was not conducted.

3.2.5 Association between Eutrophication Indicators and Physical Habitat

The physical habitat metric scores for wetted width to depth ratio were plotted against macroalgae cover measurements at the six CSM bioassessment sites (Figure 6). The figure indicates that percent algae cover increases with decreasing site depth (relative to width). Other physical habitat metrics and qualitative PHAB scores showed weak correlations with the eutrophication indicators.

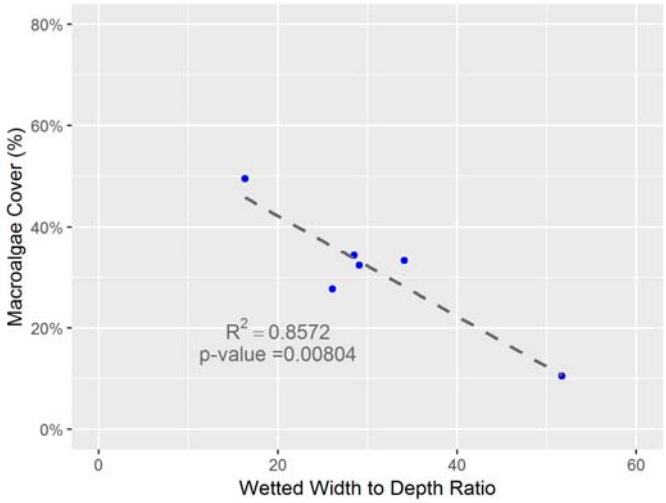


Figure 6. Scatter plots comparing macroalgae cover and wetted width to depth ratio at six bioassessment sites in Lower Silver – Thompson Creek.

3.2.6 Regional Data Comparison

The bioassessment data for the Lower Silver - Thompson Creek dataset were compared to data collected by the Program in other Santa Clara Basin watersheds between WY 2012 and WY 2018. The median CSCI score (0.43) and ASCI hybrid score (0.63) for the six bioassessment sites in Lower Silver-Thompson Creek were generally lower than the median scores for other Santa Clara Basin watersheds (Figures 7 and 8) and the median concentrations for total nitrogen (3.7 mg/L) and total phosphorus (0.087 mg/L) at six sites in Lower Silver-Thompson Creek watershed were higher than median concentrations in other Santa Clara Basin watersheds (Figures 9 and 10).

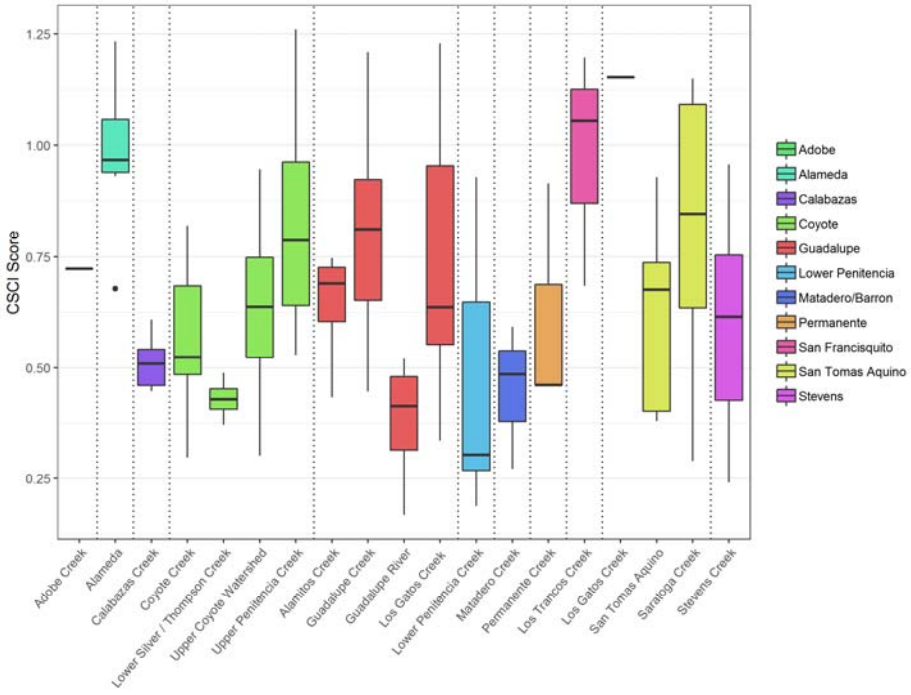


Figure 7. Box plot of CSCI scores for bioassessment sites, grouped by watershed/subwatershed, sampled between 2012 and 2018.

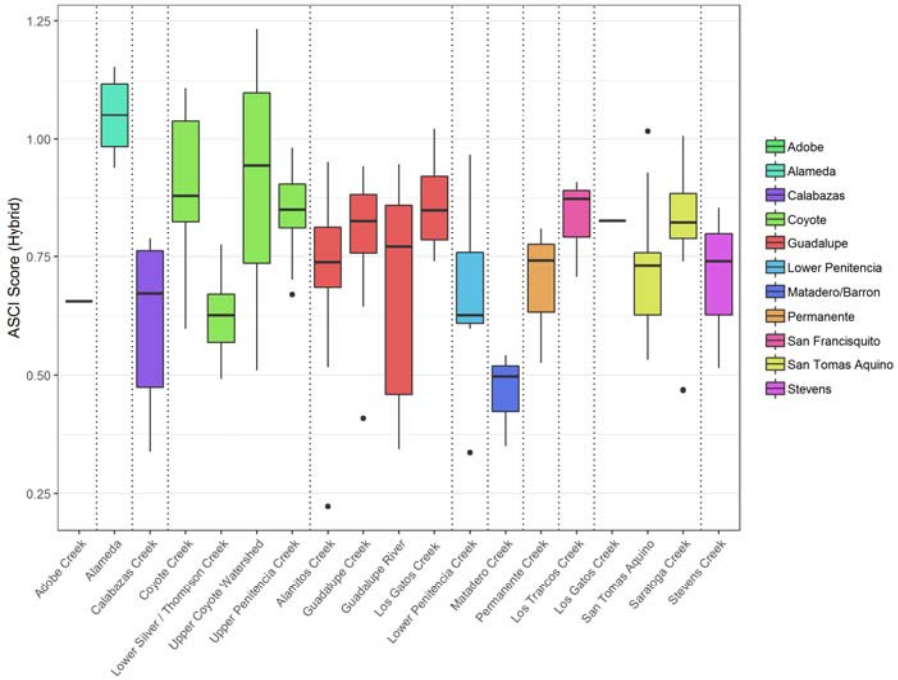


Figure 8. Box plot of ASCI hybrid scores for bioassessment sites, grouped by watershed/subwatershed, sampled between 2012 and 2018.

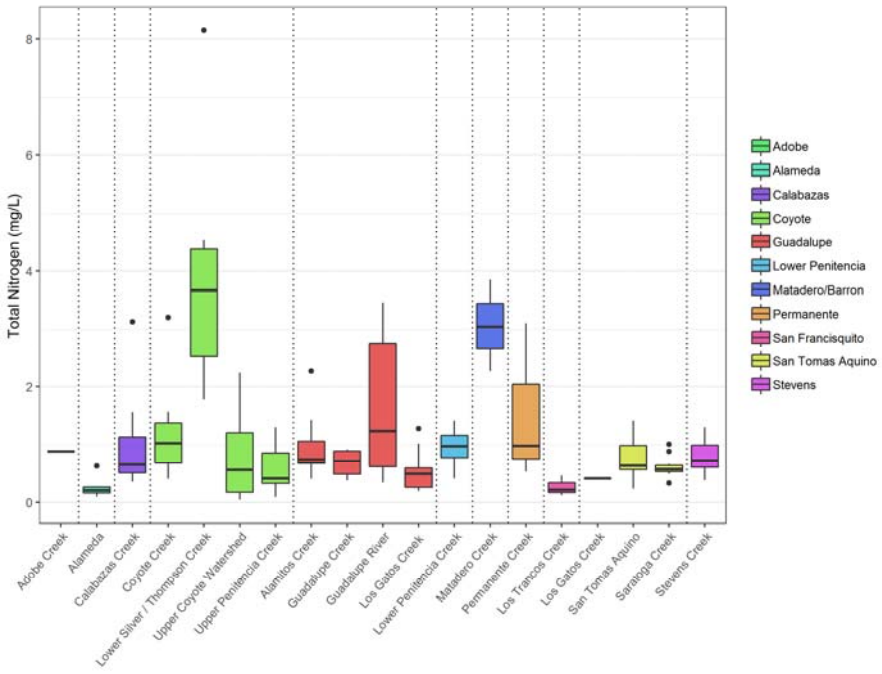


Figure 9. Box plot of total nitrogen concentrations for bioassessment sites, grouped by watershed/subwatershed, sampled between 2012 and 2018.

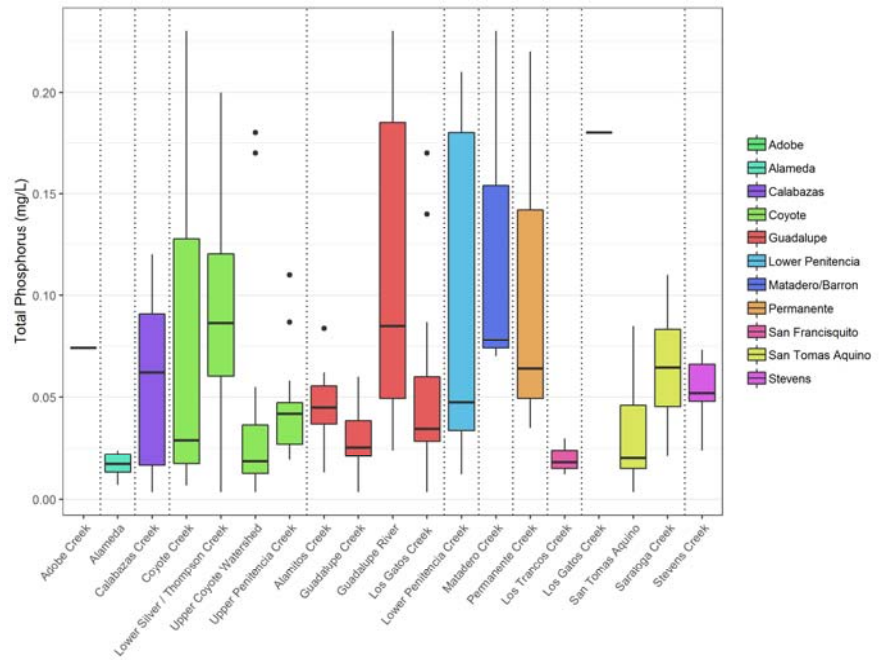


Figure 10. Box plot of total phosphorus concentrations for bioassessment sites, grouped by watershed/subwatershed, sampled between 2012 and 2018.

3.2.7 Data Evaluation for SSID Project

Based on the existing data, the following conclusions were drawn to inform monitoring design of the SSID Project:

Biological Conditions

1. Biological conditions below the MRP threshold (CSCI Score 0.795) indicate a substantially degraded biological community at all six bioassessment sites sampled between 2014 - 2018 in the Lower Silver - Thompson Creek watershed.
2. The median CSCI and ASCI hybrid scores at sites in Lower Silver-Thompson Creek were generally lower than median scores for other Santa Clara Basin watersheds.
3. Consistently low CSCI scores may reflect generally poor habitat conditions within a highly modified creek in an urban watershed. ASCI hybrid scores showed more variability across sites, indicating that other stressors (e.g., water quality, nutrients) may be impacting benthic algae community at some locations.

Stressor Data

1. In general, total nitrogen and un-ionized ammonia concentrations increased across sites in an upstream to downstream direction.
2. Limited wet season samples suggest that concentrations of total phosphorus are higher in the wet season than in the spring season. Spring season total phosphorus concentrations were highest at the Thompson Creek location upstream from Lake Cunningham ; concentrations generally decreased between sample locations along Lower Silver Creek.
3. Nutrient concentrations at most sites in Lower Silver-Thompson Creek are at levels that are associated with eutrophic rivers and streams (Dobbs and Smith, 2016).
4. Biomass indicators (AFDM, chlorophyll a, macroalgae cover) were highly variable among the bioassessment sites, indicating that site conditions (e.g., exposure to sunlight, flow conditions) may be important factors influencing algae production.
5. Biomass indicators were measured during spring season. Sampling was not conducted during the late summer season, when sunlight, temperature and flow conditions may be more conducive to the development of eutrophic conditions.
6. Physical habitat data indicate that a majority of the sites were deep, slow moving, and with a high percentage of sand and fine substrate at the time that data were collected.
7. Continuous water quality data were not available to evaluate as an indicator for eutrophication conditions.

Association of Stressors and Biological Conditions and Physical Habitat

8. Existing data indicate that different stressors may be impacting biological conditions at the different CSM bioassessment sites.
9. Biological indices results (CSCI, ASCI) in the Lower Silver - Thompson Creek watershed do not appear to be correlated to site elevation or flow regime.
10. Shallow physical habitat conditions (lower width to depth ratios) were significantly correlated with percent macroalgae cover.

3.3 Candidate Causes

Based on the available information, the candidate causes, or stressors, for poor biological conditions to be evaluated in the Lower Silver - Thompson Creek SSID Project include:

- Elevated nutrient (N, P) concentrations
- Increase in biomass (algae production)
- Water quality (changes to dissolved oxygen, pH)
- Altered physical habitat and stream flow

The focus of the SSID Project will be on evaluating sources of and impacts from nutrients. However, additional stressors associated with altered physical habitat and water quality will also be assessed. As shown in Figure 11, many of these stressors are interrelated. For example, physical habitat (channel) alteration can lead to increased delivery and/or residence time of nitrogen and phosphorus to the receiving water. And increased algal growth as a result of increased nutrient concentrations in the water can lead to reduced dissolved oxygen concentrations.

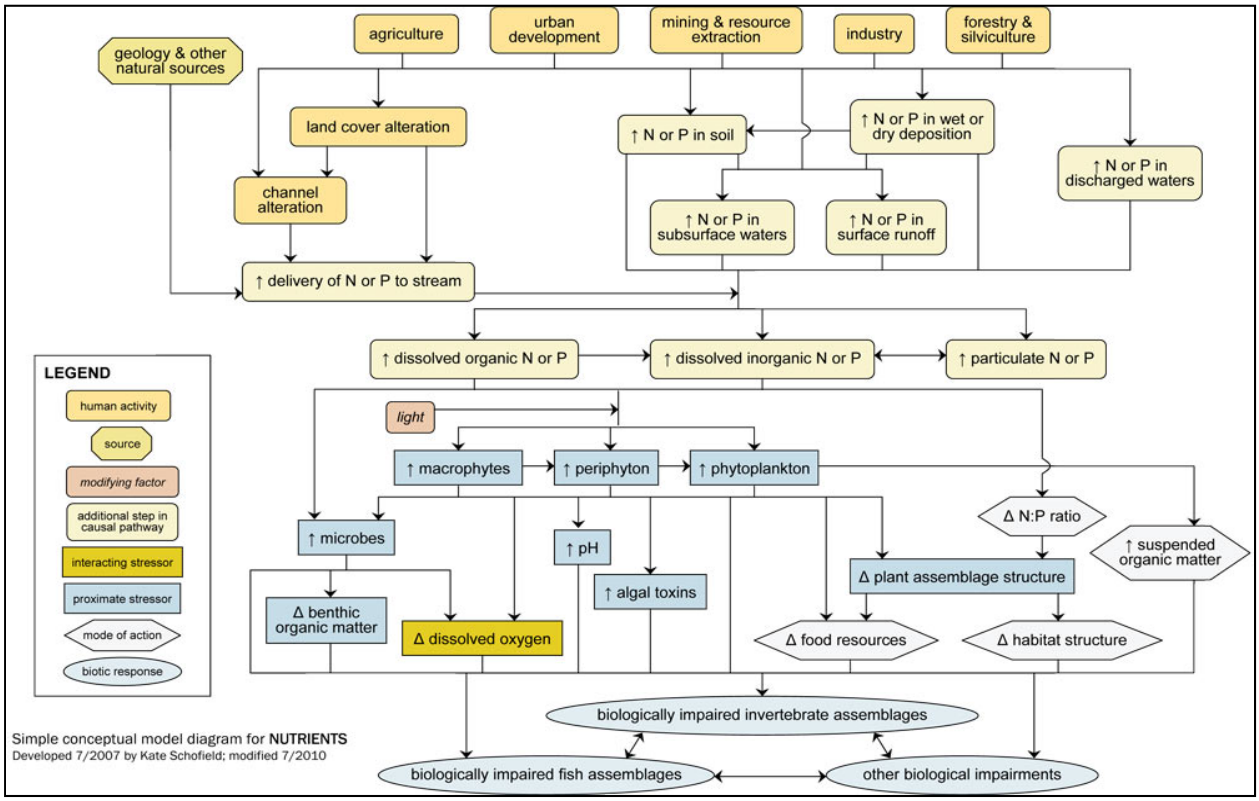


Figure 11. Conceptual model showing different causal pathways for nutrients to impact biological communities.

4 SSID MONITORING APPROACH AND SCHEDULE

The monitoring program described in this section has been designed to collect data in support of the study objectives outlined in Section 2.2 of this work plan. The program will consist of the following field data collection components:

- Nutrient Source Study
- Continuous Water Quality and Temperature Monitoring
- Biological Conditions Evaluation
- Eutrophication Assessment

The proposed schedule for each of these components is presented in Table 7 and the proposed approach is discussed in the sections below. The data will be evaluated to determine potential sources of nutrients in the watershed which can then inform potential management actions to reduce nutrient levels in the Lower Silver – Thompson Creek watershed. The monitoring data will also be evaluated to determine what, if any, correlation may existing between biological conditions and the stressor data (e.g., biomass, low dissolved oxygen).

4.1 Sample Frequency

Field sampling will occur over three seasonal time periods across two water years: dry season (WY 2019), and both spring and dry season (WY 2020) (Table 7). Water chemistry (nutrient) sampling and continuous water quality monitoring will occur during all three seasonal periods. Two nutrient sampling events will occur during both dry seasons, but only one event is planned during the spring season. The first nutrient dry season event will occur at 9 sampling locations; the subsequent sampling events will occur at 6 locations (Table 7). The continuous water quality and temperature monitoring will occur at 3 locations for all sampling periods. The biological assessments will occur at six locations during the spring of WY 2020. Eutrophication assessment will occur at the same six locations during the dry season of 2020.

Table 7. SSID Work Plan Field Data Collection Components and Schedule.

Sampling Timeframe	Water Chemistry (Nutrients)	Continuous Water Quality Monitoring	Continuous Temperature	Biological Conditions Evaluation	Eutrophication Assessment
Dry Season (WY 2019)	9 (2X)	3	3	-	-
Spring Season (WY 2020)	6	3	3	6	-
Dry Season (WY 2020)	6 (2X)	3	3	-	6
Total Samples	30	9	9	6	6

WY = water year .

4.2 Sampling Locations

The nutrient monitoring sites will be established within stream reaches that represent different channel types (flood control, natural) and hydrologic conditions (outfalls, tributary confluences). Proposed study reaches are presented in Table 8. Existing monitoring stations previously sampled by the Program as part of CSM or POC monitoring activities are shown in Figure 12. Potential new monitoring stations are indicated for study reaches above and below Lake Cunningham that do not have existing data (sites T-1 and T-2). All sampling stations will be confirmed following a field reconnaissance to verify that flow conditions are suitable for collecting water samples and/or conducting biological assessments. Additional sites may be added where suspected sources (e.g., outfall discharges) are observed. There may be no sampling locations in the lower section of Thomspon Creek (Quimby Road to Yerba Buena), due to intermittent flow conditions.

Table 8. Proposed study reaches and monitoring locations for Lower Silver – Thompson SSID Project.

Creek	Study Reach	Potential Sample Location ID	Channel Type	Major Tributaries	Number of Outfalls > 36 inch diameter	Potential Nutrient Sources
Lower Silver Creek	Coyote Cr to I-680	3795, 979	Mix of Concrete channel and earth levee; flood control project completed 2005	Miguelita Creek	6	Residential; industrial land uses; illegal encampments
	I-680 to Cunningham Ave	2771, 467	Earth levee; flood control project completed 2017	Babb Cr	4	Residential
	Cunningham Ave to Tully Rd	T-1	Channel adjacent to Lake Cunningham; earth levee; flood prone area with mature riparian forest	Flint Creek; Ruby Creek	2	Lake Cunninham (overflow; groundwater)
	Tully Rd to Quimby Rd	T-2	Wetland type channel; sediment depositional area	Norwood Cr	3	Depositional Area/wetland
Thompson Creek	Quimby Rd to Yerba Buena Rd	915	Intermittent; incised with eroding banks;	Quimby Cr; Evergreen Cr	3	Residential/ Commercial
	Yerba Buena Rd to Silver Creek Rd	4418	Mostly flowing; meandering channel, narrow riparian buffer	Yerba Buena Cr, Cribari Cr	2	Residential; Golf Course
	Upstream Silver Creek Rd	4537	Rangeland	Dry Creek	0	Agriculture and range land

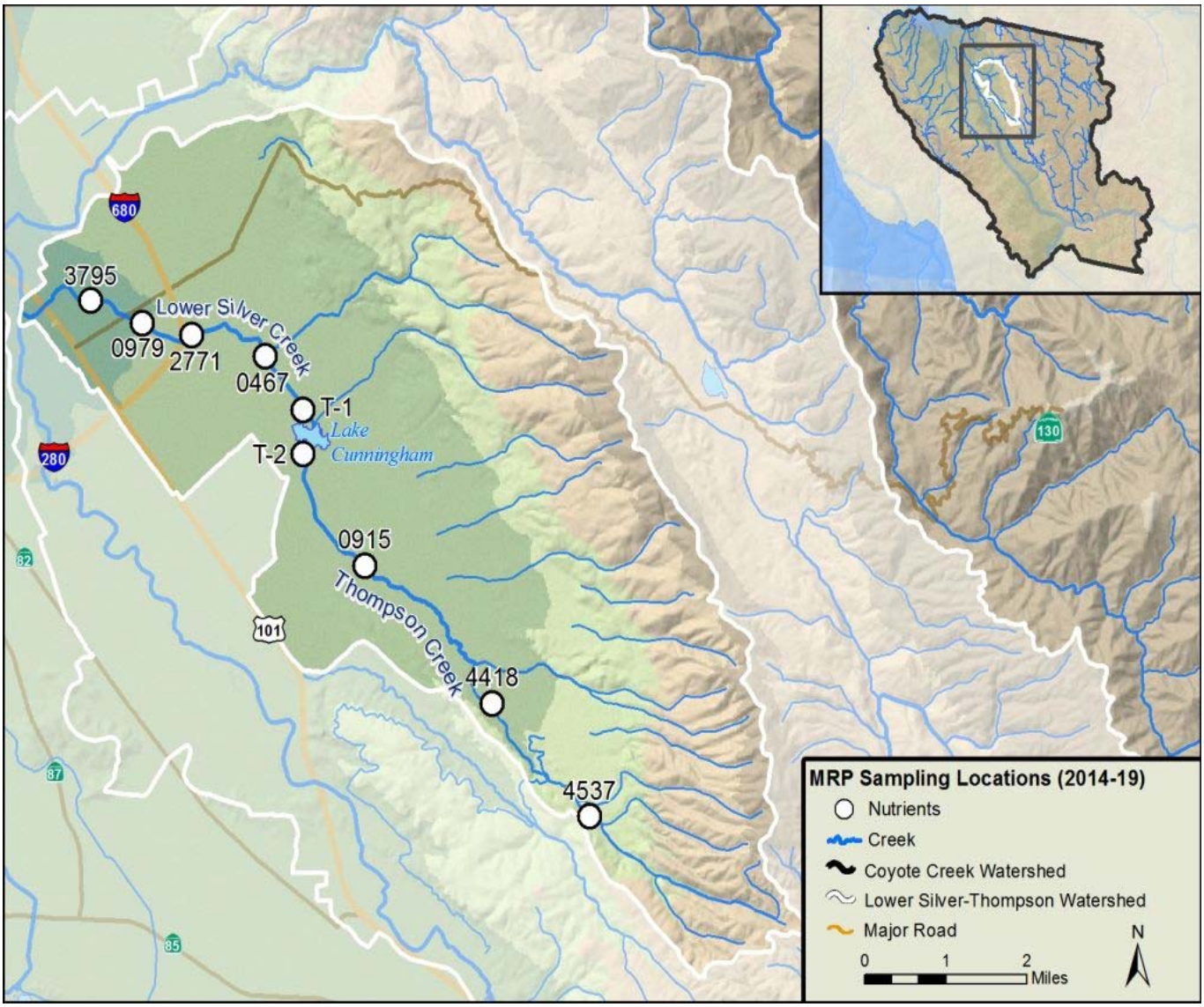


Figure 12. Proposed locations for water sampling and benthos/habitat assessment in Lower Silver-Thompson Creek.

4.3 Field Methods

4.3.1 Water Chemistry (nutrients)

Water samples will be collected at sites for nutrients and conventional analytes using the Standard Grab Sample Collection Method (BASMAA 2016a). Sample containers are rinsed using ambient water and completely filled and recapped below water surface whenever possible. An intermediate container is used to collect water for all sample containers with preservative already added in advance by the laboratory. A syringe filtration method is used to collect samples for analyses of Dissolved Ortho-Phosphate and Dissolved Organic Carbon. All sample containers will be labeled and stored on ice for transportation to laboratory.

4.3.2 Continuous Water Quality and Temperature Monitoring

Water quality monitoring equipment recording dissolved oxygen, temperature, conductivity, and pH at 15-minute intervals (YSI 6600 data sondes) will be deployed for 7-10 day period during each sampling event. Procedures used for calibrating, deploying, programming and downloading data are described in BASMAA (2016a).

Digital temperature loggers (Onset HOBO Water Temp Pro V2) will be programmed to record data at 60-minute intervals. The loggers will have pressure transducers to record water depths at same intervals as temperature data. Procedures used for calibrating, deploying, programming and downloading data are described in BASMAA (2016a).

4.3.3 Biological Conditions Evaluation

Each bioassessment sampling site will consist of an approximately 150-meter stream reach that will be divided into 11 equidistant transects placed perpendicular to the direction of flow. Benthic macroinvertebrate (BMI) and algae samples will be collected at 11 evenly spaced transects using the Reachwide Benthos (RWB) method described in the SWAMP SOP (Ode et al. 2016). The full suite of physical habitat data will be collected within the sample reach.

Biological samples will be sent to laboratories for analysis. The laboratory analytical methods for BMIs will follow Woodward et al. (2012), using the Southwest Association of Freshwater Invertebrate Taxonomists (SAFIT) Level 1 Standard Taxonomic Level of Effort, with the additional effort of identifying chironomids (midges) to subfamily/tribe instead of family (Chironomidae). Soft algae and diatom samples will be analyzed following SWAMP protocols (Stancheva et al. 2015).

4.3.4 Eutrophication Assessment

The eutrophication assessment will include two components. The first component will be to conduct field reconnaissance at each of the study reaches to determine if eutrophic conditions are present (e.g., evidence of algal blooms, fish kills). A hand-held sonde will be used to take grab samples to measure water quality conditions. Sites of algal blooms and/or fish kills will be recorded on a map.

The second component will include a modified bioassessment method that includes only the collection of benthic algae and a physical habitat assessment (Ode et al. 2016). The benthic algae samples will be sent to laboratories for analysis of taxonomic composition and ash free dry mass and chlorophyll a.

4.4 Testing and Analytical Methods

Water chemistry samples will be analyzed using the methods and reporting limits shown in Table 9.

Table 9. Analytical constituents, methods and reporting limits used for water and biogical samples collected for the Lower Silver-Thompson Creek SSID Project.

Analyte	Method	CalTest MRL	Units
Water			
Phosphorus, Total	SM 4500-PE	0.01	mg/L
Orthophosphate as Phosphorus (dissolved)	SM 4500-PE	0.01	mg/L
Nitrogen, Total Kjeldahl	SM 4500-NH_3 C	0.1	mg/L
Nitrate as Nitrogen	EPA 300.0	0.05	mg/L
Nitrite as Nitrogen	SM4500-NO_2 B	0.005	mg/L
Ammonia as Nitrogen	SM 4500-NH_3 C	0.02	mg/L
Benthic			
Benthic Macroinvertebrates	SWAMP Bioassessment SOP (2016)	Not specified	
Benthic Algae			
Chlorophyll a	SM 10200 H-2b	5	mg/L
Ash Free Dry Weight	CALTEST B-AFDW	2	mg/L

4.5 Data Analysis Methods

The BMI and algae data will be used to assess the biological condition (i.e., aquatic life Beneficial Uses) of the sampled reaches using condition index scores described in SCVURPPP (2019). Physical habitat data will be used to characterize physical habitat conditions using a multimetric index scoring tool (SCVURPPP 2019). Physical habitat and water chemistry data will also be evaluated as potential stressors to biological health using triggers and water quality objectives identified in the MRP and existing thresholds from literature (Dobbs et al. 2016, Mazor et al. (in preparation)).

The association of stressors with biological indicator scores will be evaluated using simple regression models. Linear regressions will be tested between variables within each of the stressor data types (e.g., physical habitat and water chemistry) and biological conditions indicators (i.e., CSCI and ASCI scores). Scatter plots showing trend lines will be presented for some of the variables to show positive or negative correlation.

Potential sources of nutrients to the Lower Silver – Thompson creek will be identified using available land use data and observations collected during field work. Relationships between potential sources and nutrient concentrations and biological conditions as well as other physical habitat will be evaluated qualitatively and quantitively, to the extent possible.

4.6 Quality Assurance

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

4.7 Reporting

The Program will prepare a Final Report with data results and interpretation as an attachment to the WY 2020 Urban Creeks Monitoring Report, which will be submitted to the Water Board on March 31, 2021.

5 REFERENCES

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Santa Clara Valley
Urban Runoff
Pollution Prevention Program

Watershed Monitoring and Assessment Program



Integrated Monitoring Report

Part D: Pollutants of Concern Monitoring Report

Water Years 2014 - 2019

Submitted in compliance with Provision C.8.h.v of NPDES Permit No. CAS612008,
Order No. R2-2015-049

March 31, 2020

PREFACE

In early 2010, several members of the Bay Area Stormwater Agencies Association (BASMAA) joined together to form the Regional Monitoring Coalition (RMC), to coordinate and oversee water quality monitoring required by the Municipal Regional National Pollutant Discharge Elimination System (NPDES) Stormwater Permit (in this document the permit is referred to as the MRP). The RMC includes the following participants:

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

This Integrated Monitoring Report (IMR) Part D complies with MRP provision C.8.h.v for reporting of all Pollutant of Concern (POC) monitoring data since the previous IMR was submitted in March 2014 (SCVURPPP 2014a). Data were collected pursuant to provision C.8.f of the MRP. Data presented in this report were produced under the direction of the RMC and the Santa Clara Basin Urban Runoff Pollution Prevention Program (SCVURPPP).

Monitoring data were collected in accordance with the BASMAA RMC Quality Assurance Project Plan (QAPP; BASMAA, 2016a) and the BASMAA RMC Standard Operating Procedures (SOPs; BASMAA, 2016b). Where applicable, monitoring data were derived using methods comparable with methods specified by the California Surface Water Ambient Monitoring Program (SWAMP) QAPP. Data presented in this report were also submitted in electronic SWAMP-comparable formats by SCVURPPP to the San Francisco Bay Regional Water Quality Control Board (SFBRWQCB) on behalf of SCVURPPP Co-permittees and pursuant to provision C.8.h.ii of the MRP.

LIST OF ACRONYMS

ACCWP	Alameda Countywide Clean Water Program
AFR	Alternative Flame Retardant
BASMAA	Bay Area Stormwater Management Agency Association
BASMAA BOD	BASMAA Board of Directors
BLM	Biotic Ligand Model
BMP	Best Management Practice
BSM	Bioretention Soil Media
CADDIS	Causal Analysis/Diagnosis Decision Information System
CASQA	California Stormwater Quality Association
CCCWP	Contra Costa Clean Water Program
CEC	Chemicals of Emerging Concern
CEDEN	California Environmental Data Exchange Network
CW4CB	Clean Watersheds for a Clean Bay
DDT	Dichloro-diphenyl-trichloroethane
DPR	California Department of Pesticide Regulation
DQO	Data Quality Objectives
ECWG	Emerging Contaminant Workgroup
EDD	Electronic Data Deliverable
EPA	Environmental Protection Agency
FSURMP	Fairfield Suisun Urban Runoff Management Program
GIS	Geographic Information Systems
GSI	Green Stormwater Infrastructure
HDS	Hydrodynamic Separator
HgT	Total Mercury
HSPF	Hydrologic Simulation Program FORTRAN
IMR	Integrated Monitoring Report
ISWEBE	Inland Surface Water, Enclosed Bays and Estuaries
LSPC	Loading Simulation Program in C++
MPC	Monitoring and Pollutants of Concern Committee
MRP	Municipal Regional Permit
MS4	Municipal Separate Storm Sewer System
MYP	Multi-Year Plan
ND	Non-detect
NMS	Nutrient Management Strategy
NNE	Nutrient Numeric Endpoints
NPDES	National Pollution Discharge Elimination System
PAHs	Polycyclic Aromatic Hydrocarbons
PBDEs	Polybrominated Diphenyl Ethers
PCBs	Polychlorinated Biphenyls
PFAS	Perfluoroalkyl and Polyfluoroalkyl Substances

PFOS	Perfluorooctane Sulfonate
PMT	Project Management Team
POC	Pollutant of Concern
POTW	Publicly Owned Treatment Works
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
RAA	Reasonable Assurance Analysis
RMC	Regional Monitoring Coalition
RMP	Regional Monitoring Program for Water Quality in San Francisco Bay
ROW	Right-of-Way
RWSM	Regional Watershed Spreadsheet Model
SAP	Sampling and Analysis Plan
SCVURPPP	Santa Clara Valley Urban Runoff Pollution Prevention Program
SFEI	San Francisco Estuary Institute
SFBRWQCB	San Francisco Bay Regional Water Quality Control Board
SMCWPPP	San Mateo Countywide Water Pollution Prevention Program
SOP	Standard Operating Procedures
SPLWG	Sources, Pathways, and Loadings Workgroup
SPoT	Statewide Stream Pollutant Trend Monitoring
SSC	Suspended Sediment Concentration
SSID	Stressor/Source Identification
STLS	Small Tributary Loading Strategy
STORMS	Strategy to Optimize Resource Management of Stormwater
SWAMP	Surface Water Ambient Monitoring Program
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TOC	Total Organic Carbon
TRC	Technical Review Committee
UCMR	Urban Creeks Monitoring Report
USEPA	US Environmental Protection Agency
USGS	US Geological Survey
WLA	Wasteload Allocation
WMA	Watershed Management Area
WQAS	Water Quality Attainment Strategy
WQO	Water Quality Objective
WY	Water Year

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Attachment D.5.	DRAFT - Santa Clara Basin Reasonable Assurance Analysis Addressing PCBs and Mercury: Phase I Baseline Modeling Report. Paradigm Environmental, January 31, 2020

1. INTRODUCTION

This Integrated Monitoring Report (IMR) Part D: Pollutants of Concern (POC) Monitoring Water Year[1] (WY) 2014 through WY 2019 was prepared by the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP or Program), on behalf of its 15 member agencies (13 cities/towns, the County of Santa Clara, and the Santa Clara Valley Water District) subject to the National Pollutant Discharge Elimination System (NPDES) stormwater permit for Bay Area municipalities referred to as the Municipal Regional Permit (MRP).

The MRP was first adopted by the San Francisco Bay Regional Water Quality Control Board (SFBRWQCB or Regional Water Board) on October 14, 2009 as Order R2-2009-0074 (referred to as MRP 1.0, SFBRWQCB 2009). On November 19, 2015, the Regional Water Board updated and reissued the MRP as Order R2-2015-0049 (referred to as MRP 2.0, SFBRWQCB 2015). This report fulfills the requirements of Provision C.8.h.v of MRP 2.0 for comprehensively interpreting and reporting all POC monitoring data collected since the previous IMR was submitted in March 2014 (BASMAA 2014a). Data were collected pursuant to water quality monitoring requirements in provision C.8 of the MRP. Monitoring data presented in this report were submitted electronically to the Regional Water Board by SCVURPPP and, if collected from a receiving water, may be obtained via the California Environmental Data Exchange Network (CEDEN) (http://www.ceden.org).

This report is organized according to the following sections:

1. **Introduction.** This section presents a summary of the POC monitoring requirements in both MRP 1.0 and MRP 2.0. This section also presents an overview of all the POC monitoring conducted in the Santa Clara Basin between WY 2014 through WY 2019, identifies the groups responsible and the types of monitoring conducted by each group.
2. **POC Loads Monitoring – WY 2014.** This section presents an overview of the POC loads monitoring program conducted in compliance with Provision C.8.e of MRP 1.0 and presents a summary of the data collected at two Santa Clara County stations in WY 2014.
3. **POC Monitoring Results – WY 2015 – WY 2019.** This section describes all POC monitoring conducted by SCVURPPP and its water quality partners in the Santa Clara Basin in compliance with Provisions C.8.e (MRP 1.0) and C.8.f (MRP 2.0), between WY 2015 and WY 2019. The results from WY 2015 – WY 2018 POC monitoring are summarized in this section. The results from WY 2019 POC monitoring are presented in detail.
4. **Stream Pollution Trend (SPoT) Monitoring Program.** This section presents an overview of the SPoT monitoring program conducted to evaluate POC trends in compliance with MRP 1.0 (C.8.e) and MRP 2.0 (C.8.f). This section summarizes the data collected by the SPoT Program at two Santa Clara County sites over the past seven years.

[1] Most hydrologic monitoring occurs for a period defined as a water year, which begins on October 1 and ends on September 30 of the named year. For example, water year 2019 (WY 2019) began on October 1, 2018 and concluded on September 30, 2019.

5. **Comparison to Applicable Water Quality Standards.** This section provides a comparison of the POC monitoring results collected by the Program in compliance with MRP 2.0 (WY 2016 – WY 2019) with applicable water quality standards.
6. **Conclusions and Recommendations.** This section summarizes the conclusions presented in earlier sections and identifies POC monitoring next steps and recommendations for the future.
7. **References.** This section provides all the references cited within this report.

Several of the topics identified above are summarized in this report, but described more fully in the attachments.

1.1. POC Monitoring Requirements

MRP Provision C.8 requires water quality monitoring for POCs, including polychlorinated biphenyls (PCBs), copper, nutrients, and emerging contaminants. The specific POC monitoring requirements in MRP 1.0 are applicable to monitoring conducted in WY 2014 and WY 2015. The POC monitoring requirements in MRP 2.0 provision C.8 are applicable to WY 2016 through WY 2019. Under both MRP 1.0 and MRP 2.0, Permittees may comply with the monitoring requirements of Provision C.8 through a regional collaborative effort, their Stormwater Program, and/or individually.

1.1.1. MRP 1.0

Specific monitoring requirements were detailed in MRP 1.0 Provision C.8.e for POC and Long-term trends monitoring. POC monitoring under MRP 1.0 was intended to assess inputs of POCs to the Bay from local tributaries and urban runoff, assess progress toward achieving wasteload allocations (WLAs) for Total Maximum Daily Loads (TMDLs), and help resolve uncertainties associated with loading estimates for these pollutants. The four priority management questions that were addressed though POC loads monitoring included the following:

1. Which Bay tributaries (including stormwater conveyances) contribute most to Bay impairment from POCs?
2. What are the annual loads or concentrations of POCs from tributaries to the Bay?
3. What are the decadal-scale loading or concentration trends of POCs from small tributaries to the Bay?
4. 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?

Provision C.8.e required Permittees to conduct POC monitoring to address each of the four priority management questions. The required sampling parameters and frequencies were detailed in Provision C.8.e (iii), Table 8.4 and summarized here. Requirements included:

- A minimum sampling occurrence of 4 wet weather events per year (on average) for Category 1 parameters, including PCBs, total mercury, methyl mercury, total and dissolved copper, suspended sediments (SSC), total organic carbon (TOC), nitrate, and hardness.

- A minimum sampling occurrence of 2 wet weather events per year for Category 2 (lower priority) parameters, including total and dissolved selenium, total and dissolved phosphorus, polybrominated diphenyl ethers (PBDEs), polycyclic aromatic hydrocarbons (PAHs), dichloro-diphenyl-trichloroethane (DDTs), chlordane, pyrethroids, carbaryl and fipronil.
- A minimum sampling occurrence of once per year for Category 3 parameters including toxicity and pollutants in fine-grained, bedded sediment.

Additional details about required POC and long-term trends monitoring, including parameters, methods, intervals and occurrences, and monitoring locations were identified in more detail in MRP 1.0 provision C.8.e (i) – C.8.e (vii).

1.1.2. MRP 2.0

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

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

The MRP specifies the minimum number of samples that must be collected and analyzed for each POC. For example, over the first five years of the permit (i.e., WY 2016 – WY 2020), a minimum total of 80 PCBs samples must be collected and analyzed and at least eight PCBs samples must be collected each year. The MRP also specifies the minimum number of samples for each POC that must address each Management Question. For example, by the end of Year Four of the permit term (i.e., WY 2019), each of the five Management Questions must be addressed with at least eight PCBs samples. It is possible that a single sample can address more than one Management Question. POC Monitoring requirements under MRP 2.0 are summarized in Table 1.1.

Table 1.1. MRP 2.0 Provision C.8.f pollutants of concern monitoring requirements for SCVURPPP Co-permittees.

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

a. Ammonium[2], nitrate, nitrite, total Kjeldahl nitrogen, orthophosphate, total phosphorus (analyzed concurrently in each nutrient sample).

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

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

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

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

- **Provisions C.11.a.iii and C.12.a.iii** require that Permittees provide a list of management areas (referred to in this report as Watershed Management Areas, or WMAs) in which new mercury and PCB control measures will be implemented during the permit term, as well as the monitoring data and other information used to select the watersheds. Progress toward developing the list was reported on April 1, 2016 (SCVURPPP, 2016a) and a more complete list with identified control measures is provided with each Annual Report, beginning with the 2016 Annual Report that was submitted on September 30, 2016. Provision C.8.f (POC Monitoring) is intended to support C.11/12 requirements by requiring monitoring directed toward source identification (i.e., identifying which sources or watershed source areas provide the greatest opportunities for implementing cost-effective controls to reduce loads of POCs in urban stormwater runoff).

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

- **Provision C.12.e** requires that Permittees collect at least 20 composite samples (region-wide) of the caulks and sealants used in storm drains or roadway infrastructure in public rights-of-way and report on the results of the investigation no later than the 2018 Annual Report. To achieve compliance with this provision, MRP Permittees agreed to collectively conduct this sampling via the Bay Area Stormwater Management Agencies Association (BASMAA).

- **Provisions C.11.c and C.12.c** require that Permittees submit a Reasonable Assurance Analysis to demonstrate quantitatively that mercury reductions of at least 10 kg/yr and PCBs reductions of at least 3 kg/yr will be realized by 2040 through implementation of green infrastructure projects. Although these provisions will be met through modeling, POC monitoring focused on management action effectiveness is helping to inform the models. To learn more about the effectiveness of selected stormwater treatment controls, MRP Permittees collectively conducted monitoring studies through BASMAA.

1.2. POC Monitoring in the Santa Clara Basin

POC Monitoring in the Santa Clara Basin is conducted by SCVURPPP and its water quality partners, including the BASMAA Regional Monitoring Coalition (RMC), the Regional Monitoring Program for Water Quality in the San Francisco Bay (RMP), and the State of California's Surface Water Ambient Monitoring Program (SWAMP) Stream Pollution Trend (SPoT) monitoring program. SCVURPPP strives to work collaboratively with its water quality monitoring partners to find mutually beneficial monitoring approaches.

Figure 1.1 illustrates locations of monitoring stations associated with POC monitoring conducted by SCVURPPP and its water quality partners in WY2014 through WY2019 in compliance with MRP provision C.8. This figure illustrates the geographic extent of POC monitoring conducted in Santa Clara Basin since the previous IMR (i.e., WY 2014 – WY 2019).

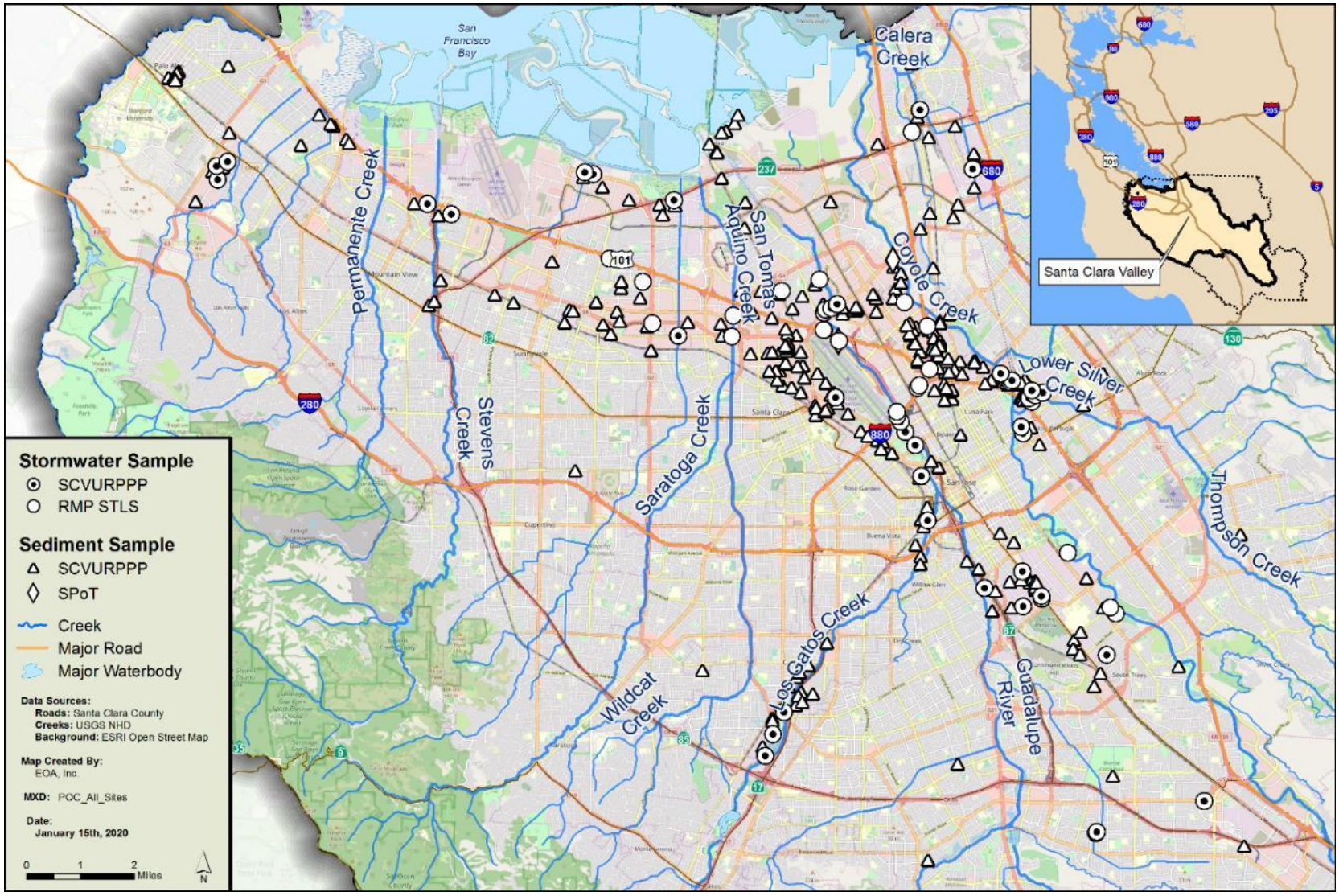


Figure 1.1. Locations of POC monitoring stations in Santa Clara County sampled between WY 2014 and WY 2019. Does not include locations of BASMAA project samples described in 3.2.3.

Additional information about each of these groups and the types of POC monitoring they conduct in the Santa Clara Basin is provided below.

1.2.1. SCVURPPP

SCVURPPP conducts monitoring for POCs, including PCBs, mercury, copper and nutrients. SCVURPPP's POC monitoring activities in WY 2014 through WY 2019 included the following:

- Continuation of monitoring at one POC loading station in WY 2014;
- POC monitoring for sources and source areas, including:
    - Implementation of a catchment-scale storm sampling program for PCBs and mercury in WY 2016 through WY 2019;
    - Implementation of a catchment-scale sediment sampling program for PCBs and mercury in WY 2015 through WY 2019;
- Collection of wet and dry weather samples for nutrients and copper analysis.

Summaries of these monitoring activities and detailed reporting for WY 2019 POC monitoring data are provided in Sections 2 and 3 of this report.

1.2.2. BASMAA RMC

Provision C.8.a (Compliance Options) of the MRP allows Permittees to address monitoring requirements through a "regional collaborative effort," their Stormwater Program, and/or individually. In June 2010, Permittees notified the Water Board in writing of their agreement to participate in a regional monitoring collaborative to address requirements in provision C.8. The regional monitoring collaborative is referred to as the BASMAA RMC. In a November 2, 2010 letter to the Permittees, the Regional Water Board's Assistant Executive Officer (Dr. Thomas Mumley) acknowledged that all Permittees have opted to conduct monitoring required by the MRP through a regional monitoring collaborative, the BASMAA RMC. Participants in the BASMAA RMC are listed in Table 1.2.

In February 2011, the RMC developed a Multi-Year Work Plan (BASMAA 2011) to provide a framework for implementing regional monitoring and assessment activities required under provision C.8 of MRP 1.0. The RMC Multi-Year Work Plan summarizes RMC projects planned for implementation between Fiscal Years 2009-10 and 2014-15. Projects were collectively developed by RMC representatives to the BASMAA Monitoring and Pollutants of Concern Committee (MPC), and were conceptually agreed to by the BASMAA Board of Directors (BASMAA BOD). Although there are no plans to update the Multi-Year Work Plan, regional projects to conduct POC monitoring relevant to provision C.8.f have been conducted in compliance with MRP 2.0.

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

Table 1.2. 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; Valley Water; and, Santa Clara County
Clean Water Program of Alameda County (ACCWP)	Cities of Alameda, Albany, Berkeley, Dublin, Emeryville, Fremont, Hayward, Livermore, Newark, Oakland, Piedmont, Pleasanton, San Leandro, and Union City; Alameda County; Alameda County Flood Control and Water Conservation District; and, Zone 7
Contra Costa Clean Water Program (CCCWP)	Cities of Antioch, Brentwood, Clayton, Concord, El Cerrito, Hercules, Lafayette, Martinez, Oakley, Orinda, Pinole, Pittsburg, Pleasant Hill, Richmond, San Pablo, San Ramon, Walnut Creek, Danville, and Moraga; Contra Costa County; and, Contra Costa County Flood Control and Water Conservation District
San Mateo County Wide Water Pollution Prevention Program (SMCWPPP)	Cities of Belmont, Brisbane, Burlingame, Daly City, East Palo Alto, Foster City, Half Moon Bay, Menlo Park, Millbrae, Pacifica, Redwood City, San Bruno, San Carlos, San Mateo, South San Francisco, Atherton, Colma, Hillsborough, Portola Valley, and Woodside; San Mateo County Flood Control District; and, San Mateo County
Fairfield-Suisun Urban Runoff Management Program (FSURMP)	Cities of Fairfield and Suisun City
Vallejo Permittees	City of Vallejo and Vallejo Sanitation and Flood Control District

The BASMAA RMC monitoring activities in Santa Clara Basin in WY 2014 through WY 2019 include the following:

- Continued participation in the RMP POC Loads Monitoring Program during WY 2014;
- Planning and coordination of POC monitoring for sources and source areas in WY 2015 through WY 2019;
- Implementation of a regional sampling program for PCBs in roadway and storm drain infrastructure caulk in WY 2017 through WY 2018;
- Implementation of a regional project to evaluate best management practices (BMPs) effectiveness for reduction of stormwater loads of PCBs and mercury in WY 2017 through WY 2018;

Summaries of these monitoring activities are provided in Sections 2 and 3 of this report.

1.2.3. Third-party Monitoring

Provision C.8.a.iii of the MRP allows Permittees to use data collected by third-party organizations to fulfill monitoring requirements, provided the data are demonstrated to meet the required data quality objectives. For example, samples collected in Santa Clara County through the RMP and the State's SPoT Monitoring Program may supplement the Program's efforts

towards achieving Provision C.8.f monitoring requirements. Third party monitoring conducted by the RMP and SPoT also provide context for reviewing and interpreting SCVURPPP monitoring results.

1.2.3.1. RMP Small Tributary Loading Strategy Monitoring

The Small Tributaries Loading Strategy (STLS) was developed by the RMP in 2009. The RMP STLS Team includes representatives from BASMAA, Regional Water Board staff, RMP staff, and technical advisors and is overseen by the RMP's Sources, Pathways, and Loadings Workgroup (SPLWG). The objective of the RMP STLS is to develop a comprehensive planning framework to coordinate POC monitoring/modeling between the RMP and RMC participants. With concurrence of participating Regional Water Board staff, the framework presents an alternative approach to the POC loads monitoring requirements described in MRP 1.0 Provision C.8.e.i, as allowed by Provision C.8.e. The framework is updated periodically with summaries of activities and products to date. The STLS Multi-Year Plan (MYP) was initially developed as an alternative POC monitoring program to the one described in MRP 1.0, and equally addresses the priority information needs identified in provision C.8.e. The RMP STLS MYP includes four main elements:

1. Watershed modeling (Regional Watershed Spreadsheet Model);
2. Bay Margins Modeling;
3. Source Area Runoff Monitoring; and
4. Small Tributaries Watershed Monitoring.

The RMP STLS Team typically conducts annual monitoring for POCs on a region-wide basis. SCVURPPP is an active participant in the RMP STLS and works with other Bay Area municipal stormwater programs to identify opportunities to direct RMP funds and monitoring activities towards addressing both short- and long-term municipal stormwater permit management questions. During WY 2012 – WY 2014 POC monitoring activities by the RMP STLS focused on pollutant loads monitoring at six region-wide stations. In WY 2015, the loading stations were discontinued and RMP STLS monitoring shifted to wet weather characterization in catchments of interest and other POC-related pilot and Special Studies identified below.

- Watershed characterization reconnaissance monitoring for POCs;
- Advanced analysis of PCBs data;
- Planning support for alternative flame retardants conceptual model;
- Development of a trends strategy;
- Regional Watershed Spreadsheet Model (RWSM) support; and
- Emerging contaminants.

Special Studies address specific scientific issues that RMP committees, workgroups, and strategy teams identify as priority for further study. These studies are developed through an open selection process at the workgroup level and selected for funding through the Technical Review Committee (TRC) and the Steering Committee. The pilot and special studies associated with the RMP STLS are intended to fill data gaps associated with loadings of POCs from relatively small tributaries to the San Francisco Bay.

The RMP STLS POC monitoring activities in the Santa Clara Basin in WY 2014 through WY 2019 include the following:

- Continuation of monitoring at one POC loads monitoring station in WY 2014;
- Continuation of coordination of field, lab analysis, Quality Assurance/Quality Control (QA/QC) review, and reporting for all POC loads monitoring stations in WY 2014;
- Continuation of opportunistic monitoring at the Guadalupe River POC loading station in WY 2017;
- POC monitoring for sources and source areas, including reconnaissance-style wet weather monitoring for PCBs and mercury at multiple locations in WY 2015 through WY 2019;
- Stormwater monitoring for emerging contaminants in WY 2019.

Summaries of these monitoring activities are provided in Sections 2 and 3 of this report.

1.2.3.2. SPoT Monitoring

The State's SWAMP currently monitors POCs at two long-term monitoring sites in Santa Clara County through its SPoT program. The goal of the SPoT program is to monitor trends in sediment toxicity and sediment contaminant concentrations in selected large rivers throughout California, and relate contaminant concentrations and toxicity to watershed land uses. Results from these large catchment stations provide context for the monitoring conducted by the Program.

The SPoT program monitoring activities in the Santa Clara Basin in WY 2014 through WY 2019 include the following:

- Long-term trends monitoring for PCBs, mercury and copper at the Coyote Creek and Guadalupe River stations.

A summary of POC monitoring results for these two Santa Clara County SPoT stations over the past seven years is included in Section 4 of this report.

2. POC LOADS MONITORING – WY 2014 RESULTS

During WY 2014, in compliance with Provision C.8.e of MRP 1.0, the Program, in collaboration with the BASMAA RMC and the RMP STLS continued to implement the agreed-upon alternative approach to the POC loads monitoring requirements of MRP 1.0. This alternative approach, which began in WY 2012, focused on intensive monitoring over multiple years at six "bottom-of-the watershed" stormwater monitoring stations across Bay Area Counties. The purpose of this monitoring was to accumulate data needed to calibrate the Regional Watershed Spreadsheet Model and assist in developing loading estimates from small tributaries for priority POCs. Monitoring was also intended to provide a limited characterization of additional lower priority analytes. The six POC loads monitoring stations are identified below.

1. Lower Marsh Creek (Contra Costa County), established WY2012
2. Guadalupe River (Santa Clara County), established WY2012
3. Lower San Leandro Creek (Alameda County), established WY2012
4. Sunnyvale East Channel (Santa Clara County), established WY2012
5. North Richmond Pump Station (Contra Costa County), established WY2013
6. Pulgas Creek Pump Station (San Mateo County), established WY2013

The stations in Lower Marsh Creek, Guadalupe River and Pulgas Creek Pump Station were operated by CCCWP, SCVURPPP, and SMCWPPP, respectively, on behalf of RMC participants. The stations in the Sunnyvale East Channel and North Richmond Pump Station were operated by the San Francisco Estuary Institute (SFEI) on behalf of the RMP STLS, as was the Lower San Leandro Creek Station in its first year before operation was transferred to ACCWP in summer 2012.

This section presents an overview of the monitoring methods used and summarizes the POC concentration data collected in WY 2014 at the Santa Clara County stations. The detailed methods and complete results and interpretation of all POC loads monitoring conducted by the RMP STLS team in WY 2012 through WY 2014 are presented in Gilbreath et al., 2016.

2.1. Monitoring Methods Overview

The two stations in Santa Clara County (Guadalupe River and Sunnyvale East Channel) are mapped on Figure 2.1. Stormwater monitoring was conducted for three years at these stations, beginning in WY 2012 and continuing through WY 2014. Monitoring methods implemented by SFEI at the Sunnyvale East Channel station are documented in the POC Loads Monitoring Report (Gilbreath et al. 2016). SCVURPPP followed the same instructions at the Guadalupe River station while allowing for minor modifications depending on site-specific conditions. During each monitored storm, composite samples and 4 discrete samples were collected at each station over the rising, peak and falling stages of the hydrograph. Samples collected were analyzed for multiple analytes (Table 2.1) consistent with the alternative monitoring approach outlined in BASMAA 2011 to comply with MRP 1.0 provision C.8.e. The turbidity of the water flowing through each station was recorded continuously during each of the entire wet weather seasons.

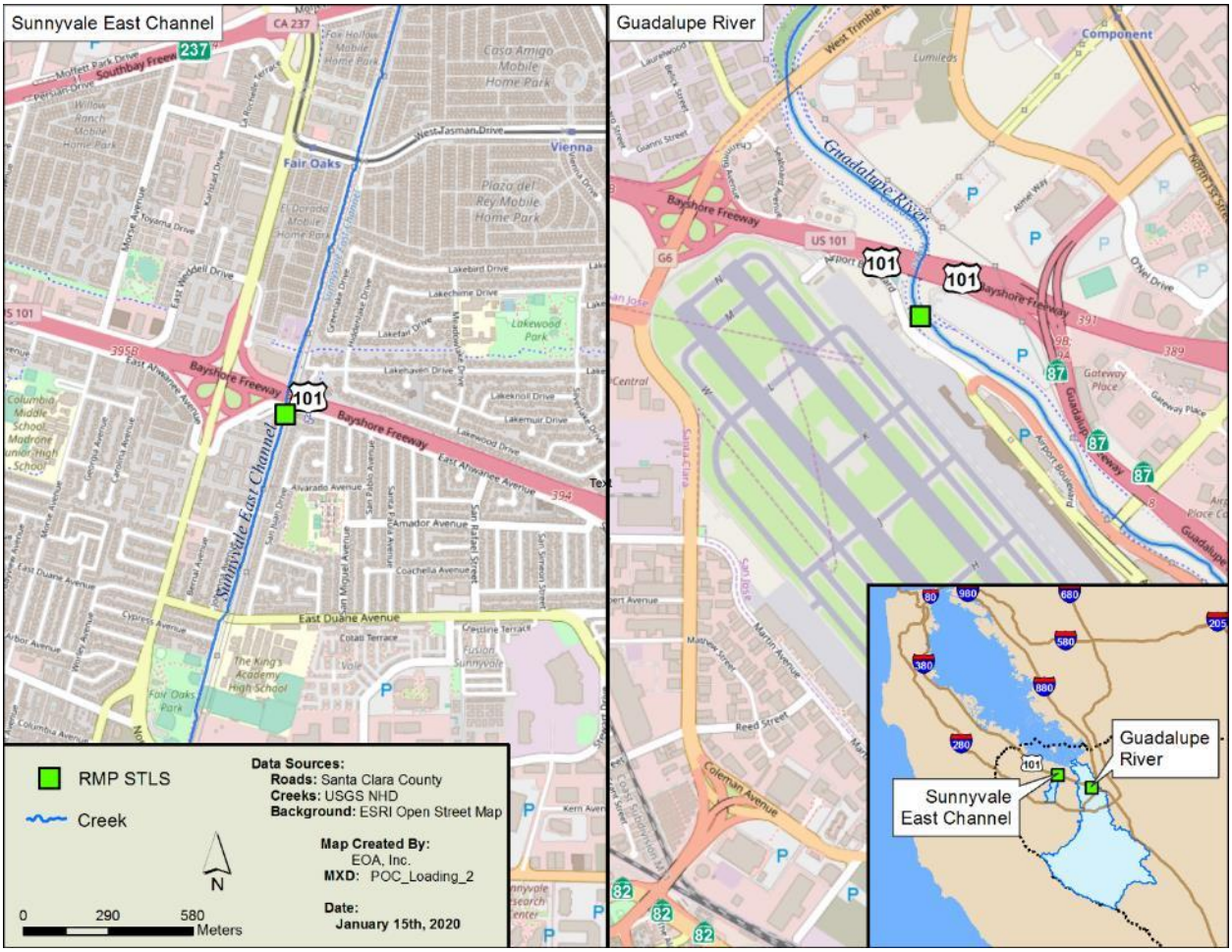


Figure 2.1. Locations of the MRP 1.0 POC loads monitoring stations in Santa Clara County, CA.

Laboratory analyses were implemented according to the BASMAA RMC Quality Assurance Project Plan (QAPP; BASMAA 2014a). For WY2014, BASMAA (on behalf of all RMC participants) contracted with SFEI to coordinate laboratory analyses, data management and data quality assurance. The goal was to ensure data consistency among all watershed monitoring stations.

Table 2.1. Laboratory analysis methods used by the RMP STLS team for POC loads monitoring in WY2014.

Analyte	Sample Type	Sample Count	Analytical Method	Analytical Laboratory
Carbaryl	Composite	1 per storm event	EPA 632M	DFC WPCL[a]
Fipronil	Composite	1 per storm event	EPA 619M	DFC WPCL
Suspended Sediment Concentration	Discrete	8 per storm event	ASTM D3977	Caltest
Total Phosphorus	Discrete	4 per storm event	SM4500-P E	Caltest
Nitrate	Discrete	4 per storm event	EPA 300.0	Caltest
OrthoPhosphate	Discrete	4 per storm event	SM 4500-P E	Caltest
PAHs	Discrete	1 per storm event	AXYS MLA-021 Rev 10	AXYS[b]
PBDEs	Discrete	1 per storm event	AXYS MLA-033 Rev 06	AXYS
PCBs	Discrete	4 per storm event	AXYS MLA-010 Rev 11	AXYS
Pyrethroids	Composite	1 per storm event	EPA 8270M_NCI	Caltest
Total Methylmercury	Discrete	4 per storm event	EPA 1630	Caltest
Total Mercury	Discrete	4 per storm event	EPA 1631E	Caltest
Copper	Composite	1 per storm event	EPA 1638	Caltest
Selenium	Composite	1 per storm event	EPA 1638	Caltest
Total Hardness	Composite	1 per storm event	SM 2340 C	Caltest
Total Organic Carbon	Discrete	4 per storm event	SM 5310 B	Caltest

[a] California Department of Fish and Game Water Pollution Control Laboratory

[c] AXYS Analytical Services Ltd.

2.2. Results

This section summarizes the results of the POC loads monitoring station data collected at the two Santa Clara County stations in WY 2014 to satisfy provisions C.8.d and C.8.g of MRP 1.0.

2.2.1. Statement of Data Quality

A comprehensive QA/QC program was implemented by SFEI covering all aspects of POC loads monitoring conducted in WY 2014. Data were assessed for seven data quality attributes, which include (1) Representativeness, (2) Comparability, (3) Completeness, (4) Sensitivity, (5) Contamination, (6) Accuracy, and (7) Precision. These seven attributes are compared to Data Quality Objectives (DQOs), which were established to ensure that data collected are of adequate quality and sufficient for the intended uses. Overall, the results of the QA/QC review indicated the data collected in WY 2014 at the POC loads monitoring stations in Santa Clara County were acceptable. A complete reporting on the project QA/QC review for WY 2014 data is provided in Gilbreath et al., 2016.

2.2.2. POC Concentrations

In WY 2014, the following monitoring was conducted at the two Santa Clara County POC loads monitoring stations:

- Six storms at the Sunnyvale East Channel Station
- Four storms at the Guadalupe River Station

The concentrations of all POCs measured at the Santa Clara County POC loads monitoring stations during WY 2014 are summarized in Tables 2.2 and 2.3.

Table 2.2. Summary of WY 2014 POC concentrations in stormwater measured at the POC loads monitoring station, Guadalupe River, San Jose.

Analyte	Units	Sample Count	Min	Max	Median	Mean	Standard Deviation
Carbaryl	ug/L	4	0.12	0.064	0.03	0.03	0.022
Fipronil	ug/L	4	0.008	0.015	0.015	0.013	0.003
Suspended Sediment Concentration	mg/L	54	5.8	358	110	150	102
Total Phosphorus	mg/L	16	0.11	1	0.48	0.46	0.27
Nitrate	mg/L	16	0.32	1.8	0.54	0.685	0.4
OrthoPhosphate	mg/L	16	0.11	0.5	0.17	0.22	0.13
PAHs	ng/L	2	692	1264	978	978	404
PBDEs	ng/L	2	97	101	99	99	3.18
PCBs	ng/L	16	3.1	33.1	11.4	14.6	11
Total Methylmercury	ng/L	10	0.09	1.2	0.58	0.61	0.37
Total Mercury	ug/L	15	0.045	0.74	0.13	0.21	0.19
Copper	ug/L	4	12	34	25.5	24.3	9.5
Selenium	ug/L	4	0.06	1.8	0.98	1.09	0.51
Total Hardness	mg/L	4	94	200	120	133.5	46
Total Organic Carbon	mg/L	16	5.3	56	12	19.3	17
Delta/Tralomethrin	ng/L	4	0	2.8	0.65	1.03	1.33
Cypermethrin	ng/L	4	1.1	5	1.65	2.35	1.8
Cyhalothrin lambda	ng/L	4	0	1.46	0.6	0.67	0.61
Permethrin	ng/L	4	7.2	14	10.6	10.6	3
Bifenthrin	ng/L	4	3.5	6.1	4.75	4.8	1.5

Table 2.3. Summary of WY 2014 POC concentrations in stormwater measured at the RMP STLS POC loads monitoring station, Sunnyvale East Channel, Sunnyvale CA.

Analyte	Units	Sample Count	Min	Max	Median	Mean	Standard Deviation
Carbaryl	ug/L	6	0	0.014	0	0.0023	0.006
Fipronil	ug/L	6	0.003	0.011	0.006	0.0068	0.003
Suspended Sediment Concentration	mg/L	75	0	514	125	173	134
Total Phosphorus	mg/L	23	0.11	0.92	0.36	0.41	0.21
Nitrate	mg/L	23	0.13	2.6	0.28	0.62	0.71
OrthoPhosphate	mg/L	23	0.006	0.285	0.13	0.15	0.069
PAHs	ng/L	4	382.5	2274	1664	1621	1262
PBDEs	ng/L	4	15.72	103	62	60.6	40.7
PCBs	ng/L	22	2.86	983	90.7	147	223
Total Methylmercury	ng/L	15	0	0.7	0.33	0.33	0.17
Total Mercury	ug/L	22	0.014	0.12	0.037	0.043	0.027
Copper	ug/L	6	11	21	18	16.5	4.1
Selenium	ug/L	6	0.33	1.9	0.55	0.71	0.59
Total Hardness	mg/L	6	92	340	100	146	97.5
Total Organic Carbon	mg/L	22	4.5	30	10.5	13.4	7.94
Delta/Tralomethrin	ng/L	6	0.6	3.25	1.13	1.42	0.95
Cypermethrin	ng/L	6	2.6	6	4.13	4.1	1.16
Cyhalothrin lambda	ng/L	5	0	0.6	0.3	0.31	0.21
Permethrin	ng/L	6	11	29	18.75	20	6.46
Bifenthrin	ng/L	6	2	18	5.3	7.6	5.94

Complete results of all POC loads monitoring conducted by the STLS team regionwide from WY 2012 – WY 2014, including estimated stormwater loads at each station, are presented in Gilbreath et al., 2016. The POC loads monitoring stations were mostly discontinued after WY 2014.

3. POC MONITORING RESULTS – WY 2015 - WY 2019

This section presents a summary of the POC monitoring and associated activities conducted in the Santa Clara Basin by the Program and its water quality partners in WY 2015 through WY 2019. POC monitoring in WY 2015 was conducted in compliance with MRP 1.0 Provision C.8.e. POC monitoring in WY 2016 through WY 2019 was conducted in compliance with MRP 2.0 Provisions C.8.f and C.11/12. The presentation of WY 2015 through WY 2019 POC monitoring results builds on a number of SCVURPPP reports that have been submitted previously to the Regional Water Board (SCVURPPP 2016a, 2016b, 2016c, 2017a, 2017b, 2017d, 2018a, 2018c, 2018d, 2019a, 2019 b and 2019c). In accordance with Provision C.8.h.iv, the POC monitoring locations, number and types of samples collected, purpose of sampling (i.e., Management Questions addressed), and analytes measured are provided in these previous reports and summarized below and in Attachment D.4. All monitoring conducted by the Program that is presented in this section was conducted in accordance with the SCVURPPP WY 2016 POC Sampling and Analysis Plan (SAP; SCVURPPP 2015b) which describes monitoring goals, methods, and QA/QC procedures. This section summarizes all the data collected between WY 2015 through WY 2018. WY 2019 monitoring accomplishments are presented in full detail below. Compliance with applicable water quality standards is described in Section 5.0.

3.1. Statement of Data Quality

A comprehensive QA/QC program was implemented by SCVURPPP covering all aspects of POC monitoring. Monitoring for PCBs, mercury, copper, and nutrients was performed according to protocols specified or referenced in the WY 2016 POC SAP (SCVURPPP 2015b). The Monitoring Plan references the Clean Watersheds for a Clean Bay (CW4CB) QAPP (BASMAA 2013) and the BASMAA RMC QAPP (BASMAA 2016a) as the basis for QA/QC procedures.

Data were assessed for representativeness, comparability, completeness, sensitivity, contamination, accuracy, and precision. These seven attributes are compared to DQOs, which were established to ensure that data collected are of adequate quality and sufficient for the intended uses. Overall, the results of the QA/QC review suggest that the POC monitoring data generated during WY 2015 through WY 2019 were of sufficient quality. However, some data were flagged in accordance with QA/QC protocols, and the following data were rejected:

- Mercury concentrations in stormwater runoff samples collected in WY 2017 were approximately an order of magnitude lower than prior years. These data were rejected by the project QA/QC officer based on comparison to the results of similar sampling of the same population of urban catchments in recent years by SCVURPPP and other Bay Area countywide stormwater programs.

Details of the QA/QC reviews for SCVURPPP monitoring data collected during WY 2015 – WY 2018 were presented previously (SCVURPPP 2016a, 2017a, 2018a, 2019a). Details of the QA/QC review for the Program's WY 2019 data are provided in Attachment D.1.

POC monitoring conducted by the RMP STLS was also subject to a comprehensive QA/QC program. The data were reviewed using the QAPP developed for the RMP (Yee et al., 2019). All data generated by the RMP STLS were of sufficient quality. The full results of the RMP STLS QA/QC reviews for WY 2015 – WY 2019 POC monitoring data are provided in Attachment D-2.

3.2. PCBs and Mercury

All POC monitoring for PCBs and mercury conducted in Santa Clara County in WY 2015 through WY 2019 is summarized in this section. This section also presents a summary of the estimated PCBs and mercury stormwater loads for the Santa Clara Basin.

The total number of samples collected for PCBs and mercury each year in WY 2015 through WY 2019, the agency conducting the monitoring, and the Management Questions addressed are listed in Tables 3.1 and 3.2, respectively. The locations and relative concentrations of PCBs and mercury concentrations measured in street dirt, MS4 sediment, and stormwater collected by SCVURPPP and third-party organizations are mapped on Figures 3.1 through 3.4. The MRP-required yearly minimum number of samples was met or exceeded each year for both PCBs and mercury.

A full report describing the results of all PCBs and mercury monitoring conducted by SCVURPPP to support source identification is included as Attachment D.2. A report describing the results of the wet weather characterization POC monitoring conducted by the RMP STLS in WY 2015 through WY 2019 is included as Attachment D.3. Attachment D.4 presents the results for all monitoring conducted by SCVURPPP and the RMP STLS in the Santa Clara Basin for PCBs and mercury in WY 2015 – WY 2019, including the identification and location of each monitoring station, the sample date, and the measured PCBs and mercury concentrations. A report describing the PCBs and mercury stormwater loads in Santa Clara Basin is included as Attachment D.5. Reports describing the results of BASMAA's Source Identification and BMP effectiveness studies were submitted previously to the Regional Water Board (BASMAA 2018, 2019a, 2019b).

Table 3.1. SCVURPPP and third-party PCBs monitoring accomplishments in WY 2015 through WY 2019.

Pollutant of Concern/ Organization	Number of PCBs Samples	Management Question Addressed[a]					Sample Type and Comments
		1. Source Identification	2. Contributions to Bay Impairment	3. Management Action Effectiveness	4. Loads and Status	5. Trends	
WY 2019							
SCVURPPP	15	15	15	--	15	15	Stormwater runoff samples to characterize WMAs
SCVURPPP	56	56	--	--	--	--	Sediment samples to identify source properties
RMP STLS	2	2	2	--	2	2	Stormwater runoff samples to characterize WMAs
SPoT	2	--	--	--	--	2	Sediment sample to assess long-term trends (PCBs only, no mercury)
WY 2018							
SCVURPPP	8	8	8	--	8	2	Stormwater runoff samples to characterize WMAs
SCVURPPP/BASMAA	5	5	--	--	--	--	Regional public infrastructure caulk/sealant samples (1/4 of project total)
SCVURPPP/BASMAA	8	--	--	8	--	--	Regional HDS unit & biochar effectiveness study (1/4 of project total)
RMP STLS	2	2	2	--	2	2	Stormwater runoff samples to characterize WMAs.
SPoT	--	--	--	--	--	--	Sediment sample to assess long-term trends (mercury only, no PCBs)
WY 2017							
SCVURPPP	16	16	16	--	16	--	Stormwater runoff samples to characterize WMAs
SCVURPPP	75	75	--	--	--	--	Sediment samples to identify source areas
RMP STLS	2	2	2	--	2	--	Stormwater runoff samples to characterize WMAs
RMP STLS	1	--	1	--	1	1	High flow sample collected in Guadalupe River
SPoT	2	--	--	--	--	2	Sediment sample to assess long-term trends
WY 2016							
SCVURPPP	9	9	9	--	9	--	Stormwater runoff samples to characterize WMAs
RMP STLS	6	6	6	--	6	--	Stormwater runoff samples to characterize WMAs
Sub-Total / MRP 2.0 Minimum[b]	*209 / 80*	*196 / 8*	*61 / 8*	*8 / 8*	*61 / 8*	*26 / 8*	
WY 2015							
SCVURPPP	202	202	--	--	--	--	Sediment samples to identify source areas.
RMP STLS	8	8	8	--	8	--	Stormwater runoff samples to characterize WMAs
SPoT	2	--	--	--	--	2	Sediment sample to assess long-term trends (PCBs only, no mercury)
Total – WYs 2015 – 2019	**421**	**406**	**69**	**8**	**69**	**28**	

[a] Individual samples can address more than one Management Question simultaneously.

[b] The MRP overall minimum number of samples must be met by the end of the five-year permit term. The MRP minimum number of samples for each Management Question must be met by the end of year four of the permit (i.e., 2019).

Table 3.2. SCVURPPP and third-party mercury monitoring accomplishments in WY 2015 – WY 2019.

Pollutant of Concern/ Organization	Number of PCBs Samples	Management Question Addressed[a]					Sample Type and Comments
		1. Source Identification	2. Contributions to Bay Impairment	3. Management Action Effectiveness	4. Loads and Status	5. Trends	
WY 2019							
SCVURPPP	15	15	15	--	15	15	Stormwater runoff samples to characterize WMAs
SCVURPPP	56	56	--	--	--	--	Upland sediment samples to identify source properties
RMP STLS	2	2	2	--	2	2	Stormwater runoff samples to characterize WMAs
SPoT	--	--	--	--	--	--	Sediment sample to assess long-term trends (PCBs only, no mercury)
WY 2018							
SCVURPPP	8	8	8	--	8	2	Stormwater runoff samples to characterize WMAs
SCVURPPP/BASMAA	5	5	--	--	--	--	Regional public infrastructure caulk/sealant samples (1/4 of project total)
SCVURPPP/BASMAA	8	--	--	8	--	--	Regional HDS unit & biochar effectiveness study (1/4 of project total)
RMP STLS	2	2	2	--	2	2	Stormwater runoff samples to characterize WMAs.
SPoT	2	--	--	--	--	2	Sediment sample to assess long-term trends (mercury only, no PCBs)
WY 2017							
SCVURPPP	16	16	16	--	16	--	Stormwater runoff samples to characterize WMAs
SCVURPPP	75	75	--	--	--	--	Upland sediment samples to identify source properties
RMP STLS	2	2	2	--	2	--	Stormwater runoff samples to characterize WMAs
RMP STLS	14	--	14	14	14	41	High flow sample collected in Guadalupe River
SPoT	1	--	--	--	--	1	Sediment sample to assess long-term trends
WY 2016							
SCVURPPP	9	9	9	--	9	--	Stormwater runoff samples to characterize WMAs
RMP STLS	6	6	6	--	6	--	Stormwater runoff samples to characterize WMAs
Total /MRP Minimum[b]	221 / 80	196 / 8	74 / 8	22 / 8	74 / 8	65 / 8	
WY 2015							
SCVURPPP	202	202	--	--	--	--	Sediment samples to identify source areas.
RMP STLS	8	8	8	--	8	--	Stormwater runoff samples to characterize WMAs
SPoT	2	--	--	--	--	2	Sediment sample to assess long-term trends (mercury only, no PCBs)
Total – WYs 2015 – 2019	**421**	**406**	**82**	**22**	**82**	**67**	

[a] Individual samples can address more than one Management Question simultaneously.

[b] The MRP overall minimum number of samples must be met by the end of the five-year permit term. The MRP minimum number of samples for each Management Question must be met by the end of year four of the permit (i.e., 2019).

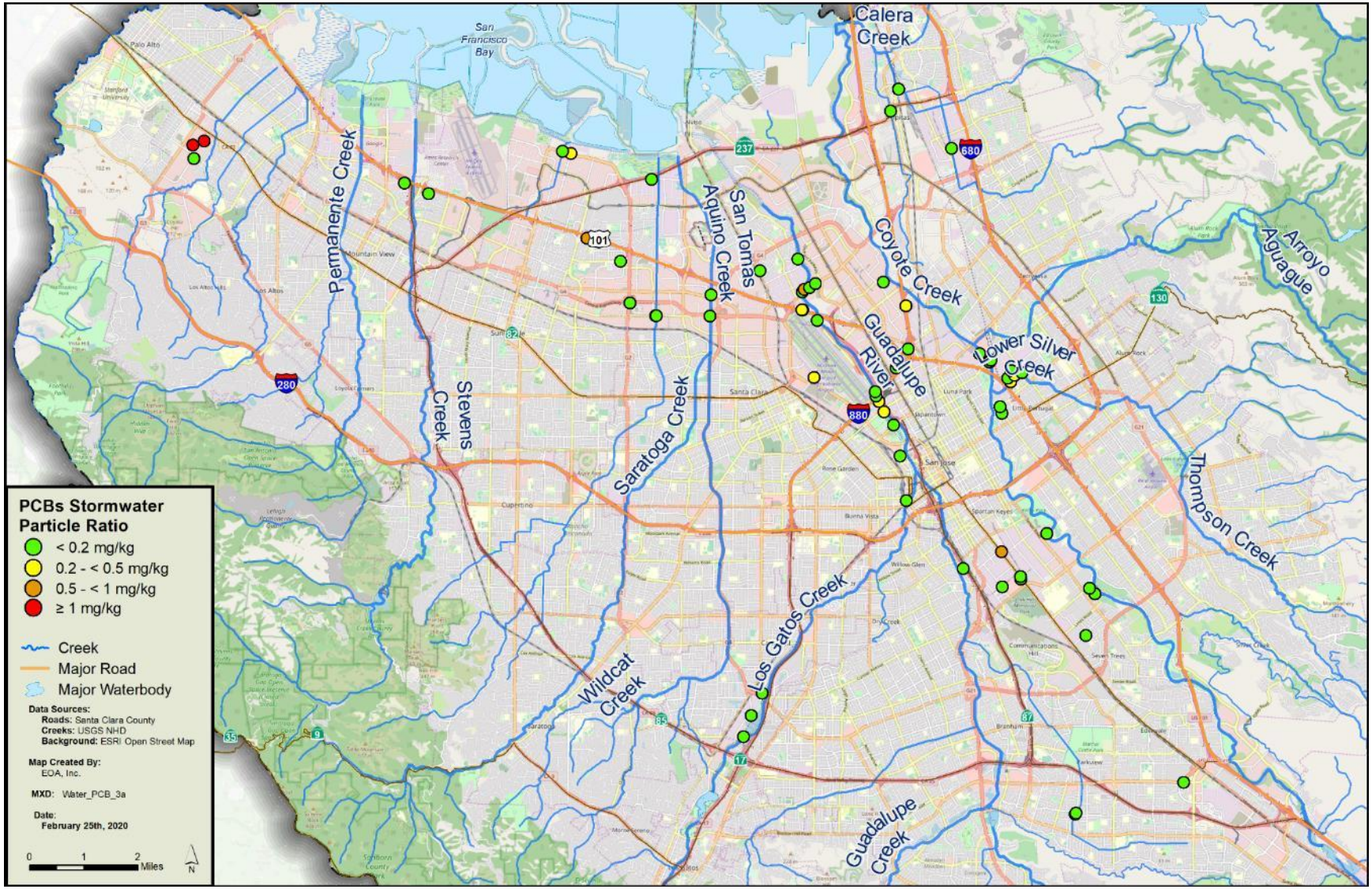


Figure 3.1. Locations and relative concentrations of PCBs measured in stormwater in the Santa Clara Basin by SCVURPPP and the RMP STLS in WY 2015 – WY 2019.

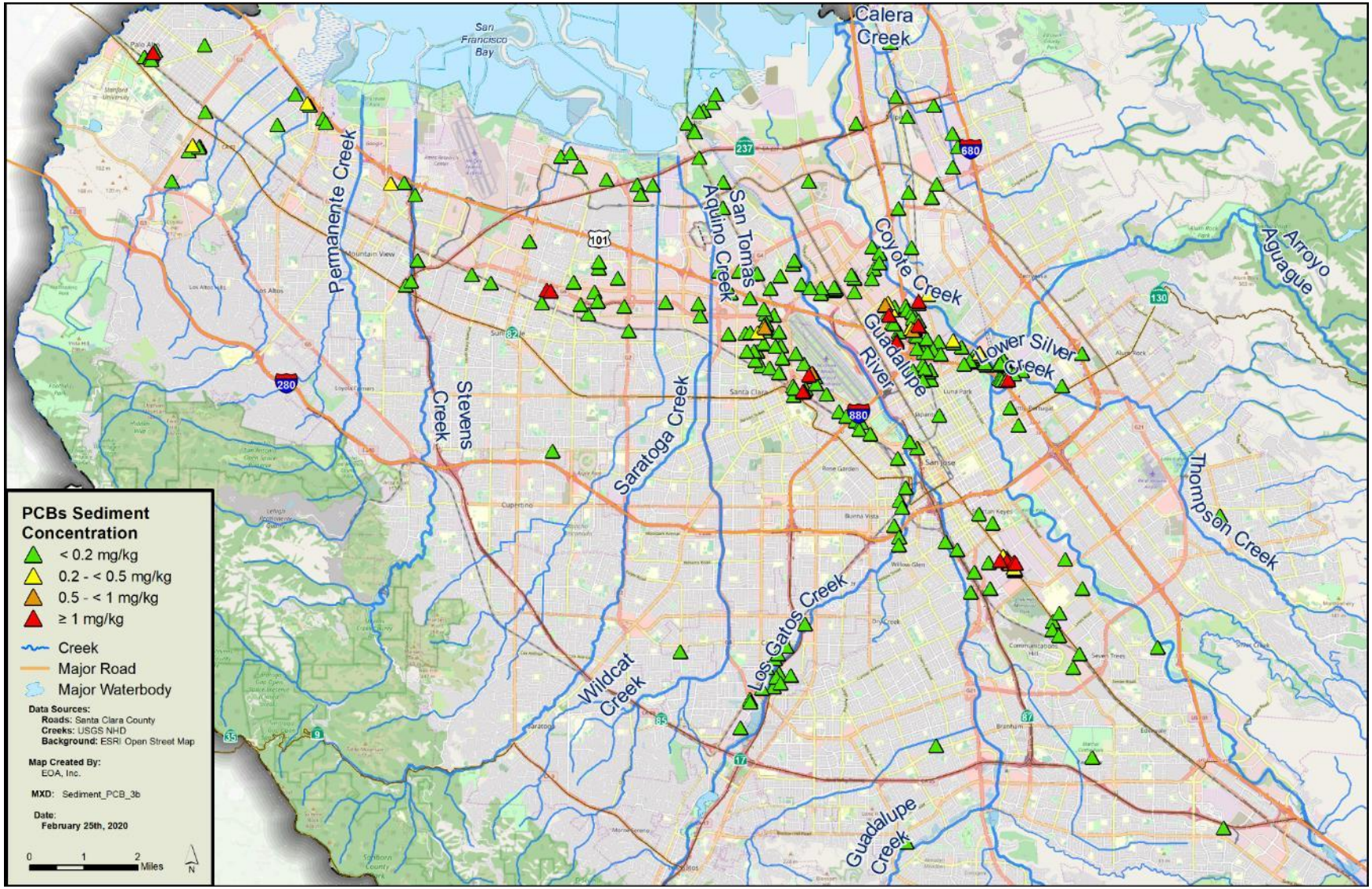


Figure 3.2. Locations and relative concentrations of PCBs measured in street dirt and storm drain sediment in the Santa Clara Basin by SCVURPPP and the RMP STLS in WY 2015 – WY 2019.

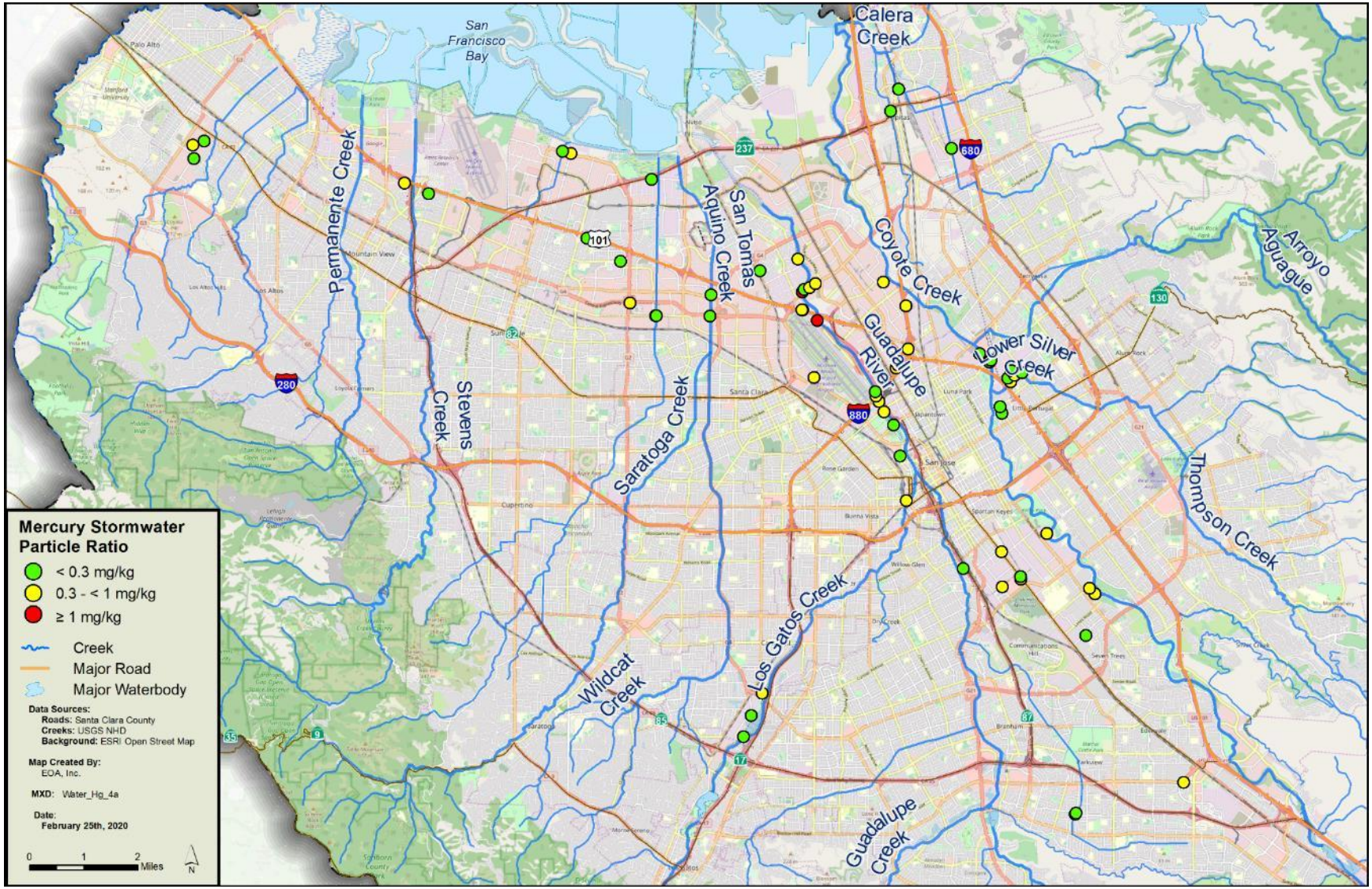


Figure 3.3. Locations and relative concentrations of mercury measured in stormwater in the Santa Clara Basin by SCVURPPP and the RMP STLS in WY 2015 – WY 2019.

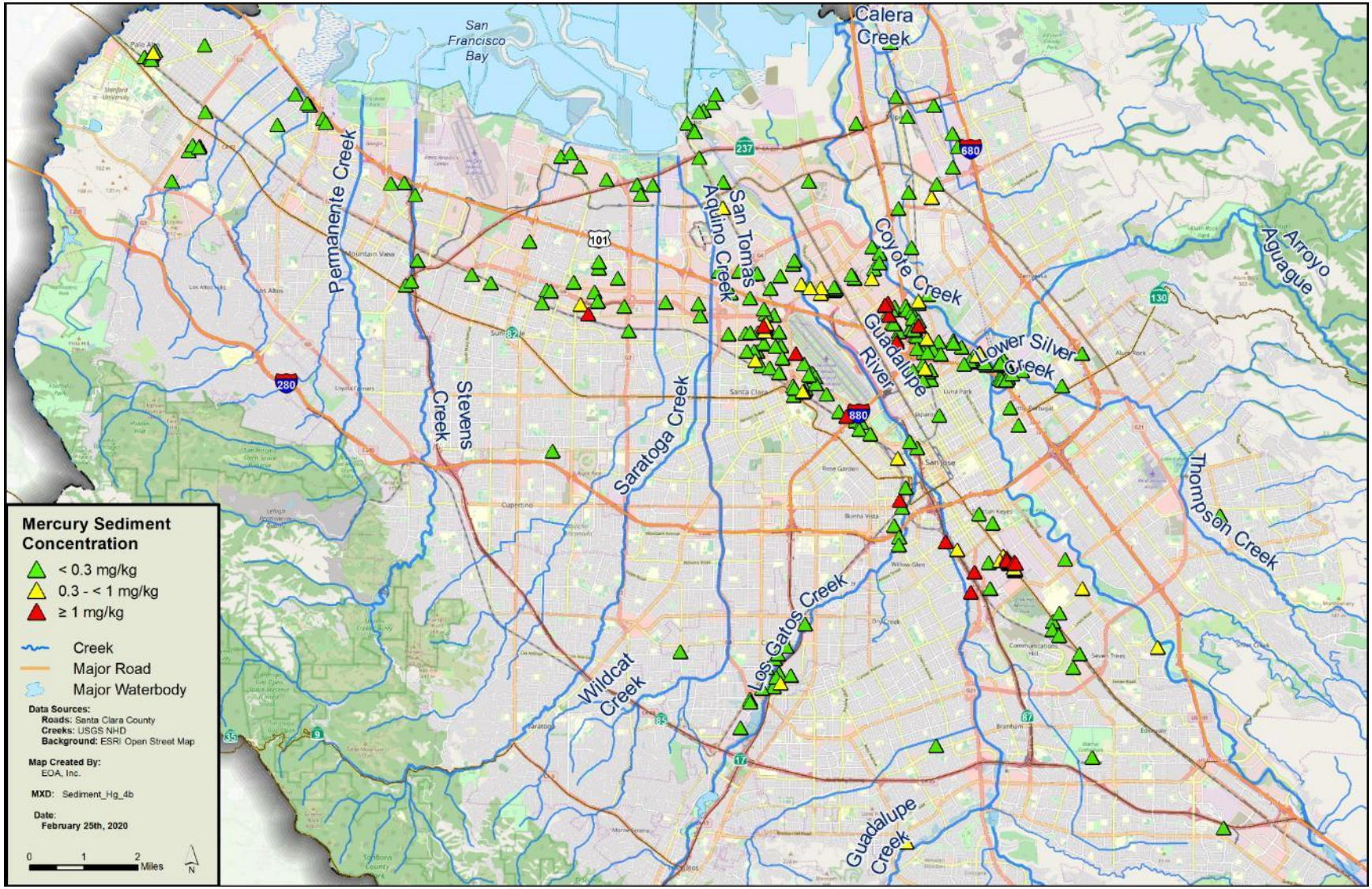


Figure 3.4. Locations and relative concentrations of mercury measured in street dirt and storm drain sediment in the Santa Clara Basin by SCVURPPP and the RMP STLS in WY 2015 – WY 2019.

3.2.1. Monitoring to Identify Sources and Source Areas

In WY 2015, SCVURPPP and the RMP STLS began implementing a revised approach to POC monitoring for PCBs and mercury in compliance with MRP 1.0 Provision C.8.e[3]. The alternative monitoring approach was discussed at numerous STLS workgroup meetings during WY 2014 and was agreed upon by STLS members, including Regional Water Board staff, as the best approach to addressing near-term high priority information needs regarding PCBs and mercury sources and loadings that were identified during the development of MRP 2.0[4]. The revised approach included the discontinuation of most POC loads monitoring stations sampled in previous years that are described in Section 2. Instead, the revised POC monitoring approach focused primarily on watershed reconnaissance monitoring to identify sources and source areas of PCBs and mercury to the municipal separate storm sewer systems (MS4s) and the San Francisco Bay, and to continue support for the RWSM. Areas with elevated POC concentrations are designated as priority WMAs, where control measures will be implemented to reduce POC loads to the Bay. Activities under the revised approach began in WY 2015 under MRP 1.0 and continued under MRP 2.0 in WY 2016 through WY 2019.

As a first step to identify the priority WMAs, the Program conducted a Geographic Information System (GIS) desktop analysis to identify areas for further investigation (SCVURPPP 2016a). The purpose of the desktop analysis was two-fold: (1) to identify "high opportunity" areas of interest in the Santa Clara Basin (i.e., areas that may contain sources of PCBs or mercury to the MS4 and thus provide greater opportunity for load reductions); and (2) to prioritize these areas for follow-up sampling. The desktop analysis identified and prioritized catchments by evaluating several types of data, including: PCBs and mercury concentrations from prior sediment and water sampling efforts, land use data showing old industrial parcels, municipal storm drain data showing pipelines and access points (e.g., manholes, outfalls, pump stations), catchment areas delineated from municipal storm drain data, and logistical/safety considerations (SCVURPPP 2015b). The outcome of the desktop analysis was a prioritized map of high opportunity, moderate opportunity, and low opportunity catchments in Santa Clara Basin.

Beginning in WY 2015 and continuing through WY 2019, both SCVURPPP and the RMP STLS have targeted high and moderate opportunity catchments for reconnaissance-style screening monitoring to identify catchments with elevated PCBs and mercury (i.e., priority WMAs). A street dirt or MS4 sediment sample is considered elevated if it has a PCBs concentration over 0.5 mg/kg, moderately elevated from 0.2 to 0.5 mg/kg, and low or urban background below 0.2 mg/kg. These thresholds were selected by the BASMAA MPC Committee as approximate benchmarks for identifying areas that should be considered for future investigation (e.g., targeted source property investigations that involve records review, additional sampling, etc.). There are currently no similar thresholds established for classifying or prioritizing PCBs or mercury concentrations in stormwater. Therefore, the Program is currently focusing on PCBs and applying the BASMAA MPC sediment concentration thresholds to particle ratio data. The "PCBs particle ratio" and "mercury particle ratio" are calculated by dividing total PCBs and total mercury by SSC. The units can be expressed as mg/kg, the same as sediment concentration

[3] The revised alternative approach summarized in this section addressed each of the POC Loads Monitoring management information needs described in MRP 1.0 provision C.8.e and was performed at an equivalent level of monitoring effort as that described in this MRP provision.

[4] Discussions about revised POC loads monitoring approaches for Water Year 2015 were discussed and ultimately agreed upon by Water Board staff and other STLS and RMC partners at the following STLS meetings: October 13, 2013; March 19, 2014; April 1, 2014; April 16, 2014; May 15, 2014; and June 9, 2014.

data. The particle ratio addresses the fact that PCBs and mercury are generally bound to sediment and is used to compare and rank monitoring stations. A sample that has a relatively low concentration but a high particle ratio may be because the storm that was sampled was relatively small, and the rainfall was not enough to mobilize much sediment. A larger storm may mobilize more sediment and PCBs, so catchments with an elevated concentration or particle ratio may be considered for a source investigation. A PCBs particle ratio greater than 0.5 mg/kg is used as a preliminary threshold for classifying water samples as high, 0.2 – 0.5 mg/kg is moderate, and less than 0.2 mg/kg is low. In addition, any WMAs with water samples in the top ten percent of all concentrations measured in stormwater in the Bay Area to date may also be considered high priority.

For high priority WMAs, one control measure that has been shown to cost effectively reduce PCBs and mercury loadings to the Bay is to identify properties that disproportionately contribute these pollutants to the MS4 and then refer these properties to appropriate agencies for further investigation and potential abatement (BASMAA 2017a). The Program uses screening monitoring data to identify priority WMAs where source property investigations are warranted. Beginning in WY 2016 and continuing through WY 2019, the Program has initiated targeted source property investigations in 18 priority WMAs. The goal of these investigations is to identify specific source properties that will be targeted for referral to the Regional Water Board for abatement, or abatement actions overseen directly by Permittees.

All the PCBs and mercury monitoring to identify sources and source areas conducted by the Program and the RMP STLS in WY 2015 through WY 2019 is summarized below. A comprehensive status report of all WMA prioritization efforts and source property investigations completed or ongoing in priority WMAs in the Santa Clara Basin to date is provided in Attachment D.2.

3.2.1.1. SCVURPPP Source Area Monitoring

In WY 2015, on behalf of its Permittees and in compliance with provision C.8.e.i of MRP 1.0, SCVURPPP conducted a countywide street dirt and MS4 sediment sampling program in high opportunity catchments identified through the desktop analysis described above. The purpose of this sampling program was to screen for areas in the urban environment with elevated POC concentrations and prepare for implementation of MRP 2.0 by identifying prioritized areas of interest for PCBs and mercury sources and eventual load reduction “opportunities.” Priority WMAs are defined as stormwater catchments that have elevated concentrations of PCBs or mercury (as described above). Priority WMAs are targeted for control measures because they have a high likelihood of containing significant sources of PCBs or mercury. The outcome of the WY 2015 sediment sampling program was the identification of seven high priority WMAs.

In WY 2016 through WY 2019, the Program continued to implement a screening monitoring program that focused on collecting both sediment and stormwater samples from the MS4 in high and moderate opportunity WMAs. The objective of this monitoring program was to continue to screen these areas and identify additional priority WMAs where cost-effective control measures could be implemented to comply with MRP PCBs and mercury load reduction requirements. In WY 2016, the Program also began to implement targeted source property investigations in the seven high-priority WMAs that were identified during the WY 2015 screening monitoring. The objective of these investigations was to use monitoring data to identify the specific parcel or parcels contributing to elevated POCs in the catchment.

Monitoring Methods

Screening monitoring sampling locations in WY 2015 were focused in high opportunity catchments identified through the desktop analysis described above. In WY 2016 – 2019, sampling locations were focused in high or moderate opportunity catchments to confirm WY 2015 sample results, and in priority WMAs as part of targeted source property investigations. All screening monitoring conducted by the Program in WY 2015 through WY 2019 implemented a reconnaissance approach to maximize the area characterized by the sampling program.

Street dirt and MS4 sediment samples were collected from the urban storm drainage system (e.g., beneath manholes, storm drain inlets) and public right-of-way (ROW) surfaces (e.g., street gutters, driveways). The sampling and analysis methods used are detailed in the SAP for PCBs and Mercury Opportunity Area Analysis and Implementation Planning (SCVURPPP 2014c). All sediment samples were analyzed for the "RMP 40" PCB congeners[5] (USEPA Method 8082M) and total mercury (EPA Method 7471A). Sediment sampling was also conducted in WY 2017 and WY 2019 using similar collection methods as the WY 2015 sampling, as described in the WY 2016 POC Monitoring SAP (SCVURPPP 2015b). All samples were analyzed for the "RMP 40" PCB congeners (EPA Method 8082M or 8270 modified) total mercury (EPA Method 7471A), and total solids (SM 2540G-11).

Wet weather sampling was conducted annually beginning in WY 2016 and continuing through WY 2019. This sampling focused on collection of storm composite samples from MS4 outfalls or manholes from high opportunity WMAs. Composite samples consisting of six to eight aliquots collected during the rising limb and peak of the storm hydrograph (as determined through field observations) were analyzed for the "RMP 40" PCB congeners (EPA Method 1668C), total mercury (EPA Method 1631E), and suspended sediment concentration (ASTM D3977-97). All wet weather monitoring was conducted in accordance with the WY 2016 POC Monitoring SAP (SCVURPPP 2015b).

Monitoring Results

The full results of all monitoring conducted between WY 2015 and WY 2018 were provided in detail in previous reports (SCVURPPP 2016a, 2017a, 2018a, 2019a) and are summarized below. Detailed results of PCBs and mercury monitoring accomplished in WY 2019 are provided below.

Sediment Sampling. In WY 2019, the Program collected 54 individual and composite upland sediment samples to address Management Question #1 (Source Identification). Samples were collected from ditches, manholes, storm drain inlets, vaults, driveways, sidewalks, and gravel pads in priority WMAs as part of the source property investigation program. The goal of this program is to identify specific source properties within WMAs where elevated POCs have been observed. Source properties may then be referred to the Regional Water Board for abatement. The sediment sampling in WY 2019 targeted WMAs with previously observed elevated PCBs concentrations. Within these WMAs, samples were collected on or near parcels with characteristics associated with potential PCBs use or release.

[5] The RMP 40 PCB congeners include: 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.

Table 3.3 presents the PCBs and mercury concentrations measured in sediment samples collected by the Program in WY 2019. Concentrations of total mercury ranged from non-detect (ND) to 8.5 mg/kg, with a median of 0.12 mg/kg and a mean of 0.55 mg/kg. Five of these samples had elevated mercury concentrations (> 1 mg/kg). Of these five samples, two of them also had elevated PCBs (> 0.5 mg/kg). Concentrations of total PCBs (sum of RMP 40 congeners) ranged from 0.001 mg/kg to 5.5 mg/kg, with a median of 0.03 mg/kg and a mean of 0.37 mg/kg. Six samples had PCBs concentrations > 0.5 mg/kg, and all but one of these elevated concentrations was > 1 mg/kg, clearly indicating proximity to PCBs sources. The full analysis of these data in combination with additional information gathered as part of ongoing source property investigations is currently underway and will be reported in the future. A complete reporting of the current status of all completed, ongoing, and planned source property investigations in the Santa Clara Basin is provided in Attachment D.2.

Table 3.3. WY 2019 PCBs and mercury concentrations measured in street dirt and storm drain infrastructure in Santa Clara Basin, CA.

Permittee	Sample ID	Date	Location Type	Latitude	Longitude	PCBs (mg/kg)	HgT (mg/kg)
Palo Alto	SC-PAO-08-A	8/20/2019	Inlet	37.41609	-122.14466	0.03	0.17
	SC-PAO-08-B	8/20/2019	Vault	37.41761	-122.14334	0.44	0.19
	SC-PAO-08-C	8/20/2019	Street Dirt	37.41709	-122.14123	0.14	0.090
San Jose	SC-SJY-04-C	8/13/2019	Street Dirt	37.38208	-121.92656	0.001	0.045
	SC-SJY-04-D	8/13/2019	Street Dirt	37.382538	-121.92707	0.022	0.16
	SC-SJY-04-E	8/13/2019	Street Dirt	37.39346	-121.91459	0.17	0.072
	SC-SJY-04-F	8/13/2019	Street Dirt	37.39172	-121.91211	0.009	0.038
	SC-SJY-04-H	8/20/2019	Street Dirt	37.38756	-121.91387	0.005	0.14
	SC-SJY-04-I	8/20/2019	Street Dirt	37.3892	-121.91207	0.009	0.085
	SC-SJY-04-J	8/27/2019	Inlet	37.38067	-121.93162	0.006	0.26
	SC-SJY-04-K	8/27/2019	Street Dirt	37.38226	-121.93157	0.011	0.28
	SC-SJY-04-L	8/27/2019	Street Dirt	37.38498	-121.94165	0.011	0.23
	SC-SJY-04-M	8/27/2019	Street Dirt	37.38137	-121.92017	0.008	0
	SC-SJY-04-N	8/27/2019	Street Dirt	37.38481	-121.92031	0.012	0.11
	SC-SJY-04-O	8/27/2019	Street Dirt	37.38495	-121.92042	0.022	0.16
	SC-SJY-04-P	8/27/2019	Street Dirt	37.38594	-121.92146	0.013	0.10
	SC-SJY-04-R	8/28/2019	Street Dirt	37.38224	-121.93524	0.078	0.96
	SC-SJY-08-AB	8/27/2019	Inlet	37.37121	-121.90037	0.025	0.11
	SC-SJY-08-AC	8/27/2019	Street Dirt	37.37126	-121.90006	0.032	0.11
	SC-SJY-08-AD	8/27/2019	Street Dirt	37.37138	-121.90017	0.027	0.12
	SC-SJY-08-X	8/12/2019	Street Dirt	37.37377	-121.89863	0.031	0.07
	SC-SJY-08-Y	8/12/2019	Street Dirt	37.37263	-121.89857	0.11	0.34
	SC-SJY-08-Z	8/12/2019	Culvert	37.37256	-121.89876	1.09	0.28
	SC-SJY-10-R	8/28/2019	Street Dirt	37.37849	-121.90899	0.42	1.90
	SC-SJY-10-S	8/28/2019	Street Dirt	37.37789	-121.90991	0.93	5.60
	SC-SJY-14-B	8/19/2019	Outfall	37.36539	-121.87803	0.32	0.24
	SC-SJY-14-C	8/19/2019	Street Dirt	37.36531	-121.87824	0.040	0.07
	SC-SJY-14-D	8/19/2019	Street Dirt	37.36537	-121.87788	0.020	0.11
	SC-SJY-14-E	8/19/2019	Street Dirt	37.36549	-121.87803	0.003	0.09
	SC-SJY-14-F	8/19/2019	Street Dirt	37.36484	-121.87876	0.016	0
	SC-SJY-14-H	8/19/2019	Street Dirt	37.36394	-121.88052	0.063	0.14
	SC-SJY-14-I	8/19/2019	Street Dirt	37.36447	-121.87997	0.031	0.11
	SC-SJY-14-J	8/19/2019	Street Dirt	37.36473	-121.97894	0.016	0.33
	SC-SJY-14-K	8/20/2019	Street Dirt	37.36307	-121.88099	0.016	0.059
	SC-SJY-14-L	8/20/2019	Street Dirt	37.36336	-121.88118	0.025	0.12
	SC-SJY-14-M	8/20/2019	Street Dirt	37.36246	-121.88313	0.014	0.088
	SC-SJY-17-I	8/12/2019	Inlet	37.35818	-121.86908	0.35	0.05
	SC-SJY-17-J	8/12/2019	Inlet	37.35823	-121.86883	0.32	0.075
	SC-SJY-17-L	8/12/2019	Street Dirt	37.35998	-121.86689	0.009	0.10
	SC-SJY-17-M	8/12/2019	Street Dirt	37.36254	-121.86877	0.033	0.083
	SC-SJY-17-N	8/12/2019	Street Dirt	37.362241	-121.86896	0.033	0.090
	SC-SJY-17-O	8/12/2019	Street Dirt	37.36369	-121.86987	0.025	0.14
	SC-SJY-17-P	8/19/2019	Street Dirt	37.36248	-121.87145	0.025	0.086
	SC-SJY-17-Q	8/19/2019	Street Dirt	37.36237	-121.87163	0.014	0
	SC-SJY-17-R	8/19/2019	Street Dirt	37.3628	-121.87098	0.010	0.11
	SC-SJY-47-M	8/13/2019	Street Dirt	37.30973	-121.86538	1.79	1.50
	SC-SJY-47-N	8/13/2019	Street Dirt	37.30999	-121.87009	5.47	0.24
	SC-SJY-47-O	8/28/2019	Street Dirt	37.30929	-121.86487	3.61	8.50
Santa Clara	SC-SCL-02-M	6/3/2019	Inlet	37.37132	-121.95014	0.065	0.13
	SC-SCL-05-F	6/3/2019	Inlet	37.37177	-121.95064	0.15	4.90
	SC-SCL-05-G	6/3/2019	Inlet	37.35885	-121.93509	0.069	0.12
	SC-SCL-05-H	6/3/2019	Manhole	37.36997	-121.95508	0.045	0.05
	SC-SCL-06-C	6/3/2019	Street Dirt	37.37639	-121.95061	0.006	0.13
	SC-SCL-23-G	6/3/2019	Street Dirt	37.35885	-121.93509	3.56	0.13

Table 3.4 summarizes all PCBs and mercury street dirt and MS4 sediment concentration data collected by the Program between WY 2015 and WY 2019. For all years combined, the total PCBs concentrations ranged from ND to 11.9 mg/kg, with a mean of 0.24 mg/kg and a median of 0.03 mg/kg. A total of 23 samples (~ 7%) exceeded the 0.5 mg/kg threshold for high-priority WMAs that should be considered for source property investigations. Total mercury concentrations ranged from ND to 18.9 mg/kg, with a mean of 0.42 mg/kg and a median of 0.11 mg/kg. Twenty-three of these samples exceeded 1.0 mg/kg. Of the 23 elevated mercury samples, 8 samples also had elevated PCBs.

Table 3.4. Descriptive statistics of PCBs and mercury concentrations measured in street dirt and MS4 sediment in the Santa Clara Basin by SCVURPPP in WY 2015 through WY 2019.

Statistic	PCBs (mg/kg)	HgT (mg/kg)
N	332	332
Min	nd	nd
10th percentile	0.005	0.049
25th percentile	0.010	0.07
50th percentile	0.027	0.114
75th percentile	0.078	0.226
90th percentile	0.30	0.57
Max	11.9	18.9
Mean	0.24	0.42

Stormwater Sampling. In WY 2019, Program collected 15 composite storm water samples from the stormwater conveyance system in priority WMAs. These samples address Management Questions #1 (Source Identification), #2 (Contributions to Bay Impairment) and provide information for assessing trends (i.e., Management Question #5). Data may also be used by the RMP STLS to improve calibration of models used to estimate the overall POC loads from small tributaries to San Francisco Bay (i.e., Management Question #4 – Loads and Status). As in prior years, the primary goal of this sampling was to identify priority WMAs and to identify specific source properties within priority WMAs. Table 3.5 presents the PCBs, mercury, and SSC concentrations and PCBs and mercury particle ratios measured in stormwater samples collected by the Program during WY 2019. Total mercury concentrations ranged from 3.0 ng/L to 67 ng/L, with a median of 13 ng/L and a mean of 18 ng/L. Mercury particle ratios ranged from 0.08 mg/kg to 1.5 mg/kg, with a median of 0.42 mg/kg and a mean of 0.52 mg/kg. Total PCBs concentrations ranged from 0.21 ng/L to 178 ng/L, with a median of 10 ng/L and a mean of 22 ng/L. PCBs particle ratios ranged from 0.030 mg/kg to 9.3 mg/kg, with a median of 0.08 mg/kg and a mean of 0.93 mg/kg.

Table 3.5. PCBs, mercury and suspended sediment concentrations in water samples collected by SCVURPPP in WY 2019.

Station Code	Sample Date	SSC (mg/L)	Total PCBs (ng/L) [a]	PCB Particle Ratio (mg/kg) [b]	HgT (ng/L)	HgT Particle Ratio (mg/g) [b]
113LGC510A	2/27/2019	146	4.40	0.030	67	0.459
099GAC240B	2/2/2019	11	0.378	0.034	4.6	0.418
083GAC900E	2/2/2019	6.9	0.516	0.075	5.2	0.754
067GAC075A	1/6/2019	55	15.5	0.282	23	0.418
067GAC010A	1/6/2019	70	15.9	0.227	35	0.500
067SCL080A	1/16/2019	56	22.6	0.404	19	0.339
066GAC150A	2/13/2019	34	10.2	0.299	13	0.382
067SCL080B	1/16/2019	235	16.7	0.071	19	0.081
067SCL120A	1/16/2019	39	13.6	0.349	27	0.692
067SCL120B	1/16/2019	132	4.20	0.032	25	0.189
050GAC020E	2/1/2019	4.3	0.334	0.078	6.5	1.50
050GAC020C	2/27/2019	7.2	0.446	0.062	5.2	0.722
050GAC020D	2/27/2019	4	0.205	0.051	2.7	0.675
031SCH250B	1/6/2019	19	178	9.30	7.4	0.389
031SCH250A	1/6/2019	20	52.7	2.60	5.8	0.290

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

Table 3.6 summarizes PCBs, mercury, and SSC concentrations and PCBs and mercury particle ratios measured in stormwater samples collected by the Program during WY 2016 through WY 2019 source area monitoring. Across these years, total PCBs concentrations in stormwater ranged from 0.15 ng/L to 178 ng/L with an average of 12.8 ng/L and a median of 4.4 ng/L. PCBs particle ratios ranged from 0.004 mg/kg to 9.34 mg/kg. Mercury concentrations ranged from 1 ng/L to 67 ng/L with an average of 14 ng/L and a median of 7.6 ng/L. Mercury particle ratios ranged from 0.028 mg/kg to 1.5 mg/kg. Eight samples had elevated PCBs particle ratios (greater than 0.5 mg/kg).

Table 3.6. Descriptive statistics for PCBs, mercury and SSC concentrations and PCBs and mercury particle ratios in stormwater samples collected by SCVURPPP in the Santa Clara Basin in WY 2016 through WY 2019.

Statistic	PCBs (ng/L)	HgT (ng/L)	SSC (mg/L)	PCBs Particle Ratio (mg/kg)	HgT Particle Ratio (mg/kg)
count	49	32	49	49	32
min	0.15	1.07	4.00	0.004	0.028
10th percentile	0.45	3.84	10.3	0.03	0.084
25th percentile	1.89	5.20	19.2	0.049	0.16
50th percentile	4.41	7.6	39.0	0.10	0.33
75th percentile	11.6	20.0	70	0.21	0.45
90th percentile	27.1	34.0	132	0.53	0.74
Max	178	67	518	9.34	1.51
Mean	12.8	14.2	61	0.40	0.37

3.2.1.2. RMP STLS Wet Weather Characterization Monitoring

With a goal of identifying watershed sources of PCBs and mercury, STLS POC monitoring beginning in WY2015 and continuing through WY 2019 focused on wet weather characterization in catchments of interest. The RMP STLS monitoring program is coordinated with the countywide stormwater programs' efforts, and provides additional data the programs can use to supplement their own efforts to identify sources and source areas. Through this program, the RMP STLS team collects composite stormwater samples in catchments located throughout the region. The sample locations are selected in consultation with the countywide stormwater programs. Between WY 2015 and WY 2019, this monitoring program has sampled 21 sites in Santa Clara County, 19 in San Mateo County, 16 in Alameda County, 10 in Contra Costa County and 1 in Solano County. The sampled catchments range in size from 0.02 to 2,842 acres and represent both natural creek watersheds and engineered MS4 drainage areas in the Bay Area. In Santa Clara Basin, based on recommendations of Program staff, the RMP STLS sampled two previously sampled catchments in WY 2019, two catchments in WY 2018, three catchments in WY 2017, six catchments in WY 2016, and eight catchments in WY 2015. All but two of the Santa Clara Basin sampling stations were located at manholes accessing the MS4 or MS4 outlets to receiving waters. Two stations were located within a receiving water (Lower Penitencia Creek and Guadalupe River). The storm composite water samples were analyzed for concentrations of PCBs, total mercury, and SSC. A subset of samples was also analyzed for other metals (arsenic, cadmium, lead, copper, zinc), total organic carbon, dissolved organic carbon, and grain size distribution. In addition, a pilot study was conducted at a subset of locations to collect fine sediments using specialized settling chambers. Table 3.7 presents a description of each sampling site and the PCBs, mercury and suspended sediment concentrations and PCBs and mercury particle ratios measured in stormwater at each of the Santa Clara Basin POC monitoring stations since WY 2015. A full description of the methods and results of this monitoring from WY 2015 through WY 2019 is provided in Attachment D.3.

The RMP STLS has a growing database, now consisting of 88 stations that have been sampled at least once during wet weather events for PCBs, mercury, and SSC since 2003. Sixty-six of these sites were monitored between WY 2015 and WY 2019. Prior to WY 2015, most of the stations were located in natural creeks, whereas the bulk of the stations sampled in WY 2015 through WY 2019 were primarily located in small catchments draining primarily old industrial land uses. At 15 of the stations beginning in WY 2015, a second sample was collected with either a Hamlin or Walling tube (or both) remote sediment sampler.

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

- A number of sites with elevated PCBs and mercury concentrations in stormwater have been identified. The highest concentrations of total mercury have been measured at the Guadalupe River site in San Jose, CA.
- PCBs positively correlate with impervious cover, old industrial land use, and mercury. They inversely correlate with watershed area. Although mercury and PCBs positively correlate, the relationship is relatively weak, probably due to the larger role of atmospheric recirculation in the mercury cycle and the differences in use history of each POC.
- Neither PCBs nor mercury have strong correlations with other trace metals (As, Cu, Cd, Pb, and Zn). Therefore, there is no support for the use of trace metals as surrogate investigative tools for either PCBs or mercury sources.

- Remote samplers showed generally good consistency with the composite stormwater sampling methods and could be used exclusively for preliminary screening of new stations to identify watershed sources of PCBs and mercury.
- Continued focus on identifying areas with elevated concentrations and resampling of some stations (i.e., those that return lower than expected concentrations) should continue in WY 2020.

Table 3.7. Description of sampling sites and POC concentrations measured at RMP STLS stormwater monitoring sites in Santa Clara County, CA in WY 2015 – WY 2019.

City	Watershed Name	Catchment ID	MS4 or Receiving Water	Latitude	Longitude	Sample Date	Area (sq km)	PCBs Particle Ratio (mg/kg)	PCBs (ng/L)	HgT Particle Ratio (mg/kg)	HgT (ng/L)	SSC (mg/L)
San Jose	E. Gish Rd SD	SC-066GAC550	MS4	37.36632	-121.90203	12/11/2014	0.44	0.099	14.4	0.590	85	145
Milpitas	Lower Penitencia Ck	Lower Penitencia	Receiving Water	37.42985	-121.90913	12/11/2014	11.5	0.016	1.59	0.160	17	106
Santa Clara	Seabord Ave SD SC	SC-050GAC580	MS4	37.37637	-121.93793	12/11/2014	1.35	0.186	13.5	0.530	38	73
Santa Clara	Seabord Ave SD SC	SC-050GAC600	MS4	37.37636	-121.93767	12/11/2014	2.8	0.236	19.9	0.550	47	85
San Jose	Ridder Park Dr SD	SC-051CTC400	MS4	37.37784	-121.90302	12/15/2014	0.5	0.488	55.5	0.330	37	114
San Jose	Outfall to Lower Silver Ck	SC-067SCL080	MS4	37.35789	-121.86741	2/6/2015	0.17	0.783	44.6	0.420	24	57
San Jose	Rock Springs Dr SD	SC-084CTC625	MS4	37.31751	-121.85459	2/6/2015	0.83	0.128	5.25	0.930	38	41
San Jose	Charcot Ave SD	SC-051CTC275	MS4	37.38413	-121.91076	4/7/2015	1.79	0.123	14.9	0.560	67	121
Santa Clara	Duane Ct and Ave Triangle SD	SC-049CZC200	MS4	37.38852	-121.99901	12/13/15 & 1/6/2016	1	0.017	0.832	0.268	13	48
Santa Clara	Lawrence & Central Expwys SD	SC-049CZC800	MS4	37.37742	-121.99566	1/6/2016	1.2	0.078	4.51	0.226	13	58
Santa Clara	Condensa St SD	SC-049STA710	MS4	37.37426	-121.96918	1/19/2016	0.24	0.074	2.6	0.329	12	35
Santa Clara	Victor Nelo PS Outfall	SC-050GAC190	MS4	37.38991	-121.93952	1/19/2016	0.58	0.051	2.29	0.351	16	45
Santa Clara	E Outfall to San Tomas at Scott Blvd	SC-049STA550	MS4	37.37991	-121.96842	3/6/2016	0.67	0.027	2.8	0.127	13	103
Santa Clara	Haig St SD	SC-050GAC030	MS4	37.38664	-121.95223	3/6/2016	2.12	0.043	1.45	0.194	7	34
San Jose	Guadalupe River at Hwy 101	Guad 101	Receiving Water	37.37355	-121.93269	1/8/2017	233	0.115	23.7	3.6	603	560
San Jose	North Fourth St SD	066GAC550B	MS4	37.36196	-121.90535	1/8/2017	1.01	0.087	4.17	0.477	23	48
San Jose	Rosemary St SD	066GAC550C	MS4	37.36118	-121.90594	1/8/2017	3.67	0.089	4.11	0.591	27	46
San Jose	GR outfall	066GAC850	MS4	37.35469	-121.91279	4/7/2018	3.35	0.045	6.63	0.107	16	149
San Jose	GR outfall	066GAC900	MS4	37.35392	-121.91223	4/7/2018	0.17	0.125	3.36	0.644	17	27
San Jose	SC100CTC400A	SC100CTC400A	MS4	37.30299	-121.83995	1/16/2019	1.38	0.038	2.92	0.303	23	77
San Jose	SC100CTC500A	SC100CTC500A	MS4	37.30148	-121.83814	1/16/2019	3.01	0.094	10.5	0.386	43	111

3.2.1.3. Source Property Investigation Outcomes

The Program has initiated source property investigations in 19 catchments in the Santa Clara Basin to date. One of these investigations was completed prior to WY 2015 and resulted in a PCBs source property referral to the Regional Water Board. That investigation (Leo Avenue) is described in detail elsewhere (SCVURPPP 2015a). The majority of the 18 investigations initiated since WY 2015 been implemented in priority WMAs with elevated PCBs that were identified during screening monitoring conducted by both the Program and the RMP STLS. The outcomes and current status of all PCBs source property investigations initiated in the Santa Clara Basin since WY 2015 are summarized below and described in more detail in Attachment D.2.

Between WY 2015 and WY 2019, the Program completed source property investigations in two high-priority WMAs (comprising 516 acres), and has ongoing investigations in 16 priority WMAs (comprising nearly 4,000 acres). The outcomes of these investigations include submission of 2 PCBs source property referrals to the RWB, and confirmation of 9 additional PCBs source properties. The Program and the associated municipal jurisdictions are currently considering next steps for the 9 confirmed source properties. The ongoing investigations in the 16 priority WMAs will continue in WY 2020.

No additional controls are currently being planned in catchments where mercury (but not PCBs) was elevated because results of the SCVURPPP Reasonable Assurance Analysis (RAA) baseline loading for mercury (reported in Section 3.2.5 and Appendix D.5) demonstrates that Santa Clara Basin is already achieving the mercury WLA for stormwater.

3.2.1.4. WMA Prioritization Status

Figure 3.5 illustrates the current state of knowledge and prioritization status of WMAs in Santa Clara Basin for the following six categories:

1. Referred Source Property
2. Confirmed Source Property
3. High Priority WMA
4. Moderate Priority WMA
5. Low Priority WMA
6. Other Catchments of Interest

Based on the combined results of the Program's screening monitoring program and the RMP STLS wet weather characterization monitoring conducted in WY 2015 through WY 2019, the Program has identified 21 high and moderate priority WMAs (i.e., catchments with at least one sample that had elevated PCBs), comprising over 4,000 acres in the Santa Clara Basin. Another 76 low-priority WMAs (i.e., catchments with no samples with elevated PCBs found to date), comprising about 30,000 acres have also been identified to date. The Program has completed or is currently conducting targeted source property investigations in 19 high-priority WMAs. Three of these high-priority WMAs, comprising almost 1,500 acres, have at least one source property that has been identified and referred to the Regional Water Board. Another 4 high-priority WMAs (comprising over 1,200 acres) have at least one confirmed source property. There remain 47 "Catchments of Interest" for PCBs and mercury sources (comprising nearly 14,000 acres) that have not yet been screened for elevated concentrations. The remainder of

the land areas in the Basin (comprising approximately 210,000 acres) do not fit into any of the WMA or Catchment of Interest categories.

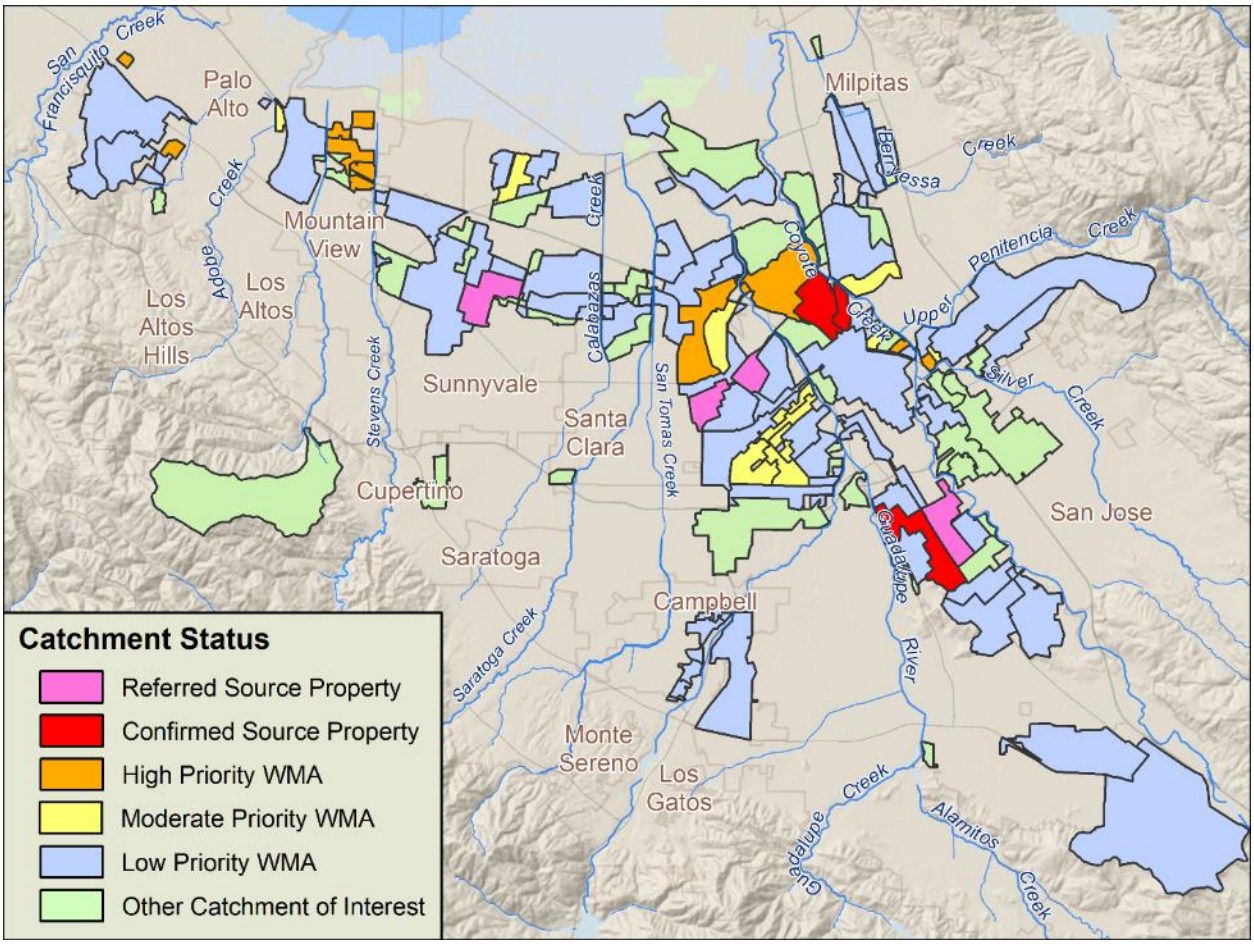


Figure 3.5. Watershed Management Area (WMA) prioritization in Santa Clara Basin, CA.

3.2.2. Guadalupe River Loading Station Contingency Monitoring

POC loads monitoring activities have been conducted since 2003 on the Guadalupe River near the Highway 101 overpass. These efforts have occurred via a combination of RMP, SCVURPPP and Valley Water funding and were generally aimed at developing robust estimates of annual mercury and other POC loading to the Bay from the watershed. One key information gap that remains is the concentrations and loading associated with high intensity storm events that necessitate the release of water from reservoirs located in the upper watershed. These events rarely occur, but the RMP has been prepared to institute contingency monitoring to sample water at the Highway 101 station in the event of a qualifying storm. No qualifying events occurred in WY2015 or WY 2016.

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

prolonged rainfall. Figure 3.6 (i.e., Figure 4 from McKee et al. 2018) illustrates how mercury concentrations varied throughout the storm hydrograph.

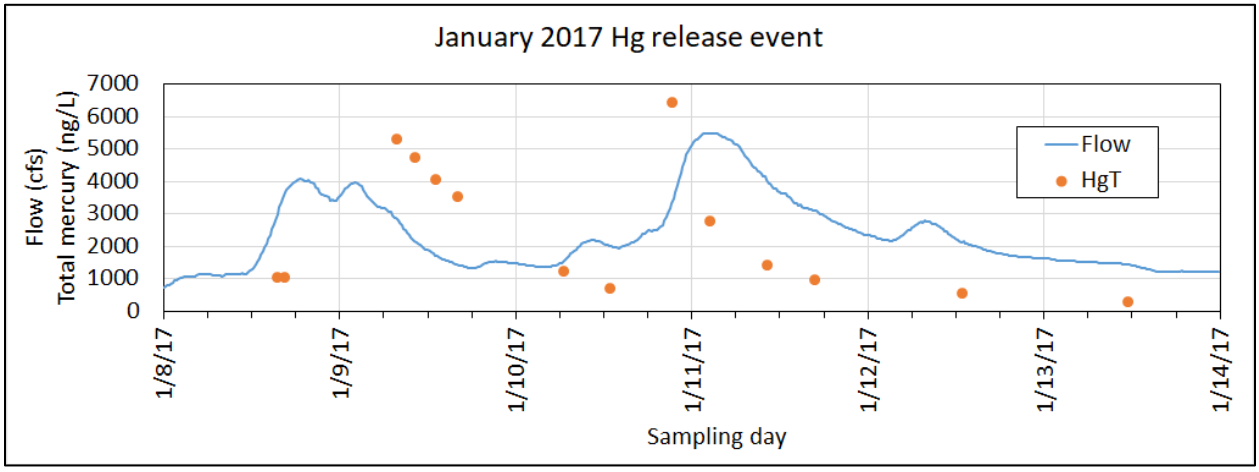


Figure 3.6. January 2017 storm hydrograph and total mercury concentrations in Guadalupe River at Highway 101 (Figure 4 from McKee et al. 2018; flow data are provisional and subject to change).

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

There have been no additional qualifying events in WY 2018 or WY 2019.

3.2.3. BASMAA Monitoring for PCBs in Infrastructure Caulk and BMP Effectiveness

This section will provide a brief summary of the regional PCBs and mercury monitoring conducted by BASMAA as part of the Infrastructure Caulk and BMP Effectiveness studies. This section will reference the previously submitted BASMAA reports for more details.

In WY 2017 and WY 2018, SCVURPPP participated in the BASMAA "POC Monitoring Project for Source Identification and Management Action Effectiveness" project. This regional project includes two (somewhat independent) monitoring studies designed during WY 2017 and implemented during WY 2018. BASMAA developed two study designs to implement these projects and a shared SAP and QAPP. The SAP/QAPP describes field and laboratory methods, measurement quality objectives, quality control procedures, and data management aspects.

As one of four Countywide Programs subject to provision C.8.f POC Monitoring requirements, SCVURPPP's POC monitoring accomplishments include ¼ of the total number of samples collected through these regional studies (Table 3.1).

- The PCBs in Infrastructure Caulk Study was developed to satisfy the provision C.12.e requirement to collect 20 composite caulk/sealant samples throughout the MRP permit area and evaluate (at a screening level) whether PCBs are present in right-of-way infrastructure caulk and sealants in the Bay Area. This study also addresses Management Question #1 (Source Identification). In WY 2018, the BASMAA project team collected 54 samples of caulk/sealant materials from ten types of roadway and storm drain infrastructure. The individual samples were grouped by structure type and sample appearance (color and texture) into 20 composites and analyzed for the RMP 40 PCB congeners using a modified method EPA 8270C. The final project report was included with the Program's Fiscal Year 2017/18 Annual Report, submitted to the Regional Water Board on September 30, 2018 (BASMAA 2018).
- The BMP Effectiveness Study was developed to satisfy provision C.8.f requirements to collect at least eight PCBs and mercury samples (per county) that address Management Question #3 (Management Action Effectiveness). A major consideration of the study was collection of data in support of conducting the Reasonable Assurance Analysis that is required by provision C.12.c.iii.(3) and must be submitted to the Regional Water Board with the 2020 Annual Report (September 30, 2020). In WY 2018, the BASMAA project team collected a total of 34 samples. Results of the study are summarized in two reports that were submitted (as appendices) with the Program's WY 2018 Urban Creeks Monitoring Report.
    - Column Study Report (BASMAA 2019a). Twenty-six samples consisting of influent/effluent pairs from column tests of biochar-enhanced bioretention soil media (BSM) were analyzed. Stormwater from two sites during two storm events was run through six columns with five different biochar-enhanced BSM mixes and one standard BSM as a control to evaluate which mix was most effective at removing PCBs and mercury. Dilutions were run on two columns to assess removal efficiencies with decreasing influent pollutant concentrations. Samples were analyzed for the RMP 40 PCB congeners (method EPA 1668C), total mercury (method EPA 1631E, SSC (method ASTM D3977-97), and total organic carbon (method EPA 9060).
    - HDS Study Report (BASMAA 2019b). Eight samples consisting of sediment and leaf debris were collected from hydrodynamic separator (HDS) unit sumps during regularly scheduled cleanouts to evaluate the PCBs and mercury load reduction

effectiveness of these units. The HDS unit samples were analyzed for the RMP 40 PCB congeners (method EPA 1668C), total mercury (method EPA 1631E), and total solids (method EPA 160.4M).

3.2.4. Regional Comparison

This section presents PCBs and mercury monitoring results within the context of other street dirt, MS4 sediment, and storm water samples collected and analyzed for PCBs and mercury in Santa Clara County and region-wide. Street dirt, MS4 sediment and stormwater data collected by SCVURPPP in WY 2015 through WY 2019 were compiled with similar data collected in Santa Clara County and throughout the region over the past 20+ years by SCVURPPP, RMC partners and the RMP STLS to create a Bay Area regional data set. The regional data includes samples collected within the MRP area in Santa Clara, San Mateo, Alameda, Contra Costa and Solano Counties.[6]

3.2.4.1. Sediment Data

The Bay Area regional data set of POC concentrations measured in street dirt and MS4 sediment now includes over 1,500 PCBs concentrations and over 1,300 mercury concentrations. The data set includes samples collected from roadways, curb and gutters, driveways, sidewalks, storm drain inlets and manholes, culverts, ditches and surface soils within public rights-of-way and on private properties.

Figures 3.7 and 3.8 display all the Bay Area regional street dirt and MS4 sediment data for PCBs concentrations (n=1,535) and mercury concentrations (n=1,351), respectively. These figures identify the current BASMAA thresholds used to prioritize WMAs and identify PCBs and mercury sources and source areas. The vast majority of PCBs samples collected to date (>75%) are below the urban background threshold concentration of 0.2 mg/kg. However, nearly 15% of the samples had concentrations at or above the threshold of 0.5 mg/kg used to identify a priority WMA and indicative of a nearby source. Eight percent of all the data are above the 1 mg/kg threshold that BASMAA currently uses to identify a PCBs source. While most (>75%) of mercury samples were below the urban background threshold of 0.3 mg/kg, at least 7% are above 1 mg/kg, suggesting a nearby a source.

[6] The sources of the regional data set include the following: ACCWP 2016, 2017, 2018, 2019, BASMAA 2017a, CCWP 2016, 2017, 2018, 2019, City of San Jose and EOA 2003, EOA 2007, Gilbreath et al. 2016, Gilbreath et al. 2020 *in preparation*, Gunther et al. 2001, KLI and EOA 2002, Kleinfelder 2005, 2006, McKee et al. 2012, 2013, 2017, Salop et al. 2002a, 2002b, SCVURPPP 2016a, 2017a, 2018a, 2019a, 2019c, SMCWPPP 2015, 2016a, 2016b, 2017, 2018, 2019a, 2019b, SMSTOPPP 2002, 2003, 2004, Yee and McKee 2010.

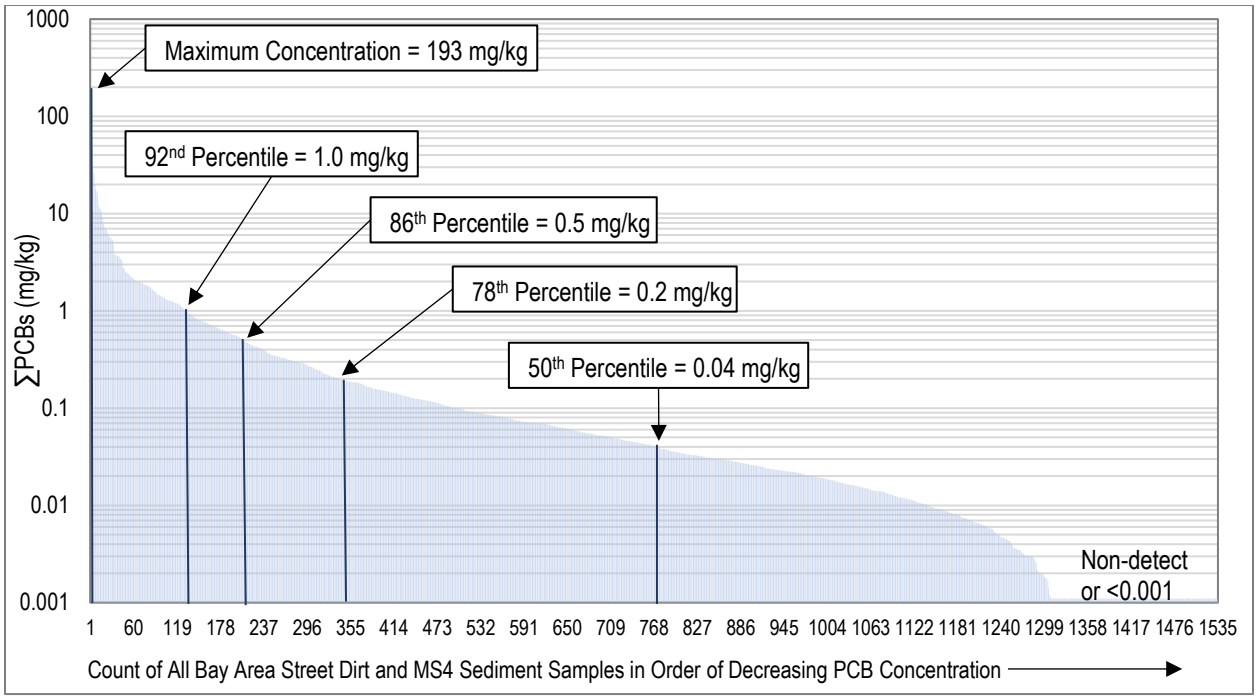


Figure 3.7. Distribution of PCBs concentrations measured in street dirt and MS4 sediment across the Bay Area.

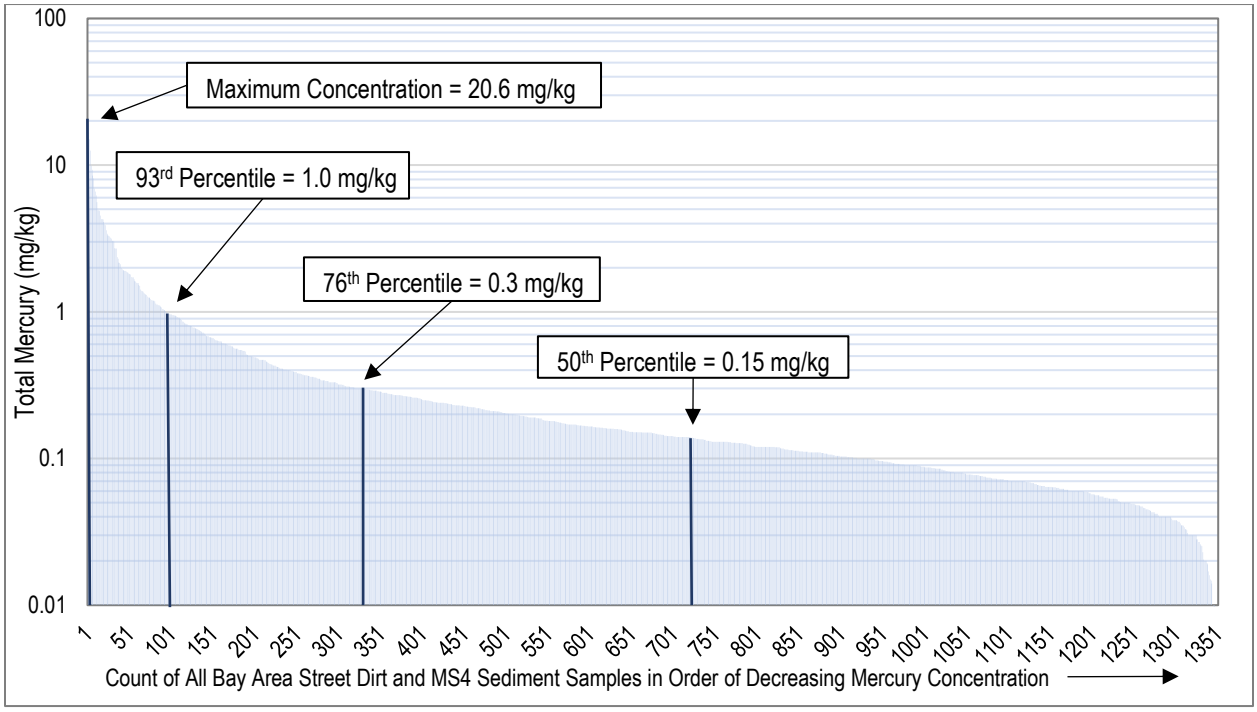


Figure 3.8. Distribution of mercury concentrations measured in street dirt and MS4 sediment across the Bay Area.

Table 3.8 presents descriptive statistics for PCBs and mercury concentrations for the entire Bay Area regional data set, compared with samples collected in Santa Clara Basin in WY 2019 and other years. Across the Bay Area, PCBs concentrations range from ND to 193 mg/kg, with a median of 0.041 mg/kg and a mean of 0.65 mg/kg. Mercury concentrations range from ND to 21 mg/kg, with a median of 0.15 mg/kg and a mean of 0.41 mg/kg. As can be seen in Figures 3.5 and 3.6, there are a few samples with highly elevated concentrations that substantially increase the mean (i.e., average) concentration statistic over the median (i.e., 50th percentile) for both PCBs and mercury. Concentrations of PCBs in Santa Clara Basin are lower on average than in the rest of the Bay Area. However, some of the highest concentrations measured in the Bay Area to date have been observed in the Santa Clara Basin. In contrast, mercury concentrations are typically higher on average in the Santa Clara Basin compared with the rest of the Bay Area. Both SCVURPPP and the BASMAA RMC are planning to collect street dirt and MS4 samples in WY 2020 to increase this dataset.

Table 3.8. Descriptive statistics of PCBs and mercury concentrations in street dirt and MS4 sediment measured across the San Francisco Bay MRP area, in Santa Clara Basin in WY 2019, and in Santa Clara Basin in all other years (through WY 2018).

	PCBs (mg/kg)			HgT (mg/kg)		
Statistic	All Bay Area Data	Santa Clara Basin WY 2019	Santa Clara Basin through WY 2018	All Bay Area Data	Santa Clara Basin WY 2019	Santa Clara Basin through WY 2018
count	1,535	54	433	1,351	54	416
min	ND	0.001	ND	ND	ND	0.020
10th percentile	ND	0.007	ND	0.054	0.047	0.054
25th percentile	0.009	0.013	0.007	0.085	0.085	0.078
50th percentile	0.041	0.027	0.026	0.15	0.12	0.14
75th percentile	0.16	0.14	0.08	0.29	0.23	0.26
90th percentile	0.77	1.0	0.35	0.74	1.23	0.84
Max	193	5.5	27	21	8.5	19
Mean	0.65	0.37	0.40	0.41	0.54	0.52

3.2.4.2. Stormwater Data

The Bay Area regional stormwater dataset now includes samples collected from 138 MS4 catchments and 28 receiving waters throughout the Bay Area. The MS4 catchment sites include storm drain manholes, outfalls, pump stations, and artificial channels. The 28 sites in receiving waters have watersheds ranging in size from less than 3,000 acres (i.e., Lower Penitencia Creek) to the entire Sacramento–San Joaquin River Delta watershed (i.e., Mallard Island). Many of the sites have been sampled during multiple storm events and had multiple samples collected during each storm event. Multiple samples were collected at 15 of the 28 receiving water sites. At each of the 15 sites, between 3 and 126 samples were collected across multiple storm events. Multiple samples were also collected at 12 of the 127 MS4 sites, with between 2 and 80

samples collected at these sites across multiple storm events. Each of these samples were analyzed for PCBs and mercury. For sites with more than one sample collected during a given storm event, the particle ratio is calculated by dividing the sum of PCB concentrations by the sum of suspended sediment concentrations. Performing the calculation in this way is effectively the equivalent of compositing all the individual samples that have been collected at a site. This is consistent with the RMP STLS approach to data evaluation (Gilbreath et al. 2020 *in preparation*).

Table 3.9 lists descriptive statistics for PCBs (n=166) and mercury concentrations (n=113) for the Bay Area stormwater dataset. The median concentration of PCBs in water is 6.98 ng/L, and the mean is 18.9 ng/L. The median PCB particle ratio is 0.11 mg/kg, and the mean is 0.37 mg/kg. Both SCVURPPP and the RMP are continuing to collect stormwater composite samples in WY 2020 to increase this dataset. In future years, it may be informative to correlate measured concentrations to various factors such as storm size, rainfall intensity, antecedent dry weather, land use characteristics, and age of development.

Table 3.9. Descriptive statistics of PCBs, mercury and SSC and PCBs and mercury particle ratios in stormwater measured across the San Francisco Bay MRP area.

Statistic	PCBs (ng/L)	HgT (ng/L)	SSC (mg/L)	PCBs Particle Ratio (mg/kg)	HgT Particle Ratio (mg/kg)
N	166	113	166	166	113
Min	ND	0.44	3.2	ND	0.008
10th percentile	1.37	4.21	15.7	0.018	0.124
25th percentile	2.7	7.36	29.2	0.047	0.201
50th percentile	6.98	15.8	55	0.110	0.341
75th percentile	16.1	35.4	112	0.222	0.532
90th percentile	38.1	67.2	244	0.690	0.748
Max	448	1,053	2,630	9.3	5.3
Mean	18.9	39.4	126	0.367	0.457

PCB concentrations in water samples for the Bay Area dataset (n=166) are plotted in Figure 3.9. PCBs particle ratios are plotted in Figure 3.10. Figures 3.9 and 3.10 symbolize samples according to three categories: collected in Santa Clara Basin in WY 2019 (n=15), collected in Santa Clara Basin in other years (n=59), and collected elsewhere in the Bay Area (n=92). Of the 74 sites in the Santa Clara Basin, 15 were sampled by SCVURPPP in WY 2019, 10 in WY 2018, 17 in WY 2017, and nine in WY 2016. Two sites each year were sampled by RMP STLS in WY 2017, WY 2018 and WY 2019, nine in WY 2016, and thirteen in WY 2015. Eight sites were sampled multiple times by the RMP in prior water years.

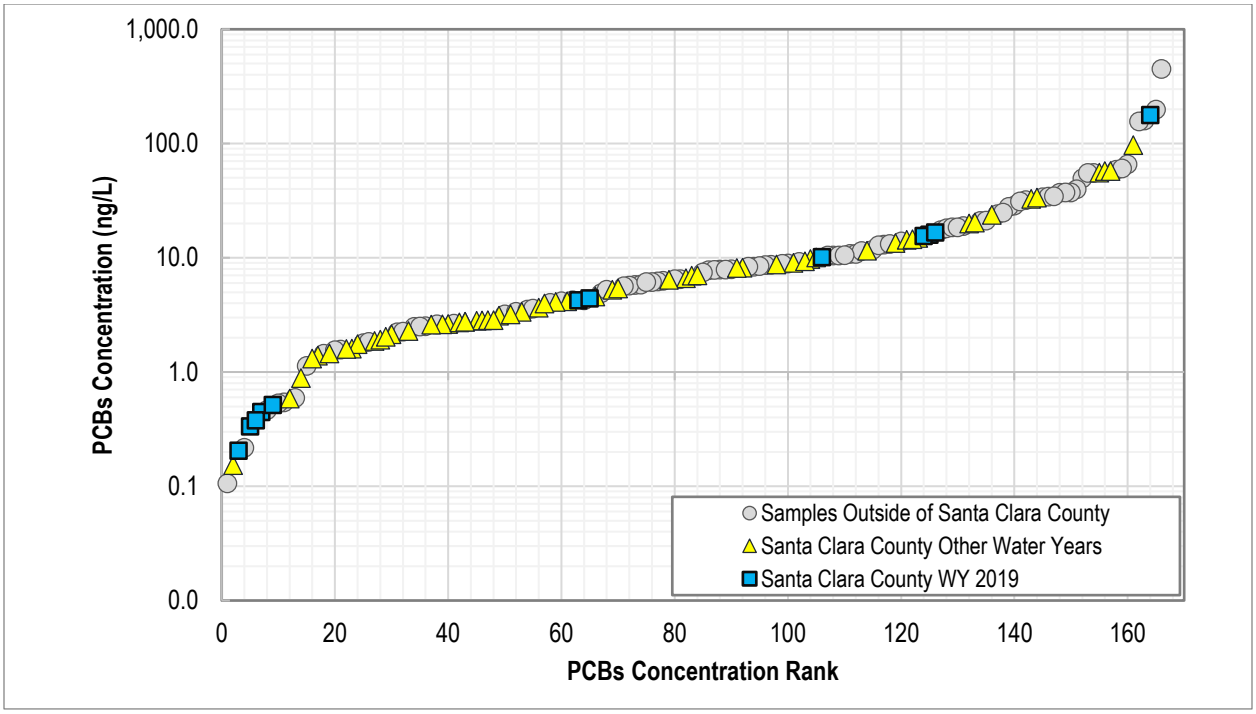


Figure 3.9. PCBs concentrations in storm water samples collected in MS4s and receiving waters draining to the Bay.

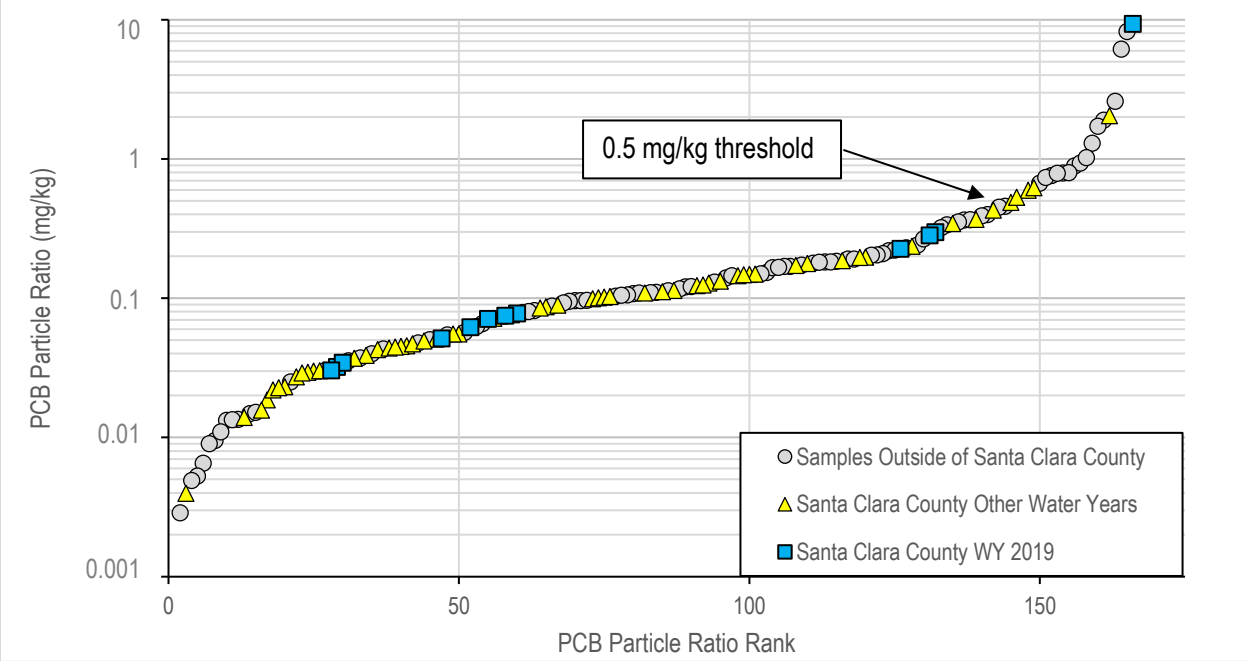


Figure 3.10. PCBs particle ratios in storm water samples collected in MS4s and receiving waters draining to the Bay.

Overall, Santa Clara Basin has relatively low PCBs concentrations and PCBs particle ratios in stormwater compared to the other three counties in the region (Alameda, Contra Costa, and San Mateo). However, some of the highest water concentrations and particle ratios measured in the Bay Area to-date have been observed in Santa Clara Basin, including site 031SCH250B sampled in WY 2019. The highest PCBs concentrations in Santa Clara Basin have been measured at:

- 031SCH250B (Palo Alto) (177 ng/L; sampled WY 2019),
- Sunnyvale East Channel (96.6 ng/L; sampled WYs 2011-14),
- 067CTC250A (Yard Court San Jose) (57.6 ng/L; sampled WY 2017),
- 083GAC900B (Monterey Road at Phelan) (57.3 ng/L; sampled WY 2018),
- 051CTC400A (Ridder Park Dr Storm Drain) (55.5 ng/L; sampled WY 2015), and
- 067SCL080A (Outfall to Lower Silver Creek) (44.6 ng/L; sampled WY 2015).

The sites with the highest PCBs particle ratios are:

- 031SCH250B (Palo Alto) (9,343 ng/g; sampled WY 2019),
- 031SCH250A (Hansen Way Palo Alto) (2,041 ng/g; sampled WY 2017),
- 067SCL080A (Outfall to Lower Silver Creek) (595 ng/g; sampled WY 2015),
- 083GAC900B (Monterey Road at Phelan) (623 ng/g; sampled WY 2018),
- 050GAC020A (Rincon 2 PS San Jose) (530 ng/g; sampled WY 2017), and
- 051CTC400A (Ridder Park Dr Storm Drain) (488 ng/g; sampled WY 2015).

Mercury concentrations in water samples for the Bay Area dataset (n=113) are plotted in Figure 3.11. Mercury particle ratios are plotted in Figure 3.12. Figures 3.11 and 3.12 symbolize samples according to three categories: collected in Santa Clara Basin in WY 2019 (n=15), collected in the Santa Clara Basin in other years (n=35), and collected elsewhere in the Bay Area (n=63). Of the 50 sites in the Santa Clara Basin, 15 were sampled by SCVURPPP in WY 2019, 10 in WY 2018, 17 in WY 2017, and nine in WY 2016. Two sites each year were sampled by RMP STLS in WY 2017, WY 2018 and WY 2019, nine in WY 2016, and thirteen in WY 2015. Two sites were sampled multiple times by the RMP in prior water years. The highest mercury concentrations measured in stormwater in the Bay Area to date were from Guadalupe River samples.

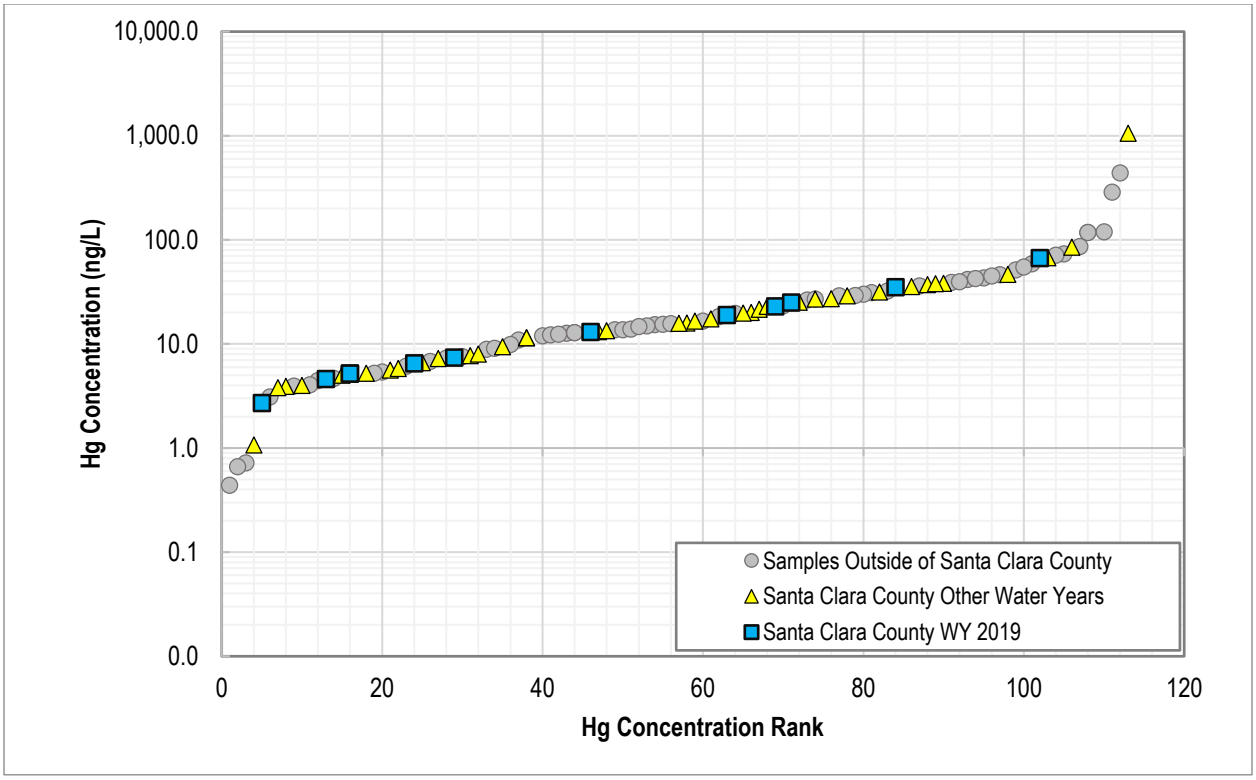


Figure 3.11. Mercury concentrations in storm water samples collected in MS4s and receiving waters draining to the Bay.

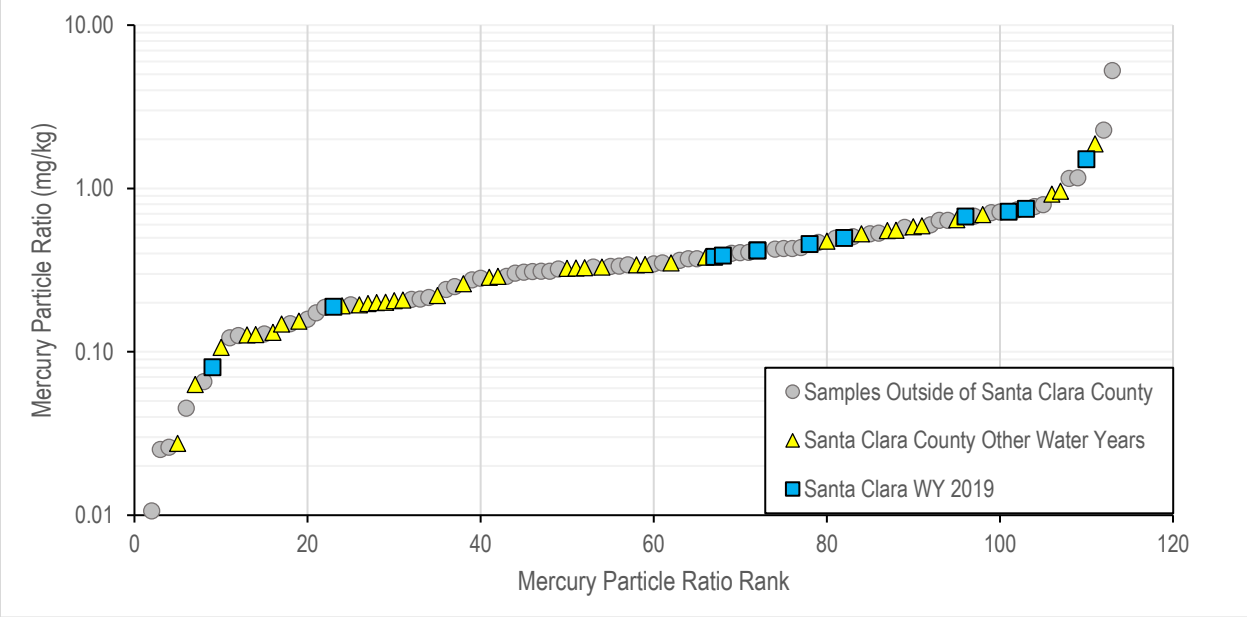


Figure 3.12. Mercury particle ratios in storm water samples collected in MS4s and receiving waters draining to the Bay.

3.2.5. Refined Stormwater Loading Estimates

This section presents modeled estimates of PCBs and mercury stormwater loads for the Santa Clara Basin. These estimates were developed by Paradigm Environmental as Phase I (baseline modeling) for RAA, as required by MRP 2.0 provision C.11/12, to quantitatively demonstrate that proposed green stormwater infrastructure (GSI) will result in sufficient load reductions of PCBs and mercury to meet TMDL wasteload allocations. The model was developed using the Loading Simulation Program in C++ (LSPC), a watershed modeling system that includes Hydrologic Simulation Program FORTRAN (HSPF) algorithms for simulating watershed hydrology, erosion, water quality process, and in-stream fate and transport processes. The model simulates upland loading and transport of sediment, mercury, and PCBs. Table 3.10 presents the modeled PCBs and mercury stormwater loads to the San Francisco Bay from the MRP Area and other NPDES Permitted Areas and Non-Urban Areas in the Santa Clara Basin. The MRP area loads are 2.2 kg/year for PCBs and 5.6 kg/year for mercury.

Table 3.10. Summary of total area and pollutant load by watershed and type of area in the Santa Clara Basin.

Permitted and Other Areas		Area (acres)	Loads (kg/year)	
			PCBs	Mercury
MS4-permitted Area (MRP-Area)		141,360	2.2	5.6
Other NPDES Permitted Areas	Non-Urban Area/Open Space	283,034	0.03	13.01
	Public Schools	4,567	0.12	0.21
	Caltrans	5,741	0.15	0.26
	Individual Industrial NPDES Permit	627	0.05	0.03
	Industrial General Permit (IGP)	5,020	0.42	0.18
	Phase 2 Small MS4	131	0.004	0.006
Total		**440,480**	**2.97**	**19.30**

The full details of the baseline model development, assumptions, model performance and calibration, and validation results are presented Attachment D-5.

3.3. Copper

This section summarizes compliance with MRP 2.0 provision C.8.f requirements for copper monitoring during WY 2016 – WY 2019. Copper data collected in compliance with MRP 1.0 provision C.8.e are summarized under the loading station summary in Section 2.

The Water Quality Control Plan for the San Francisco Bay Basin (Basin Plan) includes a Water Quality Attainment Strategy (WQAS) to support copper site-specific objectives for San Francisco Bay (SFBRWQCB 2017). The WQAS for copper states that NPDES permits for urban runoff management agencies must require implementation of best management practices and control measures designed to prevent urban runoff discharges from causing or contributing to exceedances of copper water quality objectives. These measures are included in Provision C.13 of MRP 2.0. Additionally, the WQAS requires that NPDES permits contain requirements to conduct or cause to be conducted monitoring of copper loading to the Bay. The RMP Status and Trends Monitoring Program currently collects water and sediment samples from San Francisco

Bay every two or three years for analysis of a large suite of toxic contaminants, including copper. In addition to the RMP studies, copper monitoring is required by provision C.8.f of MRP 2.0.

From WY 2016 through WY 2019, in compliance with MRP 2.0 provision C.8.f, SCVURPPP collected at least two samples per year for copper analysis. The goal of the monitoring was to address Management Question Nos. 4 (Loads and Status) and 5 (Trends). A different copper monitoring approach was followed each year, often with the objective of opportunistically conducting copper analyses on samples collected for other purposes. In addition, trends samples collected in Santa Clara Basin by the SPoT program are used to supplement SCVURPPP monitoring efforts (see Section 4.0 for a description of the SPoT program). Table 3.11 lists the number of copper samples collected each year by SCURPPP and SPoT, and the applicable Management Question(s). As described in Table 3.11, a total of 20 Santa Clara Basin samples were analyzed for copper from WY 2016 through WY 2019. Seventeen of these samples address Management Question No. 4 (Loads and Status) and 12 address Management Question No. 5 (Trends).

Table 3.11. SCVURPPP and third-party monitoring accomplishments for copper, WY 2016 – WY 2019.

Pollutant of Concern/ Organization	Number of Samples	Management Question Addressed[a]					Sample Type and Comments
		1. Source Identification	2. Contributions to Bay Impairment	3. Management Action Effectiveness	4. Loads and Status	5. Trends	
WY 2019							
SCVURPPP	2	--	--	--	2	--	Copper analyzed on a subset of PCBs/Hg stormwater runoff samples
WY 2018							
SCVURPPP	6	--	--	--	6	6	Creek water samples collected during storm event and spring base flows
SPoT	2	--	--	--	--	2	Sediment sample to assess trends at long-term monitoring station
WY 2017							
SCVURPPP	2	--	--	--	2	--	Copper analyzed on a subset of PCBs/Hg stormwater runoff samples
SCVURPPP	3	--	--	--	3	3	Creek water samples collected during storm event
SPoT	1	--	--	--	--	1	Sediment sample to assess trends at long-term monitoring station
WY 2016							
SCVURPPP	4	--	--	--	4	--	Copper analyzed on a subset of PCBs/Hg stormwater runoff samples
Total / MRP Minimum[b]	20 / 20	NA	NA	NA	17 / 4	12 / 4	

NA = Not Applicable. For this pollutant, the MRP does not require sampling to address the management question.

[a] Individual samples can address more than one Management Question simultaneously.

[b] The MRP overall minimum number of samples must be met by the end of the five-year permit term. The MRP minimum number of samples for each Management Question must be met by the end of year four of the permit.

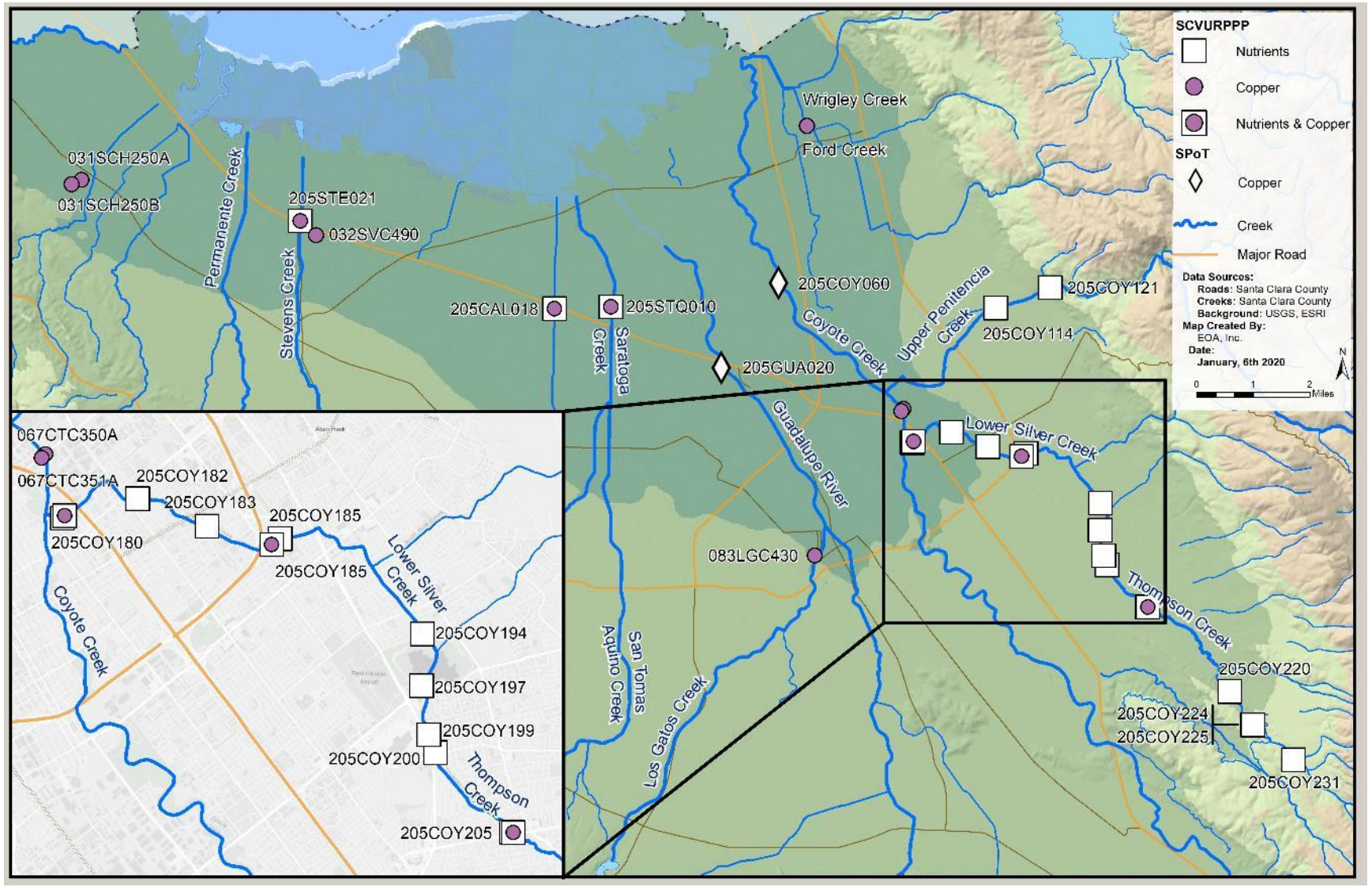


Figure 3.13. Copper and nutrient monitoring stations, Santa Clara Basin, WY 2016 – WY 2019.

The bullets below describe SCVURPPP approaches to copper monitoring in WY 2016 through WY 2019 and findings based on the laboratory results. Monitoring stations are mapped in Figure 3.13. All SCVURPPP samples were analyzed for total and dissolved copper[7] (method EPA 200.8) and hardness (method SM 2340C). Results are summarized in Table 3.12. Comparisons to applicable water quality objectives are included in Section 5.0.

- **WY 2016, WY 2017, and WY 2019: Storm Samples from High Interest Catchments.** In WY 2016, WY 2017, and WY 2019, SCVURPPP conducted copper analyses on a subset of the composite samples of stormwater runoff collected at the bottom of catchments containing parcels of high interest with respect to PCBs sources (i.e., generally old industrial land uses). See Section 3.2.1 (Monitoring to Identify Sources and Source Areas) for a discussion of WMAs and high interest parcels. Sample locations were typically located within the MS4 (e.g., outfall to receiving water, catch basin, manhole vault, pump station); however, two of the samples collected in WY 2016 were collected in small creeks (Ford Creek and Wrigley Creek).
    - The results summarized in Table 3.12 suggest that copper concentrations in stormwater runoff composite samples collected at outfalls draining catchments with old industrial land uses are generally higher than those collected from creeks draining larger watersheds with a greater mix of land uses.
    - The hardness of the receiving waters is generally higher than MS4 samples, meaning that the bioavailability of the copper entering from the MS4 would be reduced upon mixing with receiving water.
- **WY 2017: Wet Weather Upstream/Downstream Comparison.** SCVURPPP sampled three locations (upstream, middle, and downstream) within the Lower Silver Creek watershed during a storm event on January 9, 2017. The Lower Silver Creek watershed has a mix of urban and non-urban land uses with increasing urban density in the downstream direction.
    - Copper concentrations increased in the downstream direction, suggesting that stormwater runoff from the urban land uses was contributing copper to the creek.
- **WY 2018: Wet Weather/Spring Baseflow Comparison.** SCVURPPP sampled three bottom-of-the-watershed locations (Stevens Creek, San Tomas Aquino Creek, and Calabazas Creek) during a storm event on January 8, 2018 and during subsequent spring baseflow to compare seasonal differences in copper concentrations. Mobilization for storm sample collection in WY 2018 was driven by MPR 2.0 provision C.8.g (Pesticides & Toxicity) monitoring requirements.
    - Copper concentrations at all three stations (205STE021, 205STQ010, 205CAL018) were higher during the January storm event compared to the spring base flow event, suggesting an influence by stormwater runoff.
    - In addition, the dissolved portion of the total copper concentration was higher in the spring baseflow samples compared to the storm samples. This finding illustrates that copper tends to bind with suspended sediment which is higher during storm events.

[7] In order to simplify the field effort and reduce the risk of sample contamination, SCVURPPP requested that the analytical laboratory conduct the sample filtration required for dissolved copper analysis.

Table 3.12. Total and dissolved copper concentrations in SCVURPPP water samples, WY 2016 – WY 2019.

Station Code	Creek/Location	Sample Date	Total Copper (µg/L)	Dissolved Copper (µg/L)	Hardness as $CaCO_3$ (mg/L)
WYs 2016, 2017 & 2019 Stormwater Runoff Composite Samples from MS4s in catchments with High-interest Parcels					
032SVC490A	MS4 station in Mountain View	1/5/2016	10.5	4.3	30
083LGC430A	MS4 station in San Jose	1/19/2016	11.8	4.4	20
Ford_A	Ford Creek	1/17/2016	7.17	2.4	172
Wrigley_A	Wrigley Creek	1/17/2016	7.38	2.9	164
067CTC750A	MS4 station in San Jose	2/7/2017	8.8	3.0	146
067CTC810A	MS4 station in San Jose	2/7/2017	28	7.2	58
031SCH250A	Catch basin inlet in Palo alto	1/6/2019	13	4.8	10
031SCH250B	Manhole vault in Palo Alto	1/6/2019	8.5	5	12
WY 2017 Wet Weather Upstream/Downstream Comparison					
205COY180	Lower Silver (downstream)	1/9/2017	31	9.6	160
205COY185	Lower Silver (middle)	1/9/2017	29	8.7	170
205COY205	Lower Silver (upstream)	1/9/2017	14	7.5	200
WY 2018 Wet Weather/Spring Baseflow Comparison					
205STE021	Stevens (storm event)	1/8/2018	12	4.3	60
205STQ010	San Tomas Aquino (storm event)	1/8/2018	14	30 *	46
205CAL018	Calabazas (storm event)	1/8/2018	14	4.1	50
205STE021	Stevens (spring baseflow)	5/21/2018	0.59	0.22	440
205STQ010	San Tomas Aquino (spring baseflow)	5/21/2018	1.2	0.85	390
205CAL018	Calabazas (spring baseflow)	5/21/2018	0.82	0.46	460

* The dissolved copper concentration from the Jan. 8, 2018 205STQ010 sample was flagged as questionable. Dissolved copper, by definition, must be ≤ total copper, which is not the case in this sample. The data validation process did not find any other concerns with the copper results. It is possible that contamination was introduced during the laboratory filtration process for this sample.

3.4 Nutrients

This section summarizes compliance with MRP 2.0 provision C.8.f requirements for nutrient monitoring during WY 2016 – WY 2019. Nutrient data collected in compliance with MRP 1.0 provision C.8.e are summarized under the loading station summary.

Nutrients were included in the MRP 2.0 POC monitoring requirements to support Regional Water Board efforts to develop nutrient numeric endpoints (NNE) for the San Francisco Bay Estuary. The “San Francisco Bay Nutrient Management Strategy” (NMS) is part of a statewide initiative to address nutrient over-enrichment in State waters (SFBRWQCB 2012). Its goal is to lay out a well-reasoned and cost-effective program to generate the scientific understanding needed to fully support major management decisions such as establishing/revising Water Quality Objectives (WQOs) for nutrients and dissolved oxygen, developing/implementing a nutrient monitoring program, and specifying nutrient limits in NPDES permits. The NMS

monitoring program currently focuses on stations located within San Francisco Bay rather than freshwater tributaries.

Provision C.8.f of MRP 2.0 requires monitoring for a suite of nutrients (i.e., ammonium, nitrate, nitrite, total Kjeldahl nitrogen (TKN), orthophosphate, and total phosphorus). This list is similar to the list of analytes measured by the RMP and BASMAA partners at the six regional loading stations (including the Santa Clara Basin stations on the Guadalupe River and Sunnyvale East Channel) monitored in WY 2012 - WY 2014. The prior data collected in freshwater tributaries to San Francisco Bay were used by the Nutrient Strategy Technical Team to develop and calibrate nutrient loading models.

In WY 2016 through WY 2019, in compliance with provision C.8.f of MRP 2.0, the Countywide Program collected at least two samples per year for nutrient analysis. The goal of the monitoring was to address Management Question No. 4 (loads and Status) for which at least 20 samples needed to be collected by year four of the permit (i.e., WY 2019). The analytes and chemical analysis methods were ammonia (SM 4500C), nitrate (EPA 300.0), nitrite (SM 4500B), TKN (SM 4500C), orthophosphate (SM 4500E), and total phosphorus (SM 4500E).

The bullets below describe SCVURPPP approaches to nutrient monitoring in WY 2016 through WY 2019. Monitoring stations are mapped in Figure 3.11. Findings are based on the results summarized in Table 3.12. Comparisons to applicable WQOs are described in Section 5.0.

- **WY 2016: Spring Baseflow Upstream/Downstream Comparison & SSID Project Support.** POC monitoring for nutrients in Santa Clara Basin was conducted synoptically with bioassessment monitoring during spring baseflow conditions in Upper Penitencia Creek as part of a Stressor/Source Identification (SSID) study. The Upper Penitencia Creek SSID Project investigated high waters temperatures and low ecological integrity at a specific segment of the creek (i.e., based on California Stream Condition Index scores) following the Causal Analysis/Diagnosis Decision Information System (CADDIS) framework developed by the USEPA. The SSID Project Report was included with the SCVURPPP WY 2016 Urban Creeks Monitoring Report (SCVURPPP 2017).
    - Results of WY 2016 nutrient monitoring listed in Table 3.13 show that the downstream station (205COY114) had higher concentrations of all nutrient species compared to the upstream station (205COY121). More information about the differences between the two stations is provided in the SSID Project Report.

- **WY 2017: Wet Weather/Spring Baseflow Comparison.** SCVURPPP sampled three locations (upstream, middle, and downstream) within the Lower Silver Creek watershed during a storm event on January 9, 2017. Follow-up monitoring was attempted at all three stations during spring baseflow conditions; however, the upstream station (205COY205) was dry. The Lower Silver Creek watershed has a mix of urban and non-urban land uses with increasing urban density in the downstream direction.
    - During the January storm event, total nitrogen concentrations were lower at the downstream station (205COY180) compared to the upstream (205COY205) and middle (205C07185) stations. In June, this trend was reversed with higher total nitrogen concentrations at the downstream station compared to the middle station. In contrast to total nitrogen, phosphorus concentrations increased in the downstream direction during the January storm event and decreased in the downstream direction in June.

- Inorganic nitrogen (nitrate and nitrite) concentrations were higher in June compared to the January storm event and organic nitrogen (TKN) concentrations were lower in June compared to the January storm event.
- Organic nitrogen (TKN) made up a greater proportion of the total nitrogen concentration during the January storm event compared to the June event. It is likely that organically-bound nitrogen washed off surfaces during the January storm had not yet had time to cycle through the ammonification and nitrification processes before samples were collected. In June, TKN made up just a small percent of the total nitrogen.
- Phosphorus concentrations were higher during the January storm runoff sampling event compared to the June baseflow event. This finding is consistent with the draft conceptual model developed by the NMS which suggests that nutrient loads to San Francisco Bay from creeks are highest during the wet season, although considerably less than loads from publicly owned wastewater treatment works (POTWs) (Senn and Novick 2014). However, nitrogen concentrations (primarily nitrate) were higher during the baseflow event. It unknown why nitrate patterns were not consistent with the NMS model.

- **WY 2018: Wet Weather/Spring Baseflow Comparison.** SCVURPPP sampled three bottom-of-the-watershed locations (Stevens Creek, San Tomas Aquino Creek, and Calabazas Creek) during a storm event on January 8, 2018 and during subsequent spring baseflow to compare seasonal differences in nutrient concentrations. Mobilization for storm sample collection in WY 2018 was driven by MPR 2.0 provision C.8.g (Pesticides & Toxicity) monitoring requirements.
  - Concentrations of all nutrients were similar at all three stations during the January event. In contrast, there was high variability among the stations during the May event, particularly for nitrate and phosphorus which varied by an order of magnitude.
  - Similar to WY 2017, organic nitrogen (TKN) made up a greater proportion of the total nitrogen concentration during the January 2018 storm event compared to the May2018 event. It is likely that organically-bound nitrogen washed off surfaces during the January storm had not yet had time to cycle through ammonification and nitrification processes before samples were collected.
  - Phosphorus concentrations were higher during the January storm runoff sampling event compared to the May baseflow event. This finding is consistent with the draft conceptual model developed by the NMS which suggests that nutrient loads to San Francisco Bay from creeks are highest during the wet season, although considerably less than loads from publicly owned wastewater treatment works (POTWs) (Senn and Novick 2014). However, nitrogen concentrations (primarily nitrate) were higher during the baseflow event at two of the three stations. The nitrate patterns were not consistent with the NMS model but were consistent with SCVURPPP POC monitoring conducted in WY 2017 in Lower Silver Creek.

- **WY 2019: Summer Concentrations along a Creek Gradient & SSID Project Support.** SCUVRPPP sampled nutrients at 13 creek stations on Thompson Creek and Lower Silver Creek as part of a SSID study investigating causes of low biological stream condition and nutrient sources. The Work Plan for the Lower Silver-Thompson Creek

Watershed SSID Project (and a summary of preliminary findings) is included with Part C of this Integrated Monitoring Report. Additional nutrient monitoring was conducted after the August 8, 2019 POC nutrient monitoring event and is anticipated to continue into WY 2020.

- Total nitrogen concentrations increased in the downstream direction but there were several exceptions to this spatial trend. For example, total nitrogen at the downstream-most station (2.7 mg/L at 205COY180) was less than that measured at the next station upstream (7.7 mg/L at 205COY182).

- Stations 205COY197, 205COY199, and 205COY200 are located in a relatively low-gradient reach that is characterized by slow moving water and considerable amounts of algae. Total nitrogen concentrations were relatively high in this reach (2.2 mg/L to 4.5 mg/L).

Table 3.13. Nutrient Concentrations in SCVURPPP Water Samples, WY 2016 – WY 2019.

Station Code	Creek/ Location	Date	Nitrate as N	Nitrite as N	Total Kjeldahl Nitrogen (TKN)	Ammonia as N	Un-ionized Ammonia as N[1]	Ammonium[2]	Total Nitrogen[3]	Dissolved Orthophosphate as P	Phosphorus as P
WY 2016											
205COY114	Upper Penitencia (downstream)	6/9/2016	0.3	0.008	1.1	0.11	0.01	0.1	1.41	0.14	0.28
205COY121	Upper Penitencia (upstream)	6/9/2016	0.042	0.001	0.88	0.043	0.003	0.04	0.92	0.006	0.089
WY 2017											
205COY180	Lower Silver (downstream)	1/9/2017	1.2	0.011	2.1	0.073	0.0016	0.071	3.3	0.18	0.88
205COY185	Lower Silver (middle)	1/9/2017	1.4	0.012	2.0	0.095	0.0016	0.093	3.4	0.20	0.87
205COY205	Lower Silver (upstream)	1/9/2017	2.7	0.014	1.9	0.069	0.0022	0.067	4.6	0.18	0.43
205COY180	Lower Silver (downstream)	6/1/2017	5.3	0.031	0.22	0.082	0.0067	0.075	5.6	0.024	0.051
205COY185	Lower Silver (middle)	6/1/2017	4.2	0.044	0.62	0.11	0.0073	0.10	4.9	0.046	0.10
205COY205	Lower Silver (upstream)	6/1//2017	No samples collected – creek bed dry								
WY 2018											
205STE021	Stevens Creek	1/8/2018	0.22	0.017	1.1	0.13	0.002	0.128	1.34	0.11	0.24
205STQ010	San Tomas Aquino	1/8/2018	0.23	0.017	0.97	0.20	0.003	0.197	1.22	0.18	0.34
205CAL018	Calabazas Creek	1/8/2018	0.22	0.016	1.1	0.13	0.002	0.128	1.34	0.13	0.28
205STE021	Stevens Creek	5/21/2018	1.4	0.007	0.57	0.034	0.001	0.033	1.98	0.024	0.025
205STQ010	San Tomas Aquino	5/21/2018	ND	0.0016	0.66	0.053	0.007	0.046	0.67	ND	0.16
205CAL018	Calabazas Creek	5/21/2018	3.2	0.011	0.35	0.040	0.015	0.025	3.56	0.038	0.019
WY 2019											
205COY231	Thompson at Turturici Way	8/8/2019	0.58	0.003	0.25	0.05	0.001	0.05	0.8	0.088	0.09
205COY225	Thompson upstream Cribari Cr confluence	8/8/2019	0.38	0.004	0.25	0.10	0.002	0.09	0.6	0.1	0.10
205COY224	Thompson downstream Cribari Cr confluence	8/8/2019	0.4	0.007	0.55	0.58	0.012	0.57	1.0	0.16	0.17
205COY220	Thompson at Thorncreek Ct	8/8/2019	0.07	0.002	0.61	0.10	0.003	0.09	0.7	0.17	0.17
205COY205	Thompson at Aborn	8/8/2019	1.6	0.01	0.74	0.07	0.012	0.05	2.4	0.15	0.16

Station Code	Creek/ Location	Date	Nitrate as N	Nitrite as N	Total Kjeldahl Nitrogen (TKN)	Ammonia as N	Un-ionized Ammonia as N[1]	Ammonium[2]	Total Nitrogen[3]	Dissolved Orthophosphate as P	Phosphorus as P
205COY200	Thompson at Quimby	8/8/2019	4.5	0.008	ND	0.10	0.001	0.10	4.5	0.036	0.04
205COY199	Lower Silver downstream Norwood Cr confluence	8/8/2019	3.7	0.046	ND	0.18	0.002	0.18	3.7	0.021	0.03
205COY197	Lower Silver at Tully Rd	8/8/2019	2.2	0.045	0.94	0.35	0.006	0.34	3.2	0.006	0.09
205COY194	Lower Silver at Cunningham Rd	8/8/2019	1.9	0.038	0.77	0.30	0.011	0.29	2.7	0.036	0.10
205COY185	Lower Silver about 250 m upstream S. Jackson Ave	8/8/2019	1.7	0.042	0.66	0.44	0.017	0.42	2.4	0.061	0.14
205COY183	Lower Silver at Lausette	8/8/2019	1.7	0.029	0.61	0.57	0.037	0.53	2.3	0.045	0.14
205COY182	Lower Silver at footbridge in Arroyo Plato Park	8/8/2019	7.7	0.011	ND	0.54	0.008	0.53	7.7	0.042	0.06
205COY180	Lower Silver at Wooster	8/8/2019	1.9	0.021	0.8	0.57	0.061	0.51	2.7	0.029	0.09

Notes:

All constituents reported as mg/L.

J-flagged data are above the detection limit but less than the reporting limit and are therefore considered estimated.

ND = Not Detected

[1] Un-ionized ammonia calculated using formula provided by the American Fisheries Society Online Resources. Formula requires field measurements of temperature, pH, and specific conductance, which were not recorded for the Jan. 8, 2018 event. Specific conductance and pH values for Jan. 8, 2018 samples were estimated based on laboratory intake measurements reported for the concurrent toxicity samples. Temperature was estimated to be 12°C. Un-ionized ammonia calculated using ½ method detection limit for non-detect ammonia measurements.

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

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

3.5 Emerging Contaminants

Emerging contaminant monitoring is being addressed through SCVURPPP's participation in the Regional Monitoring Program for Water Quality in San Francisco Bay (RMP). The RMP has investigated Contaminants of Emerging Concern (CECs) since 2001 and established the RMP Emerging Contaminants Work Group (ECWG) in 2006. The purpose of the ECWG is to identify CECs that might impact beneficial uses in the Bay and to develop cost-effective strategies to identify, monitor, and minimize impacts. The RMP published a CEC Strategy "living" document in 2013 and completed a full revision in 2017 (Sutton et al. 2013, Sutton and Sedlak 2015, Sutton et al. 2017) and made minor updates in 2018 (Lin et al. 2018). The CEC Strategy document guides RMP special studies on CECs using a tiered risk and management action framework.

Provision C.8.f of MRP 2.0 identifies three emerging contaminants that at a minimum must be addressed through POC monitoring: Perflourooctane Sulfonate Substances (PFOS), Perfluoroalkyl and Polyfluoroalkyl Sulfonate Substances (PFAS), and Alternative Flame Retardants (AFRs). PFAS is a broad class of chemicals used in industrial applications and consumer goods primarily for their ability to repel oil and water. PFOS are a subgroup within the PFAS umbrella and are identified in the CEC Strategy as "moderate" concern due to Bay occurrence data suggesting a high probability of a low-level effect on Bay wildlife. Other PFAS and AFRs are mostly identified as "possible" concern due to uncertainties in measured or predicted Bay concentrations or in toxicity thresholds. RMP staff recently published reports summarizing PFOS and PFAS monitoring results in the Bay (Houtz et al. 2016, Sedlak et al. 2017, Sedlak et al. 2018). Organophosphate esters (OPEs), a class of AFRs widely used in plastic and polymer additives for their flame retardant properties, have recently been elevated to "moderate" concern by the ECWG due to their presence in the Bay at levels comparable to or exceeding protective thresholds; the potential for cumulative endocrine disrupting effects; lack of understanding of fate and transport; and likelihood of increased use as replacement compounds (Shimabuku et al. 2019 (Draft)). Bisphenols (another class of plastic additives with endocrine-disrupting properties) have also been elevated to "moderate" concern based on recent Bay monitoring results, and in 2019, the ECWG recommended further monitoring of OPEs and bisphenols, including stormwater monitoring.

AFRs came into use following state bans and nationwide phase-outs of polybrominated diphenyl ether (PBDE) flame retardants in the early 2000's. In 2018 the RMP STLS and ECWG worked together to conduct a special study to inform ECWG's planning activities related to AFRs. The special study compiled and reviewed available data and previously developed conceptual models for PBDE to support a stormwater-related AFR conceptual model being developed by the ECWG. Organophosphate esters were prioritized for further investigation due to their increasing use, persistent character, and ubiquitous detections at concentrations exceeding PBDE concentrations in the Bay. Limited stormwater data from two watersheds in Richmond and Sunnyvale suggest that urban runoff may be an important source of these compounds. Additional monitoring and modeling was recommended in the special study, which was published in 2018 (Sutton and Lin 2018). In 2019, based on recent results from the 2017 RMP Status and Trends Water Cruise on OPE detections, and with the opportunity to advance monitoring of OPEs and other CECs via the multi-year non-targeted analysis of stormwater-related CECs initiated in 2018, the ECWG agreed to prioritize monitoring AFRs for RMP special studies. Additional funds were recommended to supplement the Emerging Contaminants Strategy in support of developing CECs conceptual models more broadly as part of the longer-term CECs Modeling Strategy.

In 2018, the RMP's ECWG initiated a multi-year special study to analyze stormwater samples collected from urban watersheds for a large suite of CECs. The list of CECs to be analyzed is based on recent work conducted in Puget Sound streams and is intended to target urban runoff constituents rather than those found in wastewater (e.g., pharmaceuticals). In addition to vehicle tire chemicals and imidacloprid (a neonicotinoid insecticide), the list includes the CECs specifically identified in provision C.8.f of MRP 2.0 (PFOSs, PFASs, and AFRs). Pilot sampling began in 2019 in close coordination with the STLS and preliminary results were shared with the ECWG. Year-two of this three-year study was approved in 2019, with the inclusion of additional CECs, including OPEs and bisphenol A and S. The final reports and manuscripts for this study are anticipated in fall 2020.

4. SPOT MONITORING PROGRAM

The SPoT Monitoring Program conducts annual dry season monitoring (subject to funding constraints) of sediments collected from a statewide network of large rivers. The primary goal of the SPoT Program is to investigate long-term trends in water quality (Management Question #5 – Trends). Based on discussions with Regional Water Board (SWAMP) staff, RMC participants are complying with long-term trends monitoring requirements described in MRP 1.0 provision C.8.e and MRP 2.0 provision C.8.f via monitoring conducted by the SPoT program. This manner of compliance is consistent with the MRP language in provisions C.8.e.ii and C.8.a.iv. RMC representatives coordinate with the SPoT program on long-term monitoring to ensure MRP monitoring and reporting requirements are addressed. The three specific goals of the SPoT program are:

1. Evaluate long-term trends in stream contaminant concentrations and effects statewide.
2. Relate water quality indicators to land-use characteristics and management effort.
3. Establish a network of sites throughout the state to serve as a backbone for collaboration with local, regional, and federal monitoring.

The statewide network of SPoT sites represents approximately one half of California's watersheds and includes two stations in Santa Clara Basin (Coyote Creek and Guadalupe River, Figure 1.1). Sites are targeted in bottom-of-the-watershed locations with slow water flow and appropriate micromorphology to allow deposition and accumulation of sediments. In most years, stream sediments are collected and analyzed for PCBs, mercury, toxicity, pesticides, and organic pollutants (Phillips et al. 2016). The most recent technical report prepared by SPoT program staff was published in 2016 and describes seven-year trends from the initiation of the program in 2008 through 2014 (Phillips et al. 2016). The main findings from this report are summarized below. An update to the report is anticipated in the near future.

Additional information on the SPoT program can be found at http://www.waterboards.ca.gov/water_issues/programs/swamp.

4.1. Summary of Findings

The SPoT report (Phillips et al. 2016) summarizes the 2008 – 2014 data on statewide and regional scales. In addition, pollutant concentrations are correlated to SWAMP bioassessment data and land use characteristics (i.e., urban, agriculture, open space) on the 1 km, 5 km, and watershed scales. The SPoT report made the following statewide conclusions:

- Significant toxicity is consistently observed indicating beneficial uses are not fully protected.
- The percentage of toxic samples has remained consistent, but there are an increasing number of sites with "some toxicity" or "high toxicity".
- Average concentrations of pyrethroids, metals and PBDEs are significantly increasing. DDTs and PCBs are significantly decreasing. Fipronil use is increasing, as are the number of detections and average concentrations.

- Significant contaminant increases were observed in urban watersheds. Between 2010 and 2013, average concentrations of pyrethroids have doubled. The cyanotoxin microcystin was detected in 29% of sediment samples in 2014.
- Clear trends emerged after five years, and included significant increases in pyrethroid concentrations, as well as significant decreases in the organochlorine compounds PCBs and DDTs (Phillips et al., 2014). Two additional years of data confirm these trends and demonstrate additional significant increases in metals and PBDE both statewide and in urban watersheds, as well as increases in fine-grained sediment and total organic carbon (statewide only).
- Chemical contamination and toxicity are most severe in urban watersheds.
- Urban watersheds have the highest contaminant concentrations, and toxicity has the strongest correlations with urban insecticides.
- Toxicity thresholds for pesticides were exceeded in 19% of the samples. Most of the exceeded thresholds were for pyrethroids.
- Significantly more samples were toxic, and the magnitude of toxicity was much greater when samples were tested at a more environmentally relevant test temperature.
- It is too soon to tell if more stringent rules for the urban application of pyrethroid pesticides will result in reduced load to urban watersheds, or if the reduction of copper in automobile brake pads will result in a corresponding reduction of copper in SPoT sediments.
- Not all of our watersheds are healthy. When data from SPoT are combined with data from other programs, it is clear that anthropogenic stressors are affecting ecosystem health.
- Data from SPoT indicate that pesticides are the most significant environmental stressor.
- Adapting to future needs. The SPoT program is managed to adapt to changing conditions, and the revised program design in 2015 was based on trends from the first five years of data. Changes included the addition of contaminants of emerging concern, such as fipronil, addition of toxicity species/protocols sensitive to new contaminants, and the reduced emphasis on legacy contaminants that pose less of an environmental threat to California watersheds. Moving forward, the program is planning to expand the collaboration with DPR to create a water column monitoring component that will include toxicity tests and chemical 4 analyses that focus on pesticides of emerging concern (e.g., neonicotinoids). This collaboration will also address the goals of the State Water Board's Strategy to Optimize Resource Management of Storm Water (Storm Water Strategy, STORMS).

Regional conclusions include:

- Coyote Creek had significant trends of increasing amphipod survival in toxicity tests.
- Significant increases in PBDE's were observed in sediments from the Guadalupe River site.
- Despite statewide increases in pyrethroid pesticides in urban watersheds, there was no significant increases of pyrethroids at the Santa Clara Basin sites.

A summary of the data collected from the two Santa Clara Basin sites (205COY060 – Coyote Creek, and 205GUA020 – Guadalupe Creek) as reported in Phillips et al., (2016) is presented in Table 4.1.

Table 4.1. Summary of WY 2008 – WY 2014 SPoT data at two Santa Clara Basin sites from Phillips et al. (2016).

Watershed	Land Use	Sample Years	Mean % Survival 2010 - 2014	Mean Total Concentration (ng/g)						Mean Total Conc. ug/g 4 Metals	% Fines	% TOC
				Pyrethroids	Fipronil	PBDE	PAH	DDT	PCBs			
Coyote Creek; Station Code 205COY060	Urban	2008 - 2014	96	121	1.3	58.2	1269	17.7	19	250	68.1	3.67
Guadalupe River; Station Code 205GUA020	Urban	2008 - 2014	91	54.3	0.58	60.2	1891	29	72.8	334	66.8	4.37

5. COMPARISON TO APPLICABLE WATER QUALITY STANDARDS

Provision C.8.h.i of MRP 2.0 requires RMC participants to assess all data collected pursuant to provision C.8 for compliance with applicable WQOs. In compliance with this requirement, POC monitoring water sampling data collected in WY 2016 through 2019 by the Countywide Program were compared to applicable numeric WQOs[8].

The comparison to applicable WQOs takes into account the following considerations:

- **Discharge vs. Receiving Water** – WQOs apply to receiving waters, not discharges such as stormwater runoff. A WQO generally represents the maximum concentration of a pollutant that can be present in the water column without adversely effecting organisms using the aquatic system as habitat, people consuming those organisms or water, and/or other current or potential beneficial uses. During WY 2016 through WY 2019, samples for nutrient and copper analysis were generally collected in receiving waters; whereas, samples for PCBs and mercury analyses were generally collected within the engineered storm drain network where WQOs do not apply. Dilution is likely to occur when the MS4 discharges urban stormwater (and non-stormwater) runoff into local receiving waters. Therefore, it is unknown whether discharges that exceed WQOs result in exceedances in the receiving water itself, the location where there is the potential for aquatic life to be exposed to a pollutant.
- **Freshwater vs. Saltwater** - POC monitoring samples were collected from freshwater (i.e., above tidal influence in creeks) and therefore comparisons were made to freshwater WQOs.
- **Aquatic Life vs. Human Health** - Comparisons were primarily made to WQOs for the protection of aquatic life, not WQOs for the protection of human health to support the consumption of water or organisms. The rationale is that water and organisms are not likely consumed by humans at the locations of the monitoring stations.
- **Acute vs. Chronic Objectives/Criteria** – All monitoring of stormwater runoff for PCBs and mercury and several of the copper/nutrient creek sampling events was conducted during episodic storm events. Storm episode monitoring results likely do not represent long-term concentrations of the monitored constituents in receiving waters. Therefore, storm monitoring data were compared to acute WQOs for aquatic life that represent the highest concentrations of a pollutant to which an aquatic community can be exposed for a short period of time (e.g., one hour) without resulting in an unacceptable effect. Spring and summer baseflow creek monitoring data were compared to chronic WQOs developed to assess longer-term exposure.

Of the WY 2016 through WY 2019 POC monitoring analytes, promulgated WQOs for the protection of aquatic life only exist for total mercury, dissolved copper, and unionized ammonia.

- **Total Mercury**. The majority of the water samples collected in Santa Clara Basin watersheds by SCVURPPP from WY 2016 through WY 2019 were stormwater runoff

[8] Note that this section does not evaluate WY 2014 & WY 2015 data because any WQO comparisons from that time period would already have been reported.

within the MS4, not within a receiving water. Stormwater runoff results are not directly comparable to WQOs, as described above. However, all of the WY 2016 through WY 2019 mercury concentrations were well below the freshwater acute objective for mercury of 2.4 µg/L (2,400 ng/L) (Attachment D.4).

- **Dissolved Copper.** Acute (1-hour average) and chronic (4-day average) WQOs for copper are expressed in terms of the dissolved fraction of the metal in the water column and are hardness dependent[9]. The copper WQOs were calculated using the base e exponential functions described in the California Toxics Rule (40 CFR 131.38) which apply hardness values measured at the sample station. Dissolved copper concentrations were compared to the calculated WQOs. Per the above discussion, storm monitoring data was compared to acute WQOs and spring baseflow creek monitoring data were compared to chronic WQOs. Five of the 17 samples had dissolved copper concentrations that exceeded the calculated WQO (Table 5.1). However, four of these samples were collected in the MS4, not the receiving water. As stated above, WQOs do not apply to MS4 samples. Furthermore, it is unknown whether the receiving water had the same hardness as the discharge. If the hardness in the receiving water was higher, a higher WQO would have been applicable. One sample collected in San Tomas Aquino Creek during a storm event on January 8, 2018 had a dissolved copper concentration that exceeded the acute WQO. Because the total copper concentration from this sample was much lower than the dissolved copper concentration, this result was flagged as questionable in the WY 2018 electronic data deliverable (EDD). It is possible that contamination was introduced during the laboratory filtration process.
- **Nutrients**. Ammonia, specifically un-ionized ammonia, is toxic to aquatic life. Therefore, the Basin Plan states that discharge of wastes shall not cause receiving waters to contain annual median concentrations of un-ionized ammonia in excess of 0.025 mg/L or maximum concentrations above 0.4 mg/L in the Lower Bay, which includes creeks in the Santa Clara Basin (SFBRWQCB 2017). Un-ionized ammonia concentrations were calculated based on measured concentrations of ammonia in Countywide Program samples (Table 3.12). All of the WY 2016 through WY 2018 concentrations were well below the un-ionized ammonia. However, two of the 13 WY 2019 samples had un-ionized ammonia concentrations above the annual median WQO of 0.025 mg/L but below the maximum of 0.4 mg/L. These samples were collected in Lower Silver Creek on August 8, 2019 at stations 205COY180 (0.061 mg/L) and 205COY183 (0.037 mg/L). It is unlikely that the annual median would have been exceeded if more data were collected at these stations throughout the year. This assumption is based on lower concentrations of un-ionized ammonia at other stations along Lower Silver Creek on the same day and lower concentrations measured at one of the same stations (205COY180) during a storm event (0.0016 mg/L) and spring baseflow (0.0067 mg/L) in WY 2017.

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

Table 5.1. Comparison of SCVURPPP copper monitoring data to WQOs, WY 2016 – WY 2019. Bold highlighted values exceed the WQO. Bold italicized values exceed the WQO but were collected in the MS4 where WQOs do not apply.

Station Code	Station Type [1]	Sample Date	Measured Dissolved Copper (µg/L)	Measured Hardness as $CaCO_3$ (mg/L)	Acute WQO for Dissolved Copper at Measured Hardness (µg/L)	Chronic WQO for Dissolved Copper at Measured Hardness (µg/L)
WY 2016						
032SVC490A	MS4	1/5/2016	***4.3***	30	4.3	3.2 (NA)
083LGC430A	MS4	1/19/2016	***4.4***	20	2.9	2.3 (NA)
Ford_A	Creek	1/17/2016	2.4	172	22.4	14.2 (NA)
Wrigley_A	Creek	1/17/2016	2.9	164	21.4	13.7 (NA)
WY 2017						
067CTC750A	MS4	2/7/2017	3.0	146	19.2	12.4 (NA)
067CTC810A	MS4	2/7/2017	7.2	58	8.1	5.7 (NA)
205COY180	Creek	1/9/2017	9.6	160	20.9	13.4 (NA)
205COY185	Creek	1/9/2017	8.7	170	22.2	14.1 (NA)
205COY205	Creek	1/9/2017	7.5	200	25.8	16.2 (NA)
WY 2018						
205STE021	Creek	1/8/2018	4.3	60	8.3	5.8 (NA)
205STQ010	Creek	1/8/2018	**30 [2]**	46	6.5	4.6 (NA)
205CAL018	Creek	1/8/2018	4.1	50	7.0	5.0 (NA)
205STE021	Creek	5/21/2018	0.22	440	54	31
205STQ010	Creek	5/21/2018	0.85	390	48	29
205CAL018	Creek	5/21/2018	0.46	460	57	33
WY 2019						
031SCH250A	MS4	1/6/2019	***4.8***	10	1.5	1.3 (NA)
031SCH250B	MS4	1/6/2019	***5***	12	1.8	1.5 (NA)

NA = Not applicable. Chronic WQOs are not applicable to storm event grab samples.

[1] WQOs apply to creek samples but not to MS4 samples.

[2] The dissolved copper concentration from the Jan. 8, 2018 205STQ010 sample was flagged as questionable. Dissolved copper, by definition, must be ≤ total copper, which is not the case in this sample. The total copper concentration measured in this sample was 14 ug/L which also exceeds the WQO. The data validation process did not find any other concerns with the copper results. It is possible that contamination was introduced during the laboratory filtration process for this sample.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1. PCBs and Mercury Monitoring to Identify Sources and Source Areas

In WY 2015 – WY 2019, the Program and its water quality partners (RMP STLS and SPoT Monitoring Program) have collected and analyzed more than 400 samples for PCBs and mercury in compliance with provision C.8.e of MRP 1.0 and Provision C.8.f of MRP 2.0. Under MRP 2.0, the Program has met or exceeded the yearly minimum number of samples required (n=8) for both PCBs and mercury, and has exceeded the minimum number of samples required (n=80) for the entire permit term, collecting more than 200 samples since WY 2016. Moreover, the Program has exceeded the minimum number of samples required (n=8 each) to address each of the five management questions identified in Provision C.8.f (i.e., Source Identification, Contributions to Bay Impairment, Management Action Effectiveness, Loads and Status, and Trends). SCVURPPP will continue to conduct POC monitoring in WY 2020. The Program plans to continue working with other Bay Area countywide stormwater programs (through the BASMAA MPC Committee) to evaluate the results of the ongoing efforts in the Bay Area to identify PCBs and mercury source areas and plan next steps in Santa Clara Basin.

Identifying pollutant source areas is a challenging and often a multi-year process. The POC screening monitoring data collected within Santa Clara Basin since WY 2015 have been of great value to the Program. To date, the Program has used these data to identify 21 WMAs with elevated PCBs concentrations (i.e., high or moderate priority WMAs). Control measures have already been implemented in the majority of these WMAs (e.g., source identification and abatement projects) or will be implemented in the future. Source property investigations conducted since WY 2015 in these priority WMAs have resulted in 2 referrals to the Regional Water Board for abatement, and another 9 properties confirmed as sources. Those confirmed source properties are currently under review by the appropriate municipalities to determine next steps. Given these outcomes, the Program recommends maintaining the same yearly minimum PCBs monitoring requirements (8 samples per year) in MRP 3.0 in order to continue to screen catchments, prioritize WMAs and conduct source property investigations as warranted. However, if the Program returns to a loading station approach to monitoring, with the goal of addressing Management Questions related to long-term trends, it may be challenging to collect 8 storm samples per year.

The Program recommends reducing the mercury monitoring requirements in MRP 3.0. The baseline loading estimate for mercury that was developed as part of RAA efforts indicates that the Santa Clara Basin is already achieving the San Francisco Bay TMDL WLA for mercury in urban stormwater, and reduced monitoring effort is therefore warranted.

6.2. Guadalupe River Monitoring

SCVURPPP will continue to coordinate monitoring required by the MRP with mercury monitoring at the Guadalupe River loading stations, which is now conducted through the Coordinated Monitoring Program for the Guadalupe River watershed, a collaboration of entities subject to the Guadalupe River Mercury TMDL.

6.3. Monitoring PCBs in Infrastructure Caulk

The BASMAA PCBs in Infrastructure Caulk project collected and analyzed 20 composite samples of caulk from roadway and storm drain infrastructure during WY 2017 and WY 2018, as required by Provision C.12.e of MRP 2.0. This screening-level sampling program was the first step towards understanding storm drain and roadway infrastructure caulk and sealants as a potential source of PCBs to urban stormwater. Although limited by the relatively small sample number, the results of this sampling program indicate: (1) the majority of roadway and storm drain structure types that were sampled in this project (n=54) did not have PCBs-containing caulks or sealants at concentrations of concern, and (2) only black, pliable joint fillers found on concrete bridges or roadway overpasses had PCBs concentrations of potential concern to stormwater. If further investigation is conducted, a focus on bridges and roadway overpass structures is a reasonable place to continue such efforts.

6.4. BMP Effectiveness Monitoring

The BASMAA BMP effectiveness studies collected and analyzed 26 stormwater column samples and 8 HDS unit sediment sump samples for PCBs and mercury. The information gained from these studies suggest that (1) biochar may increase PCBs removal in bioretention facilities, and (2) regular maintenance of HDS units increases the PCBs and mercury load reductions from stormwater catchments where these units are located. The information gained from these studies supports a number of ongoing efforts, and is currently being considered in the update to the Interim Accounting Methodology (BASMAA 2017b) that is being conducted as part of a separate BASMAA regional study in support of RAA development.

6.5. Copper

In WY 2019, the Countywide Program continued to collect and analyze copper samples in compliance with provision C.8.f of MRP 2.0. The yearly minimum of two samples was satisfied and the requirement to have a cumulative total of four samples addressing Management Question Nos. 4 (Loads and Status) and 5 (Trends) by year four of the Permit (i.e., WY 2019) was also satisfied. A review of the WY 2016 through WY 2019 copper dataset suggests that relatively low levels of copper are being conveyed to receiving waters from urban areas during stormwater runoff events. There has only been one exceedance of an applicable WQO for copper in a receiving water sample. However, although WQOs do not apply to stormwater runoff samples collected from the MS4, these data were also compared to the hardness-dependent acute WQOs and four samples from the MS4 exceeded the WQO. It is uncertain what the copper concentration would have been after mixing with the receiving water. Furthermore, if the hardness of the receiving water was higher, a higher WQO would have been calculated.

The Program will continue to collect samples for copper analysis in compliance with provision C.8.f of MRP 2.0 with a goal of at least three samples in WY 2020 to meet the requirement of 20 samples by year five of the Permit (i.e., WY 2020). In WY 2020, it is anticipated that a subset of the composite stormwater samples collected from old industrial catchments for PCBs source identification will be analyzed for copper.

Copper data collected under MRP 2.0 have been of limited value to the Program. Copper data collected in San Francisco Bay through the RMP Status and Trends Program are more useful in tracking the effectiveness of the copper control measures required by provision C.13 of MRP 2.0 and, more importantly, the success of the Brake Pad Partnership and Senate Bill (SB) 346

which addresses the largest source of copper by requiring brake pad manufacturers to reduce the use of copper in brake pads sold in California. However, they copper data collected in compliance with provision C.8.f of MRP 2.0 can provide a relatively cost-effective check on copper discharges to tributaries to the Bay. The Program recommends maintaining the same overall copper monitoring requirements (i.e., 20 total samples) in MRP 3.0, but an elimination of the yearly minimums could result in a more effective monitoring design.

6.6. Nutrients

In WY 2019, the Countywide Program continued to collect and analyze nutrient samples in compliance with provision C.8.f of MRP 2.0. The yearly minimum of two samples was satisfied and the requirement to have a cumulative total of 20 samples addressing Management Question No. 4 (Loads and Status) by year four of the Permit (i.e., WY 2019) was also satisfied. A review of the WY 2016 through WY 2019 nutrient dataset suggests that nutrient concentrations are highest during storm events and generally higher at stations lower in the watershed. Nutrient data collected in compliance with provision C.8.f have been used to support Stressor/Source Identification studies investigating causes of low biological condition identified in creeks through provision C.8.c/d Creek Status Monitoring. An ongoing SSID study is being conducted in Lower Silver Creek where some of the highest nutrient concentrations have been measured. A Work Plan for the SSID study, along with preliminary findings, is included in Part B of this IMR. It is anticipated that the Lower Silver SSID Project will be completed in WY 2020.

In WY 2020, the Program will continue to collect samples for nutrient analysis in compliance with provision C.8.f of MRP 2.0. The yearly minimum of two samples will likely be exceeded in WY 2020 through coordination with the Lower Silver SSID Project.

Although nutrient samples provide a useful tool in some types of SSID projects required through provision C.8.e of MRP 2.0, the Program recommends that the requirement for nutrient monitoring be removed from the POC Monitoring provision under MRP 3.0. The original need for nutrient sampling in tributaries to the Bay to support Regional Water Board efforts to develop nutrient numeric endpoints for the San Francisco Bay Estuary no longer exists. This effort has now been captured and superseded by the State Water Board Biostimulatory Substances and Biological Integrity Project[10] which is proposing to adopt a statewide water quality objective for biostimulatory substances (such as nitrogen and phosphorus) along with a program of implementation as an amendment to the Water Quality Control Plan for Inland Surface Water, Enclosed Bays and Estuaries of California (ISWEBE Plan).

6.7. Emerging Contaminants

During MRP 2.0, SCVURPPP has leveraged its participation in these RMP special studies to satisfy the POC monitoring requirement for CECs within provision C.8.f. Looking ahead to the next iteration of the MRP (MRP 3.0), SCVURPPP recommends continuing support of special studies that address data gaps and the scientific understanding of fate and transport of stormwater-related CECs in the Bay. In particular, the Program is supportive of continued coordination through the STLS to identify the appropriate watersheds and sampling sites for monitoring CECs through RMP special studies. The Program is also supportive of further developing conceptual and empirical models to better evaluate the distribution and sources of CECs of interest within a stormwater and watershed context. The Program further recommends

[10] https://www.waterboards.ca.gov/water_issues/programs/biostimulatory_substances_biointegrity/

including requirements to “conduct or cause to be conducted a special study that addresses relevant management information needs for emerging contaminants;” however, it is recommended that these requirements allow more flexibility with respect to the classes of compounds identified in the permit, allowing easier alignment with RMP special studies that may address a variety of stormwater-related CECs as the science is advanced over the coming years.

6.8. SPoT Monitoring

The most current SPoT monitoring program report presents the seven-year trends encompassing WY 2008 through WY 2014 (Phillips et al., 2016). This report concludes that not all of our statewide watersheds are healthy, and toxicity and concentrations of most measured pollutants were higher in streams that drain watersheds with higher proportions of urban land cover. The Spot monitoring program will continue to focus on toxicity and contaminant trends, with an added emphasis on current-use pesticides and chemicals of emerging concern. SCVURPPP will continue to work with the SPoT program to conduct long-term trends monitoring.

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Attachment D.1

SCVURPPP WY 2019 Data Quality Review

Pollutants of Concern Monitoring – Quality Assurance/Quality Control Report, WY 2019

1.0 INTRODUCTION

The Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP) conducted Pollutants of Concern (POC) Monitoring in Water Year (WY) 2019 to comply with Provision C.8.f (Pollutants of Concern Monitoring) of the National Pollutant Discharge Elimination Program (NPDES) Municipal Regional Permit for the San Francisco Bay Area (i.e., MRP). Monitoring included analysis for polychlorinated biphenyls (PCBs), total mercury, total and dissolved copper, suspended sediment concentration (SSC), and nutrients (i.e., ammonia, nitrate, nitrite, total Kjeldahl nitrogen, orthophosphate, and total phosphorus).

This project utilized the Clean Watersheds for Clean Bay Project (CW4CB) Quality Assurance Project Plan (QAPP; BASMAA 2013) as a basis for Quality Assurance and Quality Control (QA/QC) procedures. Missing components were supplemented by the Bay Area Stormwater Management Agencies Association (BASMAA) Regional Monitoring Coalition (RMC) QAPP (BASMAA 2016) and the QAPP for the California Surface Water Ambient Monitoring Program (SWAMP), specifically for nutrient and copper samples, respectively. Data were assessed for seven data quality attributes, which include (1) Representativeness, (2) Comparability, (3) Completeness, (4) Sensitivity, (5) Contamination, (6) Accuracy, and (7) Precision. These seven attributes were compared to Data Quality Objectives (DQOs), which were established to ensure that data collected are of adequate quality and sufficient for the intended uses. DQOs address both quantitative and qualitative assessment of the acceptability of data – representativeness and comparability are qualitative while completeness, sensitivity, precision, accuracy, and contamination are quantitative assessments. Specific DQOs are based on Measurement Quality Objectives (MQOs) for each analyte.

The MQOs for each of the POC analytes are summarized in Table 1 for water and Table 2 for sediment. As there was no reporting limit listed in the QAPP for copper, results were compared to the SWAMP recommended reporting limits for inorganic analytes in freshwater. Overall, the results of the QA/QC review suggest that the data generated during this study were of sufficient quality for the purposes of the project. Additional data were flagged based on the MQOs and DQOs identified in the QAPPs, but no data were rejected. Further details regarding the QA/QC review are provided in the sections below.

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

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

RL = Reporting Limit; RPD = Relative Percent Difference

[1] From the BASMAA QAPP

[2] From the CW4CB QAPP

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

[4] TKN = Total Kjeldahl Nitrogen

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

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

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

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

RL = Reporting Limit; RPD = Relative Percent Difference

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

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

[3] RL for total solids in water

2.0 REPRESENTATIVENESS

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

3.0 COMPARABILITY

The QA/QC officer ensures that the data may be reasonably compared to data from other programs producing similar types of data. For POC monitoring, individual stormwater programs try to maintain comparability within the RMC. The key measure of comparability for all RMC data is the California Surface Water Ambient Monitoring Program.

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

All WY 2019 data were considered comparable to SWAMP data and other RMC data.

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

4.0 COMPLETENESS

Completeness is the degree to which all data were produced as planned; this covers both sample collection and analysis. An overall completeness of greater than 90% is considered acceptable for RMC chemical data and field measurements.

During WY 2019, SCVURPPP collected 100% of planned samples. Thirteen aqueous samples were collected and analyzed for nutrients (ammonia, nitrate, nitrite, total Kjeldahl nitrogen, phosphorus, and orthophosphate). Two aqueous samples were collected and analyzed for copper and hardness. Fifteen aqueous samples were collected and analyzed for PCBs, mercury, and SSC. Fifty-six (56) sediments samples were also collected and analyzed for PCBs and mercury.

Nutrient data collected for POC monitoring compliance were also used in SCVURPPP's WY 2019 Lower Silver Creek Nutrient SSID Study. The nutrient data QA assessment are not discussed in this report. Instead they are discussed in the Lower Silver Creek Statement of Data Quality. These data were assessed for compliance with the BASMAA QAPPs.

5.0 SENSITIVITY

5.1. Water

Sensitivity analysis determines whether the methods can identify and/or quantify results at low enough levels. For the aqueous chemical analyses in this project, sensitivity is considered to be adequate if the reporting limits (RLs) comply with the specifications in RMC QAPP Appendix E (RMC Target Method Reporting Limits) and the CW4CB QAPP Appendix B (CW4CB Target Method Reporting Limits).

A summary of the target and actual reporting limits for each analyte is shown in Table 3. The reporting limits for all suspended sediment concentration (SSC), copper, hardness, and mercury samples exceeded their respective target reporting limits. However, all analyte concentrations were well above their respective reporting limits.

Table 3. Target and actual reporting limits for SCVURPPP pollutants of concern monitoring in water in WY 2019

Analyte	Unit	Target	Actual	Exceeds Target RL?
Suspended Sediment Concentration	mg/L	0.5	1-3	Yes
Copper	µg/L	0.1	0.5	Yes
Hardness	mg/L	1	5-20	Yes
Mercury	ng/L	0.2	0.5-0.8	Yes
PCBs	pg/L	2000	20-42.7	No

5.2 Sediment Analysis

Due to the laboratory's procedures, there were no calculated reporting limits for WY 2019 sediment PCB samples. However, the method detection limits for a majority of sediment PCB samples were less than the CW4CB reporting limit requirement of 200 ng/kg. The target reporting limit for mercury (0.03 mg/kg) was met for a majority of the WY 2019 samples.

6.0 CONTAMINATION

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

6.1 Water Analysis

Several laboratory and equipment (filter) blanks were run during the copper, hardness, mercury, PCBs, and SSC analyses. Analytes were detected in laboratory blanks for several PCBs above the method detection limit (MDL), but all values were below the reporting limit.

6.1. Sediment Analysis

Several laboratory blanks were analyzed for WY 2019 sediment mercury and PCB samples. None of the blanks were found to be above the method detection limit.

7.0 ACCURACY

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

7.1 Water Analysis

All laboratory LCS and MS/MSD samples for hardness, copper, mercury, SSC, and PCBs in water were within their respective MQOs except for one hardness matrix spike sample collected in January. The associated hardness samples were consequently flagged. No MS/MSD samples were analyzed for PCB congeners in water. However, other analytical laboratories have acknowledged in past years that laboratory control sample and laboratory control sample duplicates for PCBs could be analyzed in lieu of matrix spike and matrix spike duplicates. It is acceptable to compare the percent recoveries calculated from the laboratory control samples to the MQOs for matrix spike percent recoveries. Given that the MQOs are the same in both cases, no other exceedances were found.

7.2 Sediment Analysis

All laboratory LCS samples for mercury and PCBs in sediment met their corresponding MQOs, but five MS/MSD samples taken for mercury resulted in PRs lower or higher than the acceptable range. Of the five MS/MSD samples associated with PR exceedances, one was collected in June, two were collected in August, and one was collected in September. The samples associated with the MS/MSDs were flagged accordingly.

8.0 PRECISION

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

8.1. Water Analysis

8.1.1. Laboratory Duplicates

Matrix spike duplicates and laboratory control sample duplicates for all analytes were well below the targeted range of < 25%. As previously stated, duplicate laboratory control samples were analyzed in place of duplicate matrix spike samples to assess precision in the measurement of PCB concentrations.

8.1.2. Field Duplicates

Four field duplicates were collected for copper, hardness, mercury, PCBs, and SSC during the WY 2019 POC monitoring. The duplicate samples met the RPD MQO for all analytes except for mercury, PCB 18/30, and SSC. All associated mercury, PCB 18/30, and SSC samples were flagged.

8.2. Sediment Analysis

8.2.1. Laboratory Duplicates

One mercury matrix spike duplicate exceeded the corresponding RPD MQO. Additionally, two laboratory duplicates exceeded the RPD MQO for the following PCBs:

- PCB 52/73
- PCB 89/90/101
- PCB 93/95
- PCB 106/118
- PCB 110
- PCB 132/168
- PCB 138/163/164
- PCB 139/149
- PCB 153
- PCB 194

All associated samples were flagged.

8.2.2. Field Duplicates

Six sediment field blind duplicates were collected in WY 2019. The field duplicates exceeded the RPD MQO for mercury and 25 PCBs. The duplicate samples taken at SC-SJY-04-H and SC-SJY-08-X had the fewest number of analytes exceeding the MQO with three total exceedances each. The duplicate sample for SC-SJY-17-P had the highest number of analytes exceeding the MQO with 20 total exceedances. The analytes that exceeded the MQO include the following (the number of samples that exceeded the MQO for that analyte are included in parentheses):

- Mercury (3)
- PCB 20/21/33 (1)
- PCB 31 (1)
- PCB 43/49 (3)
- PCB 44 (3)
- PCB 52/73 (2)
- PCB 56/60 (3)
- PCB 61/74 (2)
- PCB 66/80 (2)
- PCB 70/76 (2)
- PCB 86/97 (4)
- PCB 87/115/116 (4)
- PCB 89/90/101 (2)
- PCB 93/95 (2)
- PCB 99 (3)
- PCB 105/127 (2)
- PCB 106/118 (4)
- PCB 110 (3)
- PCB 132/168 (2)
- PCB 139/149 (1)
- PCB 153 (1)
- PCB 156 (1)
- PCB 177 (2)
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- PCB 195 (2)

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Attachment D.2
POC Monitoring to Support Source Investigations

Santa Clara Valley
Urban Runoff
Pollution Prevention Program

Watershed Monitoring and Assessment Program



Integrated Monitoring Report

Part D - Attachment 2: Pollutant of Concern Monitoring to Support Source Identification

Water Years 2014 - 2019

Submitted in compliance with Provision C.8.h.v of NPDES Permit No. CAS612008,
Order No. R2-2015-049

March 31, 2020

ACRONYMS

BASMAA	Bay Area Stormwater Management Agencies Association
Bay	San Francisco Bay
CEDEN	California Environmental Data Exchange Network
CW4CB	Clean Watersheds for a Clean Bay
CWA	Clean Water Act
DTSC	Department of Toxic Substances Control
FPE	Federal Pacific Electric
GIS	Geographic Information System
IGP	Industrial General Permit
MPC	Monitoring and Pollutants of Concern Committee
MQO	Measurement Quality Objective
MRP	Municipal Regional Permit
MS4	municipal separate storm sewer system
NPDES	National Pollutant Discharge Elimination System
PCBs	Polychlorinated Biphenyls
PG&E	Pacific Gas and Electricity
POC	pollutants of concern
QAPP	Quality Assurance Project Plan
RMP	San Francisco Bay Regional Monitoring Program
ROW	right-of-way
SAP	Sampling and Analysis Plan
SCVURPPP	Santa Clara Basin Urban Runoff Pollution Prevention Program
SFRWQCB	San Francisco Bay Regional Water Quality Control
STLS	Small Tributaries Loading Strategy
SSC	Suspended sediment concentration
TMDLs	Total Maximum Daily Loads
USEPA	United States Environmental Protection Agency
WMA	Watershed Management Areas
WY	Water Year

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1 INTRODUCTION

Fish tissue monitoring in San Francisco Bay (Bay) has revealed the bioaccumulation of Polychlorinated Biphenyls (PCBs), mercury, and other pollutants in Bay sportfish. The levels found are thought to pose a health risk to people consuming these fish. As a result, the State of California issued a sport fish consumption advisory in 1994 cautioning people to limit their consumption of fish caught in the Bay. The advisory led to the Bay being designated as an impaired water body on the Clean Water Act (CWA) "Section 303(d) list" due to elevated pollutant levels. In response, the San Francisco Bay Regional Water Quality Control Board (SFBRWQCB or Regional Water Board) adopted Total Maximum Daily Loads (TMDLs) water quality restoration programs targeting PCBs and mercury in the Bay. The PCBs and mercury TMDLs indicate that a 90 percent reduction in PCBs and 50 percent reduction in mercury found in discharges from urban stormwater runoff to the Bay are needed to achieve water quality standards and restore beneficial uses.

1.1 Regulatory Requirements

The National Pollutant Discharge Elimination System (NPDES) stormwater permit for Bay Area municipalities, referred to as the Municipal Regional Permit (MRP), implements the municipal stormwater portion of the PCBs and mercury TMDLs for the San Francisco Bay. The MRP was first adopted by the SFBRWQCB on October 14, 2009 as Order R2-2009-0074 (SFBRWQCB 2009). On November 19, 2015, the SFBRWQCB updated and reissued the MRP as Order R2-2015-0049 (SFBRWQCB 2015). MRP Provision C.8 requires water quality monitoring for pollutants of concern (POCs), including PCBs and mercury. POC Monitoring is required to address five priority management information needs (i.e., Management Questions) identified in C.8.f, including:

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

Under the MRP, Permittees may comply with Provision C.8 monitoring requirements through a regional collaborative effort, their Stormwater Program, and/or individually. POC monitoring for source identification conducted in compliance with Provision C.8 also supports compliance with Provisions C.11 and C.12 that require Permittees to implement control measures to achieve specified mercury and PCBs load reductions during the permit term. One control measure Permittees are using to reduce PCBs and mercury loadings to the Bay is to conduct

investigations to identify source properties for abatement. Source properties are land areas that contribute substantial amounts of PCBs or mercury to municipal separate storm sewer systems (MS4s). Identification and subsequent abatement of these properties and/or focused control measure implementation in the public right-of-way (ROW) around source properties to reduce pollutant release can provide an opportunity for meaningful PCBs and mercury stormwater load reductions. Abatement actions can occur via referrals to the Water Board or through enforcement actions brought against property owners by Co-permittees.

Under the current MRP, Provisions C.11.a and C.12.a also direct Permittees to identify Watershed Management Areas (WMAs), which are defined as the management areas in which new mercury and PCBs control measures will be implemented during the permit term. Permittees are directed to provide all monitoring data and other information used to identify these WMAs. The Santa Clara Basin Urban Runoff Pollution Prevent Program (SCVURPPP or Program) reported progress toward developing the initial list of WMAs in the Santa Clara Basin on April 1, 2016. The Program has submitted updates to the Regional Water Board with each subsequent Annual Report during the permit term.

1.2 Purpose of Report

The purpose of this report is to demonstrate how POC monitoring supports source identification in the Santa Clara Basin through WMA selection and prioritization, followed by targeted source property investigations in WMAs designated as high priority. This report summarizes POC monitoring data collected within the Santa Clara Basin since Water Year (WY)[1] 2015 to support these efforts. The Program uses these monitoring data to identify catchments with elevated POC concentrations (i.e., priority WMAs) where additional POC monitoring as part of targeted investigations within these areas to identify sources can occur. The goal of these investigations is to identify specific source properties that will be targeted for referral to the Regional Water Board for abatement, or abatement actions overseen directly by Permittees.

This report presents an overview of the WMA selection and prioritization process, including the current status of all WMAs in the Santa Clara Basin. This report also presents an overview of the source property investigation process and provides a summary and current status update on all source property investigations that have been implemented by the Program in priority WMAs since WY 2015. This report builds upon previously submitted reports to summarize all the information gathered to date to select and prioritize WMAs in the Santa Clara Basin, and conduct targeted source property investigations in priority WMAs.

This report is organized in the following sections:

1. **Introduction.** This section presents the relevant background information, including the regulatory requirements for POC monitoring to support source identification, definition of WMAs, and the purpose of source property investigations.
2. **WMA Selection and Prioritization.** This section presents an overview of the process used to select and prioritize WMAs for control measure implementation, including a summary of the monitoring data, and the current status of all WMAs in the Santa Clara Basin to date.

[1] Most hydrologic monitoring occurs for a period defined as a water year, which begins on October 1 and ends on September 30 of the named year. For example, water year 2019 (WY 2019) began on October 1, 2018 and concluded on September 30, 2019.

3. **Overview of Source Property Investigations.** This section provides an overview of the source property investigation process, including a description of the investigation methods used, the data collected to support source property investigations, and the criteria applied to identify and confirm PCBs and mercury source properties.
4. **Source Property Investigation Results.** This section identifies the WMAs that have been investigated or are currently being investigated in the Santa Clara Basin to date, and presents a status update of each investigation, including a summary of the monitoring data collected to support each investigation, and the current outcomes and next steps. This section is organized by Co-Permittee, and then by WMA.
5. **Conclusions and Recommendations.** This section provides a summary of the outcomes and benefits of POC monitoring in support of the WMA selection and prioritization process and targeted source property investigations conducted in the Santa Clara Basin to date. This section also identifies next steps and provides recommendations for future POC monitoring to continue to support these efforts.

This report was prepared by the Program on behalf of its 15 member agencies (13 cities/towns, the County of Santa Clara, and the Santa Clara Basin Water District) subject to the MRP. Monitoring data presented in this report were collected pursuant to water quality monitoring requirements in provision C.8 of the MRP. These data were submitted electronically to the Regional Water Board by SCVURPPP and, if collected from a receiving water, may be obtained via the San Francisco Bay Area Regional Data Center of the California Environmental Data Exchange Network (CEDEN) (http://www.ceden.org).

2 WATERSHED MANAGEMENT AREA SELECTION AND PRIORITIZATION

This section presents an overview of the process used to select and prioritize WMAs for control measure implementation, provides a summary of the monitoring data collected and used in this process, and presents the current prioritization status of all WMAs in the Santa Clara Basin.

2.1 Purpose of WMA Selection and Prioritization

The primary purpose of the WMA selection and prioritization process is to identify areas within the Santa Clara Basin where control measures should be implemented to comply with the load reductions that are required to achieve the PCBs and mercury TMDLs. Priority WMAs are defined as areas that have elevated PCBs or mercury concentrations where cost-effective control measures can be implemented to reduce stormwater loads of these pollutants to the Bay. A description of the methods used to select and prioritize WMAs in the Santa Clara Basin and the results of this process to date are summarized below and provided in more detail in SCVURPPP 2016a and 2016b.

2.2 Overall Approach

The selection and prioritization of WMAs is a multi-year process designed to identify land areas that disproportionately contribute PCBs and mercury to MS4s in the Santa Clara Basin. The intent of the WMA selection process is to identify WMAs that would provide the most benefit for PCBs and mercury reduction and therefore should be the focus of control measure implementation. Stormwater catchments were chosen as the initial geographical scale at which WMAs are defined. This scale is consistent with the intention of MRP Provision C.11/12.a.ii and will allow Permittees to more easily track control measure implementation.

The process to select and prioritize WMAs is an iterative, multi-step process:

- The first step is to conduct an “Opportunity Area Analysis” to select high-interest areas that have an increased potential to contribute PCBs or mercury to the MS4.
- The second step is to conduct screening monitoring in high-interest areas to identify locations with elevated PCBs and/or mercury concentrations. The screening monitoring data are then used to prioritize WMAs according to the criteria identified in Table 2.1.
- The high priority WMAs (and to a lesser extent, moderate-priority WMAs) are then targeted for control measures. Additional details on the methods used to select and prioritize WMAs in the Santa Clara Basin are presented below.

Table 2.1. Criteria used for prioritizing WMAs based on the magnitude of PCBs or mercury concentrations and particle ratios for samples collected in sediment within the MS4 or within stormwater in the catchment.[1]

POC	Sample Type	WMA Prioritization		
		High Priority WMA[2]	Moderate Priority WMA[3]	Low priority WMA[4]
PCBs	MS4 Sediment	≥ 0.5 mg/kg	≥ 0.2 to 0.5 mg/kg	< 0.2 mg/kg (i.e., below urban background)
	Stormwater	Particle Ratio ≥ 0.5 mg/kg OR Concentration in top 10% of region-wide data	NA	Particle Ratio < 0.5 mg/kg AND Concentration is not in the top 10% of region-wide data.
Mercury	MS4 Sediment	≥ 1 mg/kg	≥ 0.3 to 1 mg/kg	< 0.3 mg/kg (i.e., below urban background)
	Stormwater	Particle Ratio ≥ 1 mg/kg OR Concentration in top 10% of region-wide data	NA	Particle Ratio < 1 mg/kg AND Concentration is not in the top 10% of region-wide data

1: The concentration or particle ratio thresholds identified in this table were selected by the Bay Area Stormwater Management Agencies Association (BASMAA) Monitoring and Pollutants of Concern (MPC) Committee as approximate benchmarks for identifying areas that should be considered for future investigation. These thresholds were derived from the Bay Area-wide data set of soil/sediment and stormwater concentrations measured across the Bay Area over the past 20 years. This Bay Area data set is described in Section 3.2.6. Currently the top 10% of PCBs stormwater concentrations measured in the Bay Area includes anything over ~38 ng/L.
2: At least one sample collected in the WMA meets one of these criteria for a given POC.
3: The highest sample collected in the WMA meets one of these criteria for a given POC.
4: All samples collected in the WMA meet all of these criteria for a given POC.

2.3 Methods

2.3.1 Opportunity Area Analysis

The Opportunity Area Analysis conducted to select the initial areas of interest for screening-level monitoring is primarily a desktop exercise. The analysis includes review of readily available data (e.g., geographic information system (GIS) data layers, aerial photo surveys, google street maps, property cleanup reports, etc.) combined with field reconnaissance to confirm stormwater catchment boundaries. First, the analysis focuses on GIS data layers of land-use classifications over time to identify all parcels that were industrial in or prior to 1980 (i.e., old industrial parcels), or have other land uses associated with PCBs or mercury. These parcels are referred to as ***Potential High-Interest Areas***. Second, the analysis gathers additional information about the potential high-interest areas to further refine and narrow the list. This step includes reviewing the old industrial parcels using google street view and aerial photo surveys to evaluate current and past industrial activities, housekeeping, equipment on site, chemical or waste storage, and redevelopment status. Information on specific parcels was also gathered from online databases such as Geotracker that report on property cleanups. The information is reviewed, and all

parcels that had not been redeveloped, and include one or more of the following characteristics are retained on the list of high-interest areas:

- Unpaved areas;
- Pavement in poor condition or sediment is seen or suspected to move off site;
- A lack of "good housekeeping" in outdoors areas;
- A history of PCBs-related activities (e.g., identified in the United States Environmental Protection Agency (USEPA) PCBs Transformer Registration Database, Envirostor, or Geotracker);
- A current or past use associated with possible PCBs use (e.g., metals manufacturing, transportation/shipping, recycling, electrical, port, railroad);
- Heavy or electrical equipment observed on-site;
- Hazardous waste storage;
- Recent stormwater violations; or
- Monitoring results from adjacent areas that have elevated PCBs concentrations (≥ 0.2 mg/kg).

Next, the opportunity analysis includes windshield surveys in the high-interest areas to confirm GIS findings and to better delineate catchment boundaries and locations of storm drain infrastructure. The final step of the opportunity analysis is to review all of the information gathered during this process and select the parcels with the highest potential for contributing PCBs or mercury to the MS4. These parcels are categorized as high-interest areas for follow-up screening monitoring.

2.3.2 Screening Monitoring

The second step of the WMA selection and prioritization process is to conduct screening monitoring within high-interest areas to identify locations with elevated PCBs and mercury concentrations. Stormwater catchment boundaries are drawn around all high-interest areas to better understand which high-interest parcels likely contribute to a given sampling location. These catchments are then designated as ***Catchments of Interest***. Screening monitoring includes collection of street dirt and MS4 sediment samples, and/or stormwater samples. The results of the screening monitoring are used to designate Catchments of Interest as high-priority, moderate-priority or low-priority WMAs based on the criteria described in Table 2.1.

The screening monitoring implements a reconnaissance approach to maximize the area characterized by the sampling program. During the first year of screening monitoring, the Program focused entirely on collecting street dirt or MS4 sediment samples from areas in the public ROW that drain high-interest parcels. When possible, sample stations were selected that characterized multiple high-interest areas by capturing sediment at a point in the MS4 that drained multiple parcels (e.g., from a line beneath a manhole). In areas where sediment from within manholes or storm drain inlets was not available, samples were collected along street surfaces, sidewalks, or driveways that would have arrived at that location from stormwater or vehicle tracking. To increase the area characterized by inlet or surface samples, multiple nearby samples from the same stormwater catchment were often composited.

In subsequent years of screening monitoring, the Program has collected primarily stormwater samples at or near the outlets of stormwater Catchments of Interest. This process is expected to continue into the future until all Catchments of Interest have been appropriately monitored and prioritized for follow up.

2.3.2.1 Sample Collection and Laboratory Analysis

Street dirt and MS4 sediment samples are collected from the urban storm drainage system (e.g., beneath manholes, storm drain inlets) and public ROW surfaces (e.g., street gutters). The sampling and analysis methods used are detailed in the Sampling and Analysis Plan (SAP) for PCBs and Mercury Opportunity Area Analysis and Implementation Planning (SCVURPPP 2014) and WY 2016 POC Monitoring SAP (SCVURPPP 2015b). All sediment samples are analyzed for the "Regional Monitoring Program (RMP) 40" PCB congeners[2] (USEPA Method 8082M or USEPA Method 8270 modified), total mercury (EPA Method 7471A), and total solids (SM 2540G-11). Measurement Quality Objectives (MQOs) for laboratory analyses were based on the CW4CB QAPP (BASMAA 2013) but modified for differing laboratory analytical methods.

Wet weather sampling focused on collection of storm composite samples from MS4 outfalls or manholes from *Catchments of Interest*. Composite samples consisting of six to eight aliquots collected during the rising limb and peak of the storm hydrograph (as determined through field observations) were analyzed for the RMP 40 PCB congeners (EPA Method 1668C), total mercury (EPA Method 1631E), and suspended sediment concentration (SSC; method ASTM D3977-97). All wet weather monitoring was conducted in accordance with the WY 2016 POC Monitoring SAP (SCVURPPP 2015b).

2.4 Results

2.4.1 Opportunity Area Analysis Outcomes

The Opportunity Area Analysis was initially conducted in WY 2015 and the Program has periodically updated the results as additional information has become available. Table 2.2 presents the outcomes of the opportunity area analysis conducted to-date, including the number and acres of high-interest parcels that have been the focus of subsequent screening monitoring. A summary of the outcomes from the analysis:

- Of the 5,483 old industrial parcels (more than 13,000 acres) that were originally identified as potential high-interest parcels, nearly 3,000 of these parcels were reclassified to moderate or low interest based on the final results of the opportunity analysis.
- A total of 2,639 or 48% of the original 5,483 old industrial parcels identified as potential high-interest areas met one or more of the criteria identified in Section 2.2.2 and were therefore confirmed as high-interest areas for PCBs or mercury (Table 2.2).

[2] The RMP 40 PCB congeners include: 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.

- The old industrial areas identified as high-interest areas represent roughly 7,300 acres of land, or roughly 2.6% of the 279,000 acres of land in the Santa Clara Basin.
- The high-interest areas are contained within 148 stormwater Catchments of Interest, that drain stormwater from roughly 50,000 acres in the Santa Clara Basin.

Table 2.2. Results of the Opportunity Area Analysis conducted to identify low, moderate and high interest areas for screening monitoring.

Category	# of Parcels	Area (Acres)	% of Potential High Interest (Old Industrial) Areas Identified
			(5,483 Parcels)
Moderate Interest Areas	1,710	2,823	31%
Low Interest Areas (Redeveloped)	1,134	3,025	21%
Sub-Total	***2,844***	***5,848***	***52%***
High Interest Areas	2,639	7,365	48%
Total	**5,483**	**13,232**	**100%**

2.4.2 Screening Monitoring Results

Beginning in WY 2015 and continuing through WY 2019, the Program conducted reconnaissance-style screening monitoring in Catchments of Interest that contain many of the high-interest areas identified in Table 2.2. The Program conducted a large sampling campaign in these areas in WY 2015 focused entirely on collection sediment on streets and within the MS4 (collectively referred to as “MS4 Sediment). In WY 2016 - WY 2019, the Program continued screening monitoring in Catchments of Interest by collecting stormwater samples within the MS4. All monitoring conducted by the Program was conducted by Kinnetic Laboratories, Inc., under the direction of Program staff. The RMP Small Tributaries Loading Strategy (STLS) team supplemented the Program’s efforts with additional stormwater monitoring in WY 2015 – WY 2019 that was conducted in Catchments of Interest selected by the Program. In total, these efforts collected 202 MS4 sediment samples and 59 stormwater samples in 103 catchments of interest in the Santa Clara Basin.

Descriptive statistics for the PCBs and mercury concentrations measured in MS4 sediment samples and the PCBs and mercury concentrations and particle ratios measured in stormwater samples that were collected as part of the screening monitoring program by SCVURPPP and the RMP STLS are summarized in Table 2.3. The individual concentrations and particle ratios measured at each station are provided elsewhere (SCVURPPP .2016a, 207, 2018, 2019, and 2020). Of the 202 MS4 sediment samples collected in WY 2015, 17 samples had elevated PCBs concentrations that were above urban background (>0.2 mg/kg). Of these, 10 samples were elevated above 0.5 mg/kg, suggesting proximity to a PCBs source. Of 56 stormwater composite samples collected since WY 2015, 6 samples had an elevated PCBs particle ratio (> 0.5 mg/kg), and 2 samples that did not have elevated particle ratios were in the top 10% of PCBs concentrations measured in the Bay Area to date (> 38 ng/L). The Program used these

screening monitoring data to select and prioritize WMAs in the Santa Clara Basin for source investigations, as described in Section 2.5 below.

Table 2.3. Descriptive statistics of PCBs and mercury concentrations measured in MS4 sediment samples, and PCBs and mercury concentrations and particle ratios measured in stormwater samples collected during screening monitoring in the Santa Clara Basin in WYs 2015 – 2019.

Sample Type	POC	Measurement	Units	Count	Min	Max	Median	Mean	Std Dev
MS4 Sediment	PCBs	Concentration	mg/kg	202	ND	4.8	0.021	0.13	0.48
	HgT	Concentration	mg/kg	202	0.031	18.9	0.10	0.41	1.7
Stormwater	PCBs	Concentration	ng/L	59	0.154	57.6	4.14	8.62	12.0
		Particle Ratio	mg/kg	59	0.004	1.1	0.01	0.15	0.2
	HgT	Concentration	ng/L	59	ND	84.7	7.85	15.7	18.9
		Particle Ratio	mg/kg	59	ND	0.96	0.20	0.25	0.23

2.5 WMA Prioritization Status

The current status of WMA prioritization for all of the stormwater Catchments of Interest identified in the Santa Clara Basin is presented in Figure 2.1. These results are based on all of the desktop and field studies conducted to-date to select and prioritize WMAs in the Santa Clara Basin. The Program has identified seven prioritization categories:

1. Abated Source Property WMAs
2. Referred Source Property WMAS
3. Confirmed Source Property WMAs
4. High Priority WMAs
5. Moderate Priority WMAs
6. Low Priority WMAs
7. Other Catchments of Interest

A definition of each prioritization category and a summary of the catchments that are classified within each category are provided below. All other land areas within a Permittee's urbanized area that do not fit into one of these categories are lumped into a single city-wide WMA (that is not necessarily spatially contiguous). City-wide WMAs are not shown in Figure 2.1. Table 2.4 provides the distribution of land area in each WMA prioritization category and all other areas within each city. Table 2.4 also shows the percent of the total land area represented by the WMAs in each category, as well as the percent of the total high-interest area (as identified through the Opportunity Analysis) represented by WMAs in each category. This information provides a snapshot of the substantial progress that the Program and the Co-Permittees have made in identifying and investigating priority areas where PCBs and mercury sources may be found. To date, the Program has investigated, or is currently investigating over 5,000 acres in

the Santa Clara Basin in order to identify PCBs and mercury sources, as described in more detail in Sections 3 and 4.

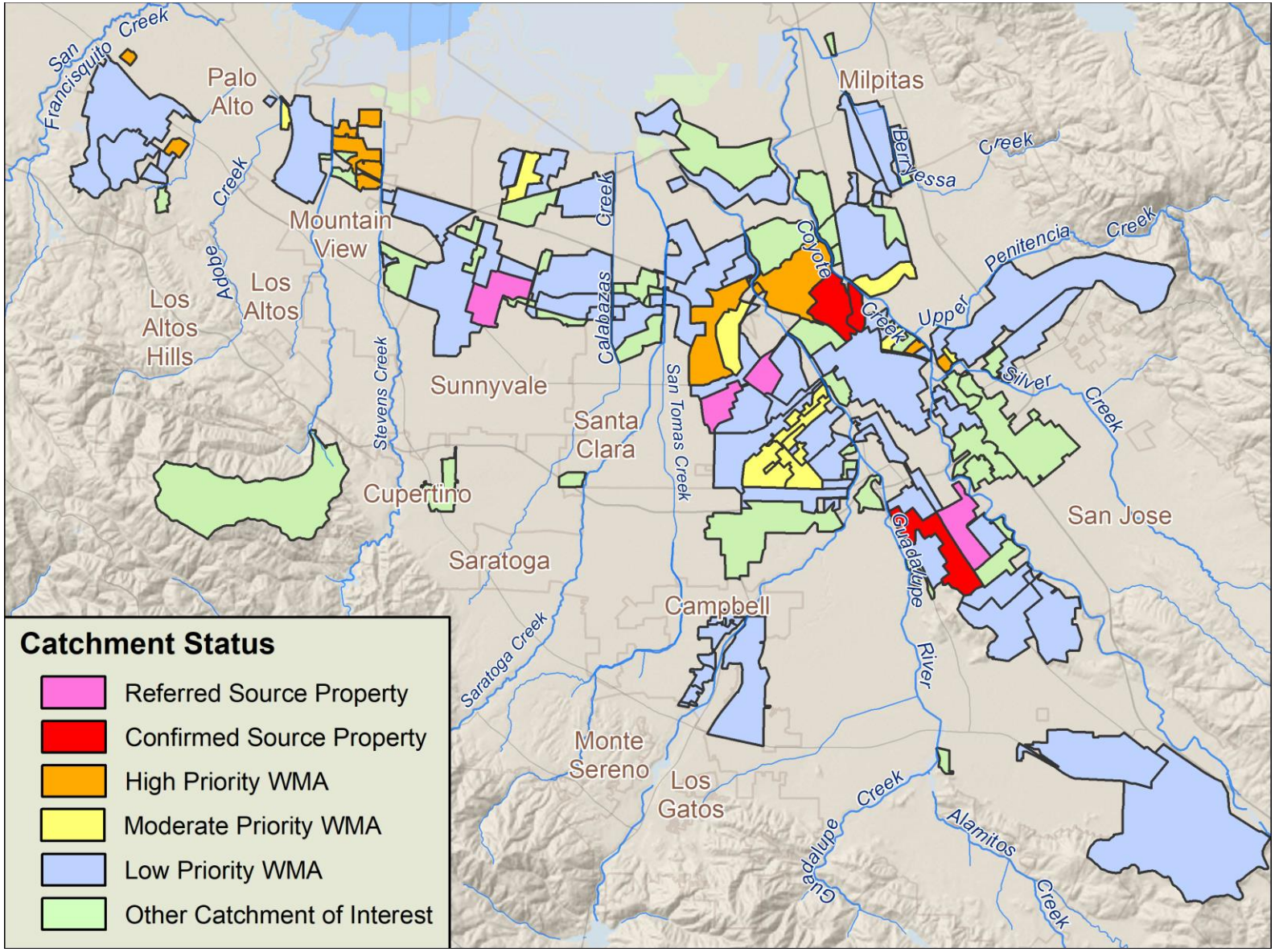


Figure 2.1. WMA Prioritization status for all catchments of interest identified in the Santa Clara Basin, CA.

Table 2.4. WMA Prioritization categories and associated areas within each Permittees' boundaries in the Santa Clara Basin, CA.

Co-permittee	Land Area within each WMA Prioritization Category (Acres)						*Other Areas (Acres)*	Total Area
	Referred Source Property WMA	Confirmed Source Property WMA	High-Priority WMA	Moderate-Priority WMA	Low- Priority WMA	Other Catchments of Interest		
Campbell	--	--	--	--	411	--	*3,091*	**3,502**
Cupertino	--	--	--	--	--	273	*6,671*	**6,944**
Los Altos	--	--	--	--	--	--	*4,175*	**4,175**
Los Altos Hills	--	--	--	--	--	--	*5,784*	**5,784**
Los Gatos	--	--	--	--	--	--	*5,003*	**5,003**
Milpitas	--	--	--	--	1,080	392	*7,182*	**8,654**
Monte Sereno	--	--	--	--	--	--	*507*	**507**
Mountain View	--	--	515	--	1,871	420	*4,564*	**7,371**
Palo Alto	--	--	104	52	2,158	66	*10,761*	**13,141**
San Jose	456	1,246	889	1,315	17,944	6,145	*72,468*	**100,462**
Santa Clara	500	--	718	333	2,435	550	*7,083*	**11,619**
Santa Clara County	--	--	--	--	--	2,543	*67,867*	**70,410**
Saratoga	--	--	--	--	--	--	*8,175*	**8,175**
Sunnyvale	480	--	--	213	4,122	3,220	*6,198*	**14,233**
Total Area	**1,436**	**1,246**	**2,227**	**1,913**	**30,020**	**13,609**	***209,528***	**259,979**
Percent of Total Area	**0.55%**	**0.46%**	**0.87%**	**0.74%**	**11.5%**	**5.2%**	***80%***	**100%**
Percent of High-Interest Area (~50,000 Acres)	**2.8%**	**2.4%**	**4.5%**	**3.8%**	**60%**	**27%**	**-**	**-**

2.5.1.1 Abated Source Property WMAs

The *Abated Source Property WMA* category includes all catchments that contain at least one source property that has been abated. The abatement may have occurred through referral to the Regional Water Board (or other regulatory authority), by the Permittee, or by the property owner. WMAs in this category may have been subject to a source investigation by the Program that identified a source property that was subsequently abated. However, this category can also include WMAs with sources that were identified and abated outside of the Program's source property investigation process. WMAs in this category may still have ongoing investigations into other potential source properties within the WMA, beyond the property that was abated. To date, Co-Permittees in the Santa Clara Basin have not identified any WMAs in this category.

2.5.1.2 Referred Source Property WMAs

The *Referred Source Property WMA* category includes all catchments that contain at least one source property referred to the Regional Water Board for follow-up investigation and abatement. All WMAs in this category have been subject to a source investigation conducted by the Program that was completed and resulted in the referral of at least one source property. WMAs in this category may still have ongoing investigations into other potential source properties within the WMA. To date, Co-Permittees in the Santa Clara Basin have identified three (3) WMAs in this category, including one in San Jose, one in Santa Clara, and one in Sunnyvale. Permittees have identified and referred one source property to the Regional Water Board from each of these WMAs. The source property investigations that were conducted to support these referrals are described in Section 4 of this report. In the future, as referred source properties are abated, these WMAs will be moved into the Abated Source Property WMA category.

2.5.1.3 Confirmed Source Property WMAs

The *Confirmed Source Property WMA* category includes all catchments that contain at least one confirmed source property that has not yet been abated or referred to the Regional Water Board. All WMAs in this category have at least one confirmed source property based on the results of a completed source investigation. WMAs in this category may still have ongoing investigations into other potential source properties within the WMA. For confirmed source properties, Permittees have two options for next steps: (1) refer the property to the Regional Water Board for abatement and conduct (or cause to be conducted) enhanced O&M activities in the public ROW adjacent to the property to prevent or reduce continued release of pollutants from the property during the abatement process, or (2) directly abate or cause the property to be abated (typically by the property owner). To-date, Co-permittees in the Santa Clara Basin have identified four (4) WMAs that have one or more confirmed source properties. These *Confirmed Source Property WMAs* comprise over 1,200 acres. All four WMAs are located in the City of San Jose. There are 3 confirmed source properties in one of these WMAs, 2 confirmed source properties each in 2 more WMAs, and 1 confirmed source property in a 4th WMA. The investigations that were conducted to support confirmation of source properties within these WMAs are described in Section 4 of this report. In the future, as confirmed source properties are either referred or abated, these WMAs will be re-classified into the appropriate WMA prioritization category (i.e., Abated Source Property WMA or Referred Source Property WMA).

2.5.1.4 High, Moderate and Low-Priority WMAs

The *High-Priority WMA, Moderate-Priority WMA,* and *Low-Priority WMA* categories include all of the Catchments of Interest that were previously identified and have been sampled at least once since WY 2015 as part of the screening monitoring program. The classifications of these WMAs are based on screening monitoring results as follows:

1. *High-Priority WMA* = At least one MS4 sediment or stormwater sample collected in the catchment had PCBs concentrations or PCBs particle ratios ≥ 0.5 mg/kg.
2. *Moderate-Priority WMA* = The highest MS4 sediment or stormwater sample collected in the catchment had PCBs concentrations or particle ratios that were between ≥0.2 mg/kg and < 0.5 mg/kg.
3. *Low-Priority WMA* = All MS4 sediment and/or stormwater samples measured in the catchment had PCBs concentrations or particle ratios < 0.2 mg/kg.

In addition to the criteria identified above, other information may be used to identify *High-Priority WMAs*, such as monitoring data from property cleanups or other indicators of PCBs sources. Also, as additional monitoring data are collected within a catchment, WMA prioritization will be revised as appropriate.

Currently, there are thirteen (13) *High-Priority WMAs* identified in the Santa Clara Basin, including six (6) in Mountain View, four (4) in San Jose, two (2) in Palo Alto, and one (1) in Santa Clara. These WMAs comprise over 2,200 acres. All of these WMAs have been investigated and/or are currently under investigation to identify source properties. The Mountain View High-Priority WMAs were prioritized based primarily on data provided from sources other than screening monitoring that indicated there is or was a source of PCBs in these adjacent WMAs. The source property investigations that have been or are currently ongoing in these WMAs are presented in Section 4.

Another eight (8) Moderate-Priority WMAs have been identified in the Santa Clara Basin, comprising nearly 2,000 acres. Only one (1) of these WMAs is currently under investigation to identify source properties, primarily because it is located adjacent to a High-Priority WMA that is also currently under investigation. That investigation is also described in Section 4.

The other seven (7) Moderate-Priority WMAs currently remain on the list for possible future investigations. There are currently seventy-six (76) *Low-Priority WMAs* identified in the Santa Clara Basin, comprising 30,000 acres. Screening monitoring conducted in each of these WMAs has not yet found elevated PCBs in MS4 sediments or stormwater. No actions are currently planned in these Low-Priority WMAs. However, if new information becomes available in the future that indicates these WMAs have sources of PCBs, they will be re-categorized into a moderate or high priority WMA, as appropriate.

2.5.1.5 Other Catchments of Interest

The *Other Catchments of Interest* category includes all of the remaining areas that were identified as Catchments of Interest through the opportunity area analysis (as described in Section 2.4), but that have not yet undergone screening monitoring for elevated POC concentrations. These catchments remain on the list for future screening monitoring. Currently, there are forty-seven (47) Other Catchments of Interest in the Santa Clara basin, comprising more than 13,000 acres.

3 SOURCE PROPERTY INVESTIGATION METHODS

This section presents an overview of the source property investigation process, including a description of the methods used to investigate and identify source properties, and the options for next steps once source properties have been confirmed. The results and current status of all WMAs that have been investigated or are currently being investigated in the Santa Clara Basin are provided in Section 4.

3.1 Purpose of Source Property Investigations

The primary purpose of source property investigations is to identify PCBs and/or mercury source properties for abatement. Source properties are defined as an elevated source of PCBs or mercury that disproportionately contribute these pollutants to a stormwater conveyance system or directly to a receiving water body. SCVURPPP has identified source properties primarily based on elevated PCBs or mercury concentrations in samples collected on a parcel, at the border of a parcel, or from the underground drainage system connecting the parcel to a Co-permittee's MS4. PCBs or mercury concentrations that are elevated above urban background (i.e., > 0.2 mg/kg for PCBs and > 0.3 mg/kg for mercury) suggest proximity to a local source. Abatement of source properties can be conducted through referral to the Regional Water Board, or other appropriate regulatory agency. Alternatively, a Permittee may choose to directly cause the property owner to conduct abatement activities.

3.2 Methods

3.2.1 Overall Approach

SCVURPPP's source property investigation process is modeled after the Clean Watersheds for a Clean Bay (CW4CB) Source Property Identification and Referral Pilot Project conducted in the Leo Avenue Watershed in San Jose, CA (SCVURPPP 2015a). The overall process focuses on categorizing all properties in a given WMAs as high- or low-interest as potential contributors to PCBs or mercury to MS4s, and then conducting MS4 sediment sampling on or adjacent to high-interest properties to identify elevated PCBs or mercury concentrations. Properties are initially categorized as high- or low-interest based on their potential for current or past use, release or storage of PCBs. Throughout each step in the process, the list of high-interest properties is refined based on the information gained during that step. The investigation process proceeds through the following five steps:

1. Records Review - to identify a preliminary list of high-interest properties based on current and historic land-use classifications, historic aerial photography, and review of other records (i.e., property records, online databases, etc.);
2. Public ROW Surveys – to observe sediment migration from high-interest properties to the public ROW, verify information obtained during records review, and refine the list of high-interest properties for follow-up site visits;
3. Facility Site Visits - to document possible sources, sediment migration, onsite flow patterns, existing stormwater control measures, identify potential sample locations, and further refine the list of high-interest properties for sampling;

4. Sampling - to find locations on or adjacent to high-interest properties where PCBs or mercury concentrations are elevated;
5. Data Analysis and Identification of Source Properties - to identify any source properties based on the combined results of the above four steps; to provide municipalities with recommendations for follow-up actions.

The investigation process may require multiple iterations before all source properties can be identified within a given WMA. In some cases, there may be insufficient data to identify all source properties within a WMA, or to confirm that a specific property is a source to MS4s. Follow-up investigation may be warranted in these cases. Follow-up investigations proceed through a second round of the five investigation steps listed above, but focused on specific properties or smaller sub-areas within a WMA. Additional details about each step of the investigation process are provided below.

3.2.2 Step 1: Records Review

The purpose of the initial records review is to gather and evaluate all available information on parcels within the WMA and categorize each parcel as high- or low-interest for follow-up public ROW surveys and/or site visits. For each WMA targeted for source property investigation, Program staff review the most current aerial photographs available in Google Earth, as well as any available historical aerial photographs from 1980 and prior to document current information about the area, as well as during the period of peak production and use of PCBs (i.e., 1950 – 1980). Next, Program staff review and compile other available records and assign preliminary interest categories to each parcel. Municipal stormwater inspectors from each WMA's jurisdiction may also review the information and provide their input based on prior inspections and general knowledge about businesses in the WMA. The type of information that is gathered during the initial records review on each parcel includes the following:

- Current and historic land-use classification;
- Site history, cleanup records, or monitoring data available through online databases (i.e., Geotracker and Envirostor);
- Cal OES records of PCBs releases from electrical utility equipment
- Facilities identified on the Regional Water Board's "Triage List of PCBs Clean Sites"
- Changes in aerial photos from prior to 1980 and present condition;
- Historical outdoor storage, suspected waste areas or ponds;
- Inspection history available for each facility, including occurrence of PCBs, spills, and numerous stormwater violations on prior inspection reports;
- Inspector's comments on business facilities and activities;
- Well monitoring reports for PCBs at open remediation sites;
- Facilities subject to the Industrial General Permit (IGP)

This information is carefully reviewed in order to categorize each parcel in the WMA as high- or low-interest properties based on their potential to be a source of PCBs and/or mercury to storm drains. High-interest properties are then targeted during the next steps (public ROW surveys and/or facility site visits).

3.2.3 Step 2: Public Right-of-Way (ROW) Surveys

Public ROW surveys provide information to help identify potential source areas, document the location of storm drain infrastructure and drainage patterns in the WMA, observe evidence of sediment release from high-interest properties, verify information obtained during records review, and document additional observations that suggest a potential source property (e.g., electrical transformers). The results of the public ROW surveys are used to further prioritize properties for site visits, and identify potential sampling locations within the WMA. These surveys focus on areas adjacent to high-interest properties. During visual roadway and sidewalk surveys, Program staff look for evidence of sediment release from a given property into the public ROW, and identify any other indicators of pollutant use, including the following:

- Unpaved or other areas where sediment erosion may occur, especially when there is evidence of migration of soil or sediment from a property to the public ROW;
- Electrical equipment associated with PCBs (e.g., transformers and capacitors);
- Old equipment with hydraulic fluids;
- Outdoor hazardous material/waste storage areas (e.g., tanks, drums), especially with poor housekeeping;
- Signs related to hazardous materials and wastes;
- Recycling/scrap yards (e.g., for automobiles);
- Building demolition, renovation or window replacement sites;
- Unusually stressed vegetation;
- Unidentified puddles or stains;
- Flow patterns and storm drain structures;
- Existing and potential stormwater control measures;
- Sediment erosion from a property and migration to the street or storm drains;
- Properties that had been redeveloped or were under construction;
- Redeveloped areas where older exposed soils were available for tracking off site.

After conducting public ROW surveys, Program staff review the information collected thus far with municipal stormwater inspectors from each participating WMA and refine the interest categories assigned to each property. They also remove properties from the high-interest category that have closed or relocated, and are now 100% paved or remediated. Program staff then use the combined information from the records review, public ROW surveys and discussions with municipal stormwater inspectors to identify the high-interest properties for follow-up facility site visits.

3.2.4 Step 3: Facility Site Visits

The purpose of this step is to conduct facility visits at sites that have been identified during records review and confirmed by public ROW surveys to be high-interest properties. Facility site visits provide additional information about current and past business practices on a site and document any additional evidence that suggests a property may be a potential source of PCBs or mercury to MS4s. The municipal stormwater inspector(s) for each WMA typically provide

access to the properties, introduce Program staff, explained the general purpose of the project, and facilitate information gathering at each site. Program staff document the information gathered during facility visits on inspection forms. The site visits, are intended to accomplish the following:

- Educate current business owner/property owner about PCBs and mercury in order to facilitate:
    - potential future sampling at the property;
    - conversations about past businesses or business activities on a property or in the area; and
    - implementation of future control measures on the property;
- Identify and document features of each site including:
    - private storm drain infrastructure on the property;
    - the drainage flow pattern(s) from the property to the public ROW;
    - any obvious PCBs or mercury sources on the property;
    - evidence of pollutant use or release;
    - unpaved areas where soil/sediment may be released to the public ROW;
    - potential soil/sediment sample sites on the property;
    - current business facility activities;
    - general housekeeping on the property; and
    - stormwater control measures already in place.

Program Staff review the combined results of the records reviews, public ROW surveys, and facility site visits and use the information gathered to continue to refine the list of high-interest properties, prioritize parcels for sampling, identify potential sampling locations, and recommend the preferred sample type at each location (i.e., street dirt, sediment or stormwater). A sampling plan that targets high-interest properties is then developed for each WMA.

3.2.5 Step 4: Sampling

The purpose of this step is to collect and analyze samples of street dirt, MS4 sediment or stormwater to provide data that can be used to identify properties associated with elevated PCBs or mercury concentrations. All sampling is conducted by a monitoring contractor under the supervision and guidance of Program staff. All properties that remain high-interest following Step 3 are initially targeted for sampling. If access to a high-interest property is available, samples are collected on site. If onsite sampling is not possible, samples are collected in the public ROW at the border of the parcel. Additional public ROW samples may be collected from high-interest locations identified during the previous steps. The sampling results are used to identify locations within the public ROW or on private properties where pollutant concentrations are elevated. This information will allow further refinement of property interest-levels and provide data that will be used in Step 5 to identify specific source properties.

The field methods and laboratory analysis procedures used follow the detailed methods described in the CW4CB QAPP and CW4CB Task 3 SAP (BASMAA 2013a,b). For sediment,

the laboratory sieves samples to 2 mm prior to analysis, consistent with previous BASMAA sediment studies (KLI 2002; SMSTOPP 2002, 2003, 2004; Yee and McKee 2010). All sediment samples were analyzed for the "RMP 40" PCB congeners (USEPA Method 8082M) and total mercury (EPA Method 7471A). Sediment sampling was also conducted in WY 2017 and WY 2019. Using similar collection methods as the WY 2015 sampling, as described in the WY 2016 POC Monitoring SAP (SCVURPPP 2015b). All samples were analyzed for the "RMP 40" PCB congeners (EPA Method 8270 modified) total mercury (EPA Method 7471A), and total solids (SM 2540G-11). All field and laboratory data are reviewed for data quality according to the CW4CB QAPP (BASMAA 2013a).

3.2.6 Step 5: Data Analysis and Source Property Identification

Program staff review the chemical analysis data and map the relative concentrations to identify any sites that had elevated PCBs or mercury concentrations, suggesting proximity to a source. In addition to the magnitude of PCBs concentrations, Program staff may also review PCBs homolog profiles to evaluate potential linkages to known Aroclors, similarities between samples collected on-site and in the adjacent MS4, and between sample sites across a catchment. Aroclors were the dominant commercial PCBs product manufactured and used in the United States. PCBs homolog profiles of samples compared with typical Aroclor homolog profiles, and with other samples in a catchment provide limited, but potentially important information about sources and transport of particle-associated PCBs through the catchment. PCBs homolog groups are comprised of PCB congeners with the same number of chlorine atoms (i.e., chloro-groups). PCB congeners with less than six chlorines atoms degrade and lose chlorine in aerobic conditions more quickly, whereas PCB congeners with 6-10 chlorine atoms are less likely to degrade in aerobic conditions but may degrade faster in anaerobic soil. Despite these generalities, there are no predictable degradation patterns that can be applied to a specific weathered Aroclor. However, weathered products from the same source may have similar PCBs homolog profiles (i.e., similar percent composition of each of the chloro-groups). Thus, similar PCBs homolog profiles for samples collected on a property and in the adjacent public ROW may suggest a linkage between the sites.

As the final step in this process, Program Staff review the information gathered throughout the investigation process on all of the properties that remain on the high-interest list. Elevated soil/sediment or stormwater concentrations from samples collected onsite, at the border of a parcel, or at the junction of an onsite underground drainage pipe (lateral) and the MS4 provide the best definitive evidence that a property is a source of PCBs or mercury to the MS4. Thus, pollutant concentrations provided the primary means of confirming the identification of source properties.

The outcome of a targeted source property investigation will result in categorization of all properties of interest in a given WMA into one of the following:

- Low Likelihood Source Property. This category comprises all properties that are unlikely to be a source property, including:
    - Properties associated with POC concentrations < 0.2 mg/kg;
    - Properties identified as low interest during previous steps of the investigation (i.e., records review, ROW survey, or site visits);

- Undetermined – This category comprises all properties that lack sufficient data to confirm that they are a source property, but that also cannot be categorized at this time as low-interest. These properties include:
    - Properties associated with PCBs concentrations between 0.2 and <1 mg/kg; other lines of evidence (e.g., onsite sample data > 1 ppm, other) are required to confirm this property is a source;
    - High- or moderate-interest properties that do not yet have any sample data associated with them.
- Confirmed Source Property - a property associated with PCBs concentrations ≥ 1.0 mg/kg.

The concentration ranges for the property categories identified above were derived from a distribution of over 1,500 PCBs and 1,300 mercury soil/sediment concentrations measured across the Bay Area over the past 20 years (ACCWP 2016, 2017, 2018, 2019, CCCWP 2016, 2017, 2018, 2019, Gilbreath et al. 2016, 2020, Gunther et al. 2001; KLI and EOA Inc. 2002, EOA Inc. 2007; City of San Jose and EOA Inc. 2003; SMCWPPP 2016, 2017, 2018, 2019, SMSTOPPP 2002, 2003, 2004; Kleinfelder 2005, 2006; Salop et al., 2002a, b; Yee and McKee 2010, SCVURPPP 2016a, 2016b, 2017, 2018, 2019). Areas associated with the highest pollutant concentrations (i.e., those ≥ 1.0 mg/Kg PCBs or mercury) represent approximately the top 10% of Bay Area measurements to-date and indicate a high likelihood of finding a source within the vicinity. Samples in the low category represent the bottom 75% of Bay Area concentrations (i.e., urban background) and indicate a low probability of finding a source property within the vicinity of the location where the sample was collected.

Generally, all properties originally identified as high-interest will remain on the high-interest list unless there is sufficient evidence that a given property is not a source of PCBs or mercury to MS4s. If sampling data are inconclusive, the property remains on the list of high-interest properties. If planned sampling has not yet been completed because property owners did not provide permission, or because there was not adequate sediment available to collect at the time of sampling, those properties are also retained on the high-interest list. Properties are removed from the high-interest list if urban background concentrations are observed and there is a lack of other evidence suggesting that the property contributes PCBs or mercury to MS4s.

3.3 Next Steps

Properties with PCBs concentrations ≥ 1.0 mg/kg are considered confirmed source properties and need no further investigation. The options municipalities may pursue for confirmed source properties include the following:

1. Submit a referral to the Regional Water Board (or other regulatory agency) for follow-up investigation and abatement. Referrals must include a plan for enhanced operation and maintenance in the public ROW adjacent to or downstream of the source property that the City will implement or cause to be implemented until the time the property is deemed abated.
2. Abate or cause the property to be abated directly, without referral to a regulatory agency. For this option, the City will work directly with the property owner to ensure the property is fully abated.

Properties categorized as “undetermined” may require follow-up investigation. Additional follow-up investigation may also be warranted in cases where no sources have been clearly identified that explain the elevated PCBs concentrations in the WMA. For these cases, Program staff discuss options with municipal staff and make recommendations for follow-up investigations or other potential actions that a city may want to consider.

4 SOURCE PROPERTY INVESTIGATION RESULTS

This section presents a summary of the results of source property investigations that have been conducted in the Santa Clara Basin. All of the WMAs where source property investigations have been completed or are currently ongoing are identified in Table 4.1. Source property investigations have been initiated in 19 WMAs in the Santa Clara Basin to date. This section is organized by City.

Table 4.1. WMAs with source property investigations completed or ongoing in the Santa Clara Basin, CA.

Permittee	WMA ID	Waterbody	Acres	Investigation Status
Mountain View	017PMC600	Permanente Creek	66	Ongoing
	017SVC500	Stevens Creek	209	Ongoing
	032PMC100	Permanente Creek	32	Ongoing
	032PMC200	Permanente Creek	69	Ongoing
	032SVC400	Stevens Creek	82	Ongoing
	032SVC470	Stevens Creek	71	Ongoing
Palo Alto	001SFC100	San Francisquito Creek	36	Completed
	031SCH250	Matadero Creek	68	Ongoing
San Jose	050GAC020	Guadalupe River	847	Ongoing
	051CTC275	Coyote Creek	454	Ongoing
	051CTC400	Coyote Creek	140	Ongoing
	067CTC250	Coyote Creek	41	Ongoing
	067SCL080	Lower Silver Creek	42	Ongoing
	067SCL120	Lower Silver Creek	27	Ongoing
	083CTC990[1]	Coyote Creek	456	Completed
	083GAC900	Guadalupe River	610	Ongoing
Santa Clara	050GAC400	Guadalupe River	718	Ongoing
	066GAC150	Guadalupe River	500	Ongoing
Sunnyvale	049SVE900	Sunnyvale East Channel	480	Completed
		Total Acres	**4,935**	

1: The source property investigation conducted in the WMA was completed prior to WY 2015 and the full details are reported elsewhere (SCVURPPP 2015)

4.1 City of San Jose

In the City of San Jose, the Program has completed a source property investigation in one WMA and initiated additional source property investigations in seven WMAs that are all currently ongoing. The source property investigation in the Leo Avenue Watershed that was completed in 2014 as part of CW4CB project and resulted in submission of a source property referral to the Regional Water Board has been thoroughly described elsewhere (SCVURPPP 2015a). The seven ongoing investigations are summarized below, including a description of each WMA, the POC monitoring data collected to support the investigation, and the current status and outcomes of each investigation.

4.1.1 WMA 083GAC900

WMA 083GAC900 is comprised of 611 acres that drain to the Guadalupe River. Street dirt and MS4 samples collected in the public ROW in WY 2015 as part of the Program's screening

monitoring found elevated PCBs concentrations in the WMA. Beginning in WY 2016, a targeted source property investigation was initiated in the WMA to identify the source(s) of elevated PCBs. Records review, public ROW surveys, site visits, and sediment and stormwater sampling were all conducted in the WMA as part of the investigation. The results of the investigation to date are summarized below. The locations and relative concentrations of all POC monitoring conducted in this WMA since WY 2015, both as part of the screening monitoring program and during the targeted source property investigation are shown on Figures 4.1 and 4.2.

According to the records review, the WMA was a mix of industrial, commercial, agricultural, and residential land uses prior to 1980. There were 114 industrial parcels at that time, comprising 34% of the total WMA area. Industrial facilities included the largest metal recycling facility in Santa Clara County (Sims Metal Management, formerly Levin Metals Corporation), and the 55-acre General Electric Motor Plant that manufactured motors and electrical parts into the 1990's. Other industries in the WMA included electrical utility substations, electro-formers (a metal forming process to produce metal equipment parts), canneries and a nut processing facility, various recycling facilities, vehicle salvage and repair, along with welding, tires and auto parts shops. Geotracker records identify three cleanup sites with known PCBs contamination in the WMA, including the General Electric Motor Plant, the San Jose Canning Company, and a Pacific Gas and Electricity (PG&E) substation. Each of these sites has since been remediated and the properties redeveloped.

Currently, Sims Metal Management continues to operate a scrap metal recycling facility in the WMA. The WMA also has active railroads and includes the Tamien station in the northern part of the WMA, which serves both Caltrain and VTA light rail. Based on the combined results of records review, public ROW surveys and site visits, the Program identified a number of high-interest properties in the WMA for sampling. In WY 2017, the Program collected 7 street dirt or MS4 sediment samples in the WMA. One sample had highly elevated PCBs, and 3 samples had moderately elevated PCBs. All the samples had moderately or highly elevated mercury concentrations. The Program evaluated the information gathered throughout the investigation and confirmed one PCBs source property. This property was also a mercury source property. However, the sources of some elevated concentrations in the WMA remained unknown, and investigation in the WMA continued. In WY 2018, stormwater monitoring conducted downstream of a suspected source property had both highly elevated PCBs concentration and PCBs particle ratio. Subsequently, two sediment samples were collected on site at that same suspected property in WY 2019. Both samples had highly elevated PCBs, confirming the property as a second PCBs source property in the WMA. The on-site data confirmed this same property is also a mercury source property. A third highly elevated PCBs street dirt sample collected in WY 2019 at the border of the driveway exit from another suspect property confirmed a third PCBs source property in the WMA. Two other stormwater samples were collected in WY 2018 and WY 2019 that targeted the drainage from the former General Electric Motor Plant that was redeveloped in 2005 to a commercial retail facility. Neither sample had elevated PCBs or mercury.

The City of San Jose is currently considering next steps for the three (3) confirmed source properties. The Program will further evaluate all of the data gathered to date in this WMA to determine if any additional investigation is needed in WY 2020.

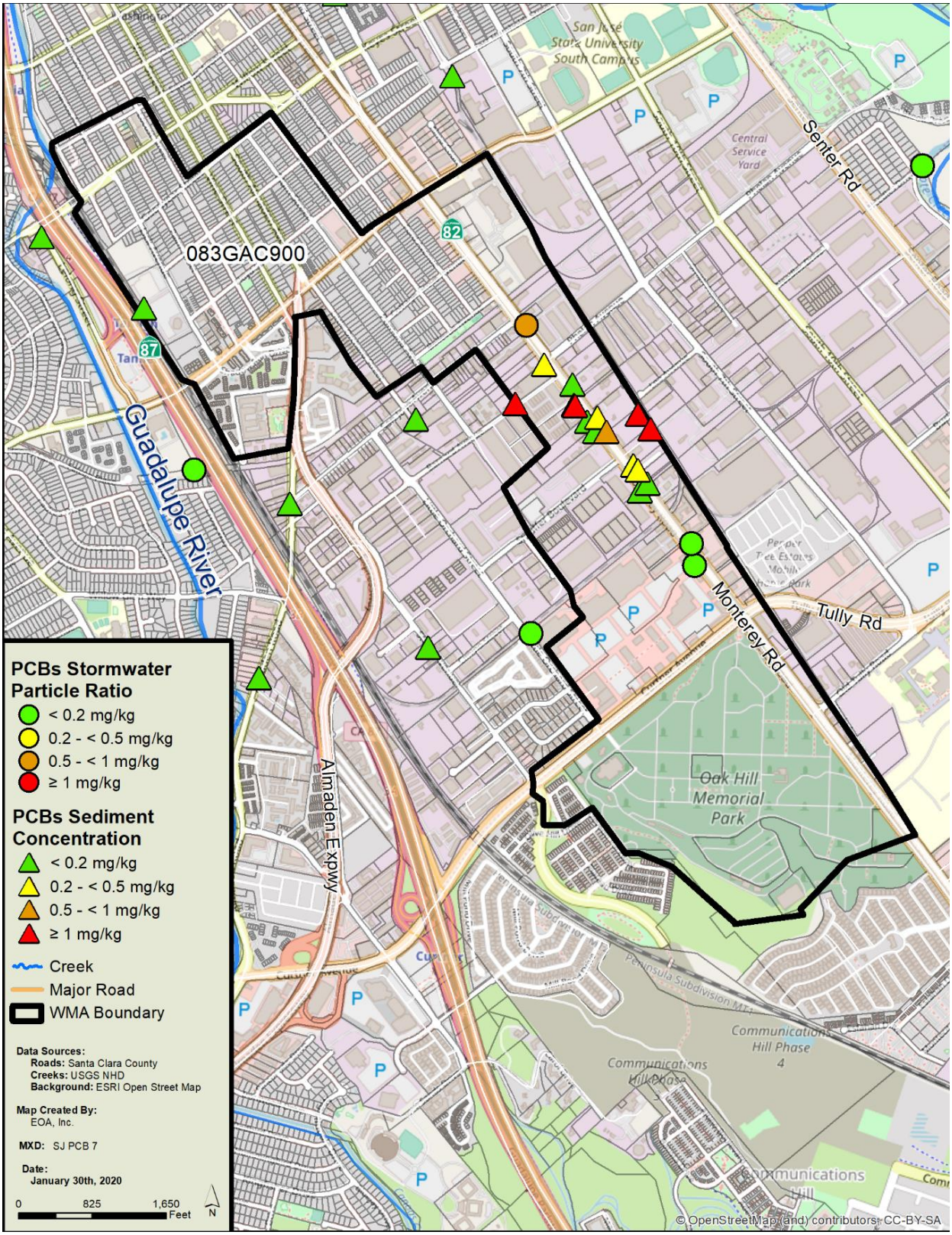


Figure 4.1. PCBs in street dirt and MS4 sediment concentrations and stormwater particle ratios measured in WMA 083GAC900 in WY 2015 through WY 2019.

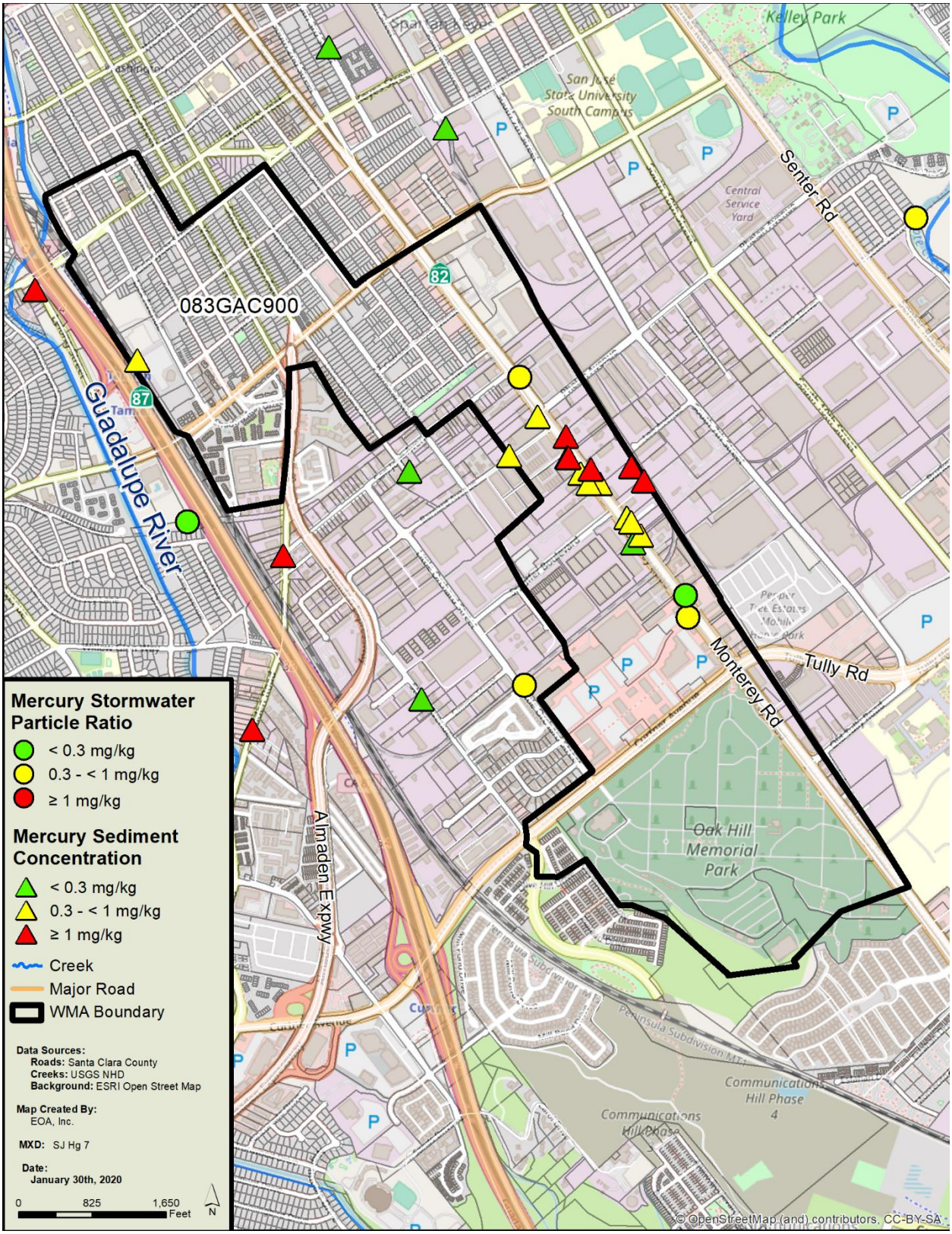


Figure 4.2. Mercury in street dirt and MS4 sediment concentrations and stormwater particle ratios measured in WMA 083GAC900 in WY 2015 through WY 2019.

4.1.2 WMA 050GAC020

WMA 050GAC020 is comprised of 843 acres that drain to the Guadalupe River. Elevated PCBs were not found in the two MS4 sediment samples collected in the WMA during the Program's screening monitoring conducted in WY 2015. However, stormwater reconnaissance monitoring conducted as part of the Program's ongoing screening program in WY 2017 collected a sample from the pump station outfall to the Guadalupe River that had an elevated PCBs particle ratio. Beginning in WY 2018, the Program initiated a targeted source property investigation in the WMA to identify the source(s) of elevated PCBs. Records review, public ROW surveys, site visits, and sediment and stormwater sampling were all conducted in the WMA as part of the investigation. The results of the investigation to date are summarized below. The locations and relative concentrations of all POC monitoring conducted in this WMA since WY 2015, both as part of the screening monitoring program and during the targeted source property investigation are shown on Figures 4.3 and 4.4.

According to the records review, the WMA was a mix of industrial, commercial, and agricultural land uses prior to 1980. Industrial parcels active at that time comprised 37% of the total WMA area. Before 1976 the WMA was almost entirely agricultural. Industrial facilities included railroads in the center of the catchment and tank farms in the north east portion of the WMA. Beginning in1976 industrial facilities included manufacturing, chemical processing, semiconductor research, food processing, an electrical utility corporation yard, and an electrical utility substation. The WMA includes two Department of Toxic Substances Control (DTSC) cleanup sites; one at a lock manufacturing facility, and one at a chemical storage handling and distribution facility. Currently, the catchment is a primarily a mix of old industrial and new urban areas, with a small amount of old urban and open space. The catchment drains directly to the Guadalupe River via a large pump station (Rincon 2) that was constructed in 2004. Several active rail line still cross the WMA.

As part of the targeted source property investigation, the Program reviewed records for 112 old industrial parcels in the WMA, completed public ROW surveys of 81 parcels of interest, and conducted site visits at 15 businesses located on high-interest parcels. Based on the combined results of records review, public ROW surveys and site visits, the Program identified a number of high-interest properties in the WMA for sampling. In WY 2019, the Program collected 3 stormwater samples and 14 street dirt samples from public ROW areas near high-interest properties. None of these samples had any elevated PCBs concentrations or particle ratios.

To date, the Program has not identified the source(s) of the elevated PCBs observed at the pump station outfall to this WMA. The Program is currently reviewing all of the data gathered in this WMA to date in order to determine if further source investigations are warranted in WY 2020.

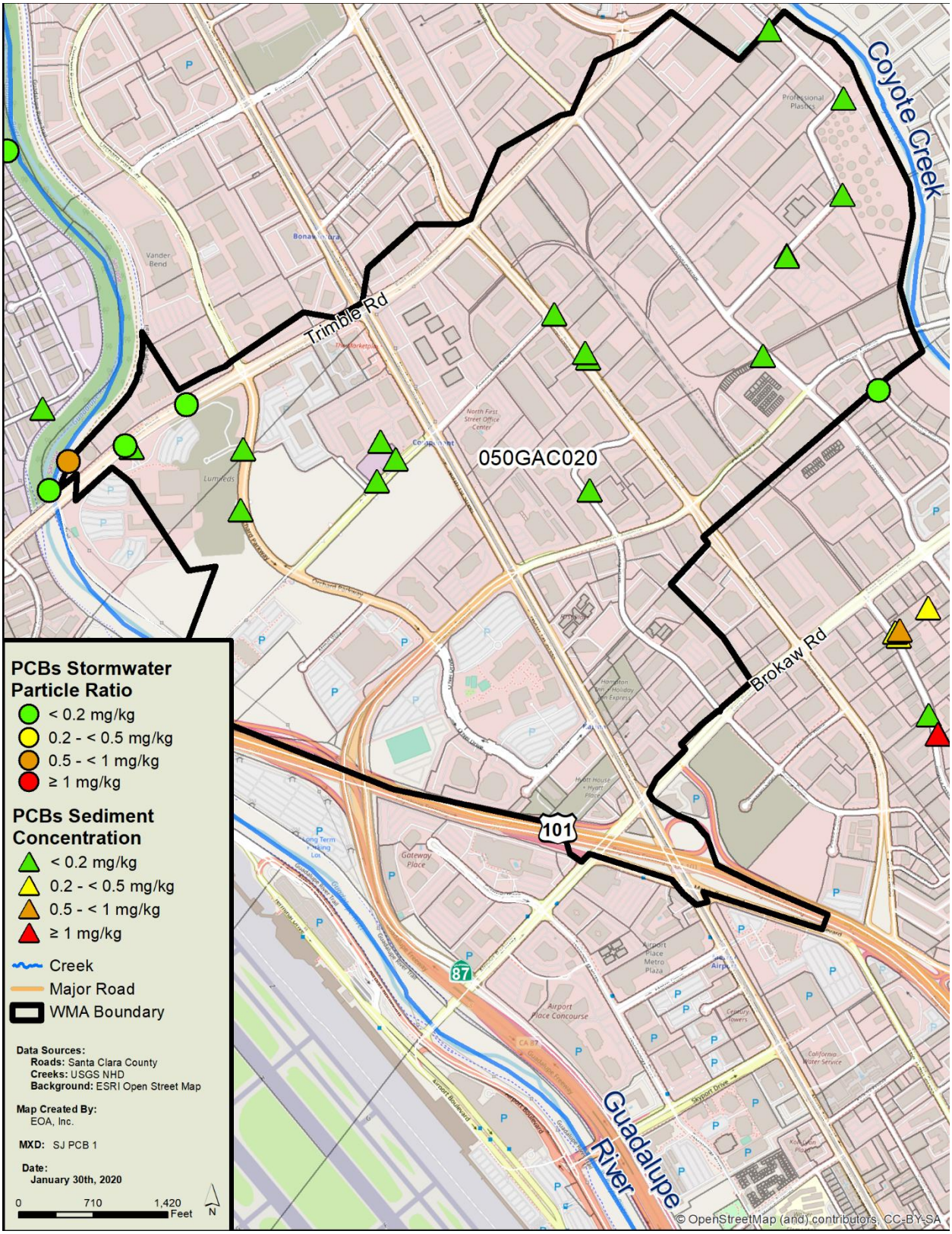


Figure 4.3. PCBs in street dirt and MS4 sediment concentrations and stormwater particle ratios measured in WMA 050GAC020 in WY 2015 through WY 2019.

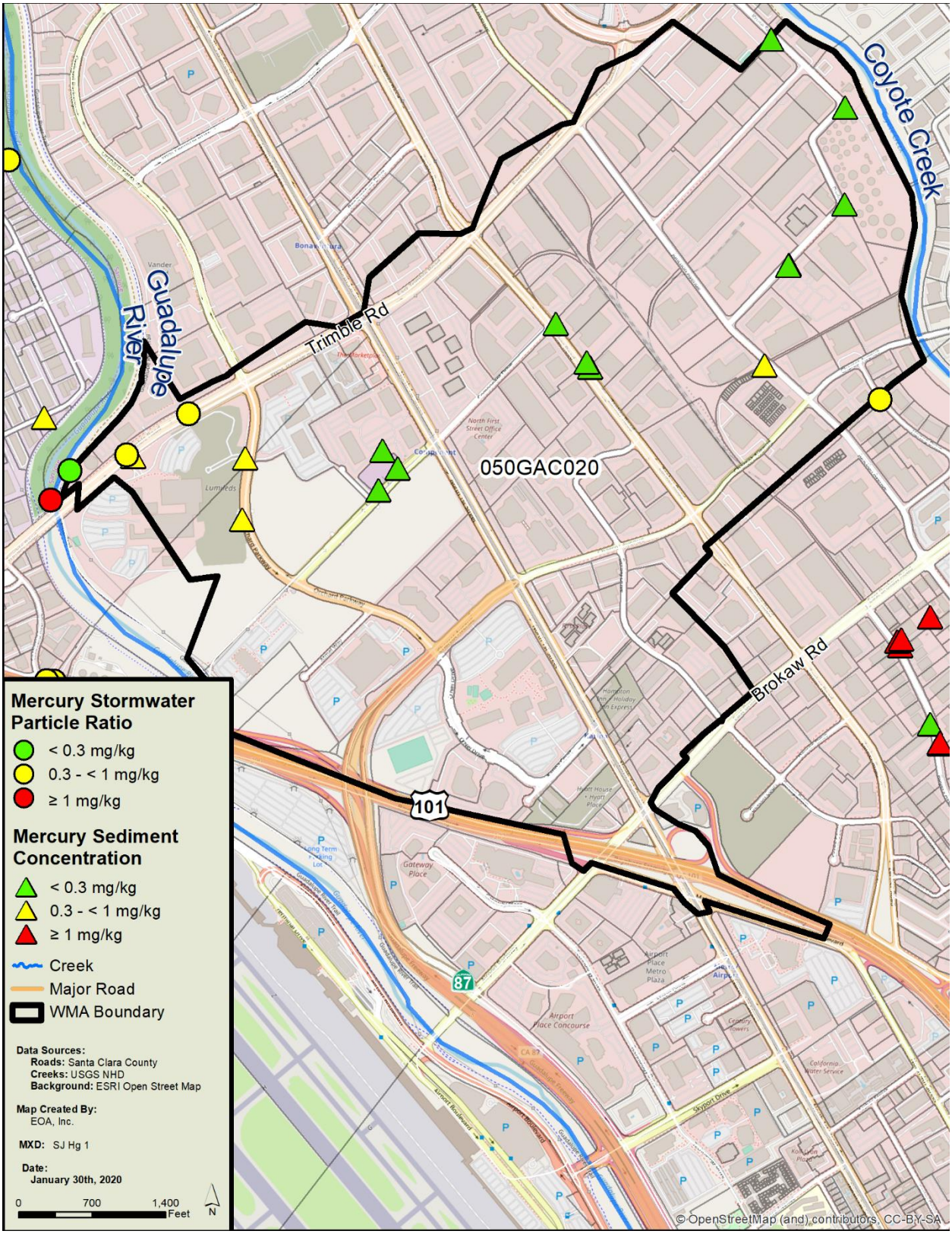


Figure 4.4. Mercury in street dirt and MS4 sediment concentrations and stormwater particle ratios measured in WMA 050GAC020 in WY 2015 through WY 2019.

4.1.3 WMA 067SCL080

WMA 067SCL080 is comprised of 28 acres that drain to Lower Silver Creek. A sample collected as part of the RMP's stormwater reconnaissance monitoring at the MS4 outfall to Lower Silver Creek during a storm event in WY 2015 had a highly elevated PCBs concentration and PCBs particle ratio. Beginning in WY 2016, the Program initiated a targeted source property investigation in the WMA to identify the source(s) of the elevated PCBs. Records review, public ROW surveys, site visits, and sediment and stormwater sampling were all conducted in the WMA as part of the investigation. The results of the investigation to date are summarized below. The locations and relative concentrations of all POC monitoring conducted in this WMA since WY 2015, both as part of the screening monitoring program and during the targeted source property investigation are shown on Figures 4.5 and 4.6.

Based on findings from the records review, the WMA was almost entirely industrial (84%) prior to 1980. Active railroad lines ran down the west side of the WMA. There were 13 industrial parcels in the WMA at that time. These industrial facilities included a plastic bag manufacturer, an e-waste recycler, and a caulking and glazing manufacturer (DAP, Inc.). The Geotracker database identified these facilities as cleanup sites for solvents and/or petroleum products. DAP, Inc. (the caulking and glazing manufacturer) operated from 1963 to 1993. Because PCBs were commonly used in caulking materials produced during much of this time period, the former DAP, Inc. property could be a source of PCBs in this WMA. Chemical transport to and from the property was ongoing during the company's operations via a now inactive railroad spur. The property was divided and redeveloped into multiple parcels in 2005. However, the main public storm drain line from the catchment runs under the former DAP, Inc. site before reaching the Lower Silver Creek outfall.

Currently the WMA is 62% industrial and includes a former railroad corridor on the western border of the WMA that is under construction for a future BART extension. Based on the combined results of records review, public ROW surveys and site visits, the Program identified a number of high-interest properties in the WMA for sampling. In WY 2017, the Program collected 7 street dirt or MS4 samples throughout the catchment, but did not find any elevated POC concentrations. The Program continued to investigate the WMA to identify the source(s) of the high PCBs measured in WY 2015 at the catchment outfall. In WY 2019 two storm water samples were collected in the MS4 simultaneously, in an effort to target the former DAP, Inc. site. The first sample was collected in the public ROW immediately upstream of the former DAP, Inc. site, and the second sample was collected at the outfall to Lower Silver Creek. The main storm drain line runs perpendicular to Lower Silver Creek and crosses under the former DAP, Inc. site just before the outfall to the creek. These results showed the PCBs concentration and particle ratio at the outfall were elevated above the sample collected upstream. In addition, materials collected from within the storm drain line on the former DAP, Inc. site in WY 2019 had highly elevated PCBs. These results confirm the former DAP, Inc. site is the source of PCBs observed at the MS4 outfall.

The City of San Jose is currently evaluating next steps for the confirmed source property. Based on a review of all the data collected in this WMA to date, the Program has determined the source of PCBs at the MS4 outfall has been identified and no further investigation of the WMA is planned at this time.

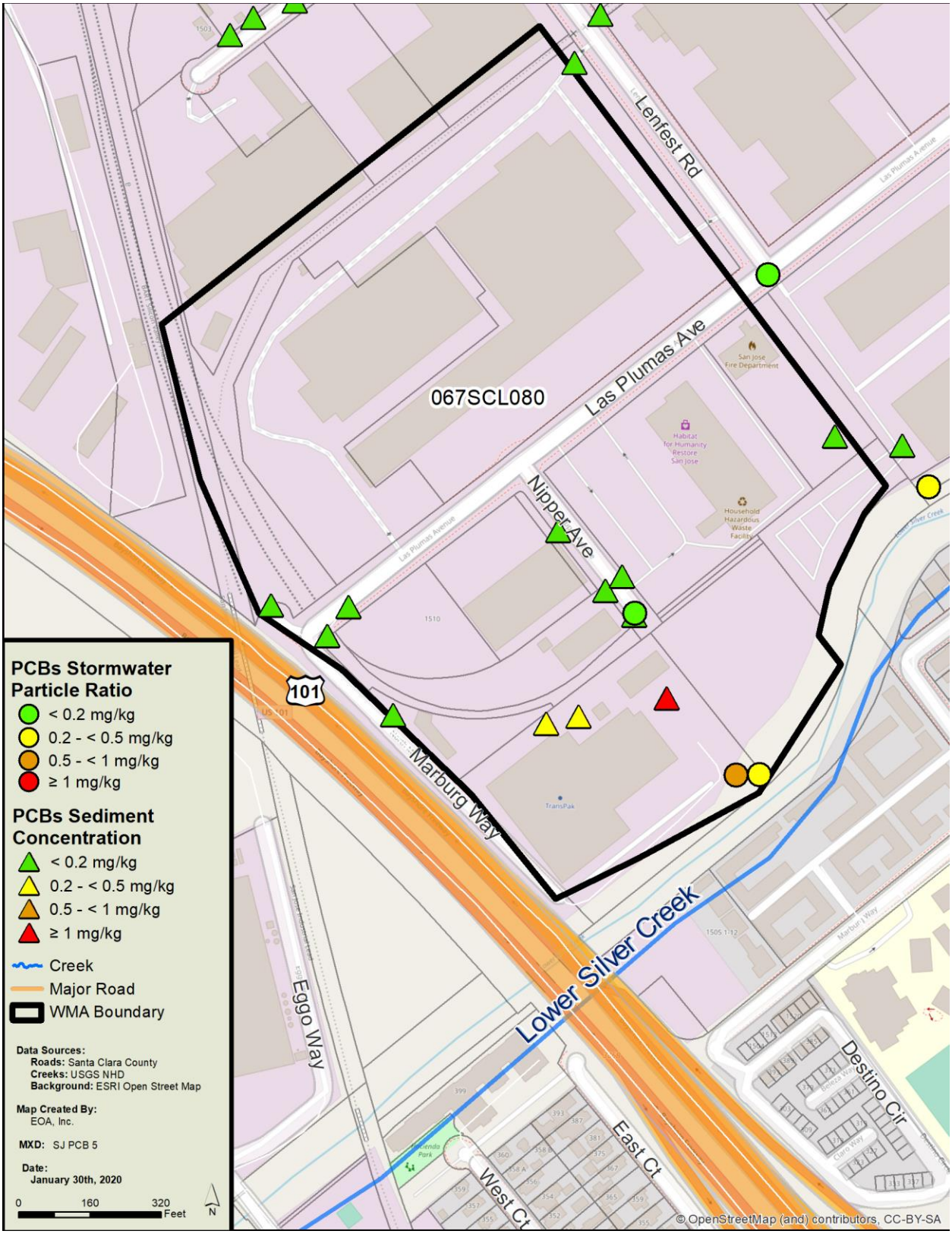


Figure 4.5. PCBs in street dirt and MS4 sediment concentrations and stormwater particle ratios measured in WMA 067SCL080 in WY 2015 through WY 2019.

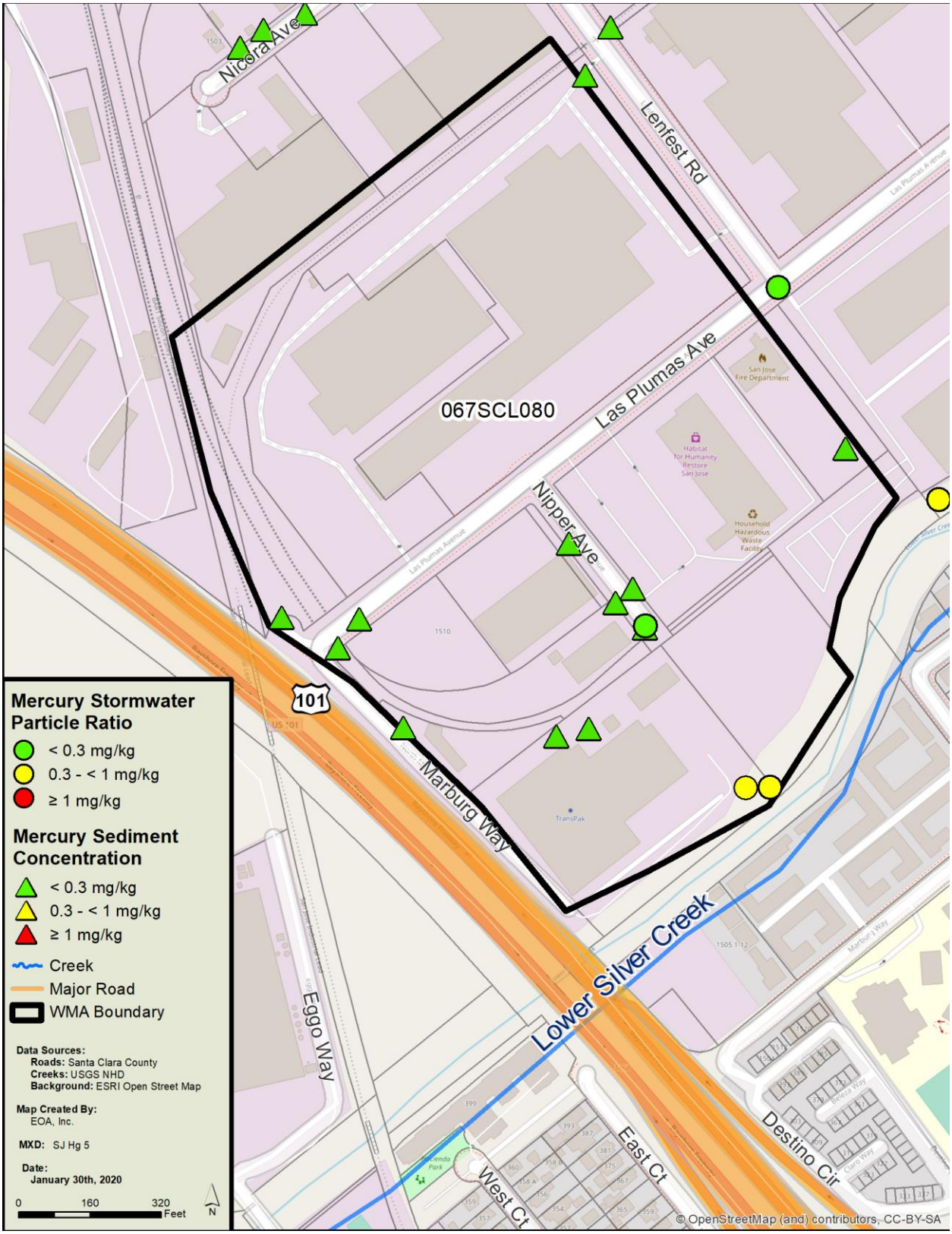


Figure 4.6. Mercury in street dirt and MS4 sediment concentrations and stormwater particle ratios measured in WMA 067SCL080 in WY 2015 through WY 2019.

4.1.4 WMA 067SCL120

067SCL120 is comprised of 40 acres that drain to Lower Silver Creek. In WY 2017, a storm water sample collected in the catchment as part of the Program's stormwater reconnaissance monitoring program found a slightly elevated PCBs particle ratio. Beginning in WY 2018, the Program initiated a targeted source property investigation in the WMA to identify the source(s) of elevated PCBs. Records review, public ROW surveys, site visits, and sediment and stormwater sampling were all conducted in the WMA as part of the investigation. The results of the investigation to date are summarized below. The locations and relative concentrations of all POC monitoring conducted in this WMA since WY 2015, both as part of the screening monitoring program and during the targeted source property investigation are shown on Figures 4.7 and 4.8.

Based on findings from the records review, the WMA was a mix of industrial and commercial land uses prior to 1980. Industrial activities included a railroad in the upper half of the catchment that served various food and beverage manufacturing facilities. The WMA borders a DTSC cleanup site at a plastics and caulk manufacturer. Currently, the WMA is comprised of primarily old urban land use, and includes some old urban and new urban land use areas. A waste transfer station is active in the WMA. The WMA also borders industrial activities including electrical repair businesses that may track soils into the WMA due to traffic patterns.

As part of the targeted source property investigation, the Program reviewed records for 17 old industrial parcels in the WMA, completed public ROW surveys of all 17 parcels of interest, and conducted business site visits at 10 businesses located on parcels identified as high priority. In WY 2019, the Program collected 2 stormwater samples in the MS4 simultaneously, one prior to crossing under private property and one directly after leaving the property at the outfall to Lower Silver Creek. Although the results indicated stormwater concentrations and particle ratios of PCBs were higher after passing through the property, neither the concentrations nor particle ratios were highly elevated. Three additional street dirt samples were collected in WY 2019 in public ROW areas adjacent to high-interest properties. None of these samples had elevated PCBs or mercury concentrations.

To date, the Program has not identified the source(s) of the elevated PCBs observed in stormwater from this WMA. The Program is currently reviewing all of the data gathered in this WMA to date in order to determine if any further source investigations are warranted in WY 2020.

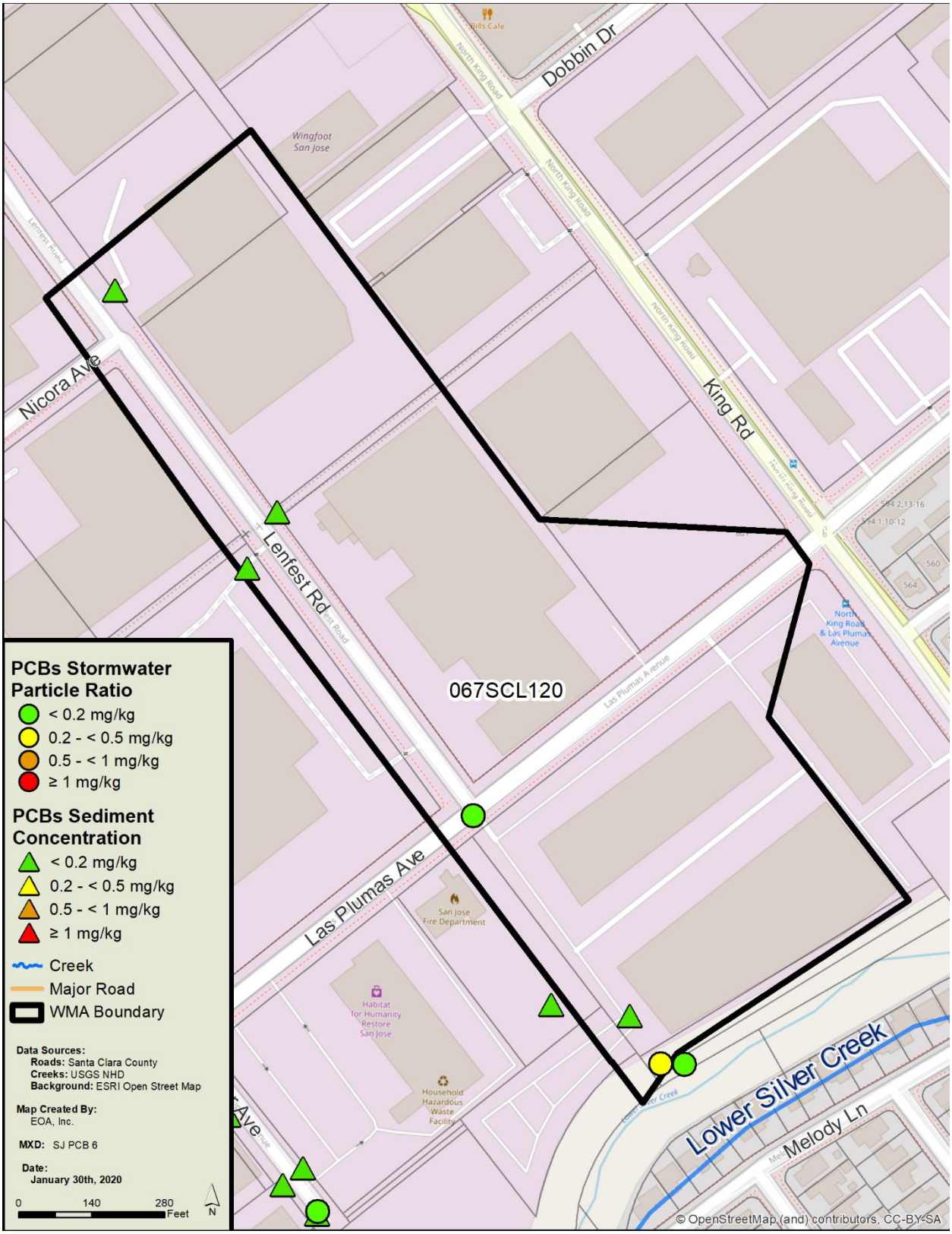


Figure 4.7. PCBs in street dirt and MS4 sediment concentrations and stormwater particle ratios measured in WMA 067SCL120 in WY 2015 through WY 2019.

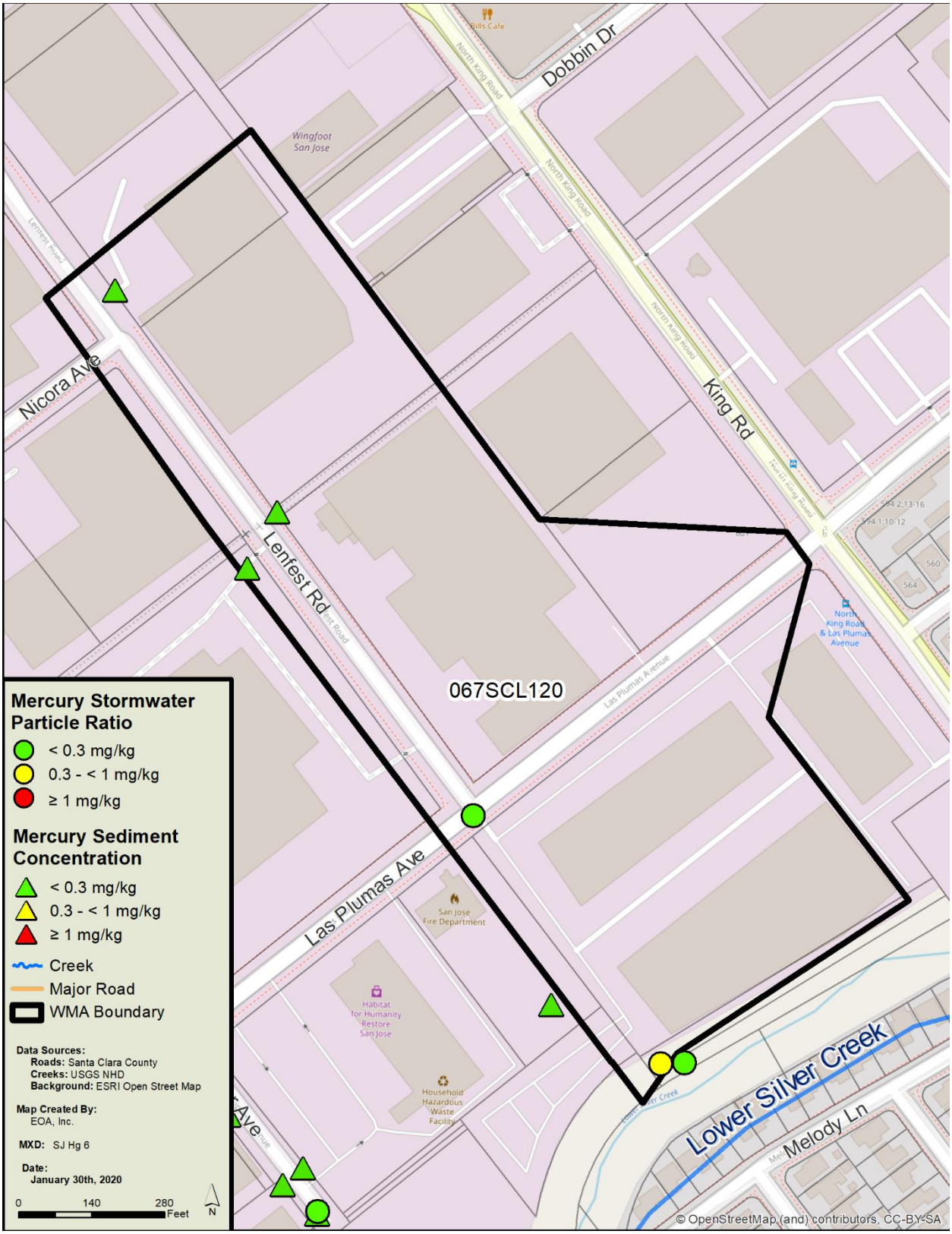


Figure 4.8. Mercury in street dirt and MS4 sediment concentrations and stormwater particle ratios measured in WMA 067SCL120 in WY 2015 through WY 2019.

4.1.5 WMA 051CTC275

051CTC275 is comprised of 443 acres that drain to Coyote Creek. In WY 2015, as part of the RMP's stormwater reconnaissance monitoring, a stormwater sample with slightly elevated PCBs was collected from the WMA. Street dirt and MS4 samples collected in the public ROW in WY 2015 as part of the Program's screening monitoring also found elevated PCBs concentrations in the WMA. Beginning in WY 2016, the Program initiated a targeted source property investigation in the WMA to identify the source(s) of elevated PCBs. Records review, public ROW surveys, site visits, and sediment sampling were all conducted in the WMA as part of the investigation. The results of the investigation to date are summarized below. The locations and relative concentrations of all POC monitoring conducted in this WMA since WY 2015, both as part of the screening monitoring program and during the targeted source property investigation are shown on Figures 4.9 and 4.10.

According to the records review, land use in the WMA prior to 1980 was primarily commercial and industrial. There were 130 industrial parcels during that time which comprised 56% of the total WMA area. Aerial photos from 1968 identified railroad spurs that have since been abandoned, as well as undeveloped areas with vehicle and equipment storage. Businesses in the WMA with the potential for PCBs or mercury use or release included metal recycling, metal manufacturing, cement manufacturing, a beverage plant, and vehicle repair facilities. Several properties that had businesses that closed in the late 1980's have been remediated for solvents.

Currently, the WMA is mostly comprised of commercial and industrial land uses. Many properties consist primarily of commercial businesses and impervious surfaces, with no activities conducted outside. There is also a relatively large vacant area in the WMA. Ongoing industrial activities in the WMA include metal manufacturing and recycling, cement manufacturing, meat packing, and vehicle repair. There is an active industrial railroad spur running down Rogers Avenue, a relatively busy street in the central part of the WMA.

Based on the combined results of records review, public ROW surveys and site visits, the Program identified a number of high-interest properties in the WMA for sampling. In WY2017, the Program collected 10 street dirt or MS4 sediment samples in the WMA. Five samples were elevated for PCBs and three were elevated for mercury. These samples confirmed the locations of two PCBs source properties, both of which actively handle recycling/demolition materials that may contain PCBs as part of their current business practices. Both properties were also confirmed as mercury sources to the MS4. Two public ROW samples in the WMA adjacent to another high-interest property were slightly elevated, and additional investigation was needed to confirm the source. In WY 2019, two sediment samples were collected on the suspect property. Both samples were elevated, but neither was above the 1 mg/kg threshold the Program uses to confirm a source property.

The City of San Jose is currently evaluating next steps for the two confirmed source properties. The Program will continue to review all the data gathered to date on sources in this WMA and evaluate options to address elevated POCs in public ROW areas. Options may include further investigation during WY 2020, and/or working with the City to implement other control measures in the WMA.

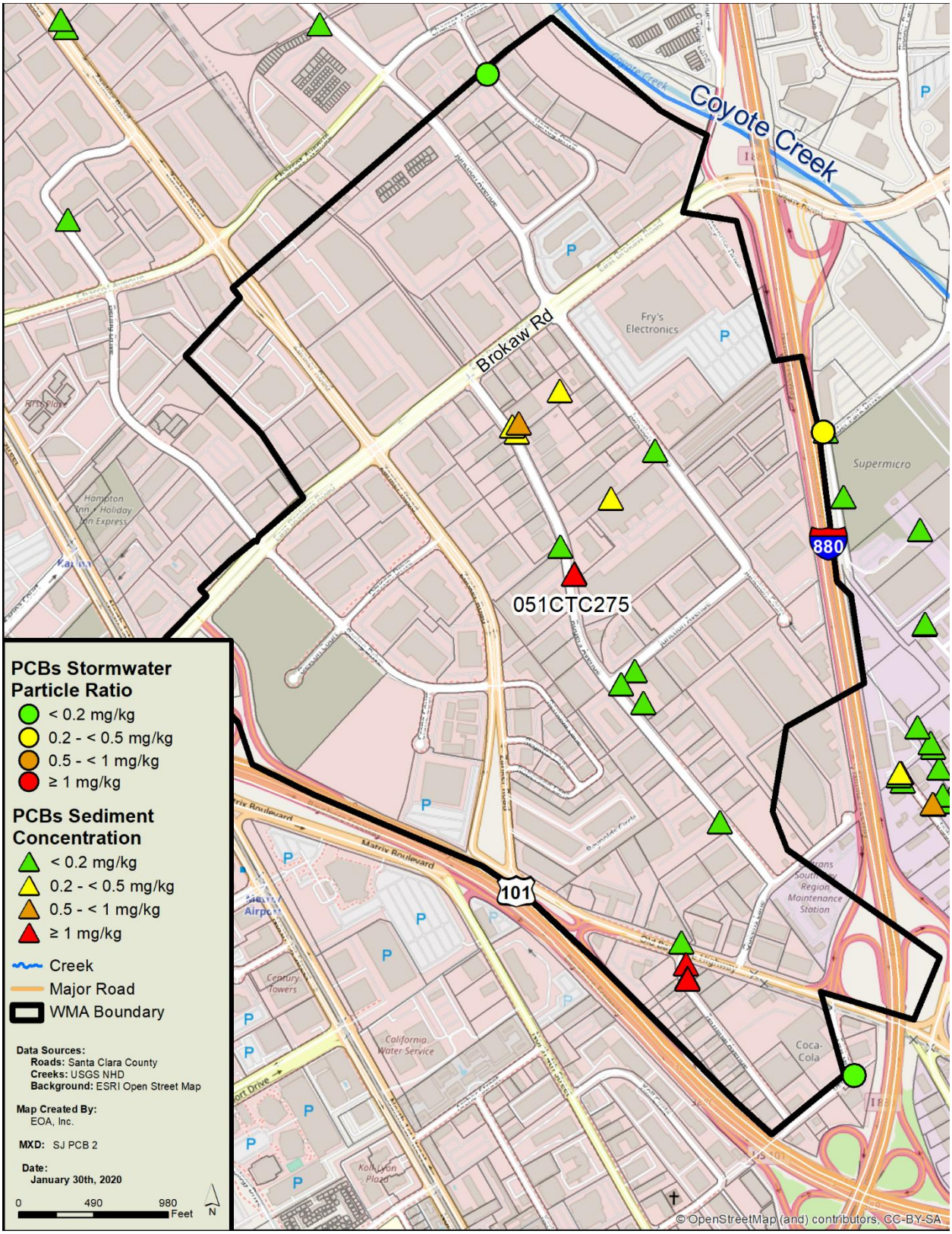


Figure 4.9. PCBs in street dirt and MS4 sediment concentrations and stormwater particle ratios measured in WMA 051CTC275 in WY 2015 through WY 2019.

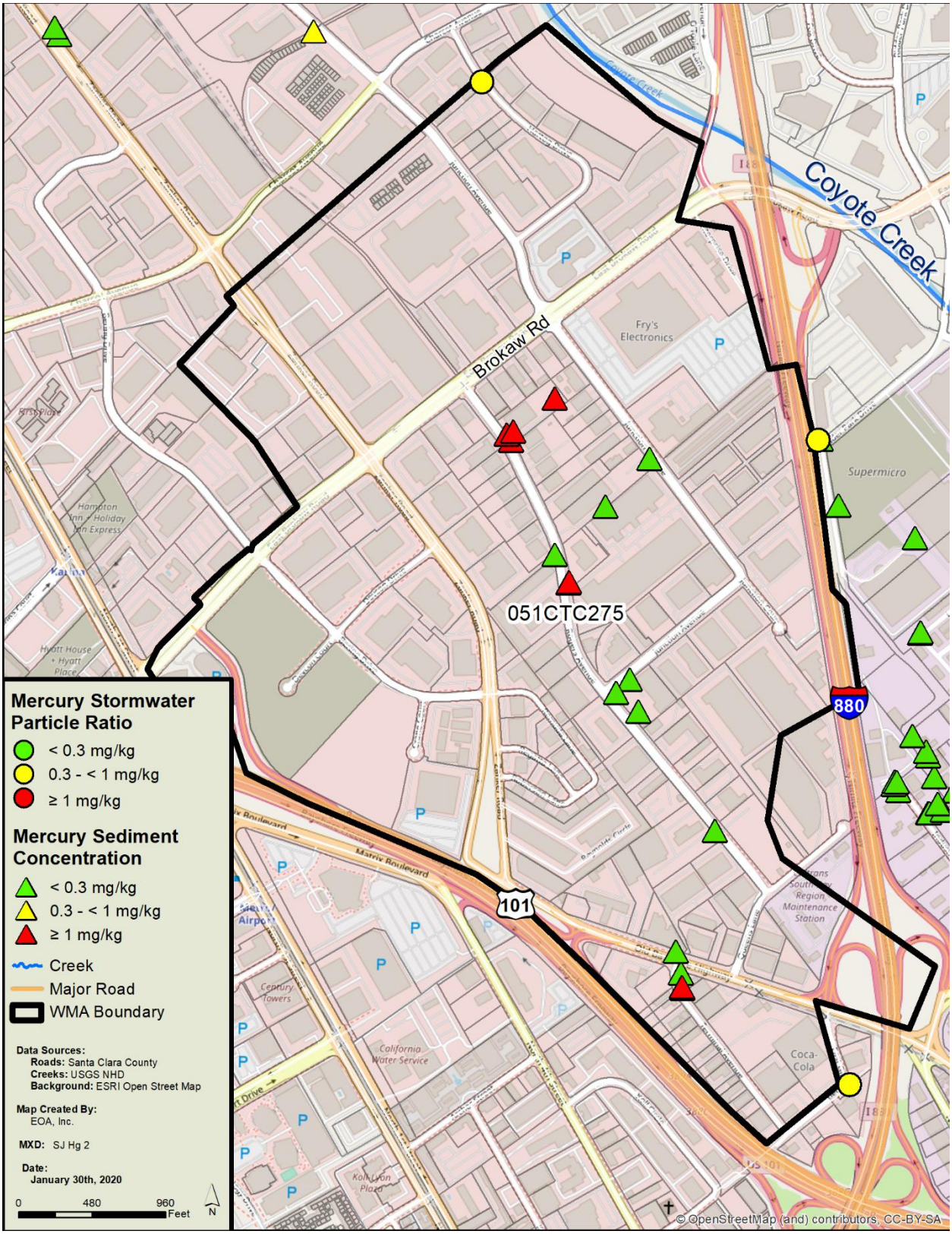


Figure 4.10. Mercury in street dirt and MS4 sediment concentrations and stormwater particle ratios measured in WMA 051CTC275 in WY 2015 through WY 2019.

4.1.6 WMA 051CTC400

WMA 051CTC400 is comprised of 130 acres that drain to Coyote Creek. In WY 2015, a stormwater sample with one of the highest PCBs concentrations measured to date in the Bay Area was collected near the WMA's outlet to Coyote Creek as part of the RMP stormwater reconnaissance monitoring. Screening monitoring conducted by the Program in WY 2015 also found elevated PCBs and mercury in MS4 sediment in both the northern and the southern portions of the WMA. Beginning in WY 2016, the Program initiated a targeted source property investigation in the WMA to identify the source(s) of elevated PCBs. Records review, public ROW surveys, site visits, and sediment sampling were all conducted in the WMA as part of the investigation. The results of the investigation to date are summarized below. The locations and relative concentrations of all POC monitoring conducted in this WMA since WY 2015, both as part of the screening monitoring program and during the targeted source property investigation are shown on Figures 4.11 and 4.12.

Based on information gained during records review, the WMA was a mix of industrial, commercial and agricultural land uses prior to 1980. There were 33 industrial parcels during that time, comprising 69% of the total WMA area. The northern portion of the WMA was mostly agricultural until the 36-acre San Jose Mercury News publishing plant was built in 1967 on Ridder Park Drive. From the 1960's onward, the railroad running along the eastern border of the WMA was used to transport scrap metal to and from Markovitz and Fox Metals, a scrap metal recycling facility located just outside the WMA to the northwest. That facility was identified as a DTSC contaminated cleanup site with PCBs contamination and the property was remediated with a cap and deed restrictions imposed. Redevelopment of the site was completed in 2016.

Currently, the WMA is a mix of commercial and industrial land uses. The southern half of the WMA has various service-oriented industrial and commercial facilities, including vehicle and equipment repair facilities, vehicle parts suppliers and salvage operations, a towing company, a waste hauler, well drilling equipment, and a gravel and rock supplier. There are more than 200 different businesses associated with two parcels in the southern half of the WMA, and many of these businesses are partially or wholly unpaved. The northern half of the WMA has mostly commercial retail and business parks that occupy larger parcels.

Based on the combined results of records review, public ROW surveys and site visits, the Program identified a number of high-interest properties in the WMA for sampling. In WY 2017, the Program collected 16 street dirt and MS4 sediment samples on or adjacent to high-interest properties in the WMA. One sample collected in the public ROW from soils that were migrating off a railroad ROW in the northern portion of the WMA had highly elevated PCBs, confirming the railroad property as a source of PCBs to the MS4. Two public ROW samples collected in the southern portion of the WMA had slightly elevated PCBs, suggesting proximity to additional source(s). Investigation continued in the WMA in WY 2018 to identify sources in the southern portion of the WMA. The Program collected 6 street dirt and MS4 samples on and around a suspect property in WY 2019. Highly elevated PCBs were found in a culvert draining the property, confirming a second PCBs source property in the WMA. The Program also attempted unsuccessfully to obtain permission to collect a sample on-site at another suspect property in the southern portion of the WMA. However, because the property is actively undergoing redevelopment, the Program is not planning to continue to investigate the property.

The City of San Jose is currently evaluating next steps for the two confirmed source properties in this WMA. In WY 2020, the Program will review all of the data collected to date in this WMA to determine if additional investigation into other potential source areas in this WMA is warranted.

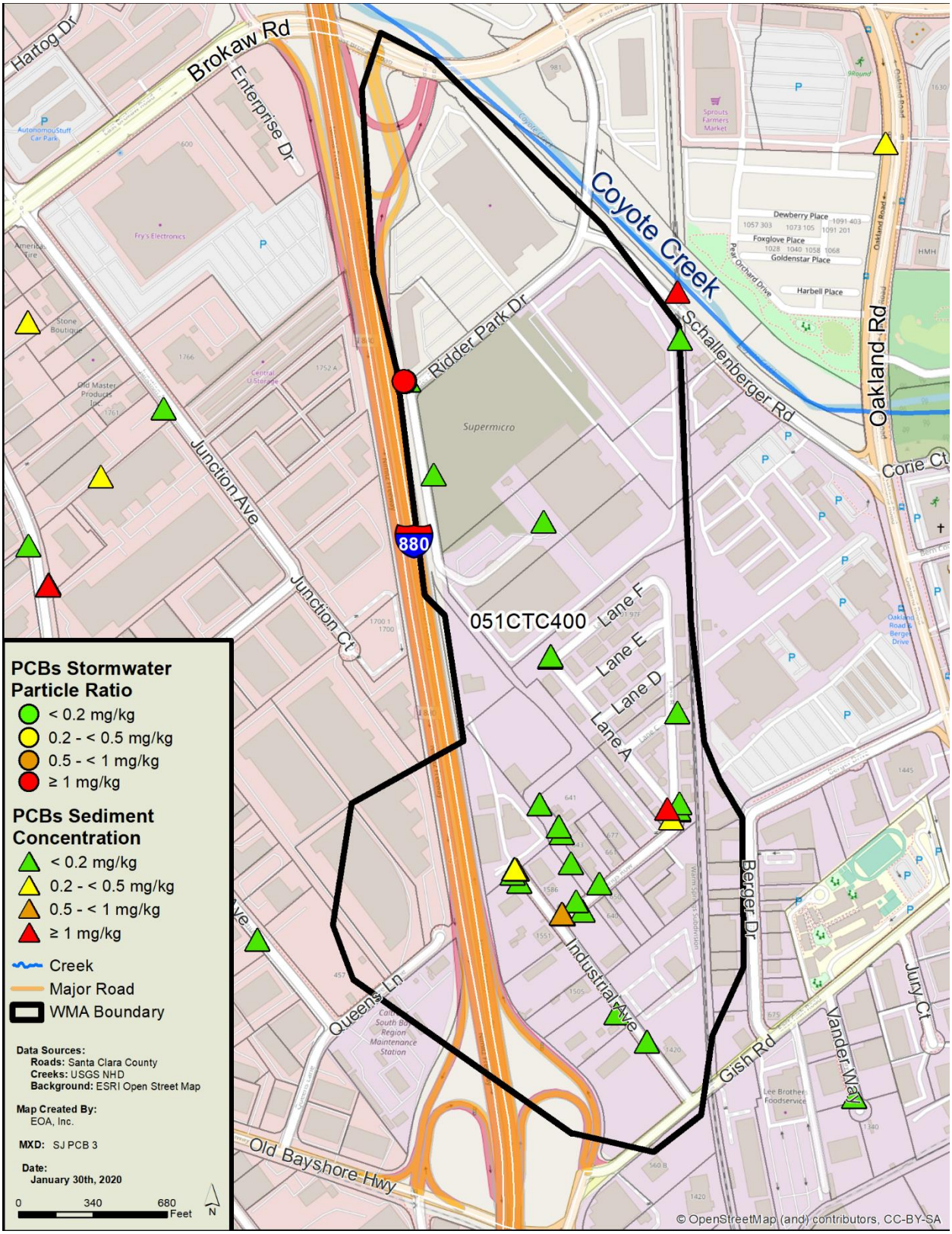


Figure 4.11. PCBs in street dirt and MS4 sediment concentrations and stormwater particle ratios measured in WMA 051CTC400 in WY 2015 through WY 2019.

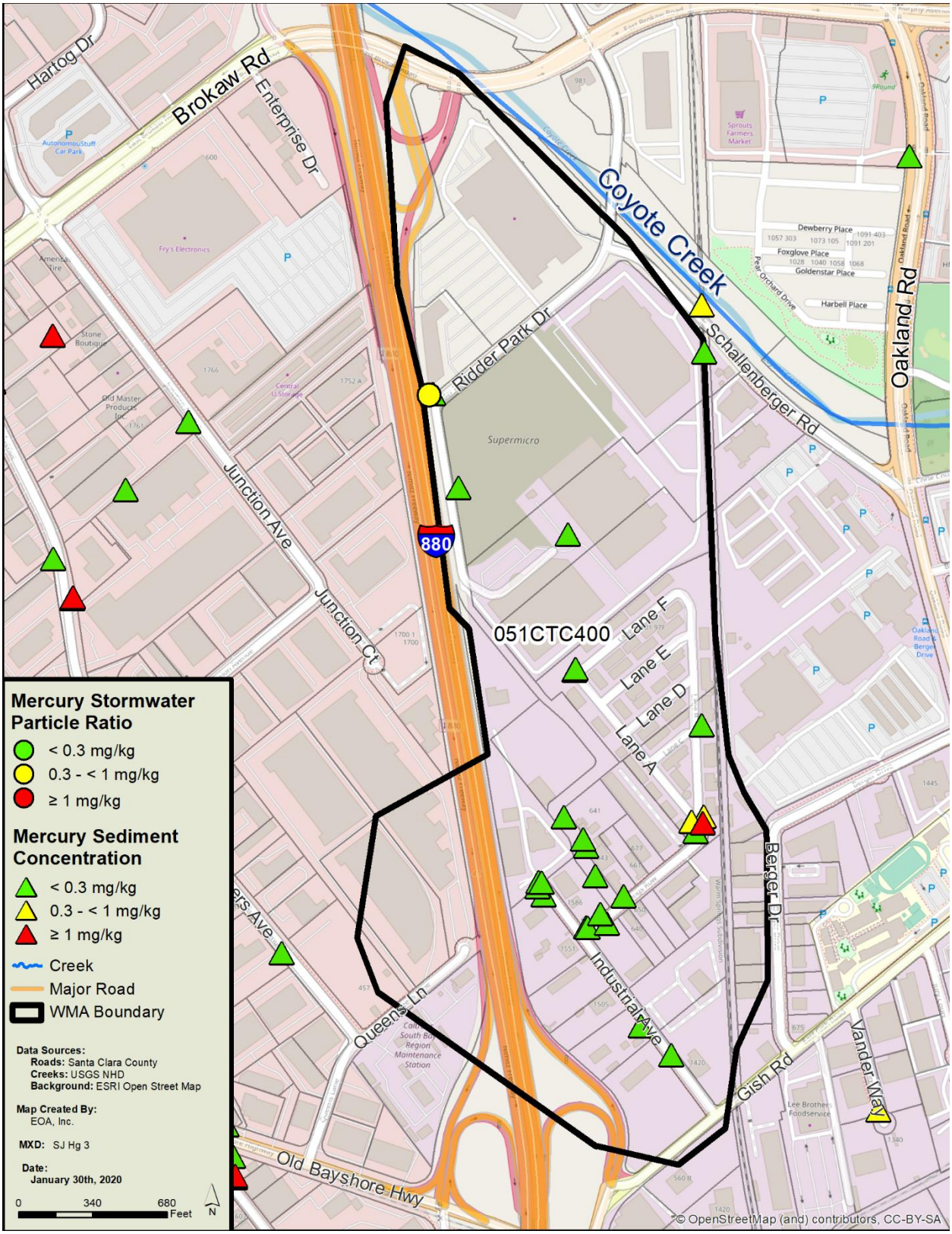


Figure 4.12. Mercury in street dirt and MS4 sediment concentrations and stormwater particle ratios measured in WMA 051CTC400 in WY 2015 through WY 2019.

4.1.7 WMA 067CTC250

WMA 067CTC250 is comprised of 41 acres that drain to Coyote Creek. In WY 2015, an MS4 sample collected in the public ROW as part of the Program's screening monitoring had slightly elevated PCBs concentrations. In WY 2017, a storm water sample collected in the catchment as part of the Program's stormwater reconnaissance monitoring program had a high PCBs concentration, although the PCBs particle ratio was not elevated. Beginning in WY 2018, the Program initiated a targeted source property investigation in the WMA to identify the source(s) of elevated PCBs. Records review, public ROW surveys, site visits, and sediment and stormwater sampling were all conducted in the WMA as part of the investigation. The results of the investigation to date are summarized below. The locations and relative concentrations of all POC monitoring conducted in this WMA since WY 2015, both as part of the screening monitoring program and during the targeted source property investigation are shown on Figures 4.13 and 4.14.

Based on the results of the records review, the WMA was a mix of industrial and commercial land uses prior to 1980. Industrial parcels comprised 61% of the WMA at that time. The industrial activities included a large waste and recycling facility, auto repair, and an electrical utility equipment manufacturer. Currently, the catchment remains primarily old industrial land use.

As part of the targeted source property investigation, the Program reviewed records for 27 old industrial parcels in the WMA, completed public ROW surveys of all 27 parcels of interest, and conducted business site visits at 16 businesses located on parcels identified as high priority. In WY 2019, the Program collected 14 street dirt or MS4 sediment samples from public ROW areas near high-interest properties. Three of these samples were collected in an adjacent catchment in an area that received sediment tracking from a property of interest. One of the samples collected in the WMA had slightly elevated PCBs concentrations and another sample had slightly elevated mercury concentrations. All of the other samples had low PCBs and mercury concentrations.

To date, the Program has not identified the source(s) of the slightly elevated PCBs observed in MS4 sediment or stormwater from in this WMA. The Program is currently reviewing all of the data gathered in this WMA to date in order to determine if any further investigation of this WMA is warranted in WY 2020.

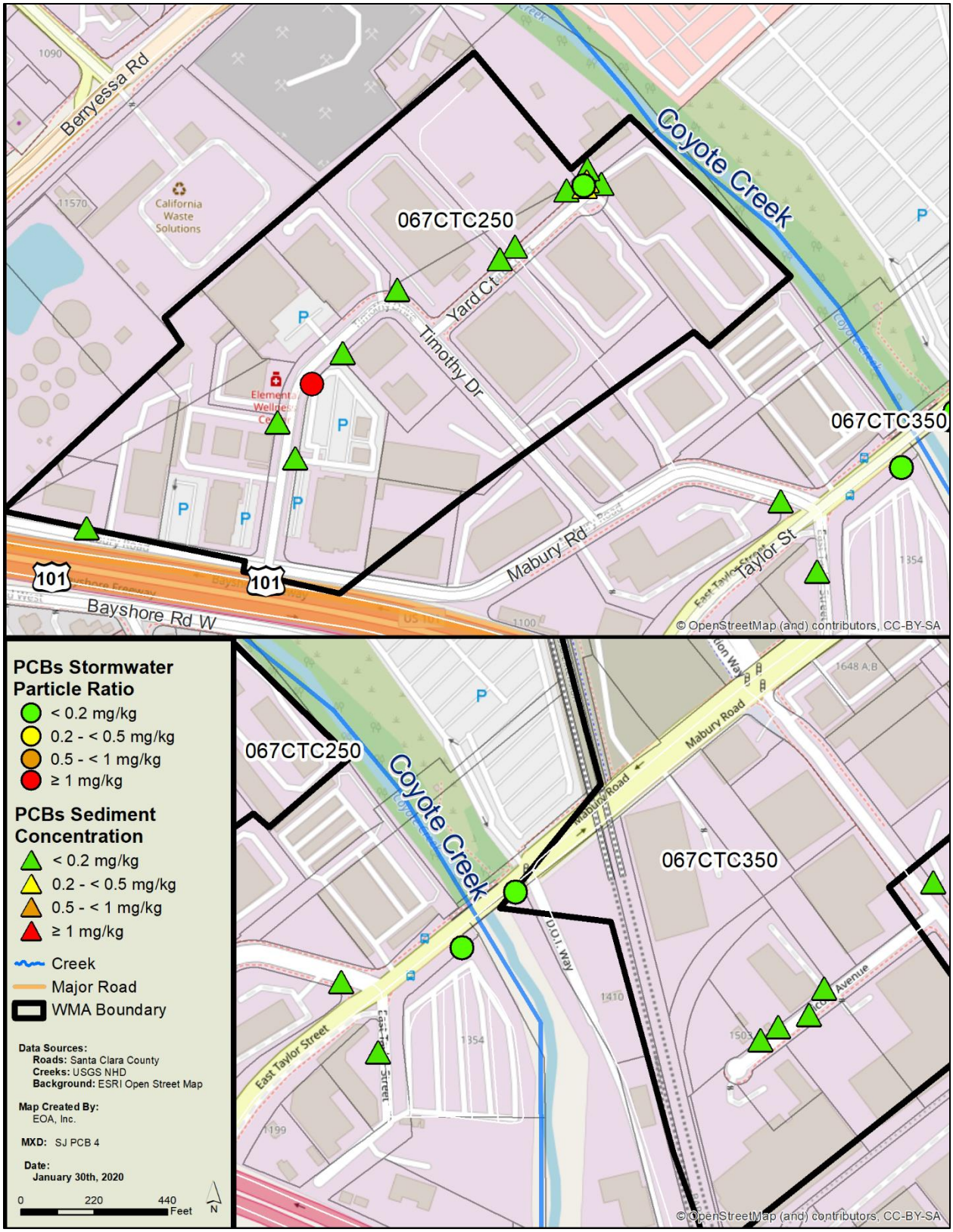


Figure 4.13. PCBs in street dirt and MS4 sediment concentrations and stormwater particle ratios measured in WMA 067CTC250 in WY 2015 through WY 2019.

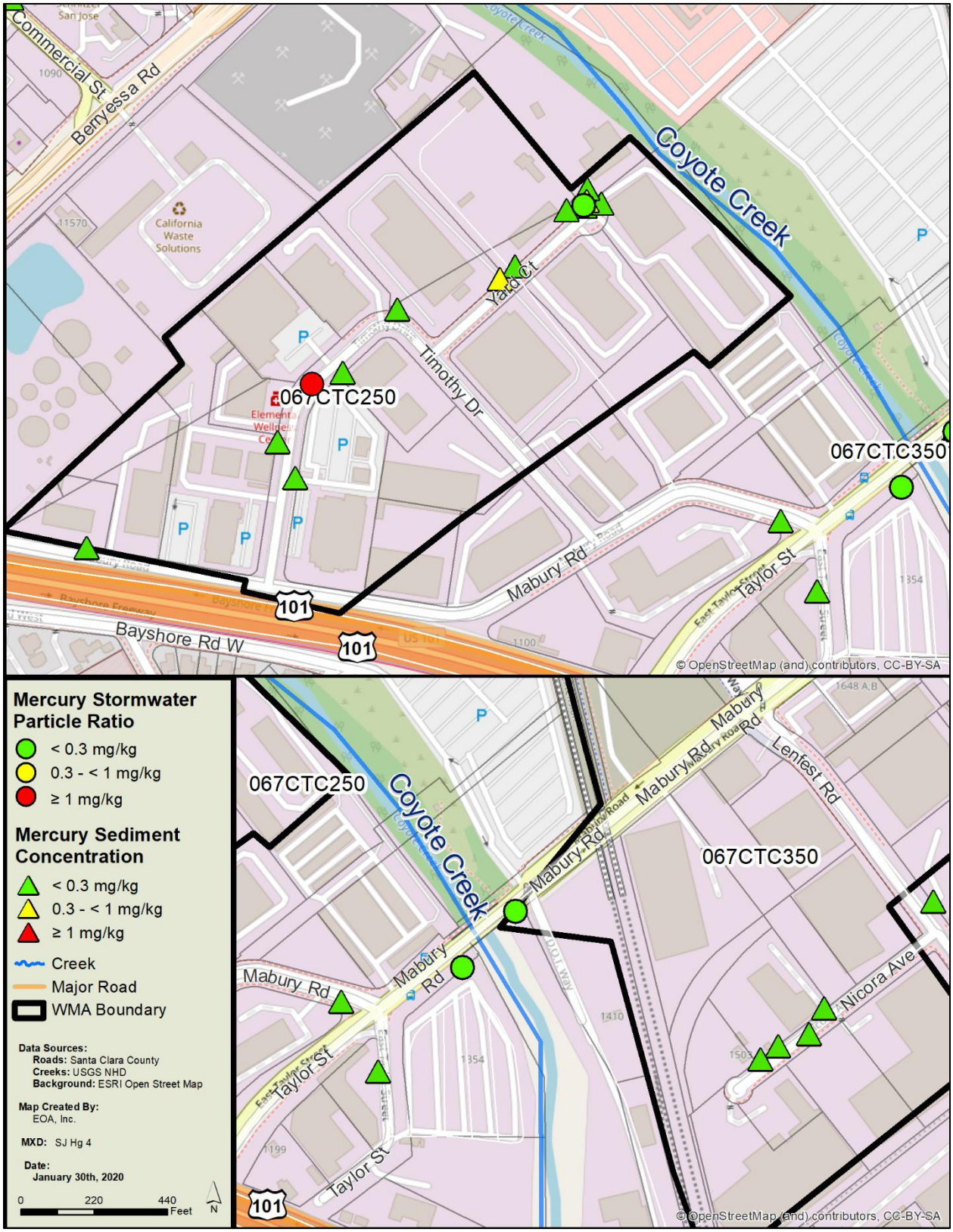


Figure 4.14. Mercury in street dirt and MS4 sediment concentrations and stormwater particle ratios measured in WMA 067CTC250 in WY 2015 through WY 2019.

4.2 City of Santa Clara

In the City of Santa Clara, the Program has initiated source property investigations in two WMAs. These investigations are summarized below, including a description of each WMA, the POC monitoring data collected to support the investigation, and the current status and outcomes of each investigation.

4.2.1 WMA 050GAC400

WMA 050GAC400 is comprised of 778 acres that drain to the Guadalupe River. A street dirt sample collected in the public ROW in WY 2015 as part of the Program's screening monitoring found moderately elevated PCBs concentrations in the WMA. Beginning in WY 2016, the Program initiated a targeted source property investigation in the WMA to identify the source(s) of elevated PCBs. Records review, public ROW surveys, site visits, and sediment and stormwater sampling were all conducted in the WMA as part of the investigation. The results of the investigation to date are summarized below. The locations and relative concentrations of all POC monitoring conducted in this WMA since WY 2015, both as part of the screening monitoring program and during the targeted source property investigation are shown on Figures 4.15 and 4.16.

This WMA is split between the City of Santa Clara and the City of San Jose. The 754 acres in the City of Santa Clara were the primary focus of the targeted source investigation. According to the records review, the WMA was a mix of agricultural, industrial and commercial land uses prior to 1980. There were 197 industrial parcels in the WMA at that time, comprising 41% of the total WMA area. The northern quarter of the WMA was mostly agricultural. Only auto truck repair establishments and an electrical utility substation existed in that portion of the WMA in 1968. Much as they are today, the southern and central sections of the WMA were residential and industrial/commercial land uses, respectively. There were also three active railroad tracks that ran east-west across the WMA that have since been abandoned. Industrial activities in the WMA included a fiberglass manufacturing plant (Owens Corning) that was established in 1949 on the largest industrial property in the WMA (42 acres), asbestos-cement pipe manufacturing (CertainTeed), and plastics and resin manufacturing (Monsanto). Geotracker identified the CertainTeed and Monsanto properties as DTSC cleanup sites with known PCBs contamination. Aerial photos from both 1968 and 1980 show the asbestos slurry waste pond on the CertainTeed property, and waste piles behind the buildings where Monsanto manufactured plastics and resins. During its operations from 1962 to 1983, CertainTeed stored transformers and conduits with PCBs from other companies on site. This equipment was removed as part of the cleanup, and DTSC considered the site remediated and required no further action. The former Monsanto site was also remediated, and currently has deed restrictions and a remedy approved by the Regional Water Board to pump and treat contaminated groundwater.

Currently, the land uses within the WMA are sharply divided by the Caltrain ROW, with the southern half mostly comprised of residential land uses and the northern half primarily industrial and commercial land uses. Owens Corning continues to manufacture fiberglass on the same property that they have occupied since 1949. Both the CertainTeed and Monsanto properties have been redeveloped into office buildings and parking lots. The two electrical utility substations that were present in the WMA prior to 1980 are both still active. These include the substation on the Owens Corning property, and the substation in the northern part of the WMA that is adjacent to the more recently constructed natural gas power plant owned by the City of

Santa Clara. Other current activities in the WMA include construction and demolition operations, equipment rental, and vehicle repair facilities.

Based on the combined results of records review, public ROW surveys and site visits, the Program identified a number of high-interest properties in the WMA for sampling. In WY 2017, the Program collected 14 street dirt and MS4 sediment samples in public ROW areas adjacent to high-interest properties. Two samples had slightly elevated PCBs and 2 samples had elevated mercury concentrations. However, specific sources of the elevated POC concentrations in the MS4 remained unidentified. The investigation in the WMA continued in WY 2018 with additional records review and public ROW surveys to better understand potential source areas. In WY 2019, the Program collected 4 street dirt and MS4 samples from on-site at 3 suspect properties. However, none of the samples had elevated PCBs. One of the samples had elevated mercury, confirming the property as a source of mercury to the MS4.

To date, the Program has not identified the source(s) of the elevated PCBs observed in public ROW areas in this WMA. The Program is currently reviewing all of the data gathered in this WMA in order to determine if further source investigations will be conducted in WY 2020. The Program is also working with the City of Santa Clara to evaluate options for other control measures to address elevated PCBs in public ROW areas.

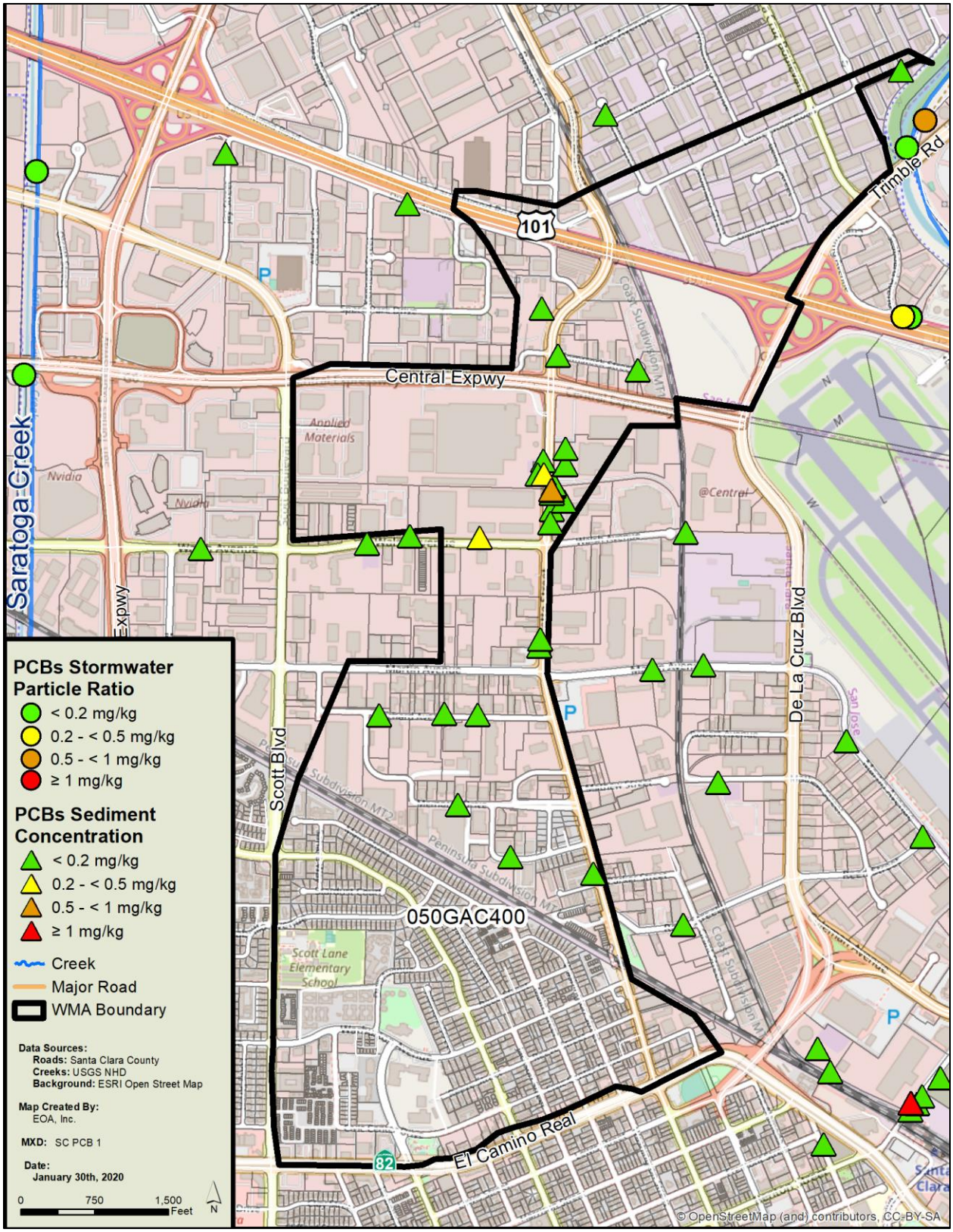


Figure 4.15. PCBs in street dirt and MS4 sediment concentrations and stormwater particle ratios measured in WMA 050GAC400 in WY 2015 through WY 2019.

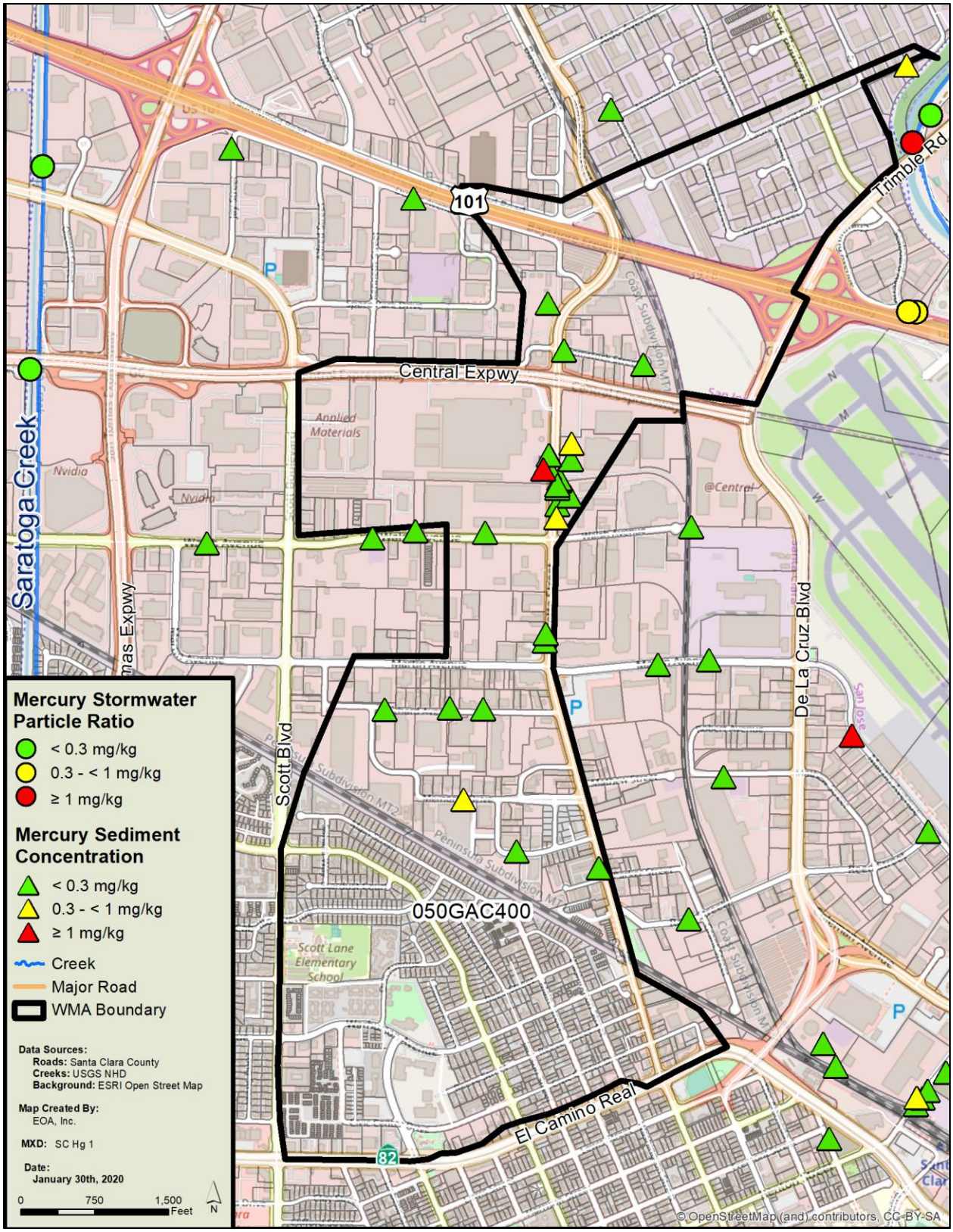


Figure 4.16. Mercury in street dirt and MS4 sediment concentrations and stormwater particle ratios measured in WMA 050GAC400 in WY 2015 through WY 2019.

4.2.2 WMA 066GAC150

WMA 066GAC150 is comprised of 504 acres near the San Jose Airport that drain to the Guadalupe River. In WY 2015 an elevated PCBs sediment samples was collected in the WMA as part of the Program's screening monitoring. Beginning in WY 2016, the Program initiated a targeted source property investigation in the WMA to identify the source(s) of elevated PCBs. Records review, public ROW surveys, site visits, and sediment sampling were all conducted in the WMA as part of the investigation. The results of the investigation to date are summarized below. The locations and relative concentrations of all POC monitoring conducted in this WMA since WY 2015, both as part of the screening monitoring program and during targeted source property investigation are shown on Figures 4.17 and 4.18.

This WMA is split between the City of Santa Clara and the City of San Jose. The 380 acres in the City of Santa Clara were the primary focus of the targeted source investigation. Findings from the records review show that prior to 1980, the western portion of the WMA was residential with some commercial facilities along the arterial street routes. The eastern portion of the WMA was mostly industrial with some commercial and agriculture activities. There were 39 industrial parcels in the WMA at that time, comprising 28% of the total area within the WMA. Past industries in the WMA associated with the use, storage, or disposal of PCBs included Federal Pacific Electric (FPE), which manufactured circuit breakers, transformers and other electrical equipment containing PCBs until about 1968. The FMC Corporation purchased the FPE property and other adjacent parcels in 1968 to form a larger property that spanned 100 acres. Geotracker identifies the former FMC property as a known PCBs cleanup site, with subsurface PCBs concentrations in the area originally occupied by FPE as high as 15,000 mg/kg. After FMC sold the property, it was sub-divided into multiple parcels that were redeveloped during the 1990's. Geotracker also identified a land disposal site east of the former FMC property as a cleanup site with unknown contaminants. Parcels adjacent to the land disposal site may have been affected over the years by migrating soils.

Currently, much of the WMA has been redeveloped and ongoing redevelopment continues throughout the WMA. Based on the combined results of records review, public ROW surveys and site visits, the Program identified a number of high-interest properties in the WMA for sampling. In WY 2017, 11 street dirt and MS4 sediment samples were collected in public ROW areas adjacent to or downstream of these high-interest properties. One sample collected in the public storm drain line adjacent to a high-interest property was highly elevated for PCBs. The sample was collected from sediment coming out of the private lateral from the property at the connection point with the public storm drain system, confirming the property as a PCBs source to the MS4. A second sample collected from street dirt at the border of a suspect property had moderately elevated PCBs. All other samples had low PCBs. Additional investigation continued in WY 2019, including both stormwater and additional sediment sampling. The stormwater sample had low concentrations of POCs. However, one of the sediment samples that was collected on a suspect property was highly elevated for PCBs, confirming a second PCBs source property in the WMA.

The City of Santa Clara referred the first PCBs source property to the Regional Water Board in WY 2019. The City is currently evaluating next steps for the second confirmed source property. The Program is also continuing to review all of the data gathered in this WMA to date in order to determine if any further source investigations are warranted in WY 2020.

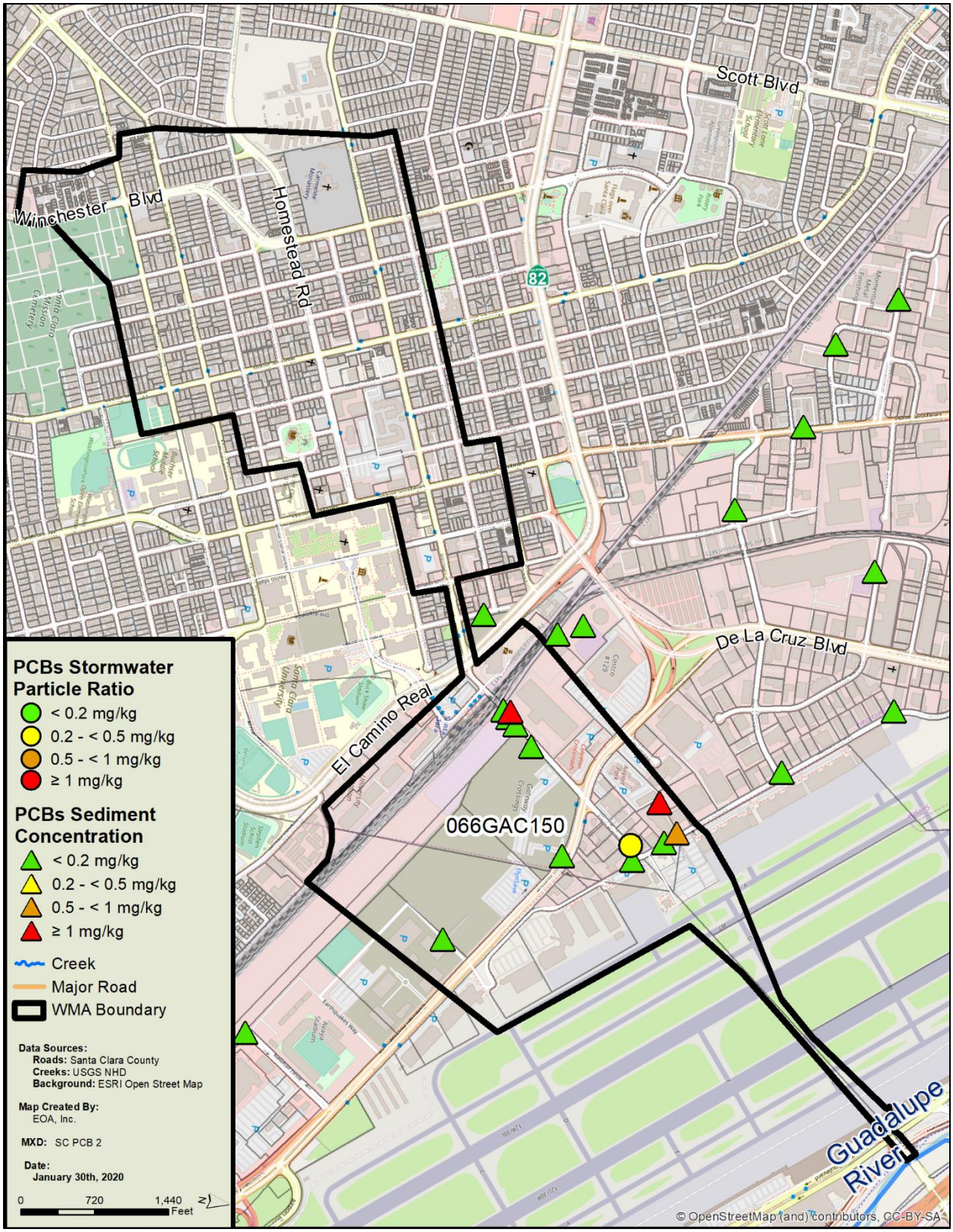


Figure 4.17. PCBs in street dirt and MS4 sediment concentrations and stormwater particle ratios measured in WMA 066GAC150 in WY 2015 through WY 2019.

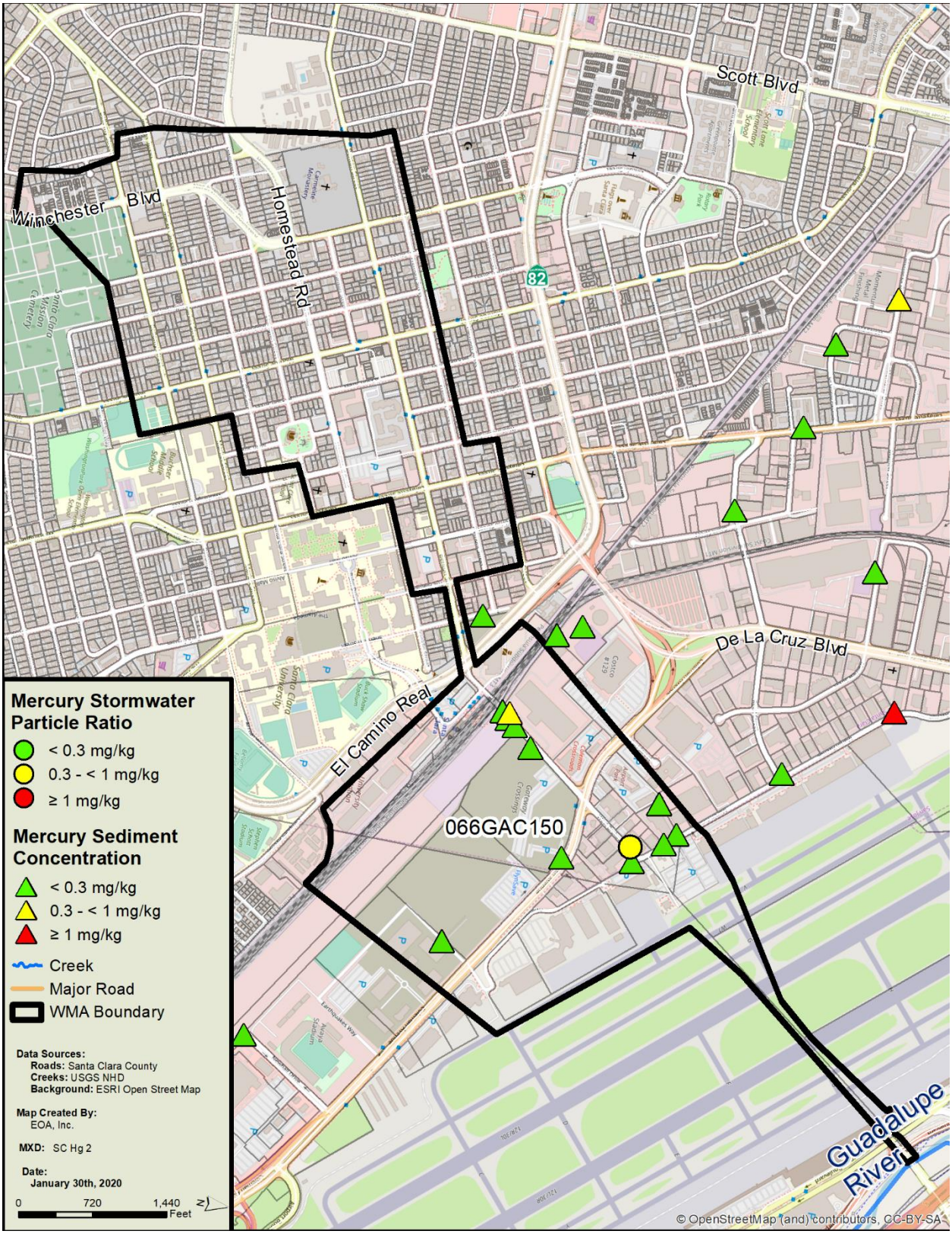


Figure 4.18. Mercury in street dirt and MS4 sediment concentrations and stormwater particle ratios measured in WMA 066GAC150 in WY 2015 through WY 2019.

4.3 City of Sunnyvale

In the City of Sunnyvale, the Program has completed a source property investigation in one WMA. The investigation is summarized below, including a description of the WMA, the POC monitoring data collected to support the investigation, and the outcomes of the investigation.

4.3.1 WMA 049SVE900

WMA 049SVE900 is a 480-acre catchment in the City of Sunnyvale that drains to the Sunnyvale East Channel. Elevated concentrations of PCBs in sediments and stormwater collected in WMA 049SVE900 have been observed during sampling conducted since the early 2000's. All of these samples have been collected either adjacent to or downstream of a known PCBs contaminated site, the former Westinghouse Superfund site located at 401 East Hendy Avenue. Between 2011 and 2014, the RMP collected 45 stormwater samples in the Sunnyvale East Channel located downstream of the property (Figure 4.19). The PCBs in these samples were highly elevated, averaging 97 ng/L, with the highest concentration at 980 ng/L (Gilbreath et al., 2016). Based on a preliminary analysis conducted by the Program, the PCBs in these samples appear to have originated from the 74-acre former Westinghouse property. This property has a history of PCBs related contamination in soils and groundwater, and is currently a Superfund site overseen by USEPA. In WY 2015, the Program measured multiple surface soil and MS4 sediment concentrations in the public ROW adjacent to the property that were all above 1 mg/kg (Figure 4.20).

Based on these results, the City and Program engaged in discussions with USEPA in WY 2016 during the issuance of the Fourth Five-Year Review Report associated with the Consent Order between USEPA and the site owner (CAD001864081). The communications with USEPA were an attempt to incorporate follow up actions associated with stormwater monitoring and management into the permit. In response, USEPA requested that the property owner develop a SAP to characterize PCBs in stormwater being discharged from the site. Five stormwater sampling events were conducted by the property owner at multiple locations on and adjacent to the property, including two events during WY 2017, and three events during WY 2018. The PCBs concentrations of the stormwater samples ranged from 13 ng/L to 2,330 ng/L. Seven of these samples had some of the highest PCBs concentrations observed in stormwater in the Bay Area to-date. These data provided confirmation that the former Westinghouse property is a source of PCBs to the MS4.

In WY 2018, the City of Sunnyvale, in collaboration with the Program, submitted a referral of this property to both the Regional Water Board and USEPA for follow-up investigation and abatement. The property is currently owned by Northrop Grumman Systems Corporation (Northrop Grumman). Under the oversight of USEPA, Northrop Grumman has implemented or plans to implement a number of actions to reduce PCBs in stormwater from the property, and reduce PCB-bound sediment in the adjacent public ROWs, including the following:

- Fitted storm drain inlets with gravel bags, filtrexx-type socks with gravel bag anchors, or geotech filter fabric; these are inspected prior to the rainy season to remove accumulated sediments;
- Installed fiber rolls near the facility boundary along Fair Oaks Avenue and California Avenue to slow the flow of stormwater off-site;

- Covered unpaved areas around the property with gravel to reduce erosion;
- Cleared sediment from the Basin gutter next to building 41;
- Inspect areas around drains before forecasted rain events to verify BMPs are in place and functioning. BMPs will be repaired or replaced if not functioning.
- Weekly sweeping of all accessible areas of the property;
- Twice annual intensive area sweeping with a HEPA filter vacuum throughout the property;
- Biweekly street sweeping in the public streets on the property's perimeter to supplement the current biweekly sweeping conducted by the City of Sunnyvale; the property owner will conduct sweeping during the weeks the City does not sweep.

In addition, Northrop Grumman is currently conducting a survey of buried storm drain pipelines to confirm locations and connections, evaluate the integrity of the storm drain pipe, and identify accumulated sediment. Pipe locations and facility drawings will be updated. Pipelines requiring maintenance will be addressed by jetting out accumulated sediment and replacing selected storm drain piping. Completion of this work will support the overall evaluation of PCBs sources on the property that have a potential to impact stormwater.

The City and Program will continue to coordinate with USEPA throughout the property abatement process and identify additional next steps. Based on a review of all the data collected in this WMA to date, the Program has determined the Northrup Grumman property is the primary source of PCBs that have been measured in stormwater from this catchment. The Program is not currently planning any additional source investigation in this WMA at this time.

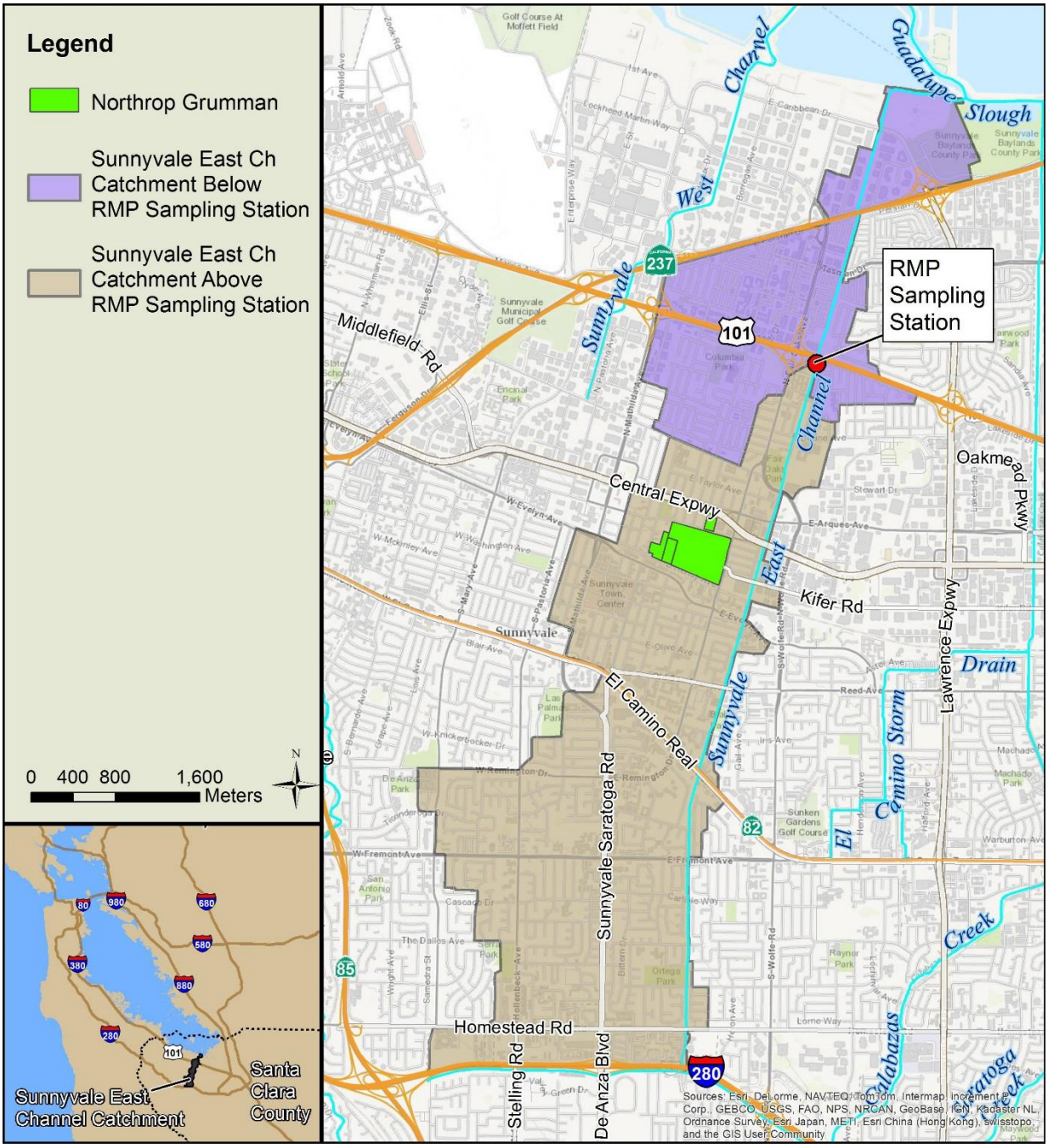


Figure 4.19. Location of RMP POC Sampling station and associated stormwater catchment (WMA 049SVE900), where highly elevated PCBs were measured in stormwater in WY 2012-2014. The Northrop Grumman PCBs source property is located upstream of the RMP sampling station.

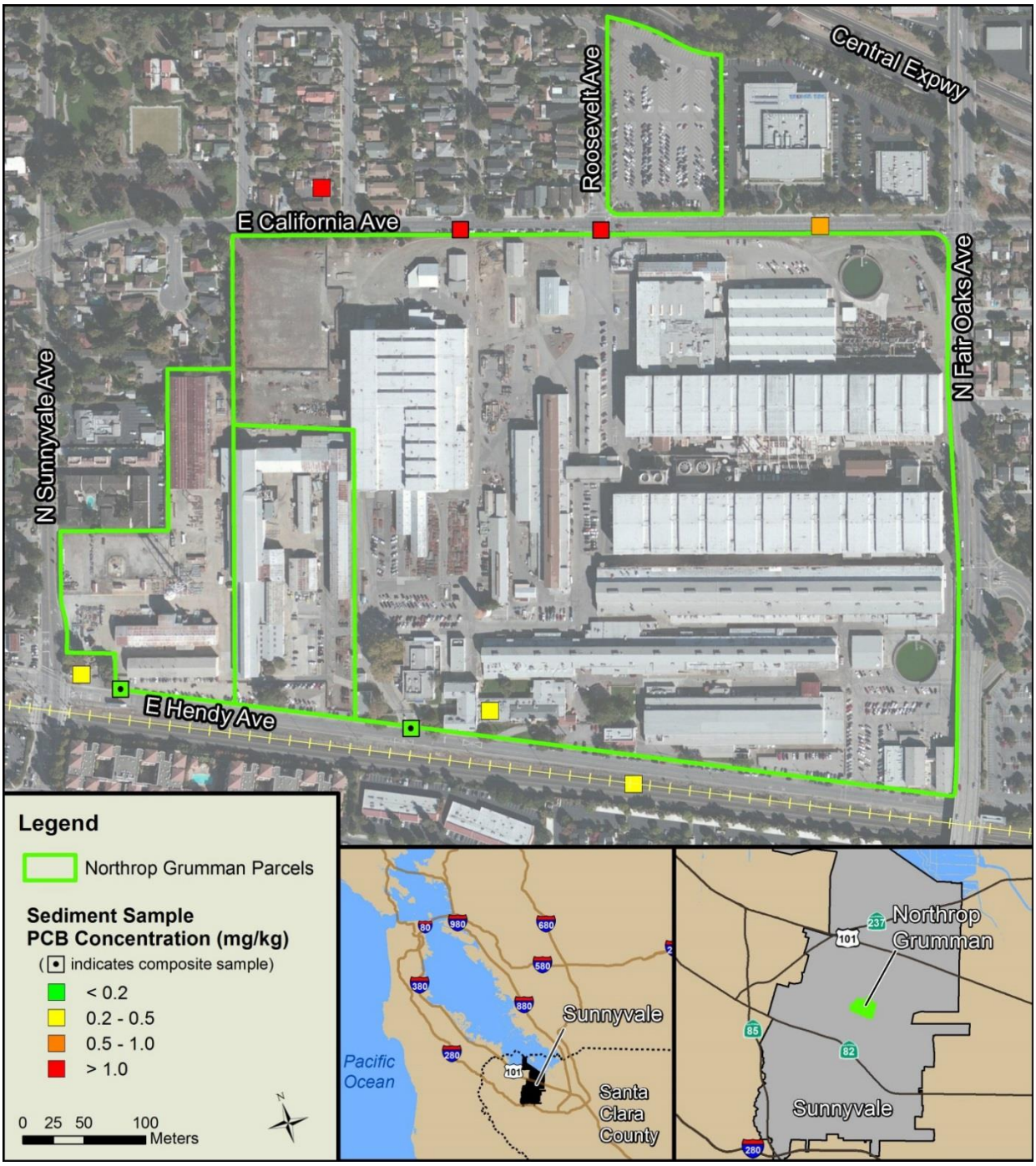


Figure 4.20. PCBs in street dirt and MS4 sediment concentrations measured adjacent to the Northrop Grumman property in WMA 049SVE900. SCVURPPP measured 2 samples > 1 mg/kg at the northern border of the property on E. California Avenue in WY 2015. Other samples shown on this Figure were measured in earlier investigations (KLI and EOA 2002, Yee and McKee 2010).

4.4 City of Palo Alto

In the City of Palo Alto, the Program has completed a source property investigation in one WMA and is currently conducting another source property investigation in a second WMA. These investigations are summarized below, including a description of each WMA, the POC monitoring data collected to support the investigation, and the current status and outcomes of each investigation.

4.4.1 WMA 001SFC100

WMA 001SFC100 is comprised of 35 acres in downtown Palo Alto that drain to San Francisquito Creek. Water samples collected by the Program during storm events in WY 2013 and WY 2014 found highly elevated PCBs concentrations and PCBs particle ratios in the WMA. In WY 2015, a highly elevated PCBs sediment sample was collected from a storm drain in the WMA as part of the Program's screening monitoring. This storm drain line drains the non-residential eastern portion of the WMA, and is immediately upstream of the location where the Program found elevated PCBs in stormwater in WY 2013 and WY 2014. Beginning in WY 2016, the Program initiated a targeted source property investigation in the eastern (non-residential) portion of the WMA to identify the source(s) of elevated PCBs. Records review, public ROW surveys, site visits, and sediment sampling were all conducted in the WMA as part of the investigation. The results of the investigation to date are summarized below. The locations and relative concentrations of all POC monitoring conducted in this WMA since WY 2015, both as part of the screening monitoring program and during targeted source property investigation are shown on Figures 4.21 and 4.22.

According to the records review findings, the eastern portion of the WMA had 5 industrial parcels comprising 8% of the WMA prior to 1980. Industrial facilities included a dairy processing plant, an electrical substation, and a number of auto repair facilities. Most of these old industrial parcels (including the electrical substation and a large auto repair facility) were redeveloped prior to 2015.

Currently, more than half of the WMA is composed of retail or commercial businesses. The eastern portion of the WMA drains an area that is mostly multi- and single-family residential, but also contains some commercial areas. The two remaining old industrial parcels are relatively small (< 1 acre), unpaved lots used for equipment storage or parking. These are scheduled for future redevelopment.

Based on the combined results of records review, public ROW surveys and site visits, the Program identified a number of high-interest properties in the WMA for sampling. In WY 2017, 9 street dirt and MS4 sediment samples were collected in public ROW areas adjacent to or downstream of these high-interest properties, including a sample collected from the same location in the storm drain line that had highly elevated PCBs in WY 2015. None of the samples collected in WY 2017 had elevated concentrations of PCBs or mercury. The Program worked with the City of Palo Alto to continue the investigation and discovered that in WY 2016, the City had conducted video inspection of the storm drain line where the elevated WY 2015 sediment sample was collected. The video inspection revealed large tree-root mats in the line that were harboring substantial amounts of sediment. One possibility is that sediment caught in the tree-root mats may have harbored PCBs from recent redevelopment projects that occurred prior to the 2015 sample collection in the MS4. The substantial rain events in the winter of 2017, prior to

the follow-up sampling that occurred later in 2017, may have flushed out all high concentration PCBs sediments that had been retained in the system.

The Program reviewed all of the information gathered during this source property investigation and concluded that there was no longer evidence of an active PCBs source in this WMA. The Program suspects the source of the PCBs that produced the elevated concentrations in earlier samples may no longer be present in the WMA. Currently, the Program is not planning any further investigation in this WMA at this time.

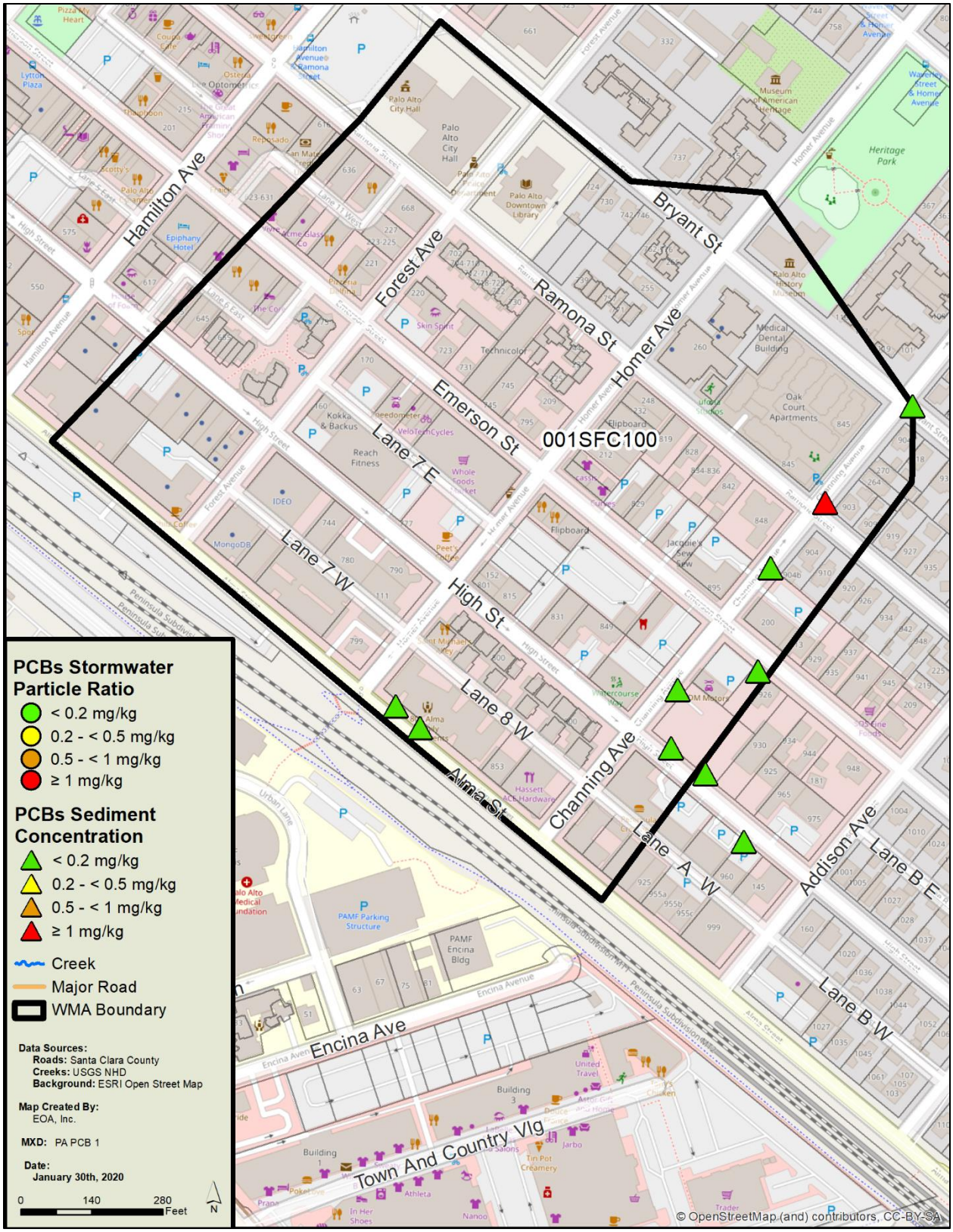


Figure 4.21. PCBs in street dirt and MS4 sediment concentrations and stormwater particle ratios measured in WMA 001SFC100 in WY 2015 through WY 2019.

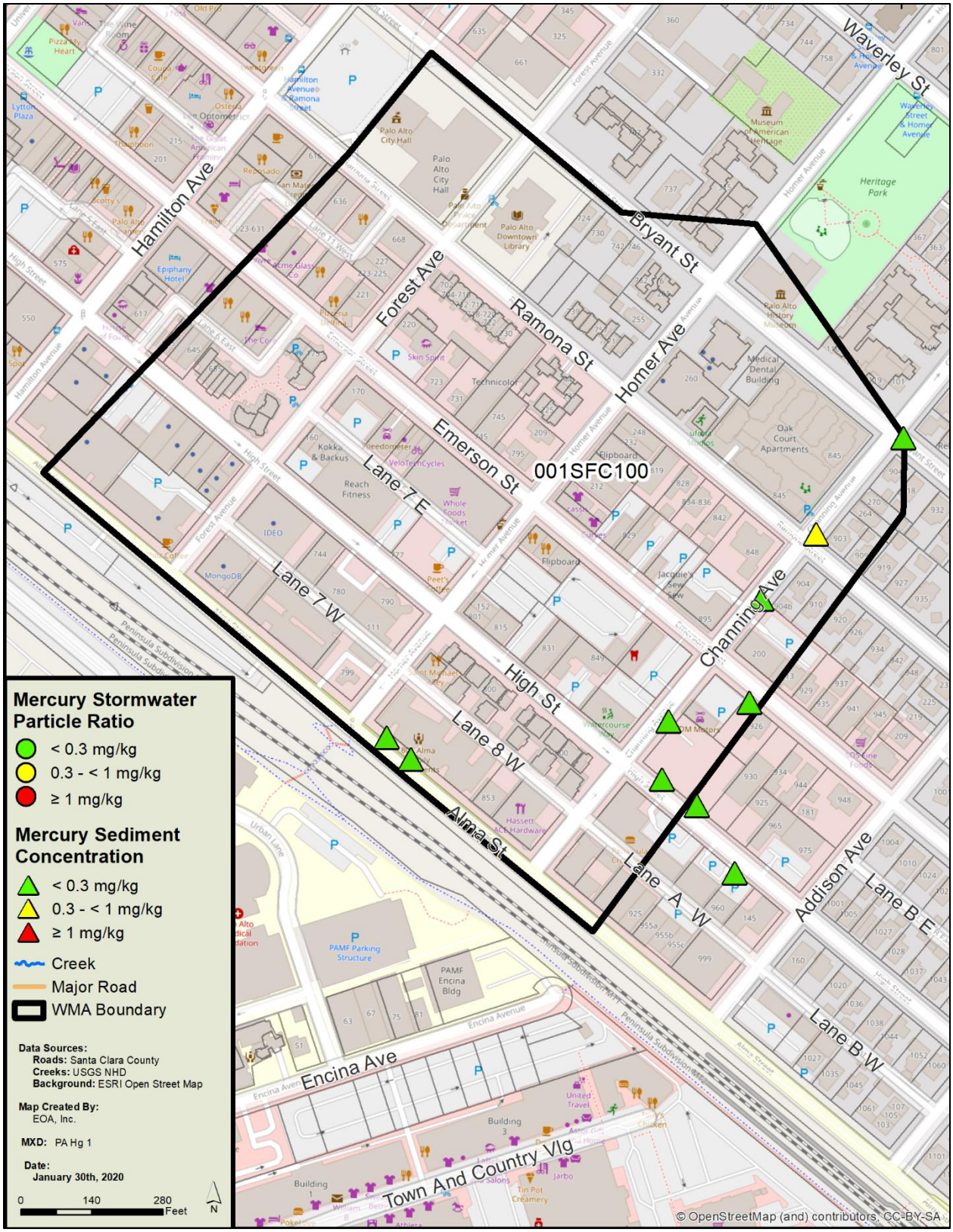


Figure 4.22. Mercury in street dirt and MS4 sediment concentrations and stormwater particle ratios measured in WMA 001SFC100 in WY 2015 through WY 2019.

4.4.2 WMA 031SCH250

WMA 031SCH250 is comprised of 42 acres that drain to Matadero Creek via the Stanford Channel. Elevated PCBs were not found in the single MS4 sediment sample collected in the WMA during the Program's screening monitoring conducted in WY 2015. However, following-up monitoring conducted as part of the Program's ongoing stormwater reconnaissance monitoring collected a sample that had an elevated PCBs concentration and a highly elevated PCBs particle ratio. Beginning in WY 2018, the Program initiated a targeted source property investigation in the WMA to identify the source(s) of elevated PCBs. Records review, public ROW surveys, and sediment and stormwater sampling were all conducted in the WMA as part of the investigation. The results of the investigation to date are summarized below. The locations and relative concentrations of all POC monitoring conducted in this WMA since WY 2015, both as part of the screening monitoring program and during the targeted source property investigation are shown on Figures 4.23 and 4.24.

According to records review, the WMA and adjacent areas were a mix of industrial and commercial land uses prior to 1980. Industrial facilities included an electrical utility substation, a repair firm for electrical transformers and other electrical equipment, and a medical device manufacturer. Geotracker identified multiple cleanup sites in the area, including 3 Superfund sites. One superfund site was remediated for PCBs around cement pads from former transformers. Another superfund site that was remediated for PCBs may still have contaminated backfill where the storm drain lines were placed. Parking lots on two adjacent parcels may also have contaminated backfill. There are also properties with transformers on site that may contain PCBs. A number of the larger properties in the WMA have been redeveloped in the last 20 years into commercial office buildings, many of which house technology companies.

As part of the targeted source property investigation, the Program reviewed records for 37 old industrial parcels in the WMA, and completed public ROW surveys of 34 parcels of interest. No business site visits were conducted due to lack of cooperation from property owners. Based on the combined results of records review and public ROW surveys, the Program identified a number of high-interest properties in the WMA for sampling. In WY 2019, the Program collected 2 simultaneous stormwater samples, downstream of two suspected source areas in the WMA. Both samples had highly elevated PCBs concentrations and PCBs particle ratios, although the sample collected from the furthest upstream suspected source area in the WMA was about 3.5 times higher than the sample collected further downstream. These results confirm the furthest upstream suspected source area is in fact a source of PCBs to the MS4. However, additional investigation may be needed to confirm specific parcels contributing to this source area. Further investigation may also be needed to determine if the downstream area is also a source, or if the elevated PCBs measured in the second sample are from the confirmed source area. It is important to note that both of these stormwater samples collected in this WMA have some of the highest PCBs concentrations and particle ratios measured to date in the Bay Area. In WY 2019, the Program also collected 3 street dirt and MS4 samples in public ROW areas adjacent to suspect properties. One of these samples, collected in the public ROW adjacent to the confirmed source area, had moderately elevated PCBs concentrations, and the other two were well below urban background. None had elevated mercury concentrations.

Additional investigation is clearly warranted in this WMA to identify specific source properties contributing to the highly elevated stormwater concentrations in the MS4. The Program will continue to investigate this WMA in WY 2020.

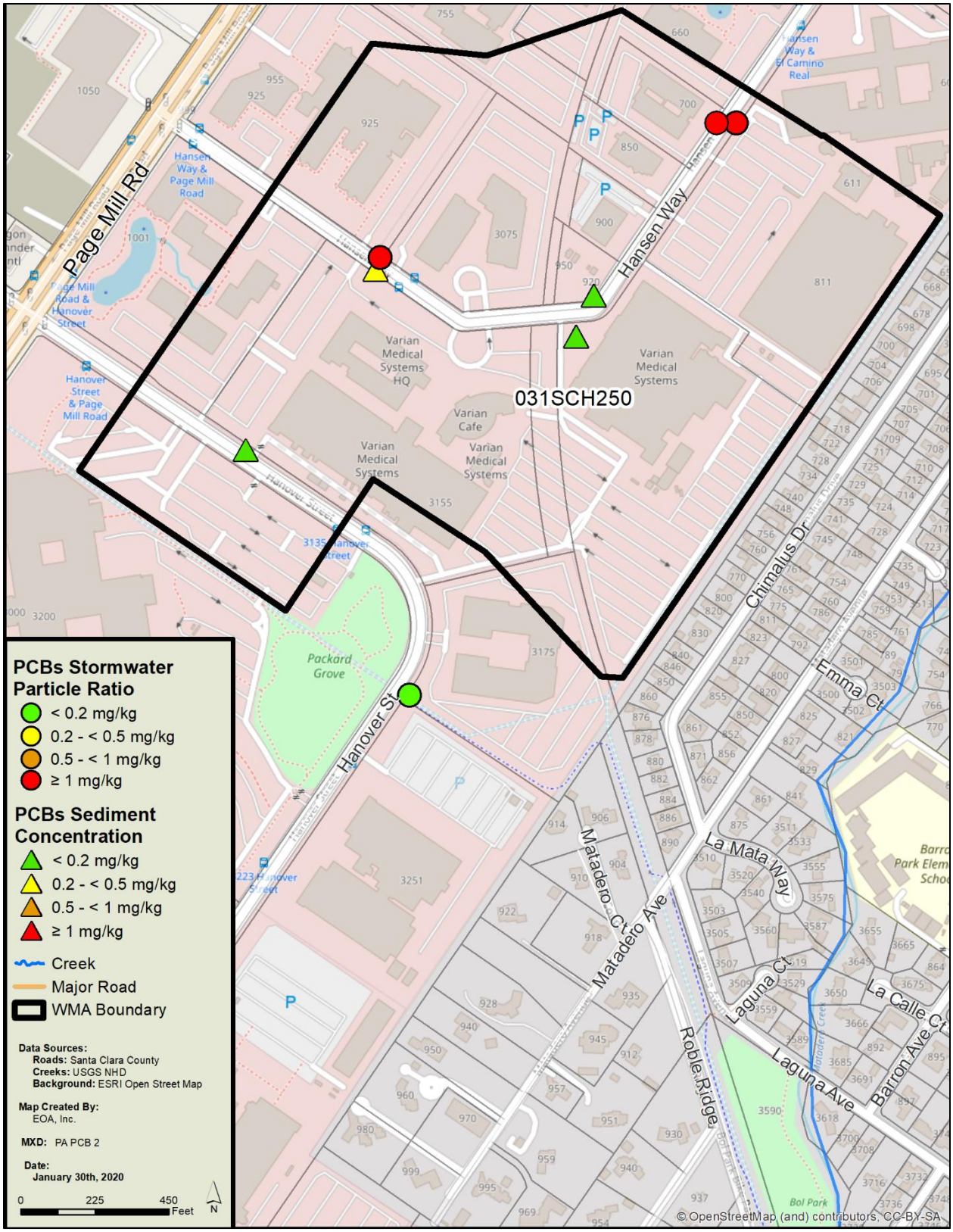


Figure 4.23. PCBs in street dirt and MS4 sediment concentrations and stormwater particle ratios measured in WMA 031SCH250 in WY 2015 through WY 2019.

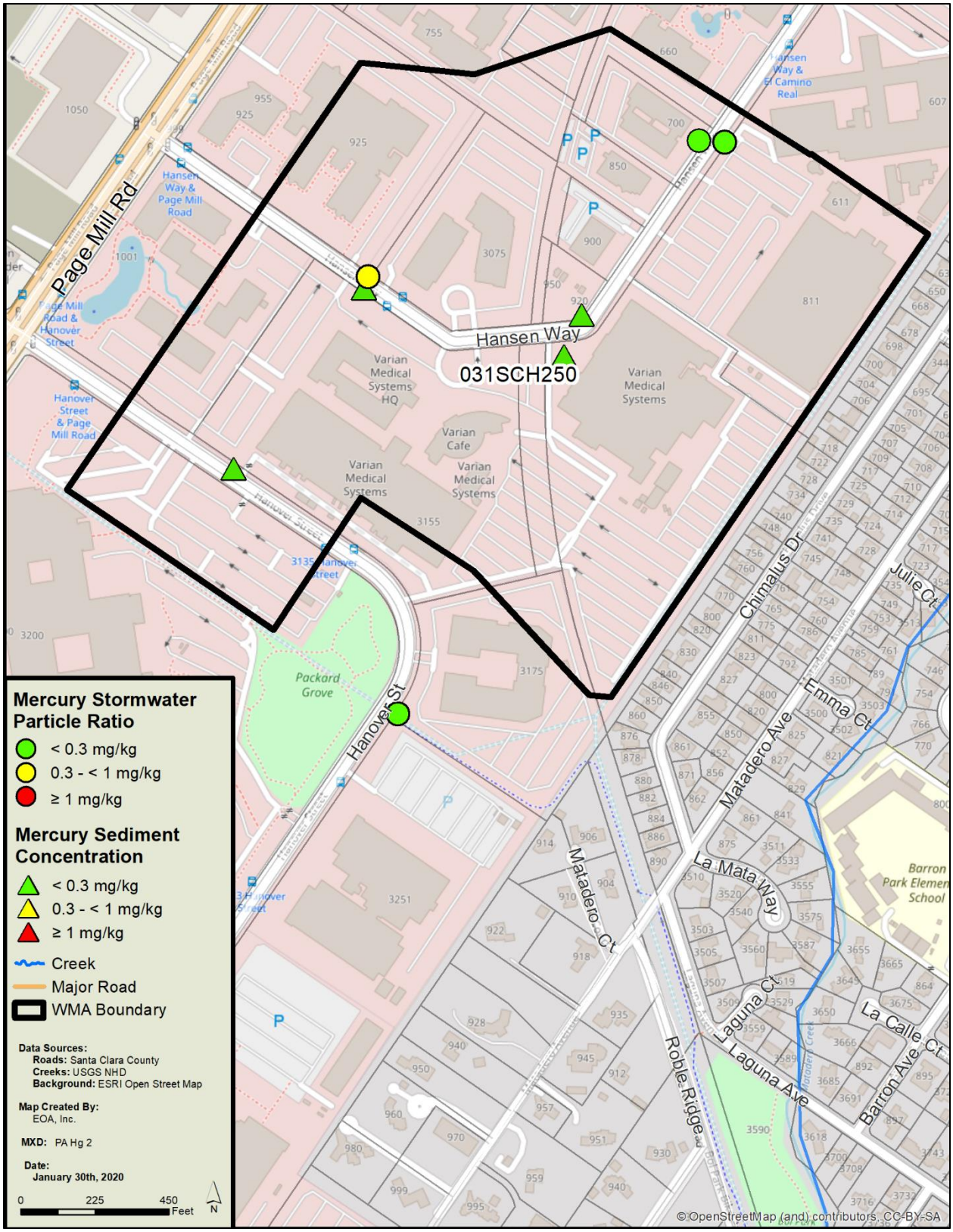


Figure 4.24. Mercury in street dirt and MS4 sediment concentrations and stormwater particle ratios measured in WMA 031SCH250 in WY 2015 through WY 2019f

4.5 City of Mountain View

The Program is currently conducting a source property investigation in a group of catchments in the City of Mountain View. This investigation is in the early stages, but the catchments included in the investigation, POC monitoring data collected to date, and a current status update on this investigation are provided below.

In WY 2019, the Program received information from the Regional Water Board about a site in the City of Mountain View that is currently undergoing redevelopment. The information indicated PCBs were found on the property at very high concentrations based on recent sampling by the contractor overseeing construction at the site. Prior to receipt of this information, the Program had not collected any MS4 sediment or stormwater screening samples from the catchment that contains this property. However, there was one MS4 sediment sample collected in an adjacent catchment in WY 2015 that had moderately elevated PCBs concentrations in street dirt. Upon further review of the catchment with the suspected source property, and the surrounding catchments, the Program decided to conduct a targeted source property investigation in this area beginning in WY 2019. The investigation area includes 6 contiguous catchments that are all relatively small. Because of their small geographic size and proximity, the Program will investigate these 6 catchments as a single source investigation. The investigation area will be referred to as the Mountain View WMA hereafter.

The six catchments that comprise the Mountain View WMA investigation area are identified on Figures 4.25 and 4.26. Each of the six catchments that comprise this investigation area are described below based on the findings of an initial records review.

- 017SVC500 is a 209-acre catchment on the northern edge of the City Mountain View that drains north and east to Stevens Creek just prior to the creek's discharge to San Francisco Bay. The catchment contains a portion of a wetland prior to the Shoreline pump station at the outfall to Stevens Creek. The land use types within the catchment are mostly commercial/industrial, with the largest area, 19 acres, occupied by the Google campus. The entire catchment lies within the Teledyne and Spectra Physics Superfund groundwater plume. This catchment contains the suspect source property that precipitated this source investigation. High sub-surface soils and groundwater concentrations of PCBs were recently found on this suspect property during construction activities. The property is owned by the City of Mountain View and leased to Google, Inc. for redevelopment. High PCBs concentrations in soil stockpiles from excavation activities on the site ranged from 170 mg/kg to 2,100 mg/kg (RPS Iris 2017). In-situ soil samples from 3 to 20 feet below ground ranged from 1.1 to 3,900 mg/kg (RPS Iris 2017) Groundwater samples had PCBs concentrations ranging from 520 ng/L to 171,000 ng/L (RPS Iris 2017). The one private drain on the site prior to construction drained to Mountain View's MS4. Track out on the south side of the construction site drains to Mountain View's MS4 prior to the wetlands and the Shoreline pump station at the outfall to Stevens Creek.
- 017PMC600 is a 66-acre catchment on the northern edge of Mountain View that drains to Permanente Creek, just prior to the creek's discharge to San Francisco Bay. This catchment lies to the north of the catchment with the suspect source property. The current land-use is mostly open space. The southern portion of the catchment drains the Google campus and a former municipal landfill site. A portion of the former landfill site is currently being redeveloped by Google into a parking lot. Historical documents indicate that the portion of the site currently undergoing redevelopment was never within the

limits of refuse for the landfill. Other businesses in the catchment include a corporation yard and a golf course. The southern portion of the catchment lies within the Teledyne and Spectra Physics Superfund groundwater plume.

- 032PMC100 is a 32-acre catchment that drains west to Permanente Creek. This catchment borders the catchment with the suspect source property to the south west. The land use types within the catchment are commercial and industrial. The Montwood cleanup site, occupies a quarter of the catchment area. This cleanup site is a known contributor to the Teledyne and Spectra Physics Superfund site groundwater plume.
- 032PMC200 is a 69-acre catchment that drains west to Permanente Creek. This catchment also lies to the south west of the catchment with the suspect source property. The land use types within the catchment are commercial/industrial. The former Spectra Physics Laser property and a portion of the Teledyne Semiconductor properties occupy the majority of the catchment area. The catchment contains the Teledyne and Spectra Physics Superfund site.
- 032SVC400 is an 82-acre catchment that drains to Stevens Creek. This catchment borders the catchment with the suspect source property to the south east. The catchment is comprised of commercial properties, and also contains the Santa Clara North Coach Terminal and Transportation Agency cleanup site. The entire catchment lies within the Teledyne and Spectra Physics Superfund groundwater plume.
- 032SVC470 is a 71-acre catchment that drains to Stevens Creek. This catchment also lies to the south east of the catchment with the suspect source property. The land use types within the catchment are predominantly commercial and industrial. The former Teledyne Semiconductor Property and clean-up site lies within the catchment, and a significant area in the catchment lies within the Teledyne and Spectra Physics Superfund groundwater plume. In WY 2015, the Program collected a MS4 sediment sample from this catchment as part of its screening monitoring program that had moderately elevated PCBs concentrations.

The Program is in the early stages of the Mountain View WMA investigation. The results of the initial records review and public ROW surveys conducted at the end of WY 2019 were used to develop a preliminary sampling plan that targeted locations that drain the suspected source property. In early WY 2020, 2 stormwater samples were collected simultaneously, upstream and downstream of the suspected source property. The results are expected back from the laboratory later this year. In the meantime, the Program is continuing to review records of other parcels in the Mountain View WMA to determine if additional site visits and sampling are warranted. The Program will continue to investigate the Mountain View WMA throughout WY 2020.

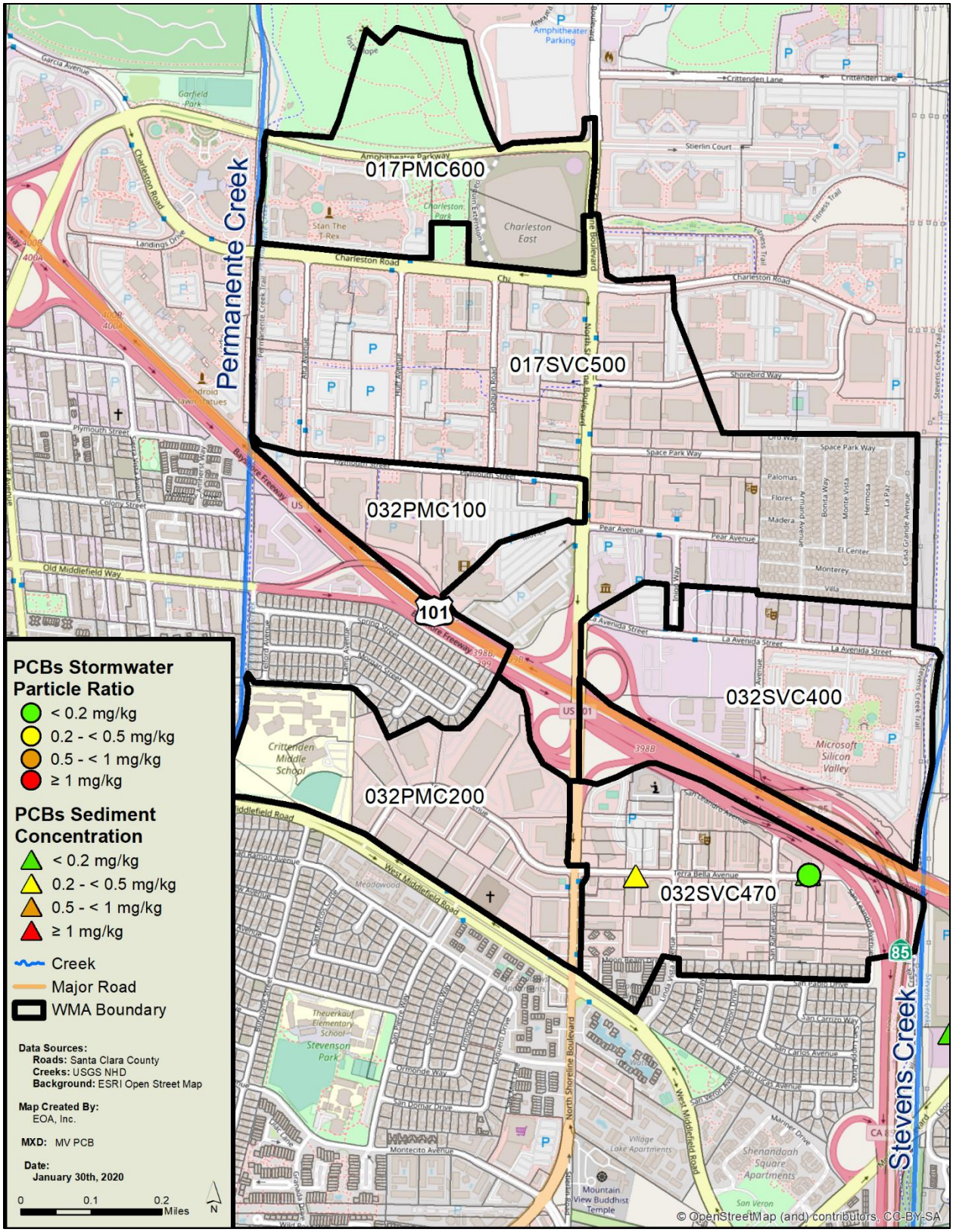


Figure 4.25. PCBs in street dirt and MS4 sediment concentrations and stormwater particle ratios measured in the Mountain View WMA investigation area in WY 2015 through WY 2019.

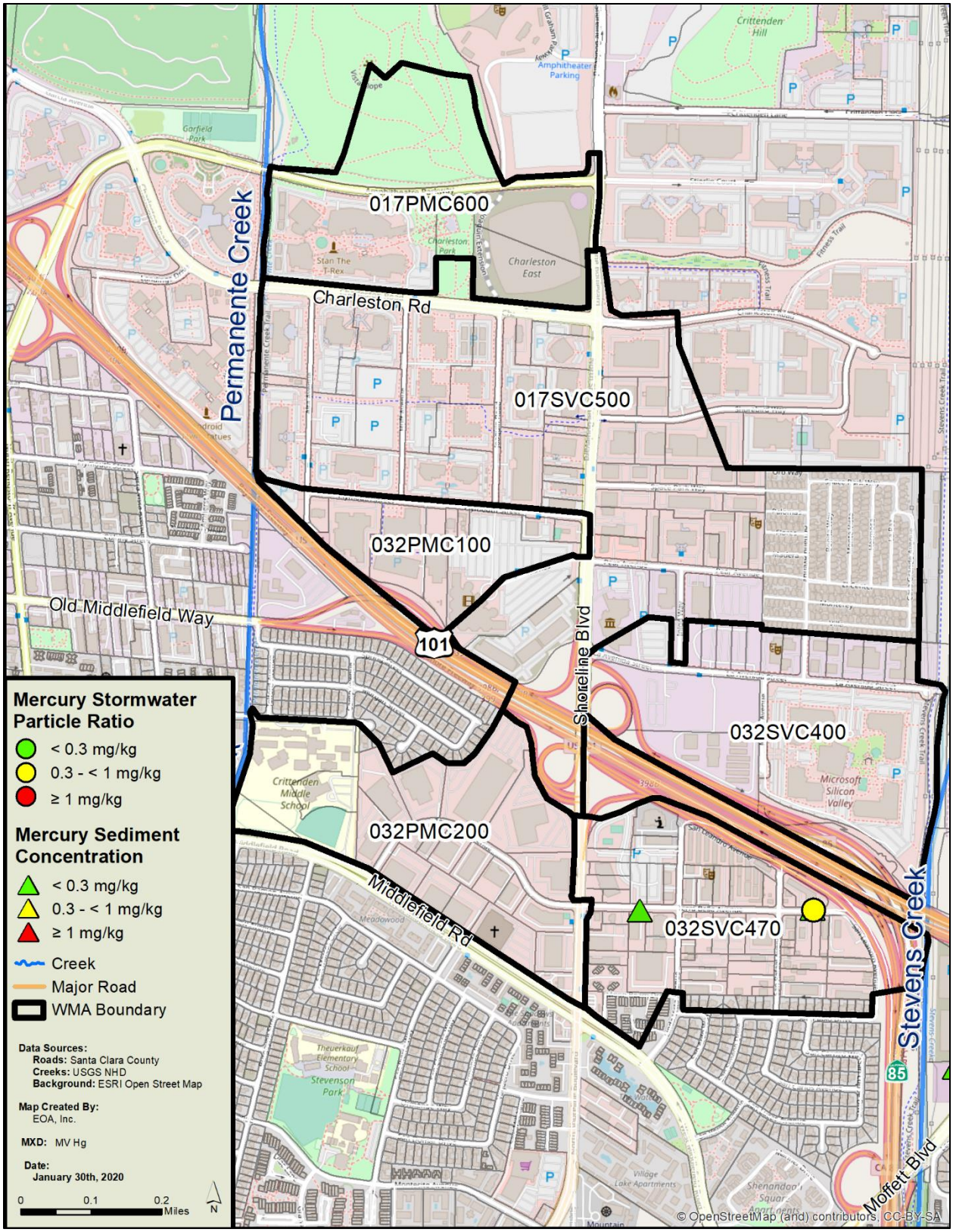


Figure 4.26. Mercury in street dirt and MS4 sediment concentrations and stormwater particle ratios measured in the Mountain View WMA investigation area in WY 2015 through WY 2019.

5 CONCLUSIONS AND RECOMMENDATIONS

This section provides a summary of the outcomes and benefits of POC monitoring in support of source identification in the Santa Clara Basin in WY 2015 through WY 2019. This section also identifies next steps and provides recommendations for POC monitoring to continue to support the Program's efforts to identify sources and reduce PCBs and mercury urban stormwater runoff loads to the Bay.

5.1 Outcomes of POC Monitoring for Source Identification

Since WY 2015, POC monitoring data have been used to support source identification in the Santa Clara Basin in two ways. First, the Program uses POC monitoring data as a screening tool to select and prioritize stormwater catchments for control measure implementation. Second, the Program uses POC monitoring data as the primary tool to identify and confirm specific PCBs or mercury source properties.

5.1.1 POC Screening Monitoring to Select and Prioritize WMAs

In WY 2015, the Program began to conduct screening monitoring to identify locations in the Santa Clara Basin with elevated PCBs in public ROW areas in order to begin a process to select and prioritize catchments for control measure implementation. The Program conducted a large-scale sampling effort in WY 2015 that collected street dirt or MS4 sediment samples from catchments of interest for PCBs and mercury sources. Since WY 2016, both the Program and the RMP have conducted follow-up stormwater monitoring on an annual basis to confirm elevated PCBs in high-priority WMAs and to continue to screen additional catchments of interest. These efforts have collected more than 200 MS4 sediment samples and 59 stormwater samples, and screened 103 catchments, comprising nearly 37,000 acres of land. A total of 19 stormwater catchments (nearly 5,000 acres) were designated as high-priority WMAs based on elevated PCBs concentrations in MS4 sediment or stormwater concentrations, and targeted for source property investigations. The outcomes of the screening monitoring used to select and prioritize WMAs to date is summarized in Table 5.1.

Table 5.1 POC monitoring efforts to screen catchments in the Santa Clara Basin for elevated PCBs and mercury concentrations in public ROWs, WYs 2015 – 2019.

Prioritization Status	Catchment Count	Total Acres	Count of Screening Samples Collected		Notes
			MS4 Sediment	Stormwater	
High-Priority WMAs	19	4,948	39	9	Elevated PCBs were found in MS4 sediment and/or stormwater samples
Catchments of Interest - Screened with MS4 Sediment samples ONLY	43	12,512	67	0	Elevated PCBs were not found in MS4 sediment; stormwater samples may need to be collected for confirmation
Catchments of Interest - Screened with BOTH Stormwater and MS4 Sediment samples	40	19,395	74	47	Elevated PCBs not found in MS4 sediment or stormwater
Catchments of Interest - Not Yet Screened	45	13,595	0	0	No collected samples to-date
Remaining Area in the Santa Clara Basin		209,528	22	3	Elevated PCBs not found in MS4 sediment or stormwater
SANTA CLARA BASIN TOTALS		**259,978**	**202**	**59**	**Total count of screening samples collected to select and prioritize WMAs**

5.1.2 POC Monitoring for Targeted Source Property Investigations

Starting in WY 2016 and continuing through the present date, the Program began conducting targeted source property investigations in high-priority WMAs. The goal of these investigations was to identify properties that contribute excess PCBs or mercury to the MS4 (i.e., PCBs or mercury source properties). Once monitoring data have confirmed the identification of a source property, the Program works with staff from the appropriate municipal jurisdiction to determine next steps to reduce PCBs loading to the MS4 from the source property and to address elevated PCBs in adjacent public ROW areas. Potential next steps include the following:

- Submit a source property referral to the Regional Water Board for follow-up investigation and abatement;
- Work directly with property owners to abate or cause property abatement;
- Implement control measures in public ROW areas adjacent to and downstream of confirmed source properties, such as:
    - Enhanced O&M in public ROW areas;
    - Construction of stormwater treatment and/or green stormwater infrastructure;
- Conduct additional investigation and monitoring.

The outcomes and current status of all source property investigations in the Santa Clara Basin to date are summarized in Table 5.2. The Program completed one source property investigation prior to WY 2015. Between WY 2015 and WY 2019, the Program completed source property investigations in two additional high-priority WMAs (comprising 516 acres), and has ongoing investigations in 16 WMAs comprising nearly 4,000 acres. The outcomes of these investigations include submission of 3 PCBs source property referrals to the RWB, and confirmation of 9 additional PCBs source properties. The next steps for the 9 confirmed source properties are currently under consideration.

For the 3 source property referrals, the Program assisted the appropriate municipal jurisdictions in evaluating options for additional control measures in these catchments to address elevated PCBs in public ROW areas downstream of source properties. Following submission of referrals, the municipalities have been implementing (or causing to be implemented) various O&M enhancements and stormwater treatment controls in the 3 WMAs with referred source properties that include enhanced street sweeping, storm drain line cleanouts, and installation of a stormwater treatment device. These efforts are documented in the Program's Annual Reports to the Regional Water Board each September.

In WY 2020, the Program and Co-Permittees will continue to conduct the ongoing source property investigations identified in Table 5.2.

Table 5.2. Outcomes of POC Monitoring conducted as part of targeted source property investigations in high-priority WMAs in the Santa Clara Basin through WY 2019.

Investigation Status	Co-Permittee	Catchment ID	Acres	Count of Samples Collected During Investigation		Investigation Outcomes
				MS4 Sediment	Stormwater	
Completed	Palo Alto	001SFC100	36	9	0	No Sources Identified
	San Jose	083CTC990[1]	456	30	0	1 Source Property Referral
	Sunnyvale	049SVE900	480	3	0	1 Source Property Referral
Ongoing	Mountain View	032SVC470	71	--	--	TBD
		017PMC600	66	--	--	TBD
		017SVC500	209	--	2	TBD
		032PMC100	32	--	--	TBD
		032PMC200	69	--	--	TBD
		032SVC400	82	--	--	TBD
	Palo Alto	031SCH250	68	3	2	TBD
	San Jose	051CTC275	454	12	--	2 Confirmed Source Properties
		051CTC400	140	22	--	2 Confirmed Source Properties
		083GAC900	610	10	3	3 Confirmed Source Properties
		067SCL080	42	10	2	1 Confirmed Source Property
		050GAC020	847	14	3	TBD
		067CTC250	41	14	--	TBD
		067SCL120	27	3	2	TBD
	Santa Clara	066GAC150	500	13	1	1 Source Property Referral; 1 Confirmed Source Property
		050GAC400	718	18	--	TBD
		Totals	**4,948**	**161**	**15**	

1: The source property investigation conducted in catchment 083CTC990 (including all associated sample collection) was done prior to WY 2015 (SCVURPPP 2015a).

5.2 Recommendations for Future POC Monitoring to Support Source Identification

The pollutant reduction benefits and costs of conducting source property investigations were examined, along with other stormwater control measures, via the CW4CB project. The findings of the CW4CB project concluded that PCBs source property investigations are much more cost-effective than retrofitting old industrial areas with stormwater treatment controls (BASMAA 2017). The Program recommends continuation of the current POC monitoring efforts to select and prioritize catchments for investigations, and to conduct targeted source property investigations in catchments where PCBs concentrations in the MS4 are elevated.

As shown in Table 5.1, there remain nearly 14,000 acres in “Catchments of Interest” for PCBs and mercury sources that have not yet been screened for elevated concentrations. Another 210,000 acres of land in the Santa Clara Basin have also not been screened, although these areas are generally considered low interest for PCBs and mercury sources. The Program recommends continuation of annual stormwater monitoring to screen the remaining “Catchments of Interest” for elevated PCBs and mercury during the next permit term. These

efforts should continue until all “Catchments of Interest” have been screened. In addition, as screening efforts identify more high-priority WMAs with elevated PCBs, targeted source property investigations in these catchments are warranted. POC Monitoring at the level needed to support these future investigations is recommended at a similar rate as during the current permit term.

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Attachment D.3

POC Reconnaissance Monitoring Progress Report, Water Years 2015-2019 (SFEI)

RMP
REGIONAL MONITORING
PROGRAM FOR WATER QUALITY
IN SAN FRANCISCO BAY

sfei.org/rmp

Pollutants of Concern Reconnaissance Monitoring Progress Report, Water Years 2015 - 2019

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CONTRIBUTION NO. / XXX 2020

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Preface

Reconnaissance monitoring for water years 2015, 2016, 2017, 2018 and 2019 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 (2020) is planned for this study. This draft report was prepared for the Bay Area Stormwater Management Agencies Association (BASMAA) in support of materials submitted on or before March 31st, 2020 in compliance with the Municipal Regional Stormwater Permit (MRP) Order No. R2-2015-0049.

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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 during the summers of 2015, 2016, 2017, 2018 and 2019. 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; and WY 2019 included Ila Shimabuku, Margaret Sedlak, Jennifer Sun, Micha Salomon, and Don Yee. The RMP data management team is acknowledged for their diligent delivery of quality-assured well-managed data. This team was comprised of Amy Franz, Adam Wong, Michael Weaver, John Ross, and Don Yee in WYs 2015, 2016, 2017, 2018 and 2019. 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, and Christian Kocher, ADH Environmental on behalf of the Contra Costa Clean Water Program.

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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.). 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 2019. 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 67 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 2020 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.

This report presents all available stormwater data[1] 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 2015-2019 reconnaissance monitoring study (total of 88 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 (28%) with estimated particle concentrations of PCBs greater than 200 ng/g and 31 sites (35%) with estimated particle concentrations of Hg greater than 0.5 µg/g have been identified. Total PCB concentrations measured 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), Santa Fe Channel (198,000 pg/L), and Industrial Rd Ditch in San Carlos (160,000 pg/L). When normalized by SSC to generate estimated particle concentrations, 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 600 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 sources in the urban environment, 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). 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 (2.8 µg/g). The two Guadalupe River stations are downstream of the historic New Almaden Mining District.

The sites with the highest particle concentrations for PCBs were typically not the sites with the highest concentrations for HgT.

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 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.

[1] 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.).

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 positively correlated with impervious cover (r_s = 0.57), old industrial land use (r_s = 0.61), and HgT particle concentrations (r_s = 0.19). PCB particle concentrations were negatively 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 and had similar but weaker relationships as PCBs to impervious cover, old industrial land use, and watershed area. Overall, the data collected to date do not support the use of any of the trace metals analyzed as a proxy for either PCB or HgT pollution sources.

Old industrial land use is believed to have both the greatest yields and loads of PCBs in the region. The watersheds/catchments for the 87 sites that have been sampled for PCBs with RMP and grant funding since WY 2003 cover about 33% of the old industrial area in the region. Of the remaining areas in the region with old industrial land use yet to be sampled (77 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 what mass of pollution is associated with these areas.

This Pollutants of Concern Reconnaissance Monitoring study will continue at least into WY 2020 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.

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Figure 8. Relationships between observed estimated particle concentrations of PCBs and total mercury (HgT), trace elements, and impervious land cover and old industrial land use.

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)[2]. Sufficient pollutant data were collected at 11 urban sites to estimate 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 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). MRP 2.0 places an increased focus on finding high-leverage watersheds, source areas, and source properties that are more polluted, and that are located upstream of sensitive Bay margin areas.

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

Specifically, the permit adds a stipulation that calls for identification of sources or watershed source areas that provide the greatest opportunities for reductions of PCBs and Hg in urban stormwater runoff.

To help support this focus and also 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 2015-2019 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, 2017a and 2017b).

This report summarizes and provides a preliminary interpretation and summary of data collected during WYs 2015-2019, as well as from previous studies by this workgroup dating back to WY 2003. The data collected and presented here contribute to a broad effort of identifying potential management areas for pollutant reduction. During Calendar Year (CY) 2018, the RMP funded a data analysis project that aims to mine and analyze all existing stormwater PCB data. 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 (McKee et al., in review). 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 trends strategy that outlines key elements including modeling needs (Wu et. al., 2018). Reconnaissance data collected in WYs 2011 and 2015-2019 may provide “baseline” data for identifying concentration or particle concentration trends over time, with the understanding that management actions to control PCB and Hg loads are increasingly being implemented throughout this period.

The report is designed to be updated annually and will be updated again in approximately 12 months to include WY 2020 sampling data currently being collected.

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 Watershed Spreadsheet Model (RWSM)
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 and 2019, 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 2014-2018, 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.

Watershed sites with a wide variety of characteristics were sampled in WYs 2015-2019 (Figure 1 and Table 1). Of these sites, 21 were in Santa Clara County, 19 in San Mateo County, 16 in Alameda County, 10 in Contra Costa County[3] 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 (75% were smaller than 5.2 km^2) with a high degree of imperviousness (75% of watersheds/catchments were greater than 60% impervious). The percentage of old industrial[4] area in watersheds/catchments ranged from 0- 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, and Colma Creek at West Orange Avenue), but none were sampled because staff and budgetary resources were allocated

[3] 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.

[4] 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).

elsewhere. 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 the "Loadings Study" (Figure 1).

2.2 Field methods

Mobilization and preparing to sample

Mobilization for sampling was typically triggered by storm forecast. When a minimum rainfall of at least one-half inch[5] over 6 hours was forecast, sampling teams were deployed, ideally reaching the sampling site about one hour before the onset of rainfall[6]. When possible, one team sampled two sites close to one another to increase efficiency and reduce staffing costs. Upon arrival, the team assembled equipment and carried out final safety checks. Sampling equipment used at a site depended on the accessibility of drainage lines. Some sites were sampled by attaching laboratory-prepared trace-metal-clean Teflon sampling tubing to a painter's pole and a peristaltic pump with laboratory-cleaned silicone pump-roller tubing (Figure 2a). During sampling, the tube was dipped into the channel or drainage line at mid-channel mid-depth (if shallow) or depth integrating if the depth was more than 0.5 m. In other cases, a DH 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, which was 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 holding times).

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

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

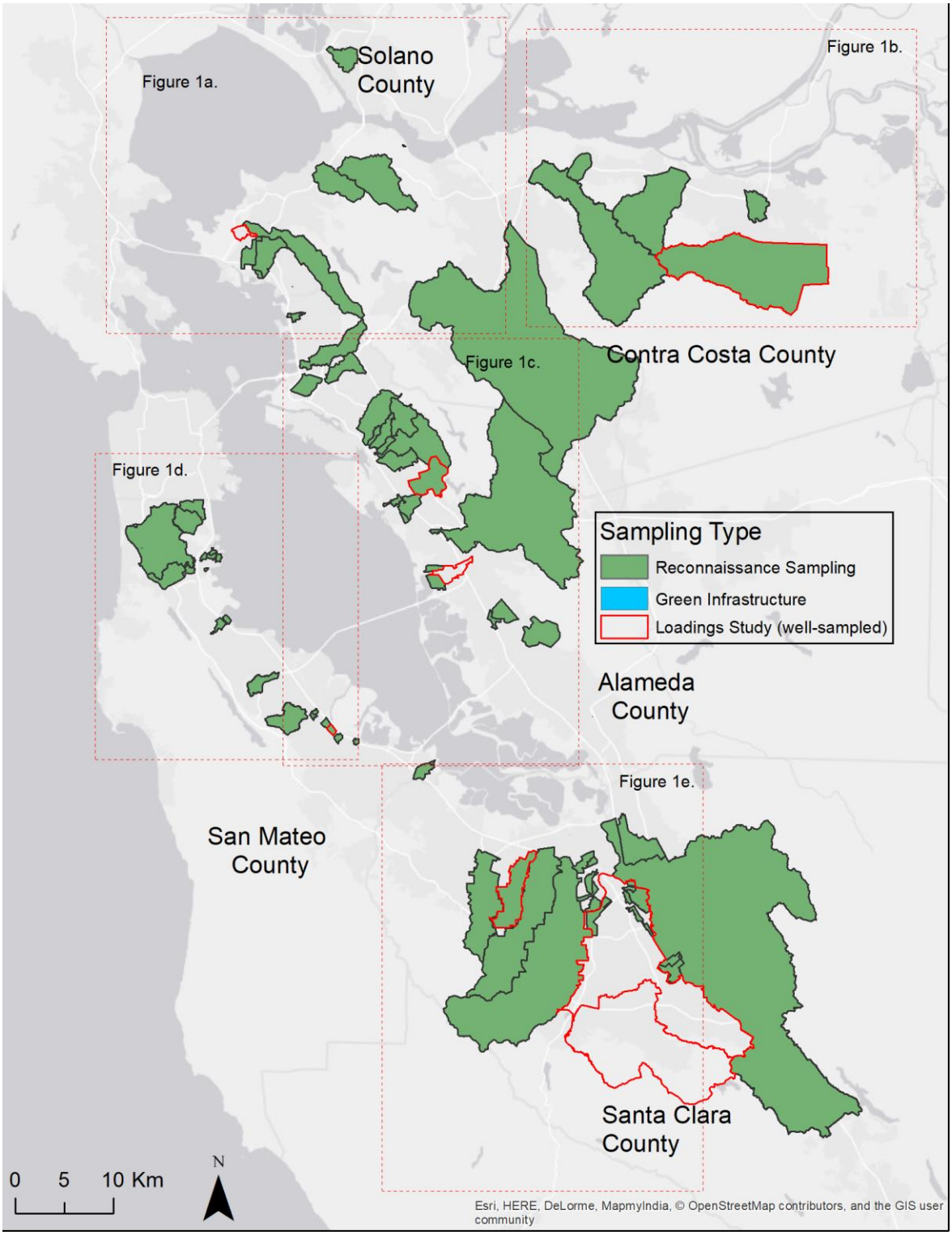


Figure 1. Watersheds/catchments sampled to date. Note: The drainage management areas (DMAs) of the Green Infrastructure sampling sites are so small they are not visible, though they are given a numeric map key identifier.

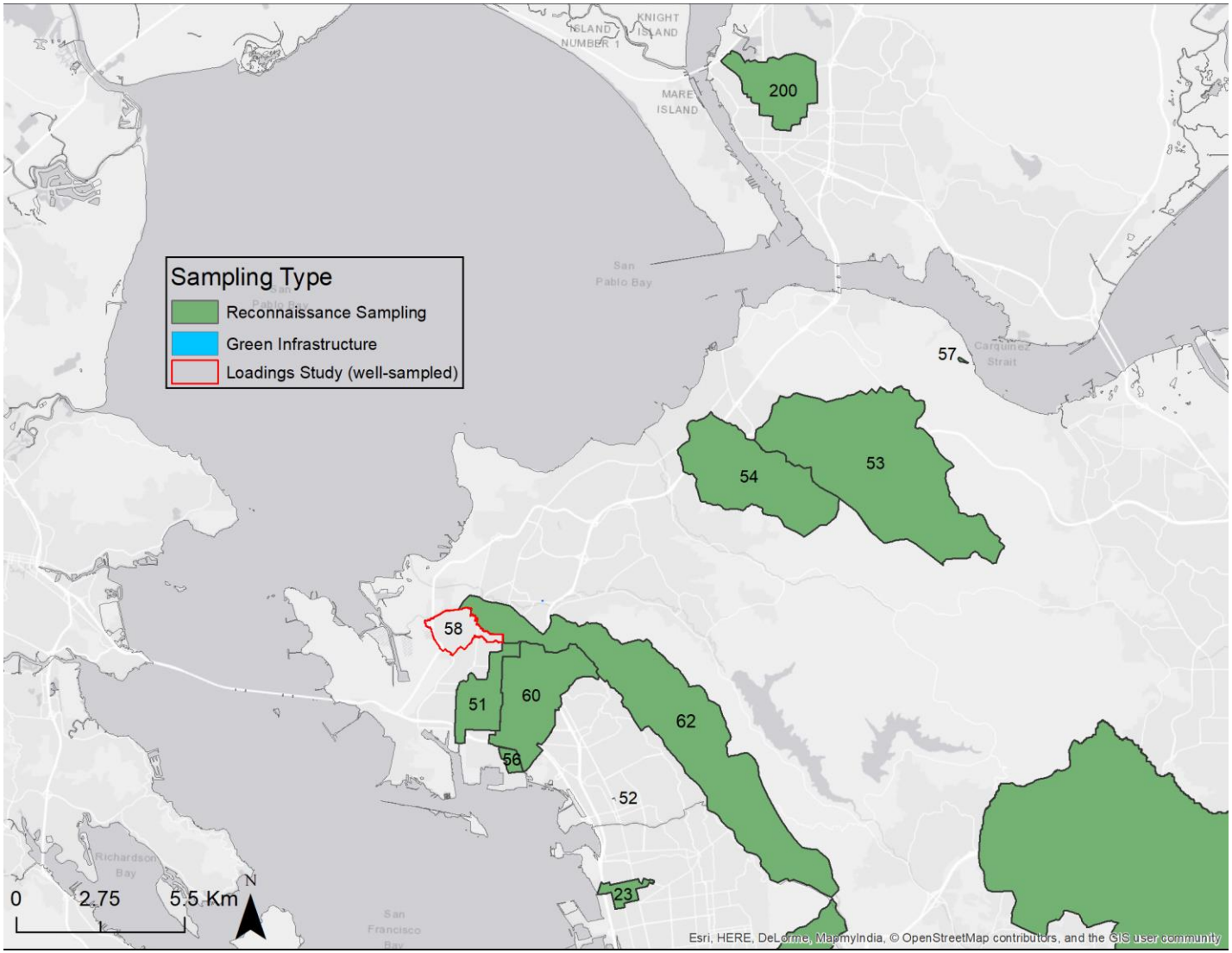


Figure 1a. Watershed boundaries of sites sampled in western Contra Costa County and Solano County. Note: The drainage management areas (DMAs) of the Green Infrastructure sampling sites are so small they are not visible, though they are given a numeric map key identifier. See Table 1 for information on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

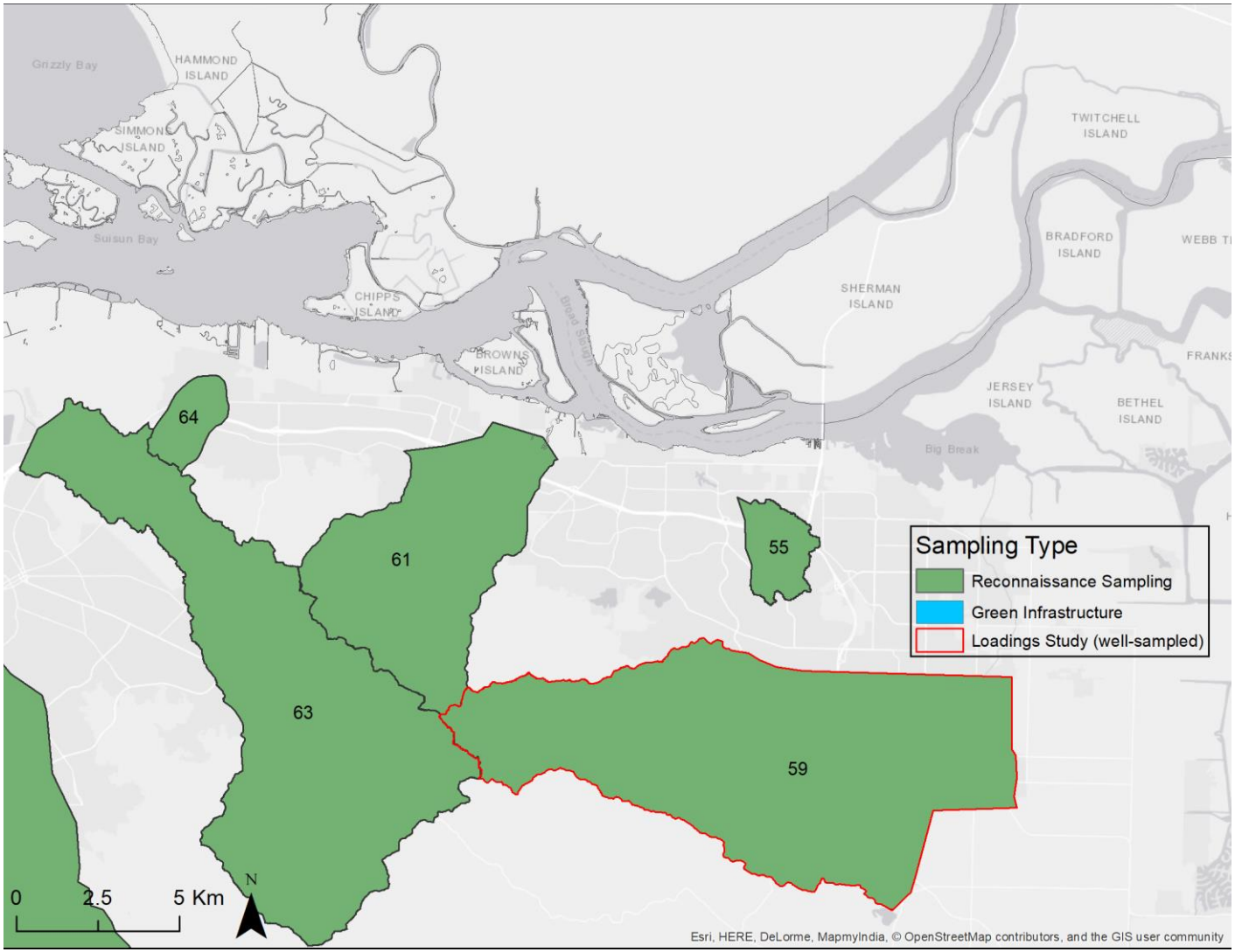


Figure 1b. Watershed boundaries of sites sampled in eastern Contra Costa County. Note: The drainage management areas (DMAs) of the Green Infrastructure sampling sites are so small they are not visible, though they are given a numeric map key identifier. See Table 1 for information on each numbered watershed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

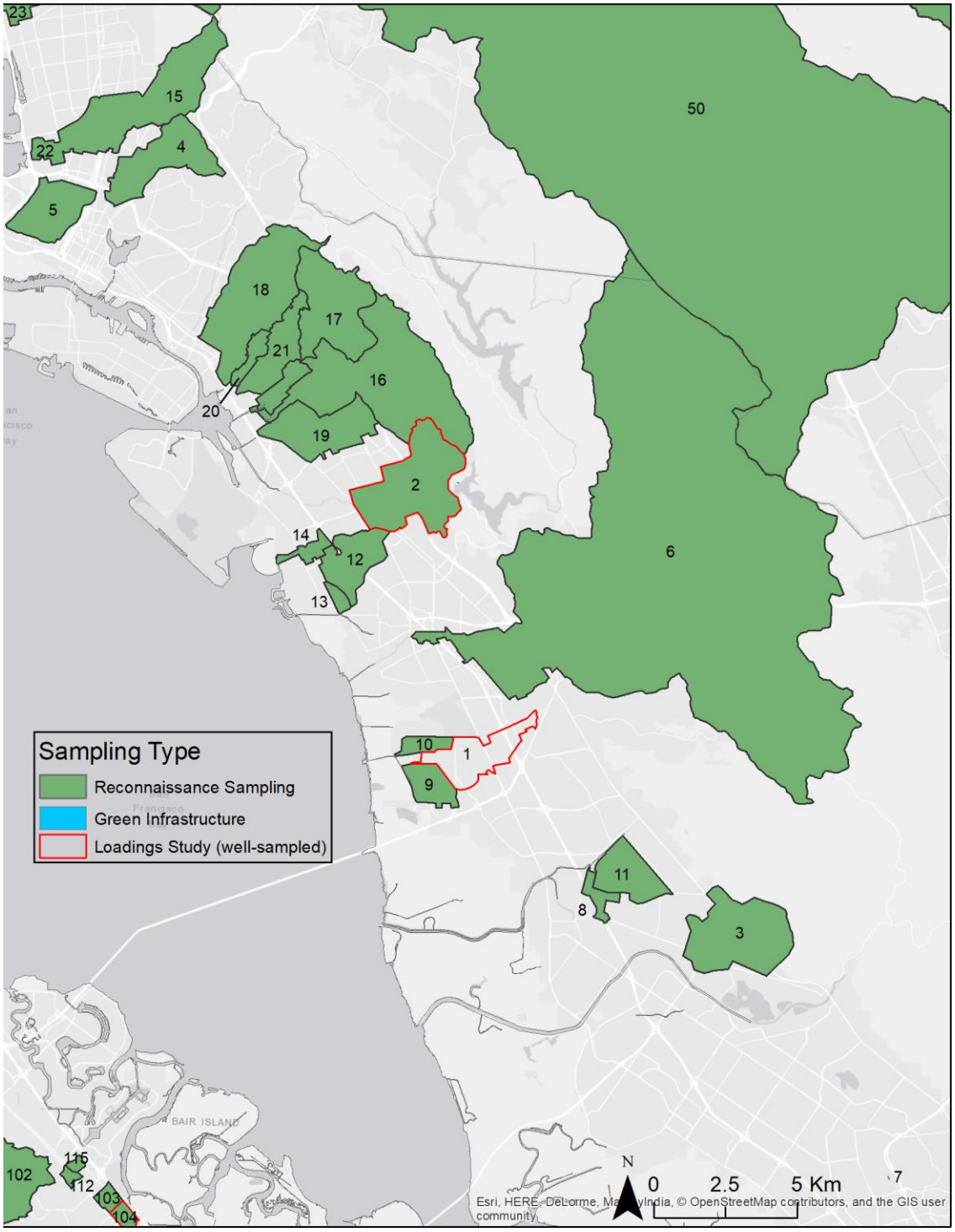


Figure 1c. Watershed boundaries of sites sampled in Alameda County. Note: The drainage management areas (DMAs) of the Green Infrastructure sampling sites are so small they are not visible, though they are given a numeric map key identifier. See Table 1 for information on each numbered watershed or drainage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

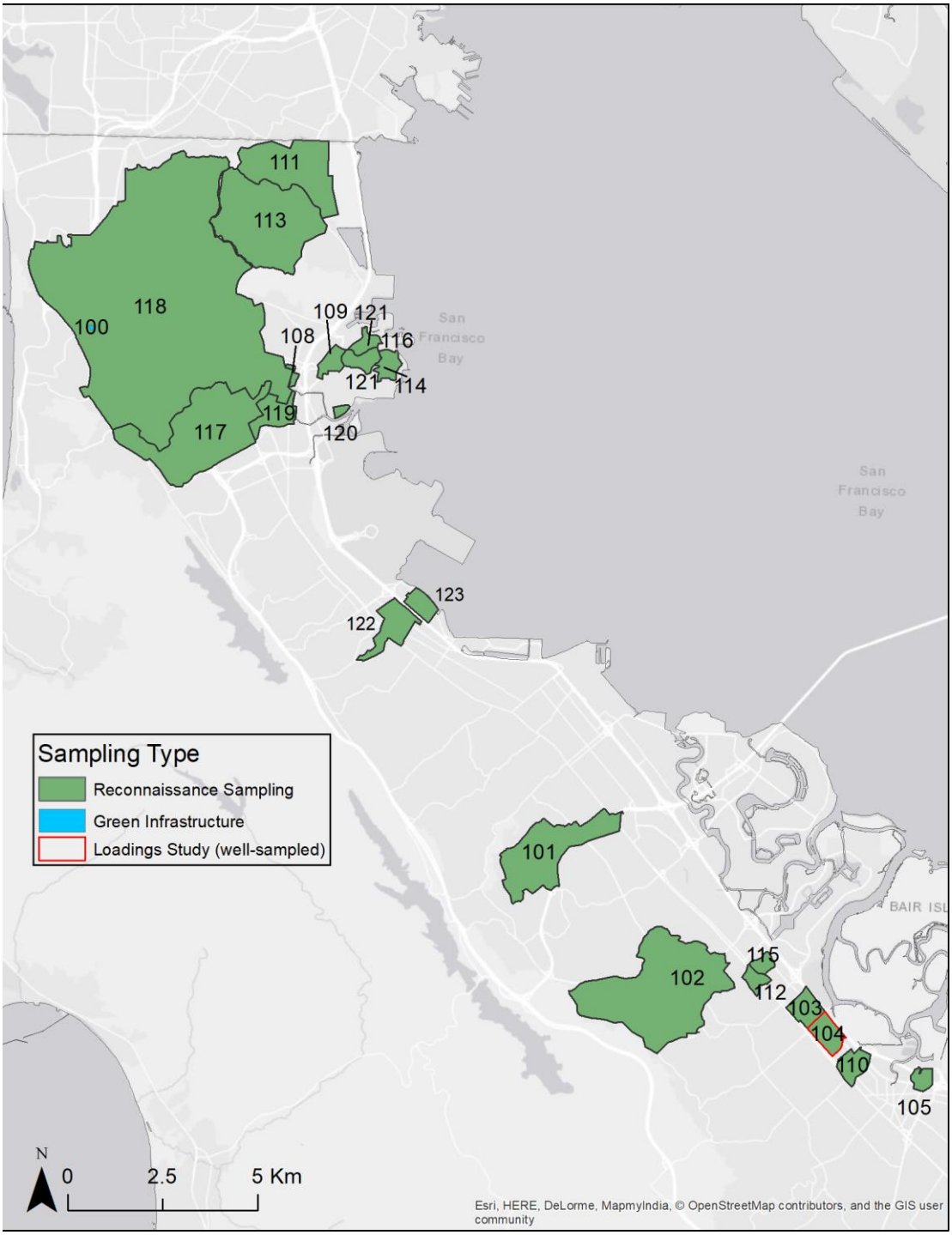


Figure 1d. Watershed boundaries of sites sampled in northern San Mateo County. Note: The drainage management areas (DMAs) of the Green Infrastructure sampling sites are so small they are not visible, though they are given a numeric map key identifier. See Table 1 for information on each numbered watershed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

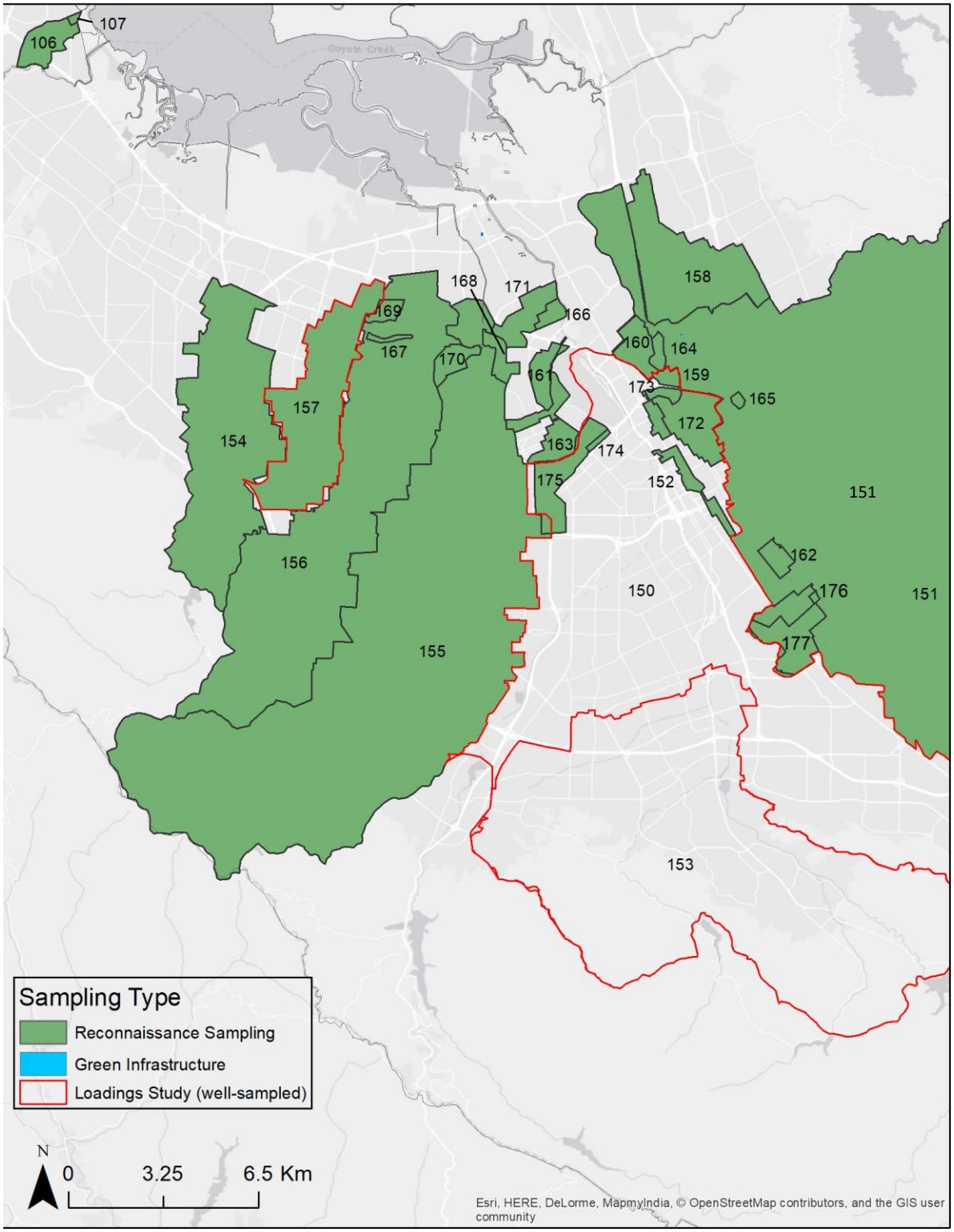


Figure 1e. Watershed boundaries of sites sampled in Santa Clara County. Note: The drainage management areas (DMAs) of the Green Infrastructure sampling sites are so small they are not visible, though they are given a numeric map key identifier. See Table 1 for information on each numbered watershed or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

Table 1. Key characteristics of the 91[7] 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%

[7] There are 91 total sampling locations. Of these, 67 were sampled during WYs 2015-2019, 87 had water concentrations for PCBs, and 88 had water concentrations for HgT.

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%
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[8]	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%
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%

[8] 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 (%)
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%
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%

Map Key	County	City	Watershed Name	Catchment Code	MS4 or Receiving Water	Latitude	Longitude	Sample Date	Area (sq km)	Impervious Cover (%)	Old Industrial (%)
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%
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%

Map Key	County	City	Watershed Name	Catchment Code	MS4 or Receiving Water	Latitude	Longitude	Sample Date	Area (sq km)	Impervious Cover (%)	Old Industrial (%)
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

In spring 2018, the SPLWG oversight committee recommended the use of remote samplers as an acceptable 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 a storm and retrieved within two days of the storm's end. Only the remote sampler was used at these sites to characterize water quality; no manual sampling was performed simultaneously. 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.

(a)



(b)



(c)



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.

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

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.

Table 3. Laboratory analysis methods.

Analysis	Matrix	Analytical Method	Lab	Filtered	Field Preservation	Contract Lab / Preservation Hold Time
PCBs (40)[9]-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	BRL	No	NA	BRL preservation with BrCl within 28 days
Mercury-Dissolved	Water	EPA 1631E	BRL	Yes	Na	BRL preservation with BrCl within 28 days
Mercury	Sediment	EPA 1631E, Appendix	BRL	NA	NA	7 days
Metals-Total (As, Cd, Pb, Cu, Zn)	Water	EPA 1638 mod	BRL	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

[9] 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).

2.4 Interpretive methods

Estimated particle concentrations

The reconnaissance monitoring field protocol is designed to collect one composite whole water sample 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 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):

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

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. Only with many years of data during many types of storms can such processes be identified.

Because of concerns regarding inter-storm variability, relative ranking of sites based on EPC from only one or two storms should be 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, a more advanced data analysis would be needed that takes into account a variety of parameters (PCB and suspended sediment sources and mobilization processes, PCB congeners, rainfall intensity, rainfall antecedence, flow production and volume) in the normalization

and ranking procedure. As mentioned above, the RMP has funded a project in CYs 2018 and 2019 to complete this type of investigation (McKee et al., 2019; Davis, J.A. and Gilbreath, A.N., 2019).

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. To compare the composite sample concentrations (comprised of multiple individual grab samples composited into a single bottle) collected in WYs 2015-19 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. 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[10] 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 infrastructure have been done intermittently since WY 2009. 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.

[10] Similar data collected by BASMAA in Santa Clara and San Mateo Counties are not included in this report.

3.1 Stormwater SSC concentrations

Suspended sediment concentrations from the 88[11] sampling locations ranged from 16 to 1,354 mg/L, with a median of 93 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 63 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 63 urban watersheds/catchments are given in Table 4.

Table 4. Summary statistics (count, minimum, maximum and percentiles) of SSC (in mg/L) for urban watersheds/catchments with agricultural and uncompacted open space <2.2%.

	All Counties	Alameda	Contra Costa	San Mateo	Santa Clara
Number of sampled (n)	63	18	5	18	21
Minimum	16	60	57	16	27
10th Percentile	26	68	NA	21	34
25th Percentile	45	81	57	26	46
50th Percentile	77	133	61	44	73
75th Percentile	143	203	123	83	118
90th Percentile	223	388	NA	160	148
Maximum	671	671	151	265	250

3.2 PCBs stormwater concentrations and estimated particle concentrations

Total PCB concentrations from 87 sampling sites[12] ranged from 533 to 448,000 pg/L, 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, Santa Fe Channel, Industrial Rd Ditch, Line 12H at Coliseum Way, Sunnyvale East Channel, Line 12M at Coliseum Way, Pulgas Pump Station-North, Ettie Street Pump Station, Ridder Park Dr Storm Drain and Gull Dr. Outfall (Table 5, Figure 3). Old industrial land use and PCB concentration were moderately correlated (r = 0.61); old industrial land use for these 10 sites ranges from 3-79% (mean 35%, median 32%), illustrating that land use alone is insufficient to identify high leverage areas. 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.

[11] 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, 67 were sampled during WYs 2015-2019, 87 had water concentrations for PCBs, and 88 had water concentrations for HgT.

[12] There are 91 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 in which only the particle ratio is comparable to the other manually collected data.

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, Ettie Street Pump Station, and South Linden Ave. SD. Sites ranked highest based on stormwater concentrations and those ranked highest based on EPCs corresponded well. Six 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 (35th) because of very low SSC.

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 the 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.

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 water concentration of <1,330 pg/L (Table 5) and none of the 87 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).

Table 5. PCB and total mercury (HgT) water concentrations and estimated particle concentrations (EPCs) measured in the Bay Area 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, 2013-2014	0.58	87%	54%	8222	1	448	1	350	46.5	19	62	54	66
Industrial Rd Ditch	San Mateo	2016	0.23	85%	79%	6139	2	160	3	535	27	14	72	26	83
Line 12H at Coliseum Way	Alameda	2017	0.97	71%	10%	2601	3	156	4	602	19	36	45	60	59.5
Santa Fe Channel	Contra Costa	2011	3.3	69%	3%	1295	4	198	2	570	22.5	86	12.5	151	23
Gull Dr SD	San Mateo	2016	0.30	78%	54%	903	5	39.8	12	320	53	5.4	85	43	74
Pulgas Pump Station-North	San Mateo	2011	0.55	84%	52%	893	6	60.3	7	400	40	24	56.5	60	59.5
Outfall to Colma Ck on service rd nr Littlefield Ave. (359)	San Mateo	2017	0.09	88%	87%	788	7	33.9	17	210	69	9	82	43	72.5
Outfall to Lower Silver Creek	Santa Clara	2015	0.17	79%	78%	783	8	44.6	11	420	37	24	56.5	57	64
Ettie Street Pump Station	Alameda	2011	4.0	75%	22%	759	9	59.0	8	690	14	55	25.5	80	51
S Linden Ave SD (291)	San Mateo	2017	0.78	88%	57%	736	10	11.8	35	775	10	12	78	16	88
Gull Dr Outfall	San Mateo	2016 & 2018	0.43	75%	42%	599	11	49.5	10	180	74.5	7.6	83	62	57
Austin Ck at Hwy 37	Solano	2017	4.9	61%	2%	573	12	11.5	37	640	17	13	76.5	20	87
Ridder Park Dr Storm Drain	Santa Clara	2015	0.50	72%	57%	488	13	55.5	9	330	51	37	44	114	34
MeekerWest	Contra Costa	2018	0.41	70%	69%	458	14	28.0	22	530	29	32	48	61	58

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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
Outfall at Gilman St.	Alameda	2016 & 2018	0.84	76%	32%	451	15	37.2	14	2820	3	233	5	81	49
Line 12I at Coliseum Way	Alameda	2017	3.4	63%	9%	398	16	37.0	15	129	82	12	80	93	44.5
Sunnyvale East Channel	Santa Clara	2011	15	59%	4%	343	17	96.6	5	200	71	50	29	250	14
Line 3A-M at 3A-D	Alameda	2015	0.88	73%	12%	337	18	24.8	23	1170	4	86	12.5	74	53
SMBUR85A	San Mateo	2019	0.42	81%	44%	334	19	31.1	19	440	34	41	40	93	44.5
Line 12M at Coliseum Way	Alameda	2017, 2019	5.3	69%	22%	280	20	82.7	6	348	48	89	11	263	13
North Richmond Pump Station	Contra Costa	2011-2014	2.0	62%	18%	241	21	13.2	33	810	9	47	30.5	58	62
Seabord Ave Storm Drain SC-050GAC580	Santa Clara	2015	1.4	81%	68%	236	22	19.9	27	550	25	47	30.5	85	46
Line 4-E	Alameda	2015	2.0	81%	27%	219	23	37.4	13	350	46.5	59	22	170	20
Kirker Ck at Pittsburg Antioch Hwy and Verne Roberts Cir	Contra Costa	2017 & 2018	36.67	18%	5%	219	24	5.64	57	540	26	16	66	27	81.5
Glen Echo Creek	Alameda	2011	5.5	39%	0%	191	25	31.1	20	210	70	73	17	348	11
Seabord Ave Storm Drain SC-050GAC600	Santa Clara	2015	2.8	62%	18%	186	26	13.5	32	530	28	38	42.5	73	54
Line 12F below PG&E station	Alameda	2017	10	56%	3%	184	27	21.0	26	373	42	43	37	114	34
South Linden Pump Station	San Mateo	2015	0.14	83%	22%	182	28	7.81	50	680	15	29	52	43	72.5
Taylor Way SD	San Mateo	2016	0.27	67%	11%	169	29	4.23	62	1156	5	29	53	25	84
Line 9-D	Alameda	2015	3.6	78%	46%	153	30	10.5	41	240	63.5	17	64.5	69	56
Meeker Slough	Contra Costa	2015 & 2018	7.3	64%	6%	140	31	7.91	49	770	11	45	33	57	65
Rock Springs Dr Storm Drain	Santa Clara	2015	0.83	80%	10%	128	32	5.25	58	930	7	38	42.5	41	75.5

WYs 2015 through 2019 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
GR outfall 066GAC900	Santa Clara	2018	0.17	66%	1%	125	33	3.36	68	644	16	17	63	27	81.5
Charcot Ave Storm Drain	Santa Clara	2015	1.8	79%	24%	123	34	14.9	30	560	24	67	19	121	32
Veterans Pump Station	San Mateo	2015	0.52	67%	7%	121	35	3.52	67	470	32	14	71	29	80
Gateway Ave Storm Drain	San Mateo	2015	0.36	69%	52%	117	36	5.24	59	440	33	20	61	45	70.5
Guadalupe River at Hwy 101	Santa Clara	2003-2006, 2010, 2012-2014	233	39%	3%	115	37	23.7	24	3600	2	603	1	560	5
Line 9D1 PS at outfall to Line 9D	Alameda	2016	0.48	88%	62%	110	38	18.1	29	720	13	118	7.5	164	21
Tunnel Ave Ditch	San Mateo	2016	3.0	47%	8%	109	39	10.5	39	760	12	73	18	96	40.5
Valley Dr SD	San Mateo	2016	5.2	21%	7%	109	40	10.4	42	276	61	27	55	96	40.5
Runnymede Ditch	San Mateo	2015	2.1	53%	2%	108	41	28.5	21	190	73	52	28	265	12
E Gish Rd Storm Drain	Santa Clara	2015	0.45	84%	70%	99	42	14.4	31	590	21	85	14	145	26
Line 3A-M-1 at Industrial Pump Station	Alameda	2015	3.4	78%	26%	96	43	8.92	44	340	49	31	49	93	43
Line 13A at end of slough	Alameda	2016	0.83	84%	68%	96	44	34.3	16	331	50	118	7.5	357	9
Line 12A at Shellmound	Alameda	2018	10.48	41%	6%	95	45	10.8	38	406	38	46	32	114	34
SC100CTC500A	Santa Clara	2019	3.01	54%	7%	94	46	10.5	40	386	41	43	36	111	36.5
Rosemary St SD 066GAC550C	Santa Clara	2017	3.7	64%	11%	89	47	4.11	64	591	20	27	54	46	69

WYs 2015 through 2019 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
North Fourth St SD 066GAC550B	Santa Clara	2017	1.0	68%	27%	87	48	4.17	63	477	31	23	59	48	67.5
Zone 4 Line A	Alameda	2007-2010	4.2	68%	12%	82	49	18.4	28	170	76	30	51	176	19
Forbes Blvd Outfall	San Mateo	2016	0.40	79%	0%	80	50	1.84	77	637	18	15	70	23	85
Storm Drain near Cooley Landing	San Mateo	2015	0.11	73%	39%	79	51	6.47	55	430	35	35	46	82	48
Lawrence & Central Expwys SD	Santa Clara	2016	1.2	66%	1%	78	52	4.51	61	226	65	13	73.5	58	63
Condensa St SD	Santa Clara	2016	0.24	70%	32%	74	53	2.60	75	329	52	12	81	35	78
San Leandro Creek	Alameda	2011-2014	8.9	38%	0%	66	54	8.61	47	860	8	117	9	136	30
Oddstad Pump Station	San Mateo	2015	0.28	74%	11%	62	55	9.20	43	370	43	55	25.5	148	25
Line 4-B-1	Alameda	2015	1.0	85%	28%	57	56	8.67	46	280	58.5	43	35	152	22
Line 12A under Temescal Ck Park	Alameda	2016	9.4		1%	54	57	7.80	51	290	57	42	38	143	27
Victor Nelo PS Outfall	Santa Clara	2016	0.58	87%	4%	51	58	2.29	76	351	44	16	68	45	70.5
SMBUR164A	San Mateo	2019	0.98	71%	37%	48	59	3.87	65	276	60	22	60	80	50
Line 12K at Coliseum Entrance	Alameda	2017	16	31%	1%	48	60	32.0	18	429	36	288	4	671	4
GR outfall 066GAC850	Santa Clara	2018	3.35	61%	6%	45	61	6.63	53	107	85	16	67	149	24
Haig St SD	Santa Clara	2016	2.1	72%	10%	43	62	1.45	79	194	72	7	84	34	79
SC100CTC400A	Santa Clara	2019	1.38	63%	8%	38	63	2.92	71	303	56	23	58	77	52
Colma Ck at S. Linden Blvd	San Mateo	2017	35	41%	3%	37	64	2.65	74	215	68	15	69	71	55
Line 12J at mouth to 12K	Alameda	2017	8.8	30%	2%	35	65	6.48	54	401	39	73	16	183	18

WYs 2015 through 2019 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
Wildcat Creek	Contra Costa	2019	23.44	53%	1%	32	66	NA	NA	No data	No data	No data	No data	**	NR
S Spruce Ave SD at Mayfair Ave (296)	San Mateo	2017	5.1	39%	1%	30	67	3.36	69	350	45	39	41	111	36.5
Lower Coyote Creek	Santa Clara	2005	327	22%	1%	30	68	4.58	60	240	63.5	34	47	142	29
Calabazas Creek	Santa Clara	2011	50	44%	3%	29	69	11.5	36	150	80	59	22	393	7
E Outfall to San Tomas at Scott Blvd	Santa Clara	2016	0.67	66%	31%	27	70	2.80	73	127	83	13	73.5	103	39
San Lorenzo Creek	Alameda	2011	125	13%	0%	25	71	12.9	34	180	74.5	41	39	228	16
Stevens Creek	Santa Clara	2011	26	38%	1%	23	72	8.16	48	220	66.5	77	15	350	10
Guadalupe River at Foxworthy Road/ Almaden Expressway	Santa Clara	2010	107	22%	0%	19	73	3.12	70	4090	1	529	2	129	31
Duane Ct and Ave Triangle SD	Santa Clara	2016	1.0	79%	23%	17	74	0.832	81	268	62	13	75	48	67.5
Lower Penitencia Creek	Santa Clara	2011, 2015	12	65%	2%	16	75	1.59	78	160	77.5	17	64.5	106	38
Borel Creek	San Mateo	2011	3.2	31%	0%	15	76	6.13	56	160	77.5	58	24	363	8
San Tomas Creek	Santa Clara	2011	108	33%	0%	14	77	2.83	72	280	58.5	59	22	211	17
Little Bull Valley	Contra Costa	2018	0.02	67%	2%	13	78	0.543	82	312	55	13	76.5	41	75.5
Zone 5 Line M	Alameda	2011	8.1	34%	5%	13	79.5	21.1	25	570	22.5	505	3	886	3
Belmont Creek	San Mateo	2011	7.2	27%	0%	13	79.5	3.60	66	220	66.5	53	27	241	15
BayPoint	Contra Costa	2019	4.35	21%	0%	12	81	NA	NA	140	81	NA	NA	**	NR

WYs 2015 through 2019 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
Refugio Ck at Tsushima St	Contra Costa	2017	11	23%	0%	9	82	0.533	83	509	30	30	50	59	61
Walnut Creek	Contra Costa	2011	232	15%	0%	7	83	8.83	45	70	87	94	10	1343	2
Rodeo Creek at Seacliff Ct. Pedestrian Br.[13]	Contra Costa	2017, 2019	23.41	2%	1%	6	84	7.21	52	93	86	65	20	1354	1
Lower Marsh Creek	Contra Costa	2011-2014	84	10%	0%	3	85	1.45	80	110	84	44	34	400	6
Mount Diablo Creek	Contra Costa	2019	75.56	9%	0%	2	86	NA	NA	157	79	NA	NA	**	NR
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
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
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
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
East Antioch nr Trembath	Contra Costa	2017	5.3	26%	3%	NR[a]	NR[a]	<MDL	NR[a]	313	54	12	79	39	77

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

[13] Rodeo Creek was sampled in WY 2017 at Seacliff Ct, Pedestrian Bridge. In WY 2019, the bridge was closed and instead sampling occurred downstream 370 m at Viewpoint Blvd. The results from the two nearby locations are combined in this row.

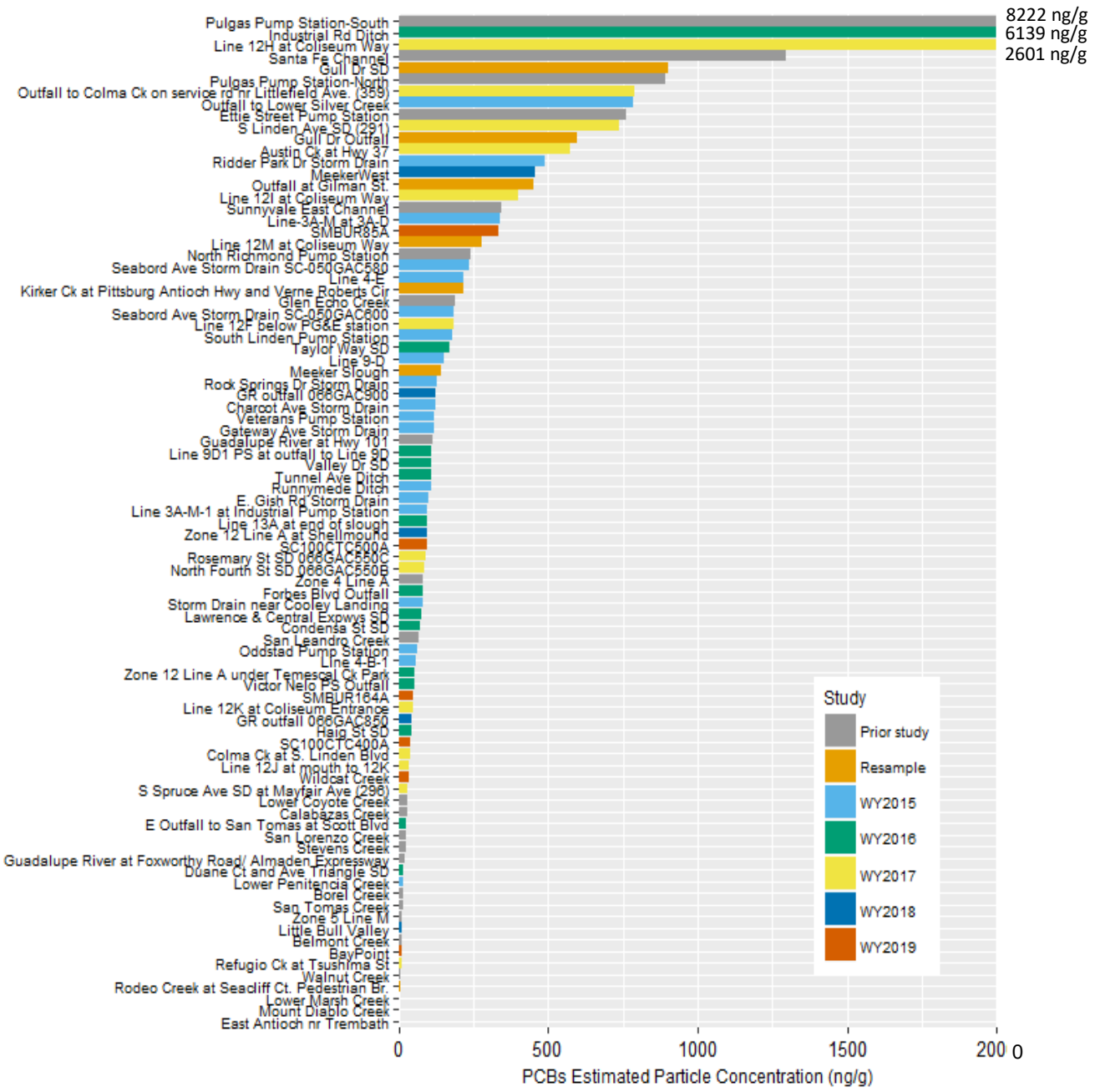


Figure 3. PCB estimated particle concentrations (EPCs) for watershed and catchment sampling sites measured in water years 2003-2019 (where more than one storm was sampled at a site, the reported concentration is the average of the storm composite samples). Note that PCB EPCs for Pulgas Pump Station-South (8,222 ng/g), Industrial Road Ditch (6,139 ng/g), and Line 12H at Coliseum Way (2,601 ng/g) extend beyond upper the bound of the graph. The sample count represented by each bar in the graph is provided in Appendix D.

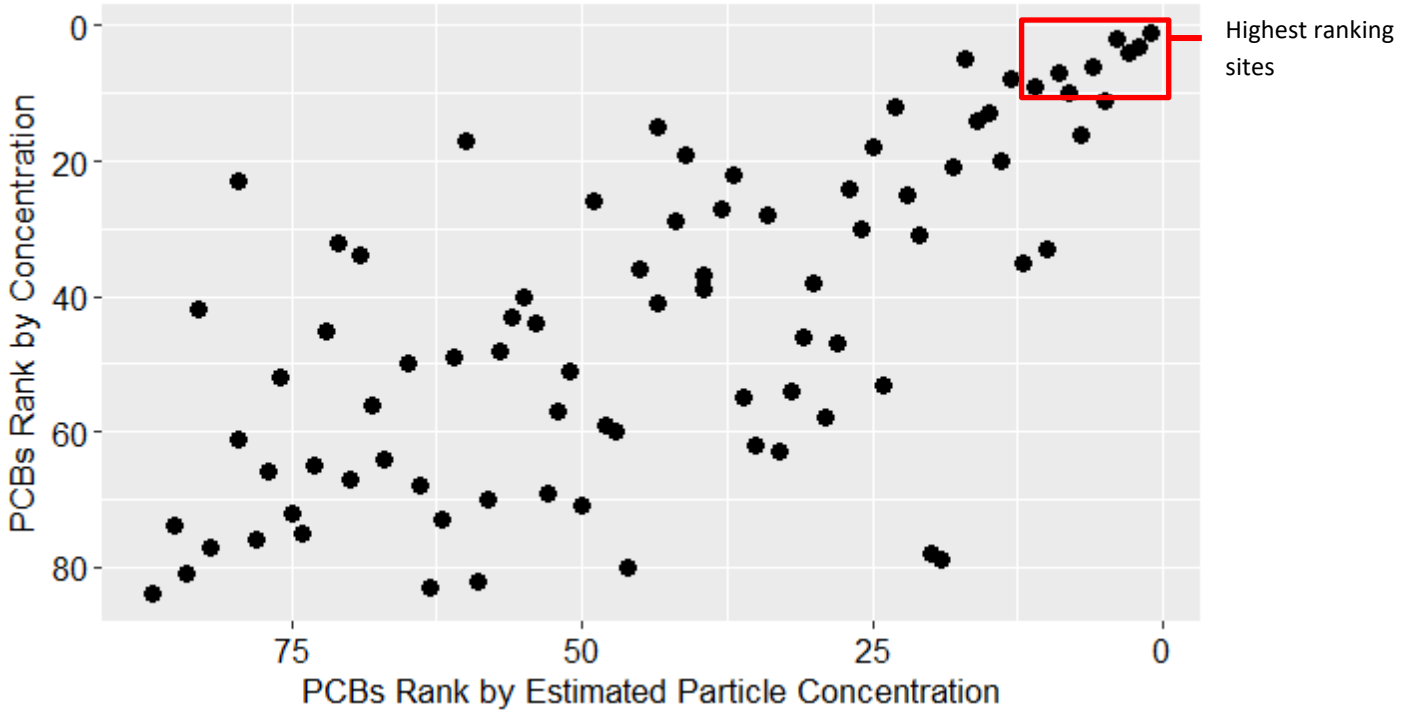


Figure 4. Comparison of site rankings for PCBs based on estimated particle concentrations (EPCs) and on water concentrations. 1 = highest rank; 84 = lowest rank.

3.3 Mercury stormwater concentrations and estimated particle concentrations

Total mercury concentrations in composite water samples ranged 110-fold from 5.4 to 603 ng/L among the 88 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), 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), San Leandro Creek at San Leandro Blvd. (0% old industrial) and Walnut Creek (0% old industrial) (Table 4). There is a weak and positive relationship between mercury concentrations and old industrial land use, in contrast to the stronger relationship between PCB concentrations and industrial land use. None of the top 10 sites for Hg were among the top 10 for PCBs, 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 88 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[14].

Estimated particle concentrations of HgT ranged between 45 and 4,090 ng/g. 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., Line 3A-M at 3A-D, Taylor Way SD, San Pedro Storm Drain, Rock Springs Dr. Storm Drain, San Leandro Creek, North Richmond Pump Station and South Linden Ave. SD (Table 4; Figure 5). Only one of these 10 sites was among the 10 most highly-ranked sites for PCBs (South Linden Ave. SD), 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 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.

[14] 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).

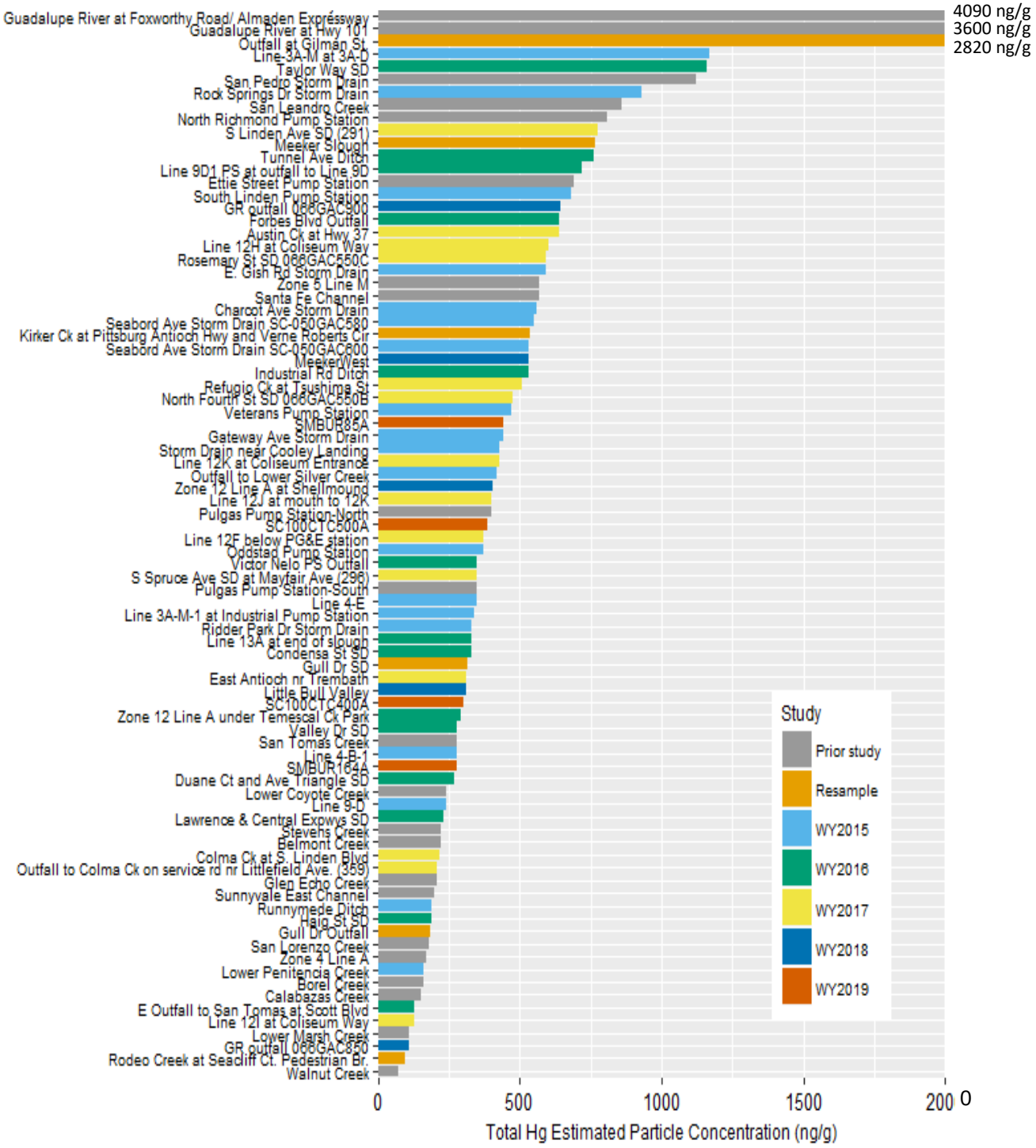


Figure 5. All sampling locations measured to date (water years 2003-2019) ranked by total mercury (HgT) estimated particle concentrations (EPCs). The sample count represented by each bar in the graph is provided in Appendix D.

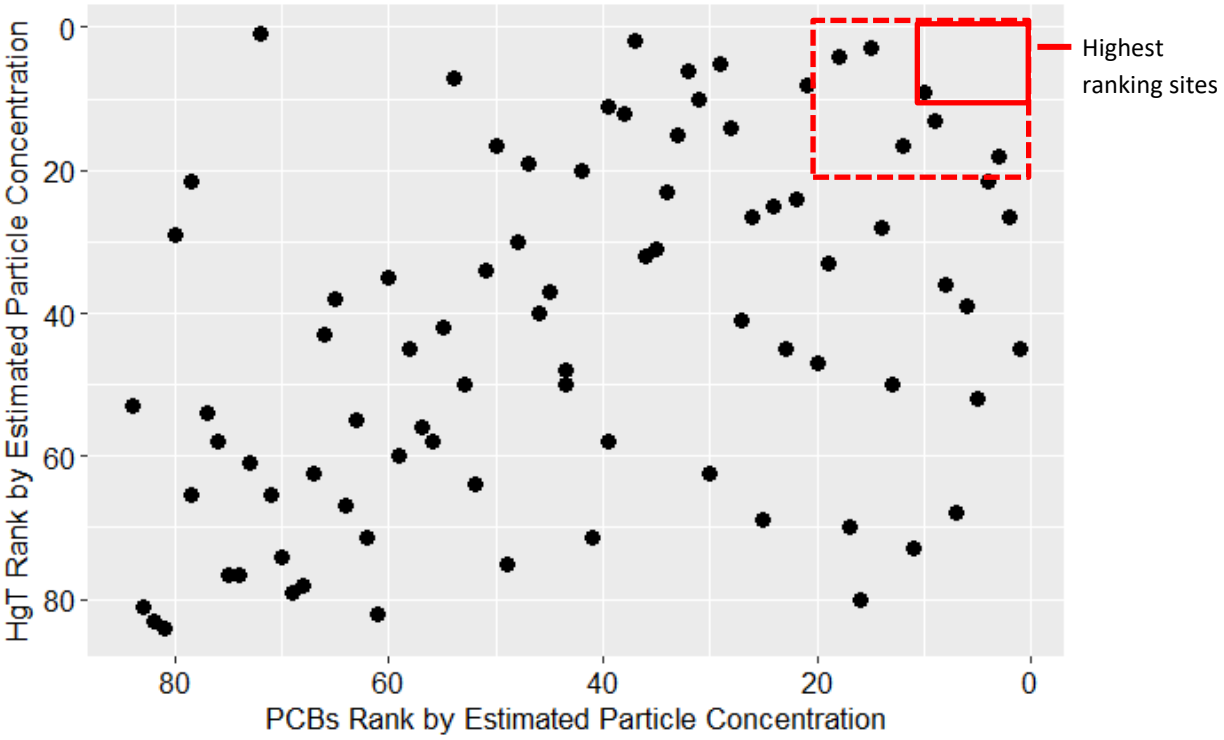


Figure 6. Comparison of site rankings for PCB and total mercury (HgT) estimated particle concentrations (EPCs). 1 = highest rank; 84 = lowest rank. One watershed ranks in the top 10 for both PCBs and HgT (in the solid red box), and seven watersheds rank in the top 20 for both pollutants (in the dashed red box).

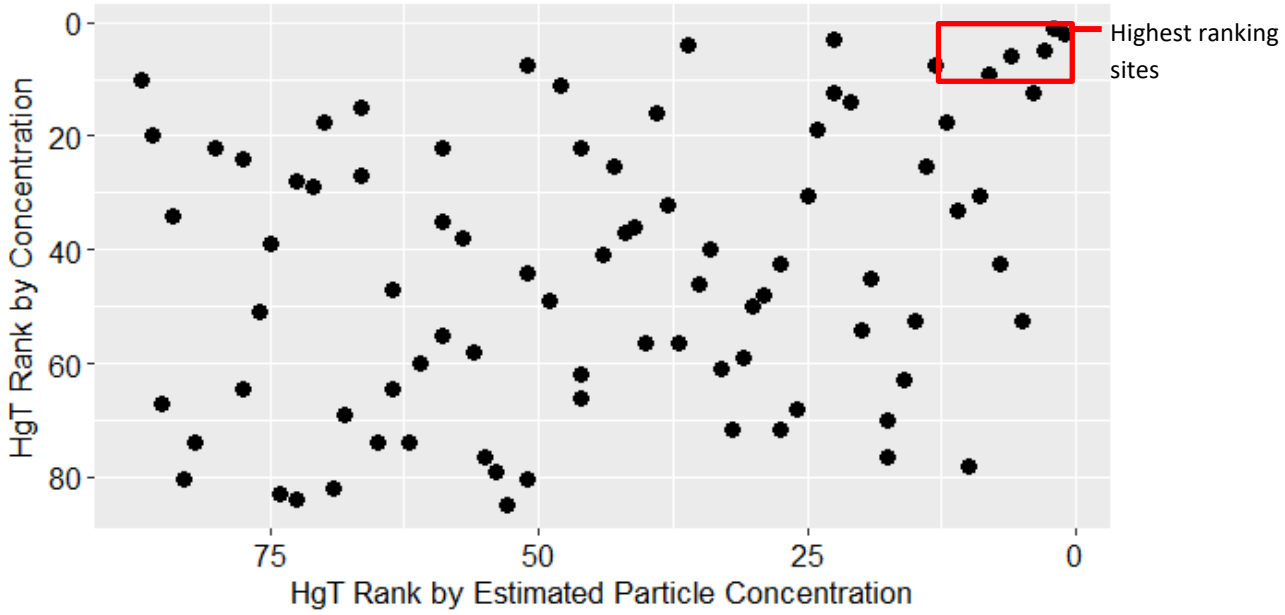


Figure 7. Comparison of site rankings for total mercury (HgT) estimated particle concentrations and water concentrations. 1 = highest rank; 85 = lowest rank.

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[15] 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). Total As concentrations of this magnitude have been measured in the Bay Area previously (Guadalupe River at Hwy 101: mean=1.9 µg/L; Zone 4 Line A: mean=1.6 µg/L) and are lower than those measured at the 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, likely were biased low relative to those measured with sampling designs that included low flow and baseflow samples (North Richmond Pump Station: 2.7 µg/L; Guadalupe River at Hwy 101: 1.3 µg/L; Zone 4 Line A: 0.48 µg/L; Mallard Island: 0.46

[15] Trace elements were not measured in WYs 2018 or 2019.

µg/). Therefore, care should be taken if Se concentrations reported here were to be used in the future to estimate regional loads.

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[16] (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 the 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[17]. 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 a negative correlation with arsenic.

These 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 correlation 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 correlation between PCBs and HgT (McKee et al., 2012). This difference might reflect a stronger focus on PCBs during the WY 2015-2019 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 small sample size without sample representation along

[16] 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).

[17] 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.

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.

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)	0.4												
Arsenic (ug/mg)	-0.61	-0.03											
Cadmium (ug/mg)	-0.28	0.25	0.67										
Copper (ug/mg)	-0.07	0.15	0.56	0.743									
Lead (ug/mg)	-0.25	0.16	0.583	0.863	0.711								
Zinc (ug/mg)	-0.24	-0.24	0.497	0.801	0.894	0.691							
Area (sq km)	-0.44	-0.28	0.00	-0.24	-0.43	-0.08	-0.41						
% Imperviousness	0.567	0.28	-0.35	0.00	0.181	-0.10	0.167	-0.76					
% Old Industrial	0.61	0.26	-0.48	-0.2	-0.21	-0.25	-0.15	-0.55	0.754				
% Clay (<0.0039 mm)	0.23	0.08	-0.12	0.046	-0.23	-0.03	-0.16	-0.19	-0.03	0.081			
% Silt (0.0039 to <0.0625 mm)	-0.07	0.15	-0.14	-0.17	0.274	0.00	0.174	0.147	0.051	-0	-0.37		
% Sands (0.0625 to <2.0 mm)	-0.13	-0.19	0.094	0.006	-0.02	0.094	-0.03	0.259	-0.09	-0.08	-0.83	-0.07	
TOC (mg/mg)	0.224	0.4	0.70	0.60	0.875	0.466	0.756	-0.46	0.406	0.157	-0.2	0.204	-0.02

p value <0.05

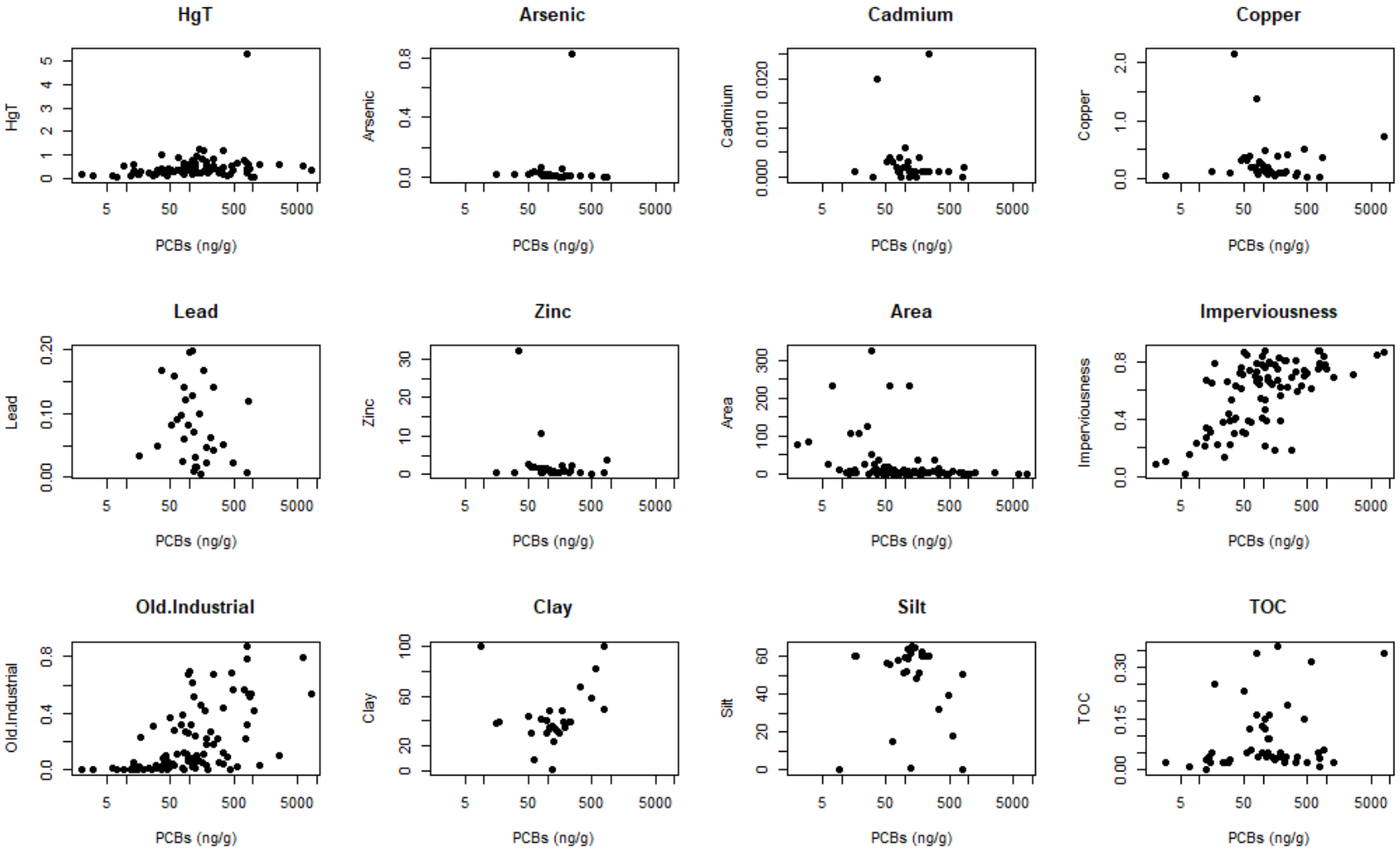


Figure 8. Relationships between observed estimated particle concentrations (EPCs) of PCBs and total mercury (HgT), trace elements, and impervious land cover, old industrial land use, grainsize (clay and silt), and total organic carbon (TOC).

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 higher concentrations and loads of PCBs and HgT (McKee et al., 2012; McKee et al., 2015). RMP sampling for PCBs and HgT since WY 2003 has included 33% 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 (31%). In Contra Costa County, only 15%[18] 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, 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 to better identify areas for potential management.

4. Summary and Recommendations

This report presents all available stormwater data[19] collected since WY 2003 when stormwater studies first began through SFEI contracts or RMP projects, not just the data collected for this WY 2015-2019 reconnaissance monitoring study (total of 91 sites). Prior to WY 2015, studies mostly employed Method 1, whereas beginning in WY 2015, sampling employed Methods 2 and 3.

> 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 2015-2019, composite water samples were collected at 66 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[20]. Sampling efficiency was increased, when possible, by sampling two nearby sites during a single storm. At three of these sites, 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

[18] 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.
[19] Similar data collected by BASMAA in Santa Clara and San Mateo Counties is not included in this report.
[20] Another 25 sites were sampled prior to WY 2015.

process that focused on older industrial landscapes. The following recommendations are based on the WY 2015-2019 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 2015-2019 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.
- Finish development of an advanced data analysis method for identifying and ranking watersheds of management interest for further characterization or investigation. This recommendation will be fully implemented as of the 2020 calendar year and possibly be ready to contribute to site selection in WY 2021. 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.

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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 (km²)**	**Impervious Surface (%)**	**Industrial (%)**	**Sampling Objective**	**Commentary**	**Proposed Sampling Triggers**	**Gauge number**	**Area at USGS Gauge (sq²**
Alameda Creek at EBRPD Bridge at Quarry Lakes	913	8.5	2.3	2, 4	Operating flow and sediment gauge at Niles just upstream will allow the computation of 1st order loads to support the calibration of the RWSM for a large, urbanizing type watershed.	7" of antecedent rainfall in Livermore (reliable web published rain gauge), after at least an annual storm has already occurred (~2000 cfs at the Niles gauge), and a forecast for the East Bay interior valleys of 2-3" over 12 hrs.	11179000	906
Dry Creek at Arizona Street (purposely downstream from historic industrial influences)	25.3	3.5	0.3	2, 4	Operating flow gauge at Union City just upstream will allow the computation of 1st order loads to support the calibration of the RWSM for mostly undeveloped land use type watersheds.	7" of antecedent rainfall in Union City, after at least a common annual storm has already occurred (~200 cfs at the Union City gauge), and a forecast for the East Bay Hills of 2-3" over 12 hrs.	11180500	24.3
San Francisquito Creek at University Avenue (as far down as possible to capture urban influence upstream from tide)	81.8	11.9	0.5	2, 4	Operating flow gauge at Stanford upstream will allow the computation of 1st order loads to support the calibration of the RWSM for larger mixed land use type watersheds. Sample pair with Matadero Ck.	7" of antecedent rainfall in Palo Alto, after at least a common annual storm has already occurred (~1000 cfs at the Stanford gauge), and a forecast for the Peninsula Hills of 3-4" over 12 hrs.	11164500	61.1
Matadero Creek at Waverly Street (purposely downstream from the railroad)	25.3	22.4	3.7	2, 4	Operating flow gauge at Palo Alto upstream will allow the computation of 1st order loads to support the calibration of the RWSM for mixed land use type watersheds. Sample pair with San Francisquito Ck.	7" of antecedent rainfall in Palo Alto, after at least a common annual storm has already occurred (~200 cfs at the Palo Alto gauge), and a forecast for the Peninsula Hills of 3-4" over 12 hrs.	11166000	18.8
Colma Creek at West Orange Avenue or further downstream (as far down as possible to capture urban and historic influence upstream from tide)	27.5	38	0.8	2, 4 (possibly 1)	Historic flow gauge (ending 1996) in the park a few hundred feet upstream will allow the computation of 1st order loads estimates to support the calibration of the RWSM for mixed land use type watersheds.	Since this is a very urban watershed, precursor conditions are more relaxed: 4" of antecedent rainfall, and a forecast for South San Francisco of 2-3" over 12 hrs. Measurement of discharge and manual staff plate readings during sampling will verify the historic rating.	11162720	27.5

Appendix B – Sampling Method Development

The monitoring protocol implemented in WYs 2015-2019 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 2015-18 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)[21] 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;

[21] 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)[22] 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.

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

[22] 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).

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.

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.

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.

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

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

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

Attachment D.4

PCBs and mercury concentrations by sample date and sample station for all monitoring conducted by SCVURPPP and the RMP STLS in the Santa Clara Basin in WY 2015-WY 2019

PCBs and mercury concentrations by sample date and sample station for all monitoring conducted by SCVURPPP and the RMP STLS in the Santa Clara Valley

LIST OF TABLES

Table 1. PCBs and mercury concentrations in MS4 sediment by sample date and sample station for all monitoring conducted by SCVURPPP in the Santa Clara Basin in WY 2015-WY 2019 1

Table 2. PCBs and mercury concentrations in stormwater by sample date and sample station for all monitoring conducted by SCVURPPP in the Santa Clara Basin by SCVURPPP and the RMP STLS in WY 2015-WY 2019 10

ACRONYMS

MS4	Municipal Separate Storm Sewer System
PCBs	Polychlorinated Biphenyls
RMP	San Francisco Bay Regional Monitoring Program
SCVURPPP	Santa Clara Basin Urban Runoff Pollution Prevention Program
STLS	Small Tributaries Loading Strategy
SSC	Suspended sediment concentration
WY	Water Year

NOTES

PCBs calculated as the sum of RMP 40 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)

Table 1. PCBs and mercury concentrations in MS4 sediment by sample date and sample station for all monitoring conducted by SCVURPPP in the Santa Clara Basin in WY 2015-WY 2019

CITY	WY	Site ID	Sample Date	Latitude	Longitude	PCBs (mg/kg)	Hg (mg/kg)
Campbell	WY 2015	SC-WVC-01-A	1/15/2015	37.26421	-121.95629	0.01533	0.246
Campbell	WY 2015	SC-WVC-03-A	1/15/2015	37.27890	-121.94358	0.00852	0.091
Campbell	WY 2015	SC-WVC-03-B	1/15/2015	37.27533	-121.94531	0.005701	0.09
Campbell	WY 2015	SC-WVC-03-C	1/15/2015	37.27790	-121.94450	0.00854	0.074
Campbell	WY 2015	SC-WVC-04-A	1/15/2015	37.27844	-121.93964	0.01167	0.097
Campbell	WY 2015	SC-WVC-05-A	1/15/2015	37.27185	-121.95322	0.04873	0.287
Campbell	WY 2015	SC-WVC-06-A	1/15/2015	37.27486	-121.94927	0.04793	0.242
Campbell	WY 2015	SC-WVC-07-A	1/15/2015	37.27112	-121.95309	0.01812	0.085
Campbell	WY 2015	SC-WVC-10-A	1/15/2015	37.27628	-121.94309	0.11271	0.551
Campbell	WY 2015	SC-WVC-15-A	1/15/2015	37.29221	-121.93512	0.00013	0.035
Campbell	WY 2015	SC-WVC-16-A	1/15/2015	37.28432	-121.97682	0.01834	0.064
Campbell	WY 2015	SC-WVC-11-A	1/16/2015	37.28038	-121.94782	0.02507	0.112
Campbell	WY 2015	SC-WVC-12-A	1/16/2015	37.28287	-121.94514	0.00712	0.076
Campbell	WY 2015	SC-WVC-13-A	1/16/2015	37.28412	-121.94412	0.00708	0.152
Campbell	WY 2015	SC-WVC-14-A	1/16/2015	37.28617	-121.94128	0.03266	0.273
Cupertino	WY 2015	SC-CUO-02-B	1/16/2015	37.33744	-122.02079	0.00637	0.042
Milpitas	WY 2015	SC-MIL-01-A	1/28/2015	37.41502	-121.88781	0.02216	0.078
Milpitas	WY 2015	SC-MIL-03-A	1/28/2015	37.40813	-121.90263	0.00362	0.06
Milpitas	WY 2015	SC-MIL-04-A	1/28/2015	37.42060	-121.88624	0.00918	0.151
Milpitas	WY 2015	SC-MIL-06-A	1/28/2015	37.43147	-121.89459	0.00085	0.056
Milpitas	WY 2015	SC-MIL-07-A	1/28/2015	37.42841	-121.90349	0.00811	0.097
Milpitas	WY 2015	SC-MIL-08-A	1/28/2015	37.44812	-121.90961	0.00174	0.037
Milpitas	WY 2015	SC-MIL-10-A	1/28/2015	37.41045	-121.89321	0.00836	0.038
Milpitas	WY 2015	SC-MIL-17-A	1/28/2015	37.42409	-121.88819	0.001	0.048
Milpitas	WY 2015	SC-MIL-18-A	1/28/2015	37.42643	-121.92057	0.00198	0.138
Milpitas	WY 2015	SC-MIL-02-A	4/16/2015	37.40689	-121.89477	0.0052	0.33
Milpitas	WY 2015	SC-MIL-13-A	4/16/2015	37.43368	-121.90733	0.009586	0.101
Mountain View	WY 2015	SC-MOV-01-A	1/29/2015	37.38114	-122.07092	0.00623	0.069
Mountain View	WY 2015	SC-MOV-01-C	1/29/2015	37.38222	-122.06915	0.00506	0.045
Mountain View	WY 2015	SC-MOV-03-A	1/29/2015	37.40532	-122.06828	0.00586	0.055
Mountain View	WY 2015	SC-MOV-04-A	1/29/2015	37.40851	-122.07205	0.07291	0.081
Mountain View	WY 2015	SC-MOV-04-C	1/29/2015	37.40840	-122.07651	0.34135	0.156
Mountain View	WY 2015	SC-MOV-09-A	1/29/2015	37.38783	-122.06712	0.02238	0.187
Palo Alto	WY 2015	SC-PAO-08-A1	1/29/2015	37.41743	-122.14104	0.02314	0.106
Palo Alto	WY 2015	SC-PAO-14-A	1/29/2015	37.44447	-122.13989	0.01191	0.033
Palo Alto	WY 2015	SC-PAO-15-A	1/29/2015	37.42654	-122.13920	0.05056	0.047
Palo Alto	WY 2015	SC-PAO-01-A	2/4/2015	37.42352	-122.11498	0.01114	0.056
Palo Alto	WY 2015	SC-PAO-02-A	2/4/2015	37.43175	-122.10899	0.15865	0.103
Palo Alto	WY 2015	SC-PAO-05-A	2/4/2015	37.42883	-122.10414	0.10164	0.072
Palo Alto	WY 2015	SC-PAO-05-B	2/4/2015	37.42939	-122.10505	0.428	0.225
Palo Alto	WY 2015	SC-PAO-09-A	2/4/2015	37.40795	-122.15010	0.00994	0.042
Palo Alto	WY 2015	SC-PAO-16-A	2/4/2015	37.42538	-122.09973	0.02153	0.07
Palo Alto	WY 2015	SC-PAO-16-B	2/4/2015	37.42430	-122.09865	0.03664	0.072
Palo Alto	WY 2015	SC-PAO-18-A	2/4/2015	37.44273	-122.15655	0.19163	0.117

CITY	WY	Site ID	Sample Date	Latitude	Longitude	PCBs (mg/kg)	Hg (mg/kg)
Palo Alto	WY 2015	SC-PAO-18-B	2/4/2015	37.44220	-122.15713	1.4489	0.82
Palo Alto	WY 2017	SC-PAO-18-G	5/15/2017	37.44036	-122.15763	0.19113	0.12
Palo Alto	WY 2017	SC-PAO-18-H	5/15/2017	37.44072	-122.15790	0.07828	0.038
Palo Alto	WY 2017	SC-PAO-18-I	5/15/2017	37.44086	-122.15814	0.03092	0.147
Palo Alto	WY 2017	SC-PAO-18-J	5/15/2017	37.44117	-122.15810	0.02365	0.051
Palo Alto	WY 2017	SC-PAO-18-K	5/15/2017	37.44128	-122.15756	0.02889	0.054
Palo Alto	WY 2017	SC-PAO-18-L	5/15/2017	37.44184	-122.15749	0.0284	0.08
Palo Alto	WY 2017	SC-PAO-18-M	5/15/2017	37.44220	-122.15713	0.04547	0.113
Palo Alto	WY 2017	SC-PAO-18-C	6/13/2017	37.44105	-122.16002	0.01932	0.0733
Palo Alto	WY 2017	SC-PAO-18-D	6/13/2017	37.44094	-122.15985	0.03791	0.0813
Palo Alto	WY 2019	SC-PAO-08-A	8/20/2019	37.41609	-122.14466	0.0266	0.17
Palo Alto	WY 2019	SC-PAO-08-B	8/20/2019	37.41761	-122.14334	0.4435	0.19
Palo Alto	WY 2019	SC-PAO-08-C	8/20/2019	37.41709	-122.14123	0.138	0.09
San Jose	WY 2015	SC-SJY-53-A	12/9/2014	37.28528	-121.84302	0.00533	0.163
San Jose	WY 2015	SC-SJY-54-A	12/9/2014	37.23426	-121.90007	0.005268	0.451
San Jose	WY 2015	SC-SJY-55-A	12/9/2014	37.23935	-121.79379	0.004497	0.079
San Jose	WY 2015	SC-SJY-57-A	12/9/2014	37.16699	-121.68965	0.008787	0.064
San Jose	WY 2015	SC-SJY-58-A	12/9/2014	37.28735	-121.81681	0.02013	0.429
San Jose	WY 2015	SC-SJY-60-A	12/9/2014	37.26024	-121.89057	0.00807	0.089
San Jose	WY 2015	SC-SJY-62-A	12/9/2014	37.32292	-121.79652	0.002633	0.031
San Jose	WY 2015	SC-SJY-47-A	12/10/2014	37.31061	-121.86790	0.11627	1.19
San Jose	WY 2015	SC-SJY-47-B	12/10/2014	37.30918	-121.86655	0.75377	0.635
San Jose	WY 2015	SC-SJY-47-C	12/10/2014	37.31120	-121.86901	0.25109	0.411
San Jose	WY 2015	SC-SJY-47-D	12/10/2014	37.30998	-121.86783	1.9726	1.81
San Jose	WY 2015	SC-SJY-48-A	12/10/2014	37.30739	-121.86522	0.127678	0.035
San Jose	WY 2015	SC-SJY-51-A	12/10/2014	37.29397	-121.85206	0.007122	0.076
San Jose	WY 2015	SC-SJY-51-B	12/10/2014	37.29169	-121.85219	0.126095	0.149
San Jose	WY 2015	SC-SJY-51-C	12/10/2014	37.29015	-121.84992	0.02022	0.212
San Jose	WY 2015	SC-SJY-52-A	12/10/2014	37.29622	-121.84987	0.01653	0.119
San Jose	WY 2015	SC-SJY-73-A	12/10/2014	37.30283	-121.84235	0.009198	0.4
San Jose	WY 2015	SC-SJY-77-A	12/10/2014	37.31061	-121.84820	0.01085	0.127
San Jose	WY 2015	SC-SJY-37-A	1/6/2015	37.32384	-121.90316	0.01559	0.174
San Jose	WY 2015	SC-SJY-38-A	1/6/2015	37.31895	-121.90578	0.02211	0.173
San Jose	WY 2015	SC-SJY-39-A	1/6/2015	37.31593	-121.90398	0.02855	0.269
San Jose	WY 2015	SC-SJY-39-B	1/6/2015	37.31371	-121.90415	0.03582	0.117
San Jose	WY 2015	SC-SJY-40-A	1/6/2015	37.31478	-121.88844	0.02591	4.52
San Jose	WY 2015	SC-SJY-41-A	1/6/2015	37.31268	-121.88446	0	0.368
San Jose	WY 2015	SC-SJY-44-A	1/6/2015	37.30144	-121.87974	0.03432	1.25
San Jose	WY 2015	SC-SJY-45-A	1/6/2015	37.31996	-121.87276	0.00824	0.113
San Jose	WY 2015	SC-SJY-46-A	1/6/2015	37.32238	-121.87733	0.0046	0.094
San Jose	WY 2015	SC-SJY-49-A	1/6/2015	37.30248	-121.87325	0.02817	0.086
San Jose	WY 2015	SC-SJY-49-B	1/6/2015	37.30944	-121.87389	0.00659	0.15
San Jose	WY 2015	SC-SJY-50-A	1/6/2015	37.30679	-121.87869	0.00898	1.11
San Jose	WY 2015	SC-SJY-29-A	1/7/2015	37.34682	-121.91918	0.02335	0.239
San Jose	WY 2015	SC-SJY-31-A	1/7/2015	37.34453	-121.91788	0.09014	0.049
San Jose	WY 2015	SC-SJY-31-B	1/7/2015	37.34638	-121.91734	0.06973	0.258

CITY	WY	Site ID	Sample Date	Latitude	Longitude	PCBs (mg/kg)	Hg (mg/kg)
San Jose	WY 2015	SC-SJY-32-A	1/7/2015	37.34332	-121.91422	0.05007	0.064
San Jose	WY 2015	SC-SJY-33-A	1/7/2015	37.33689	-121.90490	0.08338	0.595
San Jose	WY 2015	SC-SJY-34-A	1/7/2015	37.32911	-121.90205	0.01615	0.085
San Jose	WY 2015	SC-SJY-36-A	1/7/2015	37.32571	-121.90407	0.08193	1.12
San Jose	WY 2015	SC-SJY-71-A	1/7/2015	37.34917	-121.92481	0.06538	0.191
San Jose	WY 2015	SC-SJY-74-A	1/7/2015	37.33985	-121.89847	0.00758	0.225
San Jose	WY 2015	SC-SJY-74-B	1/7/2015	37.34144	-121.90098	0.03809	0.241
San Jose	WY 2015	SC-SJY-14-A	1/8/2015	37.36534	-121.87804	0.23555	0.249
San Jose	WY 2015	SC-SJY-15-A	1/8/2015	37.36222	-121.87556	0.16702	0.21
San Jose	WY 2015	SC-SJY-15-B	1/8/2015	37.36279	-121.87595	0.01424	0.05
San Jose	WY 2015	SC-SJY-16-A	1/8/2015	37.36258	-121.87112	0.01575	0.102
San Jose	WY 2015	SC-SJY-17-A	1/8/2015	37.35887	-121.87061	0.01453	0.08
San Jose	WY 2015	SC-SJY-18-A	1/8/2015	37.36084	-121.86368	0.00922	0.151
San Jose	WY 2015	SC-SJY-19-A	1/8/2015	37.35094	-121.86748	0.03018	0.253
San Jose	WY 2015	SC-SJY-21-A	1/8/2015	37.34630	-121.86456	0.02353	0.231
San Jose	WY 2015	SC-SJY-25-A	1/8/2015	37.35700	-121.85010	0.03086	0.145
San Jose	WY 2015	SC-SJY-26-A	1/8/2015	37.36569	-121.84357	0.00927	0.078
San Jose	WY 2015	SC-SJY-11-A	1/9/2015	37.36613	-121.89362	0.0479	0.105
San Jose	WY 2015	SC-SJY-11-B	1/9/2015	37.36533	-121.89673	0.01833	0.163
San Jose	WY 2015	SC-SJY-11-C	1/9/2015	37.36642	-121.89902	0.01503	0.094
San Jose	WY 2015	SC-SJY-11-D	1/9/2015	37.36541	-121.89543	0.06023	0.274
San Jose	WY 2015	SC-SJY-12-A	1/9/2015	37.36493	-121.89099	0.02493	0.193
San Jose	WY 2015	SC-SJY-12-C	1/9/2015	37.36876	-121.88684	0.21808	0.135
San Jose	WY 2015	SC-SJY-12-D	1/9/2015	37.36695	-121.88401	0.09	0.207
San Jose	WY 2015	SC-SJY-12-E	1/9/2015	37.36800	-121.88680	0.06517	0.136
San Jose	WY 2015	SC-SJY-28-B	1/9/2015	37.34863	-121.89113	0.01923	0.141
San Jose	WY 2015	SC-SJY-07-A1	1/12/2015	37.38094	-121.89552	0.34591	0.163
San Jose	WY 2015	SC-SJY-09-A	1/12/2015	37.36899	-121.89571	0.01089	0.365
San Jose	WY 2015	SC-SJY-12-B	1/12/2015	37.36835	-121.89176	0.02989	0.098
San Jose	WY 2015	SC-SJY-27-A	1/12/2015	37.36007	-121.89516	0.05843	0.229
San Jose	WY 2015	SC-SJY-27-B	1/12/2015	37.36070	-121.89431	0.01735	0.081
San Jose	WY 2015	SC-SJY-27-C	1/12/2015	37.36222	-121.89696	0.02219	0.14
San Jose	WY 2015	SC-SJY-27-D	1/12/2015	37.36049	-121.90019	0.0969	0.087
San Jose	WY 2015	SC-SJY-27-E	1/12/2015	37.36111	-121.89618	0.03835	0.681
San Jose	WY 2015	SC-SJY-28-A	1/12/2015	37.35788	-121.89680	0.01924	0.06
San Jose	WY 2015	SC-SJY-28-C	1/12/2015	37.35820	-121.89421	0.0194	0.072
San Jose	WY 2015	SC-SJY-08-A	1/13/2015	37.36998	-121.89948	0.02573	0.106
San Jose	WY 2015	SC-SJY-08-B	1/13/2015	37.37170	-121.90116	0.02263	0.166
San Jose	WY 2015	SC-SJY-08-C	1/13/2015	37.36963	-121.89899	0.09266	0.063
San Jose	WY 2015	SC-SJY-08-D	1/13/2015	37.37121	-121.90038	0.66611	0.064
San Jose	WY 2015	SC-SJY-08-E	1/13/2015	37.37254	-121.89857	0.16176	9.27
San Jose	WY 2015	SC-SJY-08-F	1/13/2015	37.37442	-121.90064	0.15662	0.101
San Jose	WY 2015	SC-SJY-08-G	1/13/2015	37.37785	-121.90296	0.03188	0.077
San Jose	WY 2015	SC-SJY-10-C	1/13/2015	37.37081	-121.90517	0.004659	0.033
San Jose	WY 2015	SC-SJY-10-D	1/13/2015	37.37519	-121.90858	1.3526	9.91
San Jose	WY 2015	SC-SJY-10-F	1/13/2015	37.37744	-121.90681	0.01199	0.07

CITY	WY	Site ID	Sample Date	Latitude	Longitude	PCBs (mg/kg)	Hg (mg/kg)
San Jose	WY 2015	SC-SJY-01-A	1/14/2015	37.42923	-121.97185	0.05105	0.295
San Jose	WY 2015	SC-SJY-01-C	1/14/2015	37.43133	-121.96889	0.02768	0.087
San Jose	WY 2015	SC-SJY-01-D	1/14/2015	37.43359	-121.96781	0.1754	0.05
San Jose	WY 2015	SC-SJY-04-A	1/14/2015	37.38150	-121.92716	0.00221	0.209
San Jose	WY 2015	SC-SJY-04-B	1/14/2015	37.38759	-121.91385	0.00649	0.034
San Jose	WY 2015	SC-SJY-10-A	1/14/2015	37.36825	-121.90587	1.08139	0.224
San Jose	WY 2015	SC-SJY-10-E	1/14/2015	37.37772	-121.90993	0.3139	1.19
San Jose	WY 2015	SC-SJY-65-A	1/14/2015	37.40382	-121.90587	0.0044	0.053
San Jose	WY 2015	SC-SJY-66-A	1/14/2015	37.39334	-121.90134	0.0074	0.04
San Jose	WY 2015	SC-SJY-01-B	1/15/2015	37.42879	-121.97330	0.00922	0.046
San Jose	WY 2015	SC-SJY-01-E	1/15/2015	37.42566	-121.97733	0.00587	0.057
San Jose	WY 2015	SC-SJY-01-F	1/15/2015	37.42377	-121.97494	0.01304	0.18
San Jose	WY 2015	SC-SJY-01-G	1/15/2015	37.42342	-121.97469	0.01956	0.128
San Jose	WY 2015	SC-SJY-03-A	1/15/2015	37.41068	-121.93626	0.00995	0.168
San Jose	WY 2015	SC-SJY-70-A	1/16/2015	37.35387	-121.92916	0.03364	0.049
San Jose	WY 2015	SC-SJY-30-A	4/16/2015	37.34791	-121.92242	0.02621	18.9
San Jose	WY 2017	SC-SJY-07-A	5/22/2017	37.37903	-121.89875	2.7991	0.378
San Jose	WY 2017	SC-SJY-08-H	5/22/2017	37.37844	-121.89870	0.18109	0.166
San Jose	WY 2017	SC-SJY-08-I	5/22/2017	37.37668	-121.90253	0.00465	0.06
San Jose	WY 2017	SC-SJY-08-J	5/22/2017	37.37612	-121.90079	0.00427	0.226
San Jose	WY 2017	SC-SJY-08-K	5/22/2017	37.37444	-121.90063	0.07202	0.095
San Jose	WY 2017	SC-SJY-08-L	5/22/2017	37.37255	-121.89857	0.04632	0.088
San Jose	WY 2017	SC-SJY-08-M	5/22/2017	37.37243	-121.89868	0.21032	0.136
San Jose	WY 2017	SC-SJY-08-N	5/22/2017	37.37160	-121.89980	0.02026	0.092
San Jose	WY 2017	SC-SJY-08-O	5/22/2017	37.37185	-121.90025	0.05398	0.117
San Jose	WY 2017	SC-SJY-08-P	5/22/2017	37.37222	-121.90040	0.01636	0.061
San Jose	WY 2017	SC-SJY-08-Q	5/22/2017	37.37231	-121.90045	0.02524	0.132
San Jose	WY 2017	SC-SJY-08-R	5/22/2017	37.37258	-121.90076	0.02761	0.072
San Jose	WY 2017	SC-SJY-08-T	5/22/2017	37.37176	-121.90114	0.28211	0.062
San Jose	WY 2017	SC-SJY-08-U	5/22/2017	37.37176	-121.90114	0.04885	0.058
San Jose	WY 2017	SC-SJY-08-V	5/22/2017	37.37175	-121.90110	0.02708	0.198
San Jose	WY 2017	SC-SJY-08-W	5/22/2017	37.37160	-121.90106	0.0152	0.114
San Jose	WY 2017	SC-SJY-10-G	5/22/2017	37.36864	-121.90599	0.03242	0.224
San Jose	WY 2017	SC-SJY-10-H	5/22/2017	37.36798	-121.90583	2.04354	0.247
San Jose	WY 2017	SC-SJY-10-I	5/22/2017	37.36800	-121.90584	11.9119	1.32
San Jose	WY 2017	SC-SJY-10-J	5/23/2017	37.37349	-121.90716	0.0259	0.085
San Jose	WY 2017	SC-SJY-10-K	5/23/2017	37.37325	-121.90746	0.03157	0.15
San Jose	WY 2017	SC-SJY-10-L	5/23/2017	37.37292	-121.90695	0.01152	0.04
San Jose	WY 2017	SC-SJY-10-N	5/23/2017	37.37521	-121.90857	0.5696	3.01
San Jose	WY 2017	SC-SJY-10-O	5/23/2017	37.37657	-121.90778	0.2764	0.121
San Jose	WY 2017	SC-SJY-10-P	5/23/2017	37.37783	-121.91004	0.2448	1.57
San Jose	WY 2017	SC-SJY-10-Q	5/23/2017	37.37569	-121.90890	0.04082	0.146
San Jose	WY 2017	SC-SJY-17-B	5/23/2017	37.35887	-121.87121	0.01269	0.139
San Jose	WY 2017	SC-SJY-17-C	5/23/2017	37.35936	-121.86900	0.12274	0.028
San Jose	WY 2017	SC-SJY-17-D	5/23/2017	37.35900	-121.86863	0.05251	0.108
San Jose	WY 2017	SC-SJY-17-E	5/23/2017	37.35909	-121.86850	0.03164	0.122

CITY	WY	Site ID	Sample Date	Latitude	Longitude	PCBs (mg/kg)	Hg (mg/kg)
San Jose	WY 2017	SC-SJY-17-F	5/23/2017	37.35869	-121.87077	0.0268	0.119
San Jose	WY 2017	SC-SJY-17-G	5/23/2017	37.35821	-121.87025	0.03968	0.264
San Jose	WY 2017	SC-SJY-17-H	5/23/2017	37.35885	-121.86840	0.09328	0.087
San Jose	WY 2017	SC-SJY-47-E	5/24/2017	37.30763	-121.86494	0.12447	0.317
San Jose	WY 2017	SC-SJY-47-F	5/24/2017	37.30802	-121.86531	0.22631	0.945
San Jose	WY 2017	SC-SJY-47-G	5/24/2017	37.30817	-121.86549	0.2466	0.765
San Jose	WY 2017	SC-SJY-47-H	5/24/2017	37.30962	-121.86691	0.304	1.95
San Jose	WY 2017	SC-SJY-47-J	5/24/2017	37.30996	-121.86778	7.062	1.88
San Jose	WY 2017	SC-SJY-47-K	5/24/2017	37.30948	-121.86730	0.07382	0.419
San Jose	WY 2017	SC-SJY-47-L	5/24/2017	37.30918	-121.86699	0.07763	0.423
San Jose	WY 2017	SC-SJY-90-A	5/24/2017	37.25767	-121.83825	0.0038	0.087
San Jose	WY 2017	SC-SJY-91-A	5/24/2017	37.22004	-121.85523	0.07782	4.29
San Jose	WY 2019	SC-SJY-08-X	8/12/2019	37.37377	-121.89863	0.0309	0.074
San Jose	WY 2019	SC-SJY-08-Y	8/12/2019	37.37263	-121.89857	0.1104	0.34
San Jose	WY 2019	SC-SJY-08-Z	8/12/2019	37.37256	-121.89876	1.0875	0.28
San Jose	WY 2019	SC-SJY-17-I	8/12/2019	37.35818	-121.86908	0.3496	0.048
San Jose	WY 2019	SC-SJY-17-J	8/12/2019	37.35823	-121.86883	0.3243	0.075
San Jose	WY 2019	SC-SJY-17-L	8/12/2019	37.35998	-121.86689	0.0091	0.1
San Jose	WY 2019	SC-SJY-17-M	8/12/2019	37.36254	-121.86877	0.0333	0.083
San Jose	WY 2019	SC-SJY-17-N	8/12/2019	37.36224	-121.86896	0.0328	0.09
San Jose	WY 2019	SC-SJY-17-O	8/12/2019	37.36369	-121.86987	0.0249	0.14
San Jose	WY 2019	SC-SJY-04-C	8/13/2019	37.38208	-121.92656	0.0014	0.045
San Jose	WY 2019	SC-SJY-04-D	8/13/2019	37.38254	-121.92707	0.0222	0.16
San Jose	WY 2019	SC-SJY-04-E	8/13/2019	37.39346	-121.91459	0.1698	0.072
San Jose	WY 2019	SC-SJY-04-F	8/13/2019	37.39172	-121.91211	0.0087	0.038
San Jose	WY 2019	SC-SJY-47-M	8/13/2019	37.30973	-121.86538	1.7868	1.5
San Jose	WY 2019	SC-SJY-47-N	8/13/2019	37.30999	-121.87009	5.467	0.24
San Jose	WY 2019	SC-SJY-14-B	8/19/2019	37.36539	-121.87803	0.3169	0.24
San Jose	WY 2019	SC-SJY-14-C	8/19/2019	37.36531	-121.87824	0.0397	0.067
San Jose	WY 2019	SC-SJY-14-D	8/19/2019	37.36537	-121.87788	0.0197	0.11
San Jose	WY 2019	SC-SJY-14-E	8/19/2019	37.36549	-121.87803	0.0031	0.091
San Jose	WY 2019	SC-SJY-14-F	8/19/2019	37.36484	-121.87876	0.016	0
San Jose	WY 2019	SC-SJY-14-H	8/19/2019	37.36394	-121.88052	0.0633	0.14
San Jose	WY 2019	SC-SJY-14-I	8/19/2019	37.36447	-121.87997	0.0313	0.11
San Jose	WY 2019	SC-SJY-14-J	8/19/2019	37.36473	-121.97894	0.0163	0.33
San Jose	WY 2019	SC-SJY-17-P	8/19/2019	37.36248	-121.87145	0.0253	0.086
San Jose	WY 2019	SC-SJY-17-Q	8/19/2019	37.36237	-121.87163	0.0139	0
San Jose	WY 2019	SC-SJY-17-R	8/19/2019	37.36280	-121.87098	0.0103	0.11
San Jose	WY 2019	SC-SJY-04-H	8/20/2019	37.38756	-121.91387	0.005	0.14
San Jose	WY 2019	SC-SJY-04-I	8/20/2019	37.38920	-121.91207	0.0088	0.085
San Jose	WY 2019	SC-SJY-14-K	8/20/2019	37.36307	-121.88099	0.016	0.059
San Jose	WY 2019	SC-SJY-14-L	8/20/2019	37.36336	-121.88118	0.0251	0.12
San Jose	WY 2019	SC-SJY-14-M	8/20/2019	37.36246	-121.88313	0.0142	0.088
San Jose	WY 2019	SC-SJY-04-J	8/27/2019	37.38067	-121.93162	0.00625	0.26
San Jose	WY 2019	SC-SJY-04-K	8/27/2019	37.38226	-121.93157	0.011298	0.28
San Jose	WY 2019	SC-SJY-04-L	8/27/2019	37.38498	-121.94165	0.010501	0.23

CITY	WY	Site ID	Sample Date	Latitude	Longitude	PCBs (mg/kg)	Hg (mg/kg)
San Jose	WY 2019	SC-SJY-04-M	8/27/2019	37.38137	-121.92017	0.008094	0
San Jose	WY 2019	SC-SJY-04-N	8/27/2019	37.38481	-121.92031	0.012315	0.11
San Jose	WY 2019	SC-SJY-04-O	8/27/2019	37.38495	-121.92042	0.021738	0.16
San Jose	WY 2019	SC-SJY-04-P	8/27/2019	37.38594	-121.92146	0.013204	0.1
San Jose	WY 2019	SC-SJY-08-AB	8/27/2019	37.37121	-121.90037	0.025258	0.11
San Jose	WY 2019	SC-SJY-08-AC	8/27/2019	37.37126	-121.90006	0.031707	0.11
San Jose	WY 2019	SC-SJY-08-AD	8/27/2019	37.37138	-121.90017	0.027067	0.12
San Jose	WY 2019	SC-SJY-04-R	8/28/2019	37.38224	-121.93524	0.07839	0.96
San Jose	WY 2019	SC-SJY-10-R	8/28/2019	37.37849	-121.90899	0.417006	1.9
San Jose	WY 2019	SC-SJY-10-S	8/28/2019	37.37789	-121.90991	0.928522	5.6
San Jose	WY 2019	SC-SJY-47-O	8/28/2019	37.30929	-121.86487	3.60948	8.5
Santa Clara	WY 2015	SC-SCL-13-A	1/15/2015	37.38525	-121.94524	0.00742	0.054
Santa Clara	WY 2015	SC-SCL-13-B	1/15/2015	37.38844	-121.94103	0.01727	0.068
Santa Clara	WY 2015	SC-SCL-14-A	1/15/2015	37.40328	-121.96494	0.007075	0.357
Santa Clara	WY 2015	SC-SCL-16-A	1/15/2015	37.41014	-121.96487	0.00793	0.115
Santa Clara	WY 2015	SC-SCL-17-A	1/15/2015	37.41655	-121.97308	0.00811	0.062
Santa Clara	WY 2015	SC-SCL-25-A	1/15/2015	37.38182	-121.94851	0.00294	0.092
Santa Clara	WY 2015	SC-SCL-01-A	1/16/2015	37.35447	-121.93708	0.8347	0.204
Santa Clara	WY 2015	SC-SCL-01-B	1/16/2015	37.35427	-121.93710	0.0296	0.063
Santa Clara	WY 2015	SC-SCL-02-A	1/16/2015	37.35931	-121.94521	0.02002	0.107
Santa Clara	WY 2015	SC-SCL-02-B	1/16/2015	37.36329	-121.94408	0.0621	0.299
Santa Clara	WY 2015	SC-SCL-03-A	1/16/2015	37.36110	-121.95130	0.05375	0.168
Santa Clara	WY 2015	SC-SCL-03-B	1/16/2015	37.36251	-121.95319	0.14289	0.55
Santa Clara	WY 2015	SC-SCL-03-C	1/16/2015	37.36505	-121.95374	0.06948	0.28
Santa Clara	WY 2015	SC-SCL-03-D	1/16/2015	37.36504	-121.95257	0.03645	0.109
Santa Clara	WY 2015	SC-SCL-05-B	1/16/2015	37.36697	-121.95045	0.00727	0.043
Santa Clara	WY 2015	SC-SCL-02-C	2/2/2015	37.36654	-121.94468	0.03512	0.247
Santa Clara	WY 2015	SC-SCL-02-D	2/2/2015	37.37023	-121.94540	0.02811	0.068
Santa Clara	WY 2015	SC-SCL-02-G	2/2/2015	37.36639	-121.94647	0.01	0.12
Santa Clara	WY 2015	SC-SCL-07-A	2/2/2015	37.37922	-121.95539	0.00365	0.06
Santa Clara	WY 2015	SC-SCL-07-B	2/2/2015	37.38052	-121.96180	0.00468	0.053
Santa Clara	WY 2015	SC-SCL-18-A	2/2/2015	37.36974	-121.95657	0.04634	0.047
Santa Clara	WY 2015	SC-SCL-18-B	2/2/2015	37.36950	-121.96239	0.00117	0.042
Santa Clara	WY 2015	SC-SCL-19-A	2/2/2015	37.37420	-121.97192	0.00213	0.061
Santa Clara	WY 2015	SC-SCL-23-A	2/2/2015	37.36189	-121.93687	0.03046	0.093
Santa Clara	WY 2015	SC-SCL-23-B	2/2/2015	37.36452	-121.93961	0.05244	3.21
Santa Clara	WY 2015	SC-SCL-02-E	2/3/2015	37.37133	-121.95013	0.8039	0.271
Santa Clara	WY 2015	SC-SCL-05-A	2/3/2015	37.37215	-121.95044	0.08454	0.199
Santa Clara	WY 2015	SC-SCL-06-A	2/3/2015	37.37473	-121.94720	0.05033	0.286
Santa Clara	WY 2015	SC-SCL-06-B	2/3/2015	37.37509	-121.95000	0.02212	0.073
Santa Clara	WY 2015	SC-SCL-09-A	2/3/2015	37.38637	-121.96592	0.00806	0.064
Santa Clara	WY 2015	SC-SCL-10-A	2/3/2015	37.38562	-121.95469	0.00331	0.066
Santa Clara	WY 2015	SC-SCL-10-C	2/3/2015	37.38580	-121.95298	0.00088	0.043
Santa Clara	WY 2015	SC-SCL-12-A	2/3/2015	37.37643	-121.99738	0.00449	0.208
Santa Clara	WY 2015	SC-SCL-13-D	2/3/2015	37.38946	-121.94055	0.01049	0.055
Santa Clara	WY 2015	SC-SCL-20-A	2/3/2015	37.37746	-121.97257	0.00631	0.078

CITY	WY	Site ID	Sample Date	Latitude	Longitude	PCBs (mg/kg)	Hg (mg/kg)
Santa Clara	WY 2015	SC-SCL-11-A	4/16/2015	37.38636	-121.95918	0.003605	0.04
Santa Clara	WY 2015	SC-SCL-21-A	4/16/2015	37.37769	-121.98364	0.01067	0.069
Santa Clara	WY 2015	SC-SCL-24-A	4/16/2015	37.38321	-121.93818	0.012217	0.58
Santa Clara	WY 2017	SC-SCL-01-C	6/12/2017	37.35447	-121.93710	3.8058	0.482
Santa Clara	WY 2017	SC-SCL-02-F	6/12/2017	37.37103	-121.94970	0.04829	0.257
Santa Clara	WY 2017	SC-SCL-02-H	6/12/2017	37.37078	-121.95011	0.0207	0.0962
Santa Clara	WY 2017	SC-SCL-02-I	6/12/2017	37.37124	-121.95012	0.07081	0.177
Santa Clara	WY 2017	SC-SCL-02-J	6/12/2017	37.37144	-121.95007	0.02169	0.199
Santa Clara	WY 2017	SC-SCL-02-K	6/12/2017	37.37150	-121.95005	0.0167	0.229
Santa Clara	WY 2017	SC-SCL-04-D	6/12/2017	37.36717	-121.95043	0.06517	0.209
Santa Clara	WY 2017	SC-SCL-04-E	6/12/2017	37.37204	-121.94967	0.0035	0.0881
Santa Clara	WY 2017	SC-SCL-04-F	6/12/2017	37.37250	-121.94967	0.01024	0.495
Santa Clara	WY 2017	SC-SCL-05-C	6/12/2017	37.36996	-121.95262	0.28653	0.236
Santa Clara	WY 2017	SC-SCL-05-D	6/12/2017	37.37176	-121.95042	0.2002	0.165
Santa Clara	WY 2017	SC-SCL-05-E	6/12/2017	37.37215	-121.95045	0.14956	0.0922
Santa Clara	WY 2017	SC-SCL-23-B	6/12/2017	37.35592	-121.94040	0.01705	0.119
Santa Clara	WY 2017	SC-SCL-23-C	6/12/2017	37.35529	-121.93995	0.02181	0.114
Santa Clara	WY 2017	SC-SCL-01-E	6/13/2017	37.35445	-121.93688	0.04132	0.0638
Santa Clara	WY 2017	SC-SCL-01-F	6/13/2017	37.35466	-121.93670	0.030622	0.0769
Santa Clara	WY 2017	SC-SCL-01-G	6/13/2017	37.35519	-121.93608	0.19349	0.0745
Santa Clara	WY 2017	SC-SCL-01-H	6/13/2017	37.35656	-121.93269	0.08943	0.142
Santa Clara	WY 2017	SC-SCL-02-L	6/13/2017	37.36068	-121.94839	0.00662	0.0532
Santa Clara	WY 2017	SC-SCL-03-E	6/13/2017	37.36497	-121.95602	0.01725	0.0853
Santa Clara	WY 2017	SC-SCL-23-D	6/13/2017	37.35946	-121.93418	0.63651	0.0652
Santa Clara	WY 2017	SC-SCL-23-E	6/13/2017	37.35917	-121.93379	0.11486	0.0911
Santa Clara	WY 2017	SC-SCL-23-F	6/13/2017	37.35843	-121.93300	0.08377	0.142
Santa Clara	WY 2017	SC-SCL-26-A	6/13/2017	37.35327	-121.94012	0.01177	0.115
Santa Clara	WY 2017	SC-SCL-02-G	6/17/2017	37.37042	-121.95014	0.05106	0.805
Santa Clara	WY 2019	SC-SCL-02-M	6/3/2019	37.37132	-121.95014	0.06474	0.13
Santa Clara	WY 2019	SC-SCL-05-F	6/3/2019	37.37177	-121.95064	0.147681	4.9
Santa Clara	WY 2019	SC-SCL-05-G	6/3/2019	37.35885	-121.93509	0.0692	0.12
Santa Clara	WY 2019	SC-SCL-05-H	6/3/2019	37.36997	-121.95508	0.044586	0.048
Santa Clara	WY 2019	SC-SCL-06-C	6/3/2019	37.37639	-121.95061	0.005663	0.13
Santa Clara	WY 2019	SC-SCL-23-G	6/3/2019	37.35885	-121.93509	3.55688	0.13
Santa Clara County	WY 2015	SC-SCC-03-A	12/9/2014	37.21744	-121.74032	0.007974	0.073
Santa Clara County	WY 2015	SC-SCC-04-A	12/9/2014	37.28166	-121.84501	0.02225	0.251
Sunnyvale	WY 2015	SC-SNV-07-A	1/16/2015	37.38027	-122.00755	0.08107	0.174
Sunnyvale	WY 2015	SC-SNV-07-B	1/16/2015	37.37771	-122.00647	0.05595	0.197
Sunnyvale	WY 2015	SC-SNV-09-A	1/16/2015	37.37427	-122.00952	0.02913	1.57
Sunnyvale	WY 2015	SC-SNV-22-A	1/16/2015	37.37677	-122.01214	0.1377	0.892
Sunnyvale	WY 2015	SC-SNV-05-B	1/26/2015	37.38662	-122.00625	0.00586	0.056
Sunnyvale	WY 2015	SC-SNV-05-C	1/26/2015	37.38832	-122.00623	0.00769	0.057
Sunnyvale	WY 2015	SC-SNV-10-A	1/26/2015	37.38052	-122.02357	4.83523	0.102
Sunnyvale	WY 2015	SC-SNV-10-B	1/26/2015	37.37708	-122.02520	0.08187	0.188

CITY	WY	Site ID	Sample Date	Latitude	Longitude	PCBs (mg/kg)	Hg (mg/kg)
Sunnyvale	WY 2015	SC-SNV-10-C	1/26/2015	37.38025	-122.02232	3.70764	0.065
Sunnyvale	WY 2015	SC-SNV-12-A	1/26/2015	37.38271	-122.01464	0.04425	0.114
Sunnyvale	WY 2015	SC-SNV-13-A	1/26/2015	37.38400	-121.99983	0.03275	0.061
Sunnyvale	WY 2015	SC-SNV-25-A	1/26/2015	37.39340	-122.02962	0.05772	0.055
Sunnyvale	WY 2015	SC-SNV-02-A	1/27/2015	37.40910	-121.99375	0.01135	0.067
Sunnyvale	WY 2015	SC-SNV-02-B	1/27/2015	37.40644	-121.99258	0.03492	0.164
Sunnyvale	WY 2015	SC-SNV-02-C	1/27/2015	37.40901	-121.98857	0.03448	0.091
Sunnyvale	WY 2015	SC-SNV-17-A	1/27/2015	37.38425	-122.04877	0.01828	0.038
Sunnyvale	WY 2015	SC-SNV-17-B	1/27/2015	37.38218	-122.04238	0.04873	0.082
Sunnyvale	WY 2015	SC-SNV-20-A	1/27/2015	37.41364	-122.01320	0.0035	0.062
Sunnyvale	WY 2015	SC-SNV-20-B	1/27/2015	37.41720	-122.01631	0.01961	0.067
Sunnyvale	WY 2015	SC-SNV-30-A	1/27/2015	37.41624	-122.01958	0.04246	0.062
Sunnyvale	WY 2015	SC-SNV-31-A	1/27/2015	37.41030	-122.00413	0.01522	0.04
Sunnyvale	WY 2015	SC-SNV-27-A	4/16/2015	37.36994	-121.99585	0.008977	0.069

Table 2. PCBs and mercury concentrations in stormwater by sample date and sample station for all monitoring conducted by SCVURPPP in the Santa Clara Basin by SCVURPPP and the RMP STLS in WY 2015-WY 2019

City	Water Year	Sampling Group	Site ID	Sample Date	Sample Type	Latitude	Longitude	SSC (mg/L)	PCBs (pg/L)	HgT (ng/L)
Campbell	WY 2017	SCVURPPP	113LGC670A	2/9/17	MS4 Large	37.26763	-121.95280	31	3,200	0
Campbell	WY 2017	SCVURPPP	113LGC900A	2/9/17	MS4 Large	37.26186	-121.95527	16	884	1
Milpitas	WY 2015	RMP	LWR_PEN_A	12/11/14	Receiving Water	37.42985	-121.90913	144	2,033	29
Milpitas	WY 2016	SCVURPPP	FORD_A	1/17/16	Receiving Water	37.43575	-121.90663	44	1,920	6
Milpitas	WY 2016	SCVURPPP	WRIGLEY_A	1/17/16	Receiving Water	37.43581	-121.90649	26	2,630	5
Milpitas	WY 2017	SCVURPPP	036BYC091A	12/23/16	MS4 Large	37.42017	-121.88842	66	8,740	3
Mountain View	WY 2016	SCVURPPP	032SVC490A	1/5/16	MS4 Large	37.40584	-122.06392	38	1,750	8
Mountain View	WY 2018	SCVURPPP	032SVC470A	11/16/17	MS4 Large	37.40850	-122.07202	40	6,954	13
Palo Alto	WY 2017	SCVURPPP	031SCH250A	12/15/16	MS4 Large	37.41889	-122.13959	12	13,000	2
Palo Alto	WY 2017	SCVURPPP	SCH-K_A	12/15/16	MS4 Large	37.41408	-122.14287	52	10,100	2
Palo Alto	WY 2019	SCVURPPP	031SCH250A	1/6/19	MS4 Large	37.41889	-122.13959	20	52,717	6
Palo Alto	WY 2019	SCVURPPP	031SCH250B	1/6/19	MS4 Large	37.41771	-122.14329	19	177,515	7
San Jose	WY 2015	RMP	051CTC275A	4/7/15	MS4 Large	37.38413	-121.91076	121	14,927	67
San Jose	WY 2015	RMP	051CTC400A	12/15/14	MS4 Large	37.37784	-121.90302	114	55,503	37
San Jose	WY 2015	RMP	066GAC550A	12/11/14	MS4 Large	37.36632	-121.90202	145	14,365	85
San Jose	WY 2015	RMP	067SCL080A	2/6/15	MS4 Large	37.35789	-121.86741	57	44,643	24
San Jose	WY 2015	RMP	084CTC625A	2/6/15	MS4 Large	37.31751	-121.85459	41	5,252	38
San Jose	WY 2016	SCVURPPP	083GAC240A	3/11/16	MS4 Large	37.33758	-121.90416	70	2,720	20
San Jose	WY 2016	SCVURPPP	083LGC430A	1/19/16	MS4 Large	37.32571	-121.90189	37	5,380	36
San Jose	WY 2016	SCVURPPP	129CNC165A	1/6/16	MS4 Large	37.25142	-121.80751	58	2,140	20
San Jose	WY 2016	RMP	050GAC030A	3/6/16	MS4 Large	37.38664	-121.95223	34	1,454	7
San Jose	WY 2016	RMP	050GAC190A	1/19/16	MS4 Large	37.38991	-121.93952	45	2,290	16
San Jose	WY 2017	SCVURPPP	050GAC020A	1/7/17	MS4 Large	37.38185	-121.93730	13	7,000	3
San Jose	WY 2017	SCVURPPP	067CTC250A	2/9/17	MS4 Large	37.36535	-121.87805	518	57,600	0
San Jose	WY 2017	SCVURPPP	067CTC350A	1/10/17	MS4 Large	37.36356	-121.87417	55	9,750	1
San Jose	WY 2017	SCVURPPP	067CTC351A	1/10/17	MS4 Large	37.36309	-121.87471	168	9,320	1
San Jose	WY 2017	SCVURPPP	067CTC750A	2/7/17	MS4 Large	37.35116	-121.87083	28	2,840	0
San Jose	WY 2017	SCVURPPP	067CTC810A	2/7/17	MS4 Large	37.34943	-121.87017	37	2,850	1
San Jose	WY 2017	SCVURPPP	067SCL120A	12/15/16	MS4 Large	37.35968	-121.86615	56	27,100	0
San Jose	WY 2017	SCVURPPP	099GAC240A	1/7/17	MS4 Large	37.30777	-121.88240	43	6,420	2
San Jose	WY 2017	SCVURPPP	100CTC500B	2/7/17	MS4 Large	37.29033	-121.84098	99	14,500	0
San Jose	WY 2017	SCVURPPP	MIGUELITA_A	12/15/16	MS4 Large	37.36041	-121.86375	85	3,990	2
San Jose	WY 2017	RMP	066GAC550B	1/8/17	MS4 Large	37.36196	-121.90535	48	4,170	23
San Jose	WY 2017	RMP	066GAC550C	1/8/17	MS4 Large	37.36117	-121.90594	46	4,110	27

City	Water Year	Sampling Group	Site ID	Sample Date	Sample Type	Latitude	Longitude	SSC (mg/L)	PCBs (pg/L)	HgT (ng/L)
San Jose	WY 2017	RMP	Guadalupe River	1/8/17	Receiving Water	37.37355	-121.93269	560	32,740	1,053
San Jose	WY 2018	SCVURPPP	067GAC150A	4/6/18	MS4 Large	37.34586	-121.90651	82	1,866	5
San Jose	WY 2018	SCVURPPP	083GAC900B	4/6/18	MS4 Large	37.31240	-121.86973	92	57,303	32
San Jose	WY 2018	SCVURPPP	083GAC900D	4/6/18	MS4 Large	37.30583	-121.86319	55	1,597	7
San Jose	WY 2018	SCVURPPP	100CTC400A	11/16/17	MS4 Large	37.30300	-121.83995	72	4,412	10
San Jose	WY 2018	SCVURPPP	100CTC500A	11/16/17	MS4 Large	37.30149	-121.83815	81	5,895	8
San Jose	WY 2018	SCVURPPP	129CNC550A	1/8/18	MS4 Large	37.24274	-121.84347	18	1,313	4
San Jose	WY 2018	SCVURPPP	CANOAS_A	1/8/18	Receiving Water	37.24249	-121.84366	39	154	1
San Jose	WY 2018	RMP	066GAC850A	4/7/18	MS4 Large	37.35469	-121.91279	149	6,631	16
San Jose	WY 2018	RMP	066GAC900A	4/7/18	MS4 Large	37.35353	-121.91261	27	3,364	17
San Jose	WY 2019	SCVURPPP	050GAC020C	2/27/19	MS4 Large	37.38229	-121.93544	7	446	5
San Jose	WY 2019	SCVURPPP	050GAC020D	2/27/19	MS4 Large	37.38339	-121.93345	4	205	3
San Jose	WY 2019	SCVURPPP	050GAC020E	2/1/19	MS4 Large	37.38108	-121.93791	4	334	7
San Jose	WY 2019	SCVURPPP	066GAC150A	2/13/19	MS4 Large	37.35831	-121.93348	34	10,150	13
San Jose	WY 2019	SCVURPPP	067GAC010A	1/6/19	MS4 Large	37.35209	-121.91153	70	15,867	35
San Jose	WY 2019	SCVURPPP	067GAC075A	1/6/19	MS4 Large	37.34937	-121.90983	55	15,518	23
San Jose	WY 2019	SCVURPPP	067SCL080A	1/16/19	MS4 Large	37.35789	-121.86741	56	22,612	19
San Jose	WY 2019	SCVURPPP	067SCL080B	1/16/19	MS4 Large	37.35887	-121.86840	235	16,660	19
San Jose	WY 2019	SCVURPPP	067SCL120A	1/16/19	MS4 Large	37.35968	-121.86615	39	13,612	27
San Jose	WY 2019	SCVURPPP	067SCL120B	1/16/19	MS4 Large	37.36096	-121.86742	132	4,243	25
San Jose	WY 2019	SCVURPPP	083GAC900E	2/2/19	MS4 Large	37.30516	-121.86306	7	516	5
San Jose	WY 2019	SCVURPPP	099GAC240B	2/2/19	MS4 Large	37.30298	-121.86931	11	378	5
San Jose	WY 2019	SCVURPPP	113LGC510A	2/27/19	MS4 Large	37.27362	-121.94921	146	4,424	67
San Jose	WY 2019	RMP	100CTC400A	1/16/19	MS4 Large	37.30300	-121.83995	77	2,916	23
San Jose	WY 2019	RMP	100CTC500A	1/16/19	MS4 Large	37.30149	-121.83815	111	10,486	43
Santa Clara	WY 2015	RMP	050GAC580A	12/11/14	MS4 Large	37.37637	-121.93793	85	19,915	47
Santa Clara	WY 2015	RMP	050GAC600A	12/11/14	MS4 Large	37.37636	-121.93767	73	13,472	38
Santa Clara	WY 2016	RMP	049CZC200A	3/6/16	MS4 Large	37.38852	-121.99902	103	2,810	13
Santa Clara	WY 2016	RMP	049CZC800A	1/19/16	MS4 Large	37.37742	-121.99566	35	2,600	12
Santa Clara	WY 2016	RMP	049STA550A	12/13/15	MS4 Large	37.37991	-121.96842	79	1,950	6
Santa Clara	WY 2016	RMP	049STA710A	1/6/16	MS4 Large	37.37425	-121.96872	58	2,616	12
Sunnyvale	WY 2016	SCVURPPP	034BFL230A	3/5/16	MS4 Large	37.41772	-122.01913	19	584	4
Sunnyvale	WY 2016	SCVURPPP	034BFL230B	3/5/16	MS4 Large	37.41719	-122.01632	25	9,040	8
Sunnyvale	WY 2016	SCVURPPP	034CZC155A	1/17/16	MS4 Large	37.41061	-121.98900	25	2,760	4
Sunnyvale/ Santa Clara	WY 2017	SCVURPPP	049CZC900A	1/7/17	MS4 Large	37.37419	-121.98697	19	2,760	0

City	Water Year	Sampling Group	Site ID	Sample Date	Sample Type	Latitude	Longitude	SSC (mg/L)	PCBs (pg/L)	HgT (ng/L)
Sunnyvale/ Santa Clara	WY 2017	SCVURPPP	049CZC910A	1/7/17	MS4 Large	37.37419	-121.98673	10	2,030	1

Attachment D.5

DRAFT - Santa Clara Basin Reasonable Assurance Analysis Addressing PCBs and Mercury: Phase I Baseline Modeling Report. Paradigm Environmental, January 31, 2020

Santa Clara Basin Reasonable Assurance Analysis Addressing PCBs and Mercury:

Phase I Baseline Modeling Report

DRAFT

Prepared for:

Santa Clara Valley
Urban Runoff
Pollution Prevention Program

Prepared by:

PARADIGM ENVIRONMENTAL

JANUARY 31, 2020

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EXECUTIVE SUMMARY

This report provides a summary of the methods and modeling approaches used to represent baseline hydrology and sediment, Polychlorinated Biphenyls (PCBs), and mercury loads resulting from municipal stormwater discharges within the Santa Clara Basin to San Francisco Bay. This baseline model supports the first step in preparation of a Reasonable Assurance Analysis (RAA) that quantitatively demonstrates that proposed green stormwater infrastructure (GSI) control measures will result in sufficient load reductions of PCBs and mercury to meet Total Maximum Daily Load (TMDL) wasteload allocations assigned to municipal stormwater discharges to San Francisco Bay. The report documents the major steps, decisions, and assumptions made in the model development process. The report also provides documentation of model performance and calibration results based on local data. This documented calibration is critical to ensuring that the baseline model reliably captures the watershed characteristics and conditions and is sufficient for estimating pollutant loads and calculating pollutant reduction goals assigned to GSI to support implementation of TMDLs.

The hydrologic and water quality model selected for the baseline model of Santa Clara Basin watersheds was the Loading Simulation Program in C++ (LSPC), a watershed modeling system that includes Hydrologic Simulation Program FORTRAN (HSPF) algorithms for simulating watershed hydrology, erosion, water quality processes, and in-stream fate and transport processes. The model can simulate upland loading and transport of sediment, mercury, and PCBs. The model was configured based on the best available spatial and monitoring datasets to represent the land, meteorological, hydrological, and pollutant loading characteristics of Santa Clara Basin watersheds. Based on criteria established by the *Bay Area Reasonable Assurance Analysis Guidance Document* (BASMAA 2017), the baseline hydrology and pollutant loading model was demonstrated to be sufficiently calibrated and validated and acceptable for estimation of existing loads of mercury and PCBs, comparison to TMDL wasteload allocations, and determination of necessary load reductions to support the planning of GSI implementation.

The Municipal Regional Stormwater Permit (MRP) (Order No. R2-2015-0049) requires a portion of the TMDL wasteload allocations for PCBs and mercury to be met through the implementation of GSI by 2040. Through comparison of modeled baseline PCB loads and the wasteload allocation assigned to municipal stormwater discharges, this study estimates that a 15.9 percent of annual PCB loads (0.35 kg/year) is to be reduced through GSI implementation. For mercury, baseline loads were less than the TMDL wasteload allocation, resulting in no required mercury load reductions for Santa Clara Basin municipalities.

The next phase of the RAA will provide a quantitative approach to establish relationships between GSI implementation and required reductions of PCB loads. Model output will estimate the amount of GSI needed to achieve the 15.9 percent PCB load reduction target for Santa Clara Basin permittees. These estimates will serve as GSI implementation goals that will support the development of GSI plans by each agency.

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Acronyms

ABAG	Association of Bay Area Governments
AGWO	Active Groundwater Outflow
BAHM	Bay Area Hydrology Model
BASMAA	Bay Area Stormwater Management Agencies Association
Bay	San Francisco Bay
BMP	Best Management Practice
Caltrans	California Department of Transportation
CIMIS	California Irrigation Management Information System
DCIA	Directly Connected Impervious Area
DEM	Digital Elevation Model
ECHO	Enforcement and Compliance History Online
EIA	Effective Impervious Area
EMC	Event-Mean Concentration
EPA	Environmental Protection Agency
ET	Evapotranspiration
FTABLE	Functional Table (Model Rating Curve)
GHCN	Global Historical Climatology Network
GIS	Geographic Information Systems
GSI	Green Stormwater Infrastructure
Hg	Mercury
HRU	Hydrologic Response Units
HSG	Hydrologic Soil Group
HSPF	Hydrologic Simulation Program–FORTRAN
IFWO	Interflow Outflow
IGP	Industrial General Permit
LSM	Land Surface Models
LSPC	Loading Simulation Program in C++
MIA	Mapped Impervious Area
MRP	Municipal Regional Stormwater Permit
MS4	Municipal Separate Storm Sewer System
NED	National Elevation Dataset
NHD	National Hydrography Database
NLCD	National Land Cover Database
NLDAS2	North American Land Data Assimilation System
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NOAA	National Oceanic and Atmospheric Administration
PCBs	Polychlorinated Biphenyls
PEVT	Potential Evapotranspiration
POI	Points of Interest

PRISM	Parameter-elevation Regressions on Independent Slopes Model
QAPP	Quality Assurance Project Plans
RAA	Reasonable Assurance Analysis
RWSM	Regional Watershed Spreadsheet Model
SCVURPPP	Santa Clara Valley Urban Runoff Pollution Prevention Program
SCVWD	Santa Clara Valley Water District
SFBRWQCB	San Francisco Bay Regional Water Quality Control Board
SFEI	San Francisco Estuary Institute
SSURGO	Soil Survey Geographic Database
STATSGO	State Soil Geographic Database
STLS	Small Tributaries Loading Strategy
SWRCB	State Water Resources Control Board
TAET	Total Actual Evapotranspiration
TMDL	Total Maximum Daily Load
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WLA	Waste Load Allocation
WMMS	Watershed Management Modeling System
WY	Water Year

1 INTRODUCTION

The Municipal Regional Stormwater Permit (MRP) requires Bay Area cities and counties to develop GSI Plans (Provision C.3) and PCBs and Mercury Control Measure Implementation Plans (Provisions C.11 and C.12) that provide the necessary pollutant load reductions to meet TMDL WLAs over specified compliance periods. A key component of these plans is a RAA to quantitatively demonstrate that proposed control measures will result in enough load reductions of PCBs and mercury to meet WLAs for municipal stormwater discharges to San Francisco Bay. SCVURPPP has initiated a county-wide effort to develop an RAA to estimate the baseline PCB and mercury loads to the Bay, determine load reductions to meet WLAs, and set goals for the amount of GSI needed to meet the portion of PCB and mercury load reduction the MRP assigns to GSI (SFBRWQCB 2015).

In 2017, the U.S. Environmental Protection Agency (EPA) Region 9 released *Developing Reasonable Assurance: A Guide to Performing Model-Based Analysis to Support Municipal Stormwater Program Planning* (EPA RAA Guide) (USEPA 2017), which provides guidance on the technical needs of the RAA and considerations for model selection. Building upon the EPA RAA Guide, the Bay Area Stormwater Management Agencies Association (BASMAA) prepared the *Bay Area Reasonable Assurance Analysis Guidance Document* (Bay Area RAA Guidance) (BASMAA 2017) to provide specific guidance on modeling to support RAAs performed in the Bay Area to meet MRP requirements, address TMDLs for PCBs and mercury, and support GSI planning. The EPA RAA Guide and Bay Area RAA Guidance both outline essential steps for performing an RAA, as depicted in Figure 1-1. The purpose of this memorandum is to document the first phase of the RAA, which includes development of a baseline hydrology and water quality model to address the first three steps of the RAA outlined in the USEPA RAA Guide and Bay Area RAA Guidance. These steps include:

1. **Designation of the Area Addressed by the Analysis**: As the RAA associated with GSI plans is developed in the context of the MRP and WLAs assigned to municipal stormwater discharges to the Bay, the area where it is applied is typically specific to urban areas within municipal jurisdictions addressed by the MRP. The first step in the designation of the area addressed by RAA is the delineation of watersheds and smaller "subwatersheds" that provide spatial resolution of model-predicted hydrology and characterization of the Santa Clara Basin stormflows discharged to the Bay. The RAA area of analysis was further refined to designate areas addressed by the WLAs assigned to municipal urban stormwater runoff (MRP areas), other National Pollutant Discharge Elimination System (NPDES) permitted areas, and open space or areas upstream of impoundments or reservoirs that are not addressed by the RAA or WLAs.
2. **Characterization of Existing Conditions**: Critical to the RAA is careful characterization of stormwater pollutant loads or flows under existing baseline conditions (average water year 2002). This understanding serves as the foundation of the RAA and identifies the starting point for planning management actions. The first step in the characterization of existing conditions is the representation of baseline hydrology and water quality. This report provides documentation of the development of the baseline model to represent hydrology and water quality and estimate Santa Clara Basin PCB and mercury loads to the Bay.
3. **Determination of Stormwater Improvement Goals**: Based on the area of analysis (Step 1), characterization of baseline hydrology and PCB and mercury loads (Step 2), and portions of pollutant reductions assigned to GSI based on TMDL WLAs and the MRP, goals can be determined in terms of the amount of pollutant load reduction to be achieved by GSI.

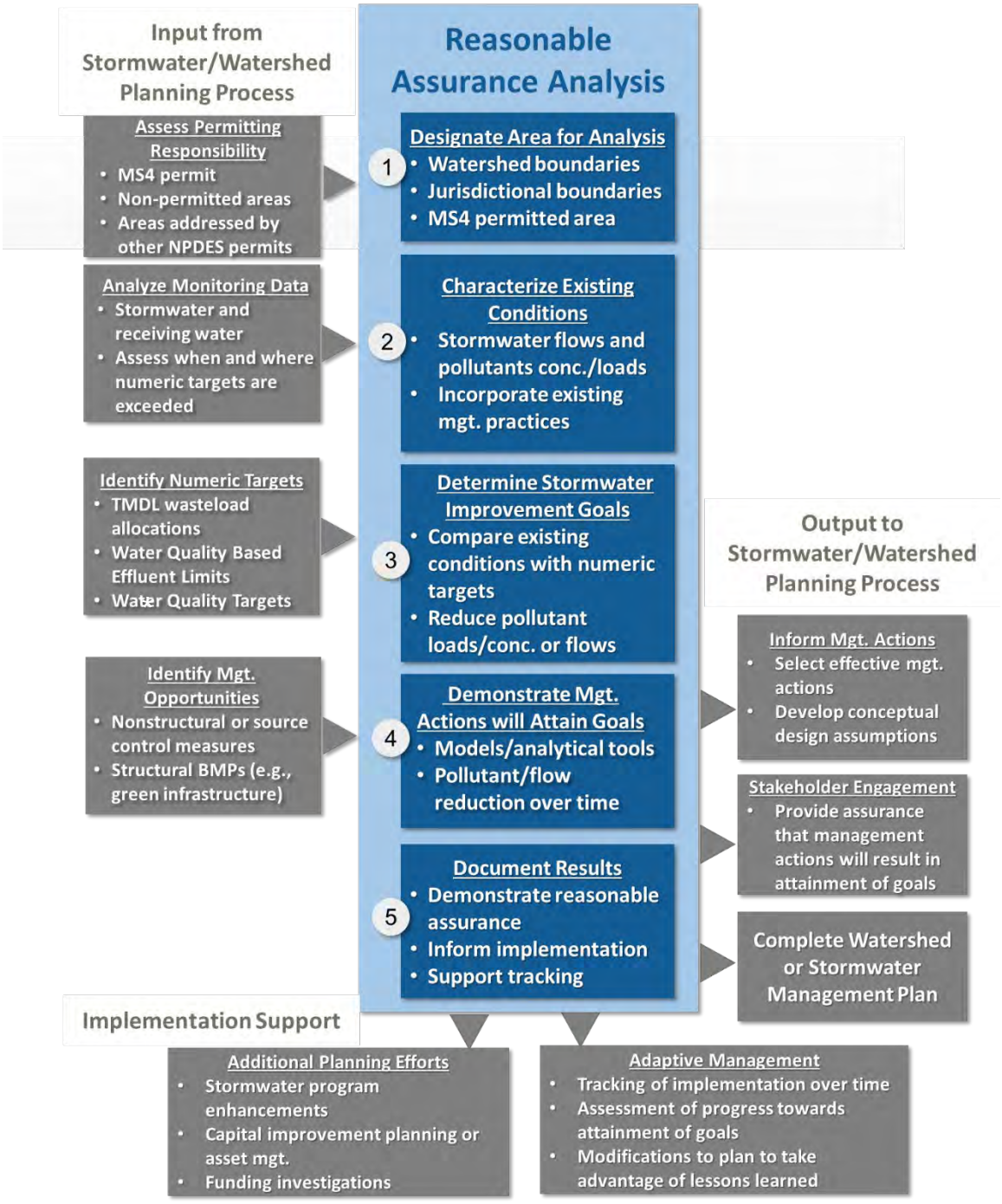


Figure 1-1. Reasonable Assurance Analysis process flow chart (USEPA 2017).

This report provides a summary of the methods and modeling approaches used to represent baseline PCB and mercury loads discharged to San Francisco Bay from Santa Clara Basin (RAA Step 2), PCB and mercury loads from MRP areas designated as the area of analysis (Step 1), and the estimation of PCB and mercury load reductions to be achieved through implementation of GSI by 2040 (Step 3). The report provides necessary documentation of model performance for predicting water quality and validation results based on methods consistent with the Bay Area RAA Guidance. The water quality modeling approach utilizes methods developed for the Regional Watershed Spreadsheet Model

(RWSM) by the San Francisco Estuary Institute (SFEI) for assigning PCB and mercury runoff concentrations (Wu et al. 2017) in combination with methods included within LSPC for simulating hydrology and sediment loads, which allows for estimation of PCB and mercury loads associated with various land uses within the Santa Clara Basin. The Bay Area RAA Guidance states that "if RWSM is used to represent pollutant concentrations or loads, this calibration is assumed to be conducted as part of the RWSM process," and "if sufficient concentration and loading data are available, these data should be used as part of model validation." The report documents the major steps, decisions, and assumptions made in the model development process.

2 OVERVIEW OF THE BASELINE MODELING APPROACH

The model development process can be a good platform for gaining valuable information and insight about the system. If well-designed, the model development process is an iterative and adaptive cycle that improves understanding of the system over time as better information becomes available. Ultimately a model can inform future data acquisition efforts and management decisions by highlighting factors that have the most impact on the behavior of a natural system. Figure 2-1 is a conceptual schematic of a model development cycle, which is conceptually represented as circular as opposed to linear. That cycle can be summarized in six interrelated steps:

1. **Assess Available Data**: these data are used for source characterization, trends analysis, and defining modeling objectives.
2. **Delineate Project Extent**: model segmentation and discretization needed to simulate stream flows at temporal and spatial scales appropriate for defining instream flow needs at specified Points of Interest (POIs).
3. **Set Boundary Conditions**: spatial and temporal model inputs defining the appropriate hydrologic inputs and outputs.
4. **Model Calibration**: the adjustment of model rates and constants to mimic observed physical processes of the natural system.
5. **Model Validation**: confirmation of model processes and patterns over space and time to assess if the model is a robust predictive tool.
6. **Assess Data Gaps**: Sometimes the nature of modeled responses can indicate the influence of unrepresented physical processes in the modeled system. A well-designed model can be adapted for future applications as new information about the system becomes available. Depending on the study objectives, data gaps sometimes provide a sound basis for further data collection efforts to refine the model, which cycles back to Step 1.

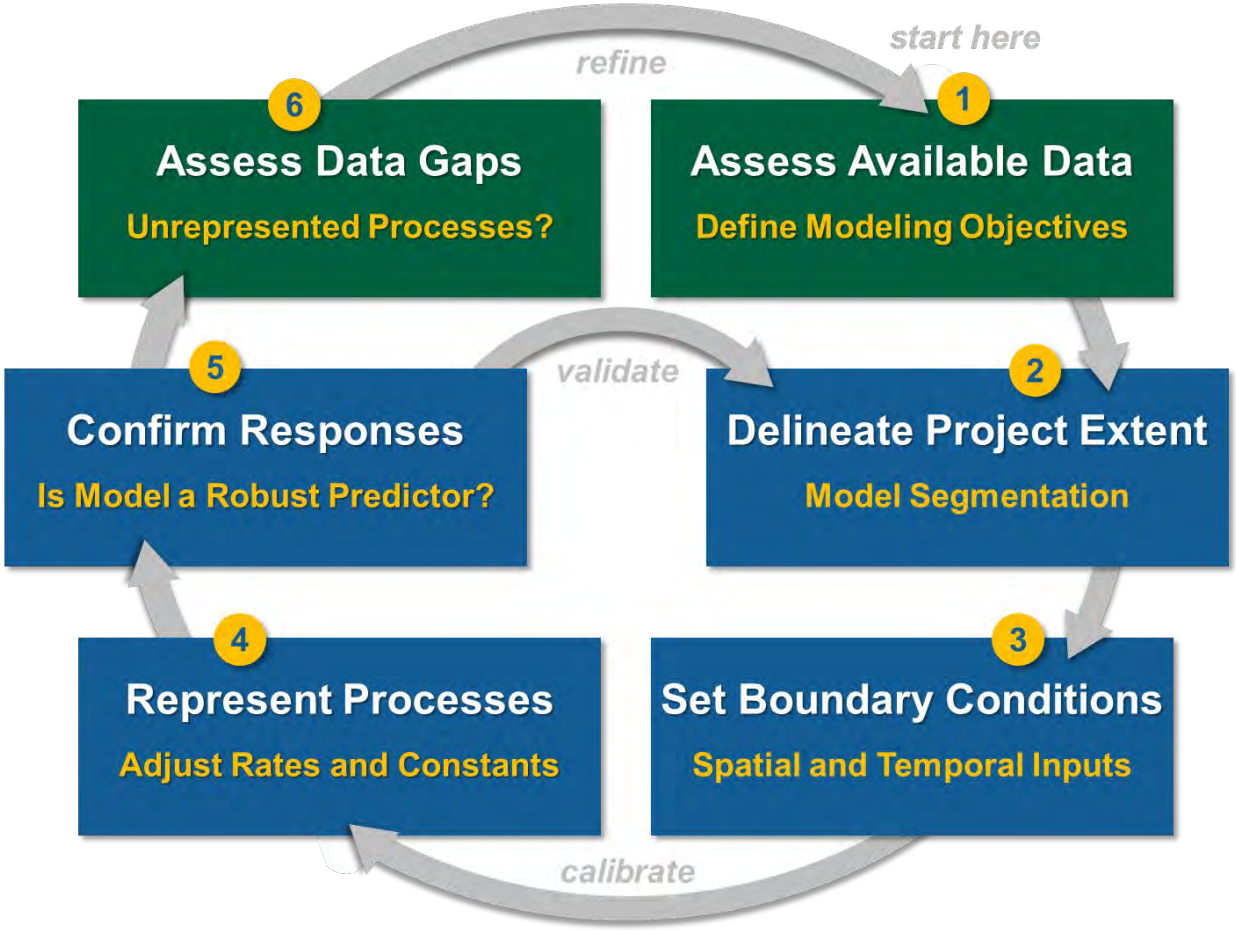


Figure 2-1. Conceptual schematic of a model development cycle.

The hydrologic and water quality model selected for the baseline model of Santa Clara Basin watersheds was the Loading Simulation Program in C++ (LSPC) (Shen et al., 2004), a watershed modeling system that includes Hydrologic Simulation Program FORTRAN (HSPF) algorithms for simulating watershed hydrology, erosion, water quality processes, and in-stream fate and transport processes. The model can simulate upland loading and transport of sediment, mercury, and PCBs.

LSPC is built upon a relational database platform, making it easier to collate diverse datasets to produce robust representations of natural systems. LSPC integrates GIS outputs, comprehensive data storage and management capabilities, the original HSPF algorithms, and a data analysis/post-processing system into a convenient PC-based Windows environment. The algorithms of LSPC are identical to a subset of those in the HSPF model with selected additions, such as algorithms to address land use change over time. A recent user's manual for LSPC is available with the Watershed Management Modeling System (WMMS), a large-scale application of LSPC in the Los Angeles, CA Region (http://dpw.lacounty.gov/wmd/wmms/) (LACDPW 2010). Figure 2-2 is a generalized schematic of the underlying hydrology model (Stanford Watershed Model) used in HSPF and LSPC. The schematic represents land-based processes for a single land unit in the model.

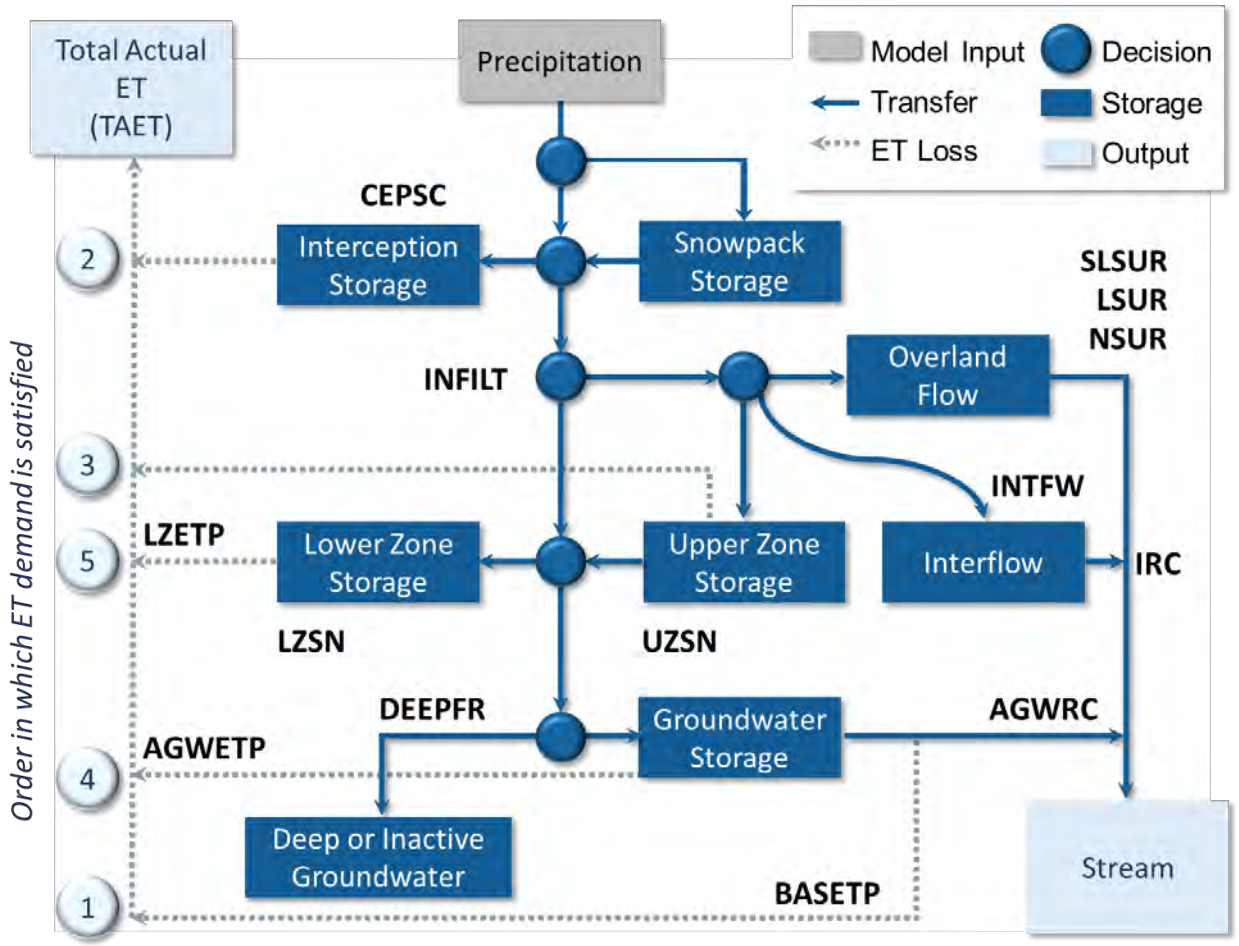


Figure 2-2. Hydrology model schematic (based on Stanford Watershed Model).

Meteorological data are the driver for the modeled hydrologic processes. As shown in the schematic, precipitation is the primary input, while total actual evapotranspiration (TAET) and streamflow are the primary outputs in the water budget. Potential evapotranspiration (PEVT; not explicitly shown in the schematic) is another key meteorological boundary condition for the model. The interaction of model parameters shown above in Figure 2-2 will ultimately determine how much PEVT becomes TAET. There are several pathways that water can take as it makes its way through the network. For each land unit, process-based parameters that reflect differences in geology, soils, vegetation, and land cover will govern the rates and volumes of water at each stage throughout the schematic.

LSPC and HSPF are open-source public-domain watershed models available from EPA and represent the state-of-the science for creating robust models that represent baseline hydrology and water quality. A representative calibrated model becomes the baseline for comparison to scenarios that consider future policies and infrastructure. An important aspect of the application of LSPC to complex hydrologic and water quality issues is the development of an approach that considers available data for model parameterization, model calibration and validation, regulatory requirements, and practical considerations. The approach developed for this RAA combines these important considerations and is consistent with the Bay Area RAA Guidance and EPA RAA Guide. The resulting model, in combination with the Phase II modeling effort described in a companion report, will provide a means for identifying and quantifying the load reduction benefits of GSI implementation options in all locations but will also identify certain locations or activities for prioritized efforts based on benefits

versus costs. GSI investment is most cost effective when costs of implementation are relatively low and pollutant load reduction is relatively high. The following provides a description of the baseline modeling approach used for this RAA.

A three-step approach was developed that leverages RWSM methods for representing PCB and mercury concentrations with the LSPC process-based modeling approach (Figure 2-3):

1. The first step entailed applying the calibrated, land-use-based PCB and mercury runoff concentrations from RWSM to estimate long-term average PCB and mercury loads from LSPC. The product of Step 1 total load of PCBs and mercury within the Santa Clara Basin. Using EMCs alone would result in a constant concentration during storm events, which would not be representative of natural processes like first-flush responses.
2. In the second step, the ratio of LSPC modeled PCB and mercury loads to LSPC modeled sediment load was used to estimate an average contaminant sediment concentration, expressed as the mass of contaminant per mass of sediment, for both PCBs and mercury. The resulting PCB and mercury sediment concentrations (i.e., potency factors) were then used to simulate contaminant loadings as a function of sediment rather than runoff. Simulating contaminants as a function of sediment allows the model to capture the first-flush effect, dilution of subsequent events, and non-linear variability of loads with storm intensity.
3. Finally, simulated concentrations are calculated in Step 3, which were then compared to observations from the Small Tributaries Loading Strategy (STLS) as validation.

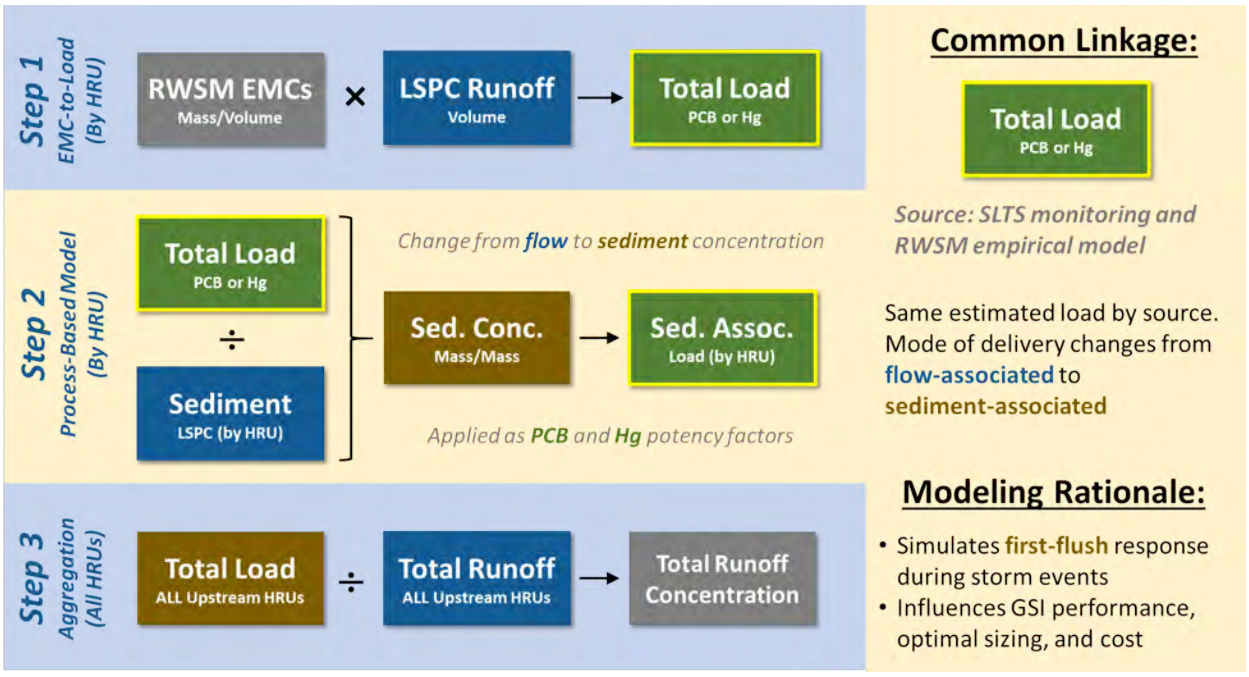


Figure 2-3. Schematic for deriving a process-based, sediment associated modeling approach for PCBs and mercury.

3 WATERSHED DELINEATION

One of the primary requirements in hydrologic model development involves watershed delineation. Identifying watershed boundaries enables modelers to portray specific characteristics of the region's watersheds such as slope, land use, impervious cover, climatic variations, elevation, etc. to inform hydrology of the region. A fine-resolution subwatershed delineation provides increased spatial resolution and model accuracy for predicting hydrologic characteristics within a watershed and allows for routing of flows and associated pollutant loads within each watershed to the Bay. The watershed delineation focused on the Santa Clara Basin, and includes the Coyote Creek and Guadalupe River watersheds and adjacent watersheds discharging to the Bay. The Uvas and Llagas watersheds were also included in the model because of overlap of the City of San José boundary.

3.1 Digital Elevation Model (DEM)

A Digital Elevation Model (DEM), or terrain surface, is a raster representing the physical land surface elevation of the watershed. This elevation dataset is critical for analyzing flow direction, natural drainage networks, and for calculating the slope of overland flow. Therefore, the DEM resolution is a key to represent level of detail and accuracy of the data. Two different DEMs were available for representing elevation in the Santa Clara Basin:

- Santa Clara County and City of San José DEM – Derived from high-resolution LiDAR data in 2006 and available at a 1-meter spatial resolution.
- USGS National Elevation Dataset – National coverage of DEMs expressing landscape elevation through a raster grid data product with 30-meter resolution.

Figure 3-1 shows the extent of the 1-meter and 30-meter DEM boundaries. The high-resolution 1-meter DEM covers 45 percent of the Santa Clara Basin primarily within the urban core around the City of San José. Much of the high-resolution coverage falls within the Coyote Creek and Guadalupe River subwatersheds. The 30-meter USGS DEM raster dataset for Santa Clara County area and 1-meter high-resolution DEM for City of San José (derived from high-resolution LiDAR data in 2006) were merged into one raster dataset with 1-meter resolution. Figure 3-2 show the absolute elevation across the entire Santa Clara Basin. Elevation ranges from less than 75 ft along the northern and south western parts of the watershed to over 2,000 ft at the highest peaks along the western and eastern edges of the watershed.

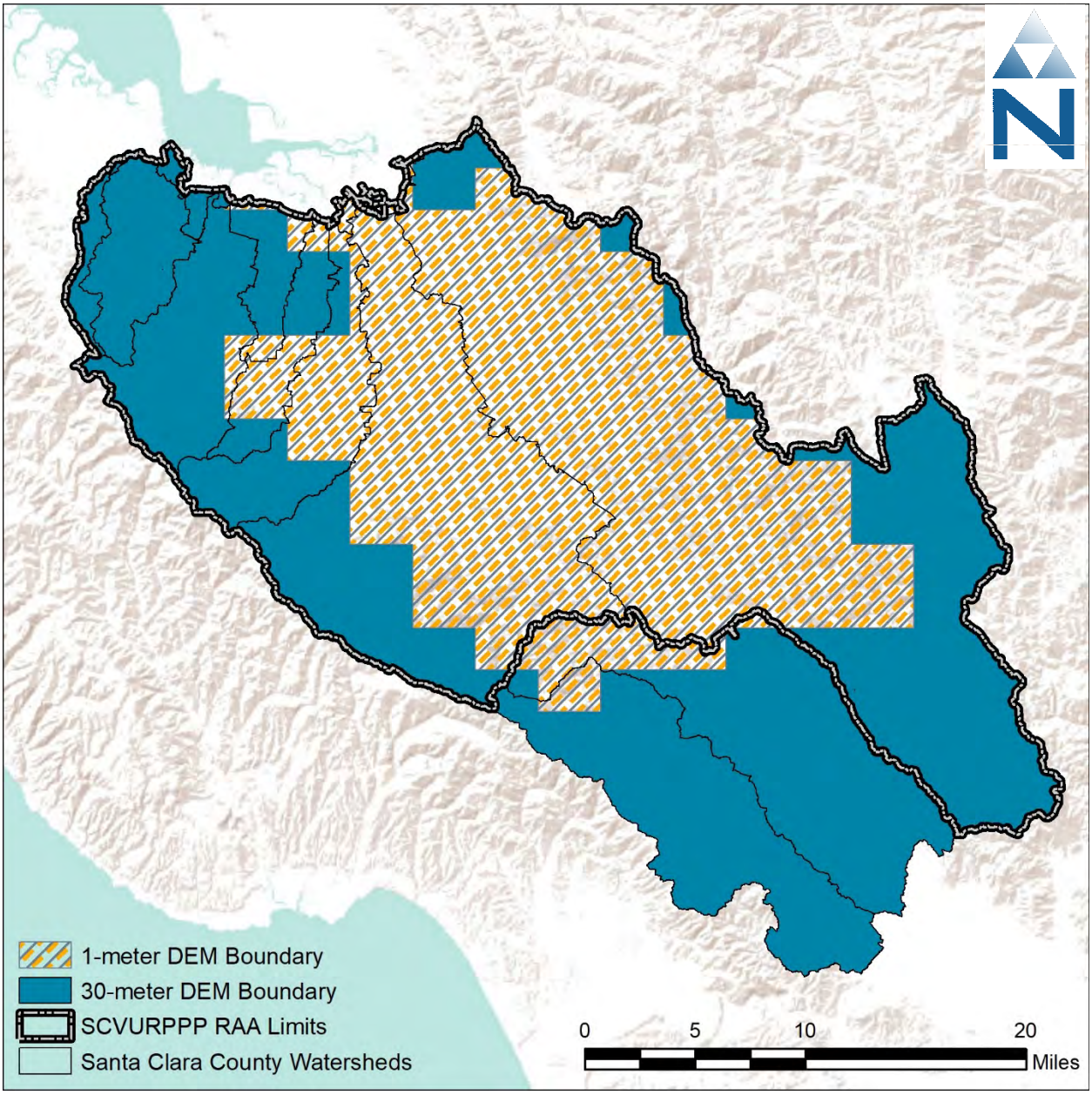


Figure 3-1. Spatial extent of the 1-meter (source: City of San José) and 30-meter (source: USGS) DEM data products.

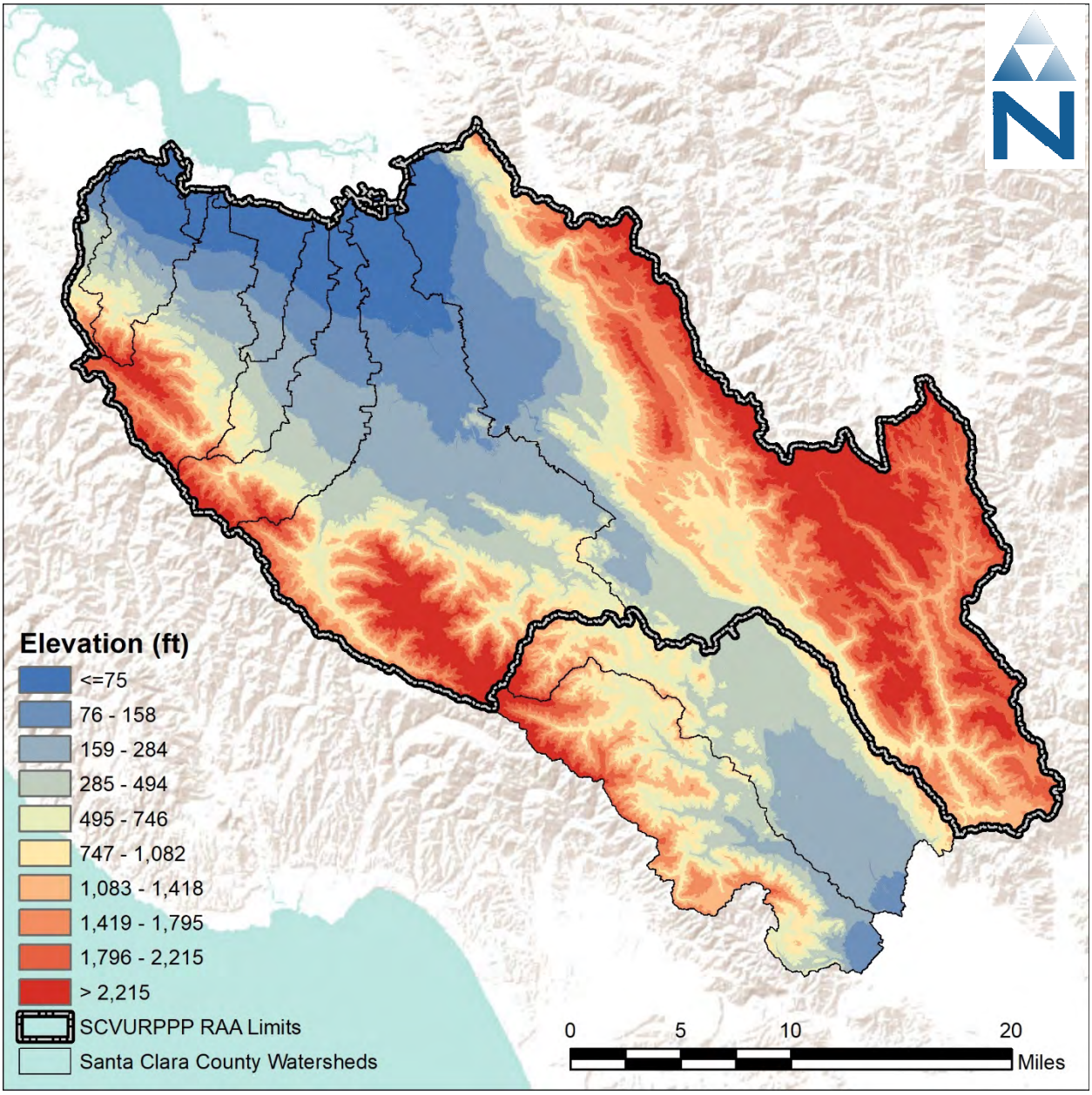


Figure 3-2. Elevation and Santa Clara County watershed boundaries.

3.2 Delineation Methodology

The subwatershed delineation was performed using the combined DEM (Figure 3-2) and an inventory of storm drains, streams, and other waterways compiled from the Santa Clara Basin SWRP and the City of San José Storm Sewer Master Plan (SSMP). A multi-step delineation process was used in GIS to ensure accuracy of the boundaries, consistency with other local efforts (e.g., SWRP, SSMP), and alignment with locations of assessment points used for model calibration. The sequence of steps for subwatershed delineation included:

1. GIS datasets representing waterways (i.e., storm drains, streams, etc.) were *burned* into the combined DEM, meaning they were inset into the raster as low points.
2. Any resulting sinks (i.e., raster cells that do not flow to a neighboring cell) were filled in to prevent artificial accumulation of potential flows.
3. A flow direction raster was then created using the filled DEM from Step 2.
4. A flow accumulation raster was created from the flow direction file from Step 3.
5. A stream flowlines raster was created from the flow accumulation layer from Step 4.

Finally, the stream flowlines created in Step 5 were used in conjunction with a set of key observation points, including locations of streamflow gages, to create a subwatershed raster that was ultimately converted into polygon subwatershed layer for sampling other spatial data for LSPC model configuration. The spatial extent of the delineated major watershed was verified to mostly align with the extents of the Santa Clara Basin and Santa Clara Valley Water District (SCVWD) watershed boundaries. The spatial extent of the delineated watersheds was also referenced against the City of San José SSMP catchments. Since the planning-level scale of the RAA water quality model does not require high-resolution subcatchments on the order of the SSMP catchments, each delineated subwatershed may include several SSMP catchments.

3.3 Model Subwatersheds

The subwatershed delineation included outlets for monitoring gages and reservoirs, while preserving stream connectivity and routing requirements for the model. Within the heavily urbanized areas that were relatively flat, the higher-resolution 1-meter DEM improved the representation of subwatershed boundaries within those areas. For non-urbanized areas, the 30-meter DEM with a coarser resolution was sufficient to establish the flow boundaries. Consequently, the mostly urban areas covered by the 1- meter DEM were divided into more subwatersheds, while the non-urban areas covered by the 30-meter DEM were divided into fewer. Table 3-1 summarizes the number of subwatersheds within the Santa Clara Basin. The Uvas and Llagas watersheds were included in the model because of overlap of the City of San José boundary. The delineation process resulted in 862 subwatersheds. The Coyote Creek watershed, the largest watershed in the Santa Clara Basin, has the most subwatersheds. The Sunnyvale Channel watershed is the smallest in Santa Clara Basin with the fewest subwatersheds. Figure 3-3 depicts the delineated subwatersheds in the area.

Table 3-1. Summary statistics of subwatershed delineations by major watershed.

Watershed	Count	Mean Size (acres)	Median Size (acres)
Coyote Creek	295	755	576
Guadalupe River	200	548	464
Llagas Creek	92	718	627
San Tomas Aquino Creek	62	455	370
Uvas Creek	57	967	691

Watershed	Count	Mean Size (acres)	Median Size (acres)
Permanente/Stevens Creeks	52	582	370
San Francisquito Creek	20	598	328
Adobe/Barron/Matadero Creeks	32	563	567
Calabazas Creek	31	427	324
Sunnyvale Channel	16	592	445
Baylands	5	1326	1678
Total	**862**	--	--

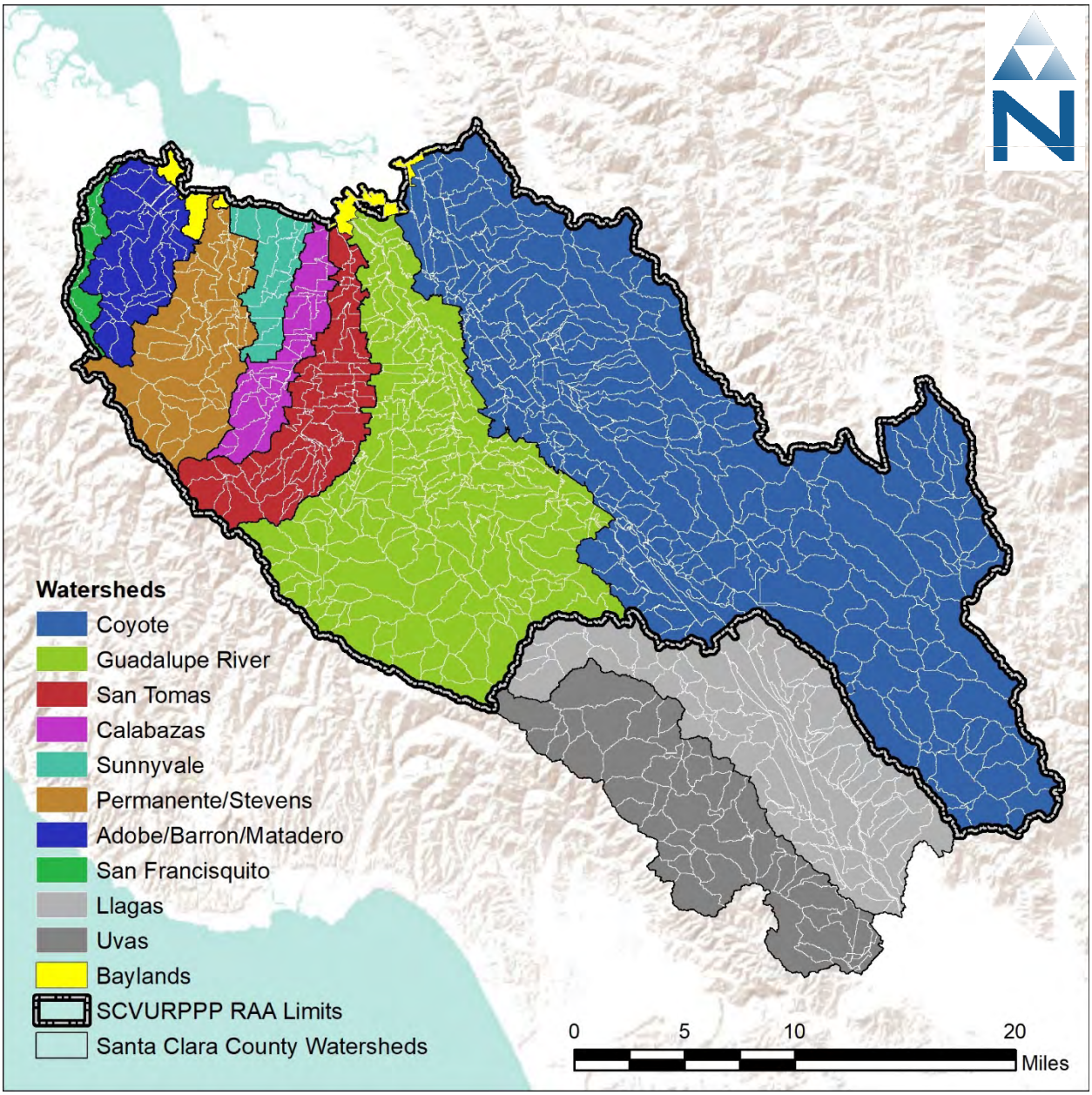


Figure 3-3. Santa Clara Basin watershed and subwatershed delineations.

4 HYDROLOGIC RESPONSE UNITS

Hydrologic Response Units (HRUs) are the core hydrologic modeling land units in the watershed model. Each HRU represents areas of similar physical characteristics attributable to certain processes. Spatial or geological characteristics, such as soils, slope or steepness, land cover, and land use, are typically used to define HRUs. These four datasets were the primary attributes used in the Santa Clara Basin for classifying HRUs. Stratifying landuse with imperviousness, soil, and slope introduces more texture for characterizing spatial variability of hydrology than using land use alone. It also provides a basis for compartmentalizing parameters. For example, all HRUs of a given soil type can have the same infiltration rate, but different interception storage values because that varies by landuse and vegetative cover. The areal combination of primary characteristics ultimately determines the number of meaningful HRU categories considered for the model. Some consolidation of HRUs is required to balance the need for spatial resolution with model simulation efficiency. Figure 4-1 shows the organizational relationship of HRUs, subwatersheds, and model parameterization. Secondary attributes are properties (e.g., impervious cover) that are summarized by HRU to estimate numerical values for the model.

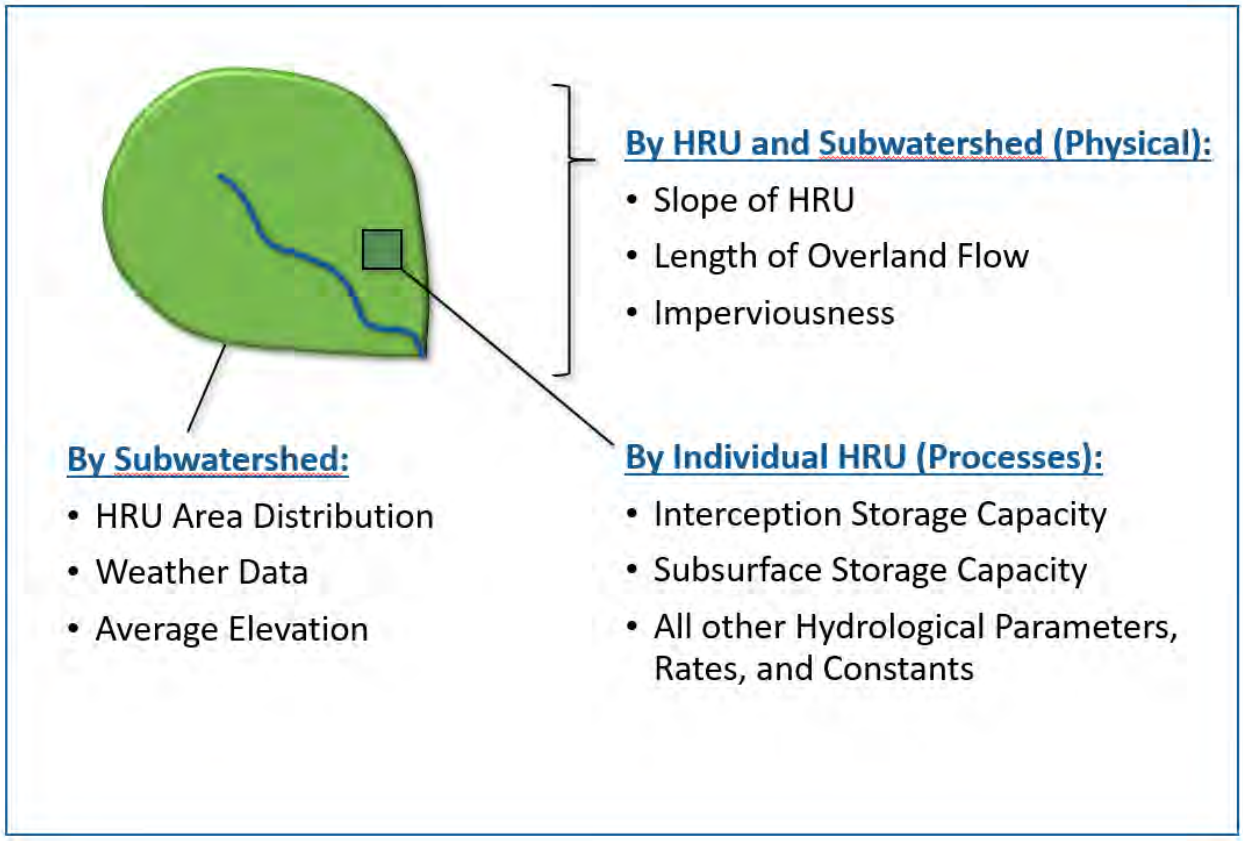


Figure 4-1. Organizational relationship of HRUs, subwatersheds, and model parameterization.

Table 4-1 summarizes the GIS datasets and the corresponding data sources used in HRU processing. All data layers were downloaded from publicly available data sources or received from municipalities (e.g. City of San José). The following subsections provide detailed descriptions of each HRU component dataset.

Table 4-1. Summary of input datasets detailing data source and type

GIS Layer	Data Source	Description
Soil Survey Geographic Database (SSURGO)	United States Department of Agriculture (NRCS 2016a)	2016 - polygon layer
State Soil Geographic Database (STATSGO)	United States Department of Agriculture (NRCS 2016b)	2016 - polygon layer
Slope	Generated from DEM	30m raster
Land Use	Association of Bay Area Governments	C. 2005
Land Cover	NLCD (Xian et al. 2011)	c. 2011 – 30m raster
Land Use	City of San José Zoning Map	c. 2018 – polygon layer
Imperviousness Cover	NLCD (Xian et al. 2011)	c. 2011 – 30m raster

4.1 Hydrologic Soil Group

Soils data were obtained from the Soil Survey Geographic Database (SSURGO) and State Soil Geographic Database (STATSGO), both published by the Natural Resource Conservation Service (NRCS). There are four primary hydrologic soil groups (HSG) used to characterize soil runoff potential. Group A generally has the lowest runoff potential whereas Group D has the highest runoff potential. Both SSURGO and STATSGO soils databases are composed of a GIS polygon layer of map units and a linked database with multiple layers of soil property. Soil characteristics of each hydrologic soil group are described in Table 4-2.

Table 4-2. NRCS Hydrologic soil group descriptions.

Hydrologic Soil Group	Description
A	Sand, Loamy Sand, or Sandy Loam
B	Silt, Silt Loam or Loam
C	Sandy Clay Loam
D	Clay Loam, Silty Clay Loam, Sandy Clay, Silty Clay, or Clay

Data Source: Natural Resource Conservation Service (NRCS), Technical Release 55 (TR-55)

Figure 4-2 presents the spatial distribution and a tabular summary of the SSURGO hydrologic soil groups for the watershed. The dominant soil group in the watershed is Group C, containing sandy clay loam with relatively low infiltration rates. Group D is the next most common soil group in the watershed, containing clay loam, and silty clay loam that typically have lowest infiltration rates, compared to other hydrologic soil groups. Less than 1 percent of the watershed areas had mixed soils, which were grouped with the nearest primary group as follows: A/D → B, B/D → C, and C/D → D. Approximately 2 percent of the watershed HSG area was unknown in the SSURGO database. For those areas, the corresponding HSG from the STATSGO dataset was used to supplement the data gaps. Finally, about 1 percent of the watershed was also unknown in the STATSGO dataset and was classified as D soil group.

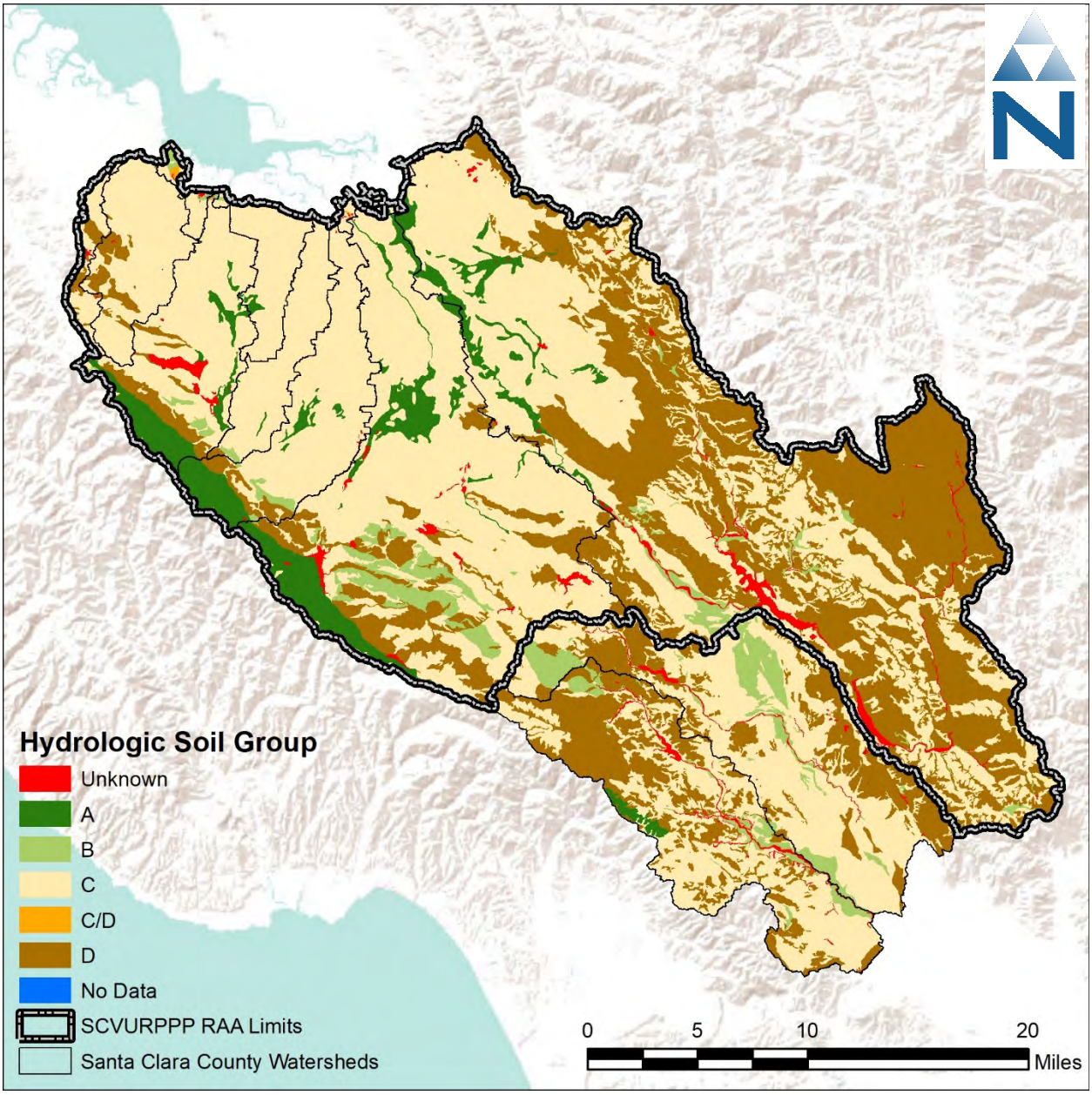


Figure 4-2. SSURGO hydrologic soil groups in the Santa Clara Basin.

4.2 Slope

The DEM grid was used to develop a percent slope raster, which was then reclassified into three groups (i.e., ≤10 percent, 10 – 35 percent, and >35 percent) corresponding to *low*, *medium*, and *high* slope areas, respectively. The *low* slope threshold of 10 percent was selected primarily as a threshold for representing urban areas as 77 percent of the total developed area lies below the 10 percent slope threshold. The slope threshold between *medium* and *high* of 35 percent was selected based on a natural breakpoint identified in the distribution of slopes across the total watershed area. This threshold results in about 48 percent of the total Santa Clara Basin area falling into the *medium* slope group, 36 percent as low and 16 percent as high. Figure 4-3 presents a map showing the spatial distribution of the reclassified slope categories.

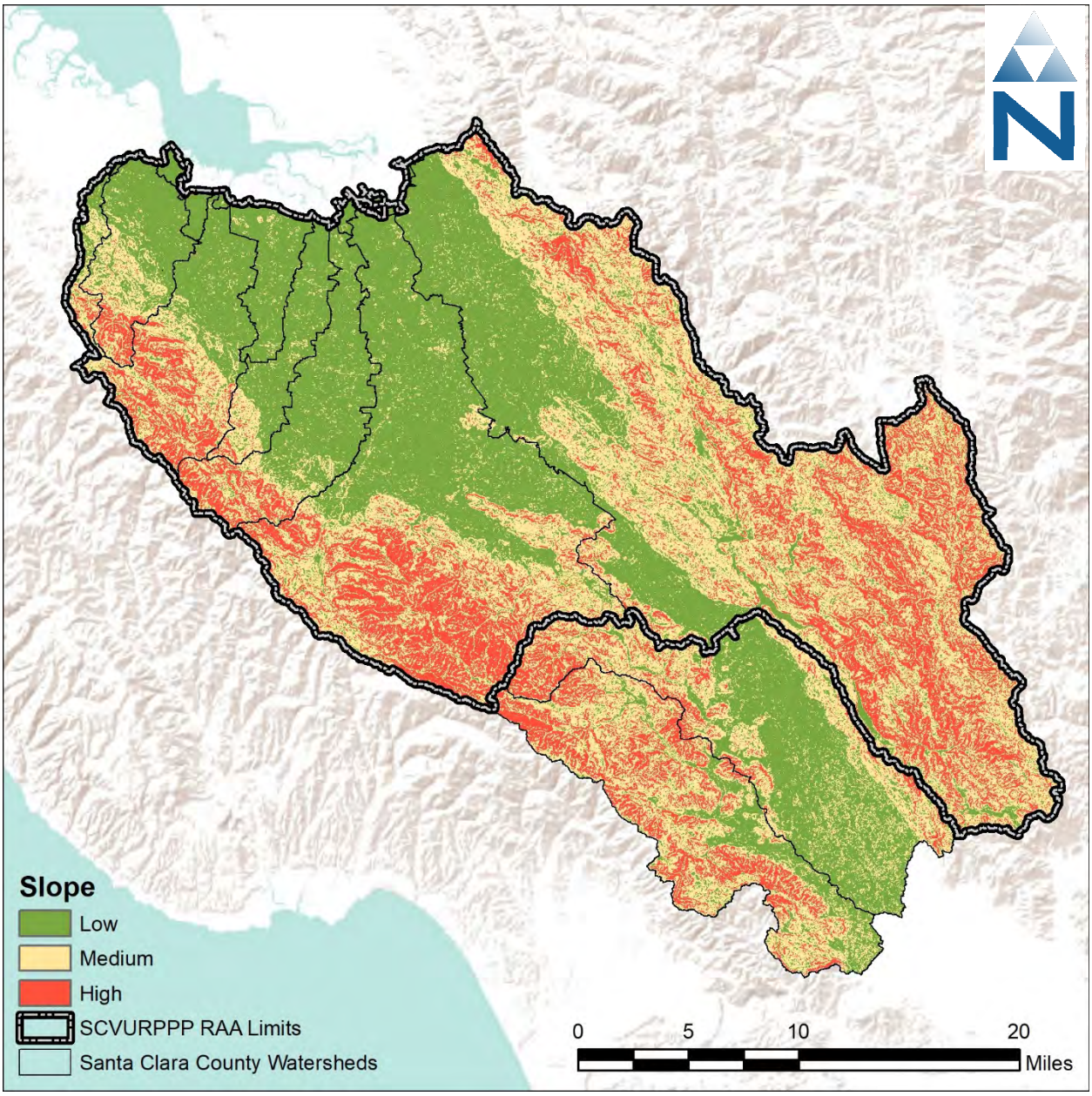


Figure 4-3. Map showing reclassified landscape slope groups.

4.3 Land Cover & Land Use

Land cover and land use data are the primary base layers for HRUs. Land cover describes the physical characteristics that cover the landscape (e.g., forest, wetlands, development) while land use describes the programmatic nature of land cover (e.g., type of development, functional use of open space, zoning etc.). The sources of land cover and land use data used in developing the LSPC watershed model were the Association of Bay Area Governments (ABAG) land use layer, the 2011 National Land Cover Database (NLCD), and the City of San José zoning map. The ABAG layer, modified by SCVURPPP staff to identify old and new urban land uses, was used as the main source of information for representing PCB and mercury source areas. This GIS layer includes the five land use source categories consistent with those used by RWSM. While hydrology and sediment were initially modeled at a higher HRU resolution using the NLCD landuse data, the ABAG layer was intersected during water quality model development, allowing for PCB and mercury sediment concentrations to be assigned spatially. Further descriptions of each dataset are as follows:

- The ABAG land use source categories are shown in Figure 4-5. These source categories were incorporated as the basis for assignment of water quality parameters (i.e., PCBs and mercury) to appropriately reflect the spatial distribution of pollutant contributions from the Santa Clara Basin watersheds.
- The City of San José Zoning dataset is the basic means of land use regulation for the City. It has 44 land use categories, including industrial, commercial, residential, open space, agriculture, water, as well as planned development lands. The zoning dataset also provides detailed classification for each zoning district (e.g. single-family residential, multifamily residential, etc.). The planned development indicates the type of development that may be built on all parcels within each district.
- The NLCD is maintained by the Multi-Resolution Land Consortium (MRLC), a joint effort between multiple federal agencies. The primary objective of the MRLC NLCD is to provide a current data product in the public-domain which provides a consistent characterization of land cover across the United States. The first iteration of the NLCD dataset was 1992. Since the 2001 NLCD version, a consistent 16-class land cover classification scheme has been adopted nationwide. The 2011 NLCD adopted this 16-class scheme at a 30-meter grid resolution. The minimum mapping unit is 5 30-m pixels (1.1 acres) for most land cover classes, except urban (1 pixel, 0.2 acres) and cropland and hay/pasture (12 pixels, 2.7 acres) (Homer et al. 2015).
- The NLCD 2011 Imperviousness layer is maintained by MRLC (MRLC) and is published as a companion to the National land Cover Dataset (NLCD). This imperviousness dataset is provided as a raster with a 30-meter grid resolution. Impervious cover is expressed in each raster pixel as a percentage of total area ranging from 0 to 100 percent.

Figure 4-4 shows the organizational relationship of the various datasets used to create HRUs.

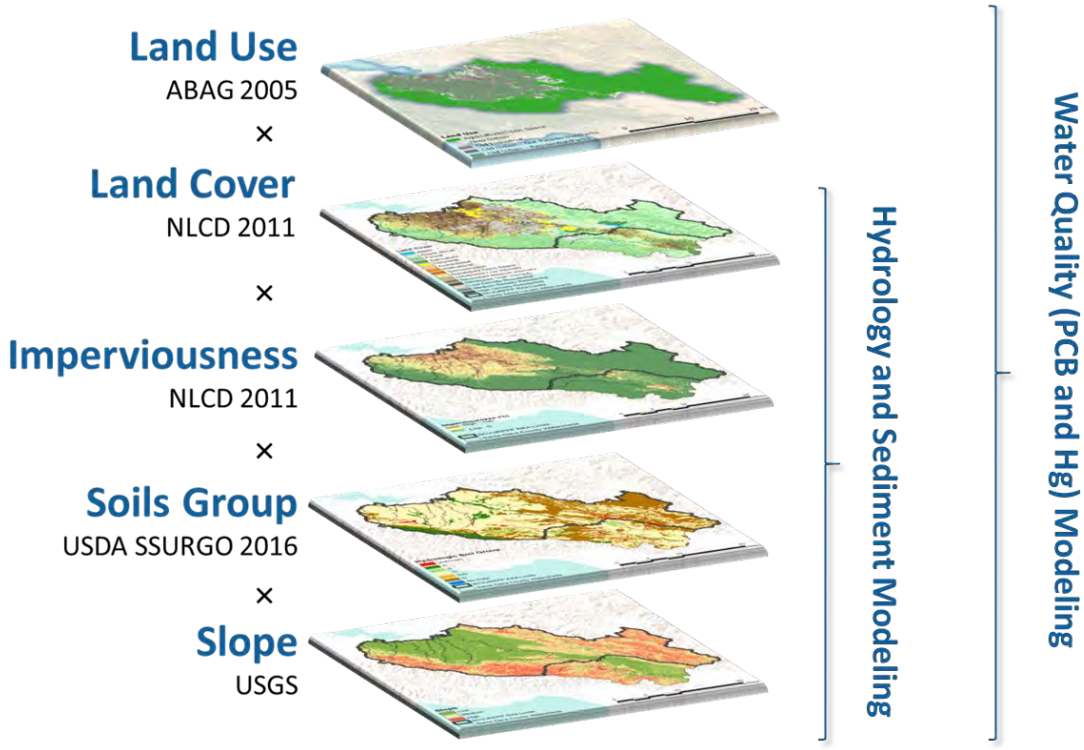


Figure 4-4. Key land characteristic datasets used to create HRUs.

Figure 4-5 shows a land use map for the Santa Clara Basin based on the ABAG dataset. Agriculture/Open areas are the dominant classification in the Santa Clara Basin, comprising approximately 63.3 percent of the total watershed area. Old Urban – Residential/Parks was the second most dominant land use, comprising 21.8 percent of the watershed. Old Urban – Not Residential/Parks, Old Industrial, and New Urban comprise the remaining 14.9 percent of the watershed.

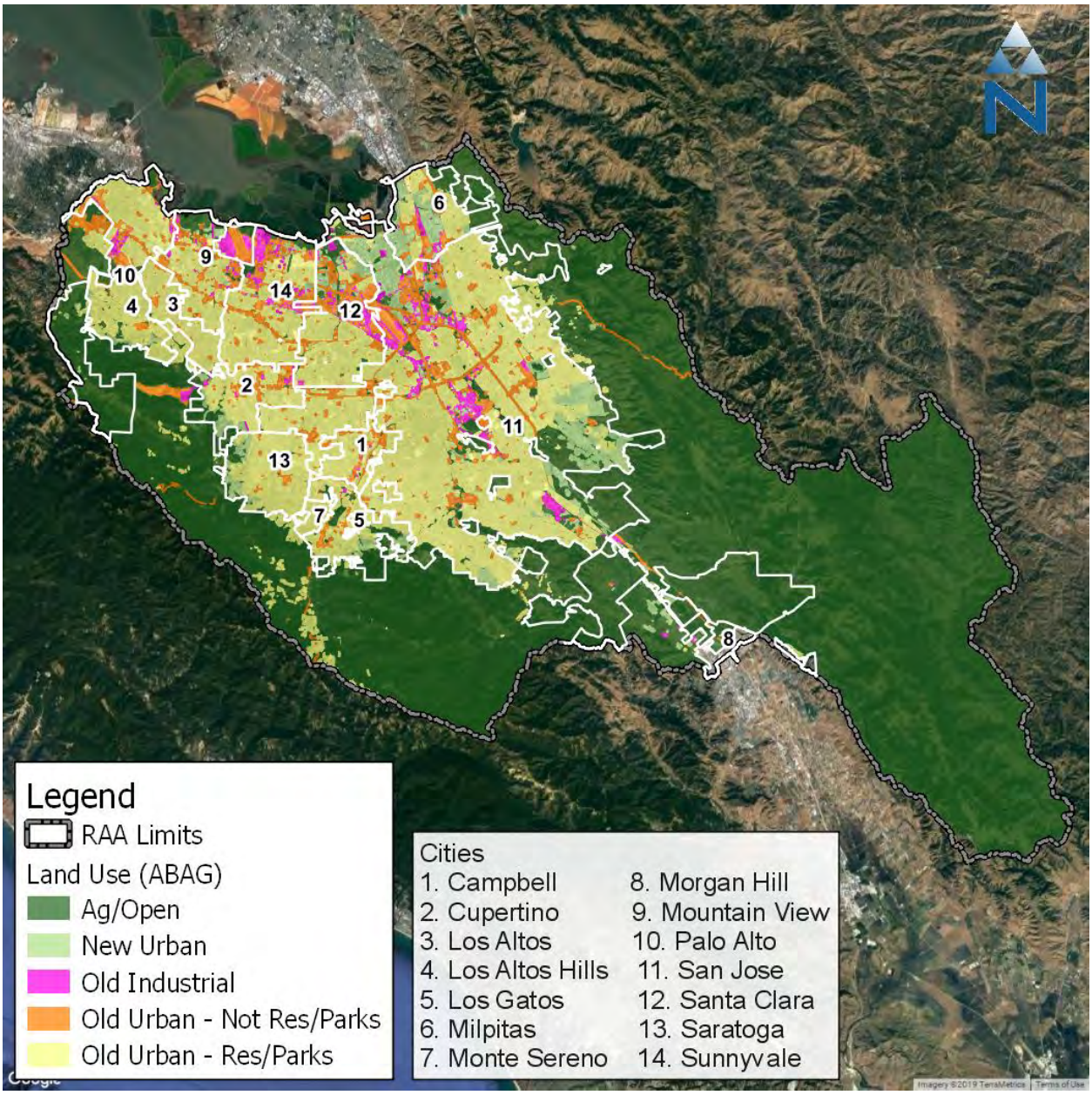


Figure 4-5. Land use source categories developed by SCVURPPP for use with RWSM.

4.4 Impervious Cover

Impervious cover is used as the basis for calculating directly connected impervious area (DCIA), or the portion of impervious cover whose runoff ultimately reaches the drainage network. The calculation of DCIA and how it is used to define the HRUs is discussed in further detail in Section 4.5. MRLC publishes a developed impervious cover dataset as a companion to the NLCD land cover. This dataset is also provided as a raster with a 30-meter grid resolution. Impervious cover is expressed in each raster pixel as a percentage of total area ranging from 0 to 100 percent. Figure 4-6 shows the NLCD 2011 developed impervious cover dataset for the Santa Clara Basin. Because this dataset provides impervious cover estimates for areas classified as *developed,* non-zero values in Figure 4-6 closely align with urban and industrial areas in Figure 4-5.

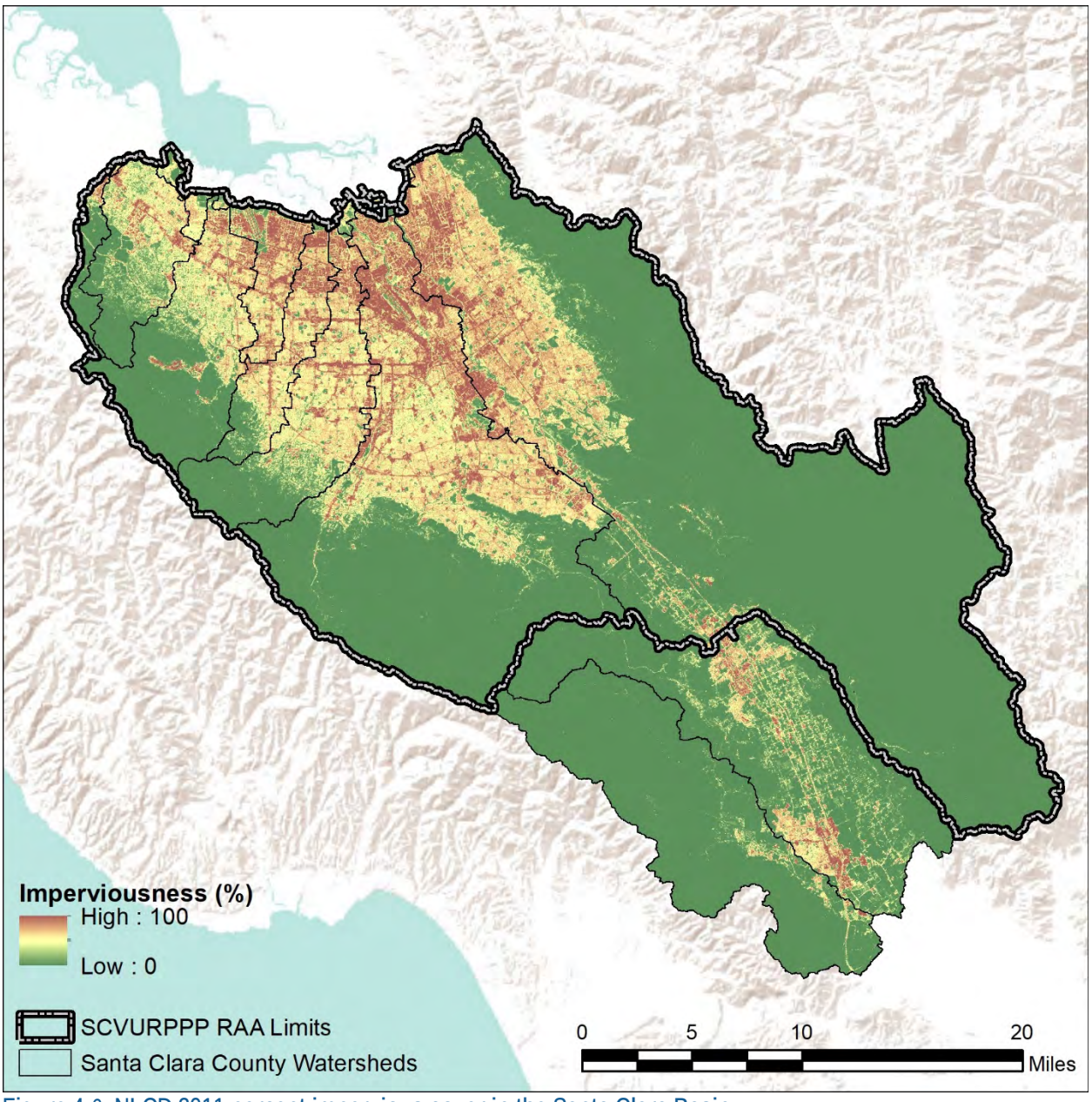


Figure 4-6. NLCD 2011 percent impervious cover in the Santa Clara Basin.

4.5 Directly Connected Impervious Cover

In the physical environment, sometimes the lines between impervious and pervious land are not clearly distinguished. Runoff from impervious surfaces may flow over pervious land on route to a storm drain or watercourse. For modeling purposes, Effective Impervious Area (EIA) represents the portion of total, or Mapped Impervious Area (MIA), that routes runoff directly to the stream segments. It is derived as a function of directly connected impervious area (DCIA), with other adjustments as needed to account for other structural and non-structural management practices in the flow network.

Figure 4-7 illustrates the transitional sequence from MIA to DCIA. Runoff from impervious areas that are not connected to the drainage network may flow onto pervious surfaces, infiltrate, and become part of pervious subsurface and overland flow. Because segments are modeled as being parallel to one another in LSPC, this process can be approximated using a conversion of a portion of impervious land to pervious land. On the open landscape, runoff from disconnected impervious surfaces can overwhelm the infiltration capacity of adjacent pervious surfaces during large rainfall/runoff events creating sheet flow over the landscape—therefore, the MIA→EIA translation is not actually a direct linear conversion. Finding the right balance between MIA and EIA can be an important part of the hydrology calibration effort.

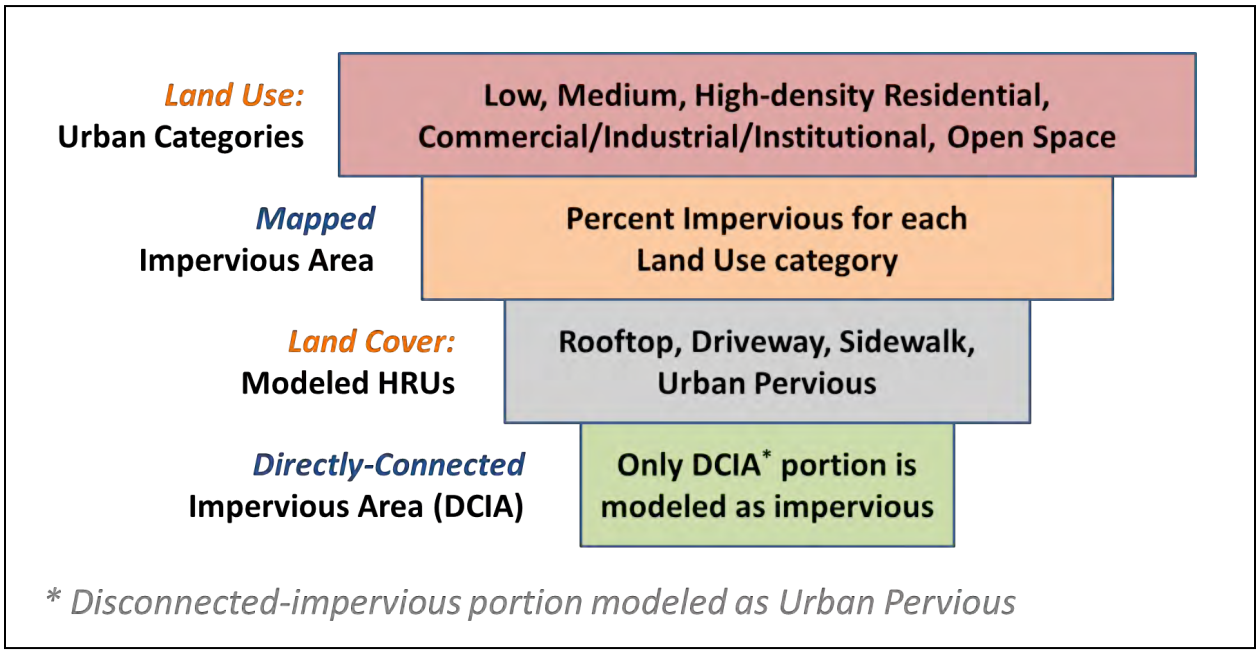


Figure 4-7. Translation sequence from MIA to DCIA.

Empirical relationships like the Sutherland Equations (2000) presented in Figure 4-8 show a strong correlation between the density of developed area and DCIA. The curve for high-density developed land trends closer to the line of equal value than the curve for less developed areas. Similarly, as the density of mapped impervious area approaches 1, the translation to DCIA also approaches 1.

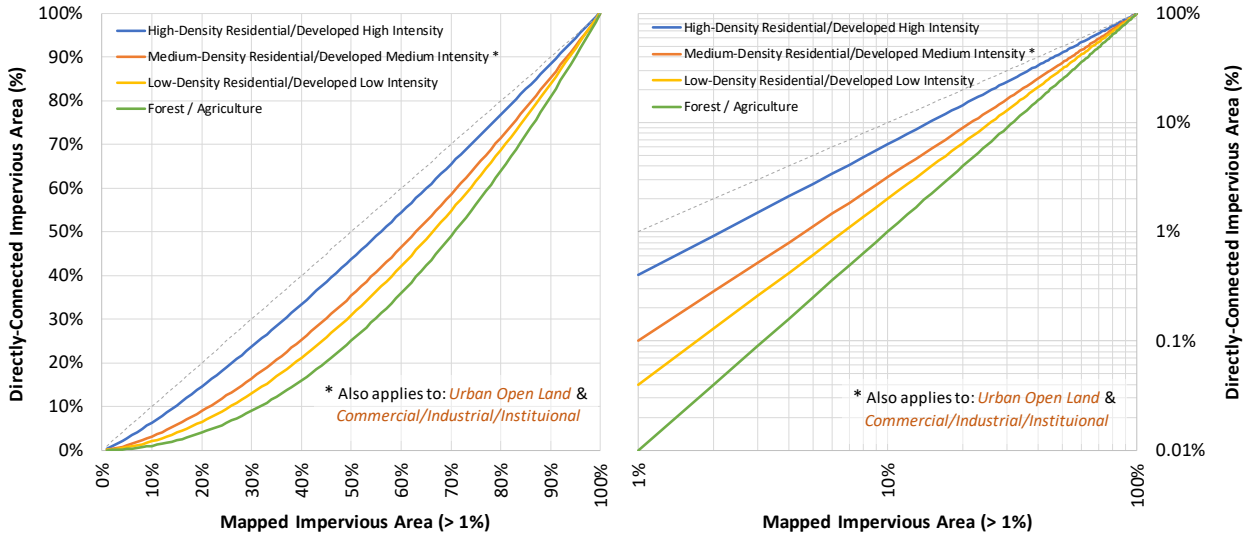


Figure 4-8. Relationships between MIA and DCIA (Sutherland 2000).

An initial estimate of EIA (acres) for each land use type in each subcatchment is determined by: (1) extracting the DCIA (%) corresponding to the MIA (%) in Figure 4-7 and (2) multiplying that DCIA (%) by the total area for that land use type. This refinement is necessary to avoid an initial overestimation of impervious surfaces contributing runoff before initiating process-based model calibration.

4.6 Hydrologic Response Units

Using the reclassified datasets discussed in the previous sections, a set of representative HRUs was developed to reflect key land characteristics of the Santa Clara Basin. These HRUs serve as the functional pervious and impervious land segment units in the watershed model. The following steps were performed to develop HRU categories:

- Re-project all GIS layers into USA Contiguous Albers Equal Area Conic projected coordinate system (EPSG-102003) to ensure proper overlay and accurate area calculations
- Clip all GIS layers to watershed extent to ensure data overlay to the same spatial extent
- Convert all vector GIS layers into raster grids, resampled to a 30-meter resolution (i.e., 30-meter pixel width by 30-meter pixel height)
- Intersect all input spatial layers and tabulate area distribution for unique combinations of "primary attributes," including land use/land cover, imperviousness, soil, and slope
- Using the final set of HRUs, summarize "secondary attributes" by HRU. Secondary attributes include characteristics such as canopy cover, which can be used to inform the parameterization of model processes

Table 4-3 summarizes the percent area by soil and slope HRU groups by each land cover HRU category. Combining the land cover groups (LUC) originally used for hydrology and sediment calibration, four soil groups, three slope groups and the ABAG groups resulted in 79 unique HRU combinations.

Table 4-3. Summary of percent land cover area distribution by HRU categories for the Santa Clara Basin.

Order	LUC	Percent of Area	Soil Group (% Landuse Area)				Slope (% Landuse Area)			ABAG (% Landuse Area)					
			A	B	C	D	0-10	10-35	>35	Ag/Open	New Urban	Old Industrial	ban – Not Res	Urban – Res/P	No Data
			1	2	3	4	1	2	3	1	2	3	4	5	6
1	Developed	40.8%	8.4%	3.7%	76.4%	11.5%	77.3%	21.6%	1.1%	17.4%	8.5%	3.7%	14.0%	39.1%	17.4%
2	Forest	31.7%	8.7%	5.5%	43.9%	42.0%	0.9%	59.5%	39.6%	69.5%	0.5%	0.0%	0.1%	0.9%	29.0%
3	Grass_Shrub	22.9%	1.9%	2.4%	36.5%	59.2%	5.6%	82.6%	11.9%	71.0%	0.5%	0.0%	0.2%	0.3%	27.9%
4	Agriculture	4.0%	5.3%	9.7%	63.7%	21.3%	74.9%	24.9%	0.3%	38.3%	1.9%	0.2%	1.8%	1.2%	56.5%
5	Water	0.6%	80.4%	1.9%	11.9%	5.9%	54.9%	44.8%	0.3%	83.1%	0.3%	0.1%	0.1%	0.3%	16.0%

Color gradients indicate more Watershed Area and increasing percentage of Soil, and Slope, and Landuse respectively.

5 METEOROLOGICAL BOUNDARY CONDITIONS

Meteorological data such as precipitation, evapotranspiration, temperature, and other climate time series are the primary forcing functions of the model. Analytical considerations of data sources include data quantity and quality. Primary meteorological data products compiled and reviewed for this effort included two observed precipitation data products from the National Climatic Dataset Center (Global Historical Climatology Network daily—GHCND and Local Climatic Data). Secondary meteorological data, which are derived or interpolated from primary sources, included monthly precipitation totals from the Parameter-elevation Regressions on Independent Slopes Model (PRISM), hourly precipitation distributions and potential evapotranspiration (ET) estimates from the North American Land Data Assimilation System (NLDAS2), a quality-controlled spatiotemporal dataset supported by the National Aeronautics and Space Administration (NASA), and reference ET rates from the California Irrigation Management Information System (CIMIS).

Because hydrologic models are highly dependent on the quantity and quality of meteorological forcing data, sometimes challenges arise when trying to associate point-sampled weather gauge data over complex terrain (Henn et al. 2018). The development and application of high-resolution gridded data products, or land surface models (LSM), to support continuous-simulation modeling and other geophysical applications has increased with advancements in computing capability and resources. Research related to those products focuses on methodology refinements, assessment of differences between products, and identification of primary drivers and geophysical conditions that affect the robustness of their application in different settings (Henn et al 2018; Behnke et al. 2016). All seven of the gridded products reviewed by Behnke et al. (2016) use the PRISM methodology to interpolate spatially because it considers orographic influence on rainfall variability.

The use of products like NLDAS2 and PRISM also helps to overcome some of the common issues encountered when working with rainfall gauge data, which sometimes contain impaired intervals of missing, deleted, or accumulated data. Missing or deleted intervals are periods during which either the gauge malfunctioned, or the data records were lost. Accumulated intervals contain cumulative precipitation reported over several hours or days, but the exact temporal distribution of the data is unknown due to a gauge malfunction. The LSM uses observed gauge data to guide the meteorological data extrapolation at fixed spatial intervals. LSM extrapolation considers orographic influence on the spatial variation, which can capture the influence of weather movements like those depicted in Figure 5-1. Topographic properties like elevation, aspect, and the windward/leeward location of the prediction point are considered when modeling rainfall variability (both timing and volume) across the landscape. As a result, LSMs extrapolate conditions for ungauged areas and interpolate spatial variability between gauged areas in a non-linear way. Gridded meteorological data representations can capture localized impacts such as rain shadow over the landscape. The quality-control and increased spatiotemporal resolution of meteorological boundary conditions improves the predictions of continuous simulation watershed models and benefits water balance calculations in large-scale continuous-simulation applications. NLDAS2 and PRISM are both also updated in real-time in a consistent format, making it easier to periodically update boundary conditions for the watershed model as new information becomes available.



Figure 5-1. Orographic influence on weather movement.

Table 5-1 presents a summary of available meteorological data by source that were reviewed as part of model development. Table icons indicate the temporal resolution of the data by source. NLDAS2 also includes the full suite of hourly meteorological timeseries that the model uses, except for dewpoint temperature; however, dewpoint temperature, which is a function of air temperature, station pressure, and specific humidity, was computed from those NLDAS2 timeseries. The approach used was to intersect NLDAS2 and PRISM and scale the NLDAS2 hourly rainfall timeseries distributions with PRISM monthly precipitation totals. The resulting intersect is an hourly 4-km spatial distribution of PRISM timeseries (based on NLDAS2 rainfall distributions) for the Santa Clara Basin—there are 137 unique sets of meteorological timeseries available for assignment to the modeled subwatersheds. The sets of meteorological timeseries covered the period between WY 1996 to WY 2017 at an hourly timestep. These timeseries includes the representative water year 2002 suggested by the Bay Area RAA Guidance for simulation of baseline loading, which is used as the evaluation period in this RAA.

Table 5-1. Summary of the climate parameters evaluated during the initial inventory

Meteorological Data	Temporal Resolution of Meteorological Data by Source (Timestep: ● Hourly, ○ Daily, ☐ Monthly)						
	(a) GHCN	(b) LCD	(c) CDEC	(d) RAWS	(e) DRI	(f) PRISM	(g) NLDAS2
Precipitation	○	●	●	●	○	☐	●
Potential Evapotranspiration	--	--	--	--	--	--	●
Air Temperature (Min/Max)	○	--	--	--	--	☐	--
Air Temperature	--	●	--	●	--	--	●
Solar Radiation	--	●	--	●	--	--	●
Cloud Cover	--	●	--	●	--	--	●
Wind Speed	--	●	--	●	--	--	●
Wind Direction	--	●	--	●	--	--	●
Station Pressure	--	--	--	--	--	--	●
Specific Humidity	--	--	--	--	--	--	●[1]
Dewpoint Temperature	--	●	--	●	--	--	●[2]

Acronyms: (a) Global Historical Climatology Network, (b) Local Climatic Data, (c) California Data Exchange Center, (d) Remote Automated Weather Stations, (e) Desert Research Institute, (f) Parameter-elevation Regressions on Independent Slopes Model-Monthly aggregated timeseries, (g) North American Land Data Assimilation System.
1: *Specific Humidity* converted to *Relative Humidity* as a function of *Air Temperature* and *Station Pressure*
2: *Dewpoint Temperature* calculated as a function of *Air Temperature* and *Relative Humidity*

5.1 Subwatershed Assignment

In the LSPC model, one set of meteorological timeseries is assigned to each of the 882 delineated model subwatersheds—it is also assumed that the associated rainfall falls uniformly within each subwatershed. To better manage the rigidity of that assumption, subwatersheds were delineated at a finer resolution in portions of the watershed where rainfall variability was relatively high over short distances. Data analysis from other modeling studies at times show notable differences in observed rainfall data collected at different locations at the same facility (e.g., opposite ends of an airport runway). Henn et al. (2018) also describe paired comparisons of observed rainfall gauges located within the extent of a single LSM grid, which report different rainfall volumes and distributions. Ultimately, the predicted hydrologic response of higher-resolution meteorological boundary conditions validates how representative they are of weather conditions upstream of the modeled assessment point.

Figure 5-2 shows regional distribution of annual average PRISM rainfall overlaid with modeled subwatersheds, PRISM, and NLDAS2 data centroids. Meteorological boundary conditions were associated with subwatersheds by assigning the grid that covered most of the subwatershed area.

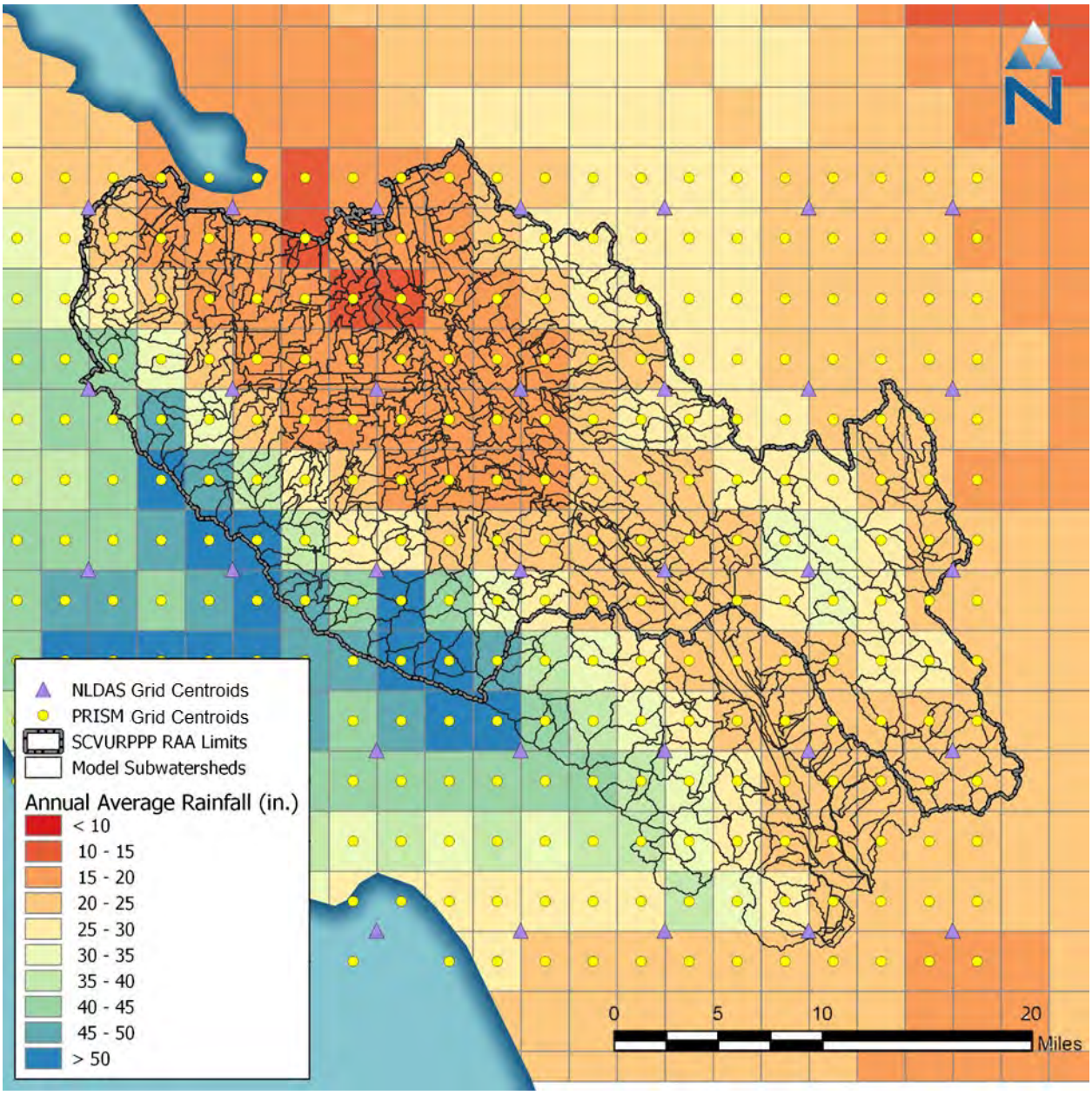


Figure 5-2. Annual average PRISM rainfall depths with associated PRISM and NLDAS2 data centroids.

5.2 Elevation and Aspect Analysis

The PRISM data were analyzed against topographic data to better understand the implications of orographic influences reflected in the PRISM annual average rainfall totals. The normal elevation of each PRISM centroid was paired with its corresponding long-term average rainfall total. The PRISM outputs are at a 4-km resolution, meaning that the model only knows about those points. It is on the basis of those elevation normal that precipitation is determined. The dominant hillslope aspect for each PRISM grid was derived from the National Elevation Dataset (NED) Digital Elevation Model (DEM). The representative aspect values were categorized into north-, east-, south-, and west-facing quadrants.

The influence of elevation was evaluated first. PRISM centroids were sorted by increasing elevation and associated average annual rainfall was plotted. The data were grouped into five equal elevation bins for analysis (low, medium-low, medium, medium-high, and high)—the median elevation of each bin is plotted for reference, as shown in Figure 5-3.

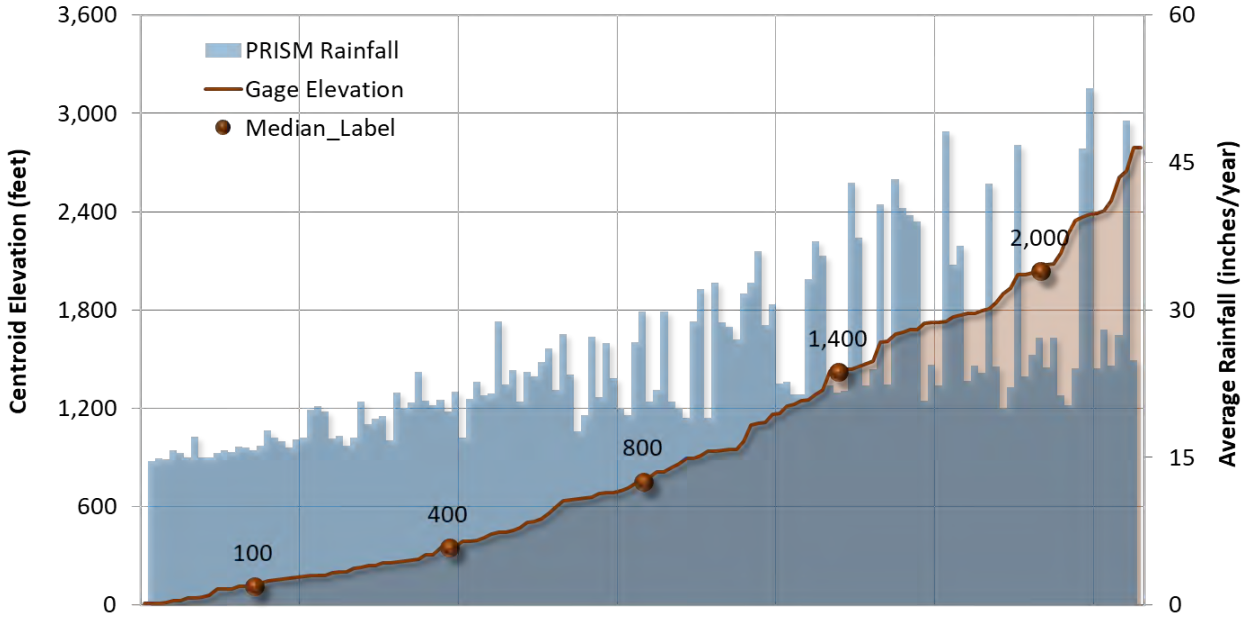


Figure 5-3. Average annual PRISM rainfall vs. centroid elevation (with median elevation of 5 bins).

The graph shows a gradual increase in rainfall with elevation; however, the variability suggests that other factors besides elevation also have an influence on annual average rainfall. The data were also binned and analyzed by aspect. Figure 5-4 shows how average rainfall varies by both elevation and aspect.

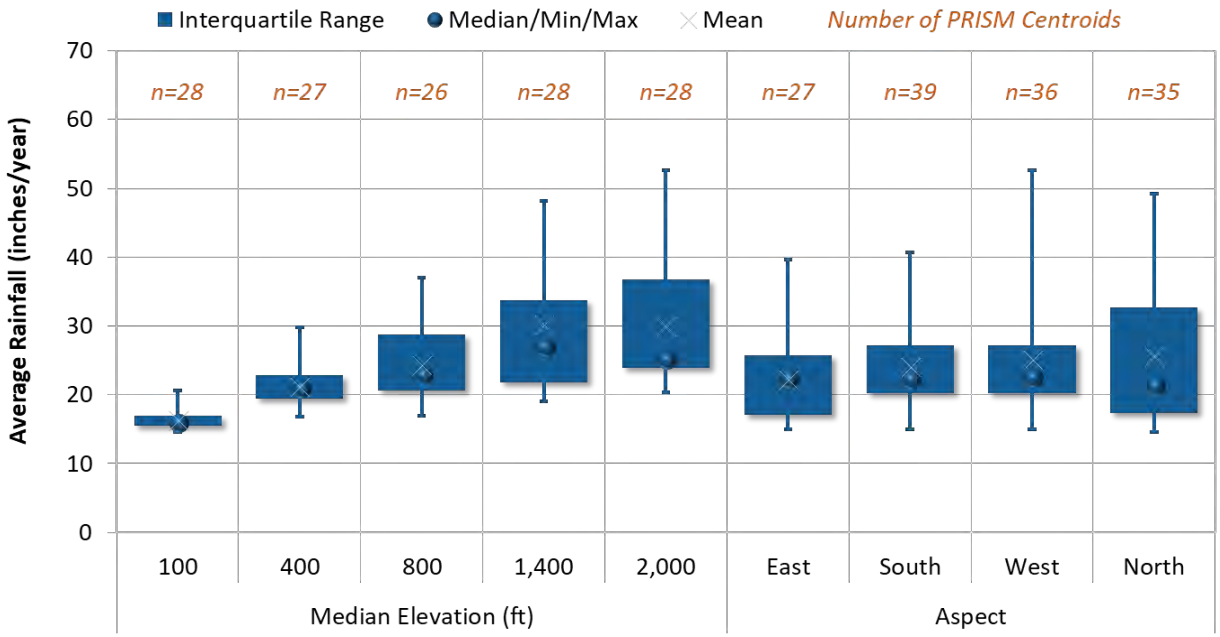


Figure 5-4. Box plots of average annual rainfall variability by elevation and aspect.

To assess the combined impact of elevation and aspect in Santa Clara Valley, PRISM average annual rainfall, the centroids were grouped into 20 bins of elevation and aspect (5 elevation × 4 aspect groups). There were about 5 to 8 centroids within each of the 20 bins, and the median rainfall was calculated for each bin, as summarized in Table 5-2.

Table 5-2. Median rainfall (and distribution of PRISM centroids) by elevation and aspect

Elevation		Hillslope Aspect (No. Centroids)				Total
Bin	Median (ft)	East	South	West	North	
1	100	6	8	7	7	**28**
2	400	5	8	7	7	**27**
3	800	5	7	7	7	**26**
4	1,400	6	8	7	7	**28**
5	2,000	5	8	8	7	**28**
Total		**27**	**39**	**36**	**35**	**137**
Elevation		**Hillslope Aspect (Median Rainfall, in./yr)**				**Median**
Bin	**Median (ft)**	**East**	**South**	**West**	**North**	
1	100	16	17	17	16	**16**
2	400	22	23	21	19	**21**
3	800	23	21	29	22	**23**
4	1,400	27	25	24	39	**31**
5	2,000	27	25	24	37	**25**
Median		**22**	**22**	**23**	**21**	**22**

Color gradient shows relative rainfall depth. Darker is higher.

Figure 5-5 is a surface plot of the median rainfall (vertical axis) versus elevation and aspect (horizontal plane)—the surface illustrates the central tendency of the combined impact of elevation and aspect on average annual rainfall. The right panel of Figure 5-5 is the birds-eye view from the top of the surface shown in the left panel—it shows horizontal and vertical surface transects for aspect and elevation, respectively.

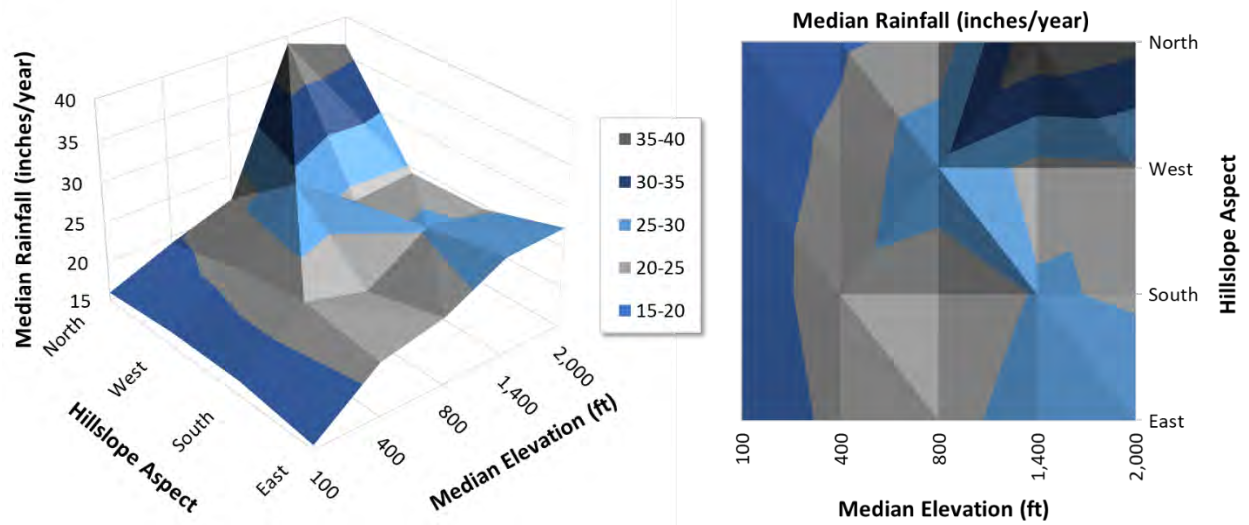


Figure 5-5. Surface plot of median rainfall (vertical axis) vs. elevation and aspect (horizontal plane).

Figure 5-5 shows that the driest areas of the study area are the lowest-elevation areas, regardless of aspect; however, the wettest are highest-elevation north-facing slopes. In general, at about 400 feet the impact of aspect on annual average rainfall volume appears to be negligible. The 100- and 400-feet elevation transects have the least variability in median rainfall. There is a lot of variability along the aspect transects, with the north-facing slopes having the widest range of variability across the range of elevations. Sometimes this insight can guide the selection/assignment of representative gages to subwatersheds and help with understanding modeled responses; however, the default assignments used for model calibration were sufficiently reflective of the spatial variability and resolution.

6 HYDROLOGY MODEL CALIBRATION

A phased weight-of-evidence approach was used for hydrology calibration. An initial set of model parameters were selected from the Bay Area Hydrologic Model (BAHM) (Clear Creek Solutions 2014) and refined by HRU using guidance from BASINS *Technical Note 6: Estimating Hydrology and Hydraulic Runoff Parameters* (USEPA 2000). The goal was to characterize the relative hydrological response of the various HRU combinations of land cover, soil type, and slope such that the routed aggregate response of the model was representative of observed trends at the flow monitoring gages. When model results diverged from observed data, Google Earth was used to further investigate and identify unrepresented features such as impoundments, concrete-lined channels, or other hydraulic features that may be attributable to the divergent model results. Finally, wherever it was possible to represent those notable features, model parameters were fine-tuned so that the calculated error statistics fell within the targeted model performance ranges.

6.1 Calibration Process & Objectives

Table 6-1 presents the recommended model performance metrics for hydrology, sediment, and PCBs from the Bay Area RAA Guidance (BASMAA 2017). The Bay Area RAA Guidance specifies annual percent difference calibration metrics, which aligns with the spatial and temporal scales of the Bay TMDLs. For additional resolution regarding the timing of flow and pollutant loads, monthly and seasonal model hydrology performance were also evaluated as part of the calibration effort.

Table 6-1. Model calibration performance targets (Bay Area RAA Guidance document, Table 4-2)

Model Parameters	%-Difference (Annual Simulated vs. Observed)		
	Very Good	Good	Fair
Hydrology/Flow[1]	< 10%	10-15%	15-25%
Sediment[1]	< 20%	20-30%	30-45%
PCBs/mercury[2]	< 30%	30-50%	50-80%

1: From Donigian 2000 as cited in LARWQCB 2014
2: Regional Watershed Spreadsheet Model (RWSM) estimates (if used) already reflect calibration considerations (Source: Wu 2017)

A two-phase weight-of-evidence approach was used to guide LSPC's calibration. In the first phase, typical parameter values from BASINS Technical Note 6: *Estimating Hydrology and Hydraulic Runoff Parameters* (USEPA 2000) were selected to refine the initial set of BAHM parameters and stratify their variability to the modeled HRUs. Land-level hydrology was calibrated to best reflect the central tendency of land use runoff using supporting information such as soil type, canopy cover, and surface cover conditions. After the model was calibrated to reflect overall trends and reasonable process dynamics, the second phase involved fine-tuning the parameters and calculating various error statistics to find a most appropriate calibration within the range of acceptable parameter values to characterize instream transport routing processes in conjunction with other natural or anthropogenic activities, as applicable. Adjusted parameters are discussed in greater detail in Section 6.3.

For hydrologic calibration of HSPF (Bicknell et al. 1997), performance targets have been specified in various literature sources to guide the assessment of long-term, annual, and seasonal patterns (Donigian et al. 1984, Lumb et al. 1994, and Donigian 2000). The LSPC model is functionally identical to the HSPF model. Based on those literature sources, performance targets for simulation of the water balance components are summarized in Table 6-2. The error is the ratio of the absolute mean error to the mean of the observations and is expressed as a percent. Model performance was deemed fully acceptable where a performance evaluation of "Good" or "Very Good" was attained. If these levels are not attained, an analysis of sources of uncertainty and implications for model usability were conducted. The values for Error in Annual Storm Volumes in Table 6-2 are equivalent to the hydrology calibration metrics recommended by the Bay Area RAA Guidance and listed in Table 6-1. The additional calibration metrics listed in Table 6-2 were considered in the hydrology calibration to provide added confidence in model performance, beyond the minimal performance criteria recommended from the Bay Area RAA Guidance.

Table 6-2. Performance targets for HSPF hydrology simulation (modeled vs. observed)

Model Statistic	Very Good	Good	Fair	Poor
Error in Total Volume	<5%	5-10%	10-15%	>15%
Error in 50% Lowest Flow Volumes	<10%	10-15%	15-25%	>25%
Error in 10% Highest Flow Volumes	<10%	10-15%	15-25%	>25%
Error in Annual Storm Volumes	<10%	10-15%	15-25%	>25%
Winter Total Volume Error	<15%	15-30%	30-50%	>50%
Winter Storm Volume Error	<15%	15-30%	30-50%	>50%
R^2 Monthly	≥0.85	≥0.75	≥0.65	<0.65

Sources: Donigian et al. (1984), Lumb et al. (1994), and Donigian (2000)

6.2 Model Assessment Points

Figure 6-1 presents a temporal summary of available streamflow data within the Santa Clara Basin from the United States Geological Survey (USGS) and SCVWD. A weight-of-evidence based modeling approach is strengthened by evaluating model performance against observed streamflow across different sized watersheds and time periods that capture a range of hydrologic conditions.

Eight streamflow gages were selected for comparison during the model calibration and validation process. Three gages with relatively large drainage areas, predominantly one land use type or another, were selected as primary calibration stations. Additionally, three small headwater gages were also segments for calibration. Finally, two large gages with mixed drainage areas and a long period of record were selected for validation. In general, USGS gages tended to have a longer observed period and provided continuous data over the entire year while SCVWD gages primarily provided more recent data with some gages operating over limited timeframes to only capture the wet season. These streamflow records were flagged to differentiate periods of "good" data from "missing" or "estimated" records, which were derived using non-standard methods. Data with a lower percentage of "missing" or "estimated" records are of higher quality.

Agency	Station Name	Station ID	Drainage Area (sq. mi.)	Water Years (October 1, 1998 – September 30, 2017)																			
				1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
USGS	Matadero Ck at Palo Alto CA	11166000	7.3	◕	◕	◕	◕	◓	◓	◕	◕	◕	◕	◕	◓	◕	◕	◕	◕	◕	◕	◕	◕
	Guadalupe River above Highway 101 at San Jose CA	11169025	160.0					◕	◕	◕	◕	◕	◕	◕	◕	◕	◕	◕	◕	◕	◕	◕	◕
	Saratoga Ck at Saratoga CA	11169500	9.2	◕	◓	◕	◕	◓	◕	◕	◕	◓	◕	◕	◕	◕	◕	◕	◕	◕	◕	◕	◕	◕
	Coyote Ck near Gilroy CA	11169800	109.0								◕	◕	◕	◕	◕	◕	◕	◕	◕	◕	◕	◕	◕
	Coyote Ck ab Highway 237 at Milpitas CA	11172175	319.0		◓	◕	◓	◕	◕	◕	◕	◕	◕	◕	◕	◕	◕	◕	◕	◕	◕	◕	◕	◕
SCVWD	Hale Creek below Magdalena Ct- High Flow Only	1456	2.7	◕	◕	◕	◕	◕	◕	◕	◕	◕	◓	◕	○	○	◕	◕	○	○	○	○	○
	Thompson Creek at Quimby Rd.-High Flow Only	1463	18.1	◕	◕	◕	◕	◕	◓	◕	◕	◕	◕	◓	◓	◕	○	○	○	○	○	○	○
	San Tomas Creek above Williams Rd	2050	13.4	◓	◕	◕	◕	◕	◕	◕	◕	◕	◕	◕	◕	◕	◕	◕	◕	◕	◕	◕	◓

Legend:

Data Quality (Percent Estimated):

	○	◔	◑	◕	●
No Data	90-100%	65-90%	35-65%	10-35%	0-10%

Data Quantity (Percent Complete, **Calibration** watersheds)

0%	25%	50%	75%	100%	Primary	Headwater

Data Quantity (Percent Complete, **Validation** watersheds):

0%	25%	50%	75%	100%	Validation

Figure 6-1. Temporal summary of USGS and SCVWD streamflow gages in the Santa Clara Basin.

The gages selected for calibration had at least five continuous years of "good" data records. Smaller, isolated watersheds with shorter periods of record were used for calibration, while the larger watersheds with longer continuous data were used for validation. The gages selected for calibration represent headwater areas where it was possible to isolate specific categories of HRUs or other features of interest for adjustment of model parameters during the calibration process (discussed in Section 6.3).

6.3 Model Calibration

A disciplined approach to calibration was employed that emphasized meaningful adjustments to a limited set of model parameters, identifying physical processes to justify parameter changes during successive iterations, and deemphasizing simple curve-fitting to match observed data. The watershed model calibration process focused on refining LSPC hydrology parameters while assessing the impact on model performance at three headwater USGS gages. Table 6-3 presents a summary of the drainage area characteristics for these three gages. These gages are in very different parts of the watershed: one is northern and more urban, one is western and highly forested, with high slopes, and the third represents the most western part of the watershed with high elevation. The watershed sizes, elevation ranges, locations, slope types, and land use distributions vary. Each gage is separately covering different, isolated aspects of the HRU combinations to accurately depict the hydrology of the region. Figure 6-2 presents a map showing the location of each of the three USGS gages selected for model calibration. All three sites are isolated from major impoundments or other visible hydromodifications that would heavily influence the calibration process.

Table 6-3. Summary of watershed characteristics for primary calibration sites

Calibration Site	Drainage Area	Predominant Land Cover	Predominant Hydrologic Soil Group	Predominant Slope
MATADERO C A PALO ALTO CA (USGS 11166000)	7.26	**Developed (85%)** Forest (14%)	**D (61%)** C (36%)	**Low (59%)** Med (39%)
SARATOGA C A SARATOGA CA (USGS 11169500)	9.22	**Forest (91%)** Developed (9%)	**A (58%)** C (19%) D (17%)	**Med (85%)** Low (14%)
COYOTE C NR GILROY CA (USGS 11169800)	109	**Grass (49%)** **Forest (49%)**	**D (68%)** C (30%)	**Low (50%)** **Med (50%)**

As previously discussed in Section 6.1, initial hydrology parameters were selected based on guidance from BASINS Technical Note 6: *Estimating Hydrology and Hydraulic Runoff Parameters* (USEPA 2000) often using land cover, soil type, or annual precipitation as the basis for selecting the starting values. Specific attention was given to the most sensitive hydrology parameters which govern total annual volume including Lower Zone Nominal Soil Moisture Storage (LZSN), Nominal Upper Zone Soil Moisture Storage (UZSN), Index to Mean Soil Infiltration (INFILT), and Groundwater Recession Rate (AGWRC). The Groundwater Recession parameter describing non-linear groundwater recession

rates (KVARY) was initially set to 0.0 globally and subsequently not changed during calibration. The ranges of individual parameter values correspond to the HRU differences and seasonal fluctuations. Monthly values were used for Interception Storage Capacity (CEPSC), Upper Zone Nominal Storage (UZSN), and Lower Zone Evapotranspiration (LZETP) parameters for each HRU to adjust for seasonal variation.

Initial hydrology parameters were then refined in the model for each of the three gages while focusing on selecting appropriate parameters for the most dominant HRU elements contributing to flows at each gage. For instance, the drainage area upstream of the Saratoga USGS gage (USGS 11169500) is heavily forested and is also one of the only instances in the model where HSG-A dominates the mix of soils. This site provided an opportunity to then target the adjustment of parameters during calibration for both forested land cover and HSG-A soils, specifically INFILT and AGWRC.

Table 6-4 and Table 6-5 present the quantitative and qualitative assessment of final model calibration at the three headwater USGS gages. Error statistics were computed using only days during the evaluation period with observed data. (i.e., days with missing data were excluded from the calculation). The following provides a summary of observations of the model performance from evaluating the quantitative, qualitative, and visual comparisons against observed data:

- At all three sites, results of these simulations meet the RAA guidance criteria requiring the error in model prediction of total annual volume within 10 percent of the observed data.
- The model performs well for both Matadero Creek and Coyote Creek when compared with observed data, achieving a *Very Good* assessment across all six error statistics.
- The model performs well at the Saratoga Creek monitoring location when evaluating the total annual volume, highest 10 percent of flows, and winter total volume; The annual storm volume and winter storm volume show error greater than the 15 percent threshold used to distinguish *Good* from *Very Good* performance. This could result from missing the timing or magnitude of an individual storm event.

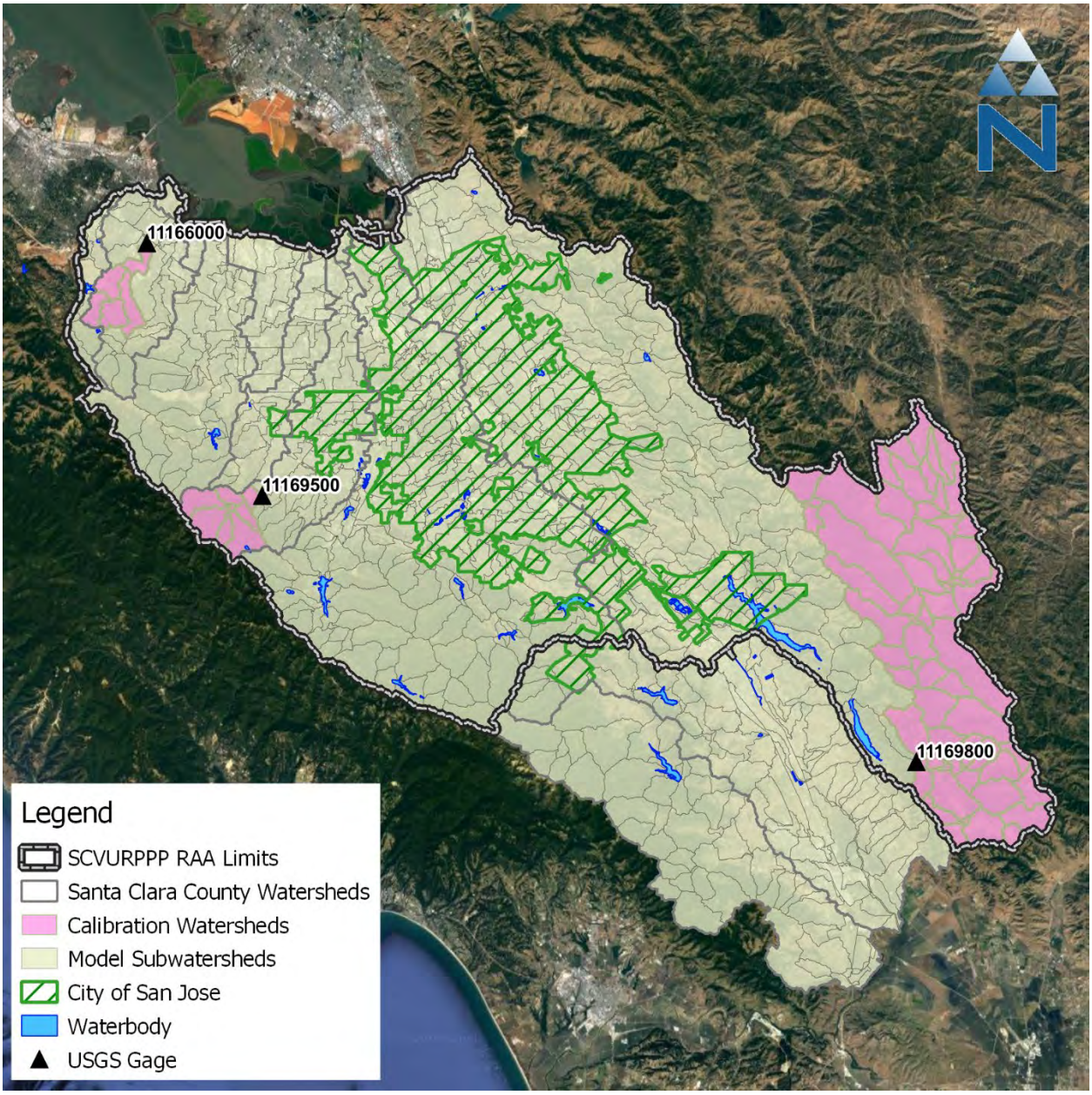


Figure 6-2. Locations of the three USGS headwater calibration gages and corresponding drainage areas.

Table 6-4. Summary of quantitative hydrology calibration performance by gage (modeled vs. observed).

Model Statistic	Matadero Creek at Palo Alto CA (USGS 11166000)	Saratoga Creek at Saratoga CA (USGS 11169500)	Coyote Creek near Gilroy CA (USGS 11169800)
Percent Error in Total Volume	1.0%	3.4%	4.0%
Error in 10% Highest Flow Volumes	-5.3%	-9.9%	0.8%
Error in Annual Storm Volumes	-9.9%	19.3%	9.0%
Winter Total Volume Error	6.3%	2.3%	-4.2%
Winter Storm Volume Error	-5.0%	15.7%	-0.8%
R^2 Monthly	0.96	0.91	0.92

Table 6-5. Summary of qualitative hydrology calibration performance by gage (modeled vs. observed).

Model Statistic	Matadero Creek at Palo Alto CA (USGS 11166000)	Saratoga Creek at Saratoga CA (USGS 11169500)	Coyote Creek near Gilroy CA (USGS 11169800)
Error in Total Volume	Very Good	Very Good	Very Good
Error in 10% Highest Flow Volumes	Very Good	Very Good	Very Good
Error in Annual Storm Volumes	Very Good	Good	Very Good
Winter Total Volume Error	Very Good	Very Good	Very Good
Winter Storm Volume Error	Very Good	Good	Very Good
R^2 Monthly	Very Good	Very Good	Very Good

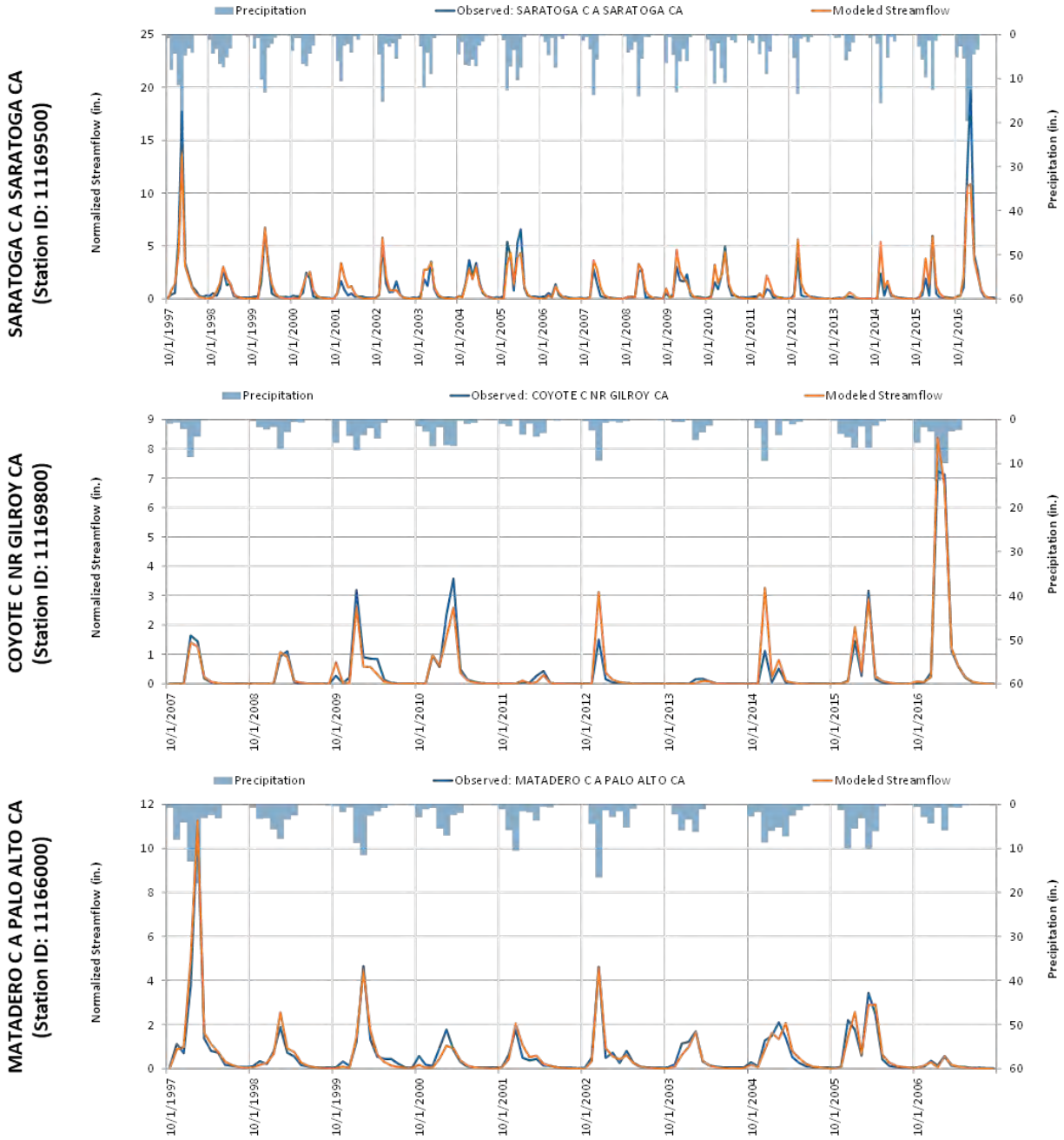


Figure 6-3. Summary of modeled vs. observed monthly streamflow at headwater calibration sites.

6.4 Model Validation: Headwaters

Model validation is often defined as a quantitative comparison of model results independently derived from experiments or observations of the environment (USEPA 2015). Sometimes validations are performed using independent points in space (i.e., observed data at different locations) while other times validation assesses independent periods of time (i.e., different years at the same locations used for calibration). An important distinction from model calibration is that no elements of the model physical or process representation are changed during the validation process.

Figure 6-4 presents a map showing the location of each of the three headwater SCVWD gages selected for model validation. These gages are located on smaller, urban tributaries with isolated upstream drainage areas and no major impoundments that were visible doing a desktop analysis of aerial photography and readily available GIS data. Some of these gages are described as only monitoring during high-flow periods, therefore, the validation statistics were calculated using only days when observed data were available.

Table 6-6 and Table 6-7 present quantitative and qualitative assessments of model validation performance. Error statistics were computed using only days during the evaluation period with observed data (i.e., days with missing data were excluded from the calculation). This is most relevant to the validation comparisons using SCVWD observed streamflow data as several stations, including Thompson Creek and Hale Creek, are noted as monitoring only during high flow periods.

The following provides a summary of observations of the model performance from evaluating the quantitative, qualitative, and visual comparisons against observed data:

- Model performance meets the RAA guidance criteria requiring the error in model prediction of total annual volume to be within 10 percent of the observed data at all three sites.
- The model performs well when compared with observed data for San Tomas Aquino Creek, achieving a *Very Good* assessment across five of six metrics. Several notable years in the graphs (i.e., Water Years 2009, 2009, 2017) were missing observed data and therefore were excluded from the calculation of performance metrics.
- Hale Creek and Thompson Creek achieve a *Very Good* assessment across all but two metrics. Error in annual storm volumes still achieves a *Good* assessment based on criteria from Table 6-2. The winter total volume error also includes periods of lower flow which were not a focus of the calibration.

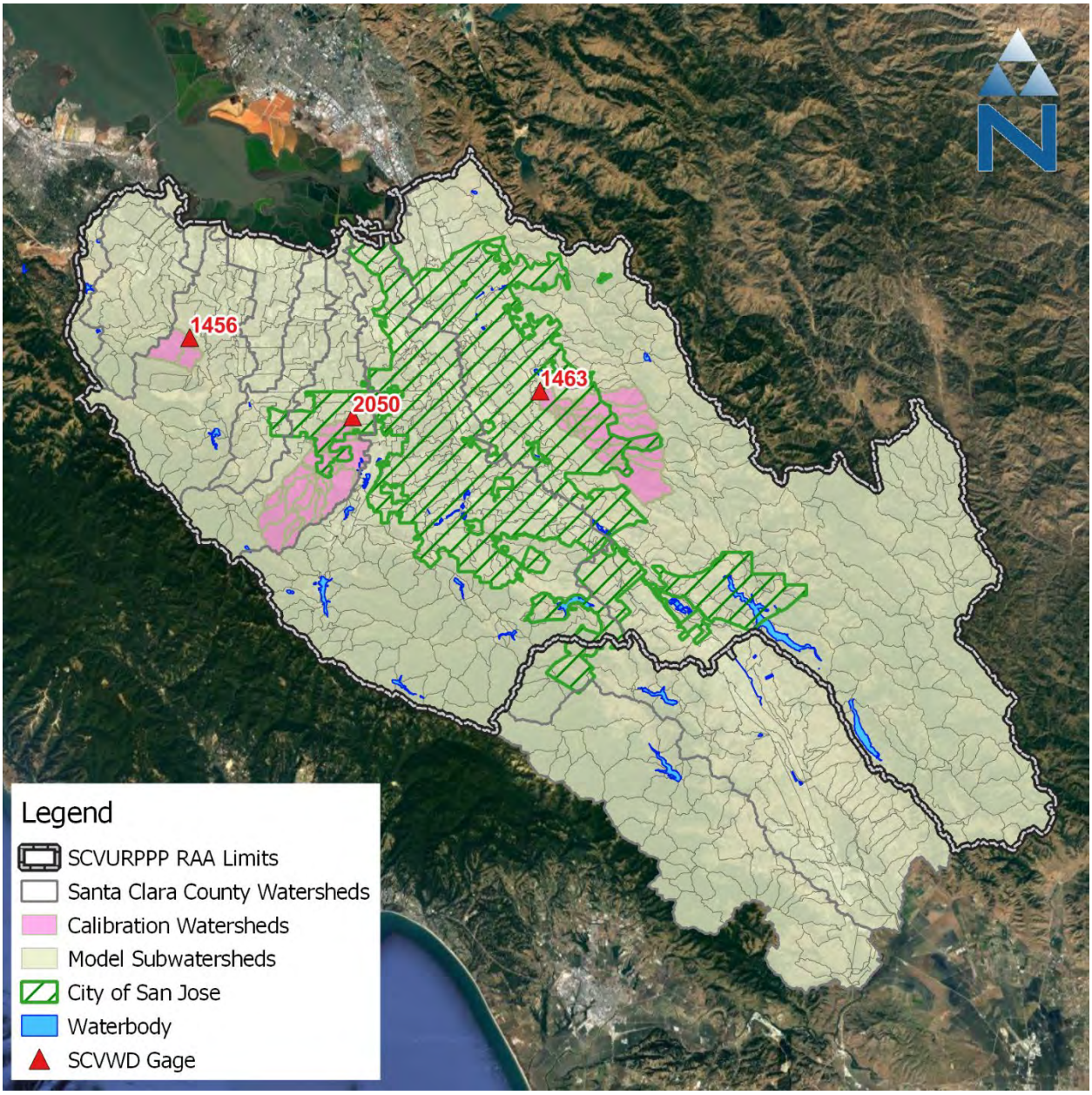


Figure 6-4. Locations of the three SCWD headwater validation gages and corresponding drainage areas.

Table 6-6. Summary of quantitative headwater validation performance by gage (modeled vs. observed).

Model Statistic	Hale Creek below Magdalena Ct (SCVWD 1456)	San Tomas Creek at Williams Rd (SCVWD 2050)	Thompson Creek at Quimby Rd. (SCVWD 1463)
Error in Total Volume	2.6%	2.7%	0.5%
Error in 10% Highest Flow Volumes	-4.3%	-15.6%	-5.5%
Error in Annual Storm Volumes	-12.4%	-4.7%	-9.6%
Winter Total Volume Error	13.6%	-1.9%	12.2%
Winter Storm Volume Error	-3.9%	-7.4%	3.9%
R^2 Monthly	0.88	0.94	0.72

Table 6-7. Summary of qualitative headwater validation performance by gage (modeled vs. observed).

Model Statistic	Hale Creek below Magdalena Ct (SCVWD 1456)	San Tomas Creek ab Williams Rd (SCVWD 2050)	Thompson Creek at Quimby Rd. (SCVWD 1463)
Error in Total Volume	Very Good	Very Good	Very Good
Error in 10% Highest Flow Volumes	Very Good	Fair	Very Good
Error in Annual Storm Volumes	Good	Very Good	Very Good
Winter Total Volume Error	Good	Very Good	Good
Winter Storm Volume Error	Very Good	Very Good	Very Good
R^2 Monthly	Very Good	Very Good	Fair

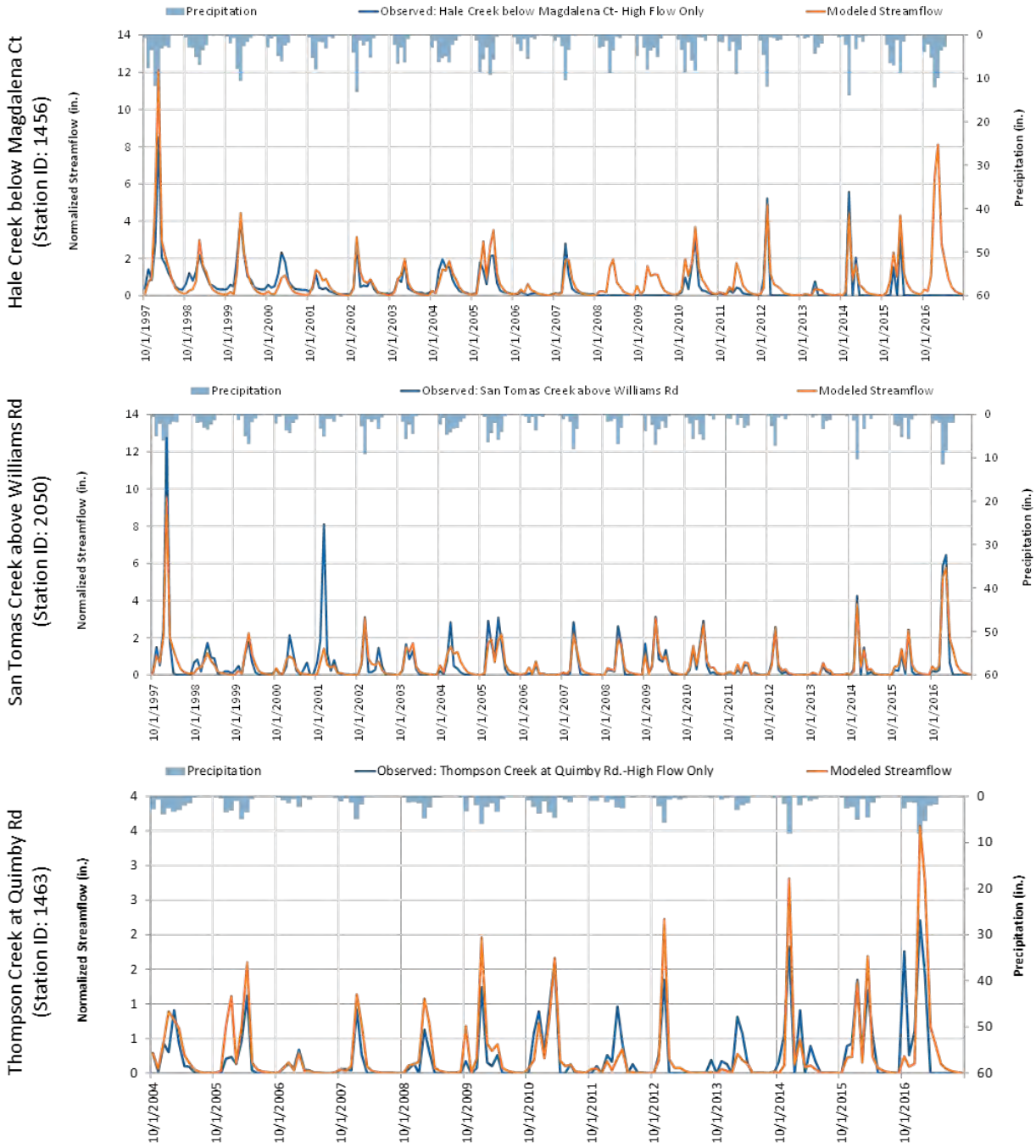


Figure 6-5. Summary of modeled vs. observed monthly streamflow at headwater validation sites.

6.5 Model Validation: Downstream

After performing calibration and validation for isolated headwater gages presented in Section 6.3 and Section 6.4, two downstream USGS gages on Coyote Creek and Guadalupe River were assessed as a final validation of the full model domain for those two watersheds. Figure 6-6 presents a map showing the location of the two downstream USGS gages selected for model validation.

The model results at these two sites required the representation of large reservoirs/impoundments in the routing network, including Guadalupe Reservoir, Coyote Reservoir, and Anderson Reservoir. The drainage area to Coyote and Anderson Reservoirs represents approximately 61 percent of the total drainage area at the downstream USGS gage on Coyote Creek. In 2011, restrictions were implemented for Anderson Reservoir that reduced the operating storage levels below full capacity of approximately 90,000 acre-feet (SCVWD 2018a). These restrictions were then adjusted in July 2011, increasing the currently allowed storage capacity by 11 percent (SCVWD 2018b). Since the watershed model is not capable of simulating this impoundment with dynamic changes in storage capacity, the validation at the Coyote Creek gage was evaluated for the three-year period from 10/1/2006 through 9/30/2009, prior to when these storage restrictions took effect.

Because reservoir releases are mostly mechanical, observed streamflow data from Coyote Creek at Madrone (SCVWD #1498) were used to develop a timeseries of operational releases for Anderson Reservoir. This process was primarily visual and involved establishing a threshold under which the observed streamflow was considered an operational release. Those releases were added to the model as a point withdrawal/diversion. Extreme events were allowed to naturally overflow the modeled reservoir spillway.

Table 6-8 and Table 6-9 present the quantitative and qualitative assessment of validation performance at the two downstream USGS gages on Coyote Creek and Guadalupe River. Error statistics were computed using only days during the evaluation period with observed data (i.e., days with missing data were excluded from the calculation). The following provides a summary of observations of the model performance from evaluating the quantitative, qualitative, and visual comparisons against observed data:

- For both gages, results of the model met the RAA guidance criteria requiring the error in model prediction of total annual volume to be within 10 percent of the observed streamflow.
- The model performs well when compared with observed data for Coyote Creek, achieving a *Very Good* assessment across all six metrics. Close to 40 percent of the drainage area to this streamflow gage is downstream of Anderson Reservoir which reflects the outcome of the LSPC model setup and calibration primarily within the City of San José.
- The model performs well for Guadalupe River when comparing against the total annual volume and highest 10 percent of flows metrics; however, the annual storm volume and wet season metrics may need additional refinement. There are other known hydraulic controls in the watershed that may not be fully represented in terms of timing and volume impacts on modeled instream flow. These include the Almaden-Calero diversion channel, recharge operations at Los Alamitos ponds, and the inflatable Kirk Dam on Los Gatos Creek (Figure 6-7). Sometimes water from behind Kirk Dam is also diverted out of the Guadalupe River watershed into recharge ponds in the neighboring watershed. Nevertheless, because differences in model performance are most likely attributable to instream hydraulic controls, the predicted runoff at the HRU level is considered suitable and representative for use as boundary conditions for GSI modeling for the RAA.

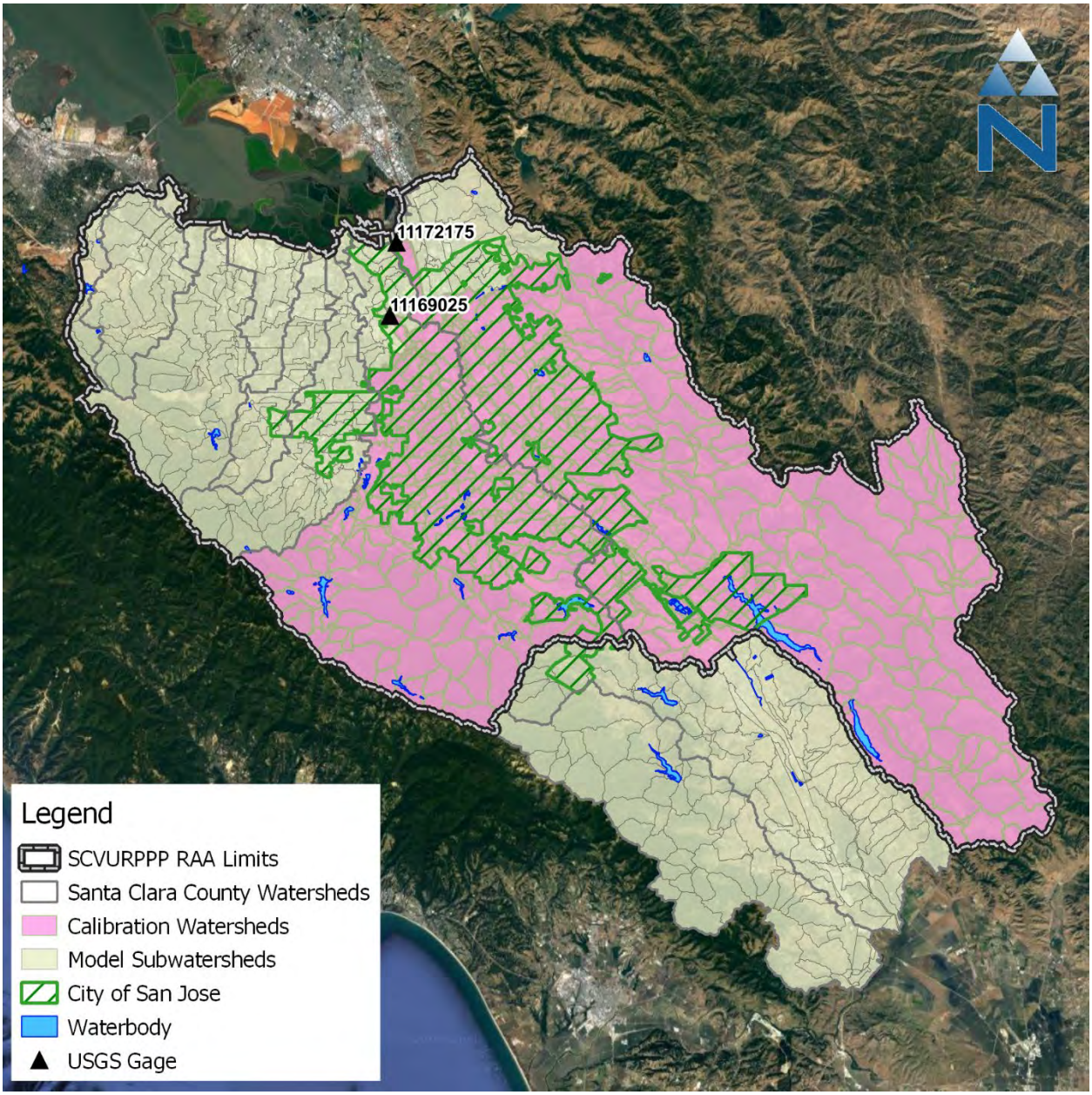


Figure 6-6. Locations of the two USGS downstream validation gages and corresponding drainage areas.

Table 6-8. Summary of quantitative downstream validation performance by gage (modeled vs. observed).

Model Statistic	Coyote Creek above Highway 237 at Milpitas CA (USSG 11172175)	Guadalupe River above Highway 101 at San José CA (USGS 11169025)
Error in Total Volume	2.7%	-3.1%
Error in 10% Highest Flow Volumes	1.2%	8.9%
Error in Annual Storm Volumes	5.6%	34.7%
Winter Total Volume Error	9.7%	13.3%
Winter Storm Volume Error	5.6%	31.2%
R^2 Monthly	0.87	0.81

Table 6-9. Summary of qualitative downstream validation performance by gage (modeled vs. observed).

Model Statistic	Coyote Creek above Highway 237 at Milpitas CA (USSG 11172175)	Guadalupe River above Highway 101 at San José CA (USGS 11169025)
Error in Total Volume	Very Good	Very Good
Error in 10% Highest Flow Volumes	Very Good	Very Good
Error in Annual Storm Volumes	Very Good	Poor
Winter Total Volume Error	Very Good	Good
Winter Storm Volume Error	Very Good	Fair
R^2 Monthly	Very Good	Good

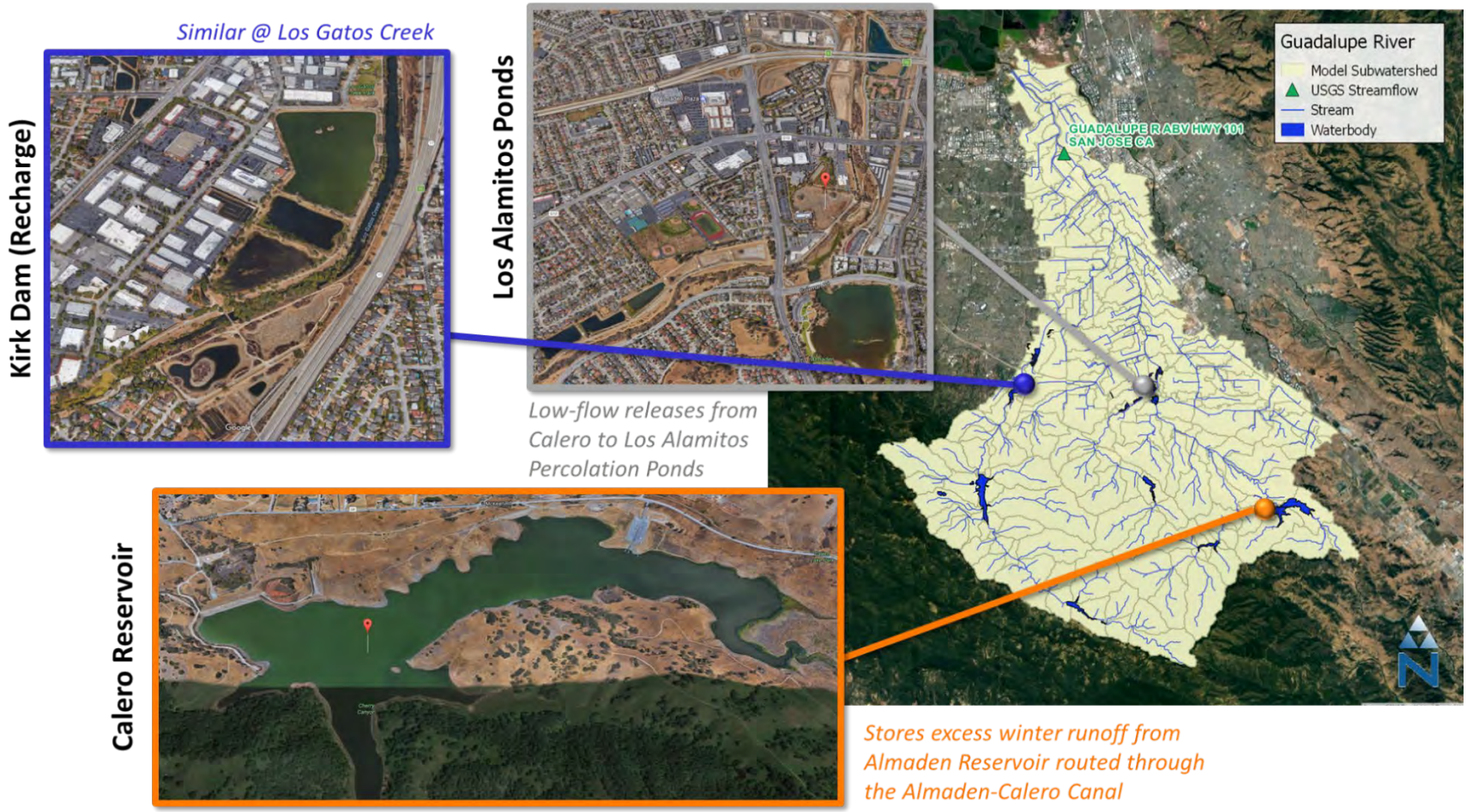


Figure 6-7. Guadalupe River watershed delineation, reservoir segments, and hydromodification features.

7 BASELINE SEDIMENT LOADING

Regional studies conducted in the Bay Area have assessed monitoring data and quantified mercury and PCB loading rates with sediment as the primary mode of delivery (Gilbreath et al. 2018; McKee 2017). Those studies show that the relative distribution of mercury and PCB yield varies spatially as a function of contributing land use, sediment, and pollutant sources. Figure 7-1 shows regression-based pollutant yield estimates at two locations in the Guadalupe River watershed. The watershed upstream of the Almaden Expressway is largely undeveloped; however, there is an urbanized portion between the Expressway and Highway 101. Yield estimates show relatively comparable sediment yield at both locations; however, PCBs and mercury are notably different and inverted in relative magnitudes. Findings from those datasets provide meaningful insight for source characterization and model parameterization. It suggests that in the Guadalupe River, PCBs are predominantly associated with urban sediment, while mercury is predominantly associated with loads from natural areas.

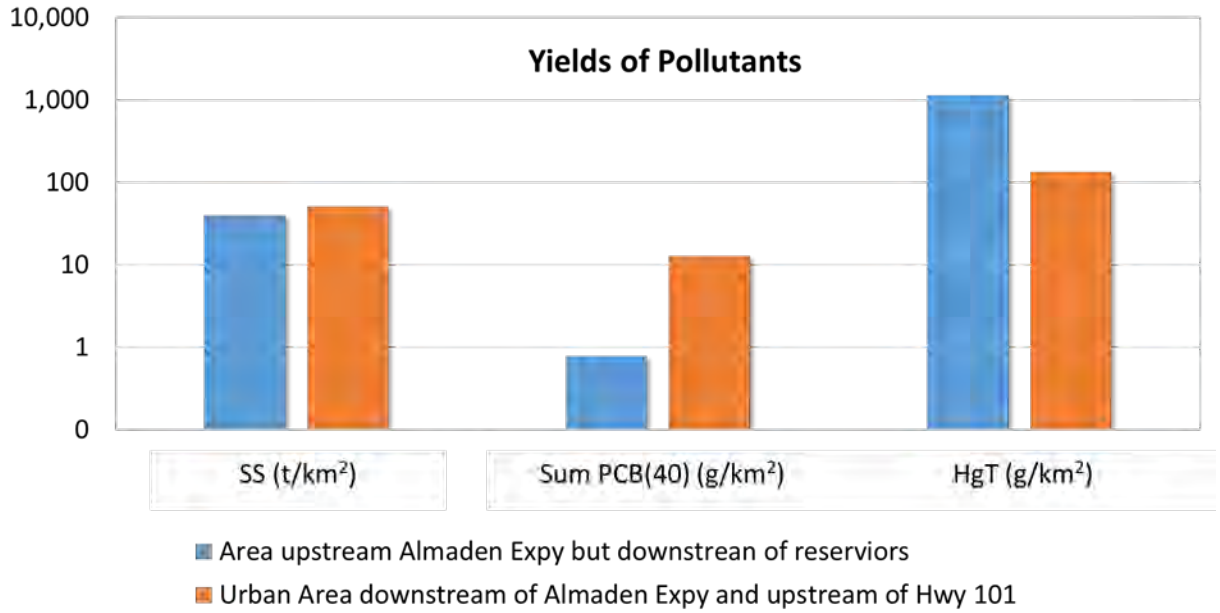


Figure 7-1. Regression-based pollutant yield estimates derived from instream monitoring data in the Guadalupe River (McKee et. al 2017).

Model representation of sediment builds upon the hydrology calibration and is considered the primary mode of delivery for PCBs and mercury in this study; therefore, modeling erosion and sediment mobilization is the next step in the top-down weight of evidence-based approach implemented for the hydrology model calibration. Once that primary mode of pollutant delivery has been established, sediment-associated mercury and PCBs are simulated. Throughout the water quality calibration process, intermediate checks, data sources, and references are consulted to ensure that assumptions are reasonable and error propagation is minimized. This section describes sediment calibration.

Sediment sources and mobilization processes vary with land cover (pervious/impervious) and soil type. PCBs and some mercury are associated with urban runoff; but, when calibrating to mixed instream sediment samples, it is helpful to characterize relative loadings from all sources. The advantage of an HRU-based approach is that it retains much of the resolution of spatial variability for

model parameterization at the level of the smallest modeling unit (land unit). This minimizes the need to specify diverse combinations of model parameter groups at the subwatershed level. Sediment calibration was performed in two steps: (1) edge-of-field yield estimation and (2) instream transport.

7.1 Edge-of-Field Sediment Yield Estimation

The edge-of-field sediment yield is the load as measured at an individual source (e.g., runoff load by land use). One of the key attributes of the STATSGO/SSURGO soil layer is the K-factor, which is a measure of soil erodibility (detachment and runoff). K-factor was estimated as an area-weighted average value of the uppermost soil layer for each HRU raster pixel. In the model, soil erodibility is a calibrated process by HRU. Clay soils, which are more resistant than sand and silt to detachment, tend to have relatively low K values (0.05 to 0.15). Likewise, coarse-textured sandy soils that are easily detached, but are not easily mobilized by runoff, also have low K values (0.05 to 0.2). Soils with moderate silt and loam content have moderate K values (0.2 to 0.4) because they are moderately susceptible to both detachment and runoff. Soils with high silt content are the most erodible of all soils (K > 0.4), because they are easily detached and are associated with high rates of runoff. K-factor was cross-tabulated for areas having the same hydrologic soil group, as summarized in Table 7-1. Soil erodibility metrics in the Santa Clara Basin differ notably. The K-factor percentile distribution was computed across all modeled watersheds. The STATSGO/SSURGO spatial layers were intersected with the model subwatersheds. Areas were binned by hydrologic soil group into 10 percentile bins of K-factor magnitude. Table 7-1 shows erodible soils composition in the Santa Clara Basin. The analysis showed that D soils were moderately erodible, while C soils were generally more erodible in both areas, suggesting that C soils parameterization should result in slightly more erodibility than D soils, even though D soils produce more runoff than C soils. This finding was used to inform parameter selection for each HRU associated with hydrologic soil groups.

Table 7-1. K-Factor vs. hydrologic soil group and associated soil erodibility (Source Data: STATSGO/SSURGO)

K-Factor (Soil Erodibility)					Hydrologic Soil Group (% of Area)			
Percentile			Min	Max	A	B	C	D
Guadalupe Watershed	← High Moderate Low →	0-10%	0.00	0.03	11.2%	1.2%	9.7%	7.7%
		10-20%	0.03	0.05	0.8%	7.1%	14.8%	1.3%
		20-30%	0.05	0.07	--	0.0%	37.7%	0.0%
		30-40%	0.07	0.10	--	--	4.4%	0.6%
		40-50%	0.10	0.13	--	--	0.2%	--
		50-60%	0.13	0.17	--	--	0.1%	--
		60-70%	0.17	0.20	--	--	--	--
		70-80%	0.20	0.21	--	--	1.2%	--
		80-90%	0.21	0.24	0.1%	--	1.9%	--
		90-100%	0.24	0.44	--	--	--	--

Erodibility	HSG	Soils Composition
Low	A	Sand, Loamy Sand, or Sandy Loam
Moderate	B	Silt, Silt Loam or Loam
High	C	Sandy Clay Loam
Moderate	D	Clay Loam, Silty Clay Loam, Sandy Clay, Silty Clay, or Clay

As shown in Table 7-1 and illustrated in Figure 7-2, soil texture and soil erodibility are both associated with hydrologic soil group. Most Santa Clara Basin watersheds that drain to the Bay do not have any soil classification because of the density of urban land cover; however, PCB-contaminated sediment originates from aging and deterioration of old urban infrastructure, building demolition, and build-up/deposition on associated urban surfaces. This analysis is part of establishing relative sediment load levels across among all sources of sediment – pollutants of interest (PCBs and mercury) are modeled as sediment-associated constituents. Within a given soil group, K-factor varies with soil texture. About 60 percent of the soils are C and 25 percent are D soils. The spatial variability of K-factor within the region is shown in Figure 7-3.

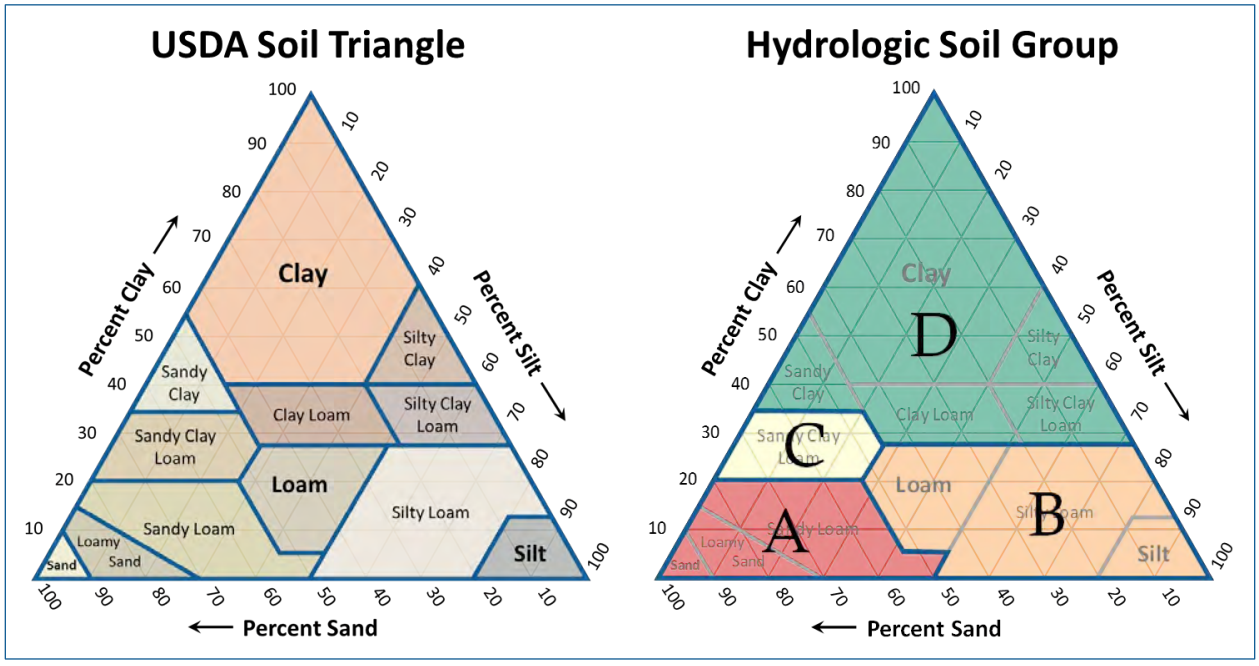


Figure 7-2. Standard USDA Soil Triangle with Hydrologic Soil Group mapping.

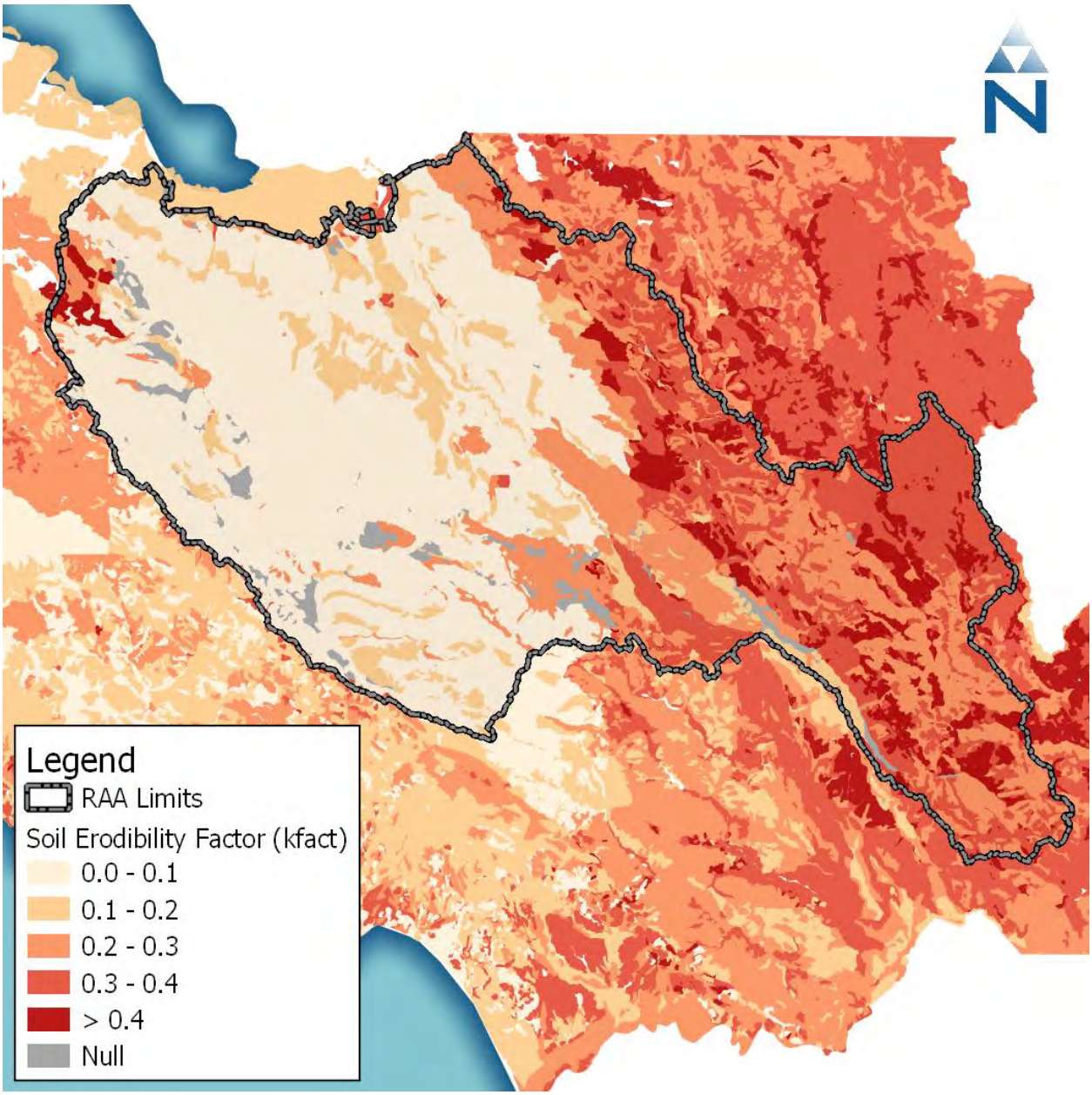


Figure 7-3. Soil Erodibility K-Factor (Source: USDA SSURGO).

A literature review of local and natural sediment yields and event-mean concentrations by land use type was conducted to summarize documented ranges of variability by source. Because the model configuration reflects physical characteristics of the land surface, such as slope and soil type, and spatial variability of meteorological conditions, the goal of model calibration is to parameterize sediment properties that capture the relative range of variability among sources observed in literature. Table 7-2 summarizes yield estimates from literature and Figure 7-4 shows the range of variability in the modeled response across different watersheds.

Table 7-2. Summary of regional sediment yield estimates by land use

Land Use	Load (t/km²/year)			Data Sources and Locations
	Min	Mean	Max	
Natural	0.3	--	72	San Francisco Bay Region[1], National[4]
Agriculture	--	2,461	--	San Francisco Bay Region[1], National[4]
Low Density Urban	21	--	450	San Francisco Bay Region[1], National[4]
High Density Urban	47	--	996	San Francisco Bay Region[1], National[4]
Industrial	--	1,836	--	San Francisco Bay Region[1], National[4]
Commercial	--	112	--	National[4]
Urban Watersheds ALL	44	--	788	San Francisco Bay Region[1]
Urban	--	24.9	--	Hayward, CA. San Francisco Bay Region[2]
Combined	--	36	--	Guadalupe River Watershed, Santa Clara, CA[2]
Combined	11.9	--	28.2	Guadalupe River Watershed, Santa Clara, CA[3]

1. Watershed specific and regional scale suspended sediment loads for Bay Area small tributaries. (McKee et al. 2009)
2. Concentrations and loads of trace contaminants in the Zone 4 Line A small tributary, Hayward, California: Water Year 2007. (McKee et al.2009)
3. Watershed specific and regional scale suspended sediment loads for Bay Area small tributaries. (McKee et al.2009)
4. Typical Pollutant loading from Runoff by Urban Land Use (USEPA 1999)

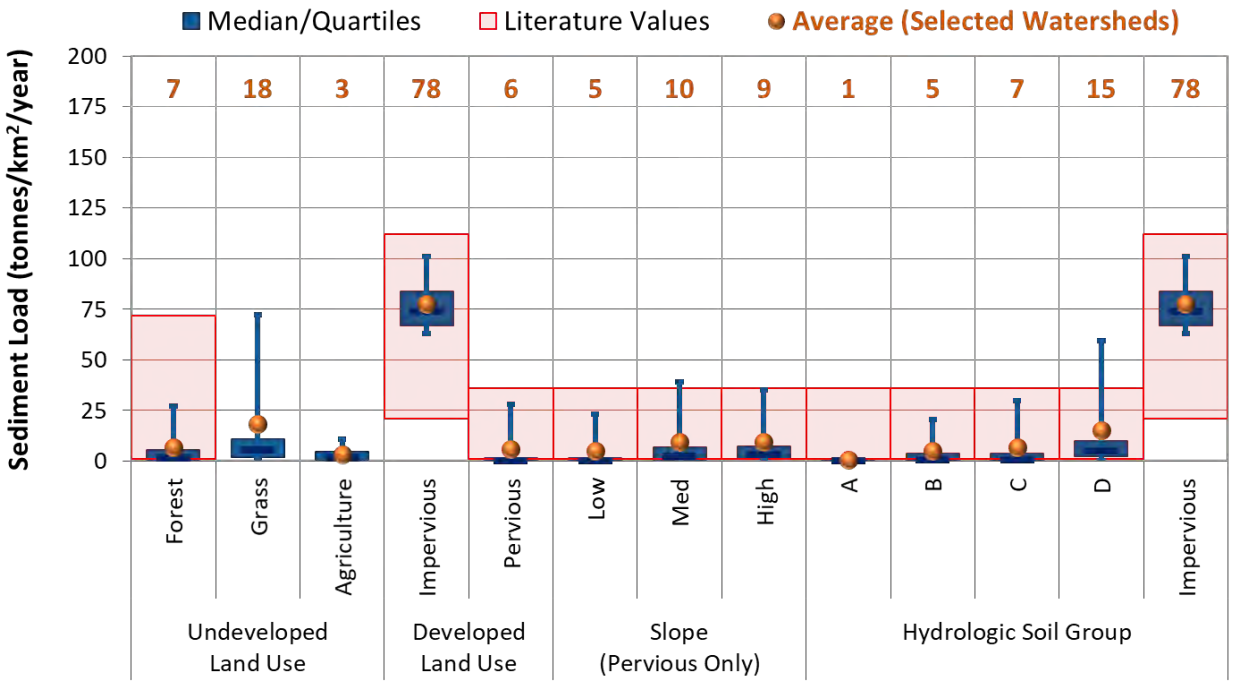


Figure 7-4. Modeled vs. literature ranges for sediment yield by land use.

7.2 Instream Sediment Transport

Sediment generated from the land is partitioned into sand, silt, and clay using fractions by land use before getting routed to stream segments associated with each subwatershed. LSPC represents sediment transport processes (i.e., settling and resuspension) as a function of modeled shear stress (τ), the lateral force of the water imposed on the channel cross-section (USEPA 2006). Simulated τ values vary as a function of stream cross-sectional area, slope, and streamflow. Modeled τ timeseries from the 882 stream segments were grouped and sorted by normalized flow depth over a long-term simulation time period, as summarized in Figure 7-5. Normalized flow depth was calculated for each modeled segment by dividing the average annual streamflow rate through the segment by the cumulative upstream drainage area for the segment. As expected, wetter stream segments have τ values that vary more widely over time than drier stream segments. The most variation in τ also occurs with wet weather (i.e., during the highest 10 percent of flows and time).

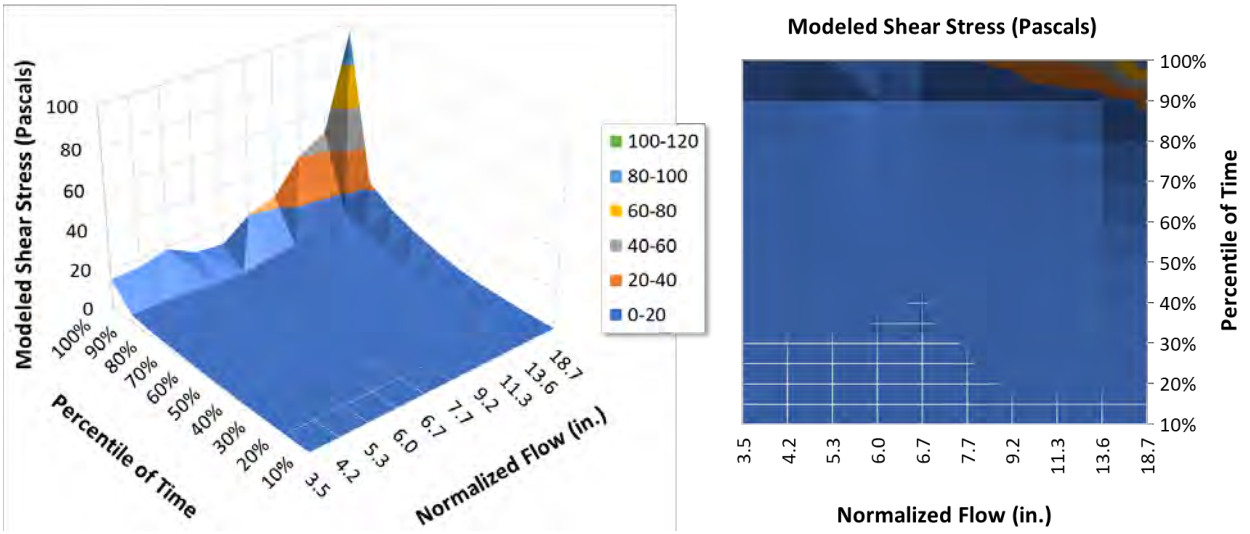


Figure 7-5. Modeled sheer stress × normalized streamflow duration surface for all modeled SCVURPPP stream segments.

Critical shear stress, the threshold that triggers settling or resuspension, is a property of the sediment classes in the transport system. Lighter particles are more easily resuspended than heavier particles and tend to remain in suspension longer than heavier particles. Streams with higher slopes and flow rates will tend to resuspend sediment more easily and more often, while streams with lower slopes and lower flow rates will tend to experience more sediment deposition. The critical shear stress values (for silt and clay) derived through calibration are summarized in Table 7-3.The critical shear stress values are plotted against the range of modeled τ-values in Figure 7-6. Figure 7-7 summarizes the percent of time that silt and clay are in deposition, transport, or resuspension by flow rate.

Table 7-3. Calibrated critical sheer stress values by sediment class

Sediment Class	Deposition	Resuspension
Sand	Power Function[1]	Power Function[1]
Silt	1.5 Pa (0.15 kg/m^2)	3.4 Pa (0.35 kg/m^2)
Clay	0.3 Pa (0.03 kg/m^2)	2.5 Pa (0.25 kg/m^2)

1: Sand transport is modeled using a power function on velocity (coefficient and exponent)

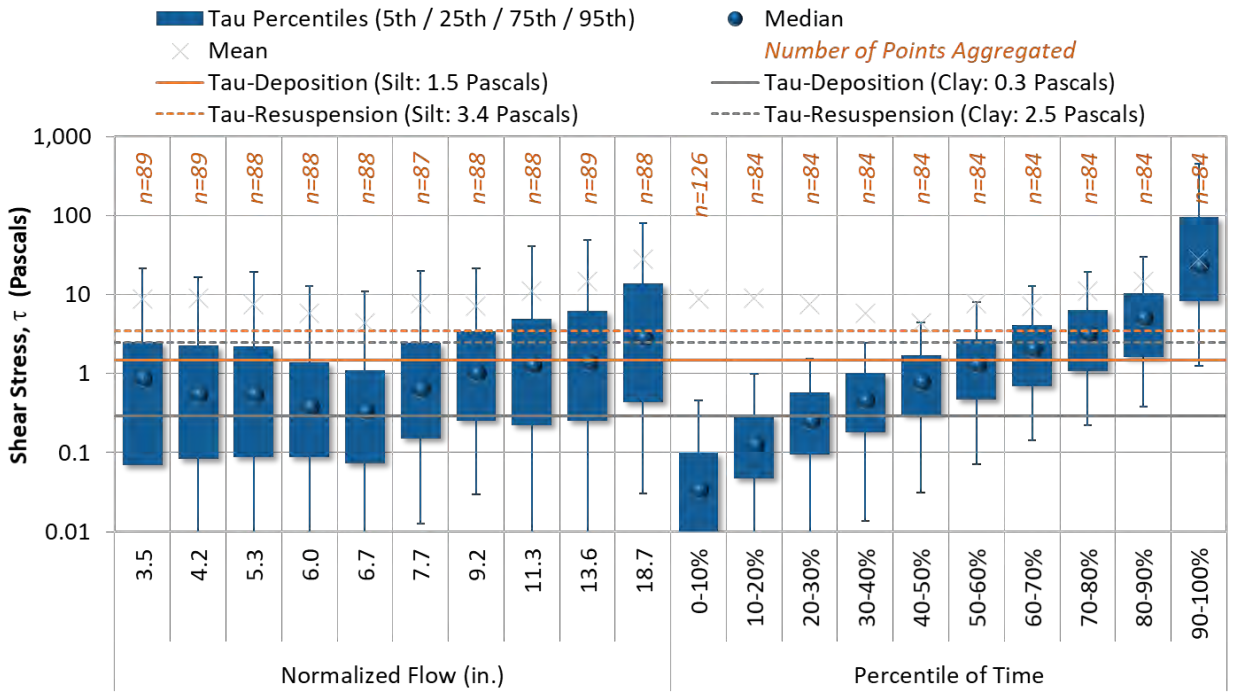


Figure 7-6. Critical shear stress for silt and clay against the range of modeled τ-values by flow and over time.

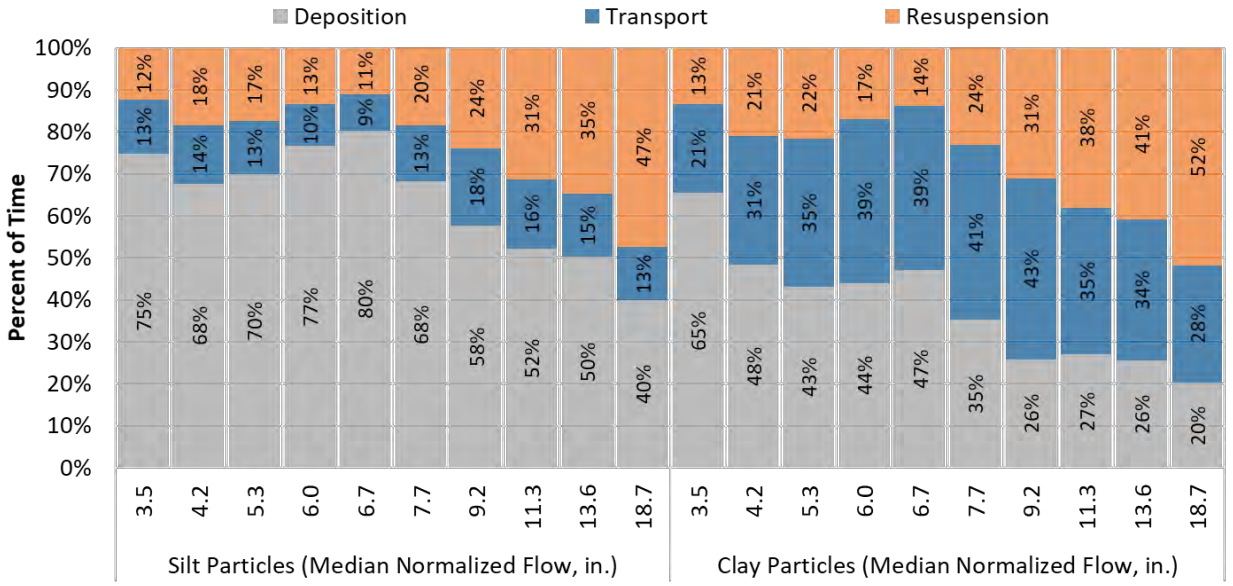


Figure 7-7. Percent of time that silt and clay particles spend in deposition, transport, and resuspension vs. normalized flow for all modeled segments (based on calibrated critical shear stress values).

Figure 7-7 highlights the fate and transport of silt and clay particles, which represent "cohesive" sediment, to which PCBs and mercury load is associated in the model. During sediment transport, heavier silt particles tend to settle more than clay particles, which tend to resuspend and remain in transport more of the time. Total sediment is modeled during model calibration because the observed data represent the sum of sand, silt, and clay; however, because PCBs and mercury are associated with cohesive sediment (i.e., silts and clays), the transport of cohesive sediment portion will be more closely

aligned with those pollutants' fate and transport for instream routing and through green stormwater infrastructure devices.

Daily mean suspended sediment concentration and discharge data from the United States Geological Survey (USGS) monitoring location on the Guadalupe River (USGS 11169025 GUADALUPE River above Highway 101 A SAN JOSE CA) were used to calibrate and validate sediment transport. Comparing point-to-point daily, monthly or annual loads produced some scatter because of underlying model configuration assumptions and differences in precipitation/runoff timing. Figure 7-8 shows a comparison of annual loads by water year from 2004 through 2015. The goal of model calibration was to replicate the range of magnitude and frequency observed instream. Load duration curves of modeled and observed loads were used to gage the central tendency and the distribution/range of modeled load relative to observed. Figure 7-9 presents a comparison of the modeled vs. observed sediment load for the period from 10/1/2003 through 4/30/2015. The left panel shows a scatter plot comparison of the load-duration curve, while the right two panels show median, average, and range of annual and monthly modeled vs. observed values, respectively. The slope (1.0183) and R^2 (0.9947) values both suggest that the LSPC model is a robust predictor of both the magnitude and range of observed sediment load over a wide range of years (water years 2004-2015).

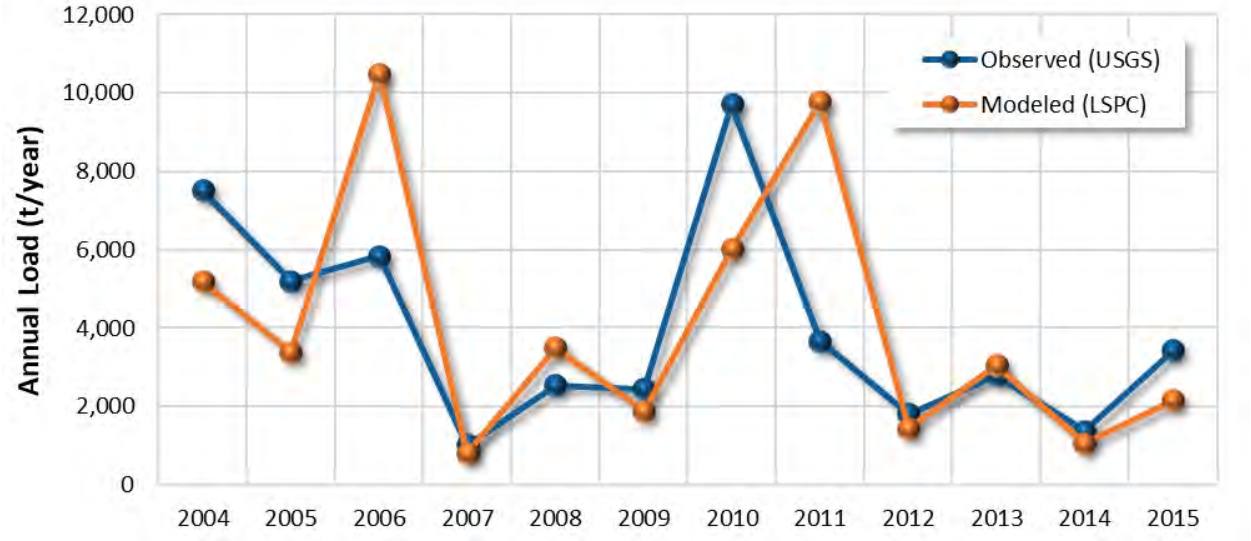


Figure 7-8. Comparison of modeled vs. observed annual load for Guadalupe River (USGS 11169025 GUADALUPE River above Highway 101 A SAN JOSE CA).

Table 7-4. Summary of annual observed and modeled loads at for Guadalupe River (USGS 11169025 GUADALUPE River above Highway 101 A SAN JOSE CA)

Water Year	Annual Load (t/year)		Rank	Ranked Comparison (t/year)		
	Observed	Modeled		Observed	Modeled	RME (%)
2004	7,503	5,191	1	9,704	10,489	7%
2005	5,205	3,389	2	7,503	9,780	23%
2006	5,839	10,489	3	5,839	6,019	3%
2007	1,006	808	4	5,205	5,191	0%
2008	2,545	3,498	5	3,677	3,498	-5%
2009	2,445	1,889	6	3,426	3,389	-1%
2010	9,704	6,019	7	2,800	3,049	8%
2011	3,677	9,780	8	2,545	2,149	-18%
2012	1,808	1,444	9	2,445	1,889	-29%
2013	2,800	3,049	10	1,808	1,444	-25%
2014	1,376	1,055	11	1,376	1,055	-30%
2015	3,426	2,149	12	1,006	808	-24%
Average	**3,944**	**4,063**	**Average**	**3,944**	**4,063**	**3%**

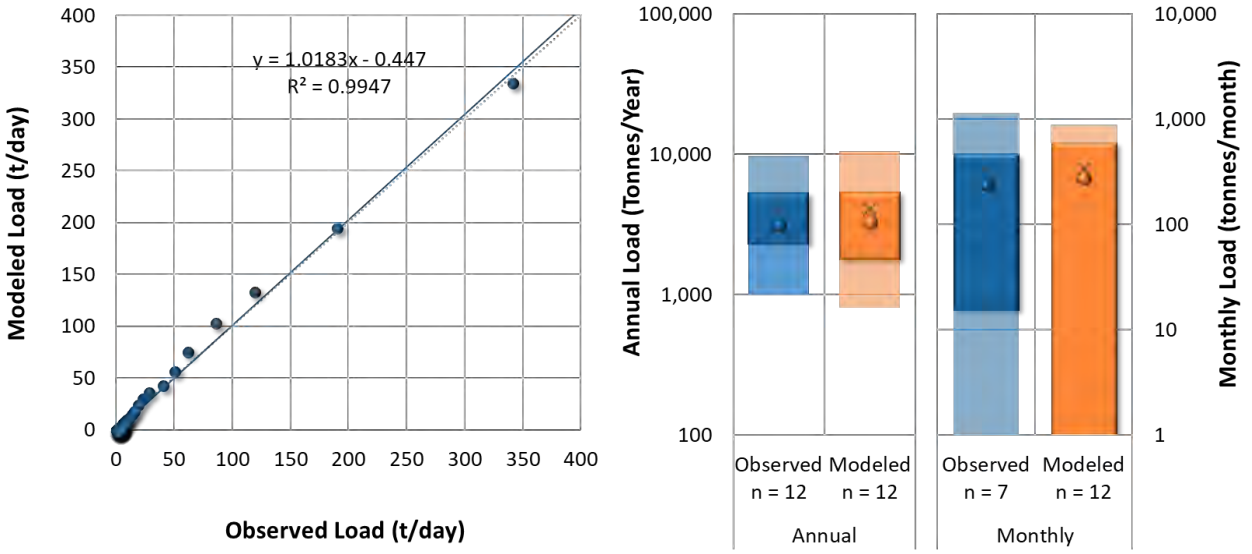


Figure 7-9. Comparison of modeled vs. observed load duration (left) and annual and monthly loads (right) for Guadalupe River (USGS 11169025 GUADALUPE River above Highway 101 A SAN JOSE CA).

To assess annual and seasonal storm impact on instream sediment concentrations, Figure 7-10 and Figure 7-11 compare modeled vs. observed instream sediment concentration during wet-weather (i.e., approximated as the top 10 percent of modeled streamflow) and the inverse condition (i.e., lower 90 percent of modeled flows). In general, both figures demonstrate by visual comparison that the model also predicts across the interquartile ranges of observed instream suspended sediment concentration. The model tends to underpredict the median concentrations but is able to capture the range of concentrations reflected in the observed data for the critical-condition winter wet-weather period (Figure 7-10). The top 10 percent of flows during the winter period is most representative of the wet-weather conditions for which runoff management through GSI is appropriate suggesting the calibrated model is suitable for conducting the RAA.

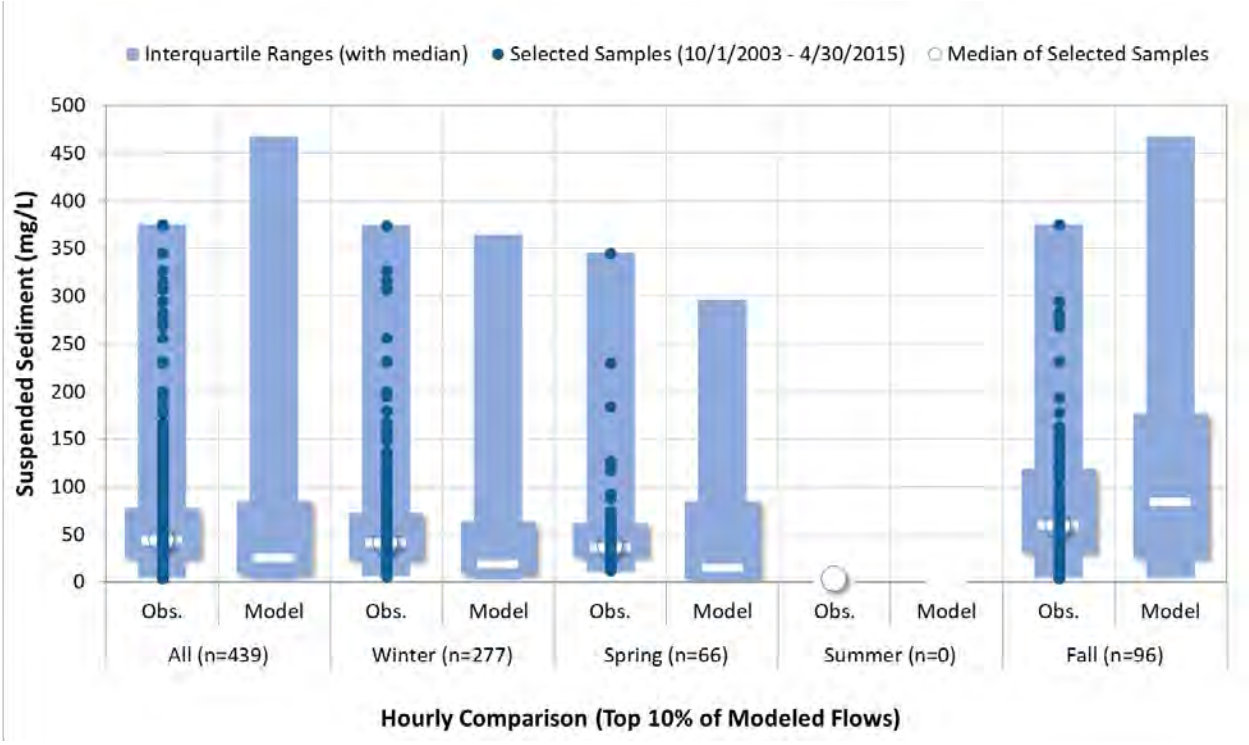


Figure 7-10. Modeled vs. observed wet-weather suspended sediment concentrations for top 10% of modeled flows at Guadalupe River (USGS 11169025 GUADALUPE River above Highway 101 A SAN JOSE CA).

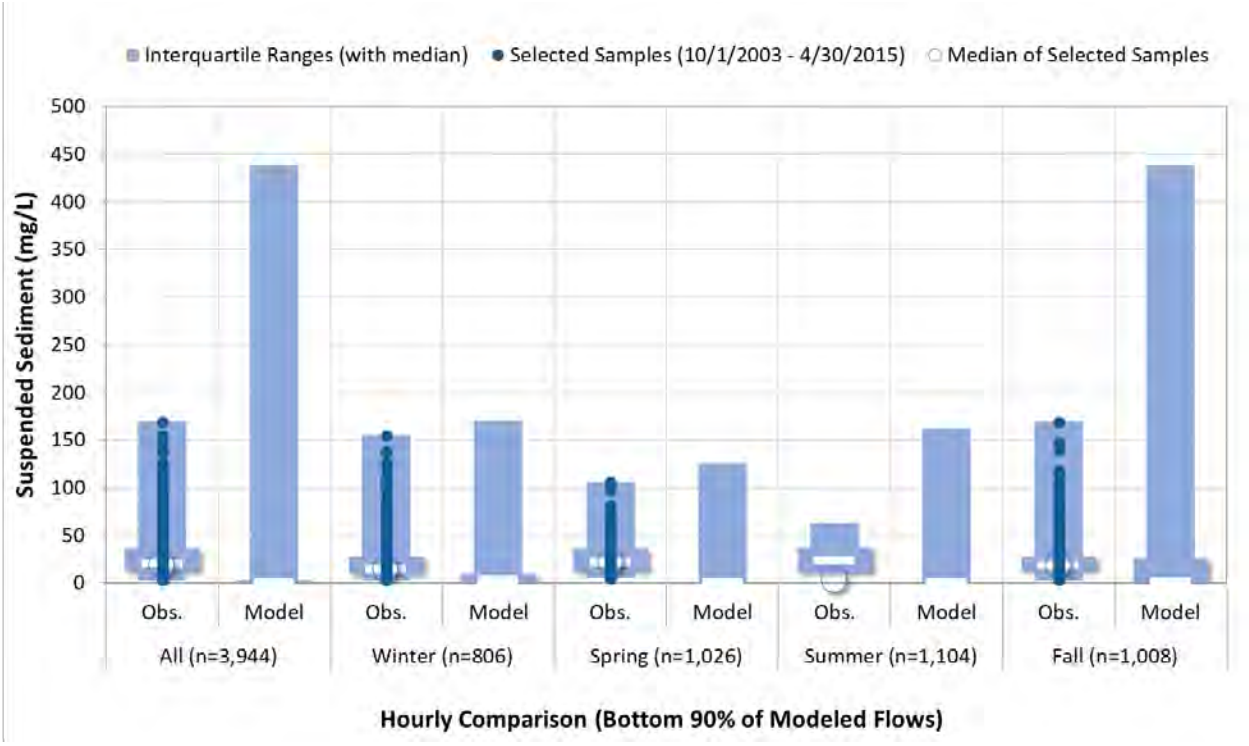


Figure 7-11. Modelled vs. observed suspended sediment concentrations for bottom 90% of modeled flows at Guadalupe River (USGS 11169025 GUADALUPE River above Highway 101 A SAN JOSE CA).

8 POLYCHLORINATED BIPHENYL (PCB) LOADING

During development of the Bay Area RAA Guidance, it was acknowledged through multiple discussions between permittees, USEPA, the Water Board, and researchers (e.g., SFEI) that limited local water quality data may impact the robustness of any new computational method developed by an individual Bay Area Permittee or stormwater program to represent PCB or mercury loading. Although Bay-wide tools such as RWSM are deemed acceptable through model calibration utilizing monitoring data collected throughout Bay watersheds, there is often not enough data within a single County jurisdiction to provide the same level of resolution needed for calibration of a model within that jurisdiction.

As demonstrated in Section 6 and 7, enough data are available for calibration of a model for simulation of hydrology and sediment loading for Santa Clara Basin watersheds. The modeling approach used for the RAA, and outlined in Figure 2-3, combines this LSPC hydrology and sediment loading model with RWSM, using RWSM values for pollutant concentrations representative of various land use and PCB source categories. The Bay Area RAA Guidance states that "if RWSM is used to represent pollutant concentrations or loads, this calibration is assumed to be conducted as part of the RWSM process," and "if sufficient concentration and loading data are available, these data should be used as part of model validation" (BASMAA 2017). This section describes the approach for using RWSM in combination with LSPC for simulating PCB loads, summarizes the local PCB monitoring data available for validation, and presents results of the calibration. The calibrated PCB runoff concentrations from RWSM are presented in Table 8-1. From the results of that model run, simulated long-term PCB and sediment loads were calculated for the model simulation period.

Table 8-1. Calibrated RWSM runoff concentrations for PCBs (BASMAA 2017, Geosyntec Consultants 2019, Wu et al. 2017)

Source Category	PCB Average Concentration (ng/L)
Old Industrial	204.0
Old Urban (Not Residential/Parks)	40.0
Old Urban (Residential/Parks)	4.0
New Urban	0.2
Ag/Open	0.2

As part of the STLS conducted by the Regional Monitoring Program for Water Quality in San Francisco Bay (RMP)[1], over 350 grab samples were collected for PCBs and over 600 grab samples were collected for mercury across the five monitoring locations in the Santa Clara Basin between 2003 and 2017. The Guadalupe River station accounted for a majority of the samples for PCBs (126 of 199 total) and mercury (278 of 387). Table 8-2 presents a summary of the time period(s) covered by each of the five monitoring locations.

[1] The RMP is a collaborative effort between the San Francisco Estuary Institute (SFEI), the San Francisco Regional Water Quality Control Board, and the regulated discharger community.

Table 8-2. Summary of STLS data available for Santa Clara Basin watersheds from WY 2003 – WY 2017

Station Name	Water Year (October 1st – September 30th)														
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Coyote Creek	--	--	●	●	--	--	--	--	--	--	--	--	●	●	--
Guadalupe at Foxworthy Road	--	--	--	--	●	--	--	--	--	--	--	--	--	--	●
Guadalupe River	●	●	●	●	●	--	●	●	●	●	●	●	●	●	●
Stevens Creek	--	--	--	--	--	●	--	--	--	--	--	--	--	--	--
Sunnyvale East Channel	--	--	--	--	--	●	●	●	●	--	--	--	--	--	--

Table 8-3 presents a summary of land uses for the Santa Clara Basin. For each STLS drainage area used for model validation, Table 8-4 summarizes land use distribution, computed percent imperviousness (based on the National Land Cover Dataset [NLDC]), and presents RWSM-calibrated PCB runoff concentrations by land use. The land classification data layer was developed in GIS for representing sources of PCBs and mercury loads within Santa Clara Basin watersheds.

Table 8-3. Summary of land use source category area and percent of total area in the Santa Clara Basin

Source Category	Summary	
	Area (acres)	% Total Area
Ag/Open	386,907.1	66.3%
New Urban	60,959.7	10.4%
Old Industrial	9,555.5	1.6%
Old Urban (Not Residential/Parks)	35,147.1	6.0%
Old Urban (Residential/Parks)	91,208.5	15.6%
Total	**583,778.0**	**100.0%**

Figure 8-1 through Figure 8-5 show drainage area boundaries and land use source categories for the five STLS monitoring locations. For the catchment boundaries shown in the map, Table 8-4 summarizes land use distribution and modeled percent imperviousness. These sites present a mix of small-scale, isolated and highly urbanized locations and large watersheds containing a mix of source categories, including open space, to validate the model PCB response against observed data for multiple storms.

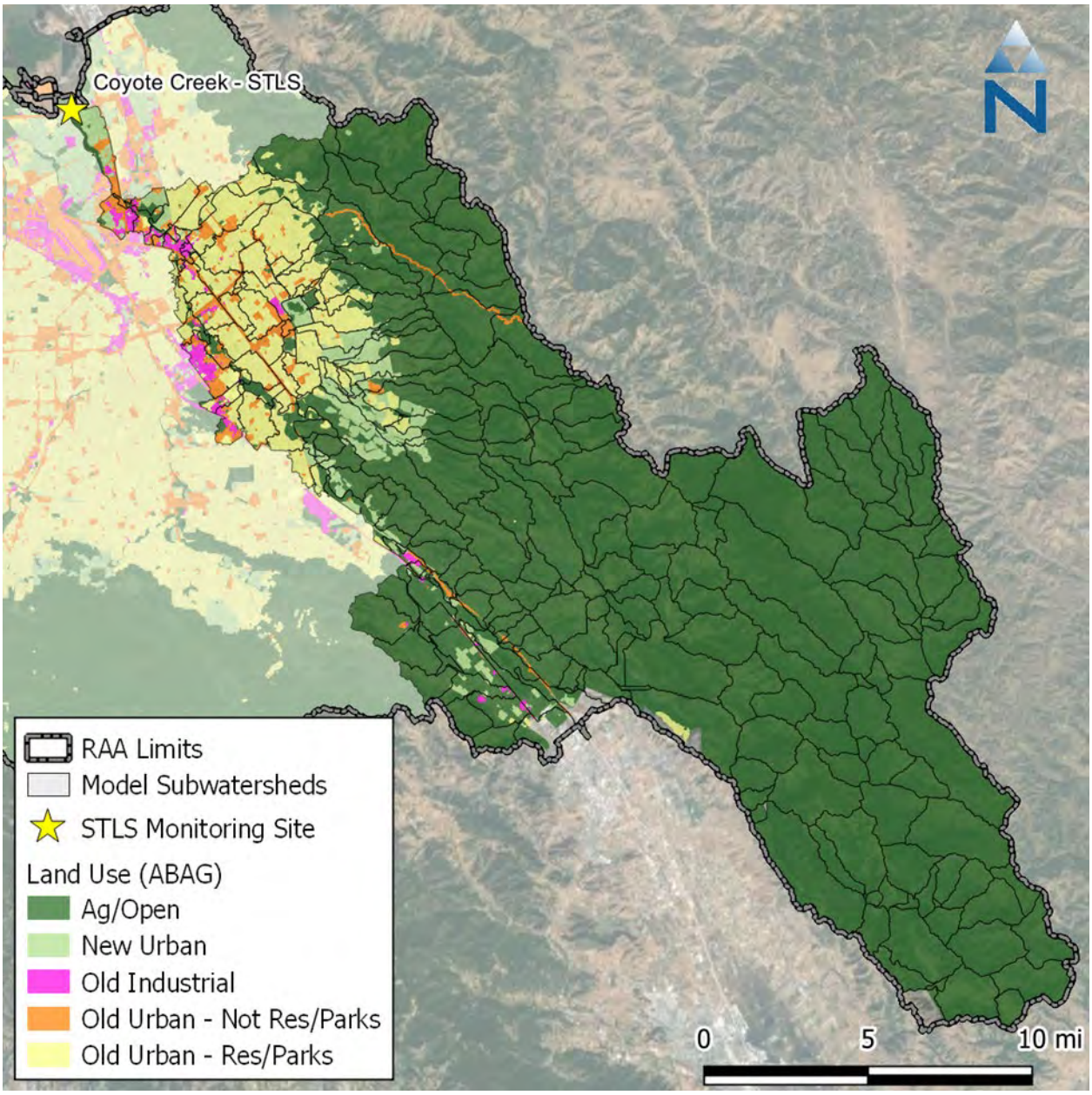


Figure 8-1. Map of the Coyote Creek STLS monitoring station and drainage area.

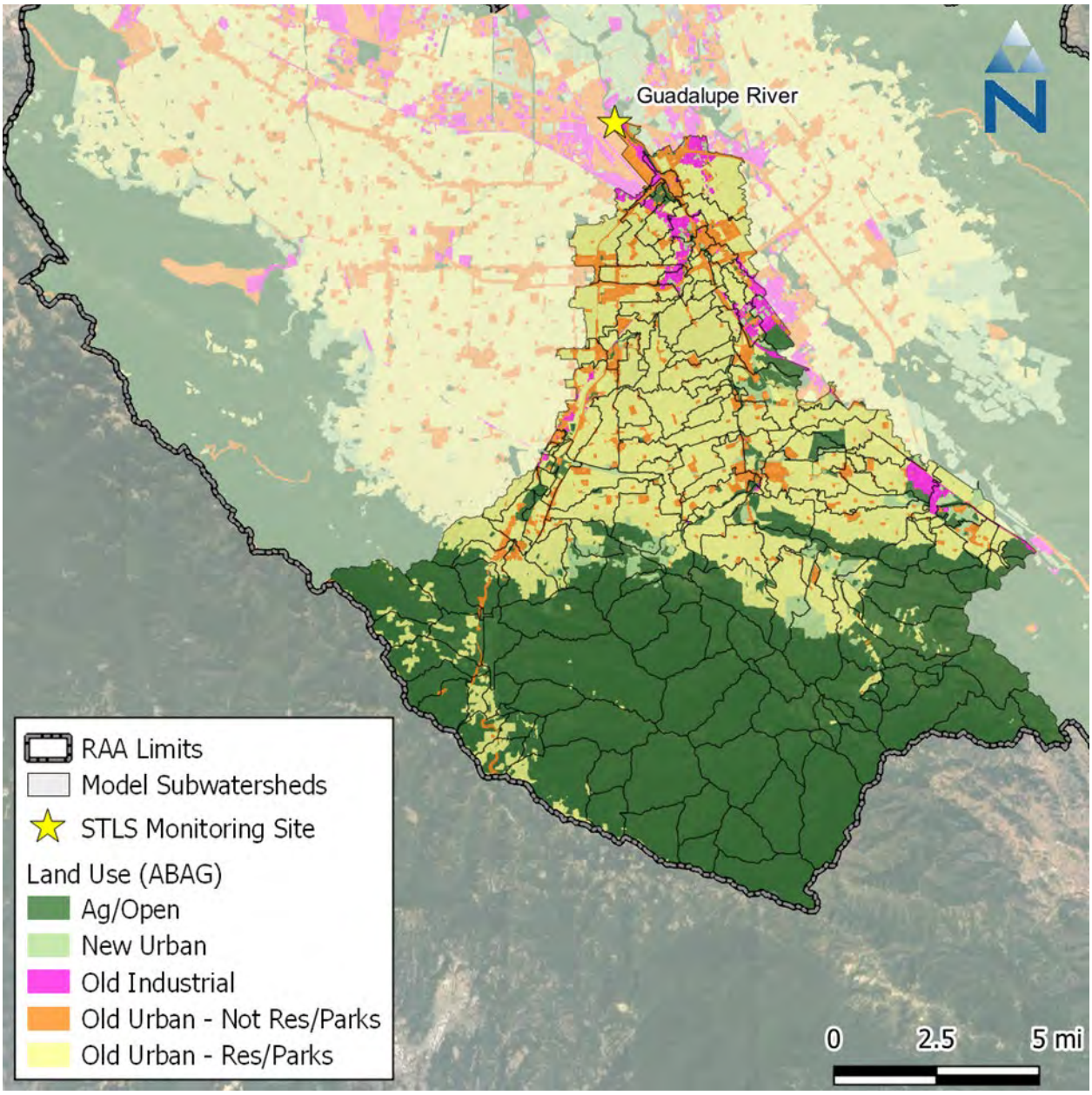


Figure 8-2. Map of the Guadalupe River STLS monitoring station and drainage area.

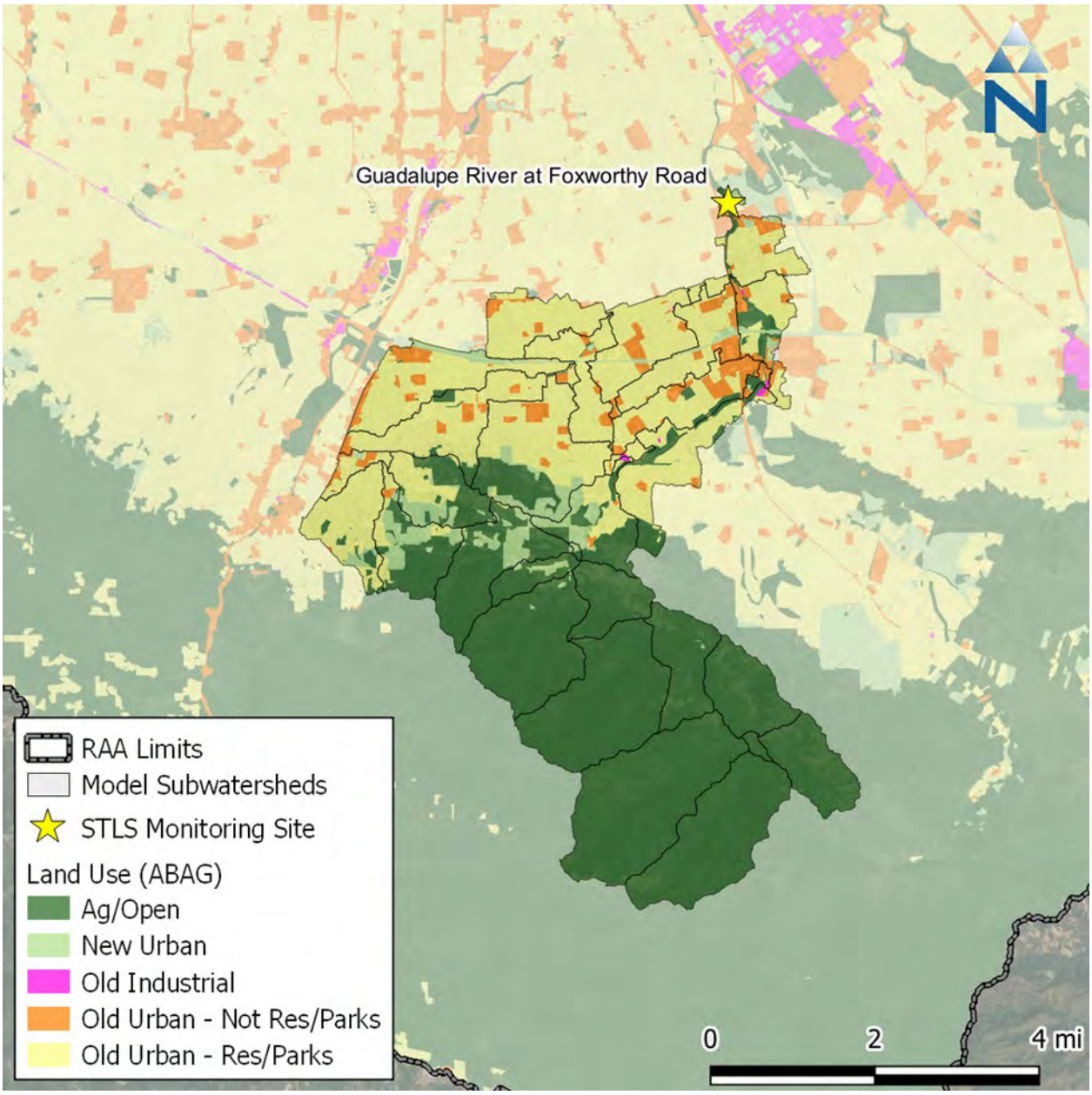


Figure 8-3. Map of the Guadalupe River at Foxworthy Road STLS monitoring station and drainage area.

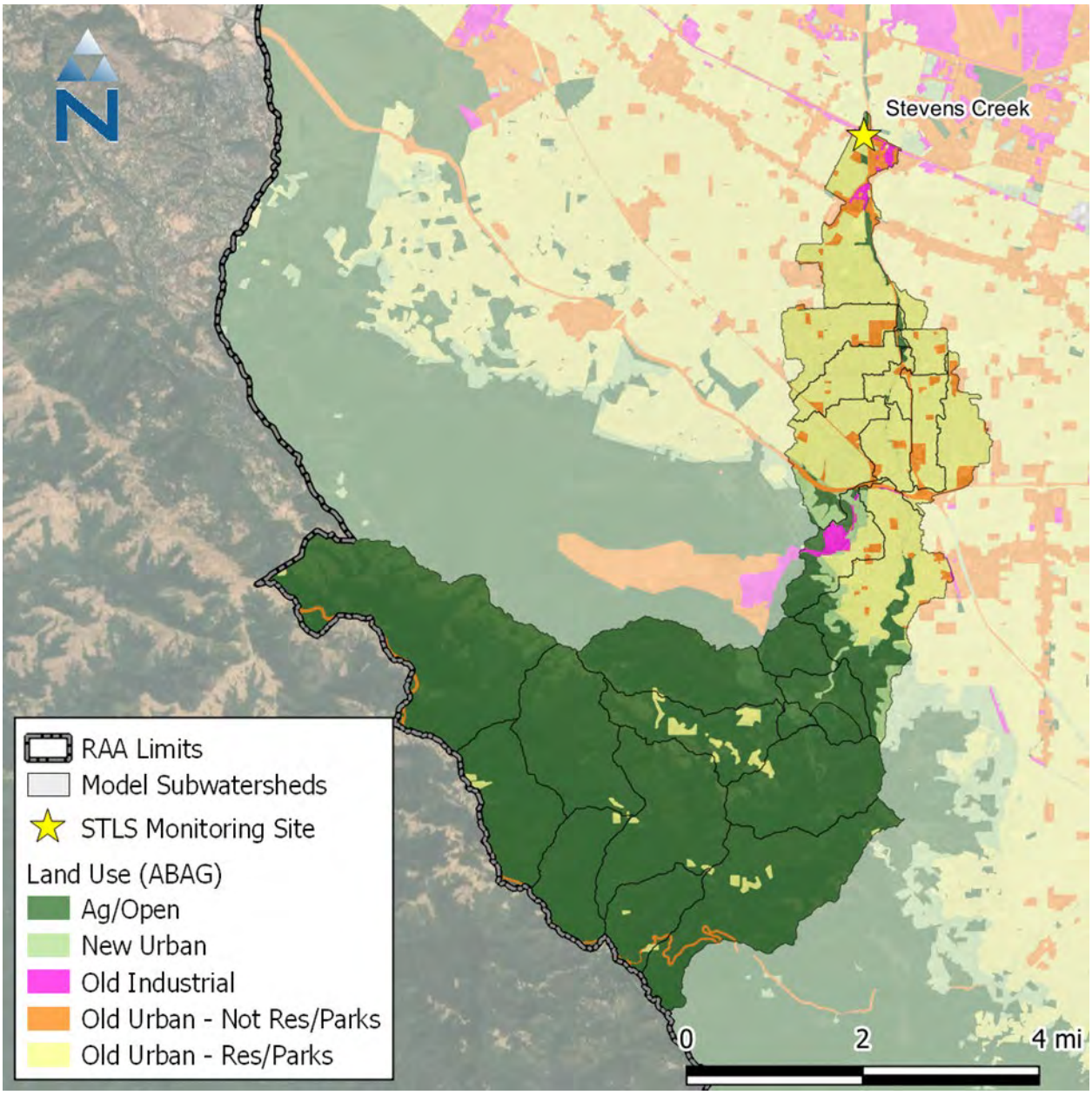


Figure 8-4. Map of the Stevens Creek STLS monitoring station and drainage area.

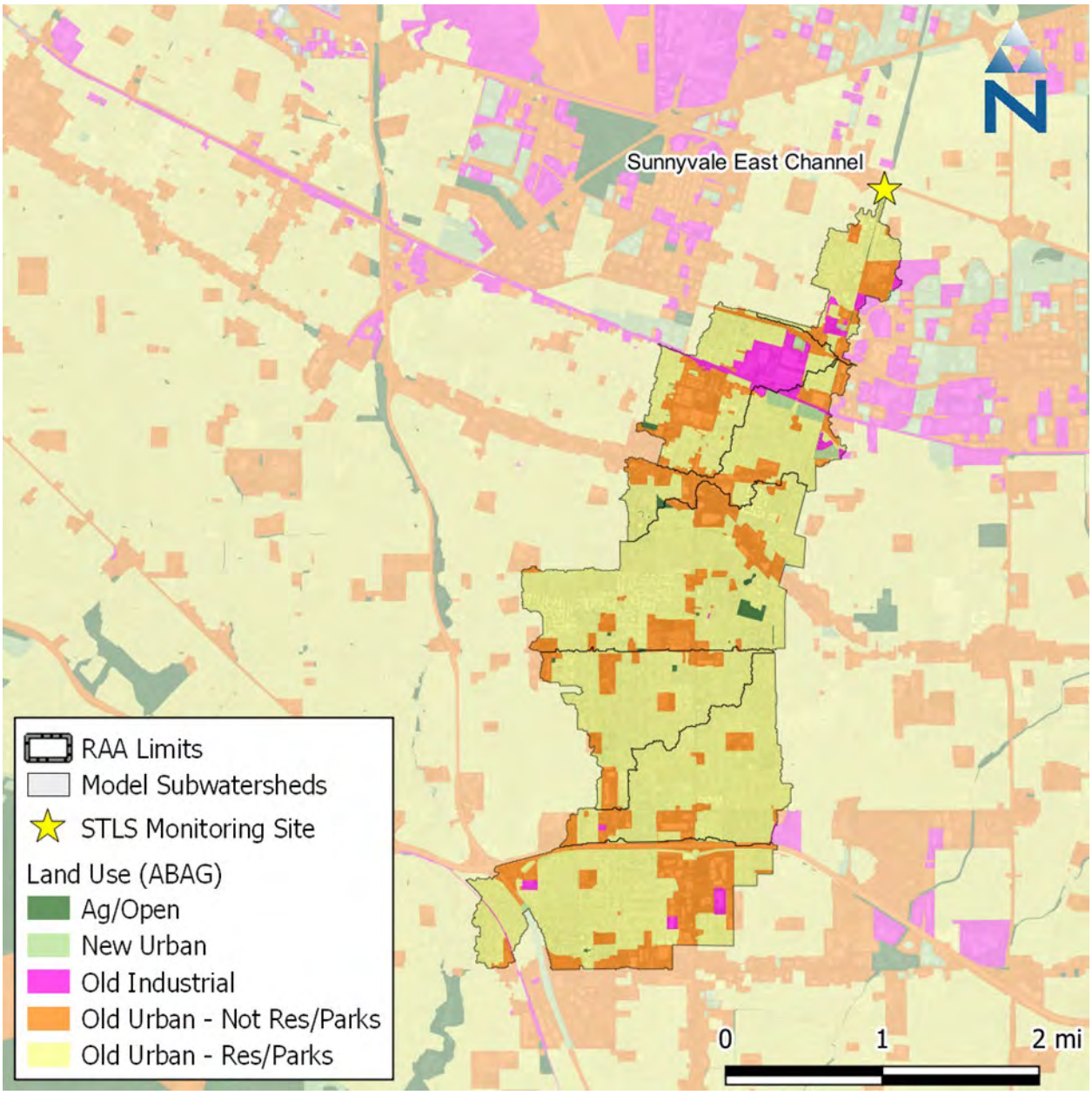


Figure 8-5. Map of the Sunnyvale East Channel STLS monitoring station and drainage area.

Table 8-4. Model land use distribution and percent impervious cover for the STLS monitoring locations

Source Category	Coyote Creek	Guadalupe River	Guadalupe River at Foxworthy Road	Sunnyvale East Channel	Stevens Creek
Total Area (acres)					
Ag/Open	174,364	59,637	10,001	52	12,275
New Urban	8,435	3,450	672	40	270
Old Industrial	1,502	1,866	13	142	117
Old Urban (Not Residential/Parks)	4,948	7,972	1,082	936	715
Old Urban (Residential/Parks)	15,224	28,702	5,614	2,469	3,438
Total Area (acres)	**204,474**	**101,626**	**17,382**	**3,639**	**16,815**
Percent of Total Area					
Ag/Open	85.3%	58.7%	57.5%	1.4%	73.0%
New Urban	4.1%	3.4%	3.9%	1.1%	1.6%
Old Industrial	0.7%	1.8%	0.1%	3.9%	0.7%
Old Urban (Not Residential/Parks)	2.4%	7.8%	6.2%	25.7%	4.3%
Old Urban (Residential/Parks)	7.4%	28.2%	32.3%	67.8%	20.4%
Percent Impervious Cover					
Ag/Open	0.5%	1.1%	0.9%	28.0%	0.5%
New Urban	32.9%	35.6%	23.9%	57.9%	14.9%
Old Industrial	65.9%	66.9%	42.3%	74.2%	39.9%
Old Urban (Not Residential/Parks)	51.1%	53.0%	48.3%	59.0%	41.4%
Old Urban (Residential/Parks)	38.0%	32.6%	30.5%	40.5%	25.7%

Except for Sunnyvale East Channel, which is about 98 percent "Old Urban" and "Old Industrial", the drainage areas for the other four STLS stations are composed of at least 50 percent "Ag/Open" source categories. These drainage areas for the five monitoring locations were already represented explicitly in the model subwatershed delineations, allowing for comparison of the model's PCB prediction to observed STLS monitoring data. Figure 8-6 through Figure 8-10 present validation comparisons for five storm events, one for each STLS monitoring location. These plots show the modeled PCB concentration from the watershed model versus the observed grab sample concentrations. The observed data in most cases bracket the model concentrations and demonstrate the model's capability to reproduce the same magnitude PCB concentrations, even though timing of peaks may be slightly off because of differences in the timing of small-scale rainfall runoff variability. In some cases, such as Sunnyvale East Channel, the model result matches the grab sample peak concentrations. In the case

of the 3-day storm sequence shown at Stevens Creek (Figure 8-10), the model peak is highest for the first day and reduces for the second and third day. The model uses a build-up wash-off approach for sediment, and PCBs are associated with sediment. Figure 8-10 demonstrates that the model predicts the potential magnitude of observed PCB concentrations on the first day, but there was not enough time to build-up loads before the second day's event. Because of uncertainties in the timing of rainfall events, tuning rates to match the second day peaks at Stevens Creek would cause overprediction for other events and locations.

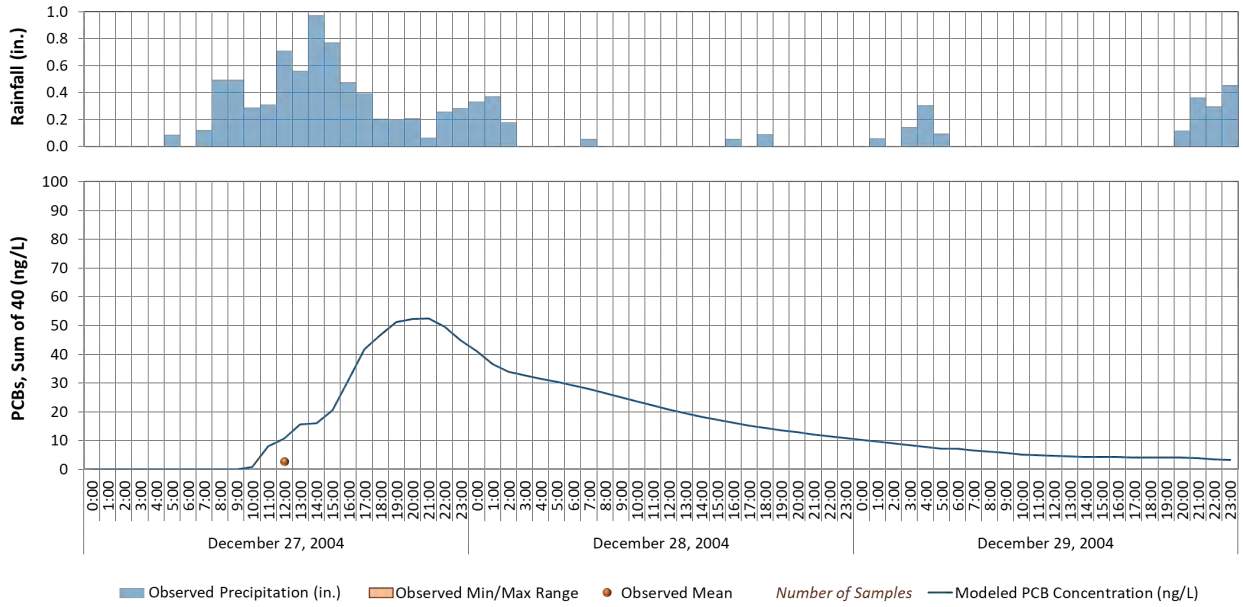


Figure 8-6. Modeled vs. observed PCBs for a selected storm at Coyote Creek Gage (12/27/2014 - 12/29/2014).

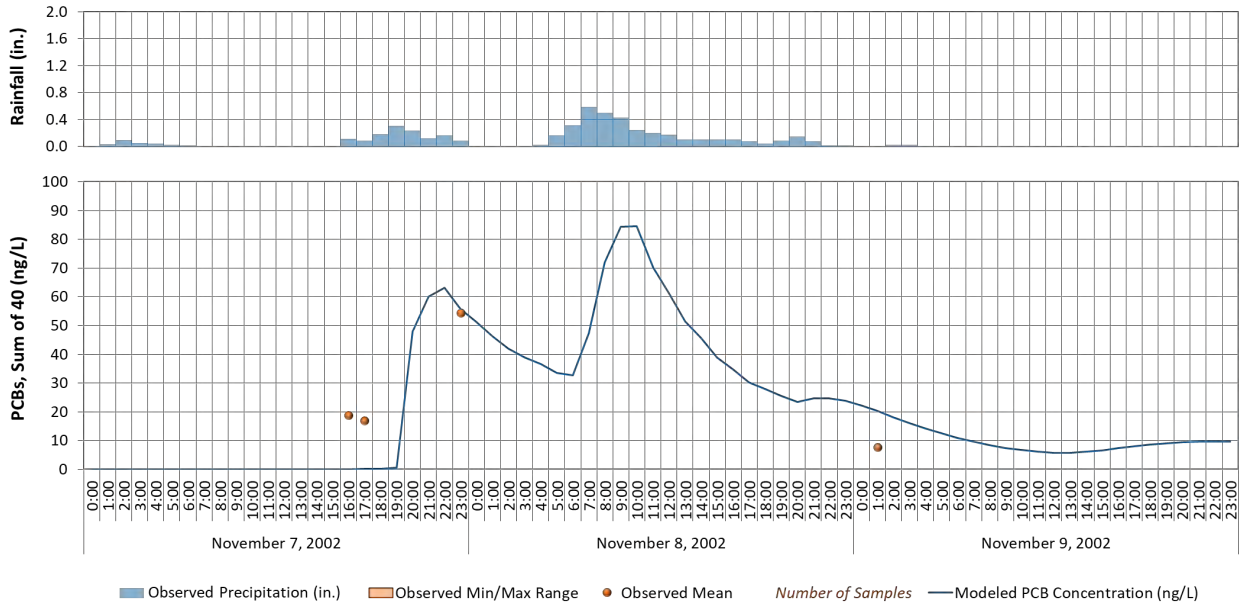


Figure 8-7. Modeled vs. observed PCBs for a selected storm at Guadalupe River Gage (11/7/2002 - 11/9/2002).

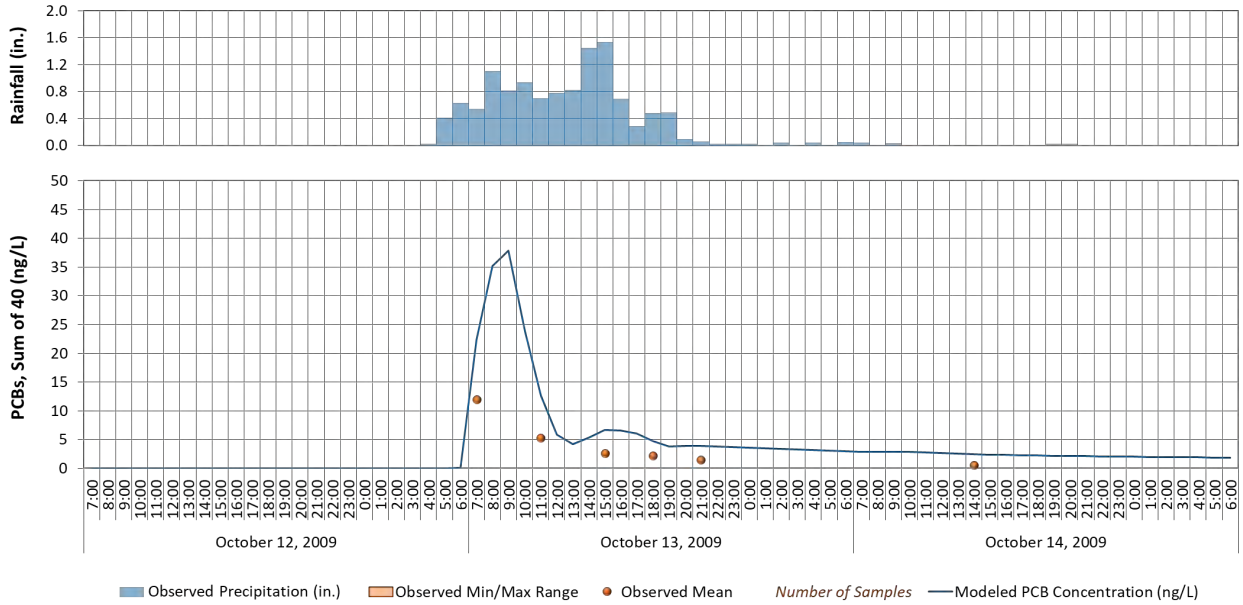


Figure 8-8. Modeled vs. observed PCBs for a selected storm at Guadalupe River at Foxworth Road (10/12/2009 - 10/14/2009).

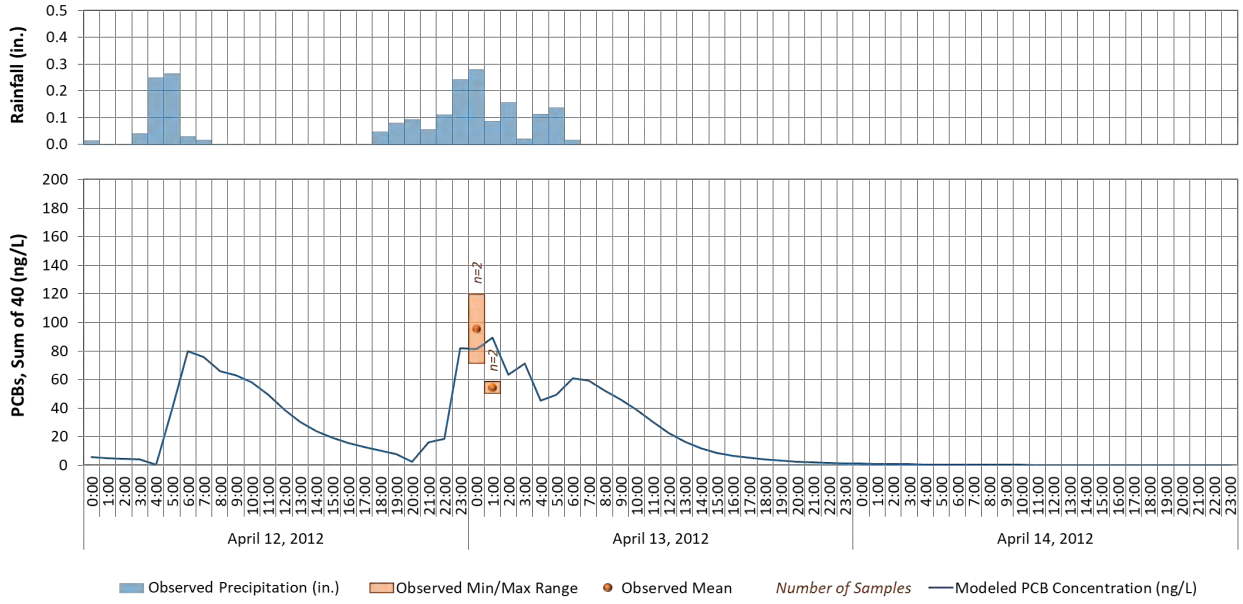


Figure 8-9. Modeled vs. observed PCBs for a selected storm at Sunnyvale East Channel (4/12/2012 - 4/14/2012).

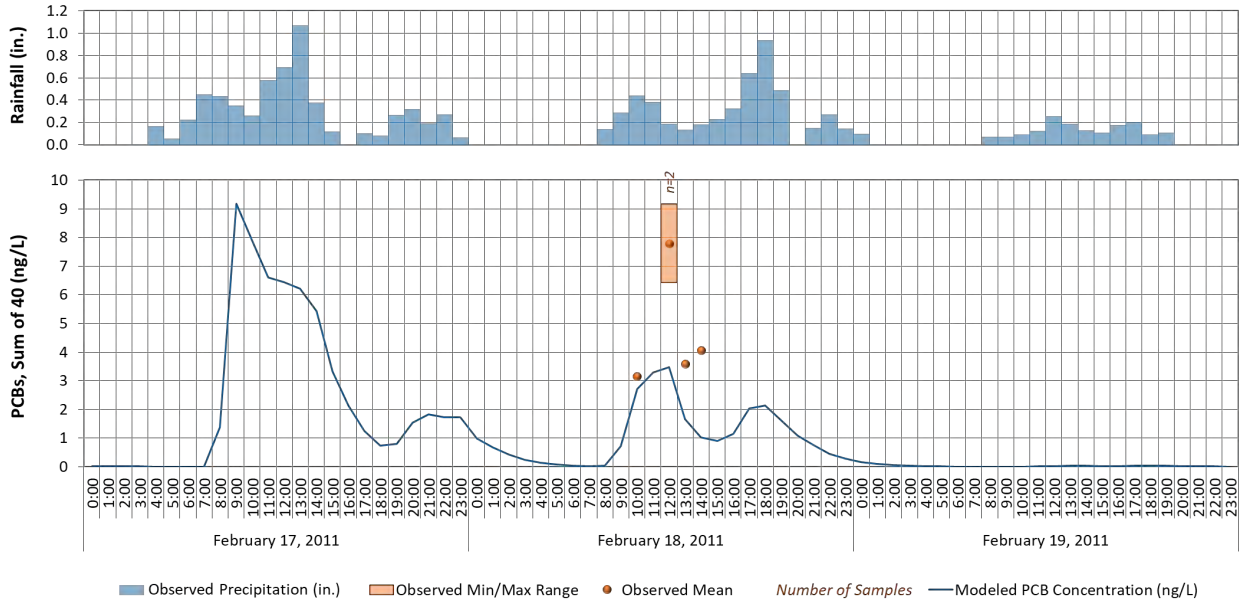


Figure 8-10. Modeled vs. observed PCBs for a selected storm at Stevens Creek Gage (2/17/2011 - 2/19/2011).

The timeseries comparisons for PCBs were for specific storms and locations and included limited samples during wet-weather events. Figure 8-11 and Figure 8-12 show boxplot ranges of modeled sediment and PCB concentrations associated with the top 1 percent of flows that were queried and compared against the full set of observed sediment and PCB samples respectively, at each station. A limited number of the observed samples (n values shown) were plotted against *all* concentrations that met the 1 percent flow threshold; therefore, the median of the modeled values are expected to be lower than the median of the limited number of samples. Nevertheless, those summary plots suggest that the relative variability of concentrations predicted by the model between stations generally follows the pattern of observed.

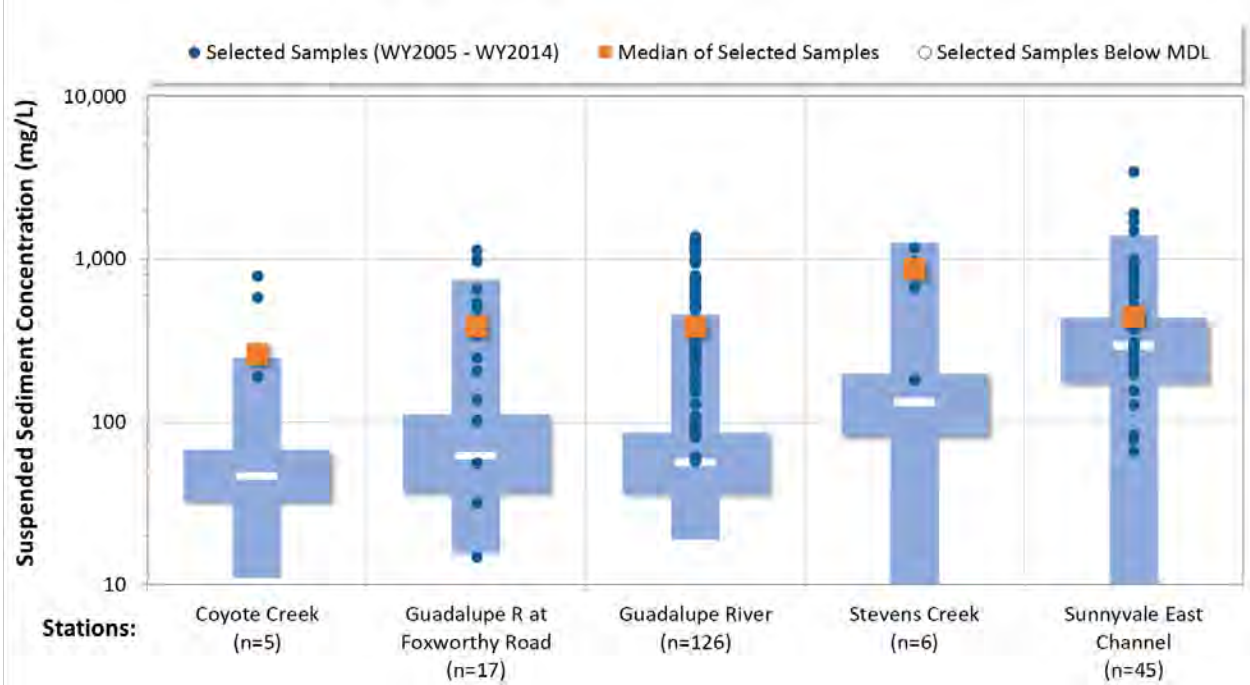


Figure 8-11. Summary of modeled concentrations as boxplots (for the top 1% of modeled flows) vs. observed sediment storm sample concentration at SLTS stations.

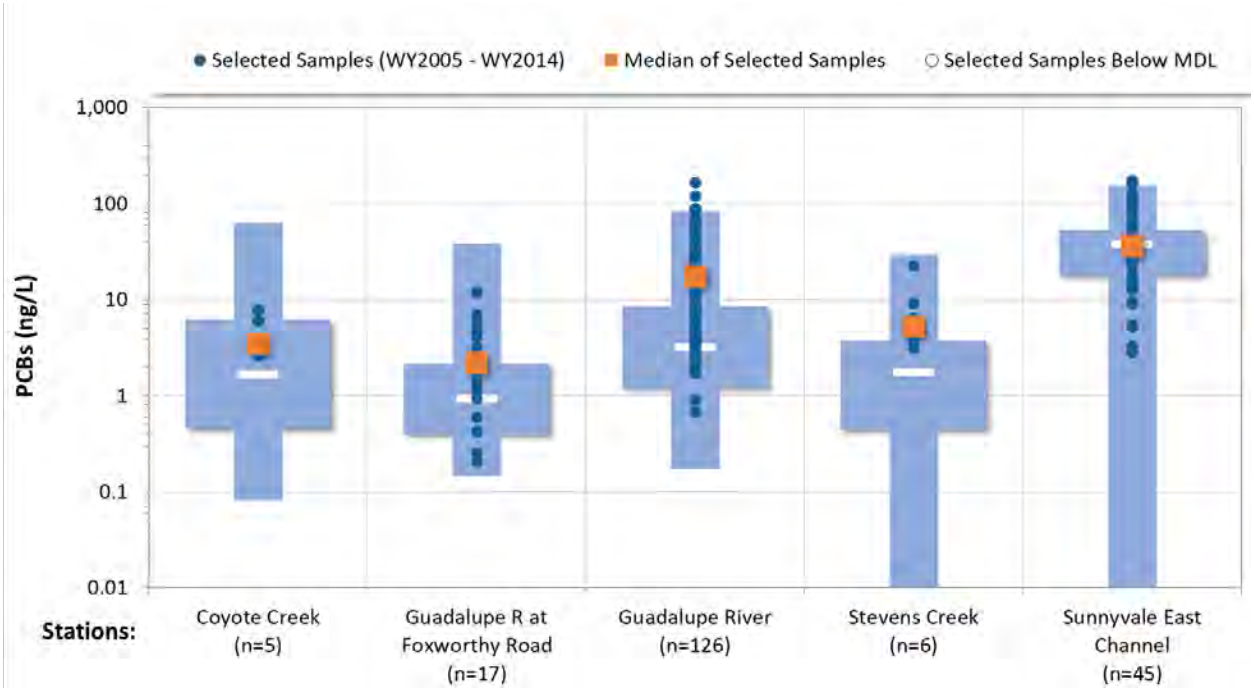


Figure 8-12. Summary of modeled concentrations as boxplots (for the top 1% of modeled flows) vs. observed PCBs storm sample concentration at SLTS stations.

Like the analysis for the validation drainage areas above, the RWSM land use concentrations were combined with the baseline LSPC model to provide an estimate of PCB loads throughout the Santa Clara Basin. The GIS layer for source categories (Figure 4-5 and Table 8-3) was intersected with the modeled HRU layer to estimate land use distribution for PCB source areas at the modeled subwatershed level. Basin-wide sediment, PCB, and mercury loads were estimated for water year 2002[2] (10/1/2001 to 9/30/2002). Mercury results will be further discussed in Section 9. Figure 8-13 shows sediment and PCB source area land use distribution and modeled PCB loads for water year 2002. The loads "at source" represent edge-of-field summaries of sediment and PCB loads, whereas the "delivered" loads account for instream pollutant transport impacts. The "delivered" loads have been adjusted to reflect the mass from each source that reaches the Bay. Many of the source areas are located near the shoreline of the Bay; therefore, the transport losses are lower for those areas than for others that are farther upstream. Figure 8-14 is a map of unit-area sediment loads at the source (left) and PCB loads from each subwatershed that are ultimately delivered to the Bay (right).

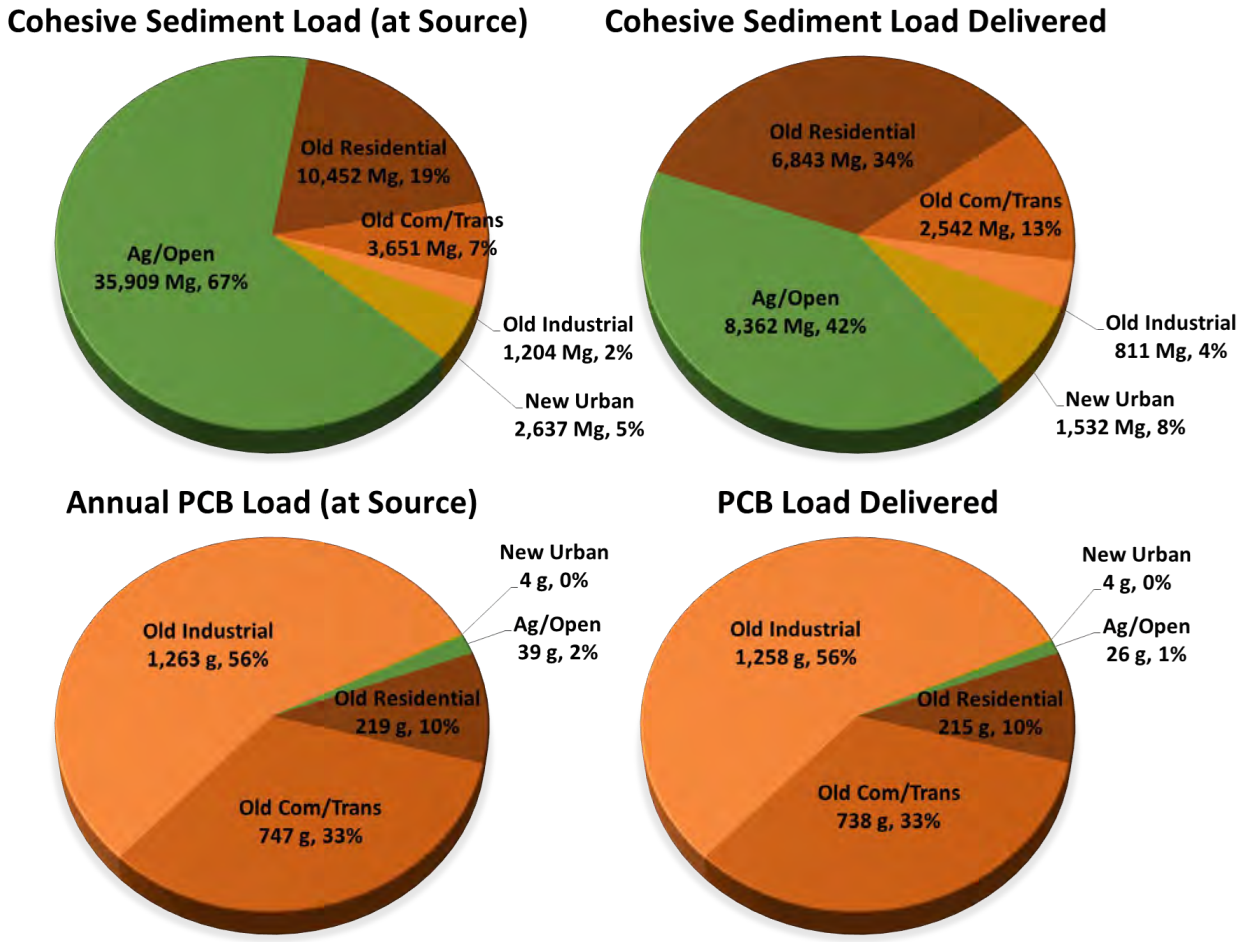


Figure 8-13. PCB source area land use distribution and modeled PCB load estimates for an average water year (2002) –"Source" is edge-of-field load; "Delivered" is adjusted for instream transport losses.

[2] For the RAA analysis and direct comparison to TMDL WLAs based on average annual loading conditions, the Bay Area RAA Guidance recommends two options for simulation of baseline loading: (1) water years 2000-2009 (for long-term continuous simulation), or (2) water year 2002 (for representative water year).

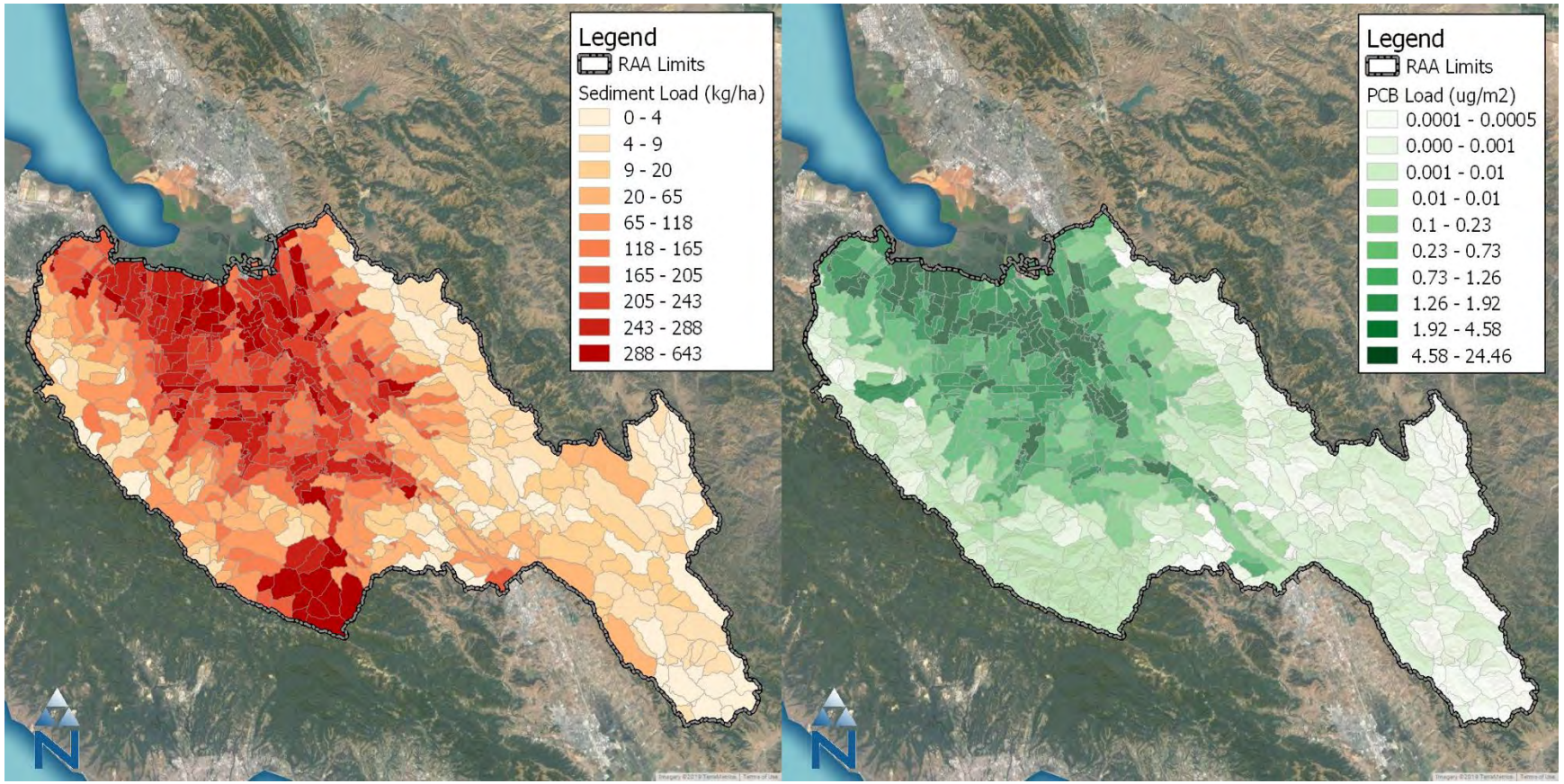


Figure 8-14. Modeled sediment and PCB unit-area loads (at source) by subwatershed in the Santa Clara Basin.

9 MERCURY LOADING

The SLTS also sampled mercury at all five station locations presented in Section 8. The observed data showed high concentrations associated with the mining district in the Guadalupe watershed. The average RWSM values are not representative of Guadalupe sources, but are assumed to be representative of regional long-term mean concentrations from developed areas. Because the mining areas are also not part of the MRP area under consideration for this analysis, validation results from the two Guadalupe stations (which include drainage from the mining areas) were excluded in the validation comparisons. SFEI calibrated mercury runoff concentrations for RWSM based on the same land use categories utilized for modeling PCBs, although the TMDL (SFBRWQCB 2006 and 2008a) and other research has not established that different mercury concentrations can be linked to these land uses. Since the major source of mercury from urban areas is generally understood to result from atmospheric deposition, mercury loading from urban land is expected to be more a function of imperviousness than land use. Regardless, since RWSM concentrations are presently accepted as the current primary method for estimating mercury loads to the Bay (BASMAA 2017), they were utilized for the RAA. Mercury runoff concentrations from RWSM, based on land use source categories presented in Section 8, were combined with LSPC-modeled hydrology to model mercury loading from each of these drainage areas.

Table 9-1. Calibrated RWSM runoff concentrations for mercury (BASMAA 2017, Geosyntec Consultants 2019, Wu et al. 2017)

Source Category	Mercury Average Concentration (ng/L)
Old Industrial	40.0
Old Urban – Not Res/Parks	63.0
Old Urban – Res/Parks	63.0
New Urban	3.0
Ag/Open	80.0

Previous SFEI studies of sediment and mercury in other regional tributaries have demonstrated a positive relationship between instream sediment and mercury concentrations. Results from a mercury monitoring study conducted in an urban tributary in Hayward, CA are plotted in black in the upper-left panel of Figure 9-1 (McKee et al. 2009). The other panels in Figure 9-1 present the results of modeled sediment and mercury concentrations for the modeled drainage areas corresponding to the three STLS monitoring locations. Consolidated data from these three stations are superimposed in blue on the Hayward samples, showing how those levels trend slightly higher than the Hayward levels, although the slopes are similar. The slope of the line provides a rough estimate of mercury concentration relative to sediment concentrations; however, because the trend line does not intersect at zero, it is reasonable to expect some level of background mercury concentration in the water column, presumably from background sources, when sediment concentrations are near zero.

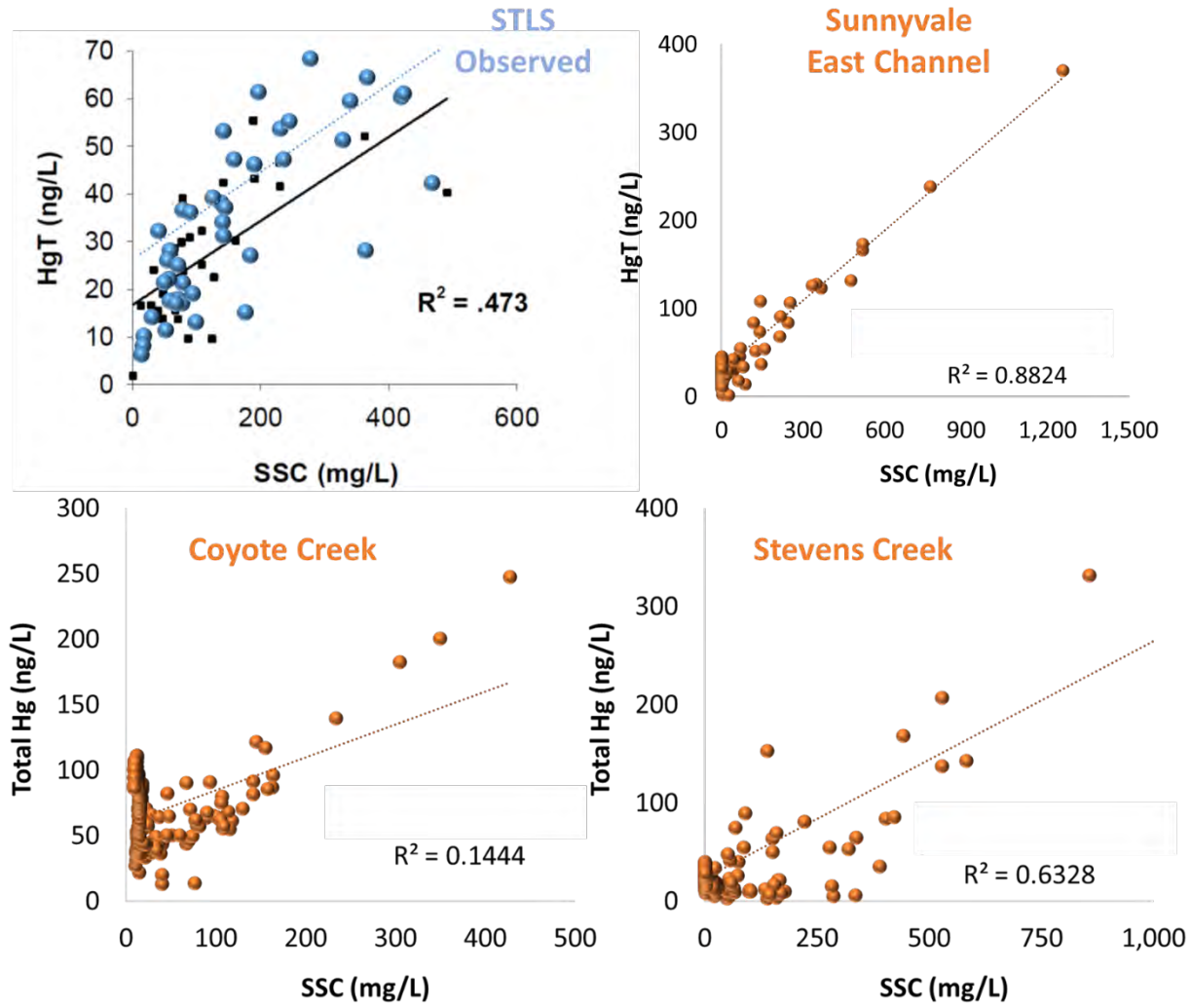


Figure 9-1. Modeled (orange) vs. observed (blue) mercury trends for SLTS sampling sites.

When applied to the timeseries output, this approach by itself produces a linear relationship that intersects the y-axis of Figure 9-1 at the zero point; however, the observed STLS relationships (McKee et al. 2009) suggest that the intercept is not zero. To better reflect this trend, a background mercury concentration of 20 ng/L was assigned to modeled baseflows as shown Figure 9-1. The model also assumes atmospheric wet-deposition concentration of 9.7 ng/L and a dry-deposition rate of 19 µg/m2/year; however, studies also indicated that only about 5 percent of the atmospheric deposition load is exported from land into waters (SFBRWQCB 2008a). As a result, the model was parameterized to reflect net mercury delivery to waterbodies from atmospheric deposition (0.485 ng/L wet deposition and 0.95 µg/m2/year for dry deposition) (SFBRWQCB 2008a). With those two mercury loading signatures added to represent contributions from natural sources, the RWSM land-based mercury sediment estimates were proportionally adjusted (maintaining the same relative distributions by source) to match the slope of the curve in the calibration panels shown in Figure 9-1.

Figure 9-2 through Figure 9-4 show modeled versus observed mercury concentrations for sampled storm events using the sediment-based RWSM concentration values in order to assess model performance at the same five STLS monitoring locations. The selected storm events are consistent with the events presented in Section 8 showing PCB concentrations. In some cases, the model

predicted mercury concentrations do not match the timing or peaks of the observed STLS concentration data. Historic sources of mercury (i.e., mines), effects of reservoirs and groundwater contributions, and other unknown processes may affect the timing or magnitude of the model concentrations versus the observed grab samples. Figure 9-6 shows sediment and mercury source area land use distribution and modeled mercury loads for water year 2002. The loads "at source" represent edge-of-field summaries of sediment and mercury loads, whereas the "delivered" loads account for instream pollutant transport impacts. The "delivered" loads have been adjusted to reflect the mass from each source that reaches the Bay. Figure 9-7 is a map of unit-area sediment loads at the source (left) and mercury loads from each subwatershed that are ultimately delivered to the Bay (right).

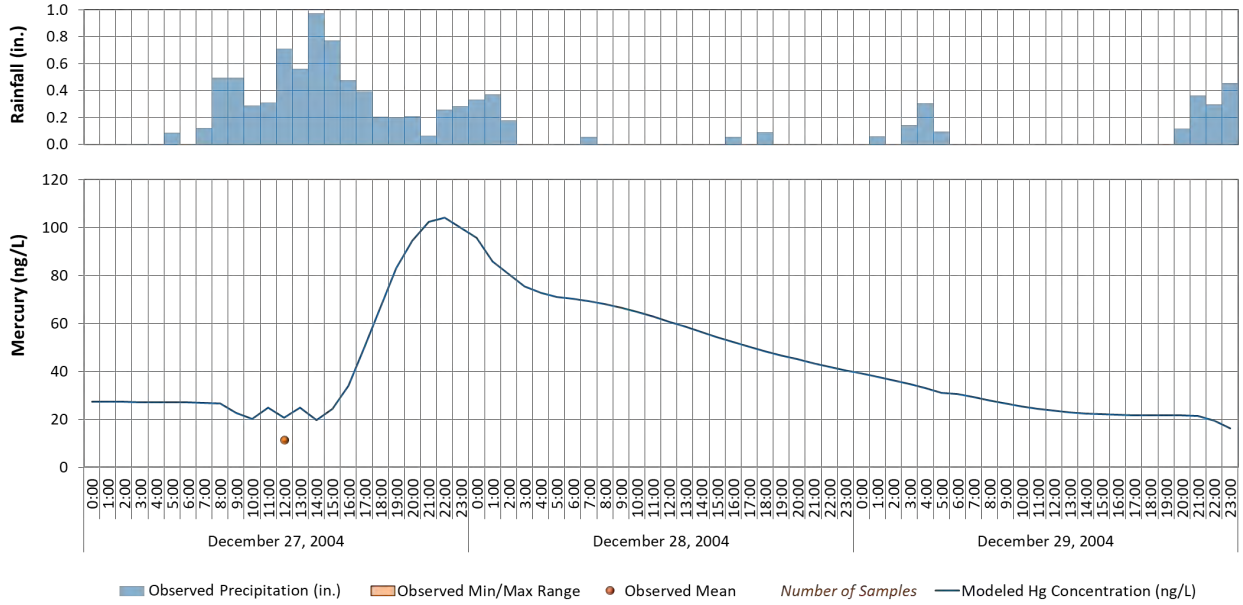


Figure 9-2. Modeled vs. observed mercury for a selected storm at Coyote Creek Gage (12/27/2014 - 12/29/2014).

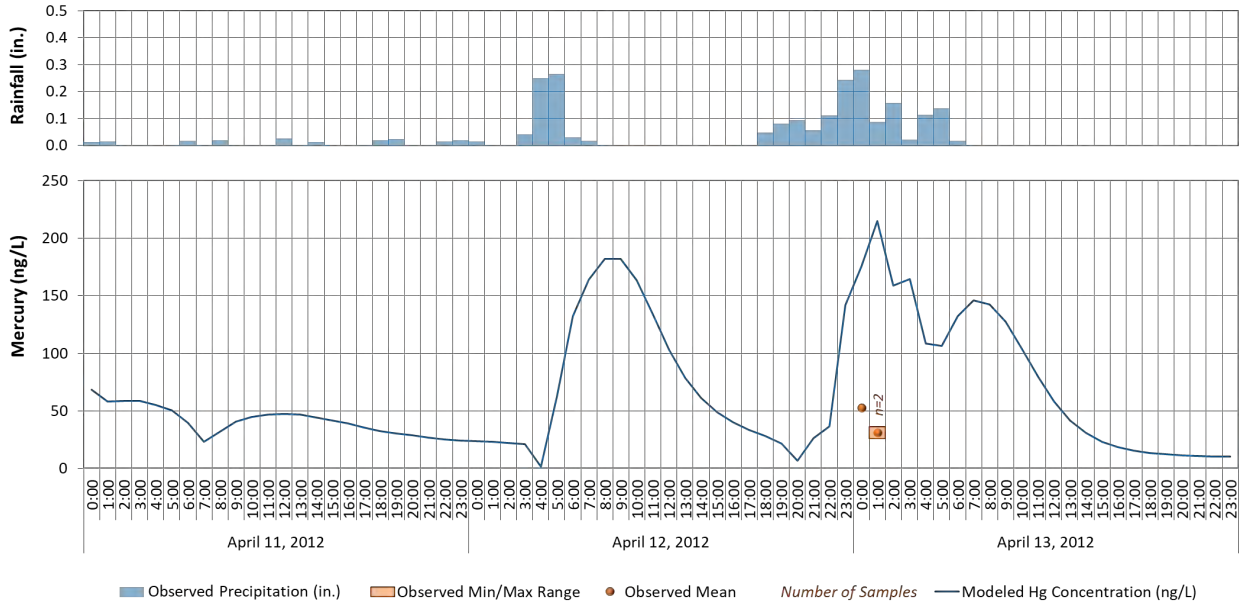


Figure 9-3. Modeled vs. observed mercury for a selected storm at Sunnyvale East Channel (4/12/2012 - 4/14/2012).

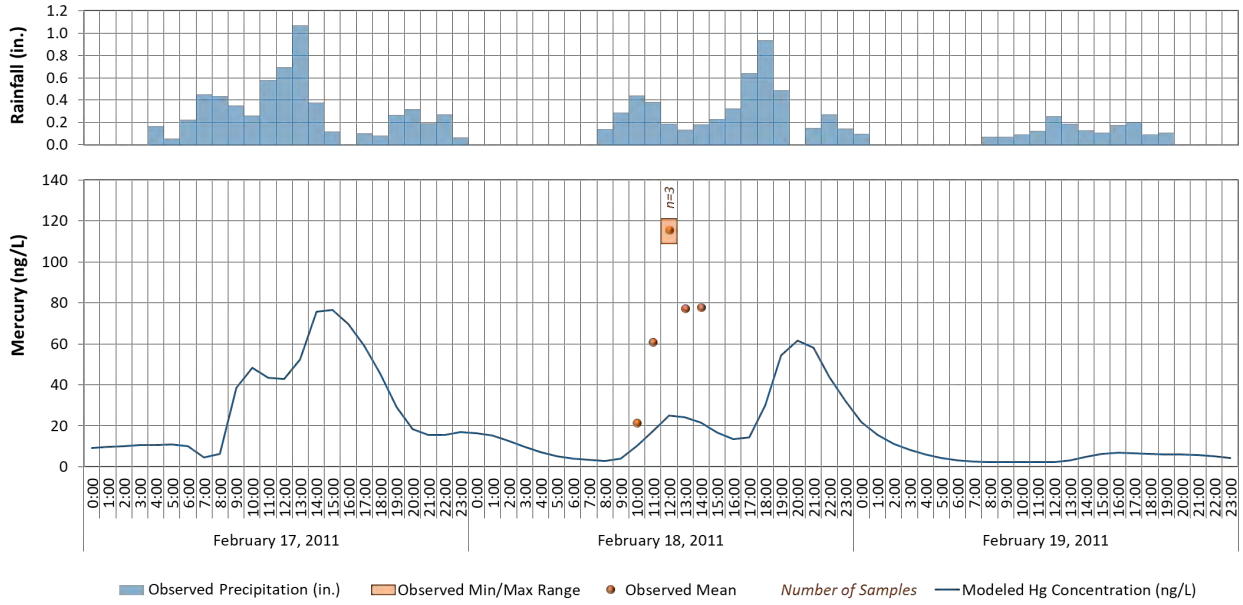


Figure 9-4. Modeled vs. observed mercury for a selected storm at Stevens Creek Gage (2/17/2011 - 2/19/2011).

Figure 9-5 shows the range of concentrations associated with the top 1 percent of flows that were queried and compared against the full set of mercury samples respectively, at each station. A limited number of observed sample (n values shown) were plotted against ALL modeled concentrations that met the 1 percent flow threshold; therefore, the median values of modeled are expected to be lower than the median value of the limited number of samples. With the exception of Guadalupe River, for which mining-related loadings were not modeled, the summary plots suggest that the relative

variability of concentrations predicted by the model between stations generally follows the pattern of observed.

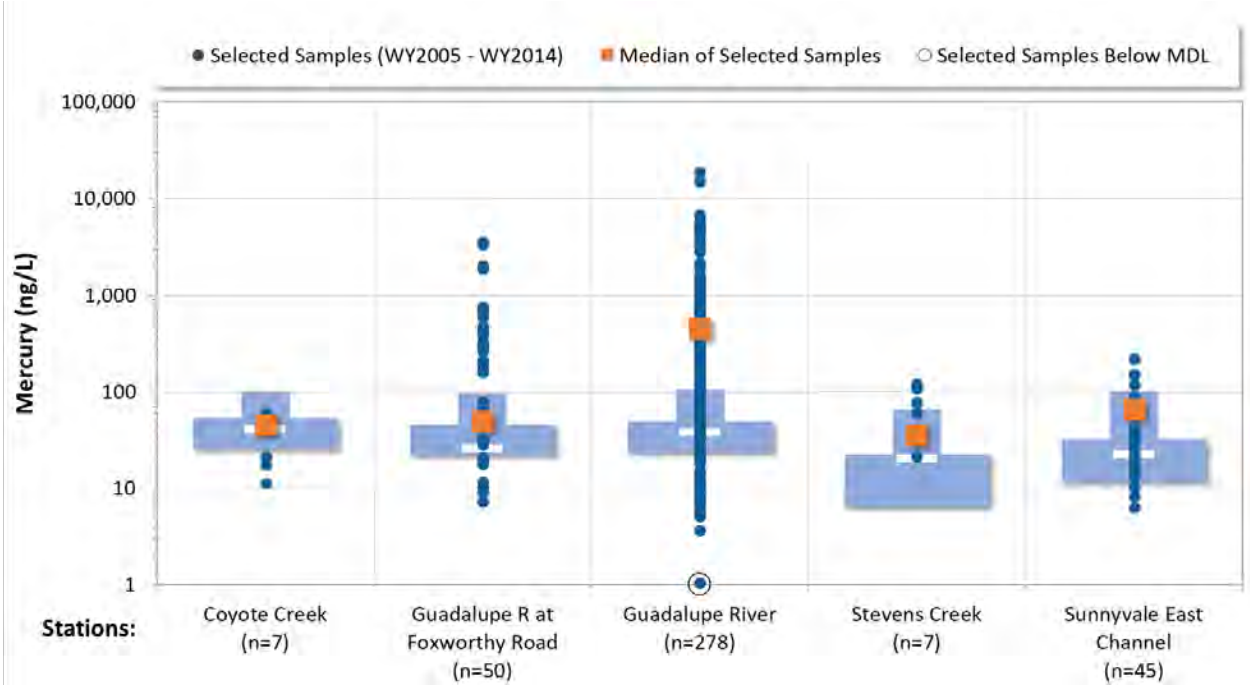


Figure 9-5. Summary of modeled concentrations (for the top 1% of modeled flows) vs. observed mercury storm sample concentration at SLTS stations.

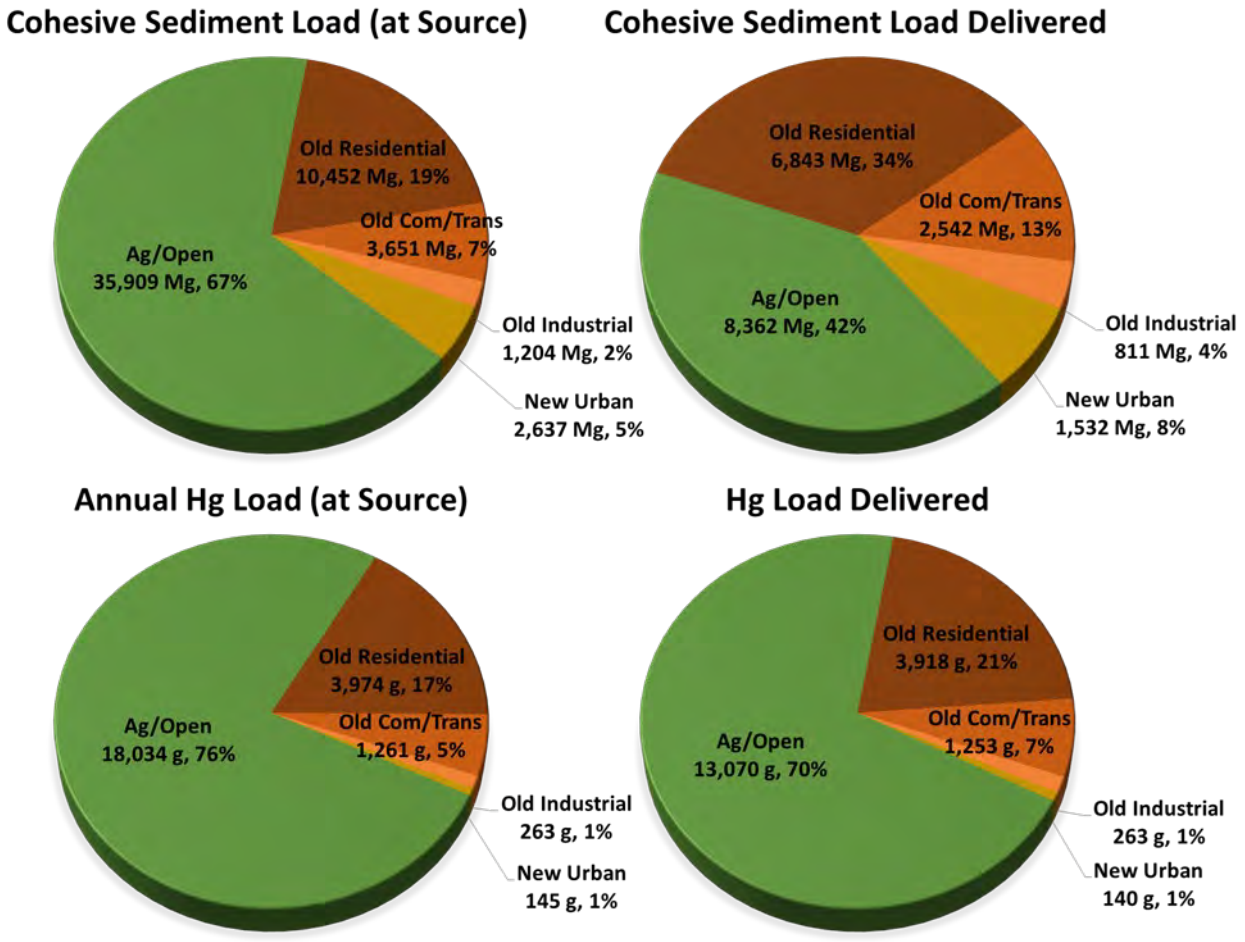


Figure 9-6. Mercury source area land use distribution and modeled mercury load estimates for an average water year (2002) –"Source" is edge-of-field load; "Delivered" is adjusted for instream transport losses.

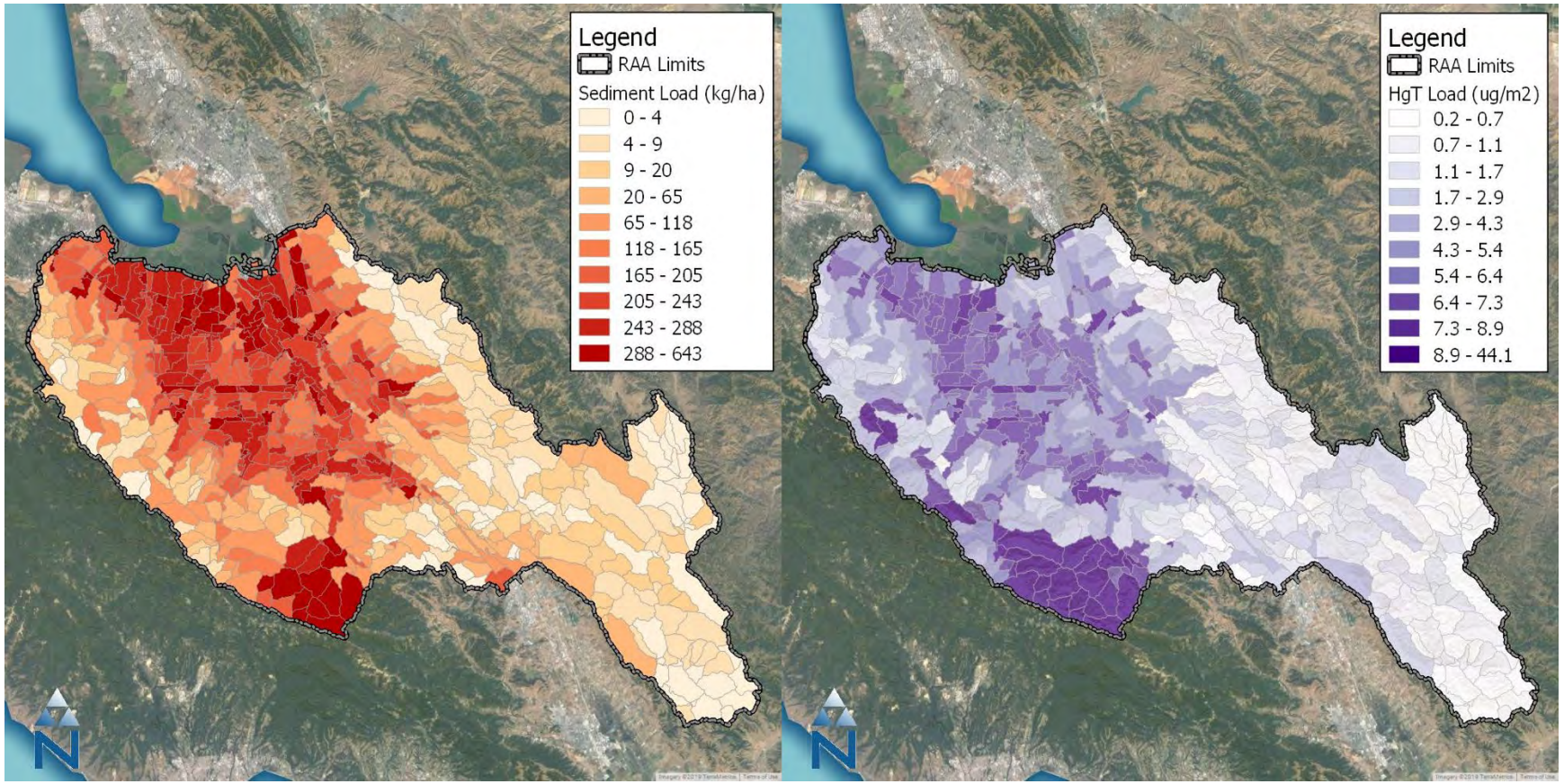


Figure 9-7. Modeled sediment and mercury unit-area loads (at source) by subwatershed in SCVURPPP.

10 IDENTIFICATION OF AREA FOR ANALYSIS

As recommended in the EPA RAA Guide and Bay Area RAA Guidance, the RAA provides an accounting of sources of stormwater from areas addressed by Municipal Separate Storm Sewer System (MS4) permits, areas addressed by other National Pollutant Discharge Elimination System (NPDES) permits, and other non-permitted areas (e.g., open space) (BASMAA 2017, USEPA 2017). This allows for estimation of stormwater improvement goals specific to areas addressed by MS4 permits, and identification of management actions (e.g., GSI) that are designed to manage stormwater runoff from these areas. The Bay Area RAA Guidance states that "if areas not subject to municipal jurisdiction are included, their flows and loads should be distinguishable" (BASMAA 2017). Therefore, the RAA area of analysis includes MS4 permitted areas, other NPDES permitted areas, and non-urban areas with stormwater volumes estimated for each category. However, the stormwater improvement goal for GSI was identified for only those areas addressed by the MRP. The following subsections describe the processes for separating and allowing modeling of distinguishable flows from MRP area, other areas addressed by NPDES permits (e.g., Caltrans, industrial areas) and non-urban open space/agriculture.

10.1 Non-Urban Open Space

The PCB and mercury TMDLs present WLAs specific to urban stormwater runoff. Consequently, non-urban open space within the Santa Clara Basin was categorized as non-MS4 and separated into distinguishable modeled areas for the RAA. These areas were identified by separating all the land designated as *Ag/Open* in the ABAG land use layer from the other categories.

10.2 Public Schools

K-12 public schools are generally not subject to the NPDES requirements, including requirements for new development and redevelopment. However, the State Water Resources Control Board recently released *Guidance on Stormwater and Dry Weather Runoff Capture (California Practices to Use Runoff Effectively) at Schools*, which encourages public schools to collaborate with Permittees on joint use projects that can capture stormwater runoff (SWRCB 2018). To facilitate discussions on potential collaborative efforts between schools and Permittees, public school parcels were separated from the MS4 permitted area to distinguish load contributions from these areas.

10.3 Caltrans

Caltrans operates with a statewide stormwater NPDES permit that regulates the discharge of stormwater associated with the operation and management of the State's highway system. Since the State's highways are permitted separately, these areas are classified as non-MS4. Caltrans properties were provided directly to SCVURPPP via GIS.

10.4 Industrial Stormwater Permits

Land areas with either individual NPDES permits or covered under the Industrial General Permit (IGP) are regulated under a program separate from MS4 permits and must meet requirements outlined in their respective permits for managing stormwater at the parcel or site level. SCVURPPP identified land areas regulated by individual industrial NPDES permits by querying the USEPA Environmental Compliance History Online (ECHO) database and areas addressed by the IGP by querying the Stormwater Multiple Application and Reporting System (SMARTS) database. These industrial parcel

areas were separated from the MS4 area within the model to distinguish MS4 load contributions from those covered by the industrial permits. While these parcels encompass a relatively small area compared to the size of the Santa Clara Basin, some of these facilities are located within areas of higher pollutant loading.

10.5 Phase II Small MS4 Permits

Phase II Small MS4 permit which are considered as a non-traditional permit regulated separately form industrial permits and the MRP. Within the SCVURPPP RAA boundary, Phase II Small MS4 permits were identified by querying the USEPA ECHO database. San José State University operates under a Phase II Small MS4 permit totaling approximately 131 acres within the City of San José. This is the only Phase II Small MS4 permit which was identified within the SCRURPPP RAA limits. Figure 10-1 shows MS4-permitted areas, other NPDES-permitted areas, and non-urban areas.

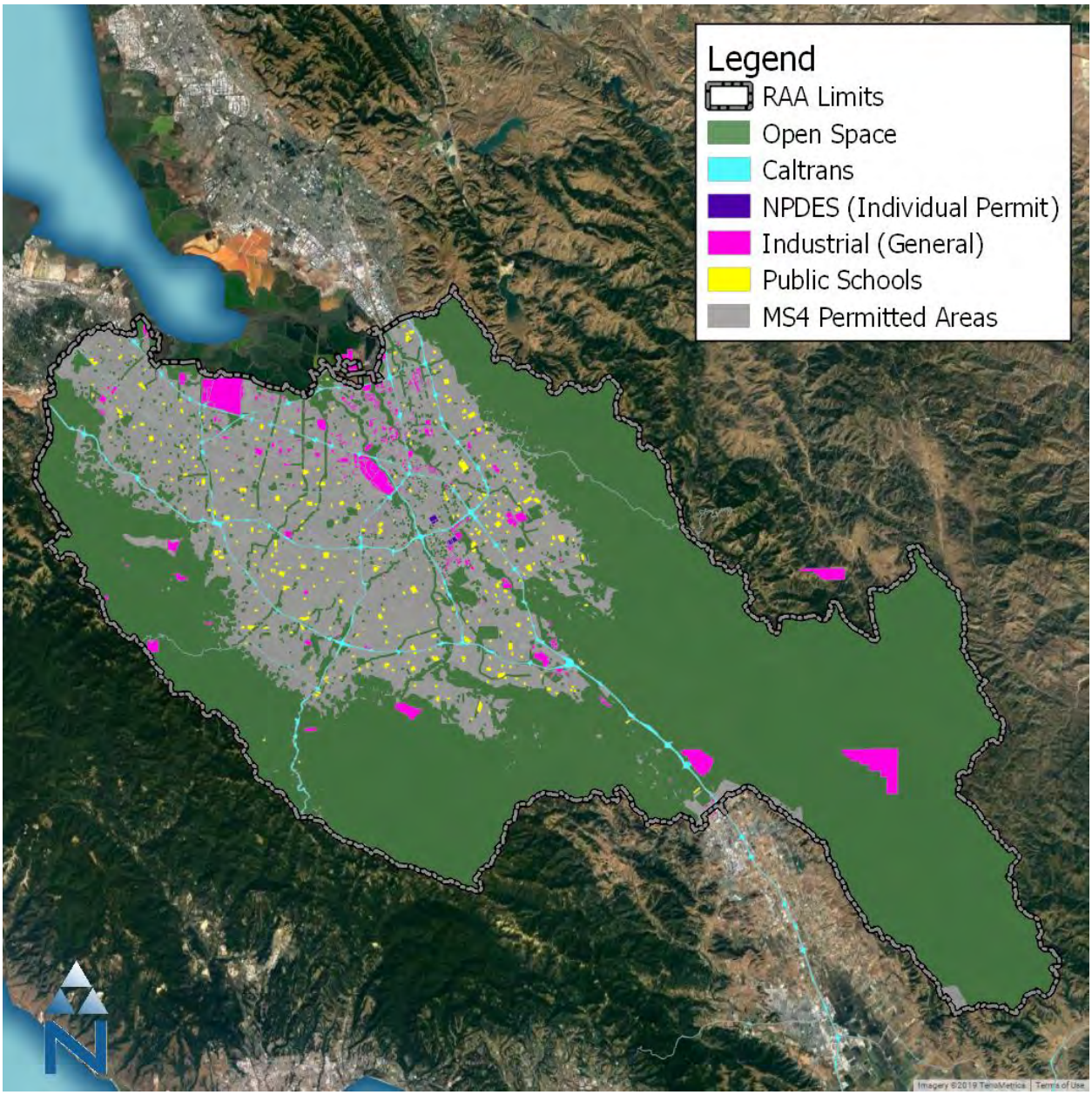


Figure 10-1. MS4 permitted areas, other NPDES permitted areas, and non-urban areas considered in the area of analysis.

11 IDENTIFICATION OF BASELINE POLLUTANT LOADS AND STORMWATER IMPROVEMENT GOALS

To provide direct comparison to WLAs assigned to municipal stormwater discharges to the Bay, the pollutant loadings associated with land areas identified in Section 10 were separated from loads associated with land areas regulated by the MRP. Table 11-1 summarizes the MRP and non-MS4 land areas and their pollutant loads. The MS4 Permit pollutant loads in Table 11-1 can be directly compared to respective TMDL WLAs for determination of necessary Stormwater Improvement Goals.

Table 11-1. Summary of total area and pollutant loading by watershed and type of area

Permitted and Other Areas		Area (acres)	PCB (kg/year)	Mercury (kg/year)
MRP		141,360	2.2	5.6
Other NPDES Permitted Areas and Non-Urban Areas	*Open Space*	283,034	0.03	13.01
	Public Schools	4,567	0.12	0.21
	Caltrans	5,741	0.15	0.26
	Individual Industrial NPDES Permit	627	0.05	0.03
	Industrial General Permit (IGP)	5,020	0.42	0.18
	Phase 2 Small MS4	131	0.004	0.006

Table 11-2 and Table 11-3 provide a summary of the calculation of Stormwater Improvement Goals, or pollutant load reductions, to meet WLAs for PCBs and mercury, respectively. The tables summarize values reported in the TMDLs for existing pollutant and sediment loads for all stormwater loads to the Bay (Rows 1 and 2, Column 1); sediment targets (Row 3); WLAs and pollutant reductions assigned to all municipal stormwater discharges to the Bay (Rows 4 and 5, Column 1); the SCVURPPP portion of the WLAs (green box); and the existing pollutant and sediment loads and load reductions estimated by the RAA model for MRP areas designated in Table 11-1 (Column 2). For PCBs, a 77.2 percent reduction in annual loads is estimated for municipal discharges within SCVURPPP to meet the SCVURPPP portion of the TMDL wasteload allocation. For mercury, the baseline annual load is estimated to be less than the SCVURPPP portion of the wasteload allocation, requiring no load reduction. The model is not determined to be under-predicting mercury load, as can be demonstrated by the validation of modeled mercury concentrations presented in Section 9 and sediment loads (basis for mercury load predictions) presented in Section 7.

Table 11-2. Calculation of Stormwater Improvement Goals to Address PCBs TMDL

TMDL Component		PCB Loads	
		1	2
		Bay-wide	Santa Clara Basin
1	Existing PCB Load (kg/year)	20[2]	2.2[1]
2	Existing Sediment Load (t/year)	2,000,000[2]	17,943[1]
3	Target Sediment Concentration (µg/kg)	1[2]	n/a
4	Wasteload Allocation for PCBs in Municipal Stormwater Discharges (kg/year)	2[2]	0.5[2]
5	Load Reduction for Municipal Stormwater Discharges (kg/year)	18[3]	1.7[4]
6	Percent Reduction	90[2]%	77.2%

1 Based on the RAA model
2 Reference: SFBRWQCB 2008b
3 Calculated by subtracting the Municipal WLA from the Bay-wide Existing PCB Load.
4 Orange is calculated based on the difference between the RAA modeled Existing PCB Load (blue = 2.2 kg/yr) and the Wasteload Allocation (green = 0.5 kg/yr)

Table 11-3. Calculation of Stormwater Improvement Goals to Address Mercury TMDL

TMDL Component		Mercury Loads	
		1	2
		Bay-wide	Santa Clara Basin
1	Existing Mercury Load (kg/year)	160[2]	5.6[1]
2	Existing Sediment Load (t/year)	410,000[2]	17,943[1]
3	Target Sediment Concentration (mg/kg)	0.2[2]	n/a
4	Wasteload Allocation for Municipal Stormwater Discharges(kg/year)	82[2]	23[2]
5	Load Reduction for Municipal Stormwater Discharges (kg/year)	78[3]	0[4]
6	Percent Reduction	48.8[2]%	0%

1 Based on RAA the model
2 Reference: SFBRWQCB 2006
3 Calculated by subtracting the Municipal WLA from the Bay-wide Existing Mercury Load.
4 Orange is calculated based on the difference between the RAA modeled Existing Mercury Load (blue = 5.6 kg/yr) and the Wasteload Allocation (green = 23 kg/yr)

The baseline load estimates in the TMDLs indicate load reductions of 62 kg/yr (mercury) and 14.4 kg/yr (PCBs) are needed to achieve water quality goals. The MRP designates Permittees must quantitatively demonstrate at least 10 kg/yr (mercury) and 3 kg/yr (PCBs) load reductions will be

achieved through the implementation of GSI by 2040. Through the development of the Bay Area RAA Guidance, it was agreed that if a new baseline model is developed that results in a revised calculation of the load reduction required to meet WLAs, the percent of the Permittee load reduction can be used as the Stormwater Improvement Goal to guide GSI planning. Table 11-4 provides a summary of the MRP required PCB and mercury load reductions and the interpretation of percent of permittee load reductions reported by the Bay Area RAA Guidance.

Table 11-4. MRP Required Pollutant Load Reductions Achieved through GSI Bay-wide

Pollutant	MRP Required Load Reduction (kg/yr)	Percent of Permittee Load Reduction
PCBs	3.0[1]	20.8[2]%
Mercury	10.0[1]	16.1[2]%

1 Reference: SFBRWQCB 2015
2 Reference: BASMAA 2017

Based on the total load reductions calculated for PCBs and mercury (Table 11-2 and Table 11-3, respectively), and the percentage of these load reductions to be achieved through GSI (Table 11-4), new totals for PCB and mercury load reductions can be calculated as goals for GSI. Summarized in Table 11-5 and Table 11-6, these load reductions serve as goals for GSI plans to be achieved by 2040.

Table 11-5. Calculation of Santa Clara County PCBs Load Reduction by 2040 Through Green Stormwater Infrastructure

Achieved Through GSI Implementation by 2040	Santa Clara County (Based on RAA Model)
PCBs Load Reduction (kg/yr)	0.35[1]
Percent Reduction	15.9[2]%

1: Bay Area RAA Guidance reports that 20.8% of the permittee load reduction from the MRP is to be addressed with GSI. The 0.35 kg/yr load is calculated as 20.8% of the 1.7 kg/yr PCB Load Reduction for the Santa Clara Basin based on the RAA model (Table 11-2).
2: Calculated based on the required Load Reduction reported above (0.35 kg/yr) and Existing PCB Load (2.2 kg/yr, Table 6-2).

Table 11-6. Calculation of Mercury Load Reduction by 2040 Through Green Stormwater Infrastructure

Achieved Through GSI Implementation by 2020	Santa Clara County (Based on RAA Model)
Mercury Load Reduction (kg/yr)	0[1]
Percent Reduction	0[2]%

1: Bay Area RAA Guidance reports that 16.1% of the permittee load reduction from the MRP is to be addressed with GSI. The 0 kg/yr load is calculated based on 16.1% of the Mercury Load Reduction in Table 11-3.
2: Calculated based on difference of the Municipal WLA reported above (23 kg/yr, Table 6-3) and Existing Mercury Load (5.6 kg/yr, Table 6-3). Because the existing load is less than the WLA, no reduction is required.

12 SUMMARY AND NEXT STEPS

Based on criteria established by the Bay Area RAA Guidance, the baseline hydrology and pollutant loading model is considered calibrated and validated and sufficient for estimation of existing loads of mercury and PCBs, comparison to TMDL WLAs, and determination of necessary load reductions to support the planning of GSI implementation. Based on requirements of the MRP and results of the baseline model, Table 11-5and Table 11-6 provide a summary of the PCB and mercury load reduction goals, respectively, to be attained by 2040 through the implementation of GSI.

The next Phase II of the RAA will provide modeling and cost-optimization of GSI projects to determine the amount GSI needed over time to meet pollutant load reduction goals by 2040. SCVURPPP has started identifying opportunities for GSI projects opportunities through development of the Santa Clara Basin Stormwater Resource Plan (SWRP) (SCVURPPP 2018). The SWRP categorized GSI project opportunities in three primary types:

- Regional projects, where stormwater is managed at the neighborhood or watershed scale;
- Green streets, where stormwater is managed in the public rights-of-way at the block scale; and
- Parcel-based or Low Impact Development (LID), where stormwater is managed at parcel level.

For the RAA, these primary GSI project types comprise the following implementation categories:

1. **Existing Projects**: Stormwater treatment and GSI projects that have been implemented since FY-2004/05. This is primarily all of the Regulated Projects that were mandated to treat runoff via Provision C.3 of the MRP, but also includes any public green street or other demonstration projects that were not subject to Provision C.3 requirements. For Regulated Projects in the early years of C.3 implementation, stormwater treatment may have been achieved through non-GSI means, such as underground vault systems or media filters. Existing projects may consist of all three primary GSI types – regional projects, green streets, and LID.
2. **Future New and Redevelopment:** This is all the regulated projects that will be subject to Provision C.3 requirements to treat runoff via GSI and is based on spatial projections of future new and redevelopment tied to regional models for population and employment growth. Future New and Redevelopment consists of parcel-based LID.
3. **Regional Projects (identified)**: The SWRP identified five projects within public parks to provide regional capture and infiltration/treatment of stormwater, and included conceptual designs to support further planning and designs. Through development of the City of San José GSI Plan, the City of San José identified three additional regional project opportunities considered for the RAA (City of San José 2019).
4. **Green Streets**: The SWRP identified and prioritized opportunities throughout the Santa Clara Basin for retrofitting existing streets with GSI in public rights-of-way. Green streets were ranked as high, medium, and low priority based on a multiple-benefit prioritization process developed for the SWRP. For the City of San José GSI Plan, the prioritization process was modified for the ranking of green street project opportunities within the City of San José (City of San José 2019).
5. **Other GSI Projects (to be determined)**: Other types of GSI projects on publicly owned parcels or public rights-of-way, representing a combination of any of the three primary GSI types – regional projects, green streets, and LID. The SWRP screened and prioritized public parcels for opportunities for onsite LID and regional projects. Additional green streets that were not identified by the SWRP may contribute to this category. These opportunities need further investigation to determine the best potential projects.

Phase II of the RAA will provide a quantitative approach to establish relationships between GSI implementation and pollutant load reduction. Model output will estimate the amount of GSI, or capacity expressed in acre-feet of treatment area, needed to achieve pollutant load reduction targets for Co-permittees, and the resultant amount of impervious area treated. During development of the SWRP, SCVURPPP and the City of San José developed a street- and parcel-level project identification and prioritization process to identify and rank potential locations suitable for implementation of GSI. This list will be used to develop assumptions for GSI project opportunities used as input to the RAA model. Figure 12-1 presents an example GSI implementation scenario showing the distribution of selected GSI categories versus incremental reductions in pollutant loading and increasing cost.

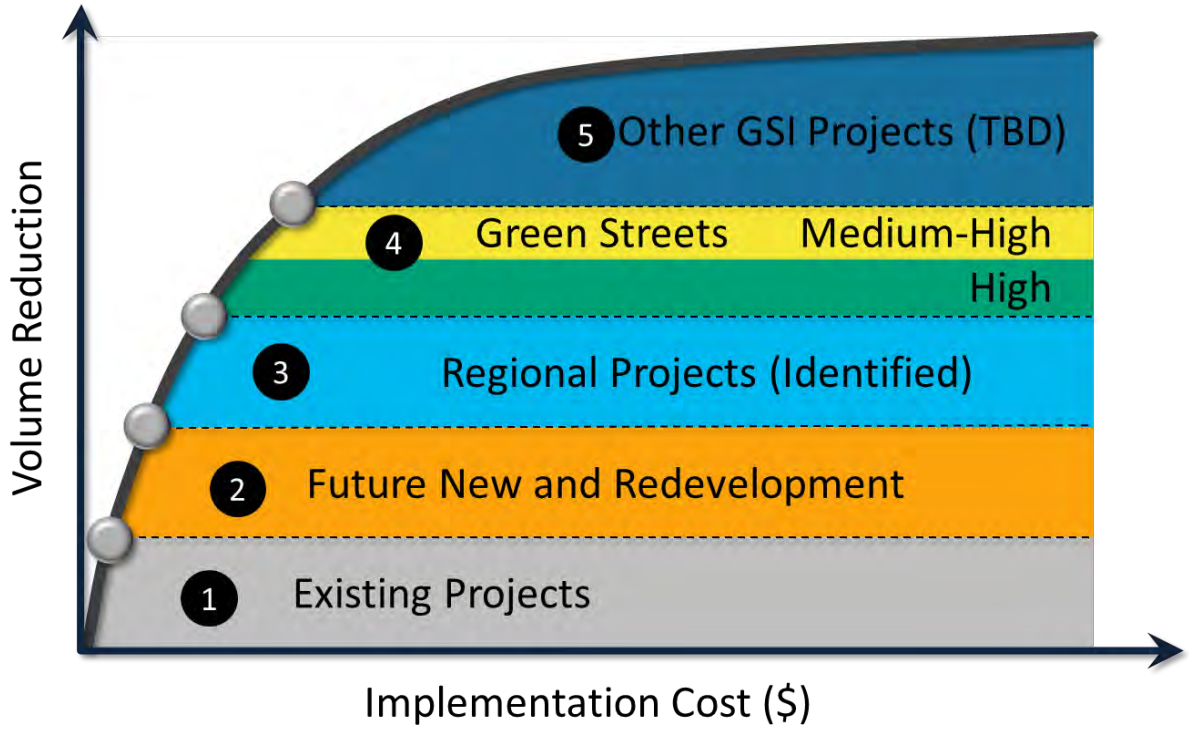


Figure 12-1. Example implementation recipe showing the general sequencing of GSI categories.

Phase II of the RAA will provide a useful tool for investigation of alternative implementation scenarios through cost-benefit optimization that can inform cost-effective GSI implementation within each Co-permittee jurisdiction. After modeling and cost-optimization has been performed for each Co-permittee, the GSI types presented in Figure 12-1 will be summarized by jurisdiction in a single implementation "recipe" capable of meeting the required pollutant load reduction. A unique GSI recipe will be developed for each jurisdiction representing the distribution of GSI categories recommended through the RAA. The results of the RAA will be presented as tables and maps for each jurisdiction and will set the goals for GSI planning efforts for each Co-permittee.

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Santa Clara Valley
Urban Runoff
Pollution Prevention Program

Watershed Monitoring and Assessment Program



Integrated Monitoring Report
Part E: Water Quality Monitoring Cost Summary

Water Years 2014-2019

Submitted in compliance with Provision C.8.h.v of NPDES Permit No. CAS612008,
Order No. R2-2015-049

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1.0 INTRODUCTION

This Integrated Monitoring Report (IMR) Part E: Monitoring Costs Summary, Water Years[1] (WYs) 2014 through 2019 was prepared by the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP or Program), on behalf of its 15 member agencies (13 cities/towns, the unincorporated County of Santa Clara, and the Santa Clara Valley Water District), which are subject to the National Pollutant Discharge Elimination System (NPDES) stormwater permit for Bay Area municipalities referred to as the Municipal Regional Permit (MRP). The MRP was first adopted by the San Francisco Bay Regional Water Quality Control Board (SFRWQCB or Regional Water Board) on October 14, 2009 as Order R2-2009-0074 (SFRWQCB 2009; referred to as MRP 1.0). On November 19, 2015, the Regional Water Board updated and reissued the MRP as Order R2-2015-0049 (SFRWQCB 2015; referred to as MRP 2.0).

This report fulfills the requirements of provision C.8.h.v(4) of MRP 2.0, which requires that the IMR include a budget summary for each monitoring requirement. As such, this report includes the costs expended by SCVURPPP member agencies, through contributions to the Program, from WY 2014 through WY 2019 to comply with provision C.8 requirements. The previous IMR submitted to the Regional Water Board in 2014 summarized costs associated with monitoring activities conducted during WY 2012 and WY 2013 in compliance with MRP 1.0 (SCVURPPP 2014).

Water quality monitoring required by provision C.8 of MRP 2.0 is intended to assess the condition of water quality in the Bay area receiving waters (creeks and the Bay); identify and prioritize stormwater-associated impacts, stressors, sources, and loads; identify appropriate management actions; and detect trends in water quality over time, including the effects of stormwater control measure implementation. The Program conducts creek water quality monitoring and monitoring projects in the Santa Clara Valley (Lower South Bay) in collaboration with the Regional Monitoring Coalition (RMC), and actively participates in the San Francisco Bay Regional Monitoring Program (RMP), which focuses on assessing Bay water quality and associated impacts. This section provides a summary of monitoring costs expended by the Program and provides qualitative estimates of the water quality benefits gained through monitoring that was conducted to comply with MRP 2.0.

2.0 WATER QUALITY MONITORING COST SUMMARY

Table 2.1 presents the Program's costs to comply with provision C.8 of MRP 2.0. Monitoring costs presented in this section are associated with those incurred in (WYs) 2014 through 2019, which correspond to the Program's FY 2013-14 through FY 2018-19 budgets.[2] Costs presented include all aspects of implementing provision C.8, including:

- Monitoring program coordination and management,
- Program/project planning,
- Sample and data collection,

[1] Most hydrologic monitoring occurs for a period defined as a Water Year, which begins on October 1 and ends on September 30 of the named year. For example, Water Year 2019 (WY 2019) began on October 1, 2018 and concluded on September 30, 2019.

[2] Costs presented do not include costs incurred by Permittees to implement other water quality monitoring activities and programs required by other NPDES permits issued to Permittees (e.g., POTW monitoring, Aquatic pesticide application monitoring, stream maintenance program monitoring, etc.)

- Laboratory analyses,
- Quality assurance/quality control (QA/QC),
- Data evaluation and analysis,
- Data interpretation and reporting, and
- Information management.

Direct financial contributions were made to the RMP by SCVURPPP on behalf of Co-permittees and NPDES permit fee surcharges paid by Co-permittees. Funds used by the State and/or Regional Water Board to fund its Surface Water Ambient Monitoring Program (SWAMP) are also included in the reported costs.

The costs listed in Table 1 illustrate the considerable (~$6.8 M) resources that SCVURPPP has expended over the course of WYs 2014-2019 towards complying with water quality monitoring requirements described in provision C.8 and addressing the SWAMP surcharge included with NPDES permit fees. Average total annual costs to SCVURPPP Co-permittees during this six-year timeframe were roughly $1.1M. These costs covered the following monitoring activities:

- San Francisco Bay Estuary Receiving Water Monitoring (RMP) - Co-permittee monetary contributions and Program and Co-permittee staff time spent actively participating in the RMP, including participation in the RMP Steering Committee, Technical Review Committee, and numerous Work Groups and Strategy Teams, in compliance with MRP 2.0 provision C.8.c.
- Creek Status Monitoring – Preparation, coordination, management and implementation of the Program's Creek Status Monitoring Program, which is implemented in compliance with MRP 2.0 provision C.8.d.
- Stressor/Source Identification (SSID) Projects - Preparation, coordination, management and implementation of SSID projects that were implemented in compliance with MRP 2.0 provision C.8.e.
- Pollutants of Concern Monitoring - Preparation, coordination, management and implementation of the SCVURPPP Pollutants of Concern (POC) Monitoring Program that was implemented in compliance with MRP 2.0 provision C.8.f. Please note that the costs included in the category do not include those associated with POC source property investigations that are conducted to comply with provisions C.11/12, not necessarily provision C.8.
- Pesticides and Toxicity Monitoring - Preparation, coordination, management and implementation of the SCVURPPP Pesticides and Toxicity Monitoring Program that was implemented in compliance with MRP 2.0 provision C.8.g.
- Data Management & QA/QC – Coordination and implementation of the SCVURPPP Water Quality Monitoring Data Management and Quality Assurance Program, which implements all aspects of data management and quality assurance procedures required by MRP 2.0 provision C.8.b, and consistent with approved Standard Operating Procedures (SOPs) and Quality Assurance Project Plans (QAPPs).
- Reporting – Analysis, interpretation and reporting of all data collected via the Program's Creek Status Monitoring, SSID projects, POC Monitoring, and Pesticides and Toxicity Monitoring Programs, consistent with MRP 2.0 provision C.8.h.

- NPDES Surcharge: SWAMP - Monetary contributions provided by Co-permittees to the State of California as part of the SWAMP surcharge issued to Co-permittee as part of their annual NDPES fee.

Table 2.1. Water quality monitoring cost summary for implementing MRP provision C.8 during Water Years (WYs) 2014-2019. See text on the previous page for the activities that are included in each monitoring line item.

MRP 2.0 Subprovision		Costs During WYs 2014-2019 (6 years)	Average Costs per WY	% of Costs
C.8.b	Data Management & Quality Assurance/Quality Control (QA/QC)	$414,153	$69,025	6.1%
C.8.c	San Francisco Bay Estuary Receiving Water Monitoring (RMP)	$1,346,123	$224,354	19.7%
C.8.d	Creek Status Monitoring	$2,266,644	$377,774	33.2%
C.8.e	Stressor/Source Identification (SSID) Projects	$508,581	$84,763	7.4%
C.8.f	Pollutants of Concern (POC) Monitoring	$1,522,106	$253,684	22.3%
C.8.g	Pesticides and Toxicity Monitoring	$114,793	$19,132	1.7%
C.8.h	Reporting	$342,028	$57,005	5.0%
NA	NPDES Surcharge - Surface Water Ambient Monitoring Program (SWAMP)	$317,532	$52,922	4.6%
Totals		**$6,831,961**	**$1,138,660**	**100%**

3.0 RELATIVE COSTS AND BENEFITS OF MRP-REQUIRED WATER QUALITY MONITORING

Monitoring activities funded by Co-permittees consistent with the C.8 provision, generate information designed to answer core management questions outlined in the MRP. In many instances, these management questions are further refined into scientific monitoring questions, which help develop and implement appropriate monitoring designs. These scientific monitoring questions are generally described in program/project-specific SCVURPPP monitoring plans.

This section provides a qualitative cost-benefit evaluation of the of the water quality monitoring data collection programs implemented by SCVURPPP to comply with MRP provision C.8. The cost-benefit evaluation was conducted based on the ability of the Program to answer core management and program/project-specific scientific monitoring questions using the data collected in compliance with MRP provision C.8. The results of the evaluation are presented in Table 3.1 and are discussed in the following section. The results of this evaluation were used to identify the recommendations for water quality monitoring that would be conducted under MRP 3.0, the next version of the MRP. The recommendations for future monitoring are described in IMR Parts A, B, C, and D, and summarized in the Executive Summary for the IMR.

Table 3.1. Qualitative cost-benefit evaluation of water quality monitoring conducted under MRP 2.0 provision C.8.

MRP 2.0 Subprovision		Relative Costs of Implementing ($ - $$$$)[3]	Relative Benefit Towards Answering Core Management Questions (★ - ★★★★)	Evaluation Summary
C.8.c	San Francisco Bay Estuary Receiving Water Monitoring (RMP)	$$$$	★★★	Contributions to the RMP provided useful information on the status and trends of water quality in the Bay and provided supplemental information to help SCVURPPP identify PCBs and mercury source areas for management actions. Attempts to focus RMP-led monitoring on high priority issues remains an on-going challenge due to competing interests and information needs. Overall, the RMP provides useful information to track water quality conditions in the Bay and helps inform broad-scale management and policy directions based on science, but at a relatively high cost.
C.8.d	Creek Status Monitoring	$$$$	★★★	Creek status monitoring continued to provide useful information on the status of water quality in urban creeks that receive stormwater discharges, and the biological condition of those creeks. Many parameters were monitored, however, the utility of the data that the MRP requires to be collected is variable between parameters. Some parameters have provided valuable, baseline data or helped identify concerns that should be addressed. Other parameters were less useful and did not directly assist stormwater managers in validating, refining, or adjusting current practices. The high relative costs and the variability in the usefulness of data collected via this provision suggest that refinements are needed to improve the cost-effectiveness of Creek Status Monitoring during MRP 3.0.
C.8.e	Stressor/Source Identification (SSID) Projects	$$	★★★	SSID studies have provided useful information needed to help identify potential water quality concerns and sources of pollutants or environmental stress in Santa Clara Valley streams. However, complex watershed/runoff processes create challenges in differentiating the specific causes of stress and sources of pollutants and stressors in streams. The relatively moderate costs and moderate/high benefits of data collected via this provision suggest that SSID projects are cost-effective endeavors, but thatmethods and expections should be refined to improve the utility of the data collected during MRP 3.0.

[3] Qualitative categories for costs are based on the relative percentage of costs associated with each monitoring component. Costs for data management/QA and reporting were not included in the evaluation because their costs are functions of the other monitoring requirements/components. Qualitative categories are as follows:$ = 1-5%, $$ = 5-10%; $$$ = 10-15%; $$$$ = >15%.

MRP 2.0 Subprovision		Relative Costs of Implementing ($ - $$$$)[3]	Relative Benefit Towards Answering Core Management Questions (★ - ★★★★)	Evaluation Summary
C.8.f	Pollutants of Concern (POC) Monitoring	$$$$	★★★	Monitoring conducted under provision C.8.f provided valuable data on potential sources of POCs in Watershed Management Areas (WMAs) and helped prioritize land areas for further source property evaluations. Additionally, the data collected under this provision helped further understand the geographical distribution of POCs in the urban portion of the Santa Clara Basin. Although there were high relative costs associated with POC monitoring, there was a high level of benefit associated with the data collected during MRP 2.0. Nutrient and copper monitoring were less useful in answering monitoring questions associated with these pollutants. Considerations of whether similar POC data collection efforts are predicted to be useful during MRP 3.0 should be taken before MRP 3.0 POC monitoring requirements are finalized. As source property identification efforts become less fruitful, it may be helpful to shift POC monitoring resources away from source characterization and towards other priority monitoring questions (e.g., trends and control measure effectiveness).
C.8.g	Pesticides and Toxicity Monitoring	$	★★	There were relatively low costs expended by the Program for Pesticides and Toxicity Monitoring during MRP 2.0. Data collected via the statewide SPoT program provides important information on pesticide and toxicity trends in stream sediments and helps supplement important data needs. Low costs and low/moderate benefits suggest that refinements are needed to improve the cost-benefits of the data collected via provision C.8.g during MRP 3.0. Currently a statewide effort to develop an Urban Pesticide Coordinated Monitoring Program is underway, and the Program is actively participating in this process. For SCVURPPP, the goal is to stabilize costs for pesticide/toxicity monitoring, while improving and enhancing coordination of data collection efforts statewide with the California Department of Pesticide Regulation (DRP) to fill important information gaps that will improve the regulation of pesticides that effect stormwater quality.
NA	NPDES Surcharge - Surface Water Ambient Monitoring Program (SWAMP)	$$	★	Provided limited usefulness to local programs and stormwater managers. Benefits are not readily apparent. Moderate costs, with limited benefits.

REFERENCES

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