

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

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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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1. INTRODUCTION

This Integrated Monitoring Report (IMR) Part D: Pollutants of Concern (POC) Monitoring Water Year¹ (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 through 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. Ammonium², 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).

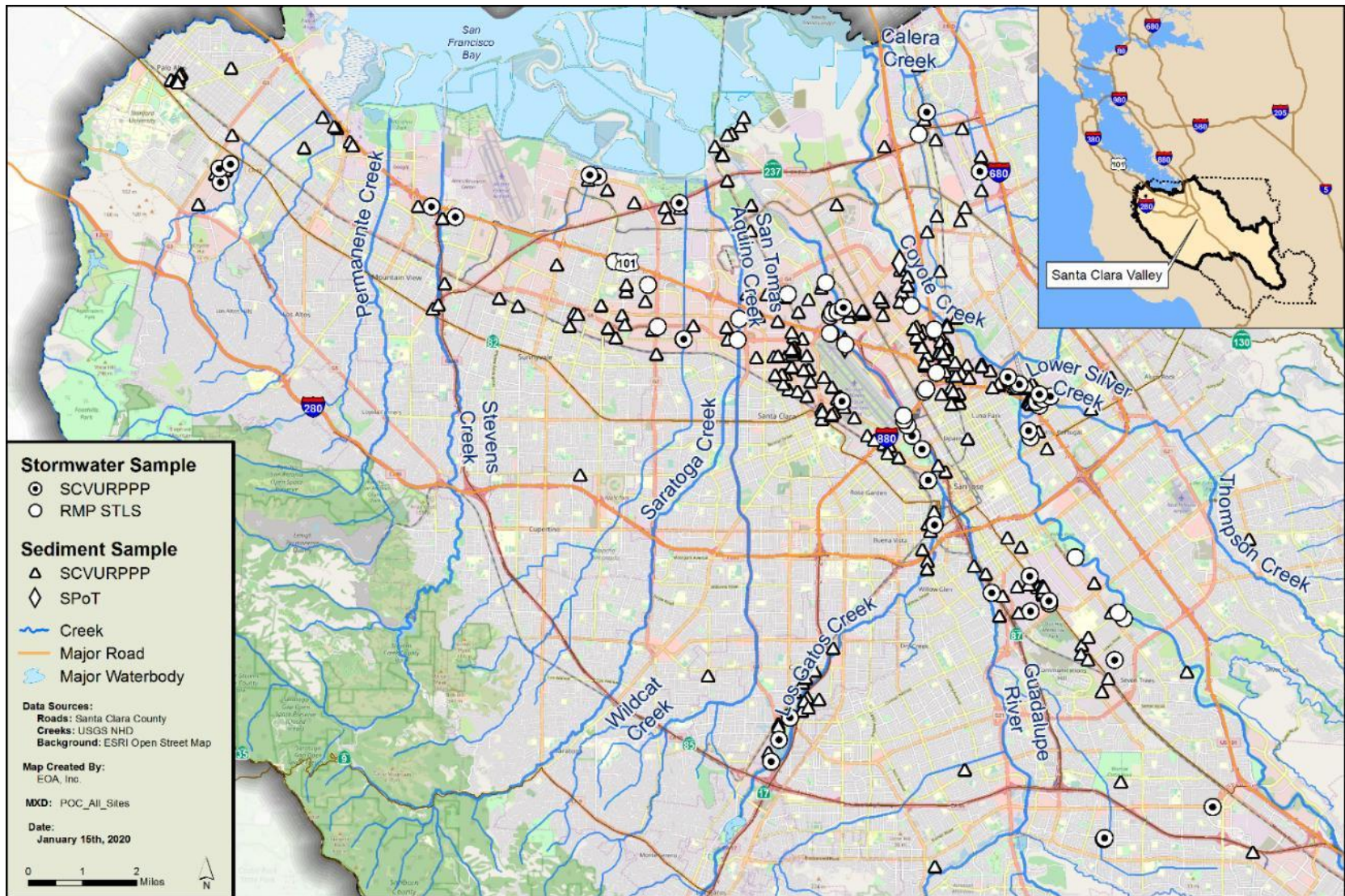


Figure 1.1. Locations of POC monitoring stations in Santa Clara County sampled between WY 2014 and WY 2019. Does not include locations of BASMAA project samples described in 3.2.3.

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.

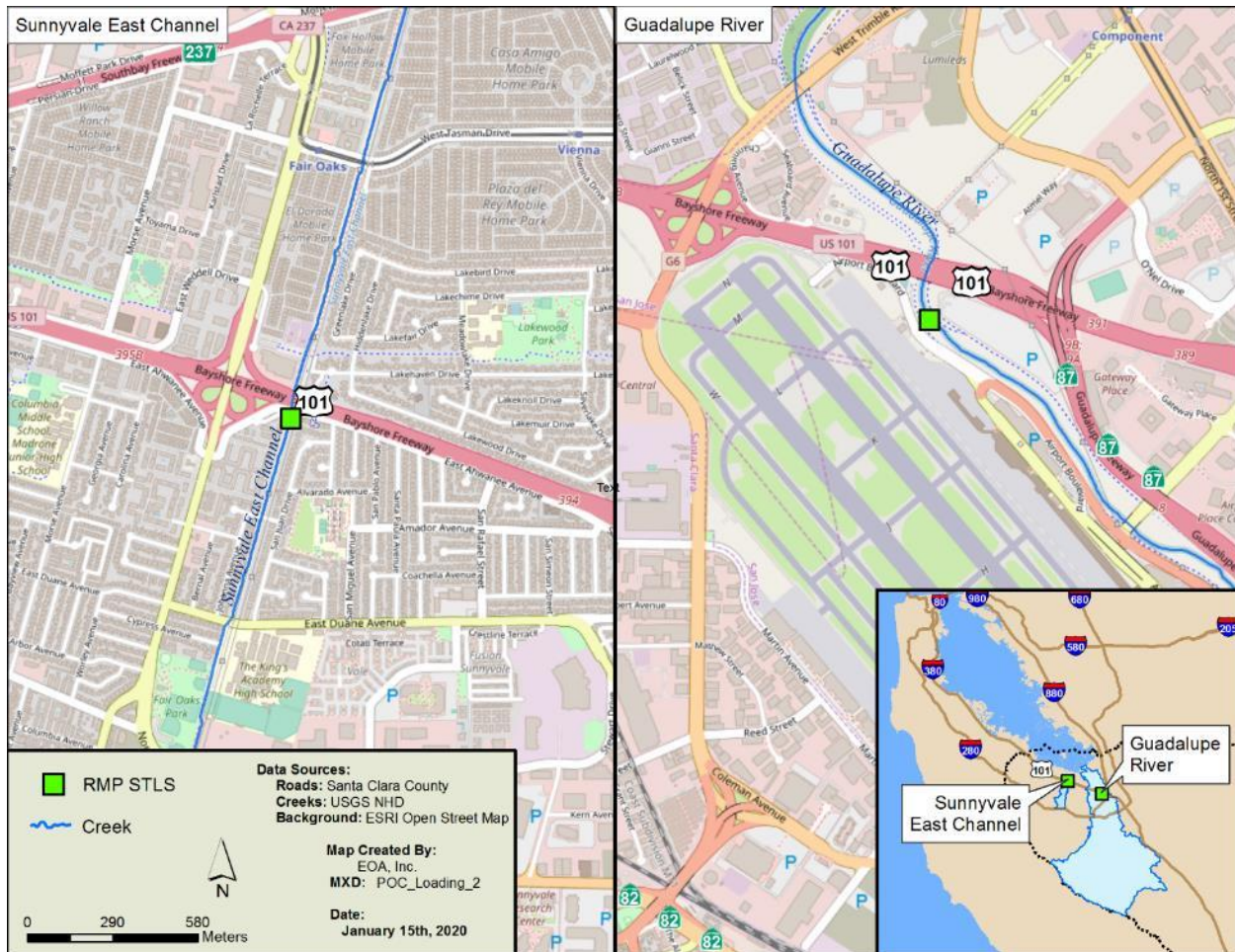


Figure 2.1. Locations of the MRP 1.0 POC loads monitoring stations in Santa Clara County, CA.

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

^b 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).

SCVURPPP IMR Part D: Pollutants of Concern Monitoring Report

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
<i>Sub-Total / MRP 2.0 Minimum^b</i>	<i>209 / 80</i>	<i>196 / 8</i>	<i>61 / 8</i>	<i>8 / 8</i>	<i>61 / 8</i>	<i>26 / 8</i>	
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).

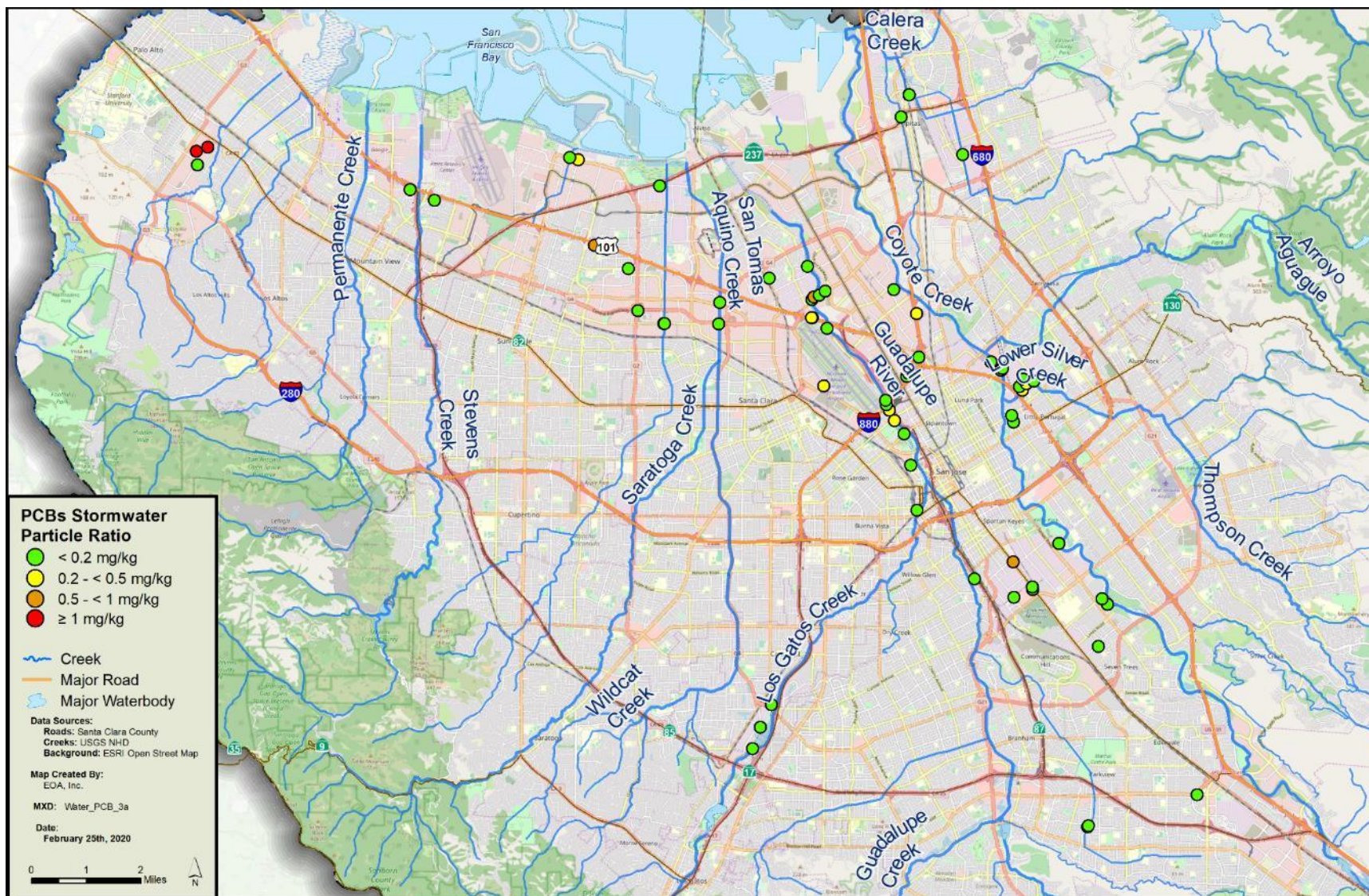


Figure 3.1. Locations and relative concentrations of PCBs measured in stormwater in the Santa Clara Basin by SCVURPPP and the RMP STLS in WY 2015 – WY 2019.

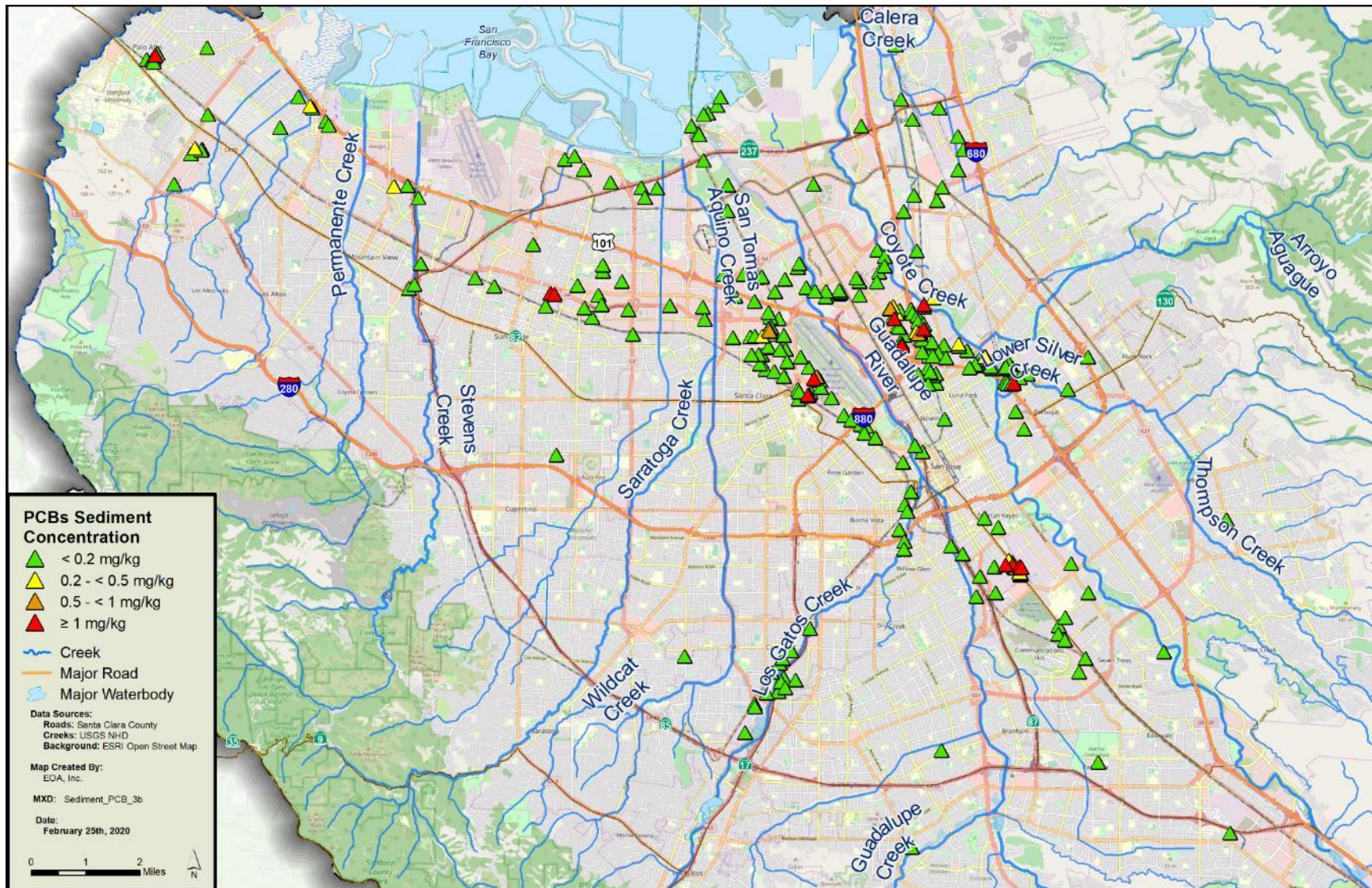


Figure 3.2. Locations and relative concentrations of PCBs measured in street dirt and storm drain sediment in the Santa Clara Basin by SCVURPPP and the RMP STLS in WY 2015 – WY 2019.

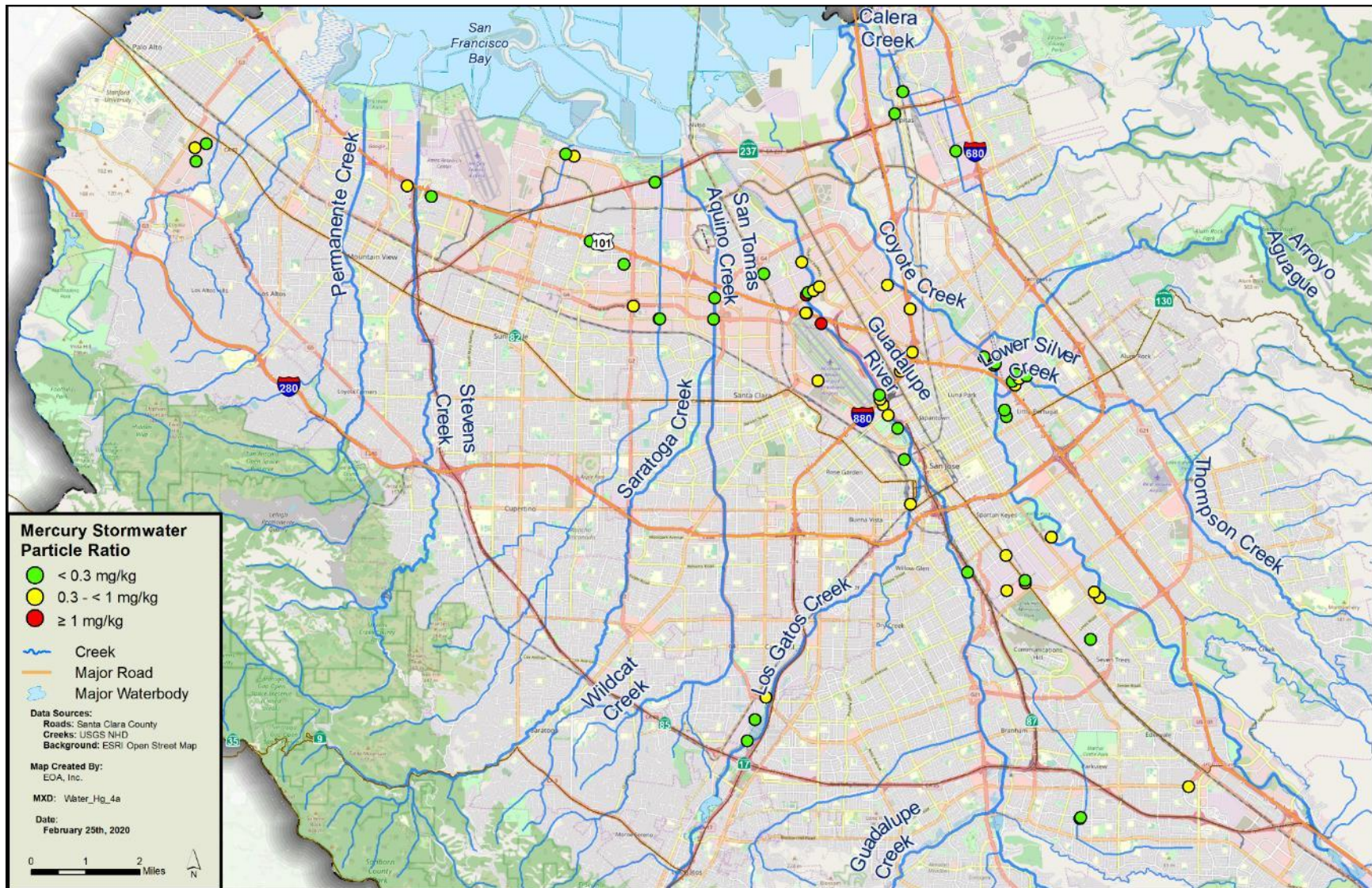


Figure 3.3. Locations and relative concentrations of mercury measured in stormwater in the Santa Clara Basin by SCVURPPP and the RMP STLS in WY 2015 – WY 2019.

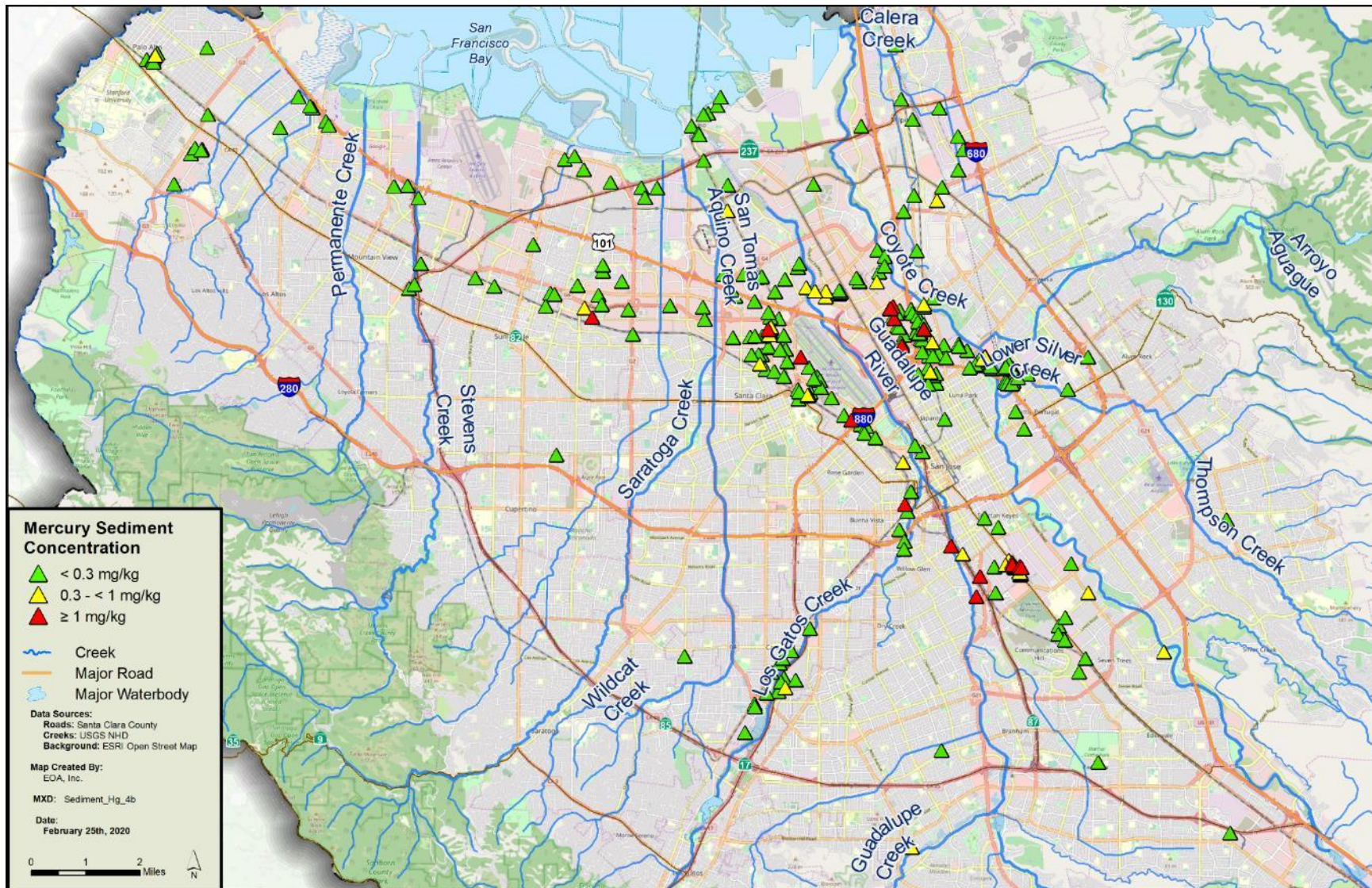


Figure 3.4. Locations and relative concentrations of mercury measured in street dirt and storm drain sediment in the Santa Clara Basin by SCVURPPP and the RMP STLS in WY 2015 – WY 2019.

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.e³. 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 2.0⁴. 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 congeners⁵ (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.

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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.

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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.

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- 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	Seaboard 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	Seaboard 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.

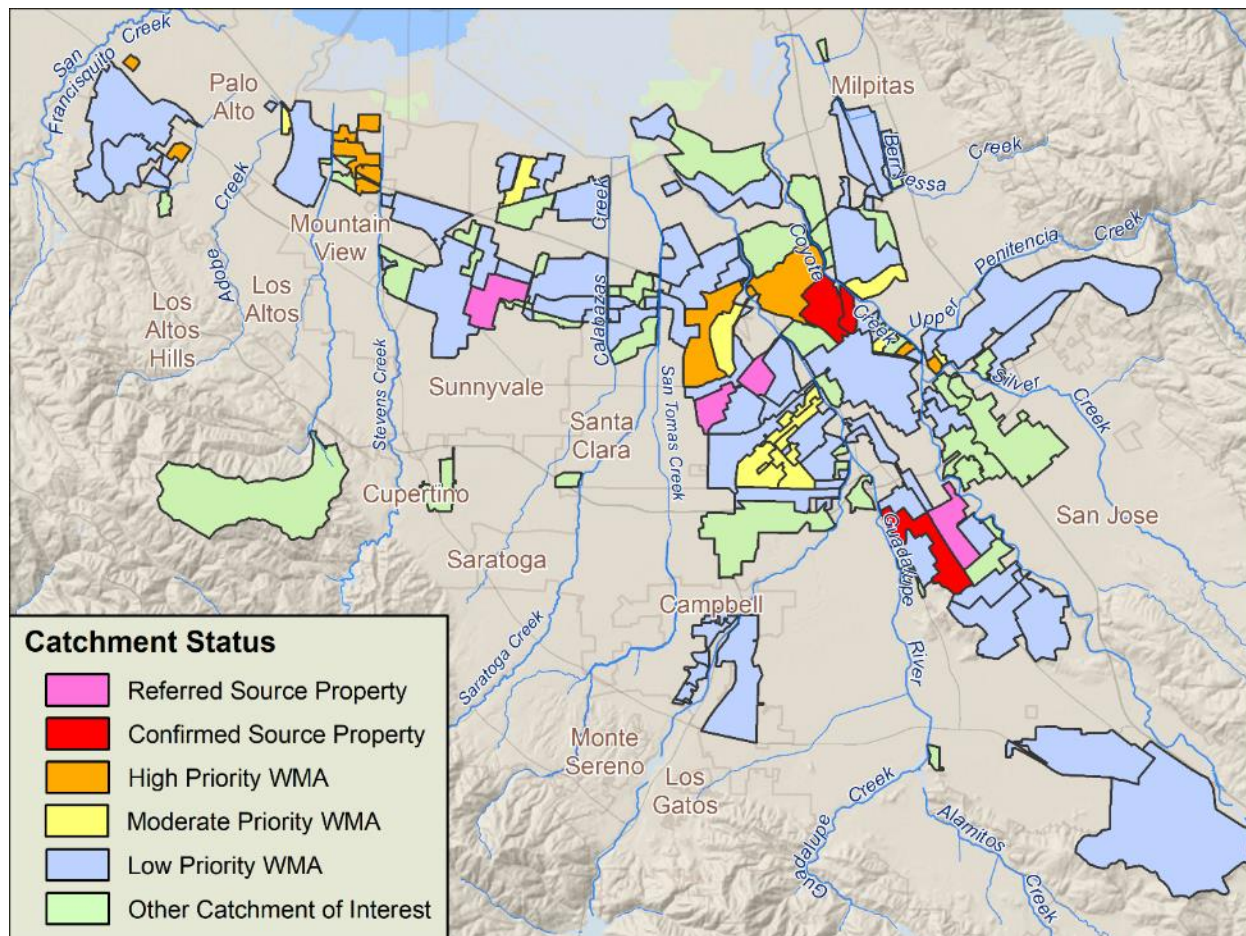


Figure 3.5. Watershed Management Area (WMA) prioritization in Santa Clara Basin, CA.

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.

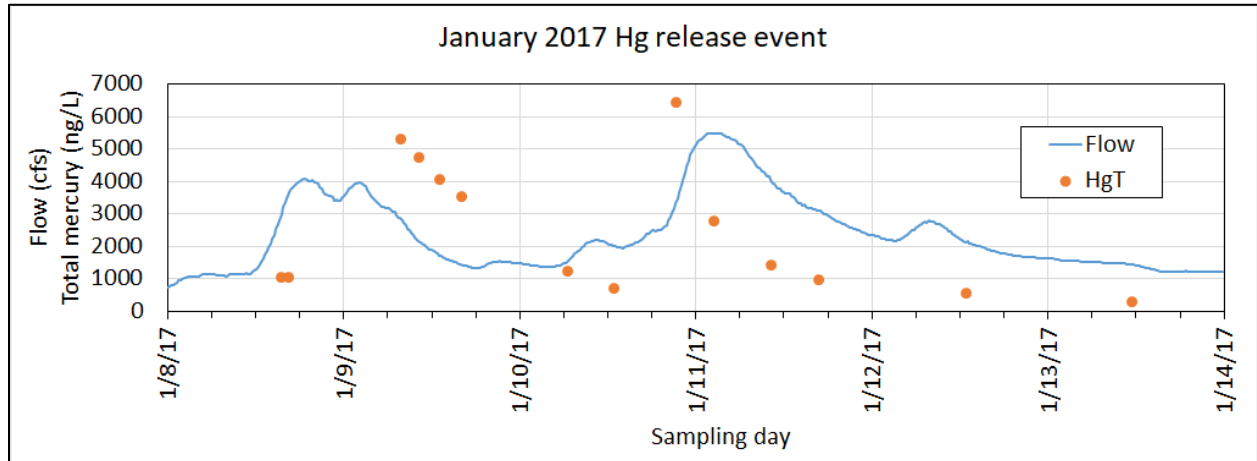


Figure 3.6. January 2017 storm hydrograph and total mercury concentrations in Guadalupe River at Highway 101 (Figure 4 from McKee et al. 2018; flow data are provisional and subject to change).

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.

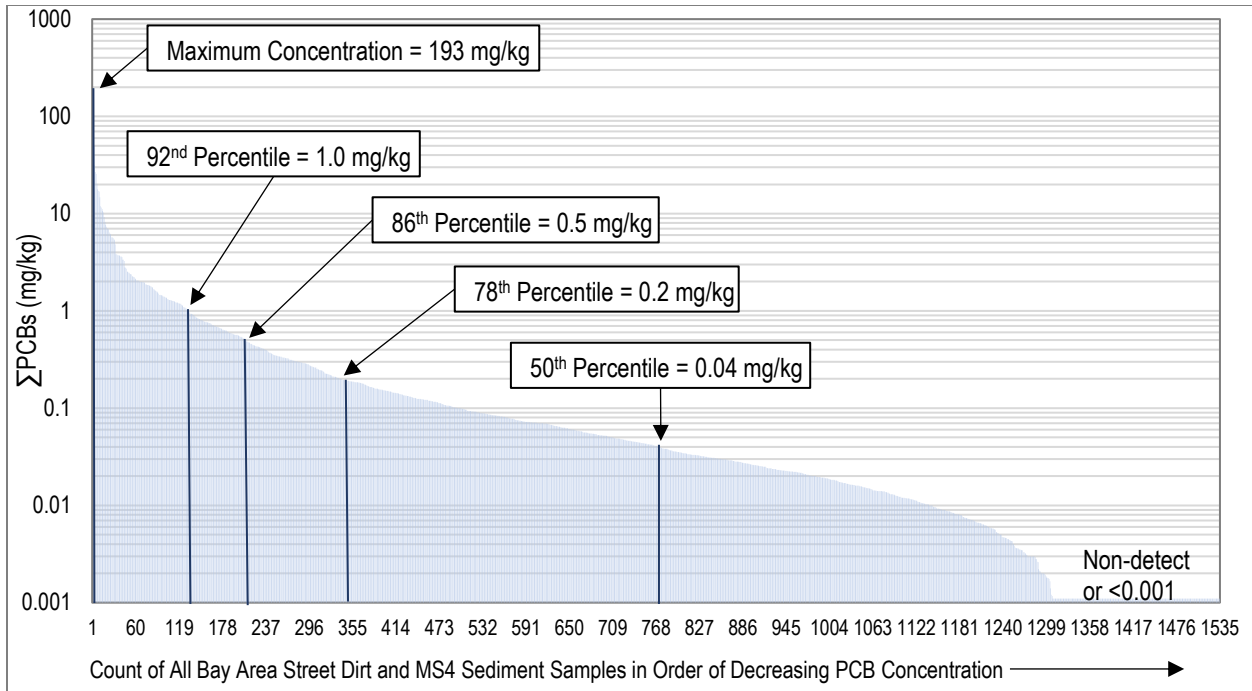


Figure 3.7. Distribution of PCBs concentrations measured in street dirt and MS4 sediment across the Bay Area.

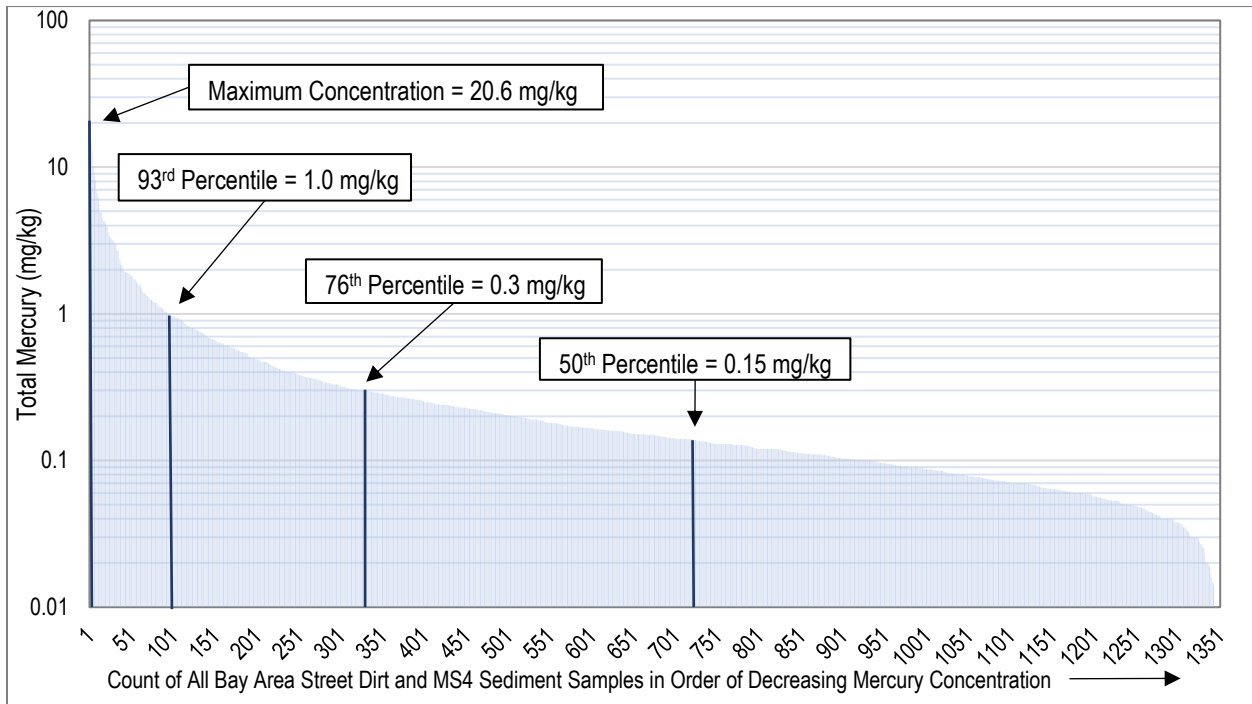


Figure 3.8. Distribution of mercury concentrations measured in street dirt and MS4 sediment across the Bay Area.

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).

Statistic	PCBs (mg/kg)			HgT (mg/kg)		
	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.

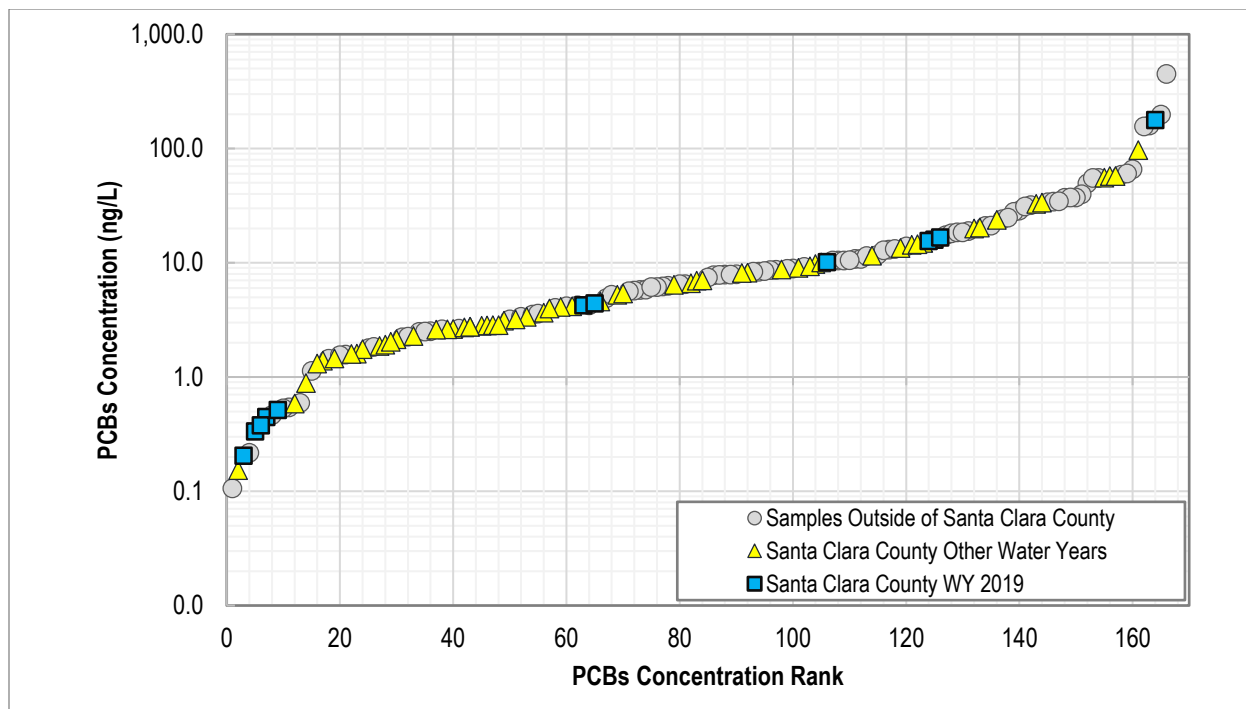


Figure 3.9. PCBs concentrations in storm water samples collected in MS4s and receiving waters draining to the Bay.

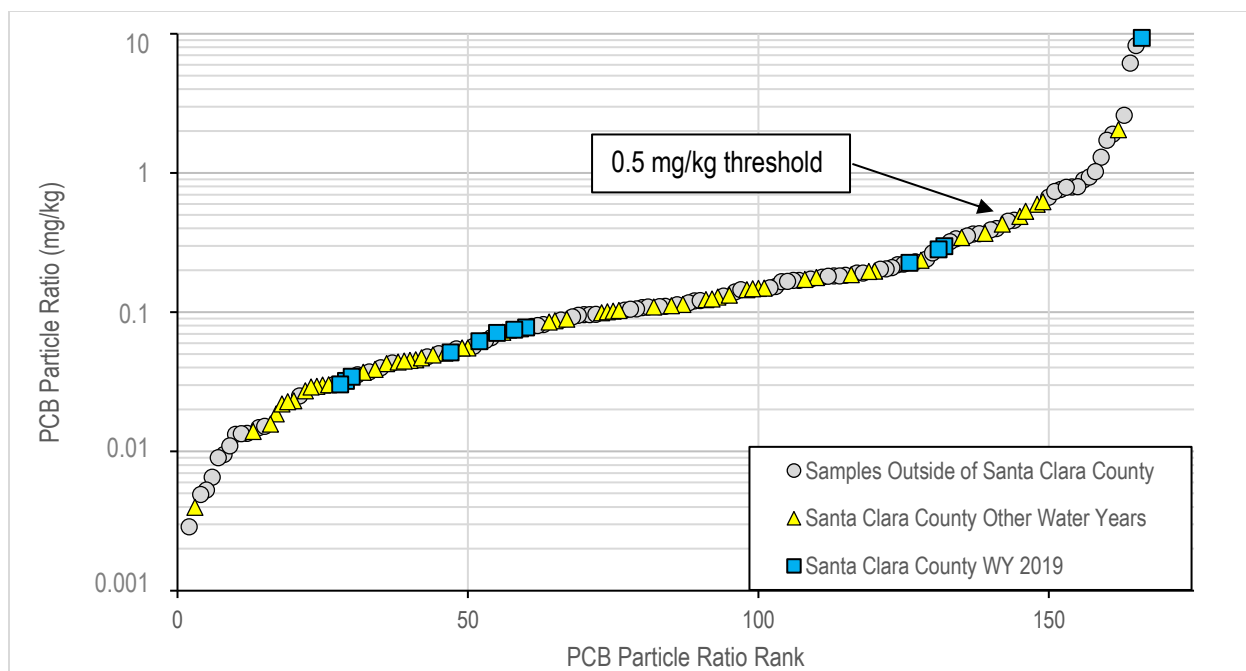


Figure 3.10. PCBs particle ratios in storm water samples collected in MS4s and receiving waters draining to the Bay.

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.

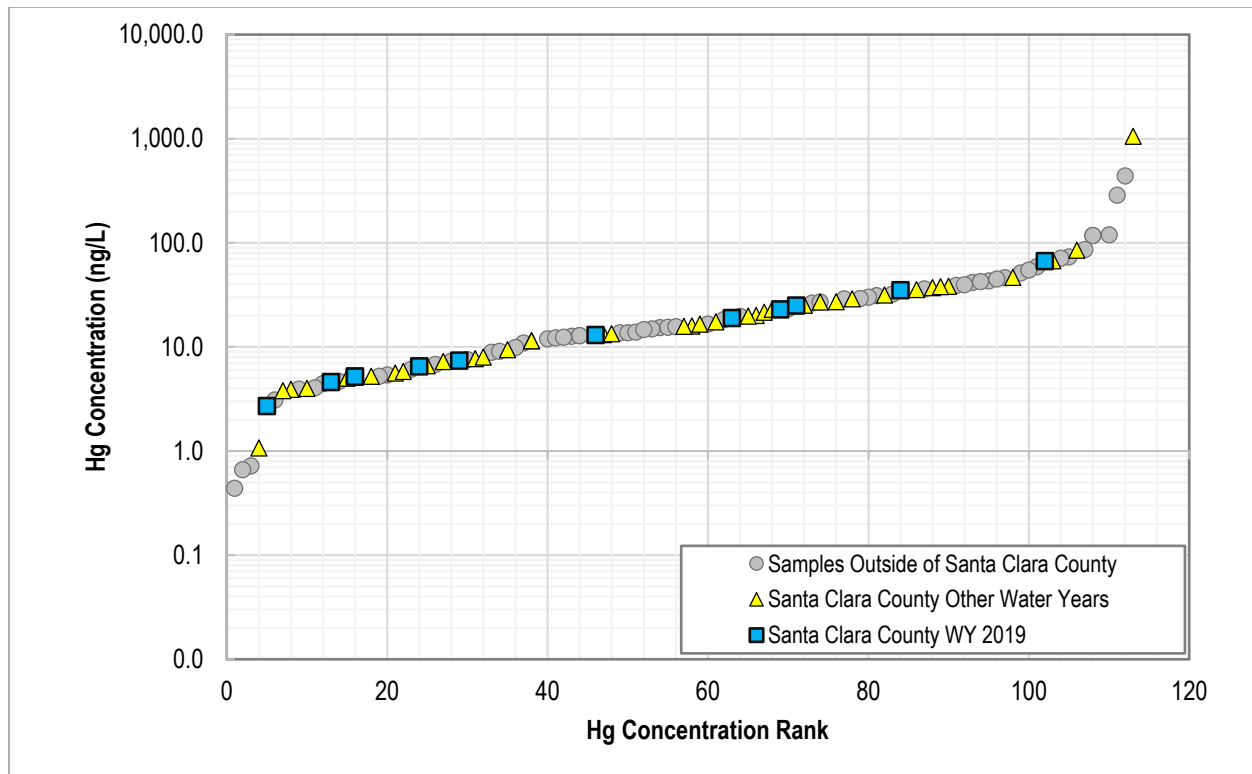


Figure 3.11. Mercury concentrations in storm water samples collected in MS4s and receiving waters draining to the Bay.

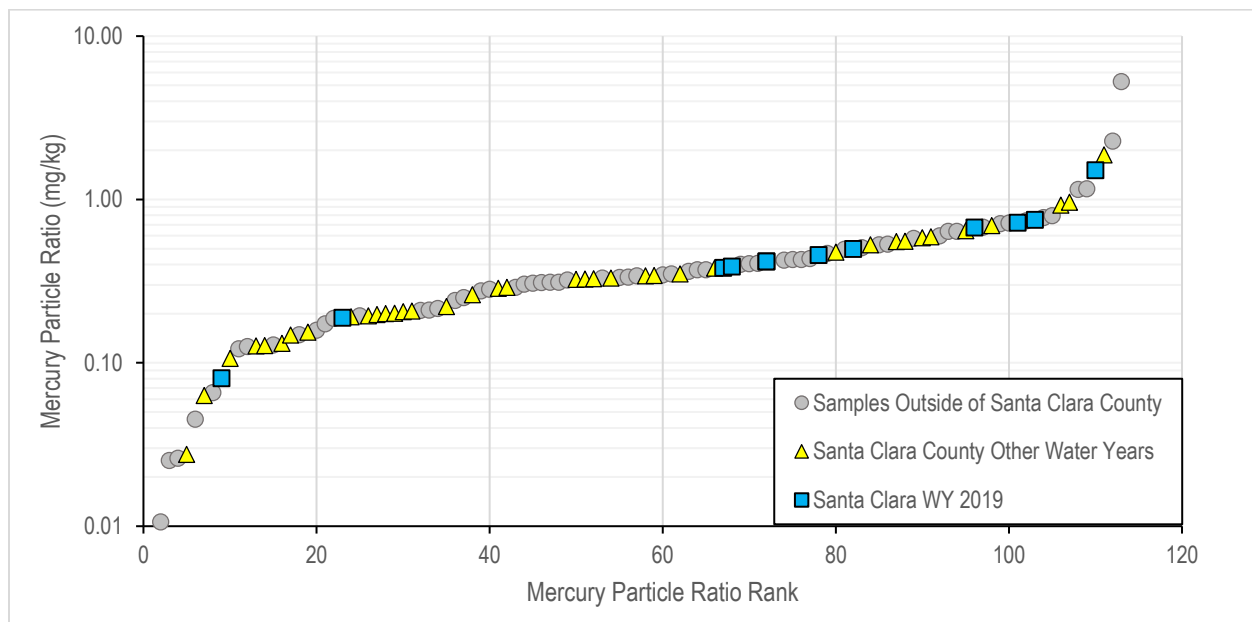


Figure 3.12. Mercury particle ratios in storm water samples collected in MS4s and receiving waters draining to the Bay.

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

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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.

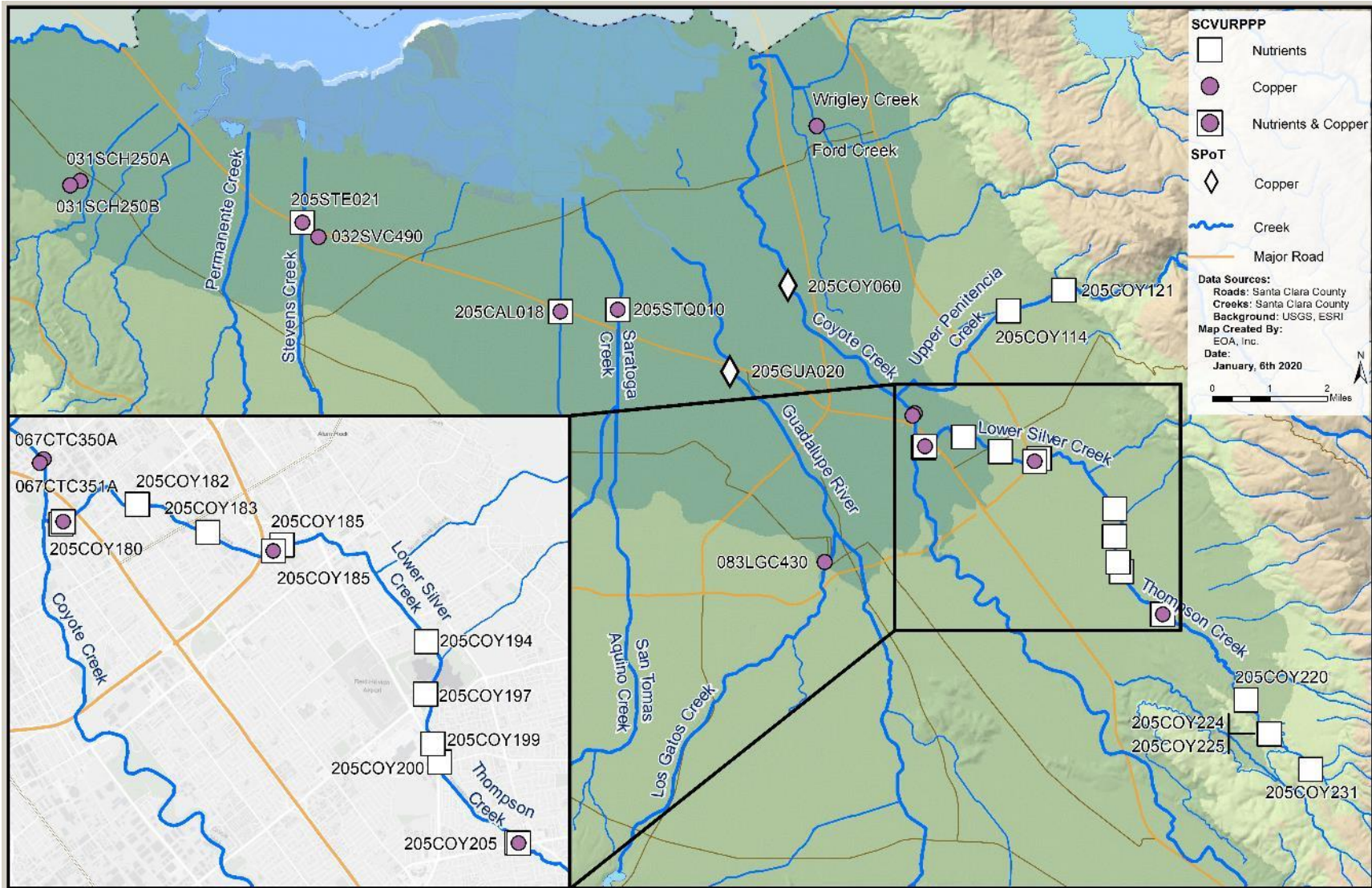


Figure 3.13. Copper and nutrient monitoring stations, Santa Clara Basin, WY 2016 – WY 2019.

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 copper⁷ (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 is 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 May 2018 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.** SCVURPPP 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

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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: Perfluorooctane 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.

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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.

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- 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 WQOs⁸.

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 dependent⁹. 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 consider 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).

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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 µg/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, the 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 Project¹⁰ 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 lists¹. Completed templates were reviewed using SWAMP's online data checker², 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 70/76 (2) | • PCB 132/168 (2) |
| • PCB 20/21/33 (1) | • PCB 86/97 (4) | • PCB 139/149 (1) |
| • PCB 31 (1) | • PCB 87/115/116 (4) | • PCB 153 (1) |
| • PCB 43/49 (3) | • PCB 89/90/101 (2) | • PCB 156 (1) |
| • PCB 44 (3) | • PCB 93/95 (2) | • PCB 177 (2) |
| • PCB 52/73 (2) | • PCB 99 (3) | • PCB 194 (2) |
| • PCB 56/60 (3) | • PCB 105/127 (2) | • PCB 195 (2) |
| • PCB 61/74 (2) | • PCB 106/118 (4) | |
| • PCB 66/80 (2) | • PCB 110 (3) | |

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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 congeners² (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.

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- 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 Kinetic 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

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the Santa Clara Basin in order to identify PCBs and mercury sources, as described in more detail in Sections 3 and 4.

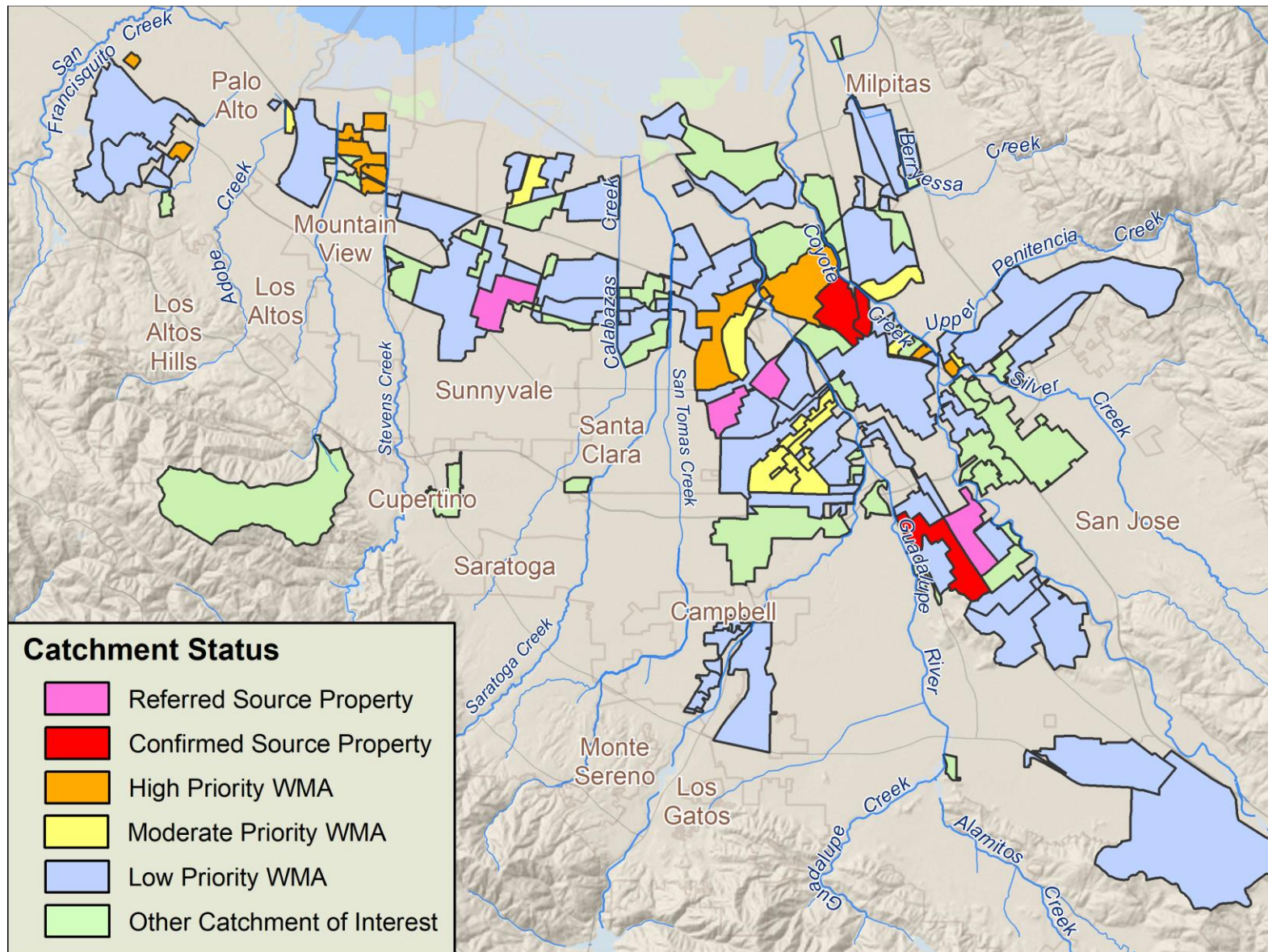


Figure 2.1. WMA Prioritization status for all catchments of interest identified in the Santa Clara Basin, CA.

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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;

SCVURPPP Pollutants of Concern Monitoring to Support Source Identification

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.

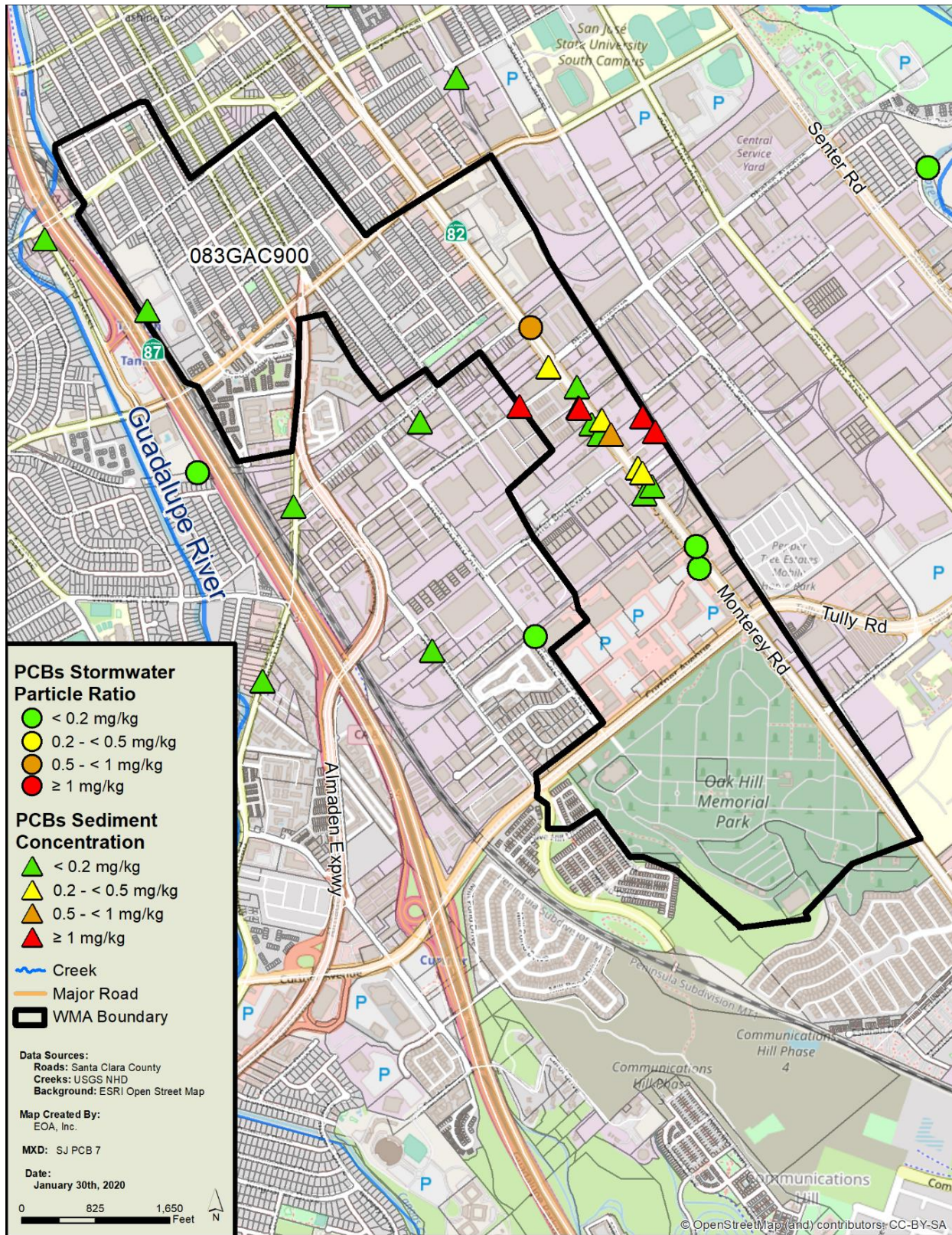


Figure 4.1. PCBs in street dirt and MS4 sediment concentrations and stormwater particle ratios measured in WMA 083GAC900 in WY 2015 through WY 2019.

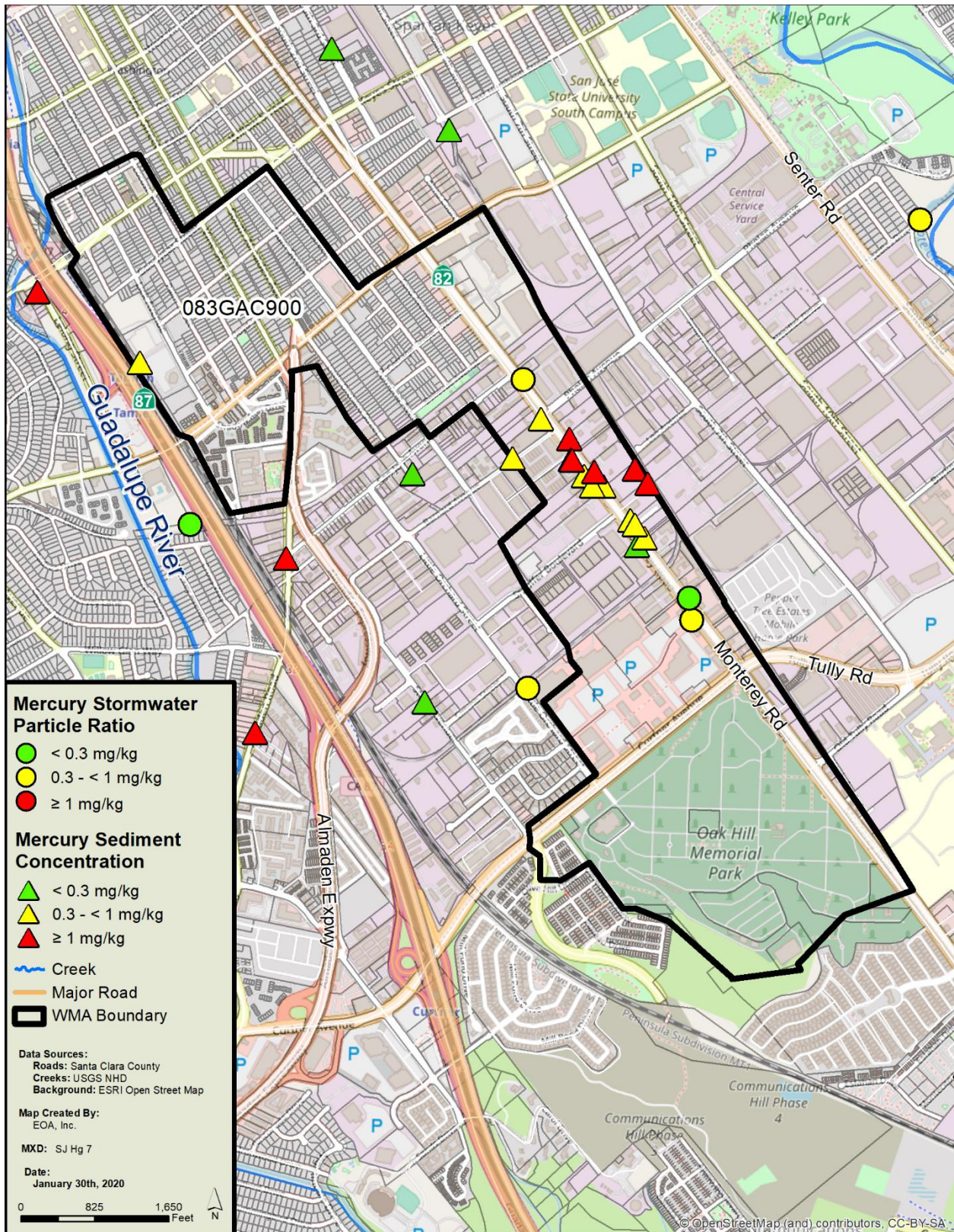


Figure 4.2. Mercury in street dirt and MS4 sediment concentrations and stormwater particle ratios measured in WMA 083GAC900 in WY 2015 through WY 2019.

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 in 1976 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.

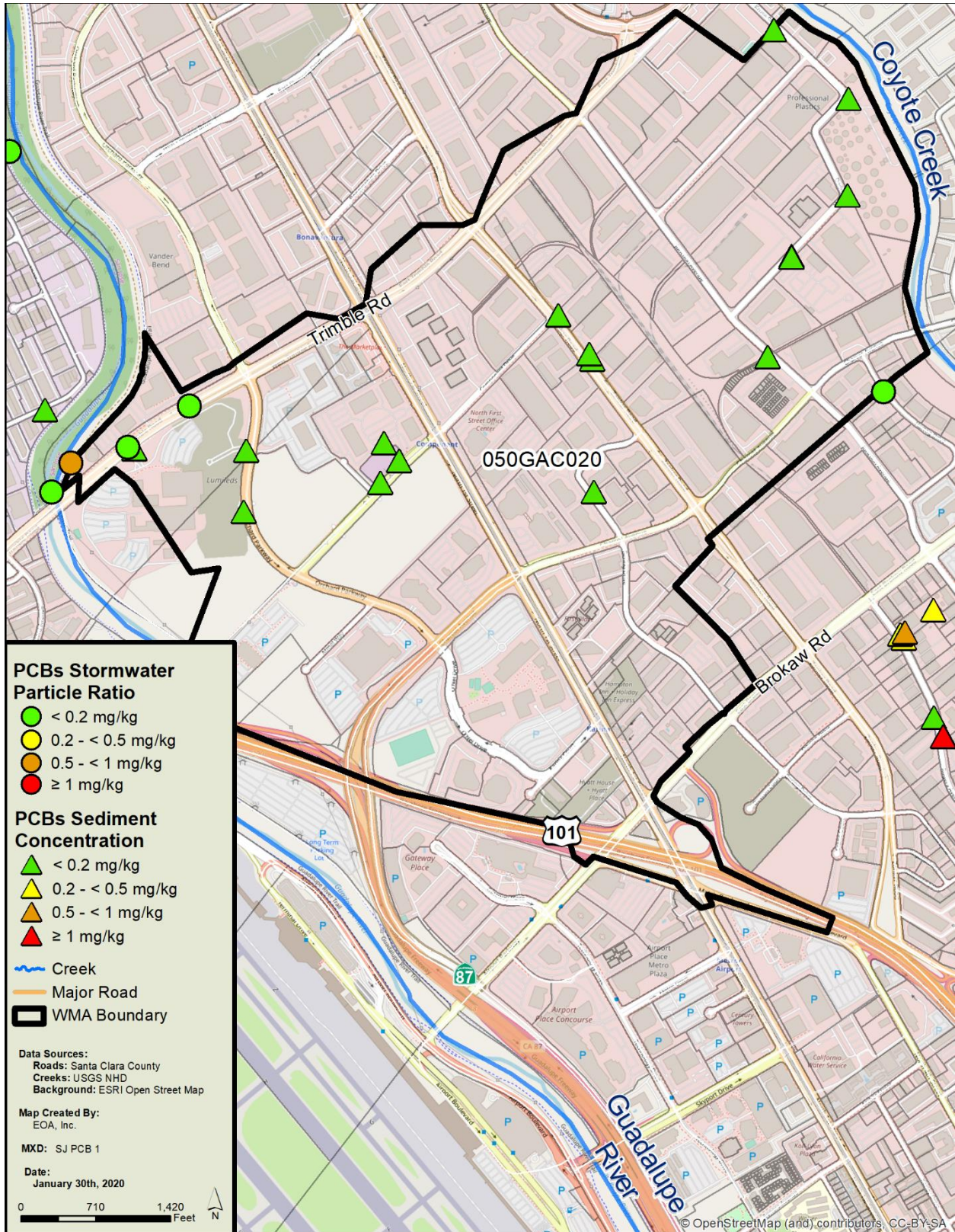


Figure 4.3. PCBs in street dirt and MS4 sediment concentrations and stormwater particle ratios measured in WMA 050GAC020 in WY 2015 through WY 2019.

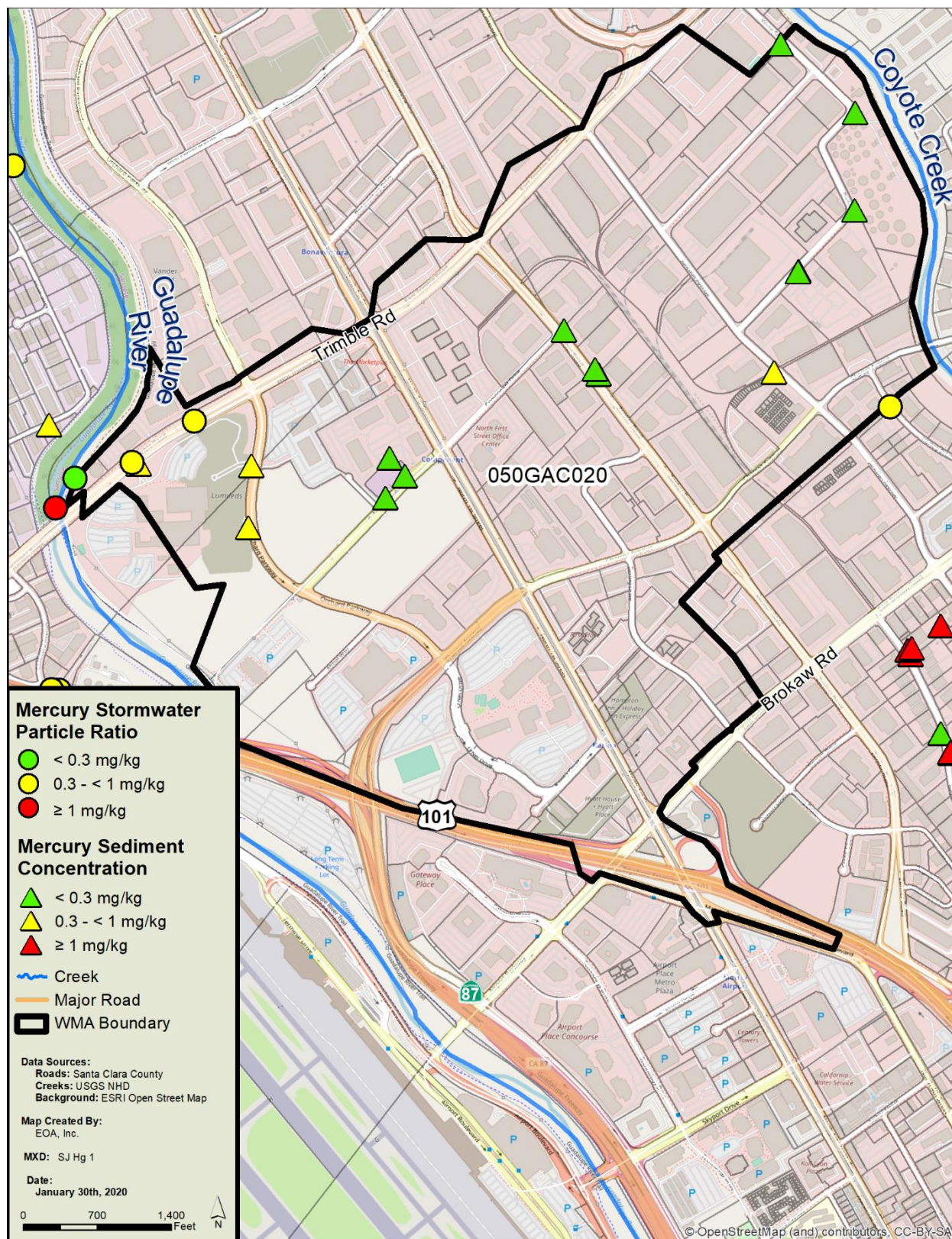


Figure 4.4. Mercury in street dirt and MS4 sediment concentrations and stormwater particle ratios measured in WMA 050GAC020 in WY 2015 through WY 2019.

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.

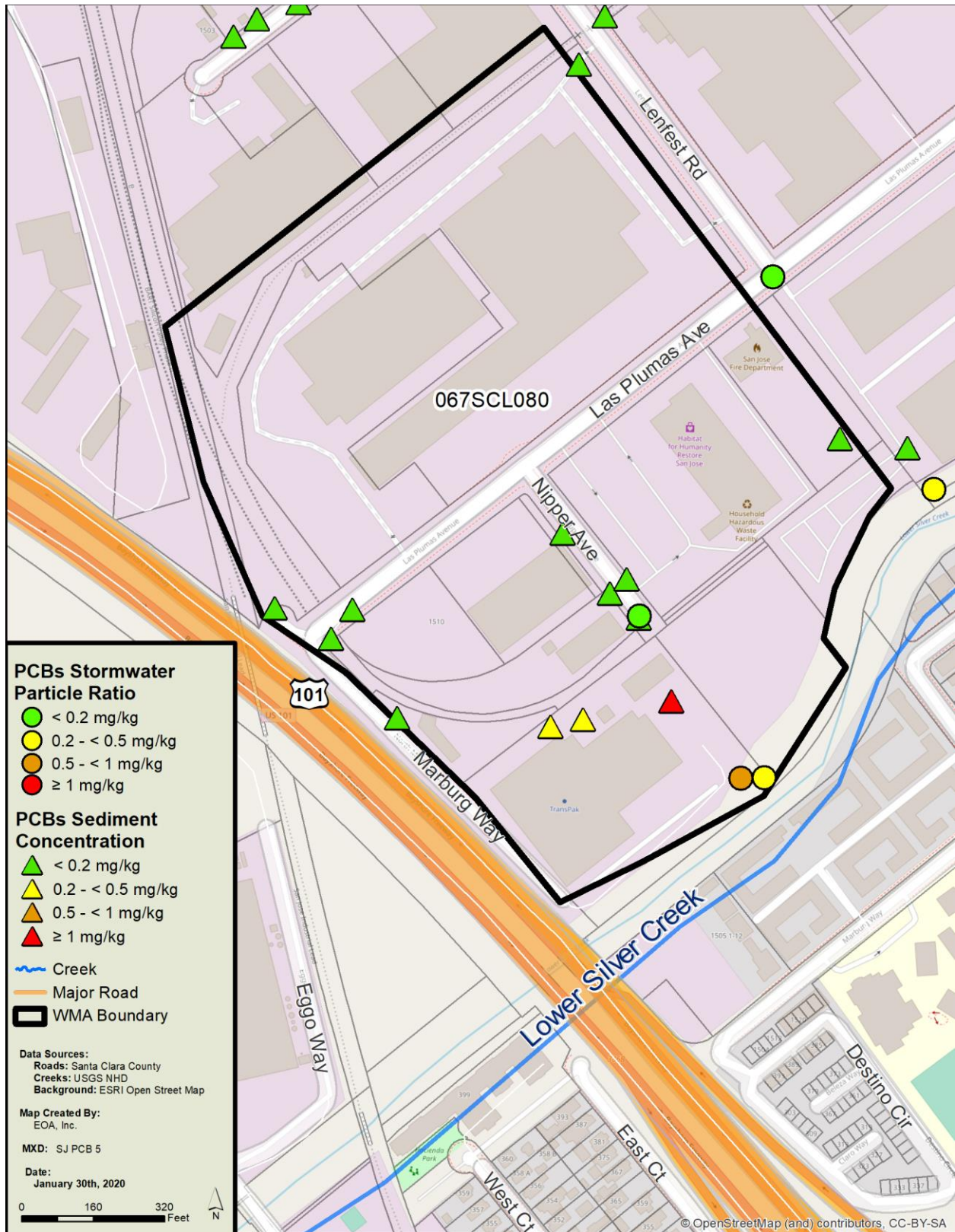


Figure 4.5. PCBs in street dirt and MS4 sediment concentrations and stormwater particle ratios measured in WMA 067SCL080 in WY 2015 through WY 2019.

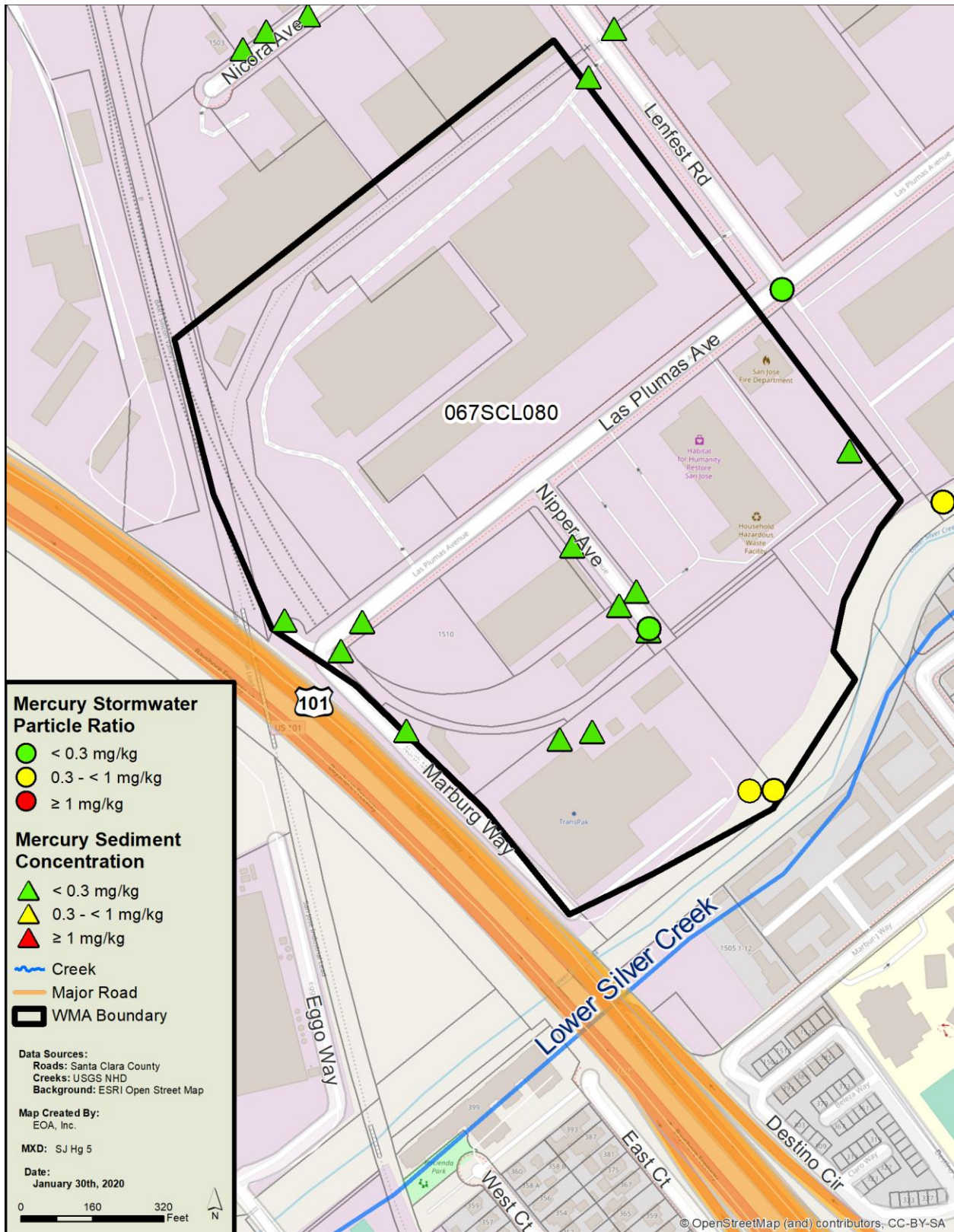


Figure 4.6. Mercury in street dirt and MS4 sediment concentrations and stormwater particle ratios measured in WMA 067SCL080 in WY 2015 through WY 2019.

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.

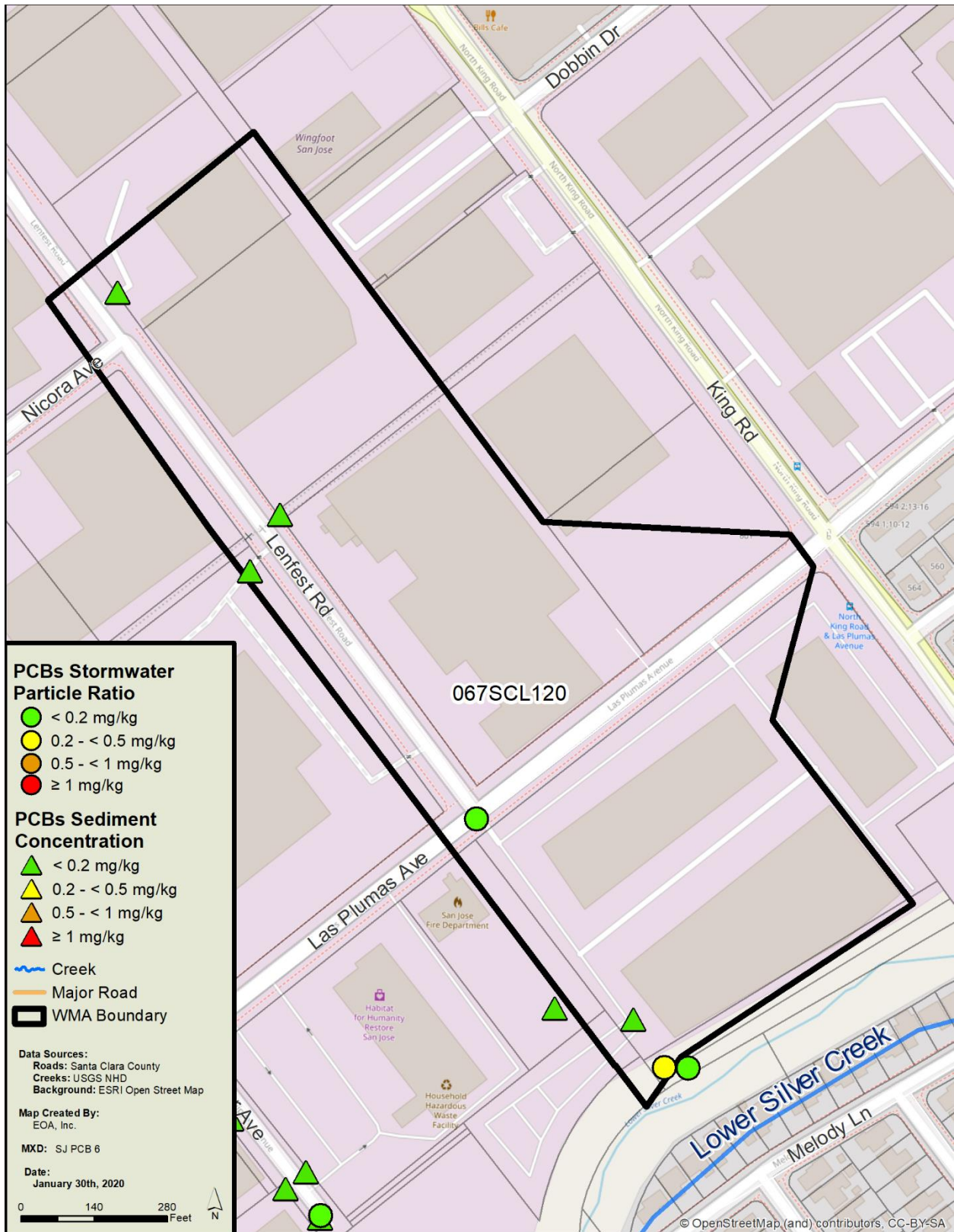


Figure 4.7. PCBs in street dirt and MS4 sediment concentrations and stormwater particle ratios measured in WMA 067SCL120 in WY 2015 through WY 2019.

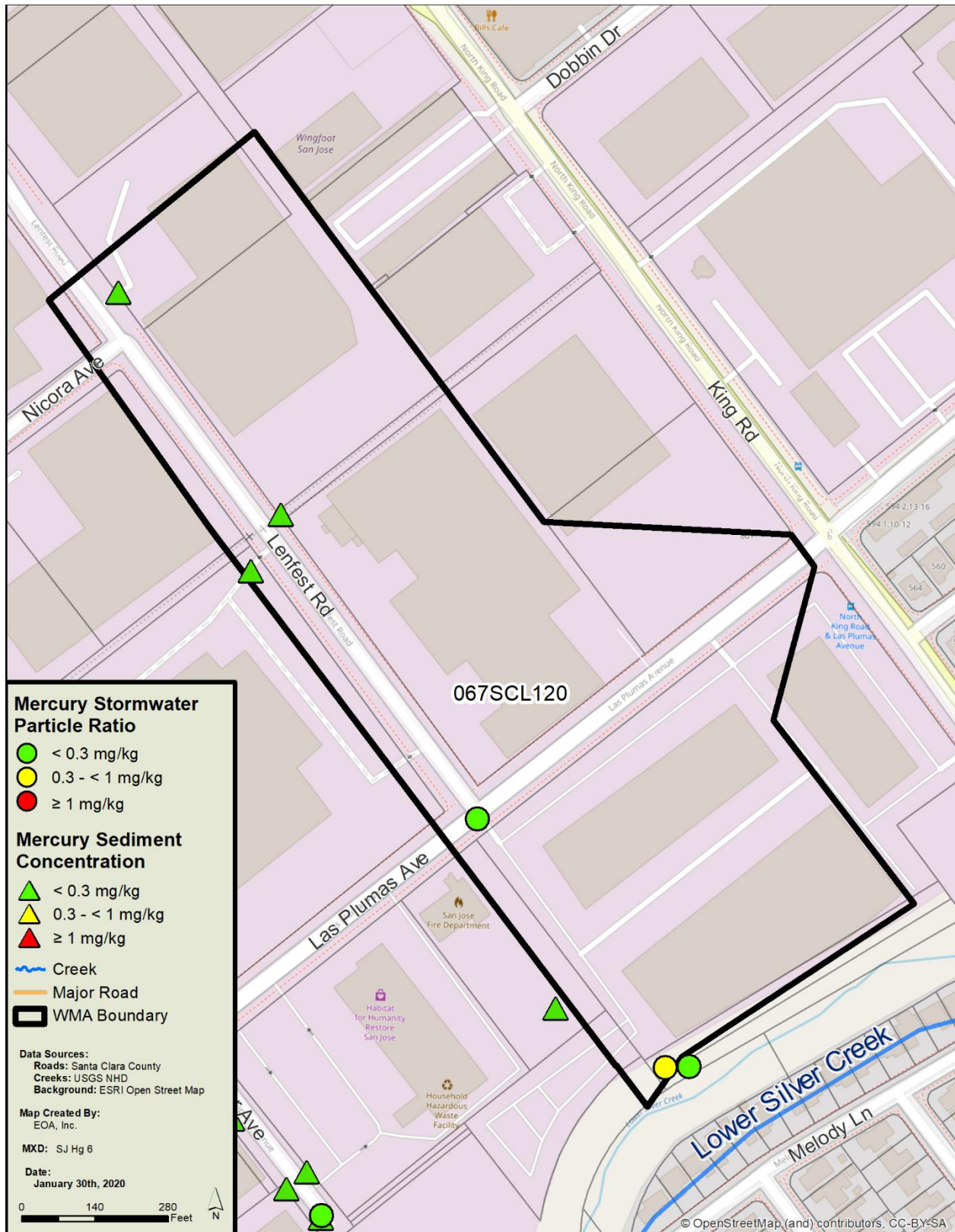


Figure 4.8. Mercury in street dirt and MS4 sediment concentrations and stormwater particle ratios measured in WMA 067SCL120 in WY 2015 through WY 2019.

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.

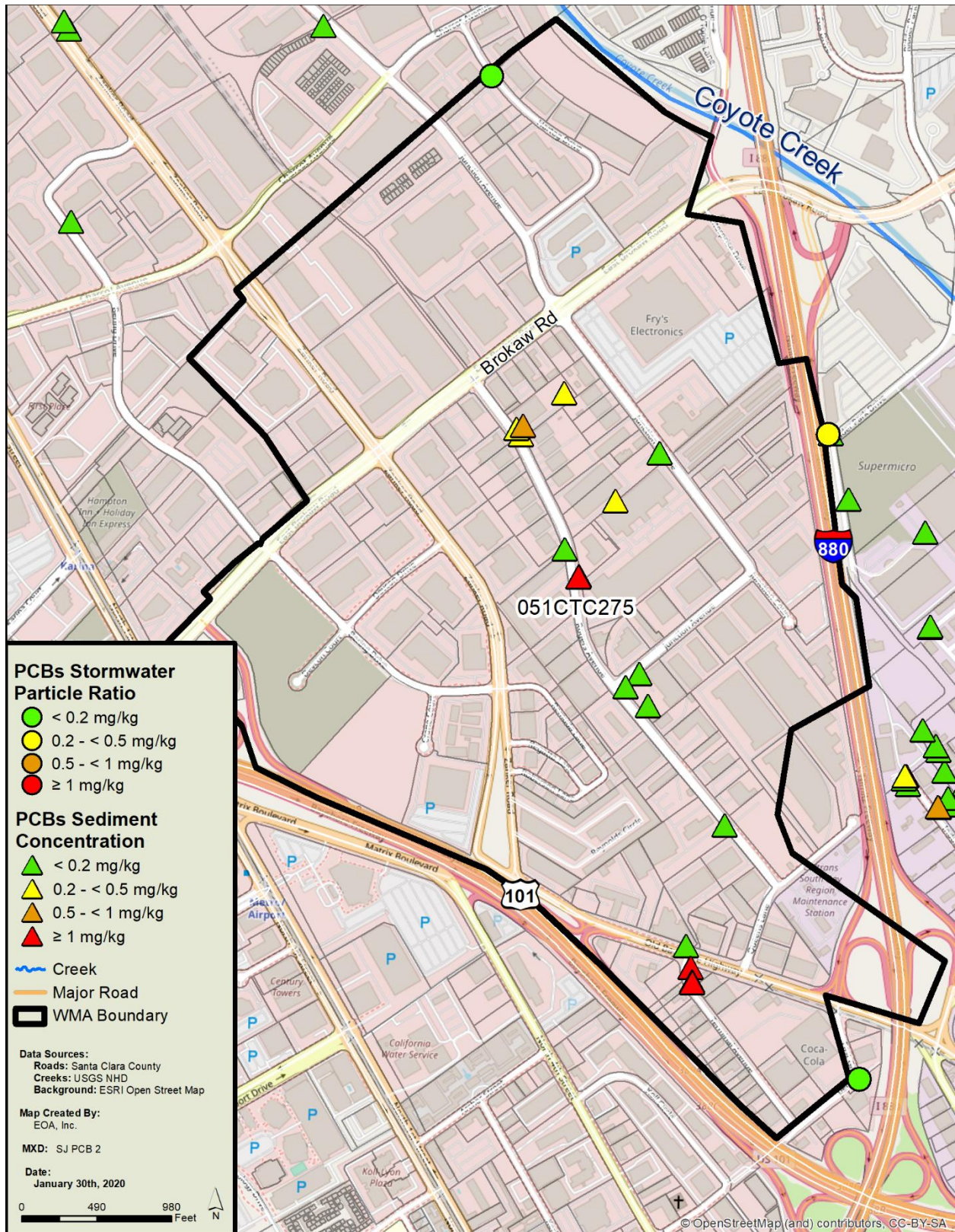


Figure 4.9. PCBs in street dirt and MS4 sediment concentrations and stormwater particle ratios measured in WMA 051CTC275 in WY 2015 through WY 2019.

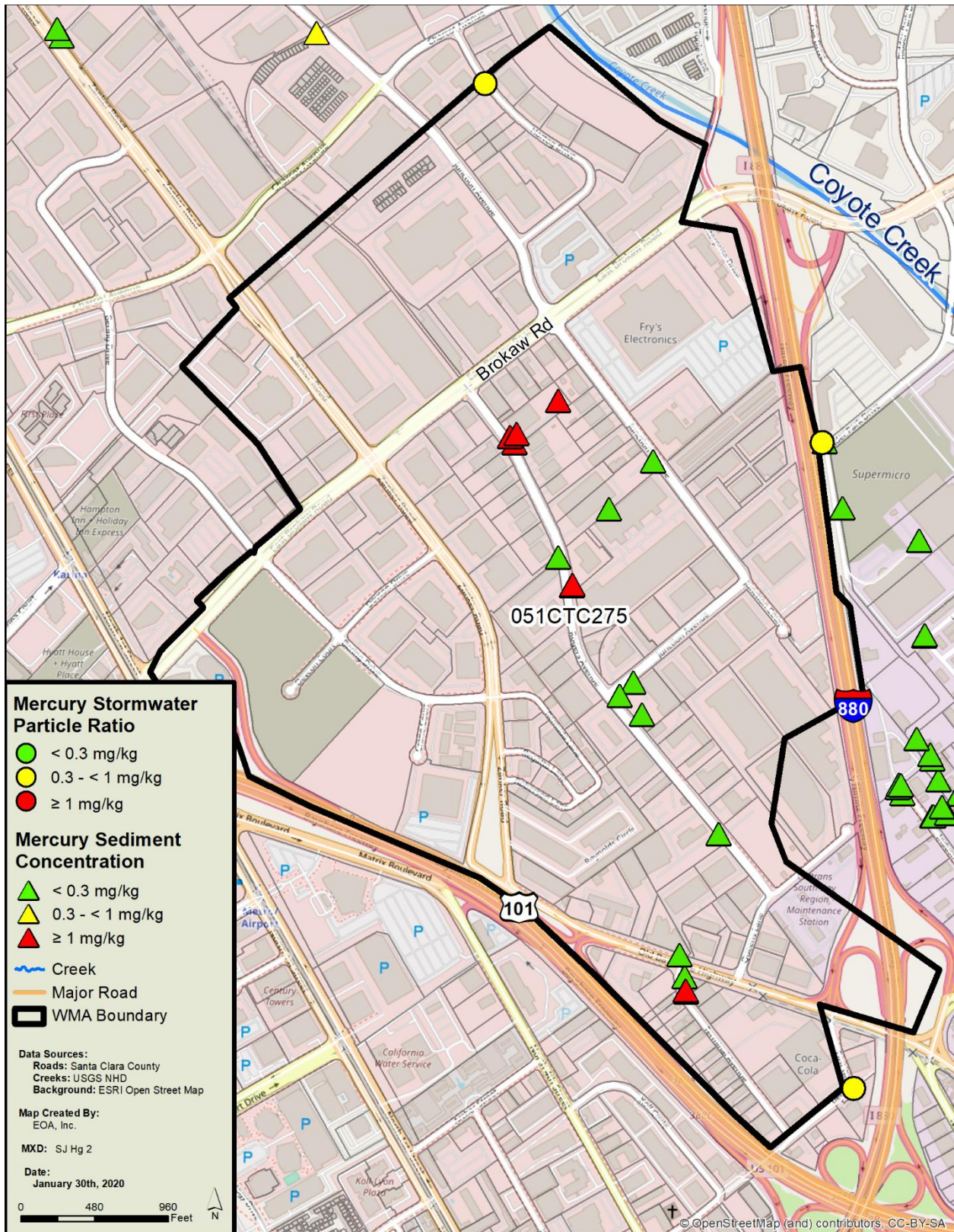


Figure 4.10. Mercury in street dirt and MS4 sediment concentrations and stormwater particle ratios measured in WMA 051CTC275 in WY 2015 through WY 2019.

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.

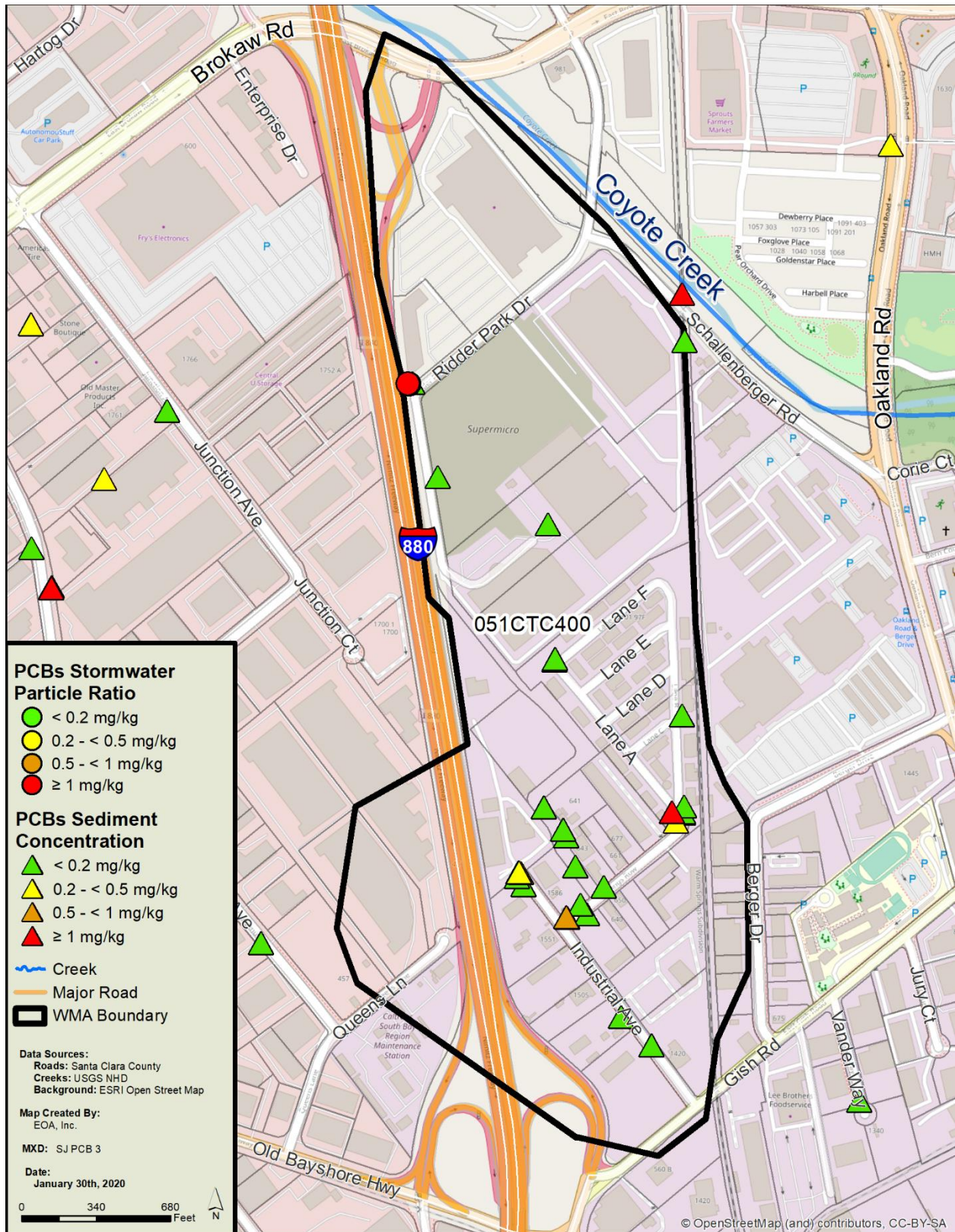


Figure 4.11. PCBs in street dirt and MS4 sediment concentrations and stormwater particle ratios measured in WMA 051CTC400 in WY 2015 through WY 2019.

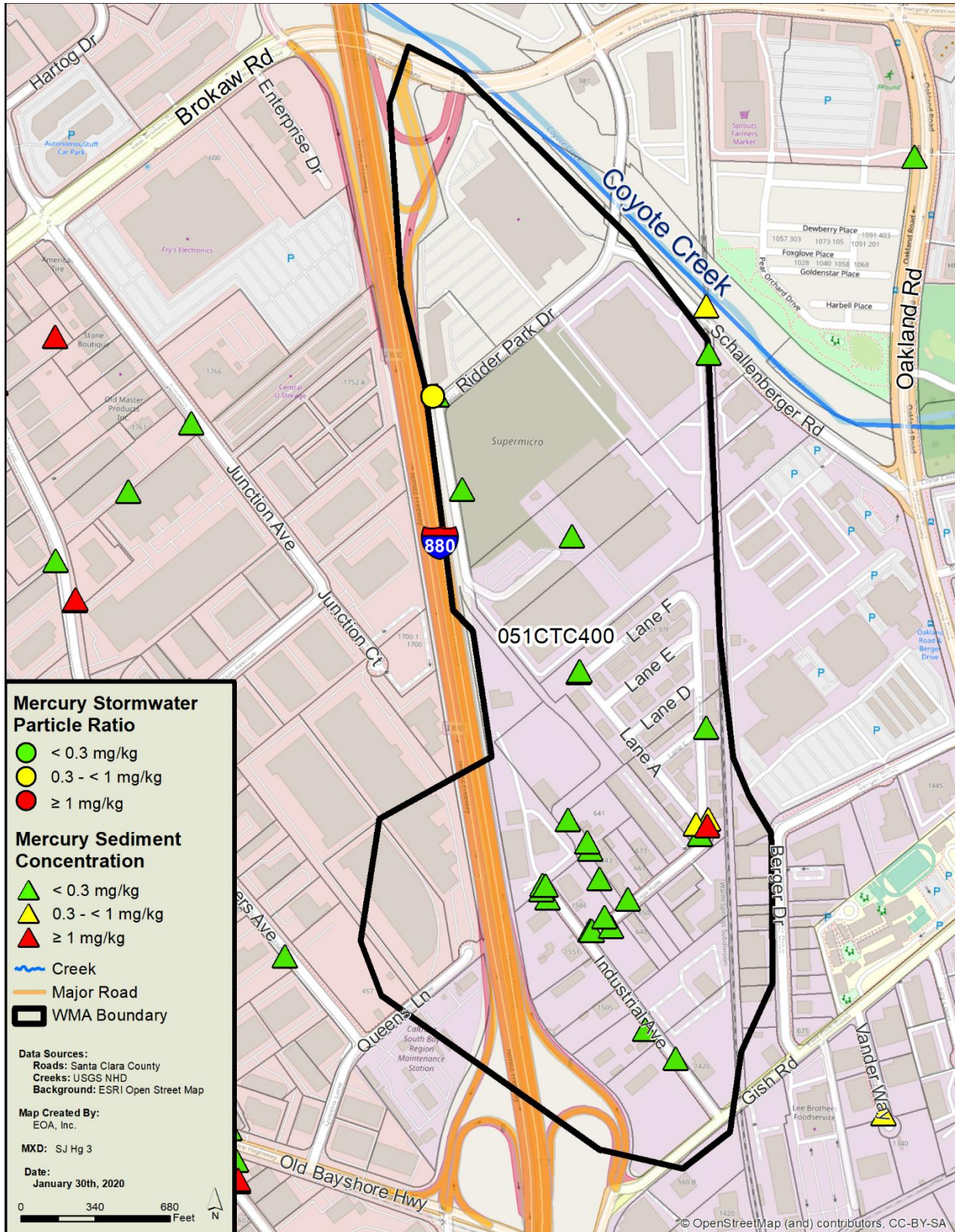


Figure 4.12. Mercury in street dirt and MS4 sediment concentrations and stormwater particle ratios measured in WMA 051CTC400 in WY 2015 through WY 2019.

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.

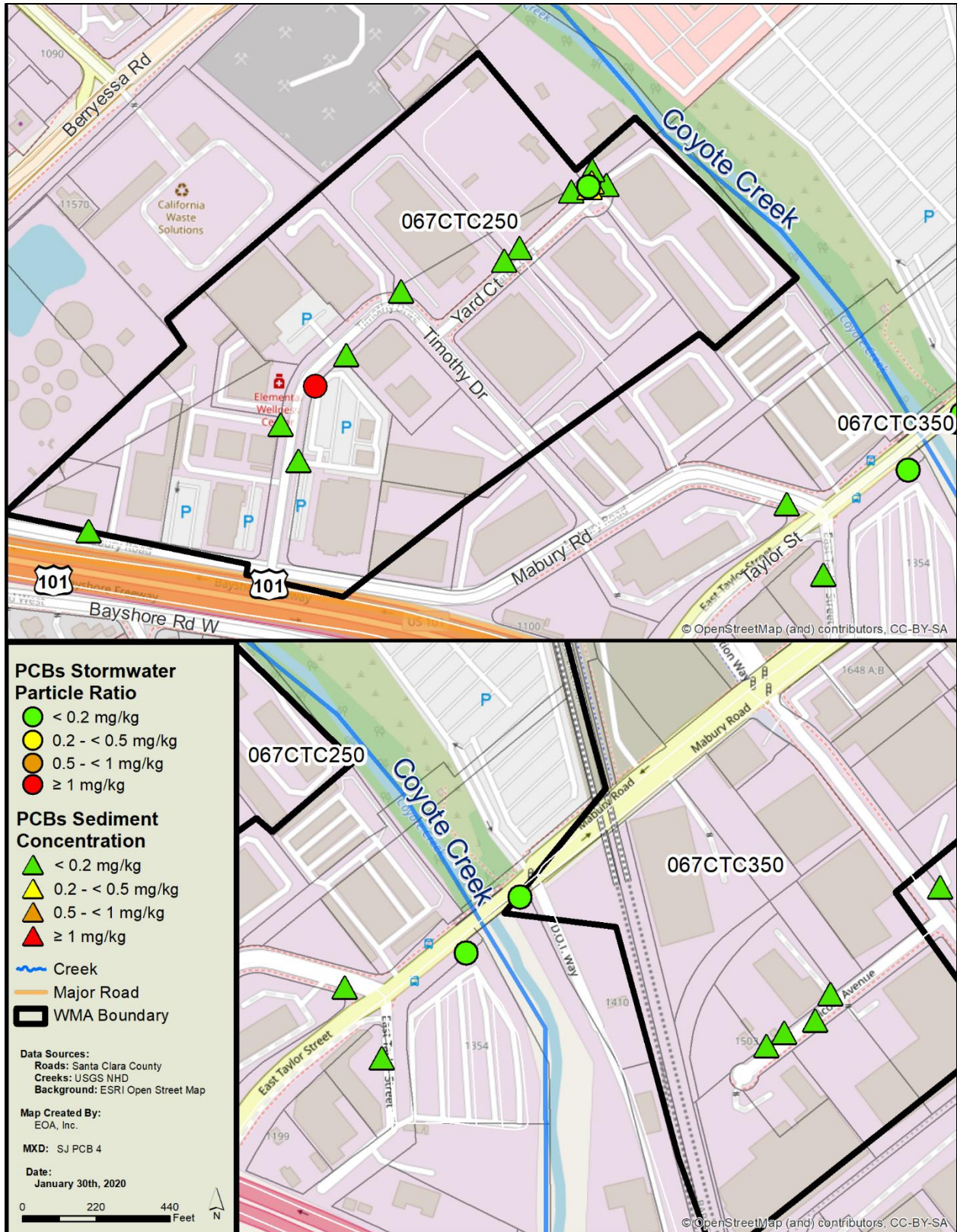


Figure 4.13. PCBs in street dirt and MS4 sediment concentrations and stormwater particle ratios measured in WMA 067CTC250 in WY 2015 through WY 2019.

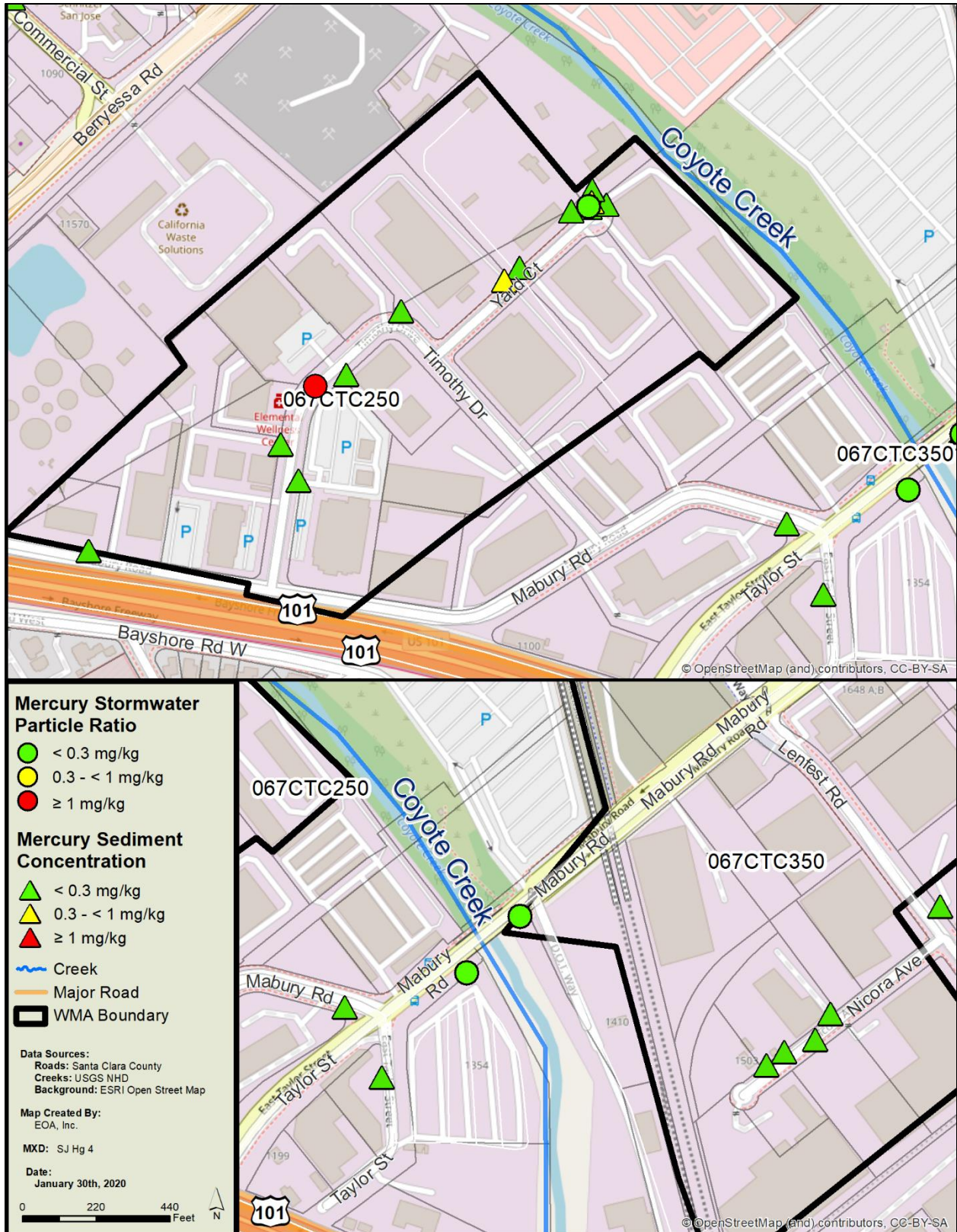


Figure 4.14. Mercury in street dirt and MS4 sediment concentrations and stormwater particle ratios measured in WMA 067CTC250 in WY 2015 through WY 2019.

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

SCVURPPP Pollutants of Concern Monitoring to Support Source Identification

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.

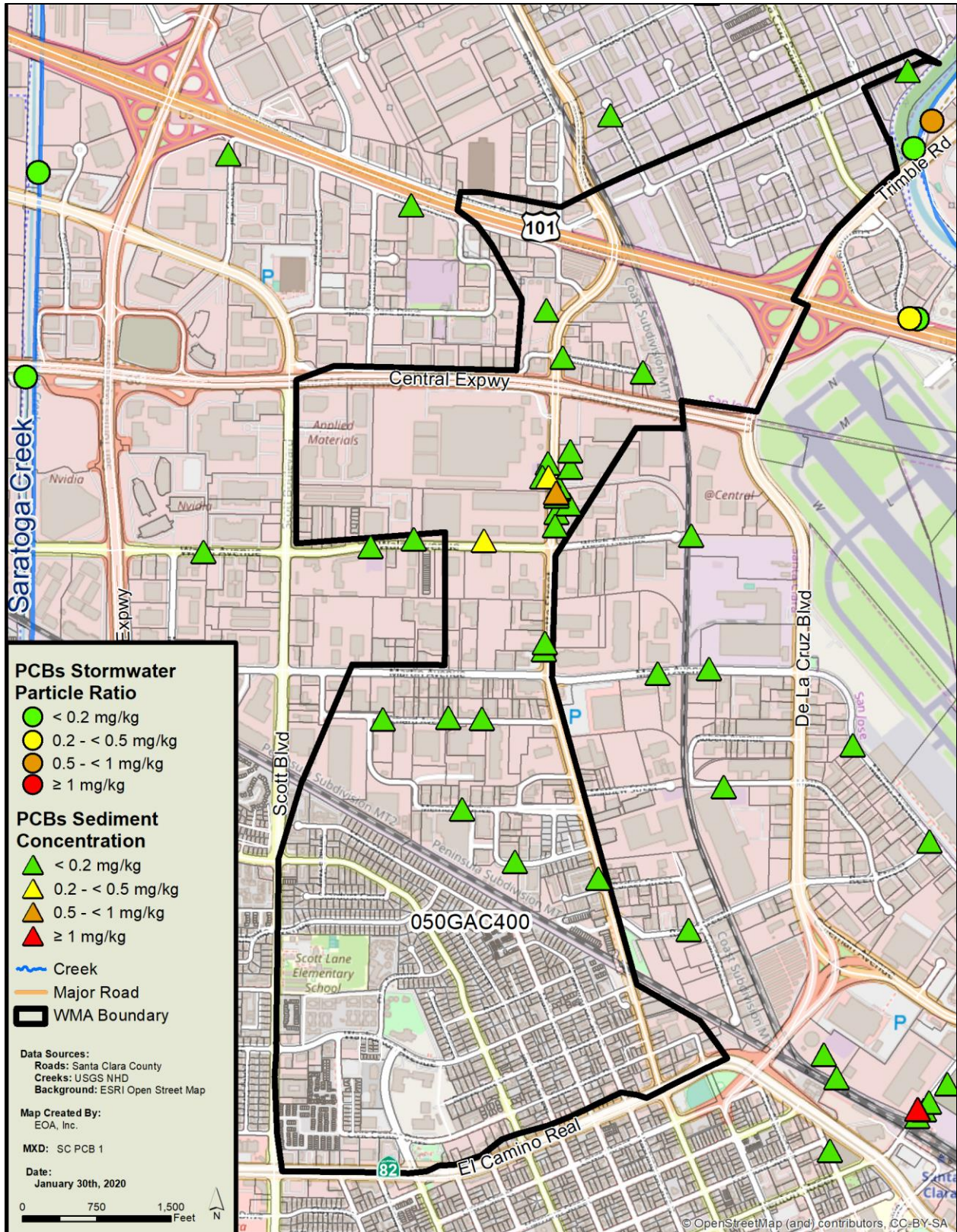


Figure 4.15. PCBs in street dirt and MS4 sediment concentrations and stormwater particle ratios measured in WMA 050GAC400 in WY 2015 through WY 2019.

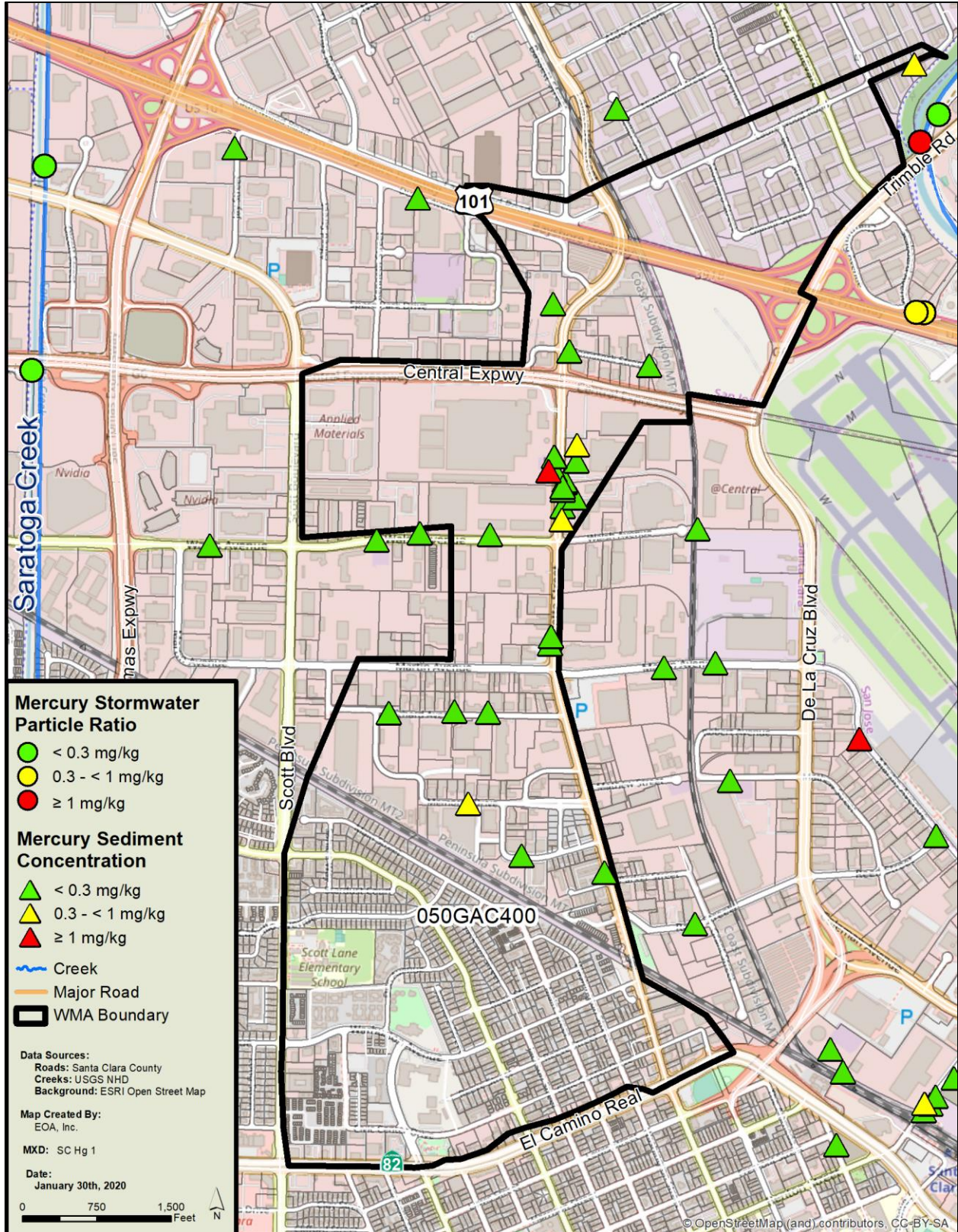


Figure 4.16. Mercury in street dirt and MS4 sediment concentrations and stormwater particle ratios measured in WMA 050GAC400 in WY 2015 through WY 2019.

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.

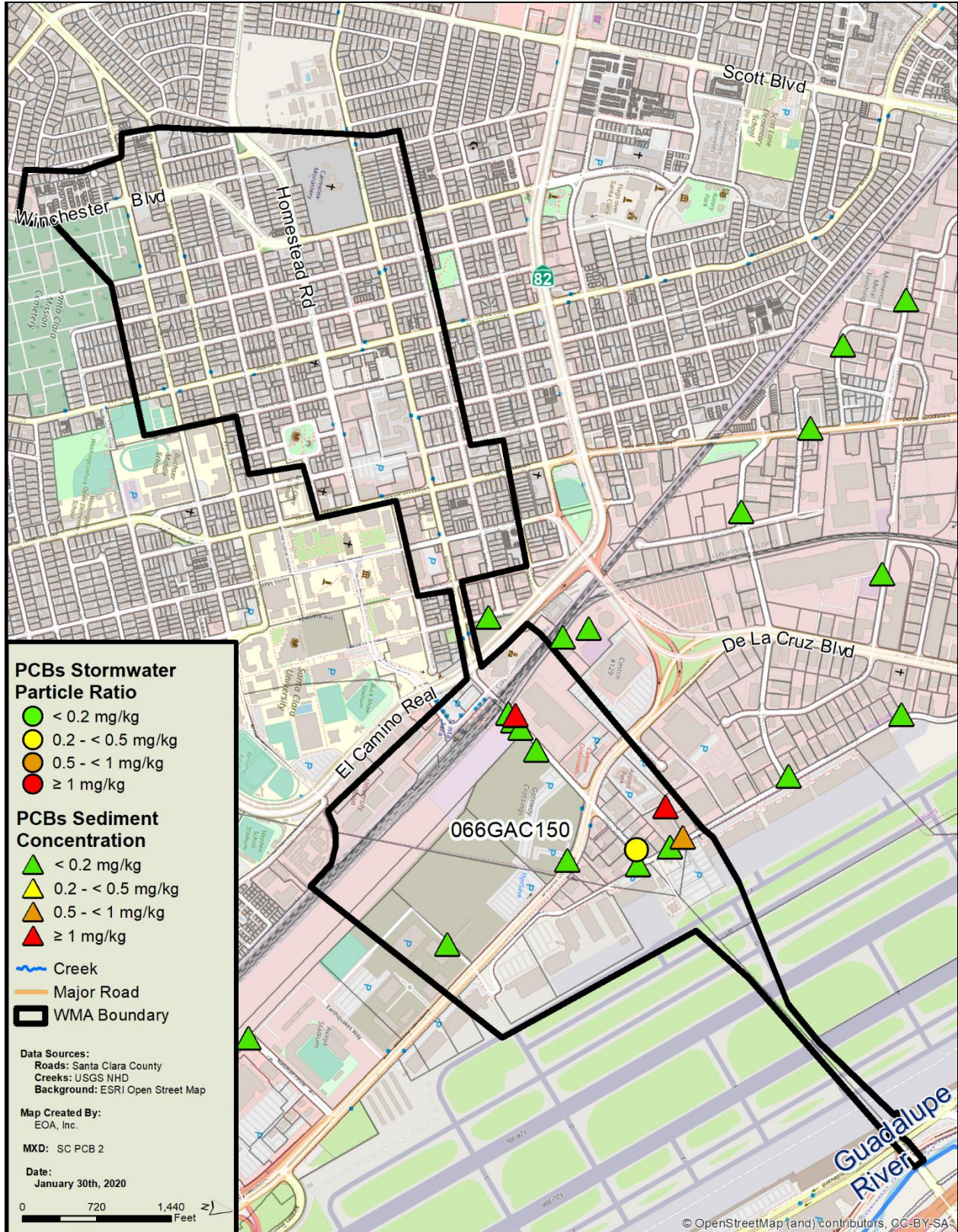


Figure 4.17. PCBs in street dirt and MS4 sediment concentrations and stormwater particle ratios measured in WMA 066GAC150 in WY 2015 through WY 2019.

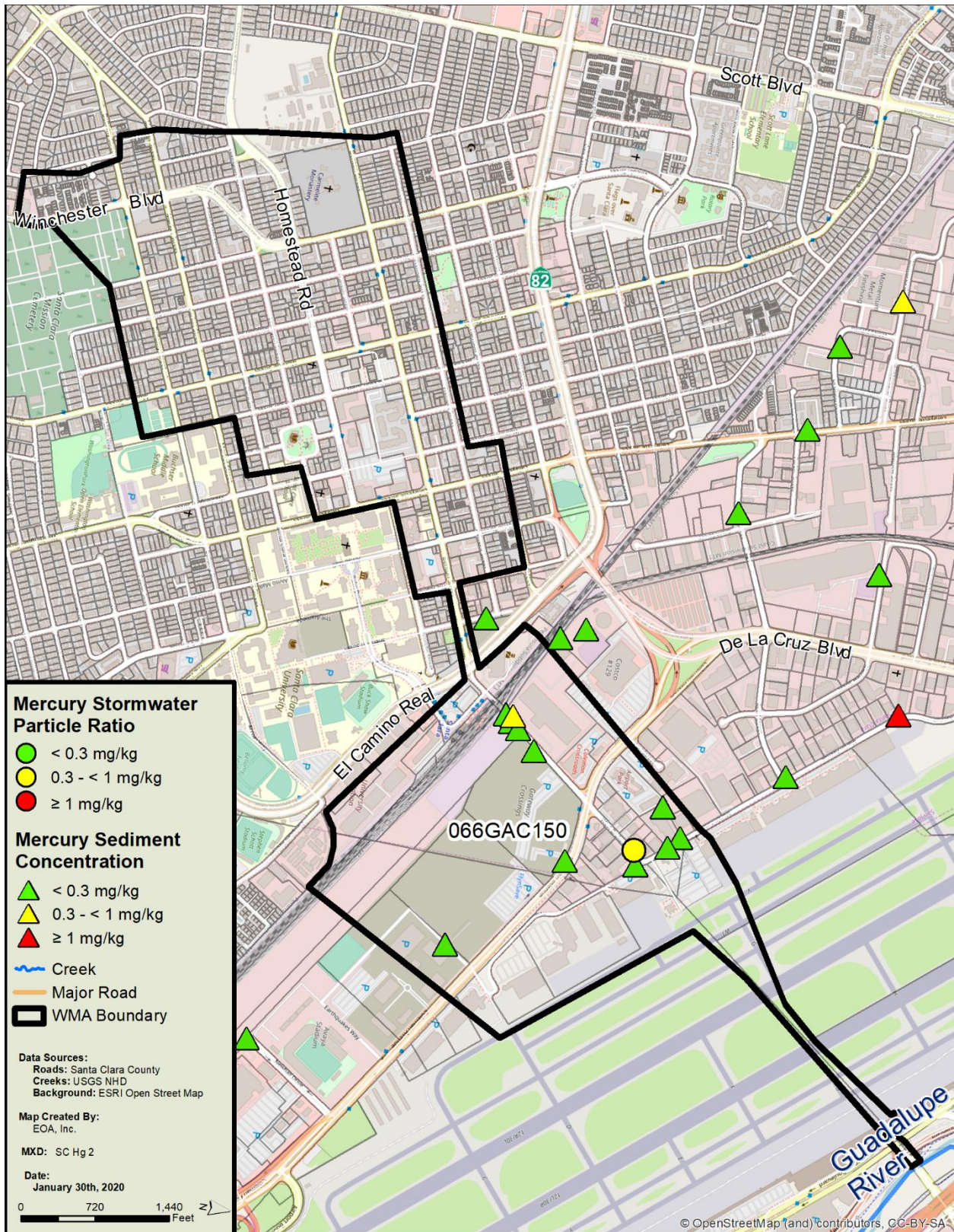


Figure 4.18. Mercury in street dirt and MS4 sediment concentrations and stormwater particle ratios measured in WMA 066GAC150 in WY 2015 through WY 2019.

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, filtrex-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 Northrop 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.

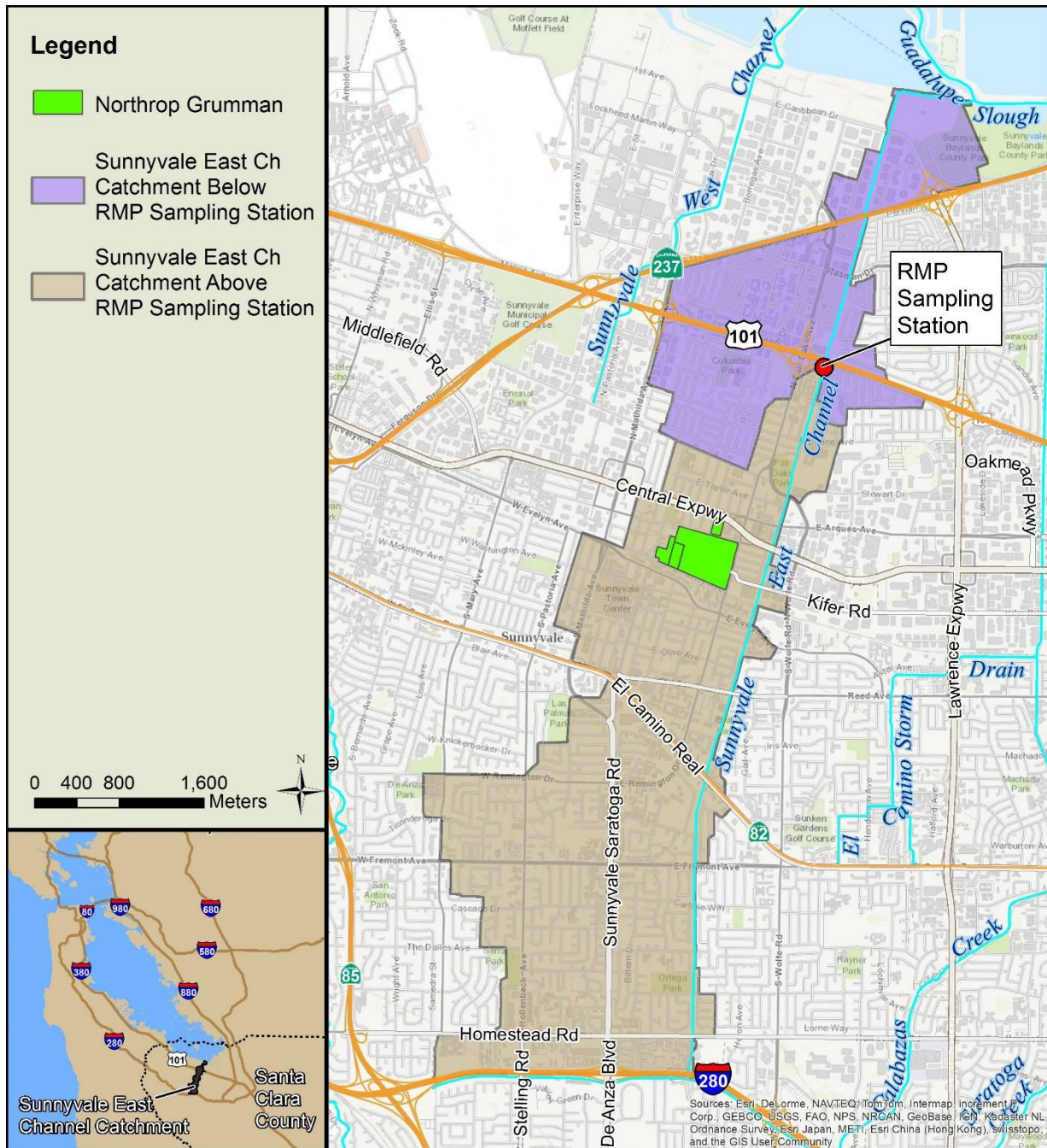


Figure 4.19. Location of RMP POC Sampling station and associated stormwater catchment (WMA 049SVE900), where highly elevated PCBs were measured in stormwater in WY 2012-2014. The Northrop Grumman PCBs source property is located upstream of the RMP sampling station.

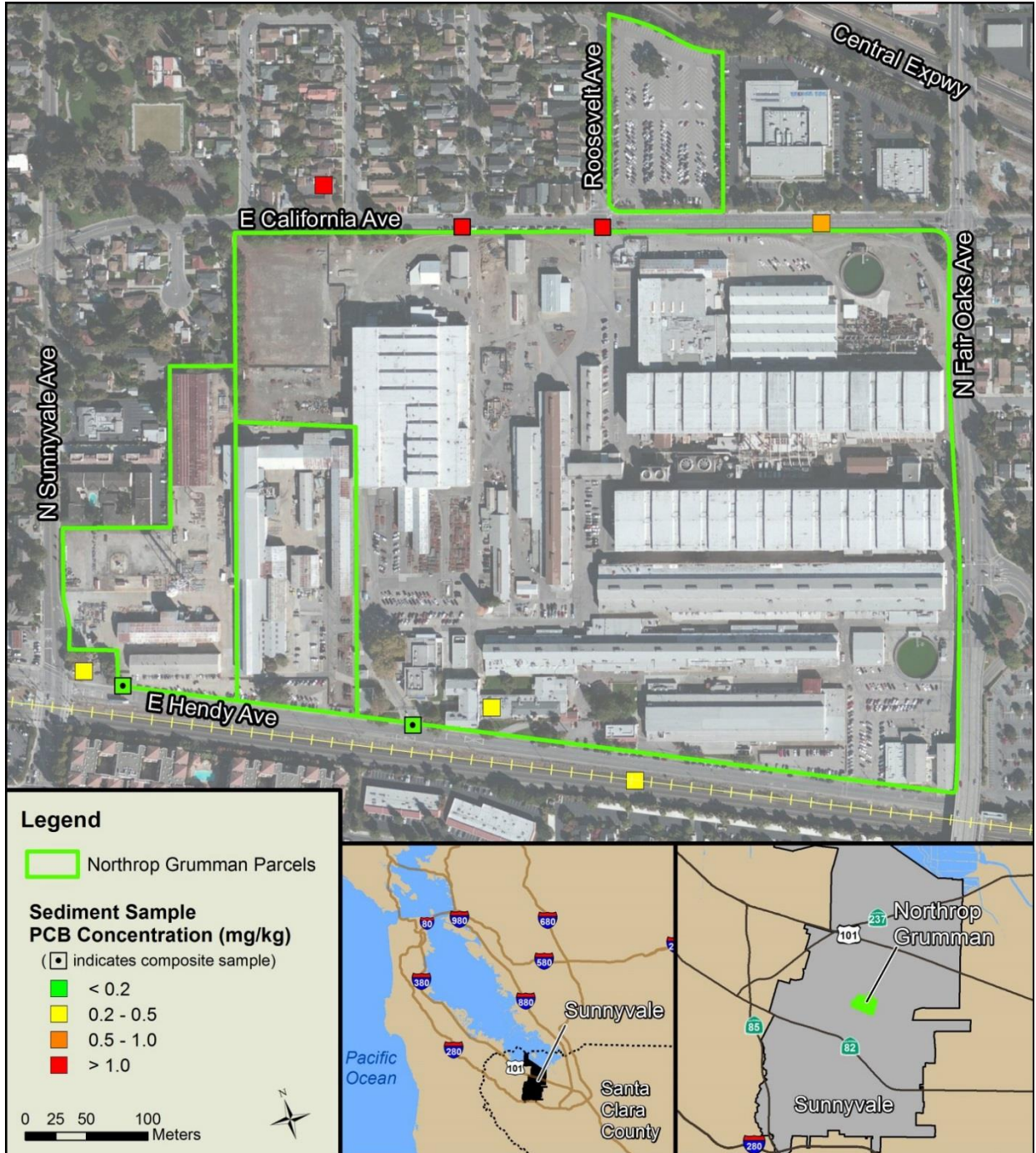


Figure 4.20. PCBs in street dirt and MS4 sediment concentrations measured adjacent to the Northrop Grumman property in WMA 049SVE900. SCVURPPP measured 2 samples > 1 mg/kg at the northern border of the property on E. California Avenue in WY 2015. Other samples shown on this Figure were measured in earlier 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.

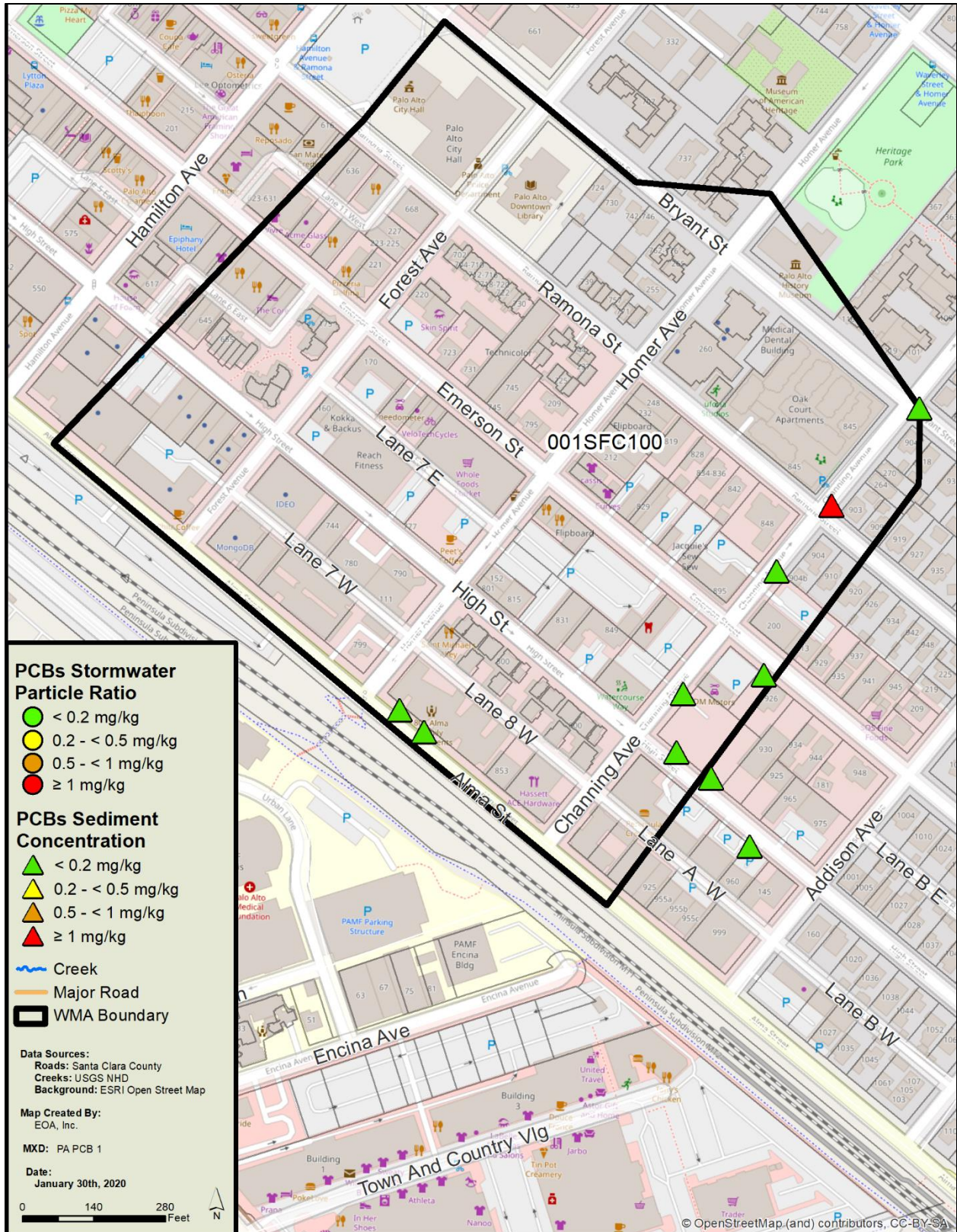


Figure 4.21. PCBs in street dirt and MS4 sediment concentrations and stormwater particle ratios measured in WMA 001SFC100 in WY 2015 through WY 2019.

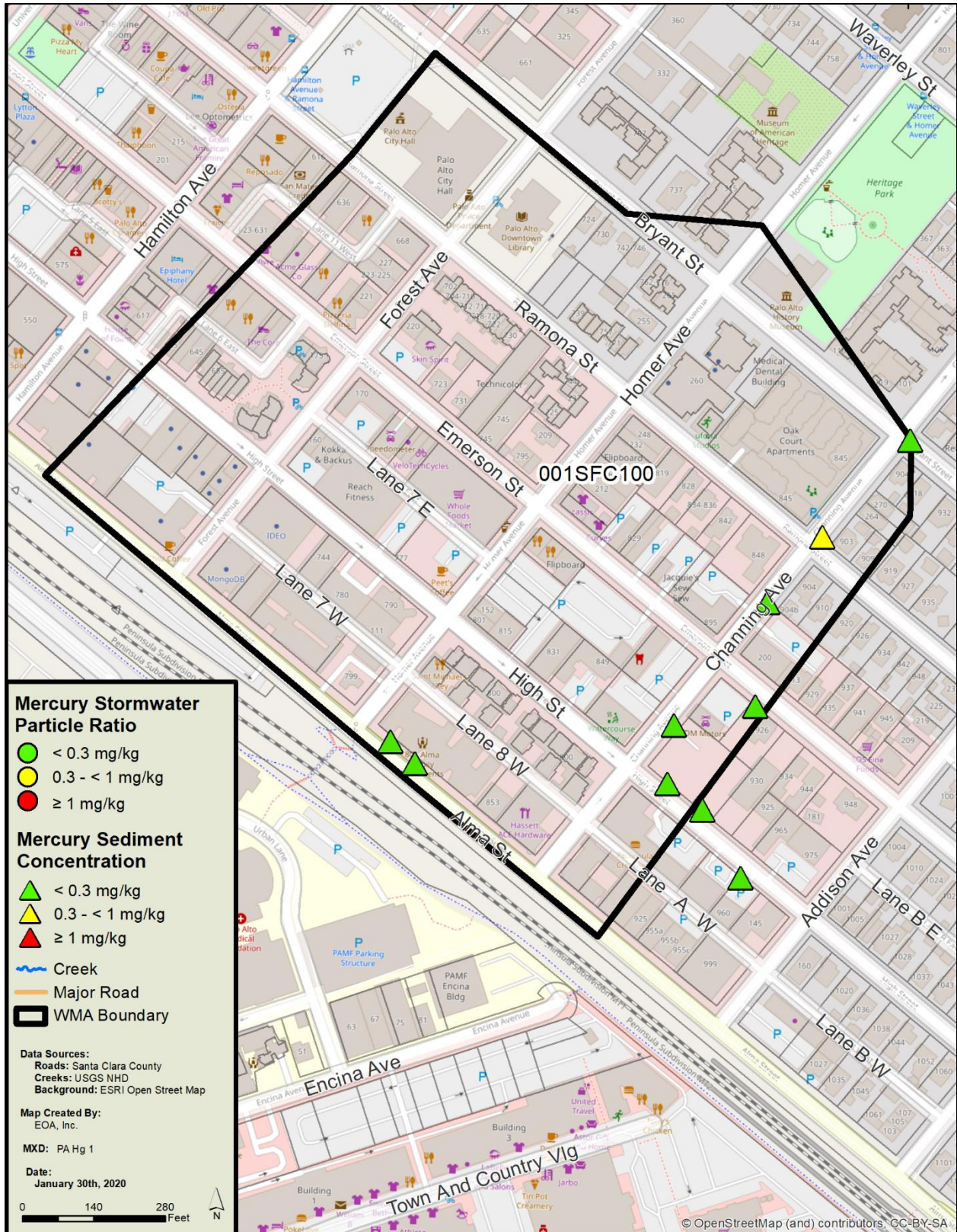


Figure 4.22. Mercury in street dirt and MS4 sediment concentrations and stormwater particle ratios measured in WMA 001SFC100 in WY 2015 through WY 2019.

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.

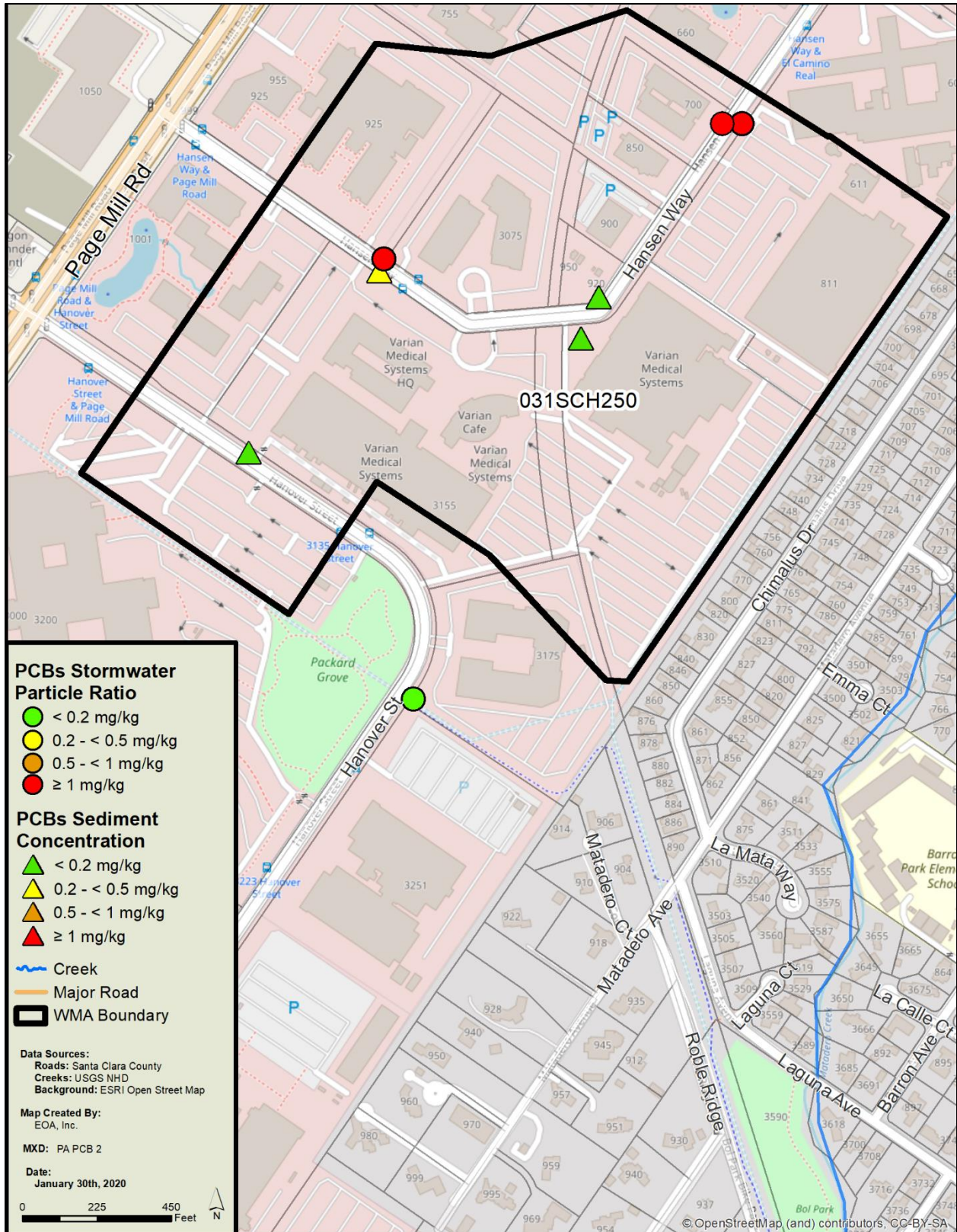


Figure 4.23. PCBs in street dirt and MS4 sediment concentrations and stormwater particle ratios measured in WMA 031SCH250 in WY 2015 through WY 2019.

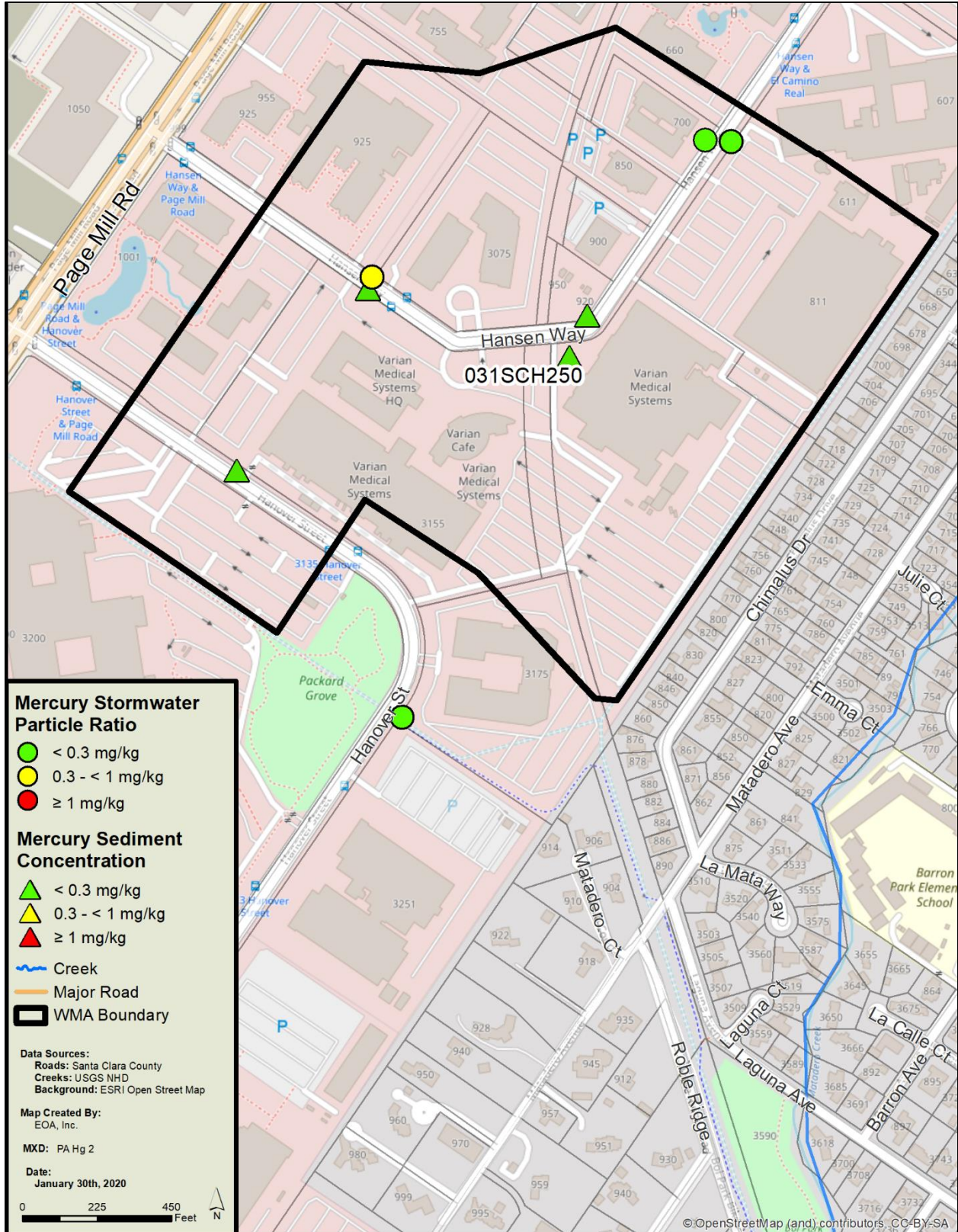


Figure 4.24. Mercury in street dirt and MS4 sediment concentrations and stormwater particle ratios measured in WMA 031SCH250 in WY 2015 through WY 2019f

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.

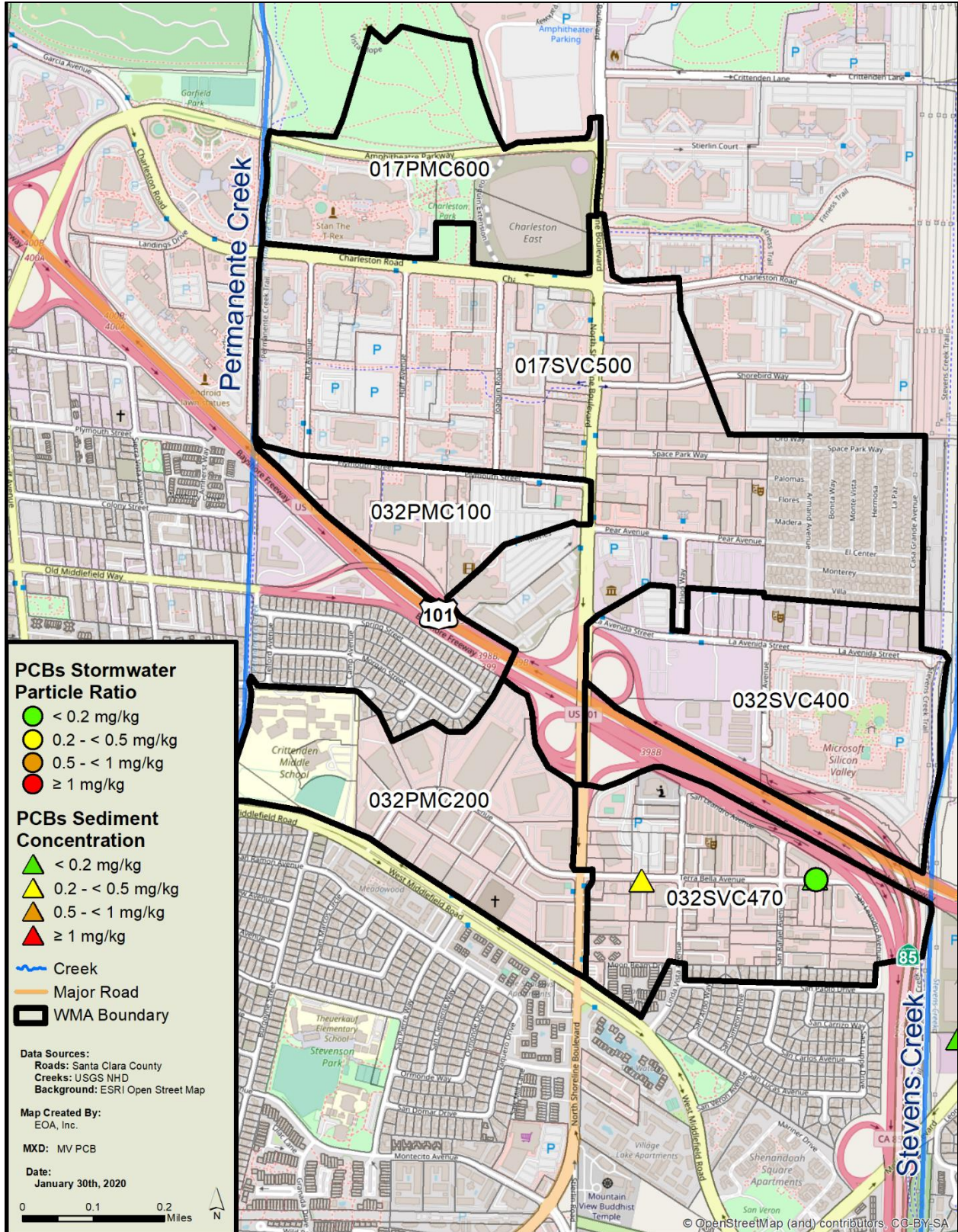


Figure 4.25. PCBs in street dirt and MS4 sediment concentrations and stormwater particle ratios measured in the Mountain View WMA investigation area in WY 2015 through WY 2019.

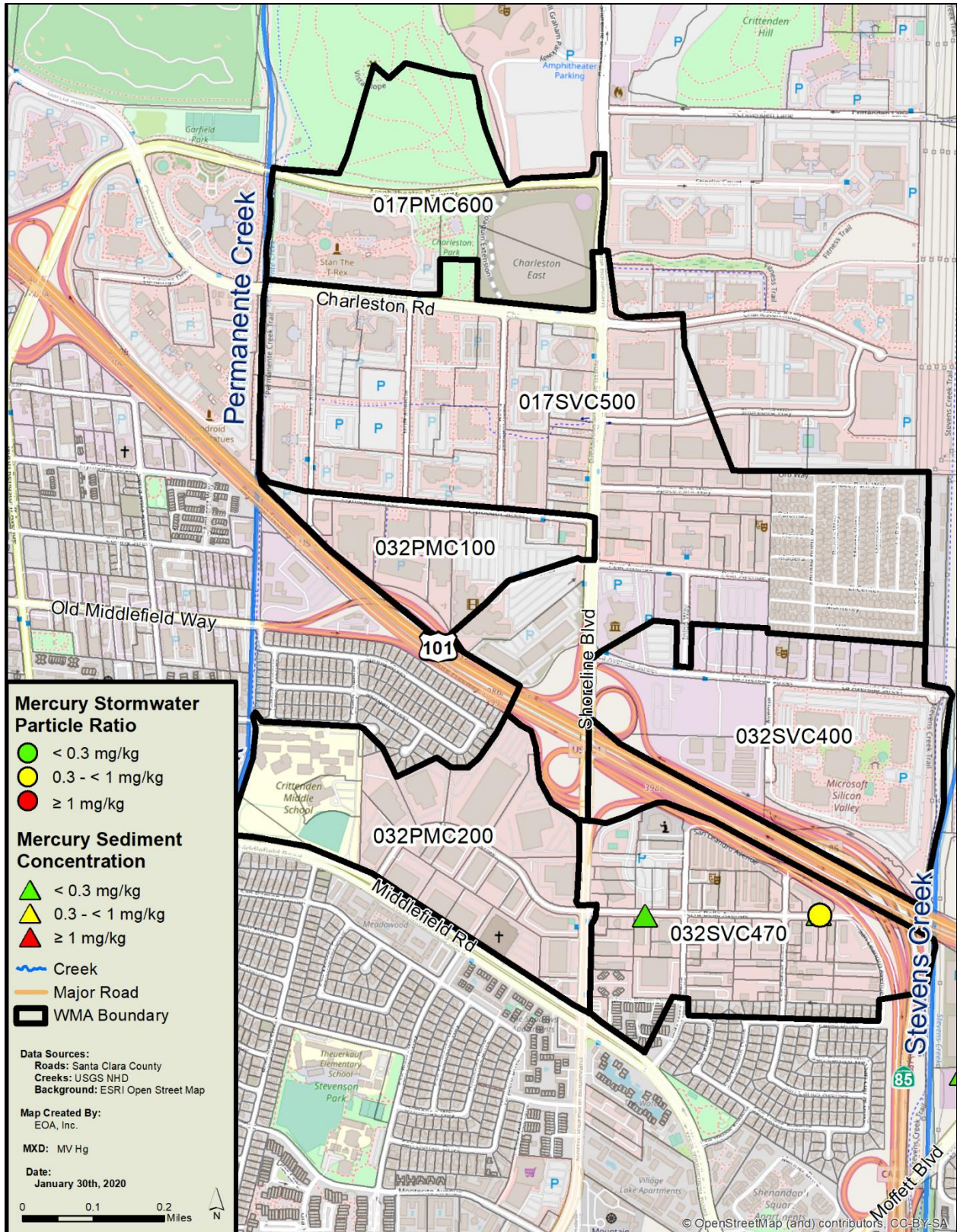


Figure 4.26. Mercury in street dirt and MS4 sediment concentrations and stormwater particle ratios measured in the Mountain View WMA investigation area in WY 2015 through WY 2019.

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.

SCVURPPP Pollutants of Concern Monitoring to Support Source Identification

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	
<i>High-Priority WMAs</i>	19	4,948	39	9	Elevated PCBs were found in MS4 sediment and/or stormwater samples
<i>Catchments of Interest - Screened with MS4 Sediment samples ONLY</i>	43	12,512	67	0	Elevated PCBs were not found in MS4 sediment; stormwater samples may need to be collected for confirmation
<i>Catchments of Interest - Screened with BOTH Stormwater and MS4 Sediment samples</i>	40	19,395	74	47	Elevated PCBs not found in MS4 sediment or stormwater
<i>Catchments of Interest - Not Yet Screened</i>	45	13,595	0	0	No collected samples to-date
<i>Remaining Area in the Santa Clara Basin</i>		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

Prepared by

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San Francisco Estuary Institute

CONTRIBUTION NO. / XXX 2020

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.

Acknowledgements

We appreciate the support and guidance from members of the Sources, Pathways, and Loadings Workgroup of the RMP. The detailed work plan for this study was developed by the RMP Small Tributaries Loading Strategy (STLS) Team during a series of meetings in the summer of 2014, with slight modifications made 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.

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This report presents all available stormwater data¹ 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 km²), 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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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

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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

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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 County³ and 1 in Solano County. The drainage area for each sampling location ranged from 0.02 to 233 km² 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 km²) with a high degree of imperviousness (75% of watersheds/catchments were greater than 60% impervious). The percentage of old industrial⁴ 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 inch⁵ over 6 hours was forecast, sampling teams were deployed, ideally reaching the sampling site about one hour before the onset of rainfall⁶. 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.

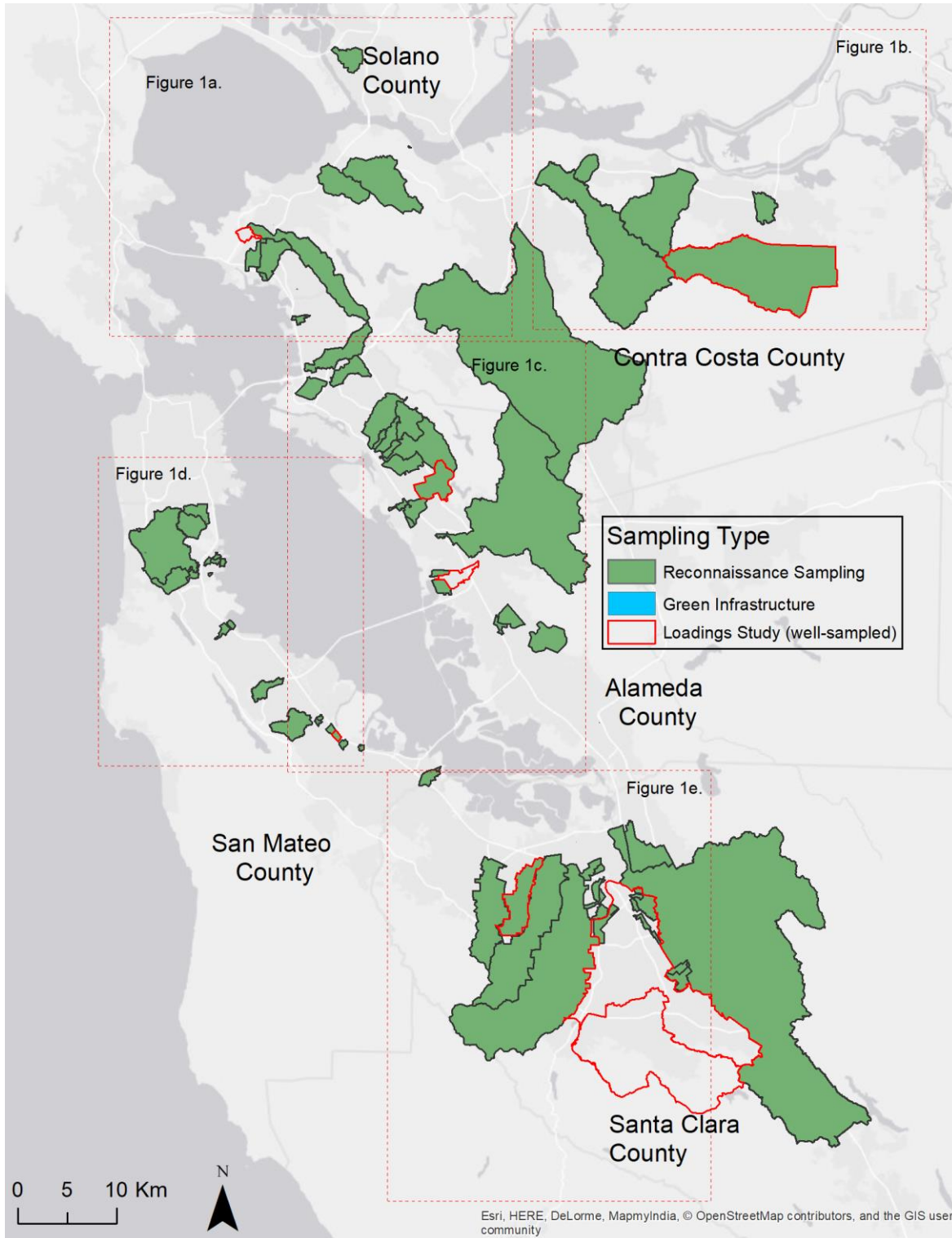


Figure 1. Watersheds/catchments sampled to date. Note: The drainage management areas (DMAs) of the Green Infrastructure sampling sites are so small they are not visible, though they are given a numeric map key identifier.

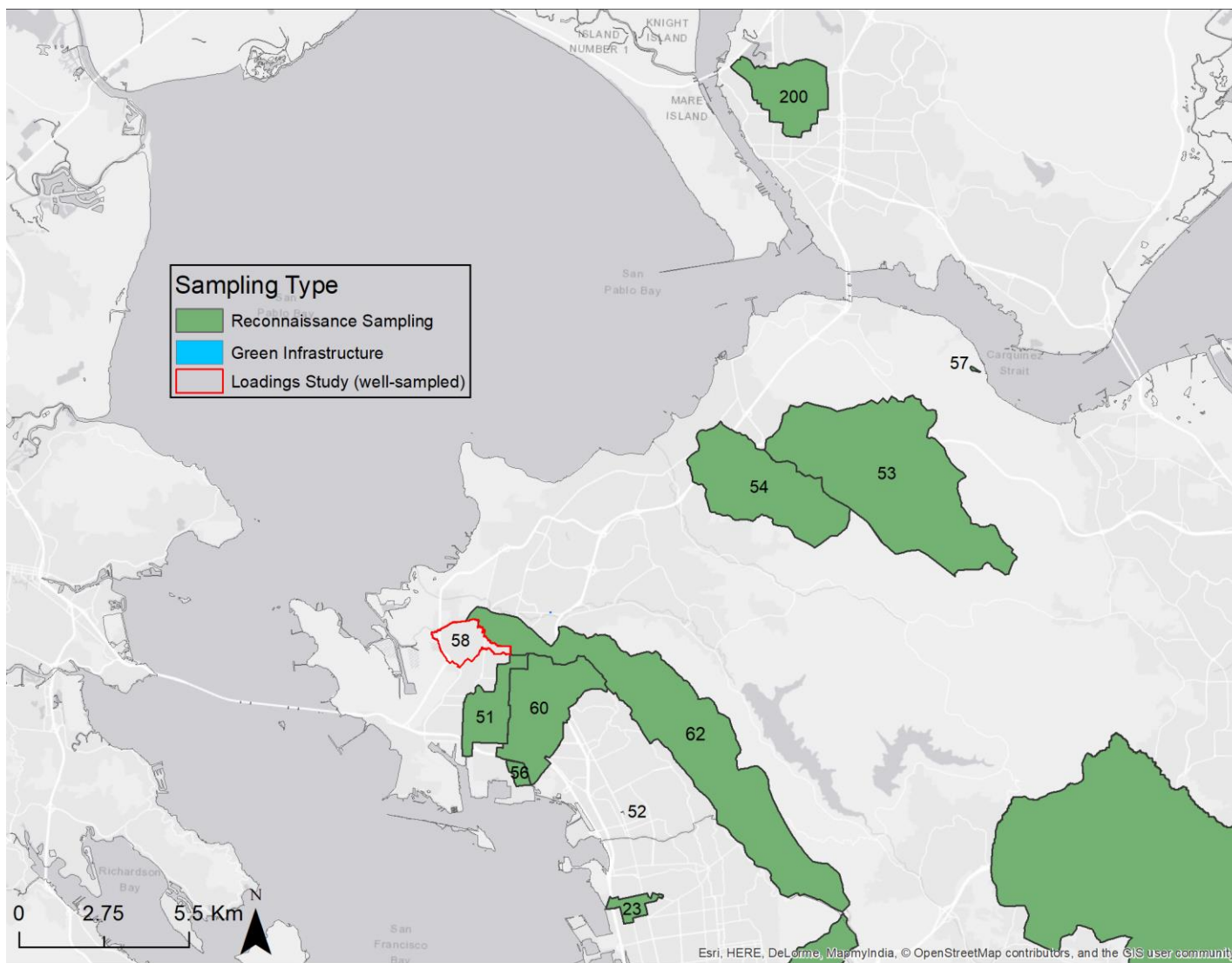


Figure 1a. Watershed boundaries of sites sampled in western Contra Costa County and Solano County. Note: The drainage management areas (DMAs) of the Green Infrastructure sampling sites are so small they are not visible, though they are given a numeric map key identifier. See Table 1 for information on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

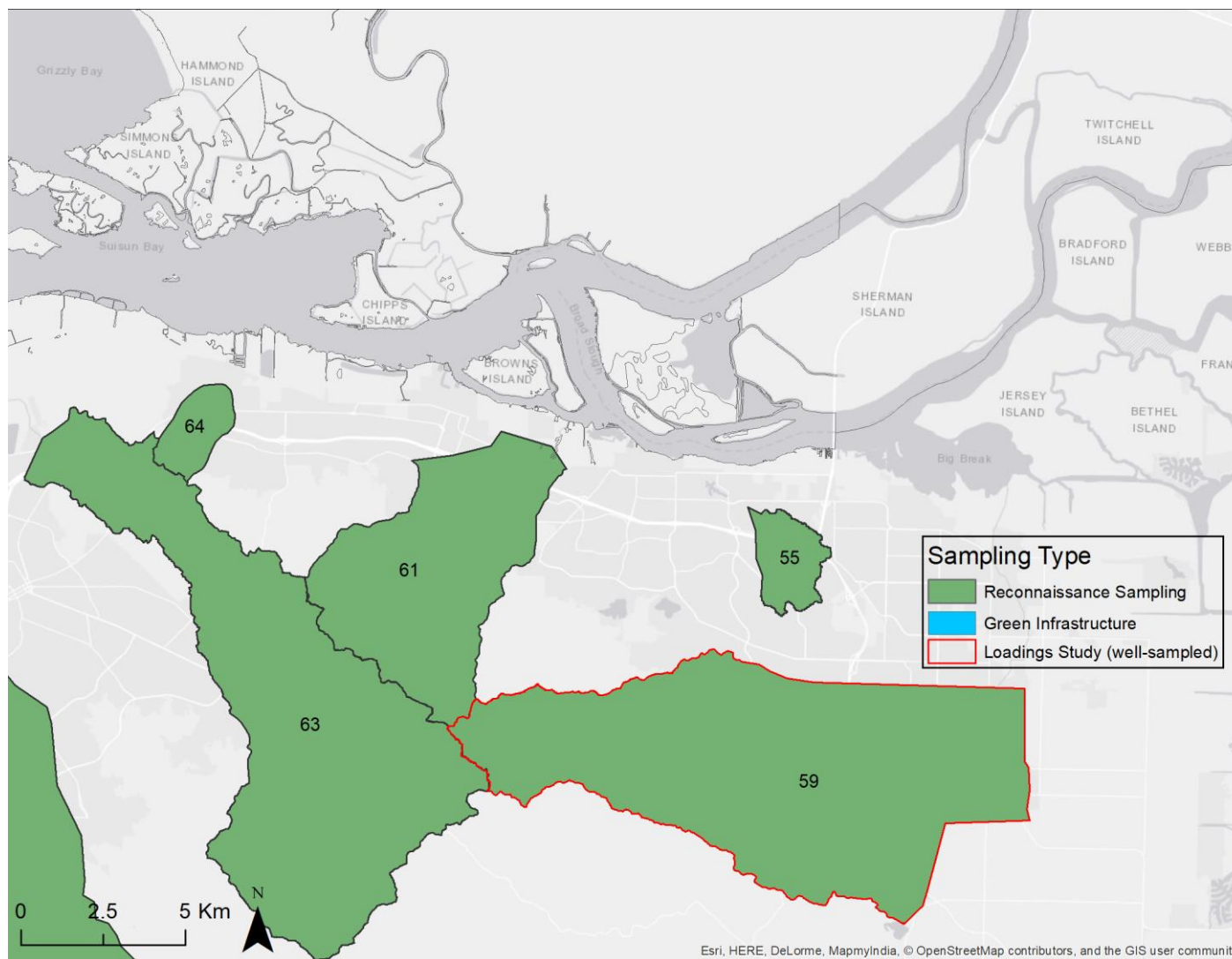


Figure 1b. Watershed boundaries of sites sampled in eastern Contra Costa County. Note: The drainage management areas (DMAs) of the Green Infrastructure sampling sites are so small they are not visible, though they are given a numeric map key identifier. See Table 1 for information on each numbered watershed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

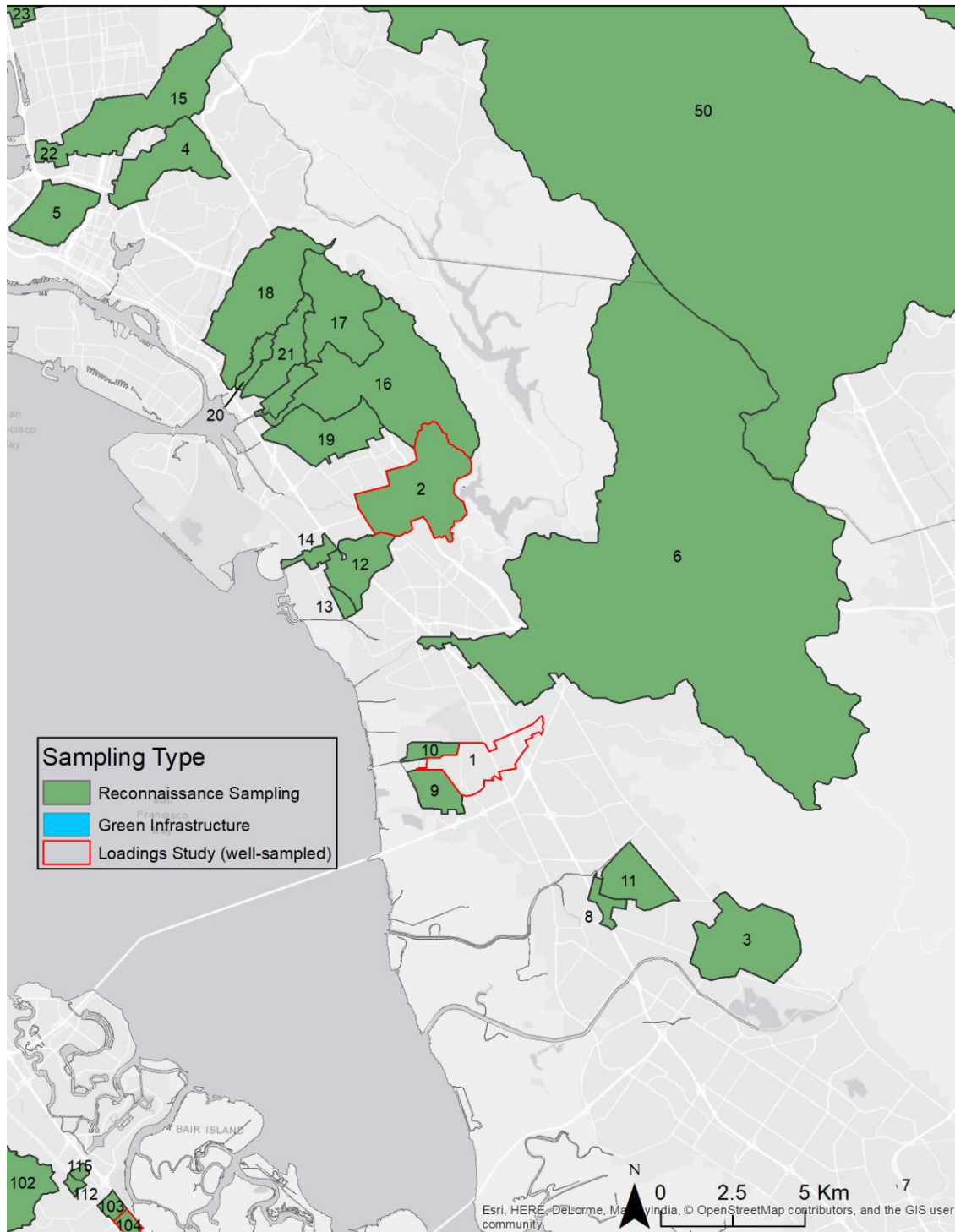


Figure 1c. Watershed boundaries of sites sampled in Alameda County. Note: The drainage management areas (DMAs) of the Green Infrastructure sampling sites are so small they are not visible, though they are given a numeric map key identifier. See Table 1 for information on each numbered watershed or drainage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

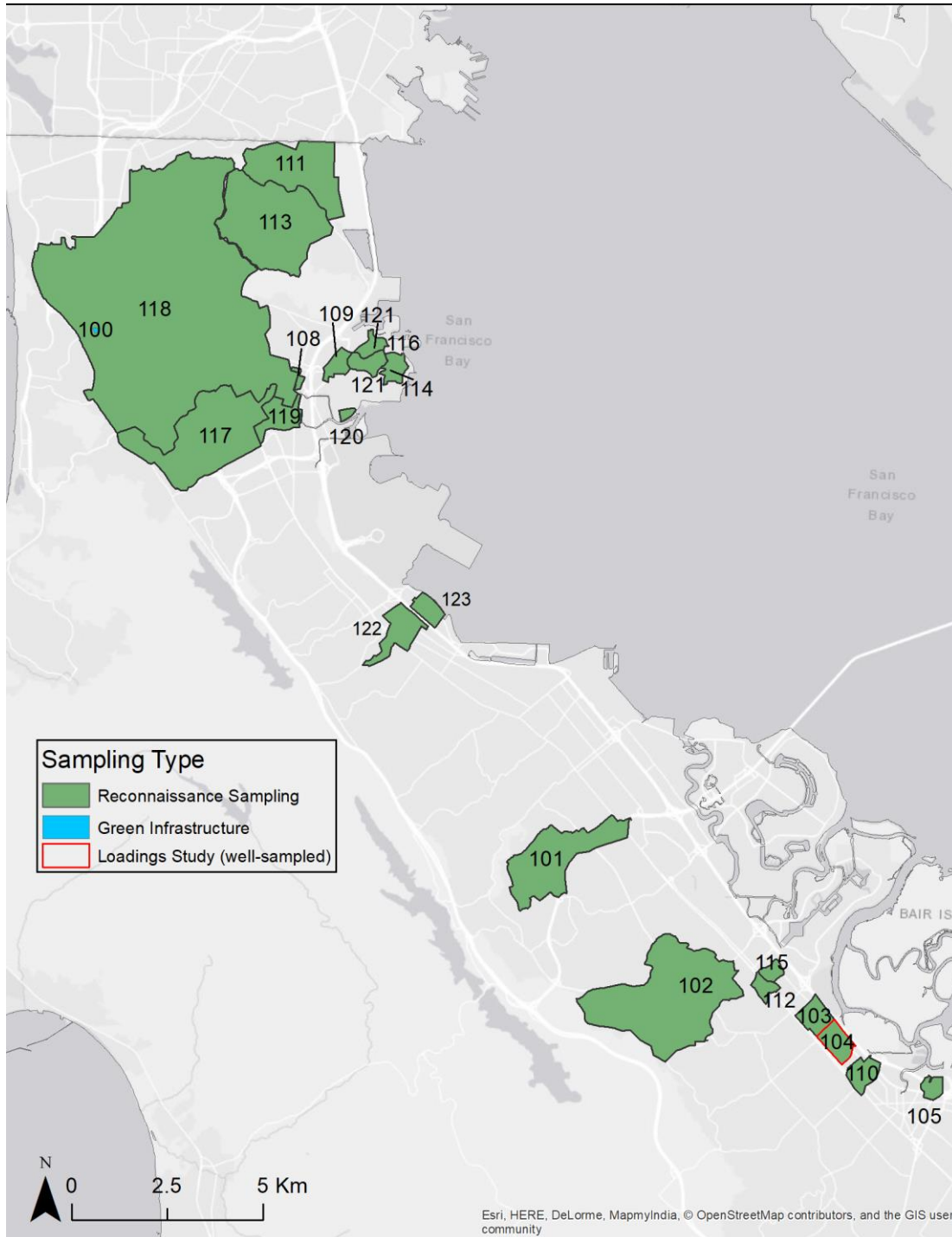


Figure 1d. Watershed boundaries of sites sampled in northern San Mateo County. Note: The drainage management areas (DMAs) of the Green Infrastructure sampling sites are so small they are not visible, though they are given a numeric map key identifier. See Table 1 for information on each numbered watershed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

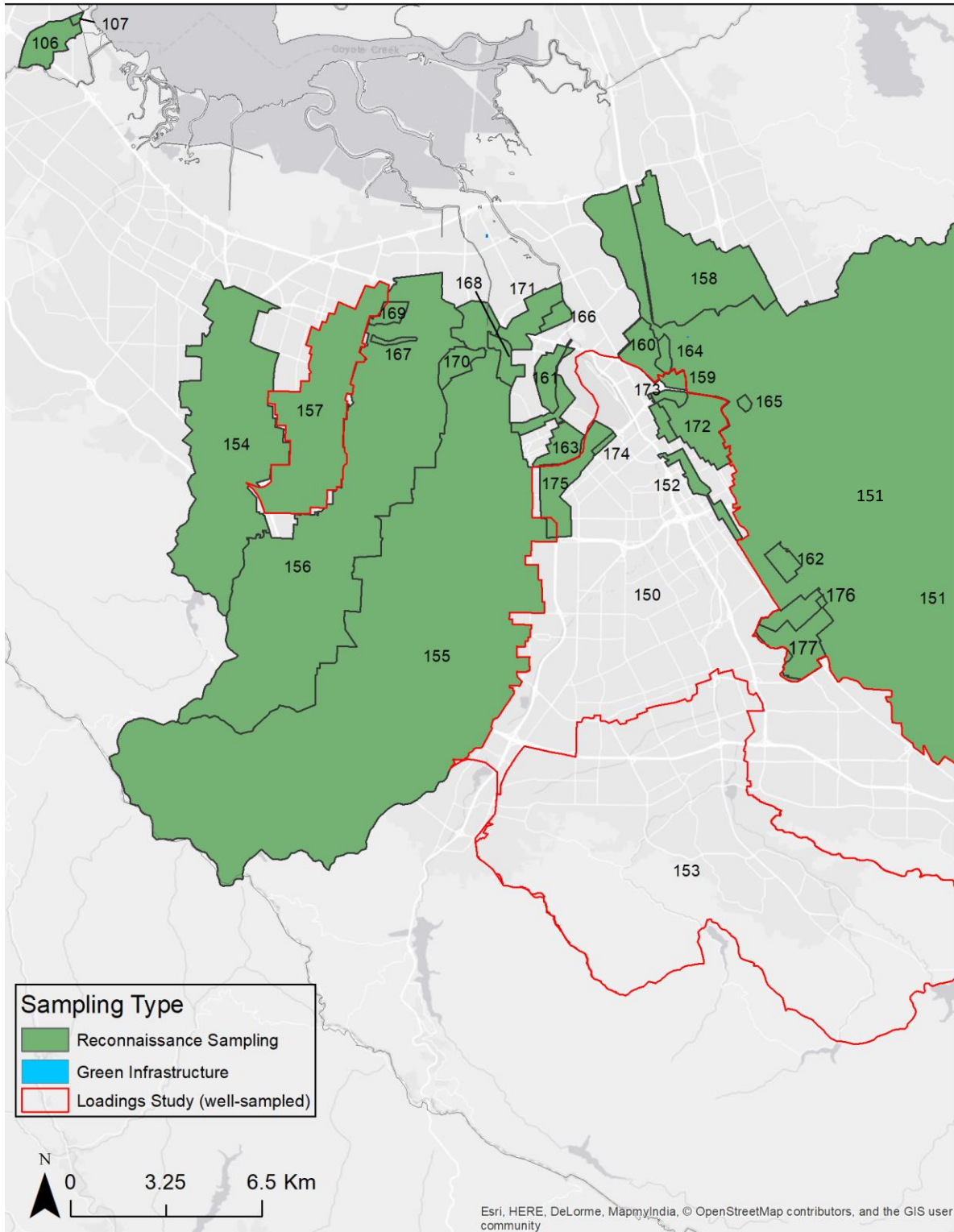


Figure 1e. Watershed boundaries of sites sampled in Santa Clara County. Note: The drainage management areas (DMAs) of the Green Infrastructure sampling sites are so small they are not visible, though they are given a numeric map key identifier. See Table 1 for information on each numbered watershed or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

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Table 1. Key characteristics of the 91⁷ 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.

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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.

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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%

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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	Seaboard 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	Seaboard 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%

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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.

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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

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				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):

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

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 data¹⁰ 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 88¹¹ 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
10 th Percentile	26	68	NA	21	34
25 th Percentile	45	81	57	26	46
50 th Percentile	77	133	61	44	73
75 th Percentile	143	203	123	83	118
90 th 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 sites¹² 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.

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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 km³ (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).

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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
Seaboard 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
Seaboard 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

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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
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

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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
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

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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
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

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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
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.

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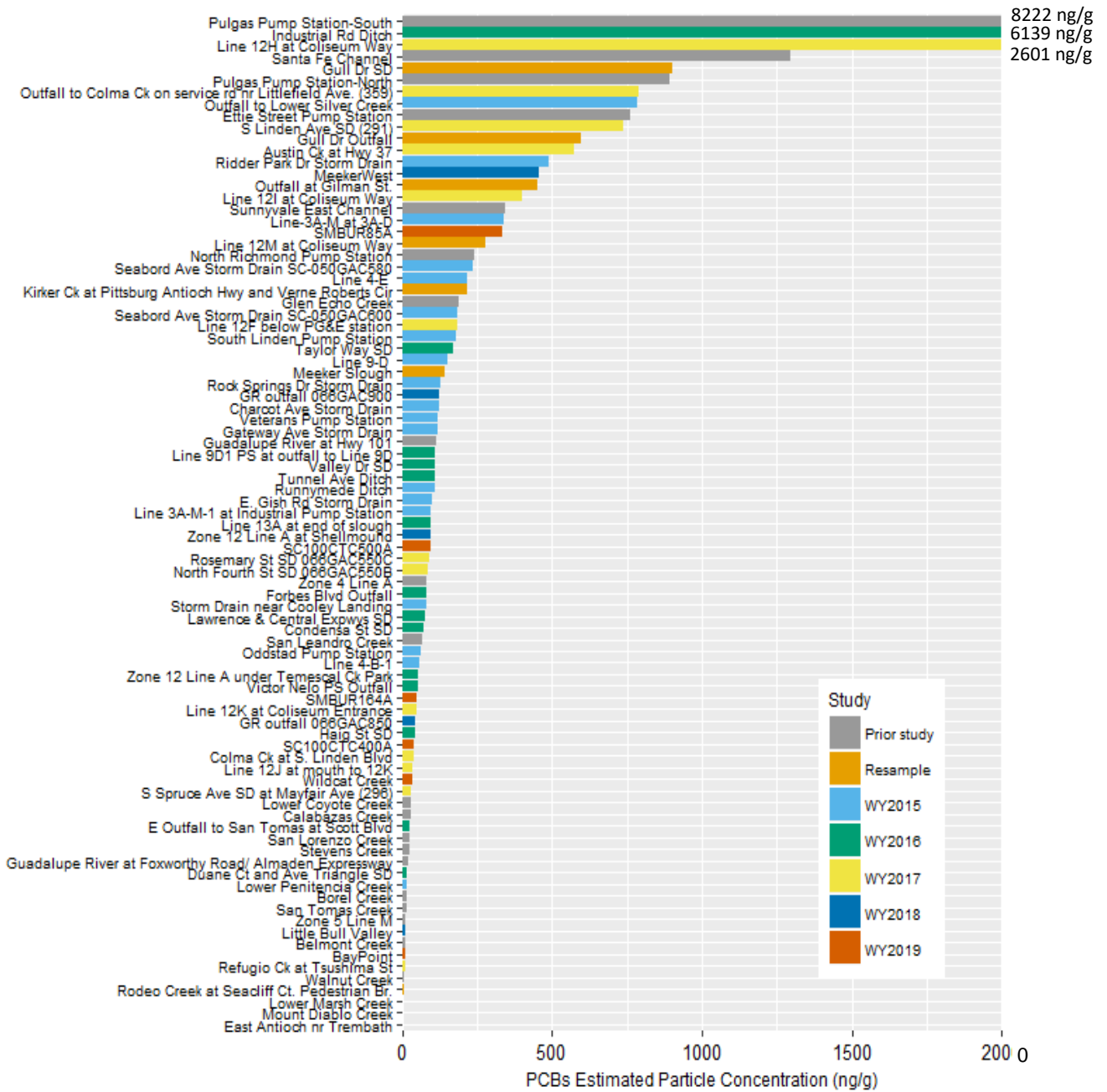


Figure 3. PCB estimated particle concentrations (EPCs) for watershed and catchment sampling sites measured in water years 2003-2019 (where more than one storm was sampled at a site, the reported concentration is the average of the storm composite samples). Note that PCB EPCs for Pulgas Pump Station-South (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.

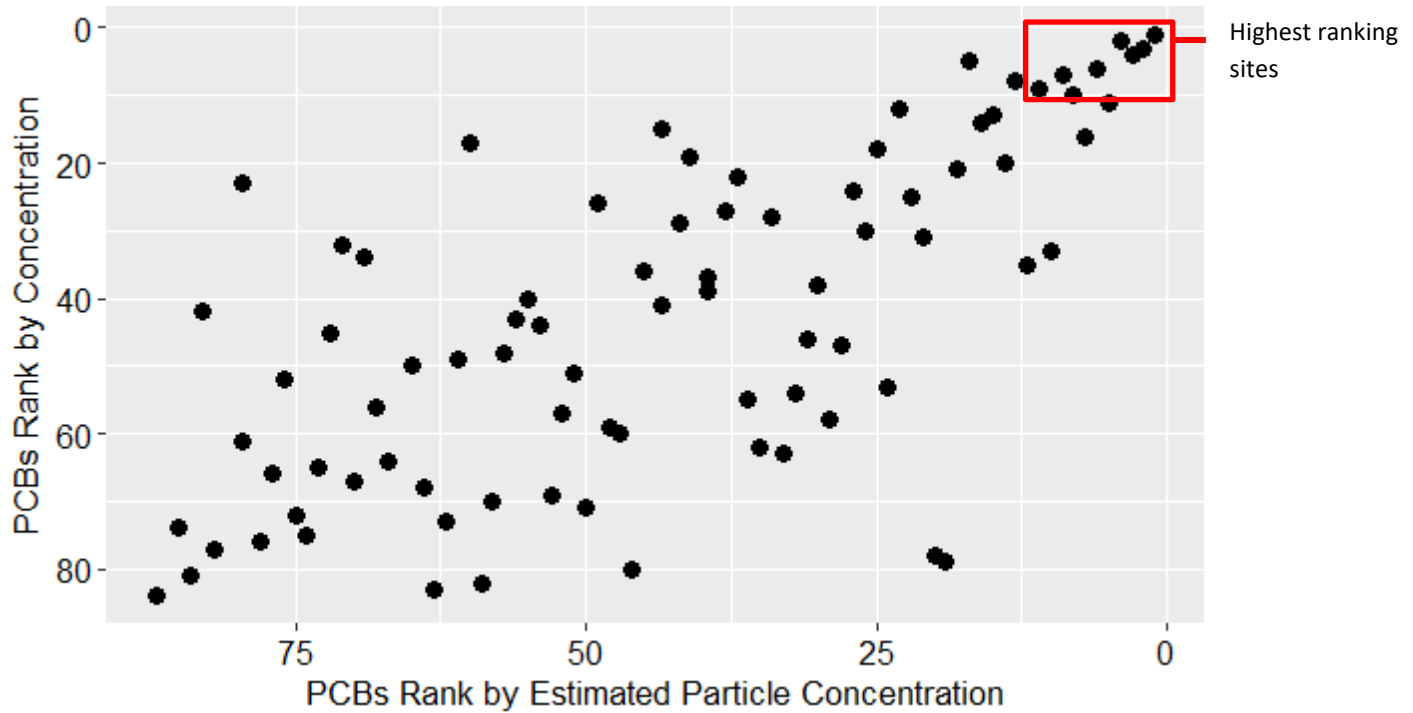


Figure 4. Comparison of site rankings for PCBs based on estimated particle concentrations (EPCs) and on water concentrations. 1 = highest rank; 84 = lowest rank.

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 km³ (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 deposition¹⁴.

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 $\mu\text{g}/\text{m}^2/\text{y}$ (Tsai and Hoenicke, 2001) and 4.4 $\mu\text{g}/\text{m}^2/\text{y}$ (Steding and Flegal, 2002), and Tsai and Hoenicke reported a total (wet + dry) deposition rate of 18-21 $\mu\text{g}/\text{m}^2/\text{y}$. 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 ($8 \text{ ng/L}/0.18 = 44 \text{ ng/L}$).

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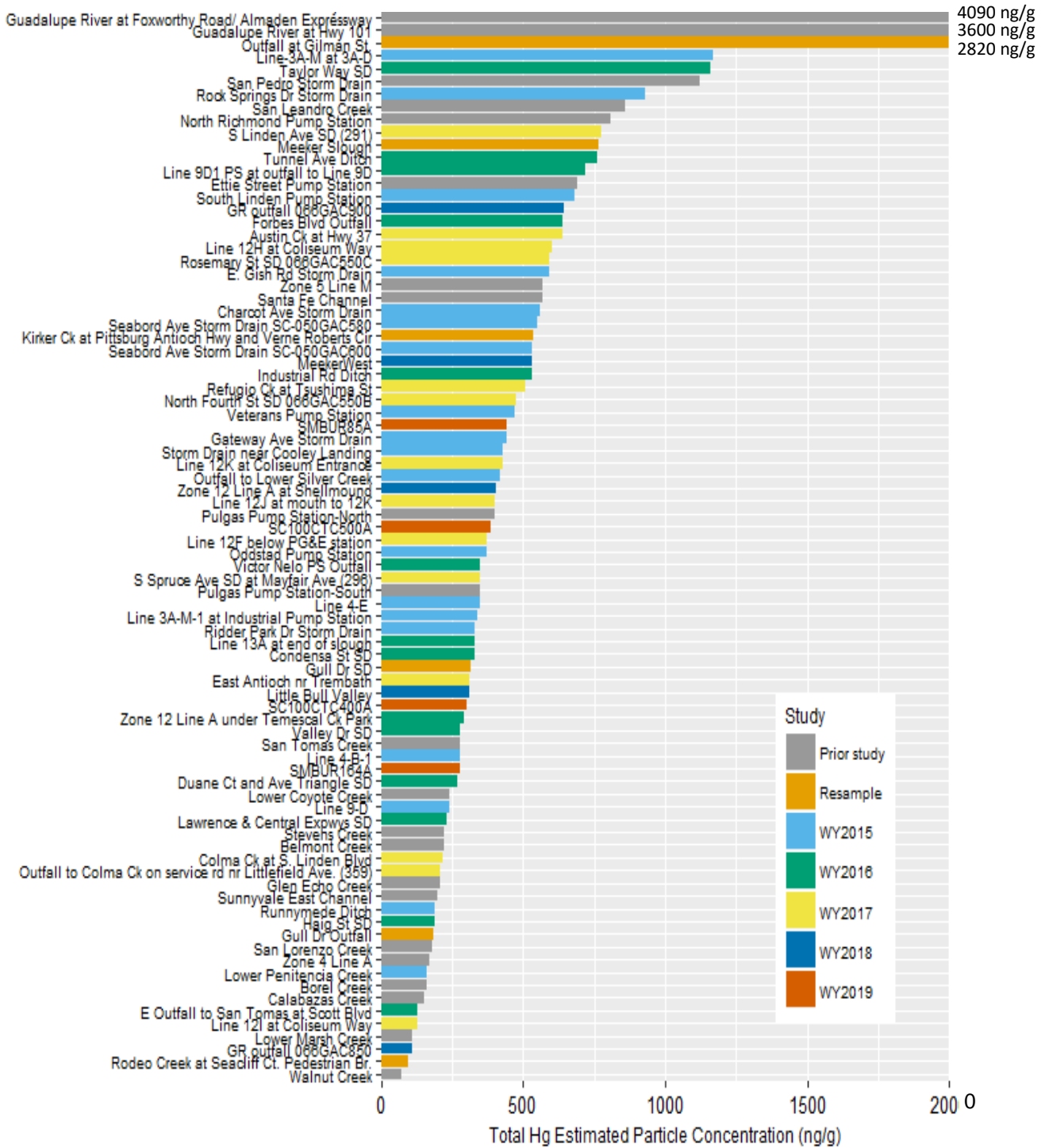


Figure 5. All sampling locations measured to date (water years 2003-2019) ranked by total mercury (HgT) estimated particle concentrations (EPCs). The sample count represented by each bar in the graph is provided in Appendix D.

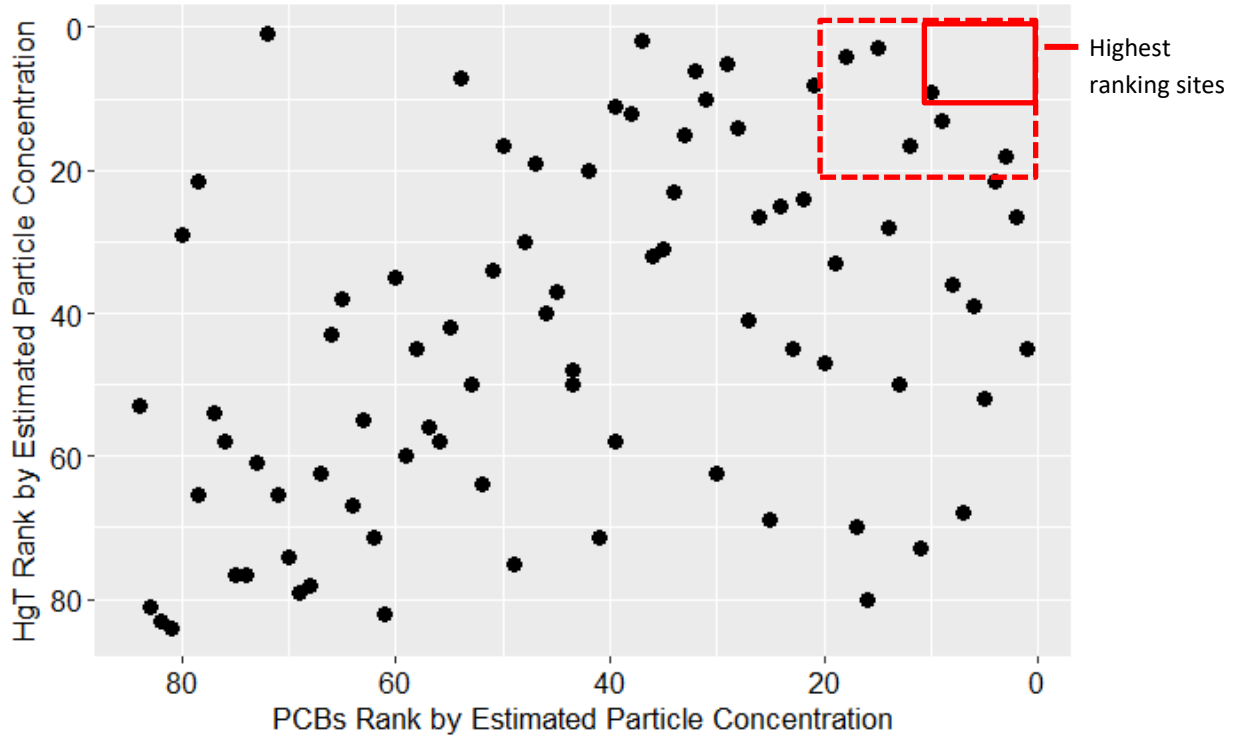


Figure 6. Comparison of site rankings for PCB and total mercury (HgT) estimated particle concentrations (EPCs). 1 = highest rank; 84 = lowest rank. One watershed ranks in the top 10 for both PCBs and HgT (in the solid red box), and seven watersheds rank in the top 20 for both pollutants (in the dashed red box).

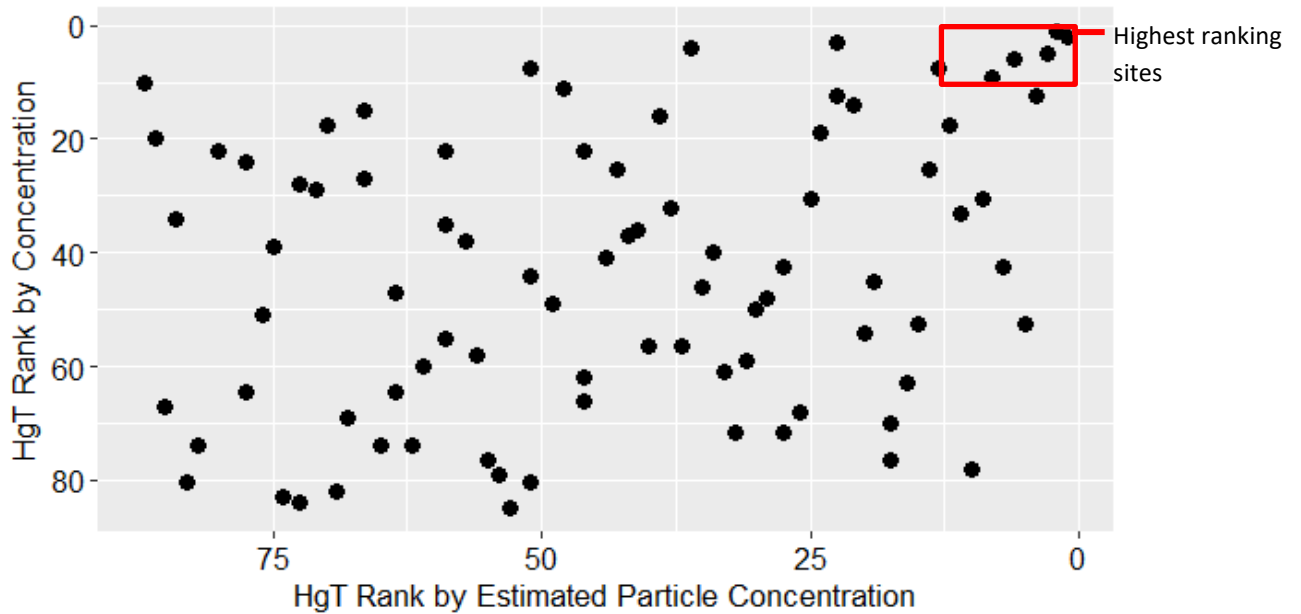


Figure 7. Comparison of site rankings for total mercury (HgT) estimated particle concentrations and water concentrations. 1 = highest rank; 85 = lowest rank.

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 2017¹⁵ 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.

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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 variables¹⁶ (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 analysis¹⁷. 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.

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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

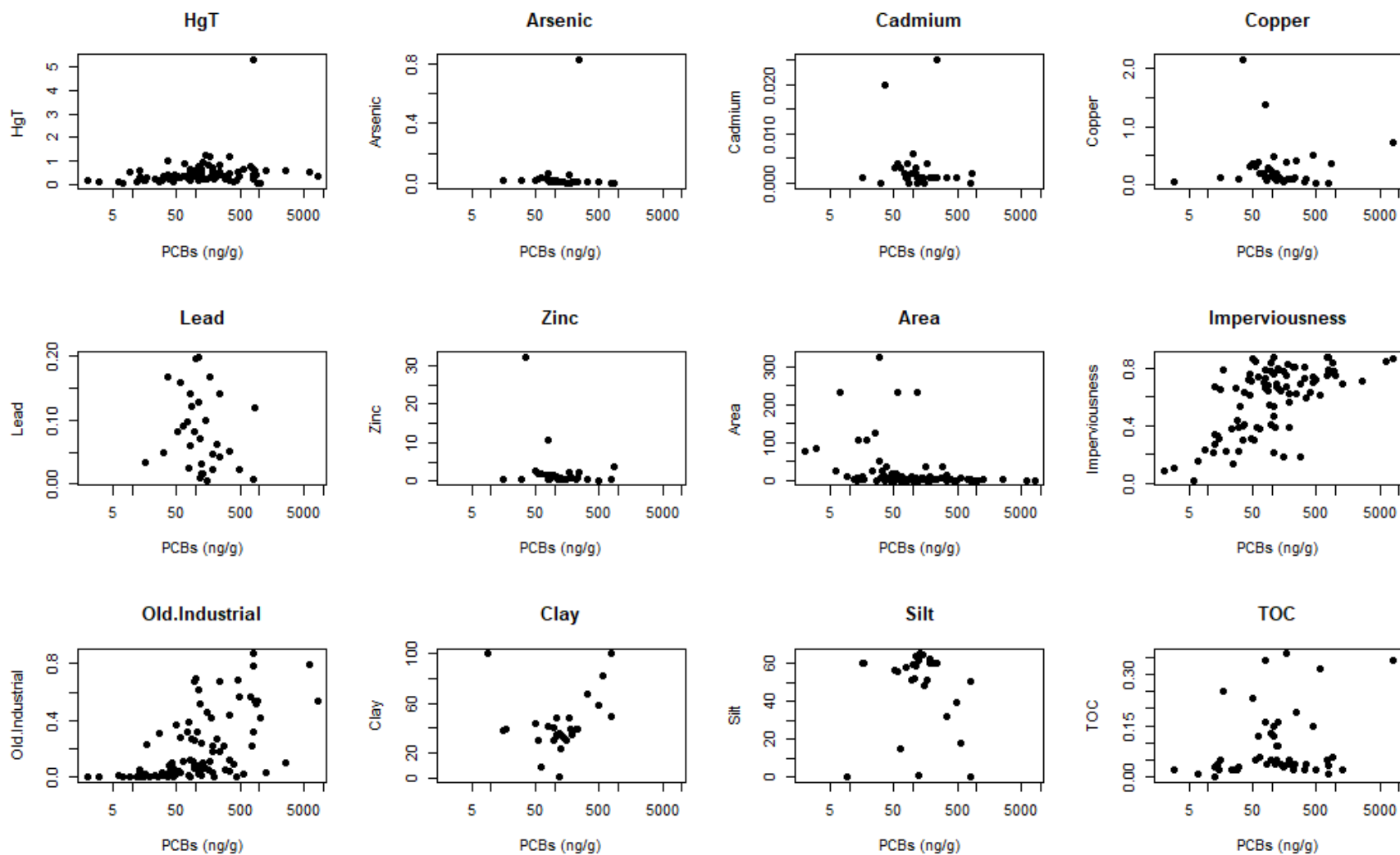


Figure 8. Relationships between observed estimated particle concentrations (EPCs) of PCBs and total mercury (HgT), trace elements, and impervious land cover, old industrial land use, grainsize (clay and silt), and total organic carbon (TOC).

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 data¹⁹ 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 size²⁰. 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.

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

Appendix B – Sampling Method Development

The monitoring protocol implemented in WYs 2015-2019 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

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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).

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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).

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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 its 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,

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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.

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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 CaCO₃), 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 CaCO₃), 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

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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

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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.

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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

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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

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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

SCVURPPP IMR Part D – Attachment D.4. PCBs and Mercury Data

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

SCVURPPP IMR Part D – Attachment D.4. PCBs and Mercury Data

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

SCVURPPP IMR Part D – Attachment D.4. PCBs and Mercury Data

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

SCVURPPP IMR Part D – Attachment D.4. PCBs and Mercury Data

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

SCVURPPP IMR Part D – Attachment D.4. PCBs and Mercury Data

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

SCVURPPP IMR Part D – Attachment D.4. PCBs and Mercury Data

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

SCVURPPP IMR Part D – Attachment D.4. PCBs and Mercury Data

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

SCVURPPP IMR Part D – Attachment D.4. PCBs and Mercury Data

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

SCVURPPP IMR Part D – Attachment D.4. PCBs and Mercury Data

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:



Prepared by:



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.

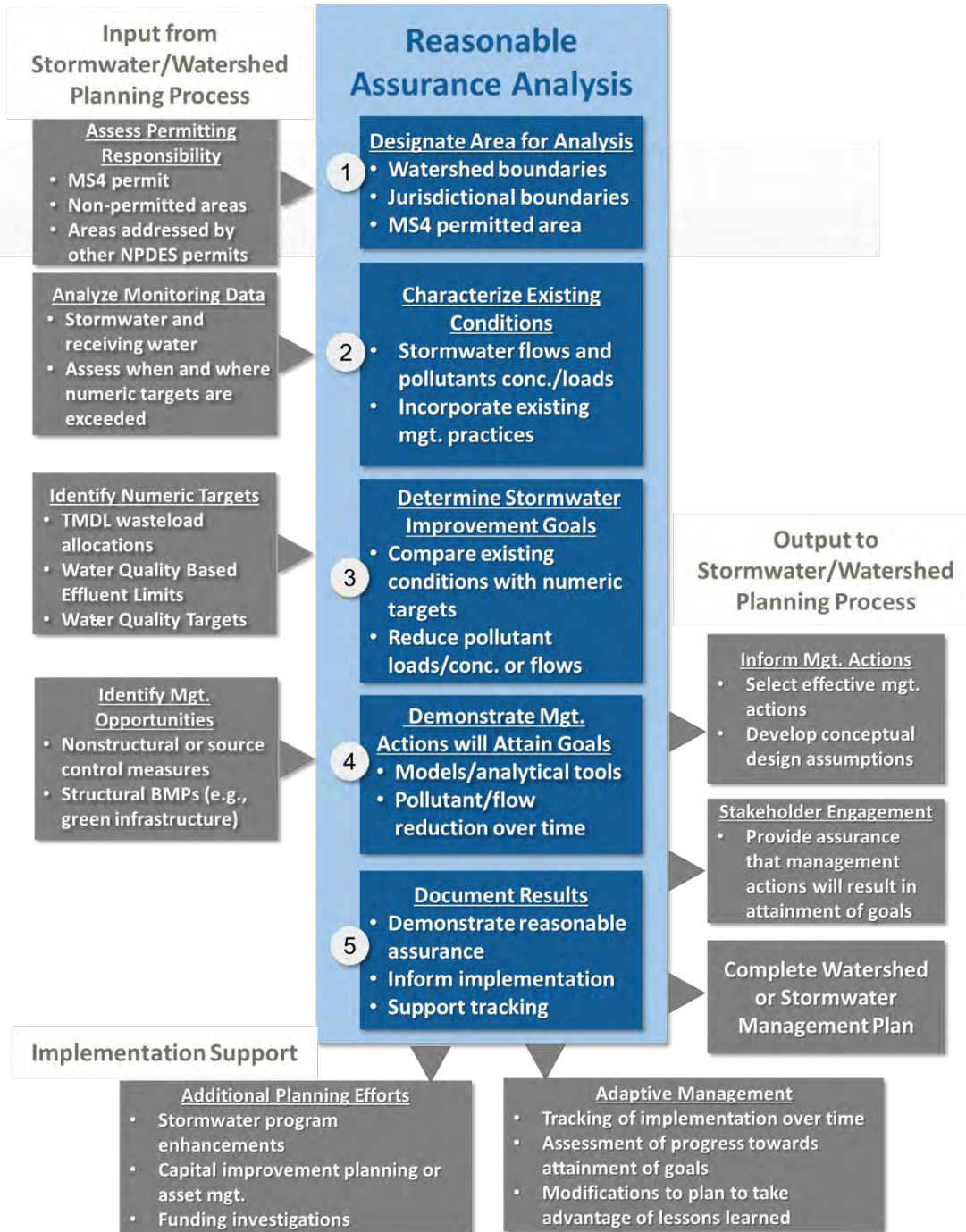


Figure 1-1. Reasonable Assurance Analysis process flow chart (USEPA 2017).

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.

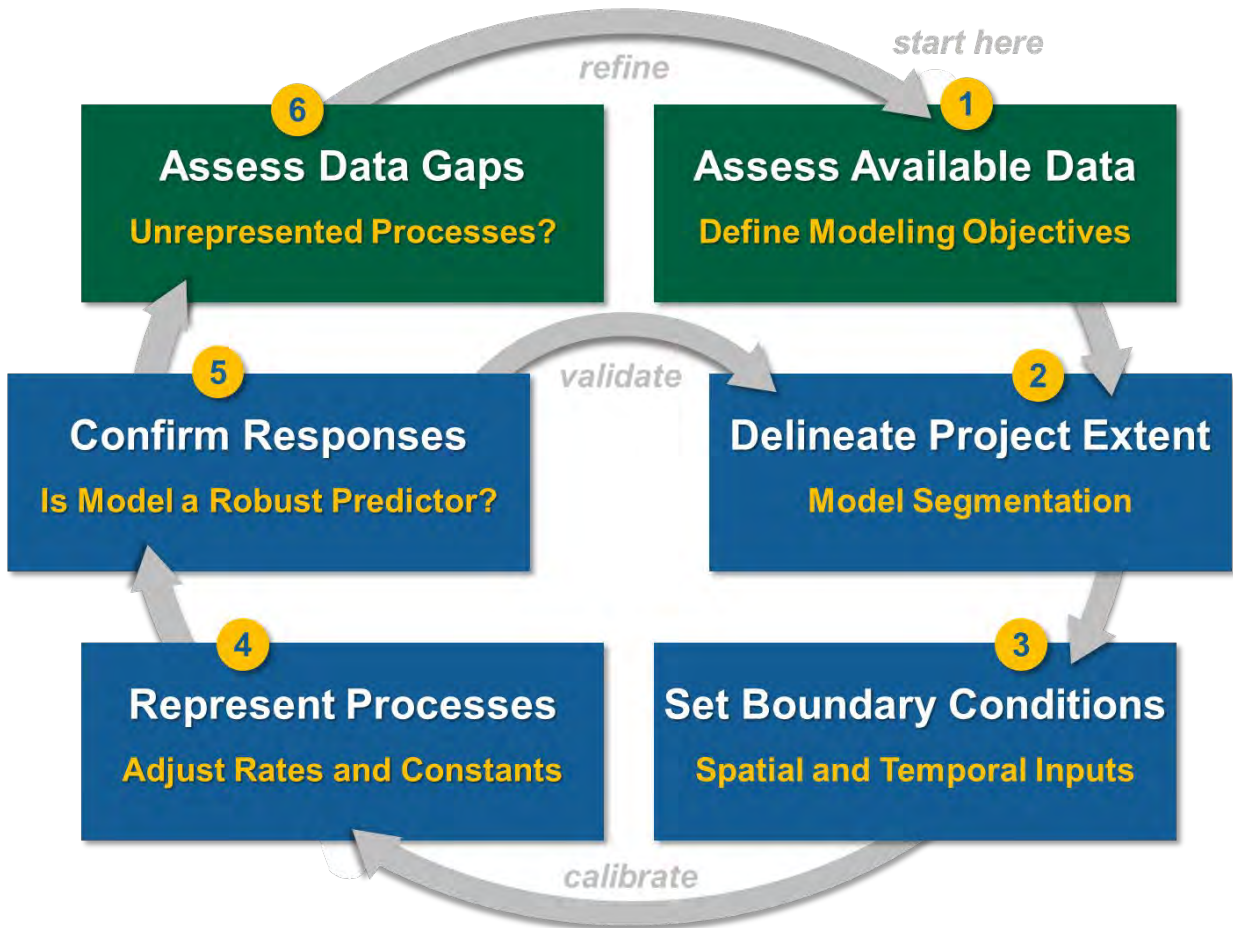


Figure 2-1. Conceptual schematic of a model development cycle.

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.

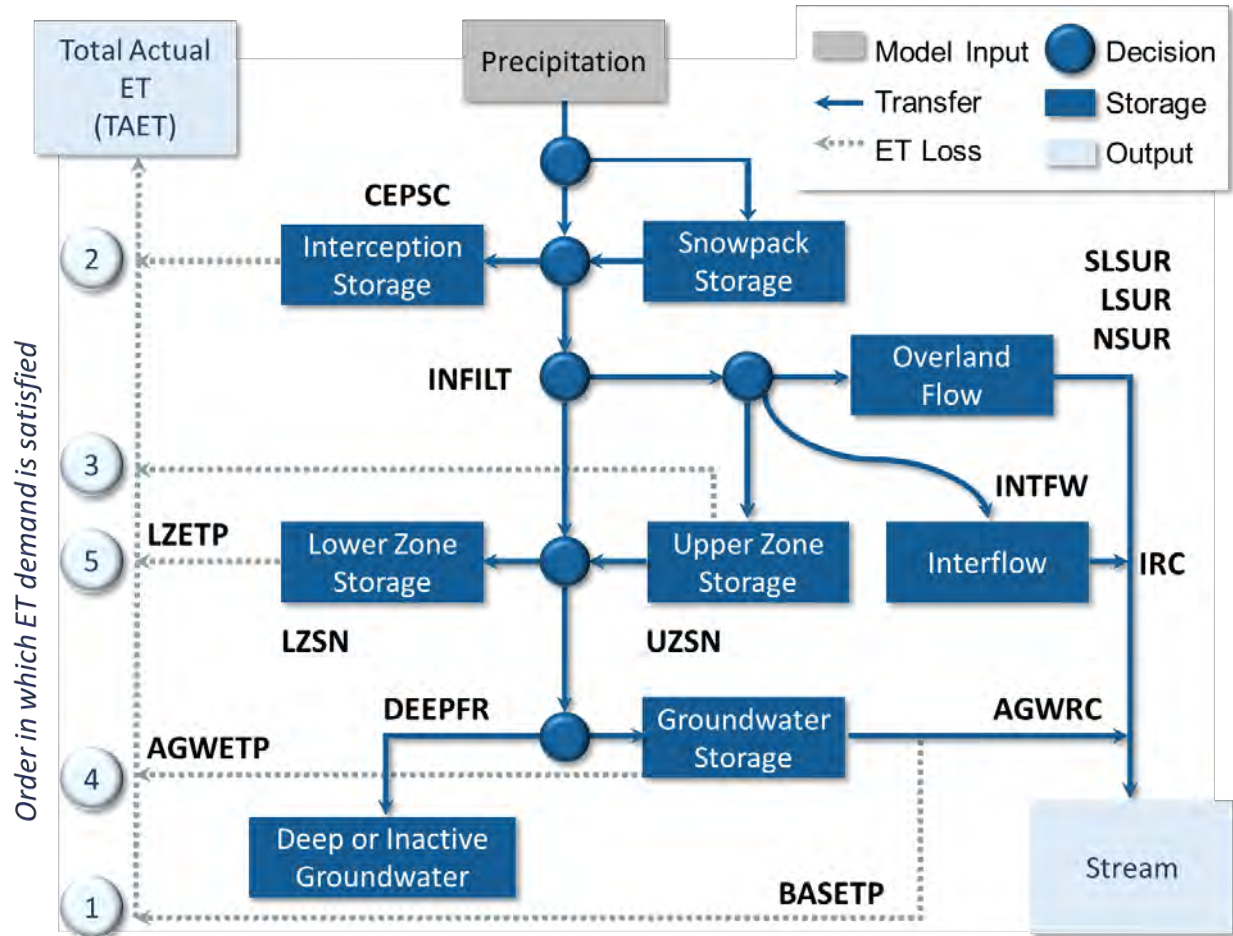


Figure 2-2. Hydrology model schematic (based on Stanford Watershed Model).

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.

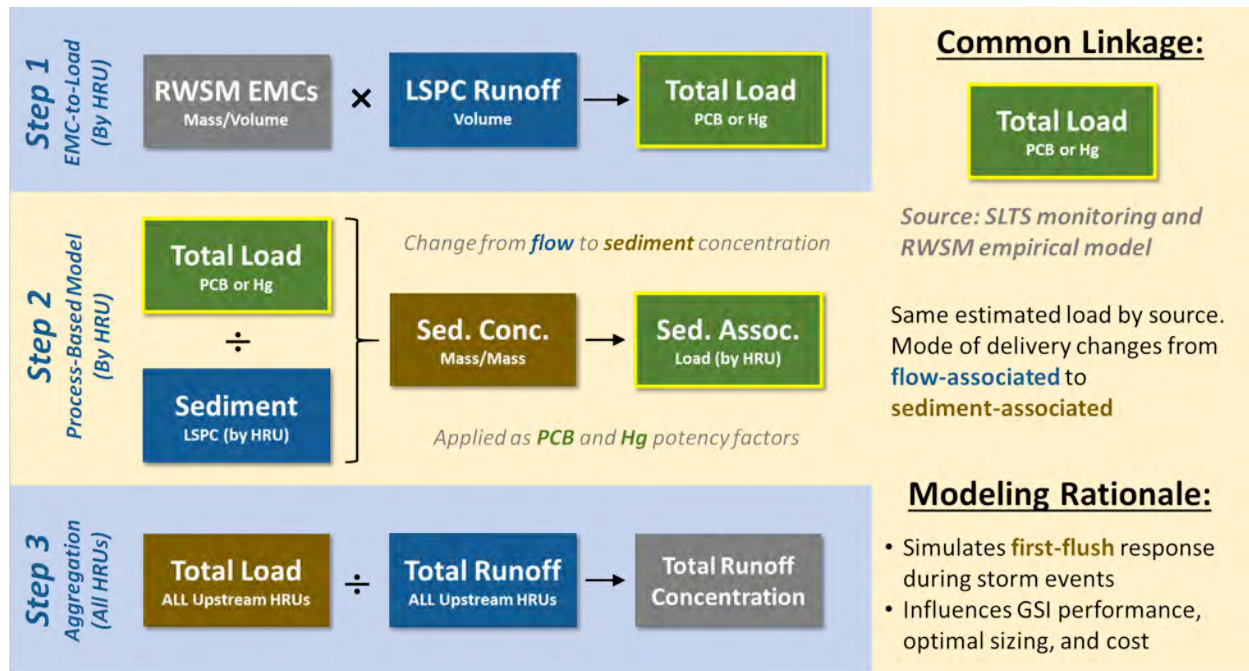


Figure 2-3. Schematic for deriving a process-based, sediment associated modeling approach for PCBs and mercury.

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.

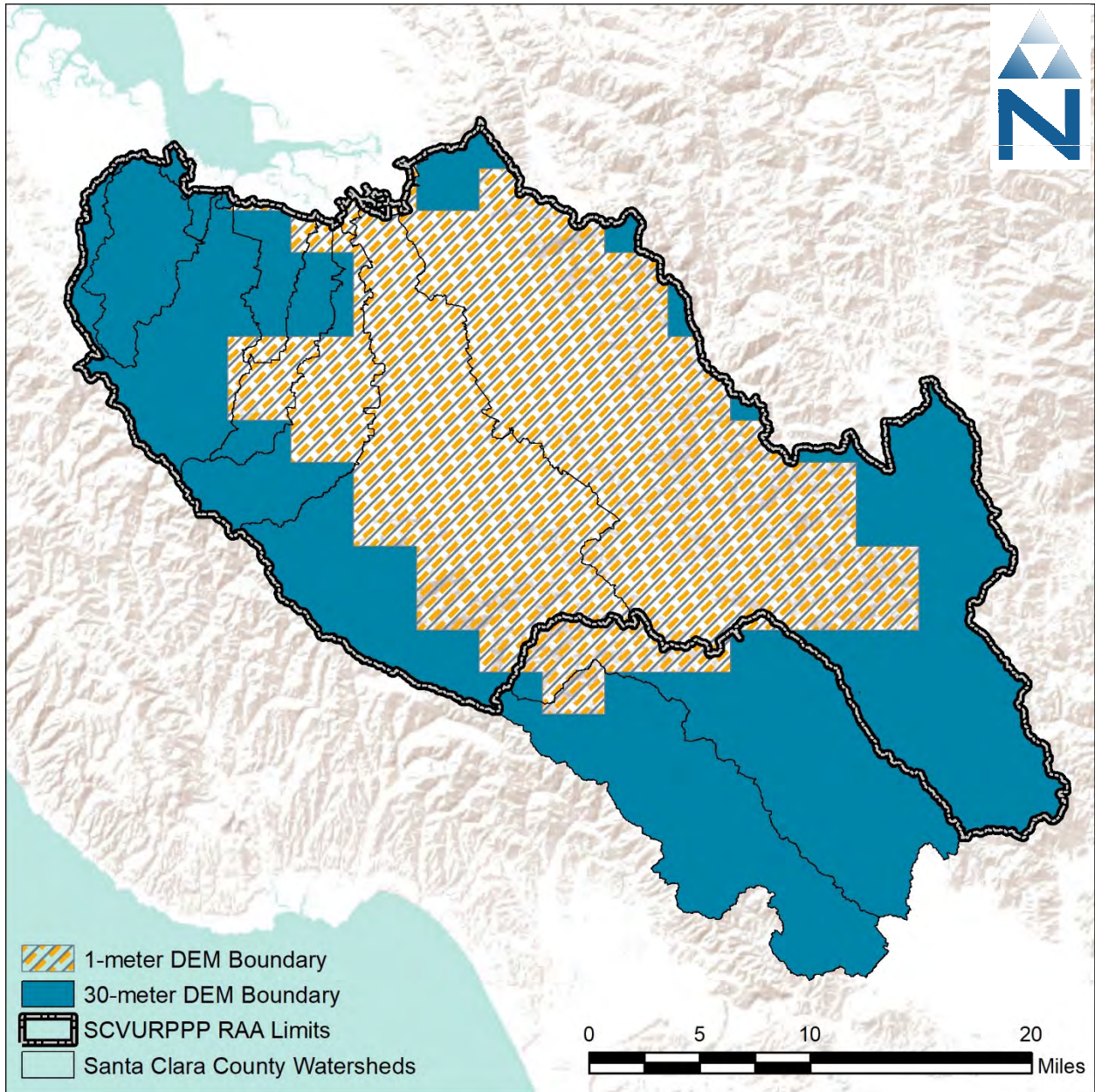


Figure 3-1. Spatial extent of the 1-meter (source: City of San José) and 30-meter (source: USGS) DEM data products.

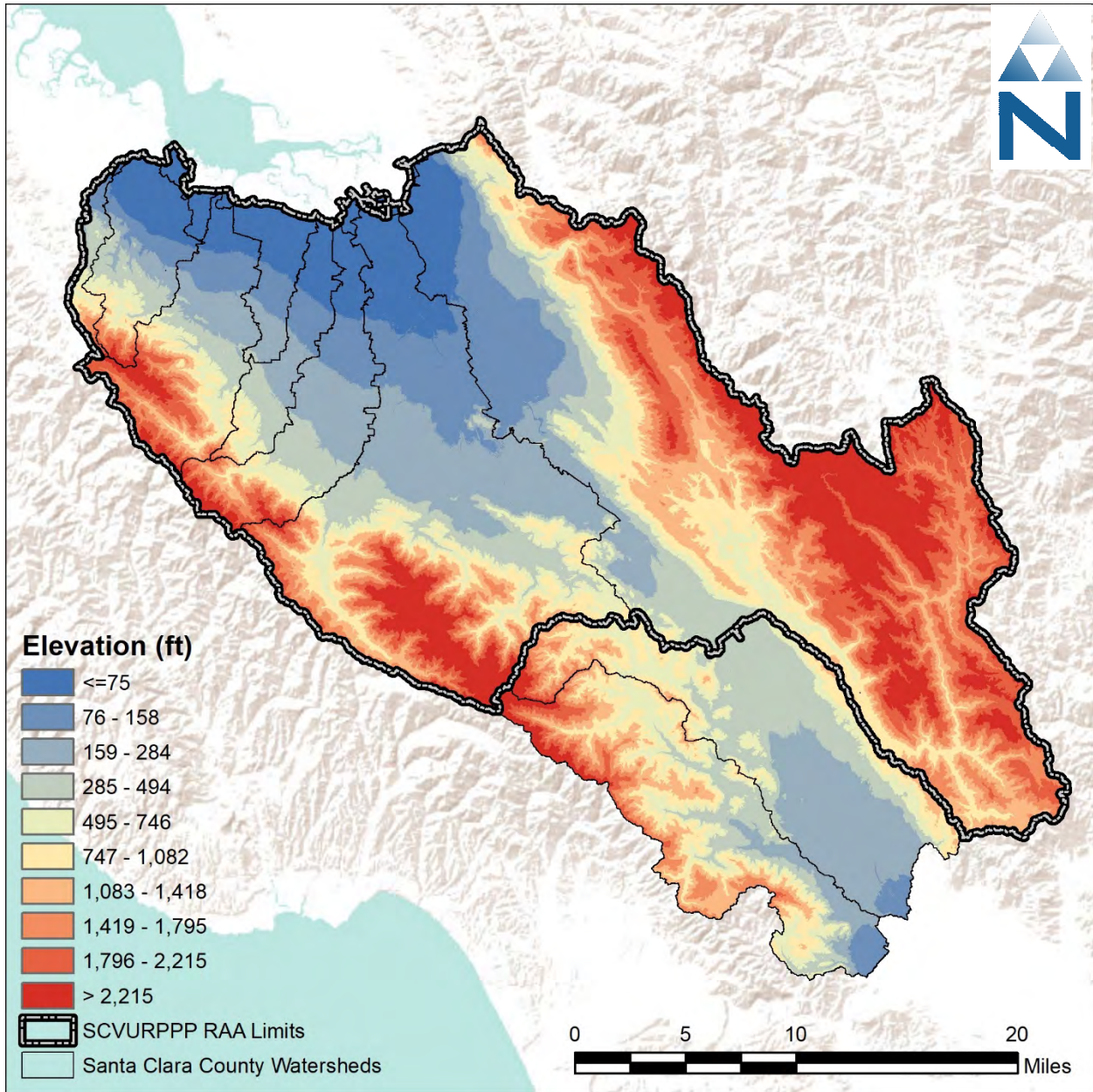


Figure 3-2. Elevation and Santa Clara County watershed boundaries.

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	--	--

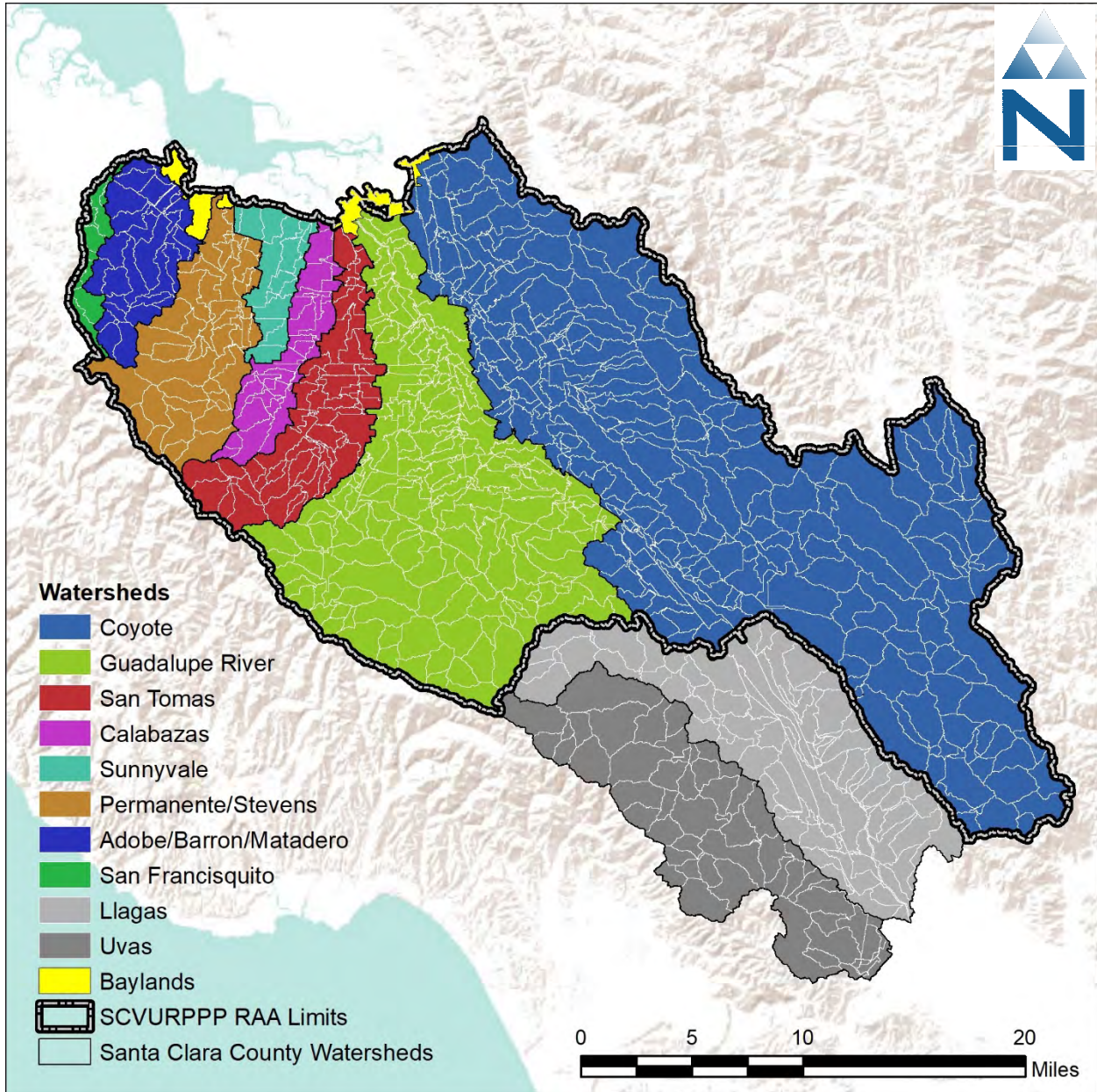


Figure 3-3. Santa Clara Basin watershed and subwatershed delineations.

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.

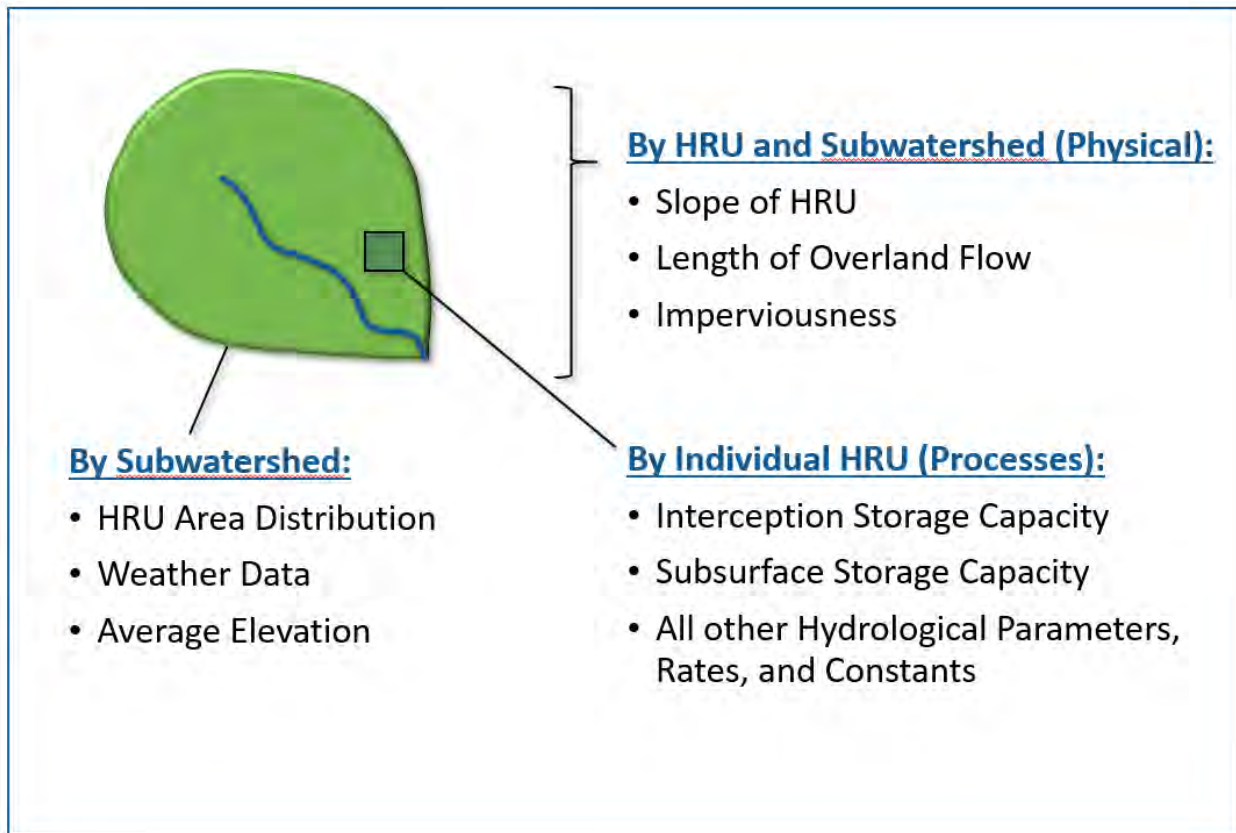


Figure 4-1. Organizational relationship of HRUs, subwatersheds, and model parameterization.

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.

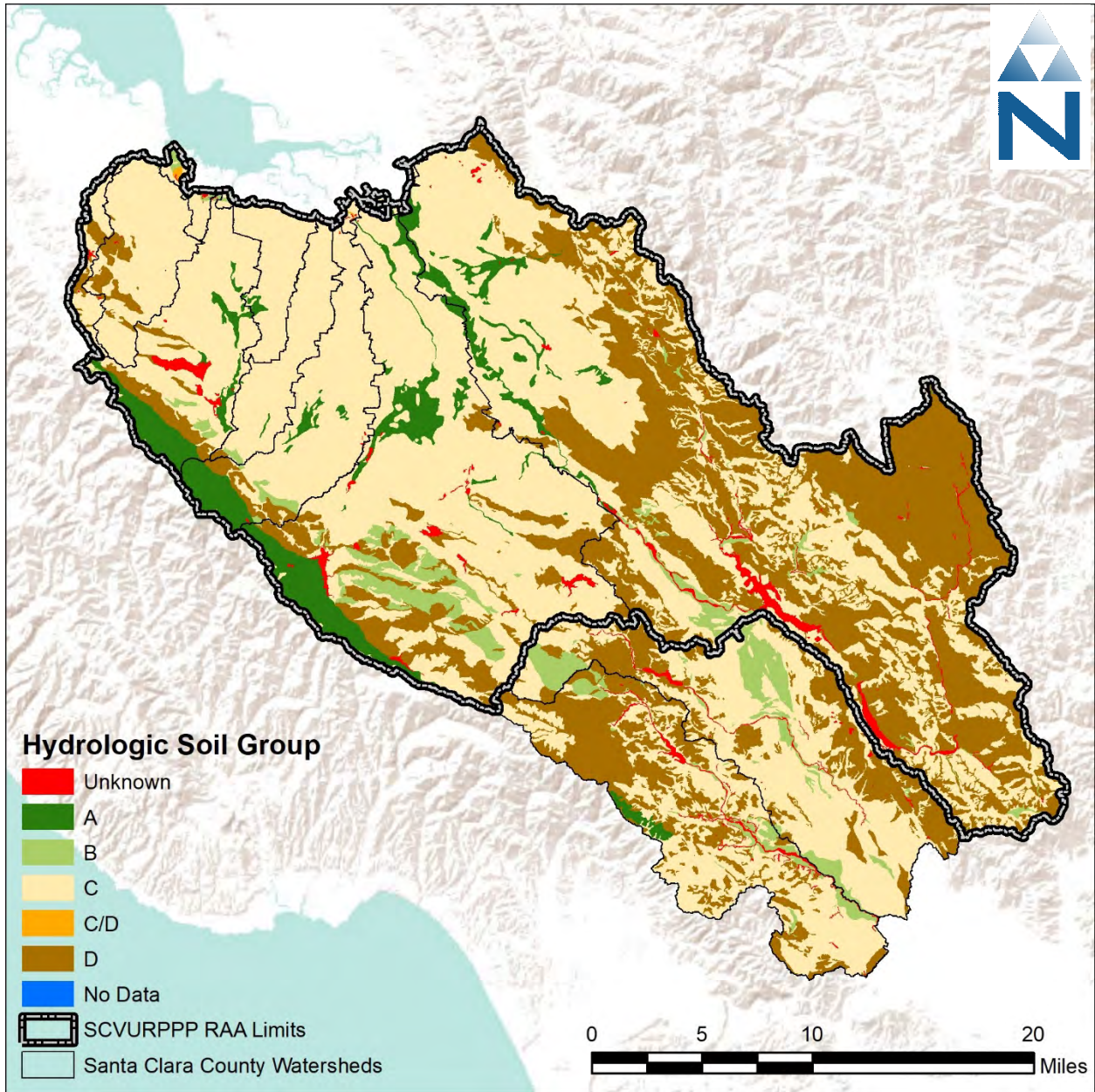


Figure 4-2. SSURGO hydrologic soil groups in the Santa Clara Basin.

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.

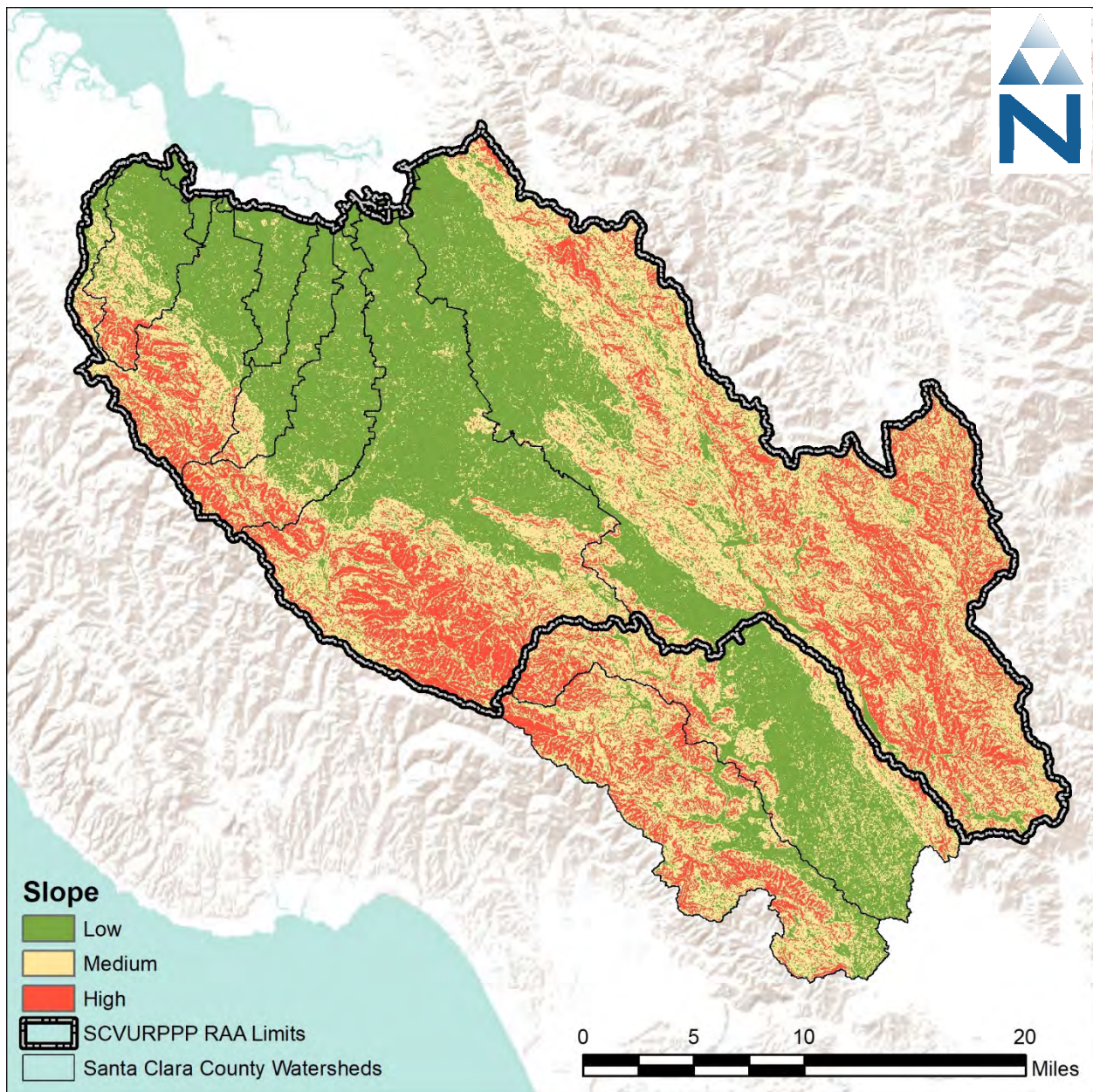


Figure 4-3. Map showing reclassified landscape slope groups.

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.

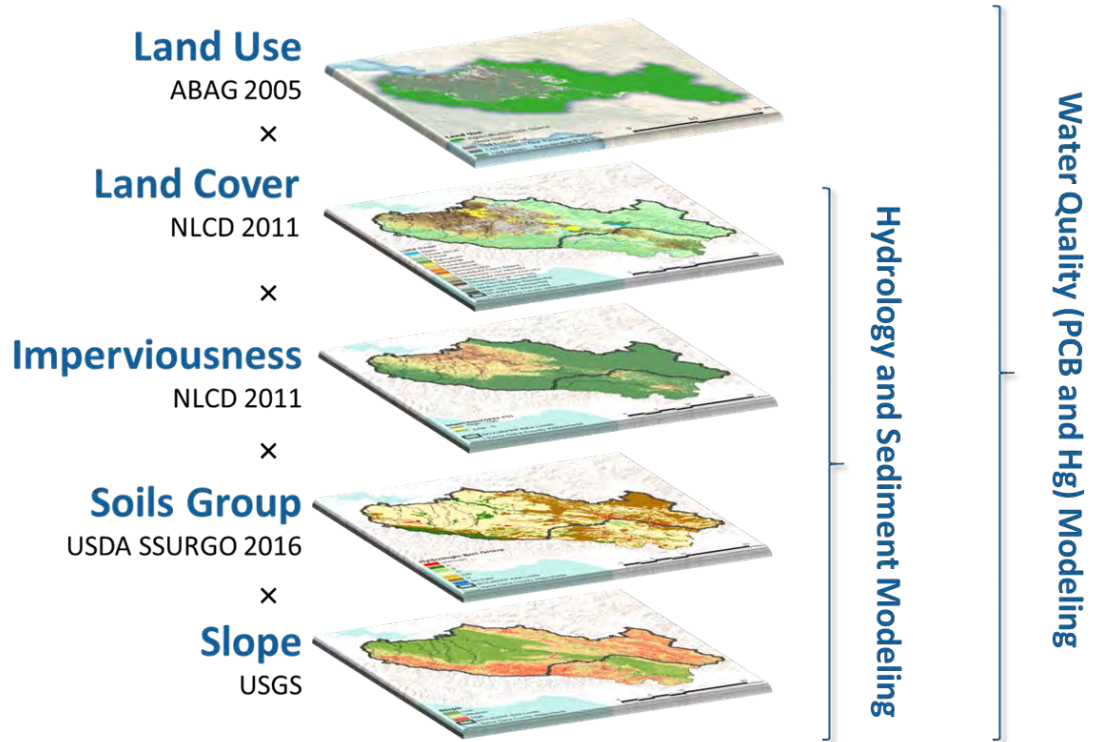


Figure 4-4. Key land characteristic datasets used to create HRUs.

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.

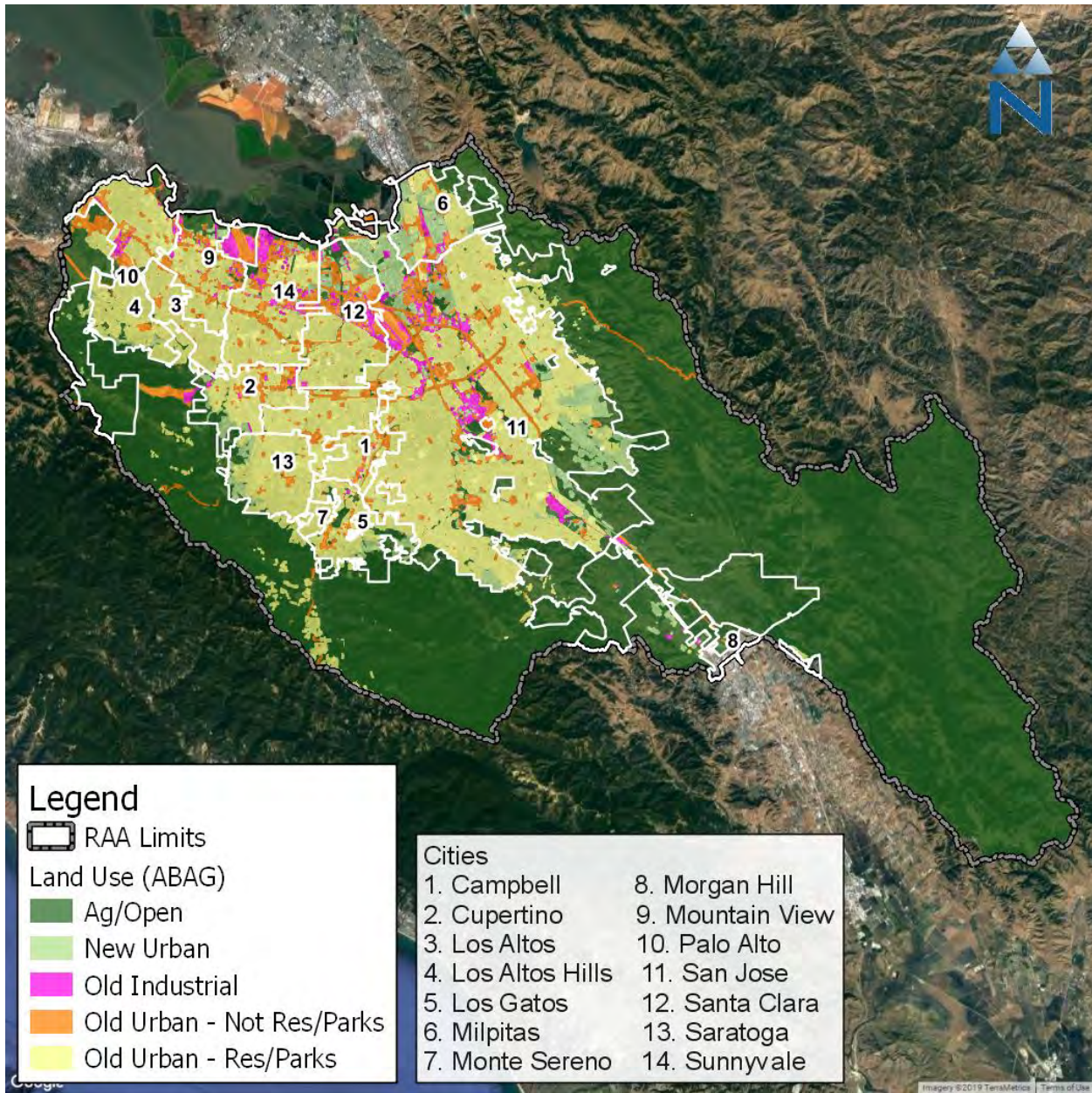


Figure 4-5. Land use source categories developed by SCVURPPP for use with RWSM.

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.

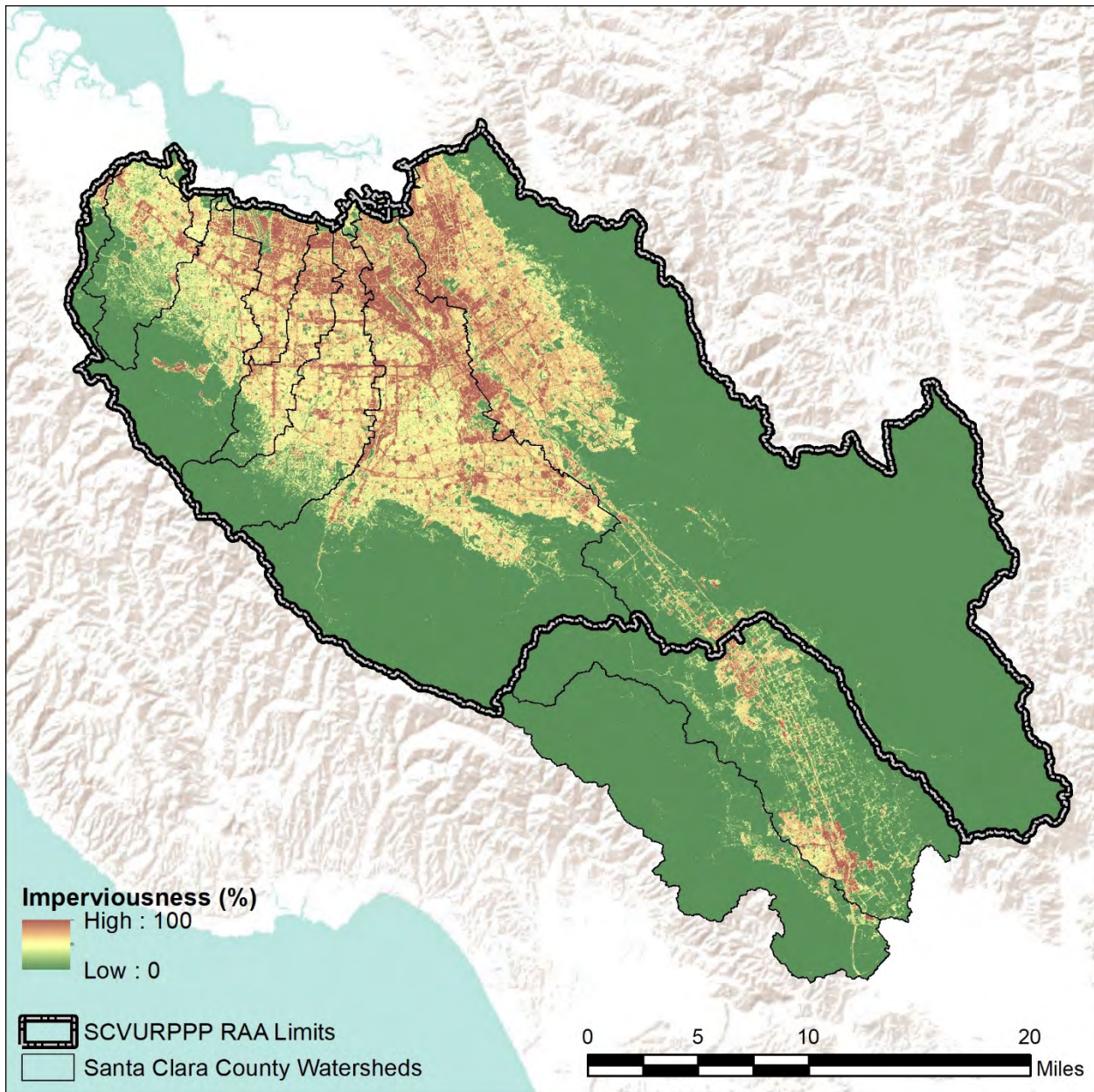


Figure 4-6. NLCD 2011 percent impervious cover in the Santa Clara Basin.

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.

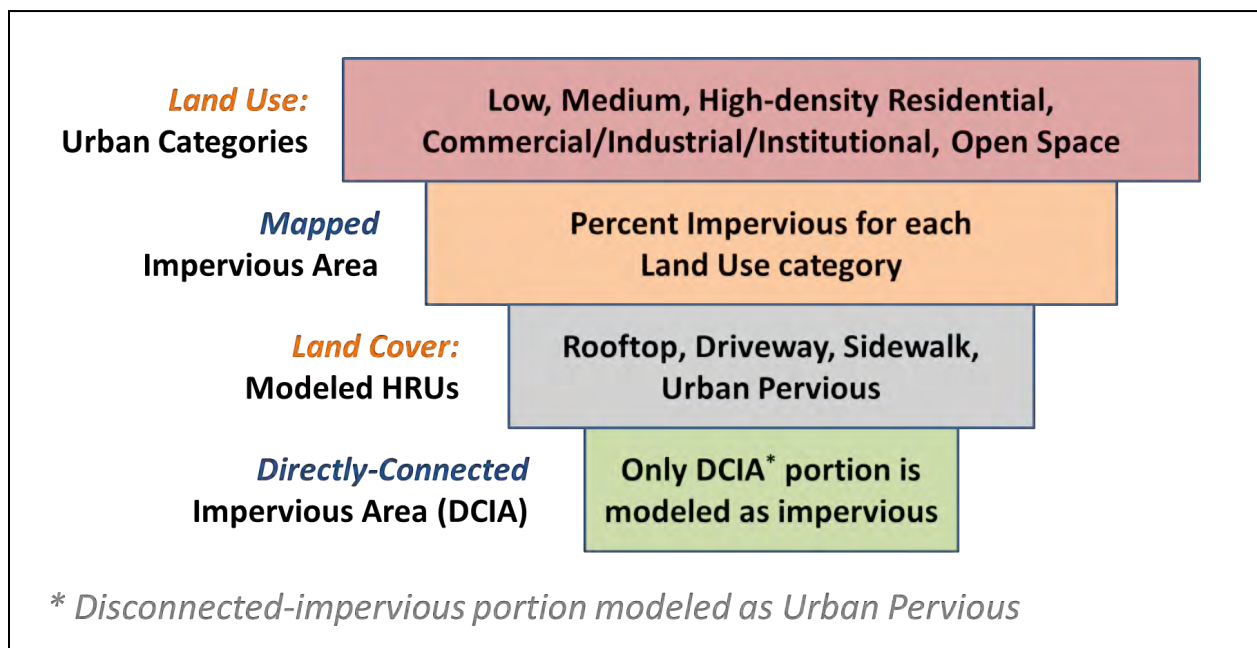


Figure 4-7. Translation sequence from MIA to DCIA.

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.

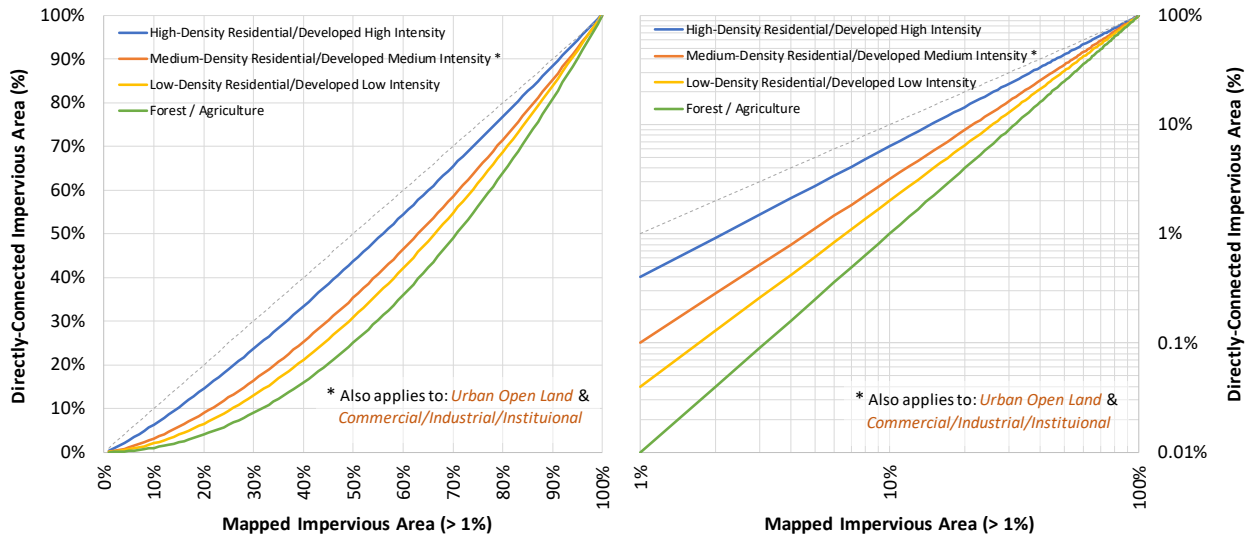


Figure 4-8. Relationships between MIA and DCIA (Sutherland 2000).

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	Urban – 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.

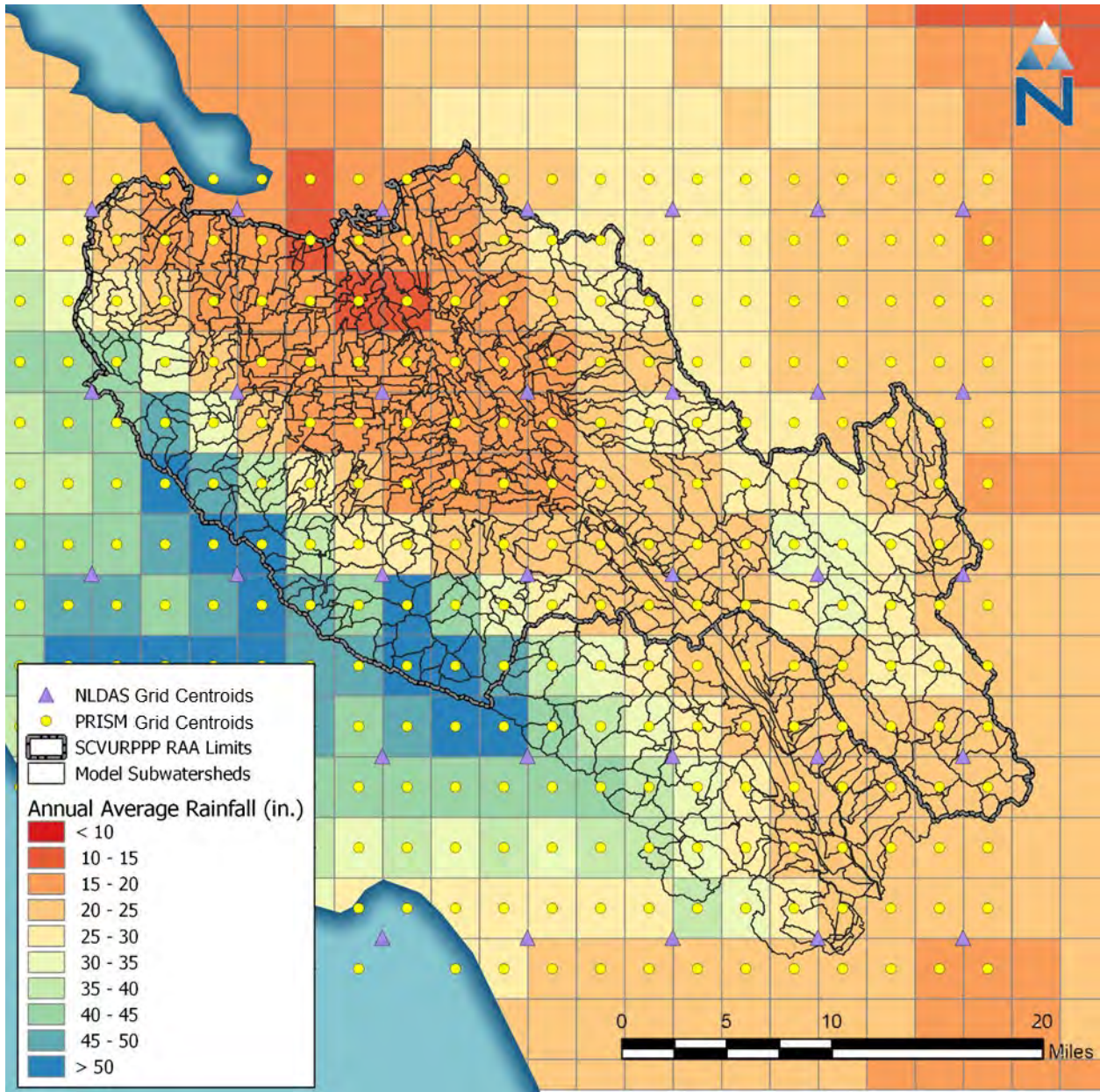


Figure 5-2. Annual average PRISM rainfall depths with associated PRISM and NLDAS2 data centroids.

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.

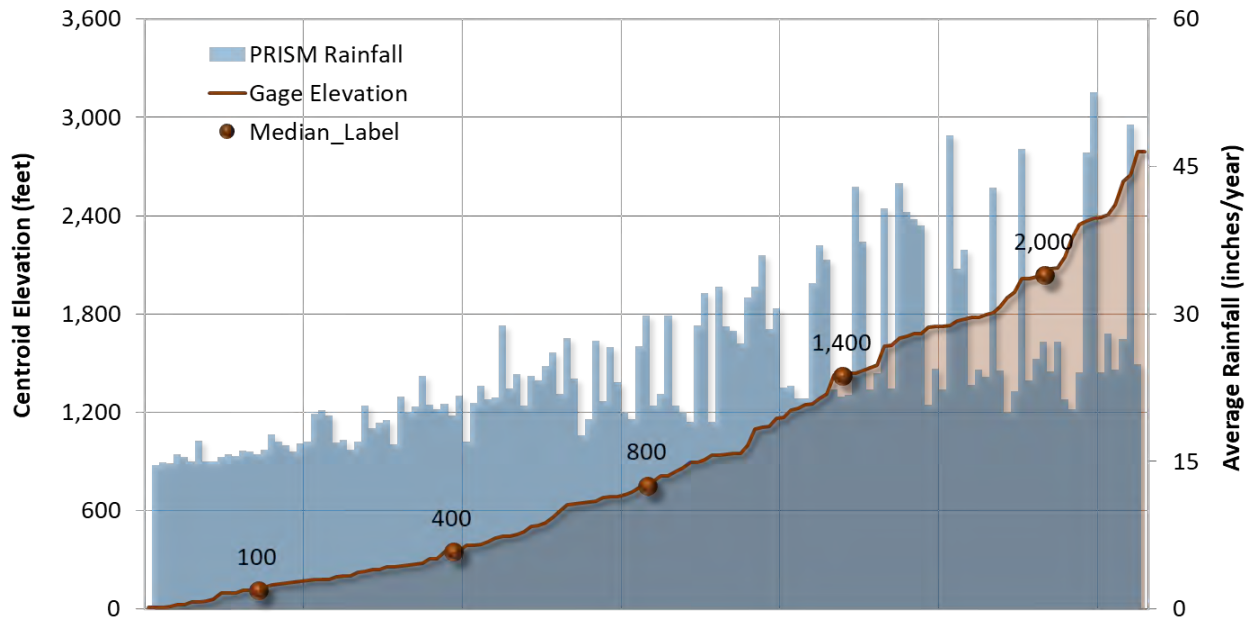


Figure 5-3. Average annual PRISM rainfall vs. centroid elevation (with median elevation of 5 bins).

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.

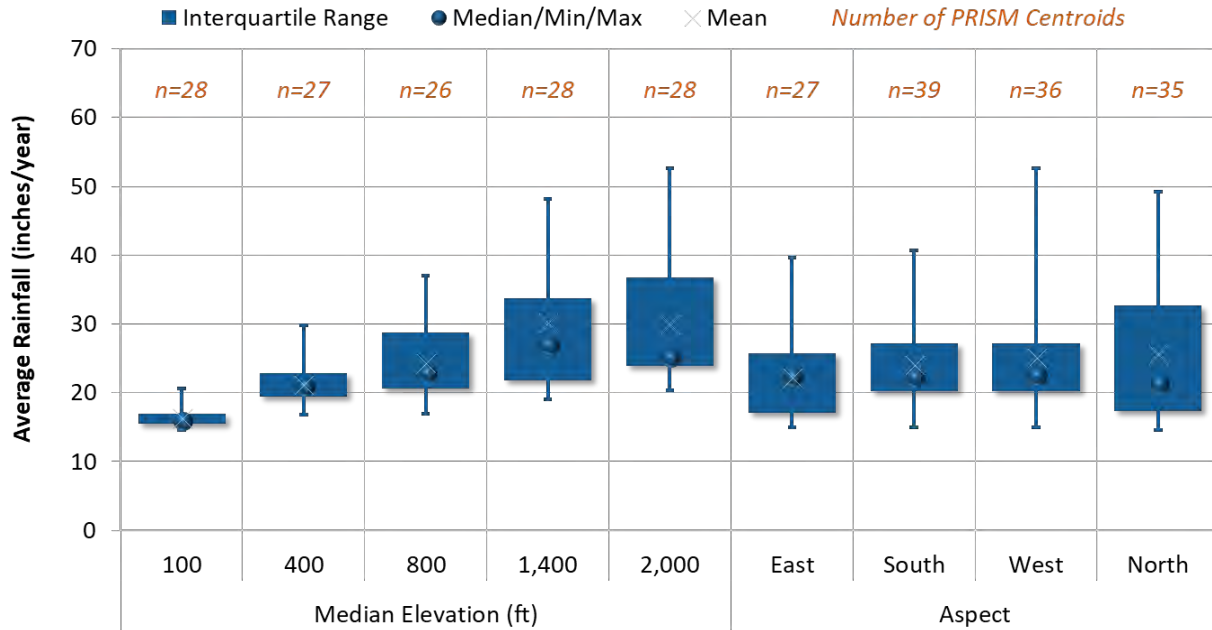


Figure 5-4. Box plots of average annual rainfall variability by elevation and aspect.

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.

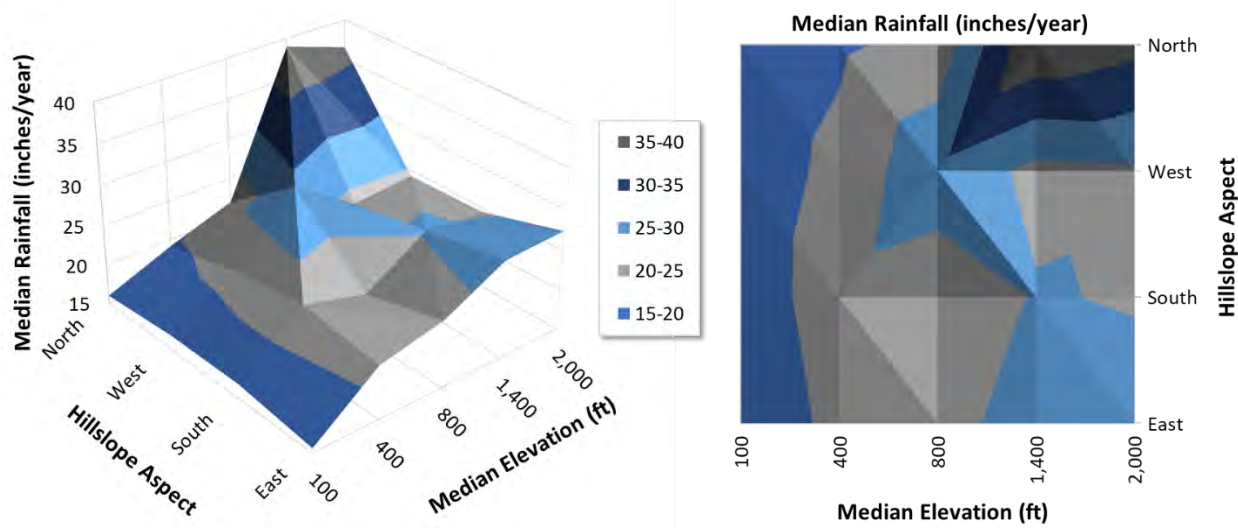


Figure 5-5. Surface plot of median rainfall (vertical axis) vs. elevation and aspect (horizontal plane).

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-foot 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
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
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Data Quantity (Percent Complete, **Validation** watersheds):

0%	25%	50%	75%	100%	Validation
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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.

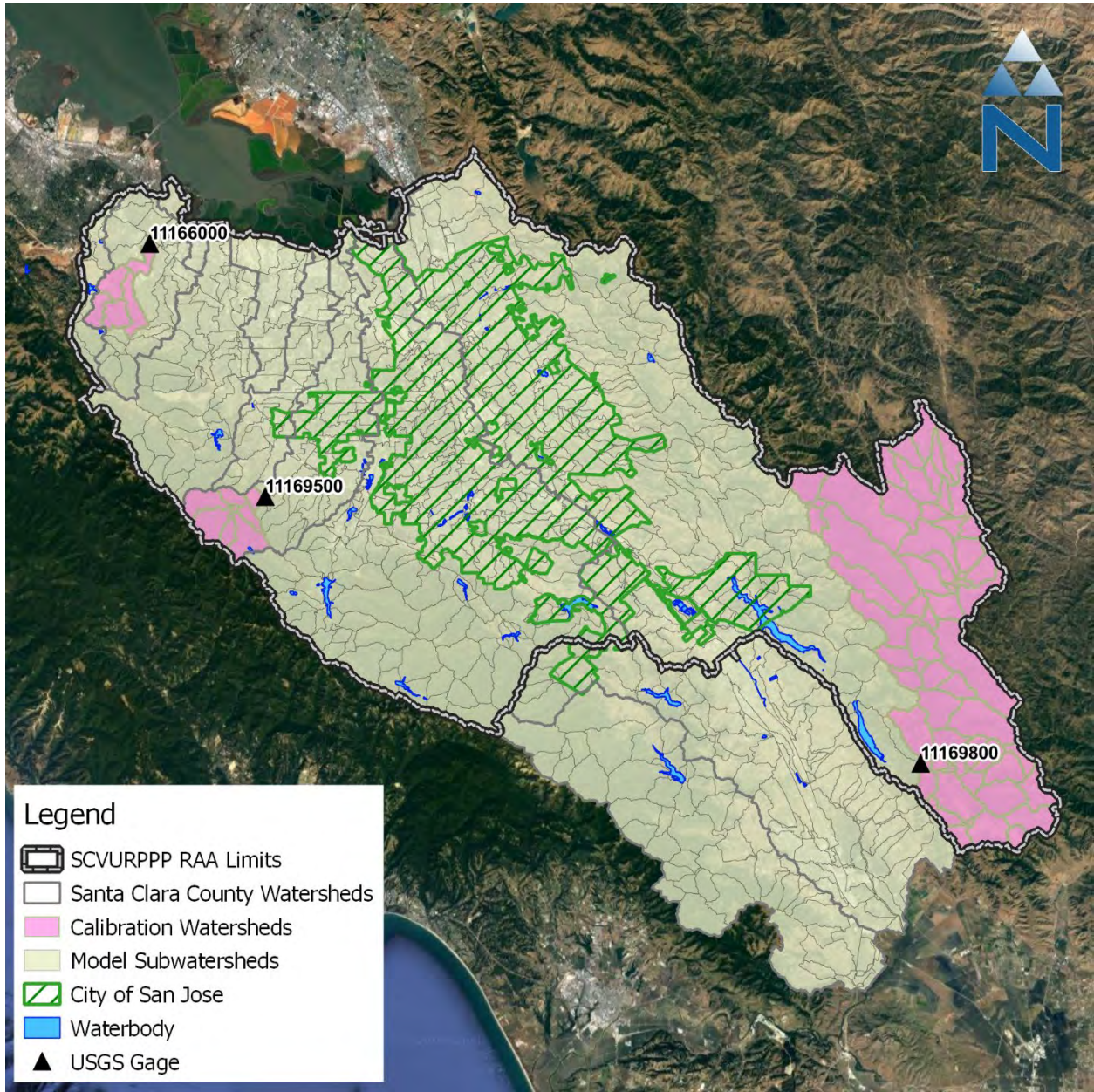


Figure 6-2. Locations of the three USGS headwater calibration gages and corresponding drainage areas.

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

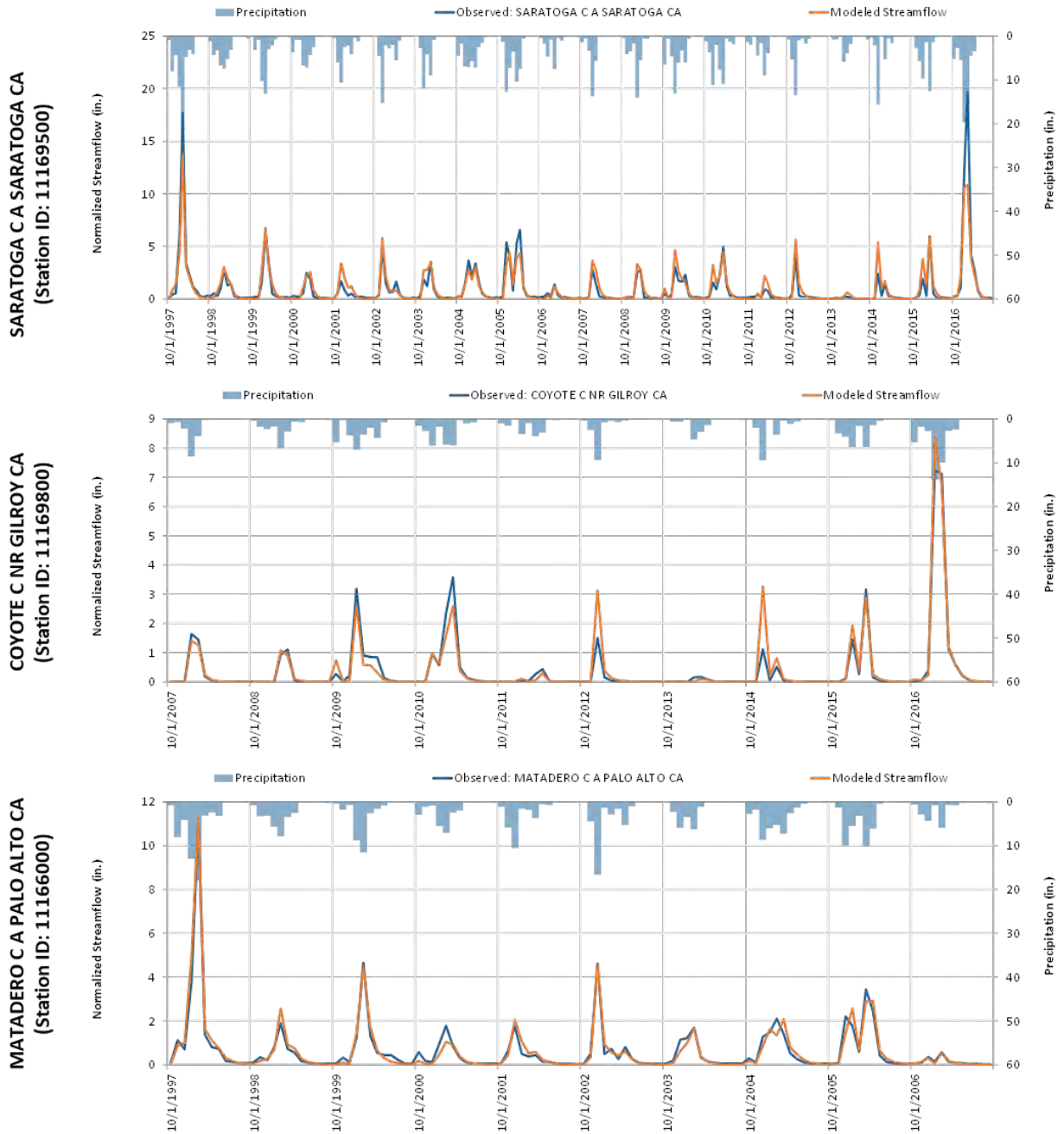


Figure 6-3. Summary of modeled vs. observed monthly streamflow at headwater calibration sites.

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.

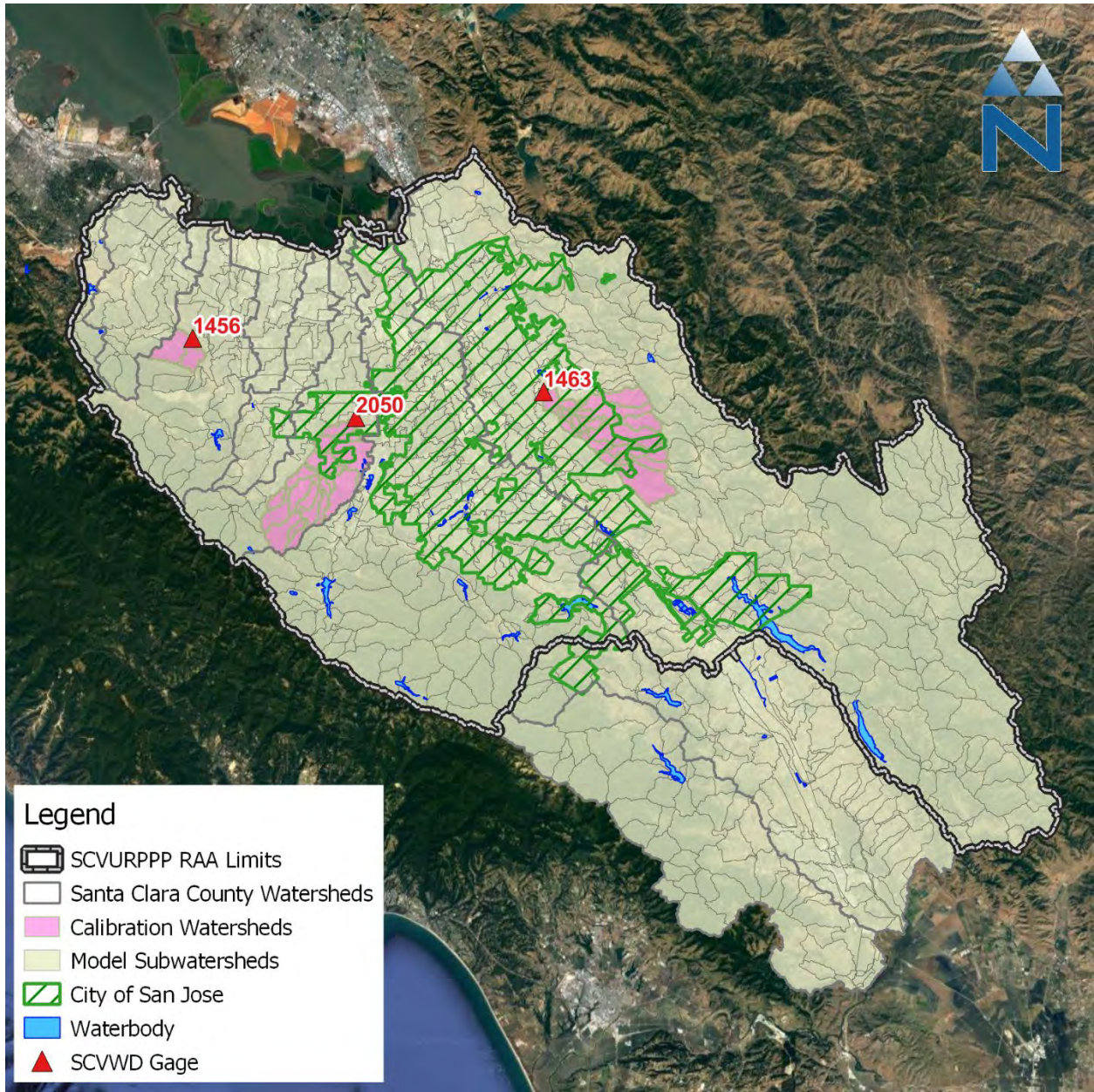


Figure 6-4. Locations of the three SCVWD headwater validation gages and corresponding drainage areas.

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 at 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

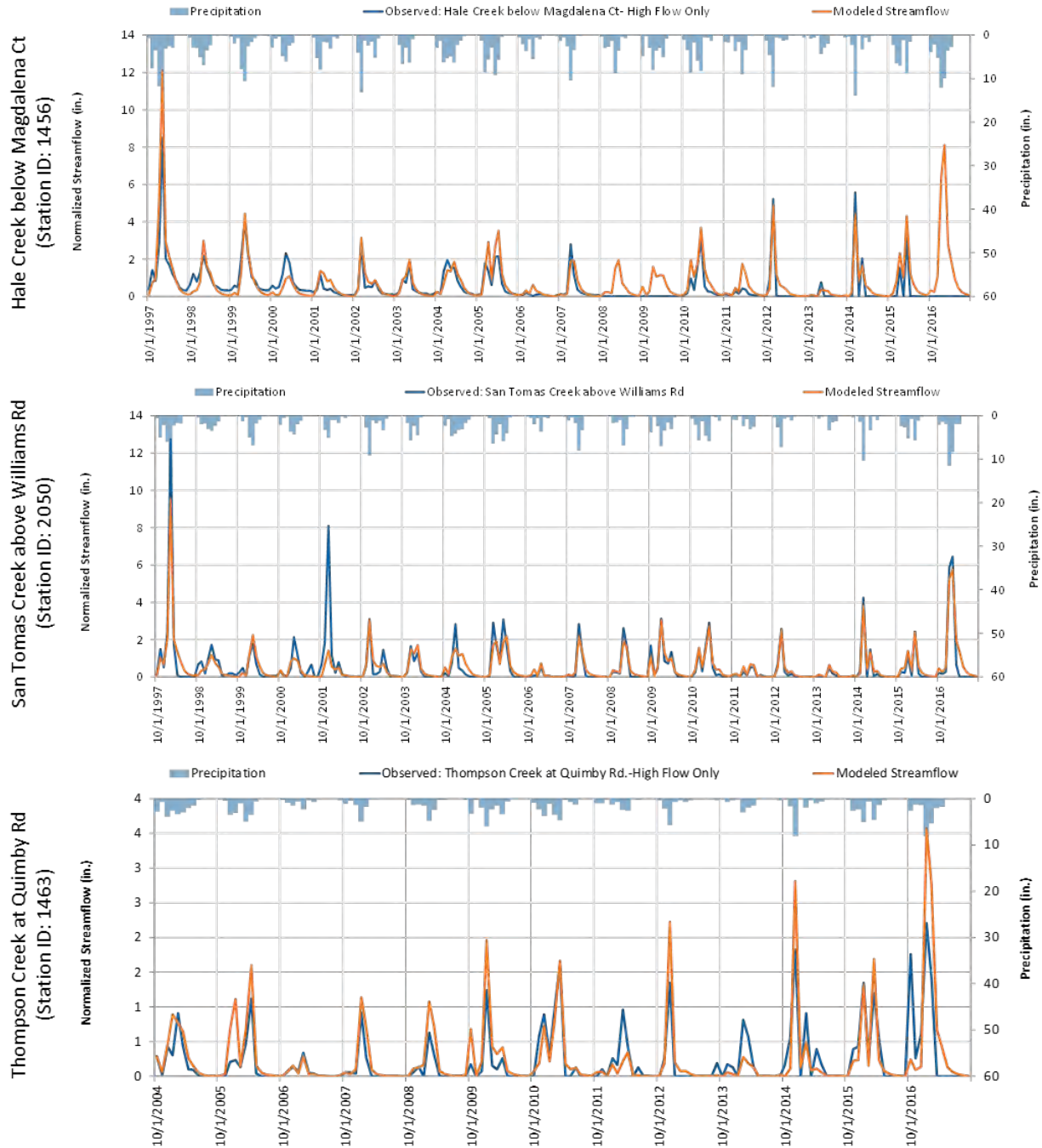


Figure 6-5. Summary of modeled vs. observed monthly streamflow at headwater validation sites.

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.

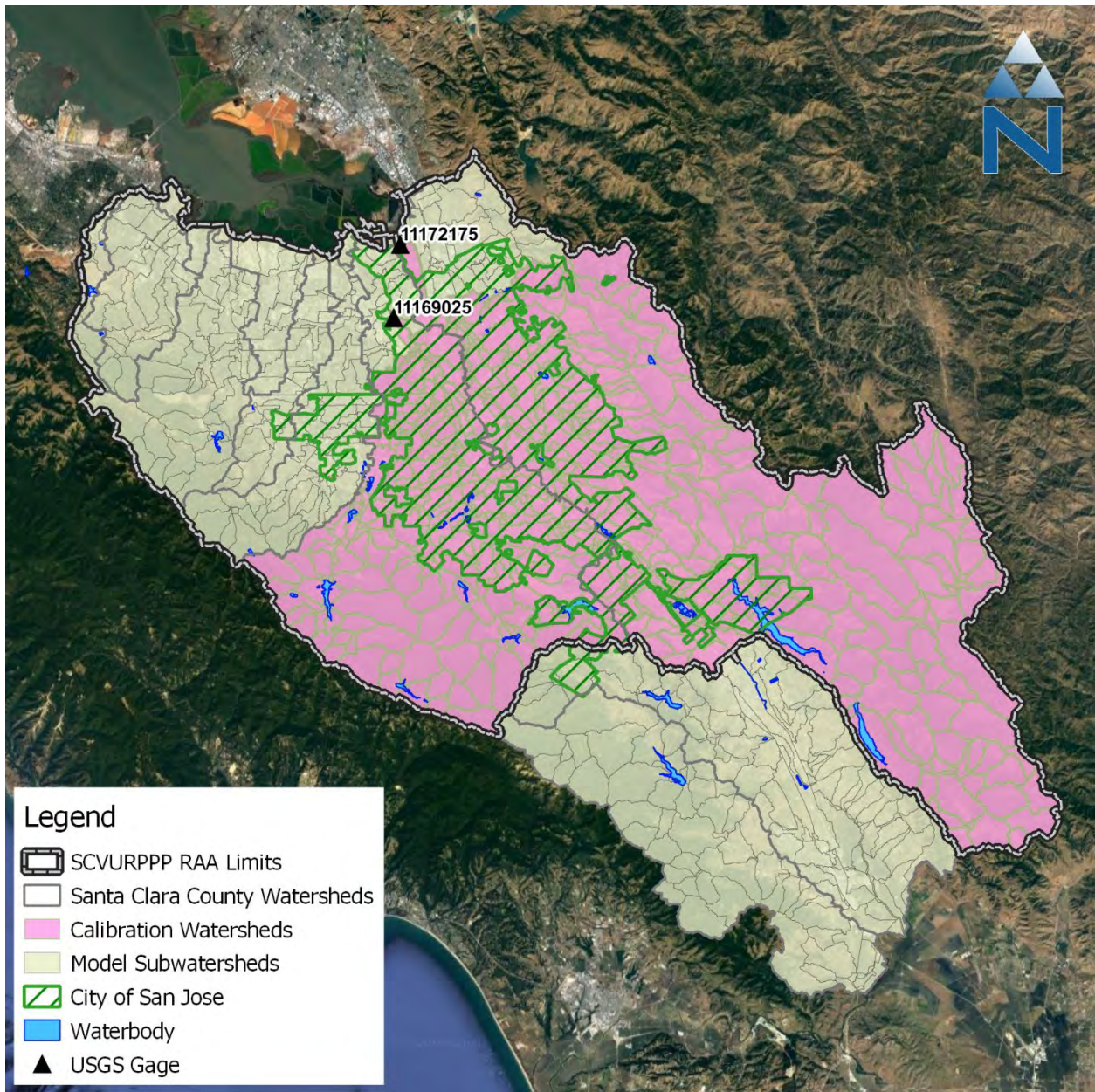


Figure 6-6. Locations of the two USGS downstream validation gages and corresponding drainage areas.

Table 6-8. Summary of quantitative downstream validation performance by gage (modeled vs. observed).

Model Statistic	Coyote Creek above Highway 237 at Milpitas CA (USGS 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 (USGS 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

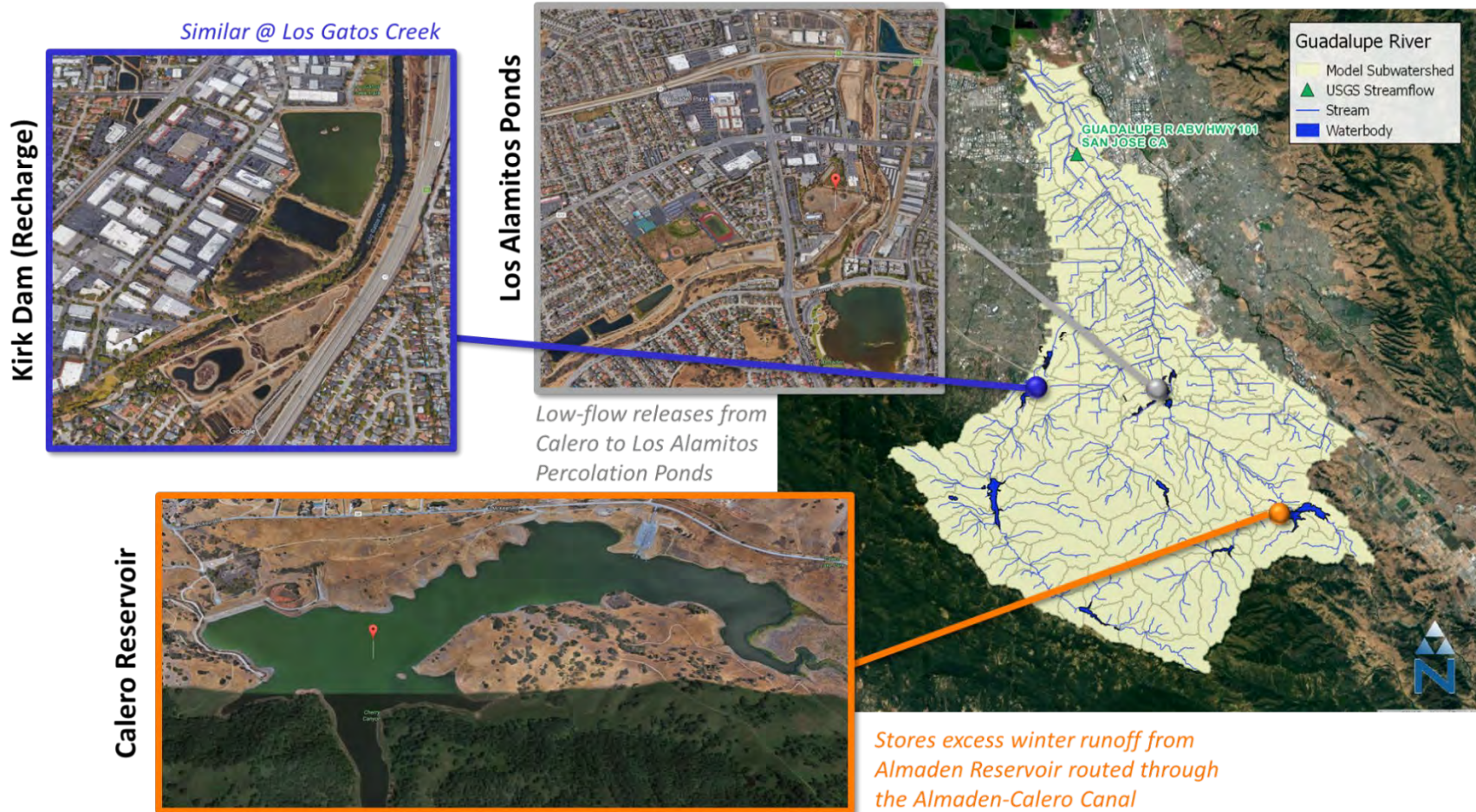


Figure 6-7. Guadalupe River watershed delineation, reservoir segments, and hydromodification features.

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.

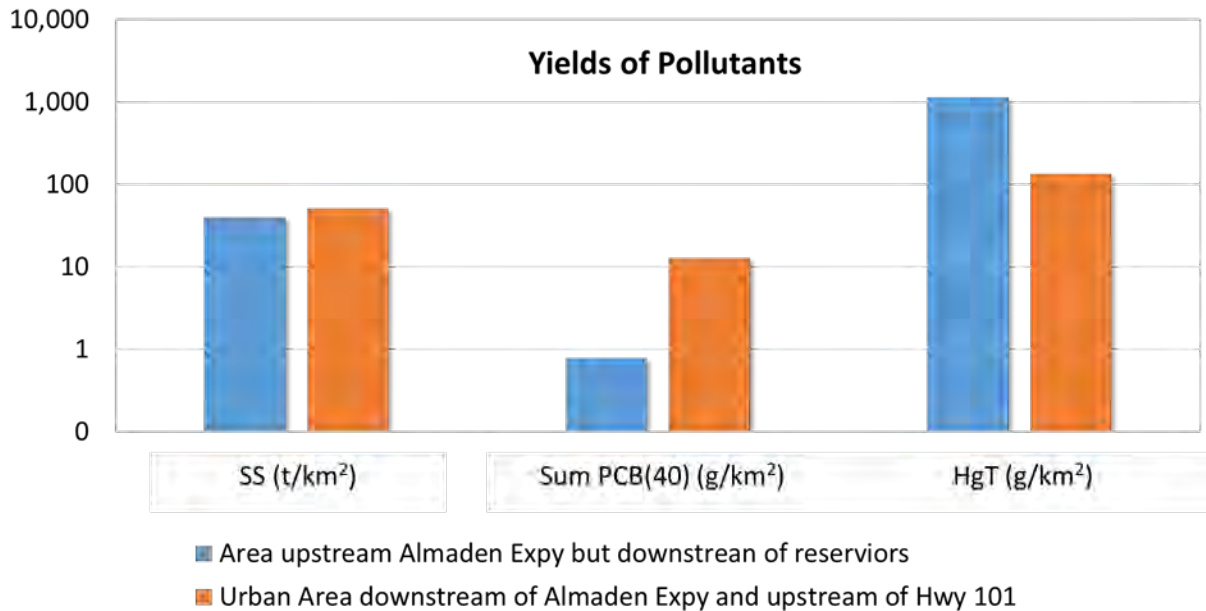


Figure 7-1. Regression-based pollutant yield estimates derived from instream monitoring data in the Guadalupe River (McKee et. al 2017).

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	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%
	Moderate ↓	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.

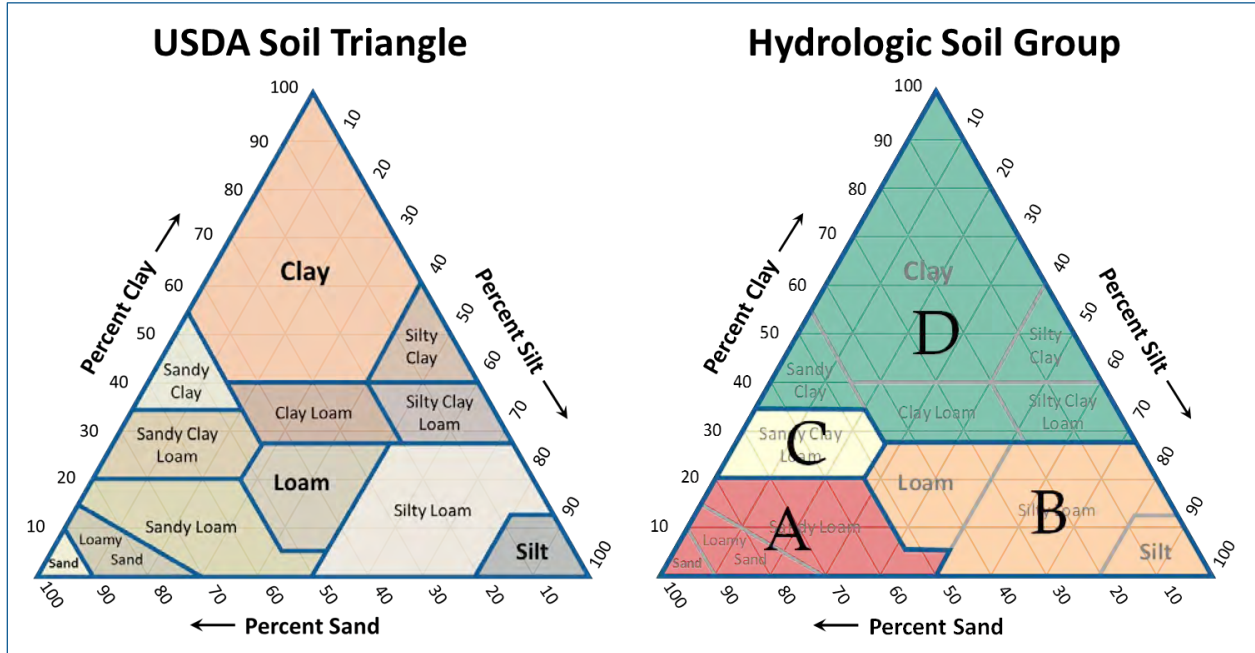


Figure 7-2. Standard USDA Soil Triangle with Hydrologic Soil Group mapping.

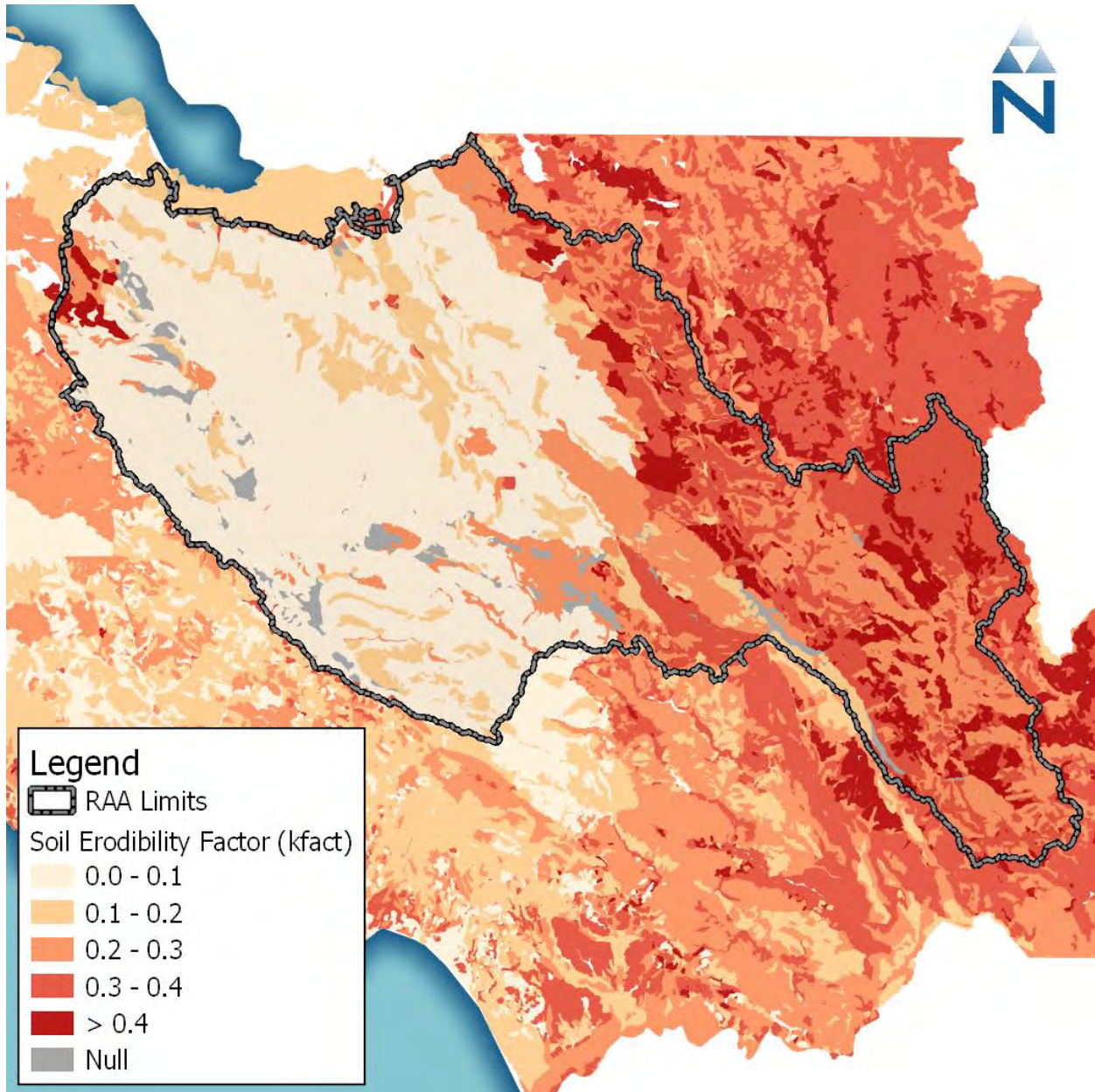


Figure 7-3. Soil Erodibility K-Factor (Source: USDA SSURGO).

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/km ² /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)

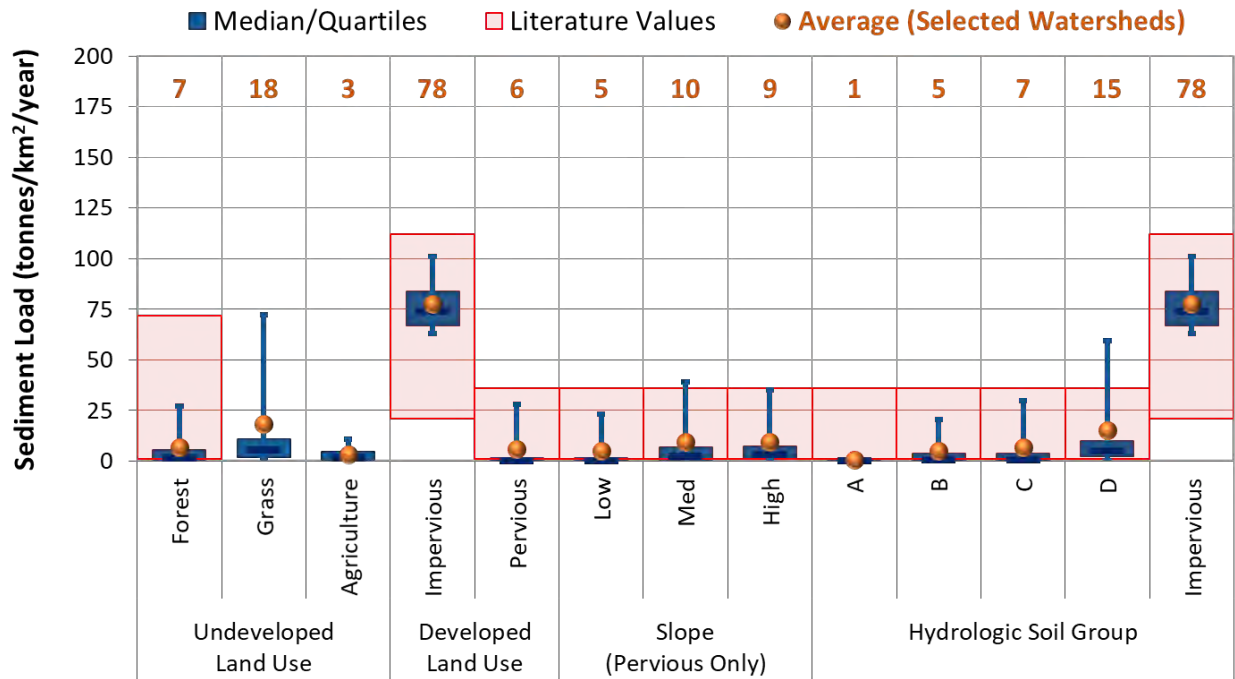


Figure 7-4. Modeled vs. literature ranges for sediment yield by land use.

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).

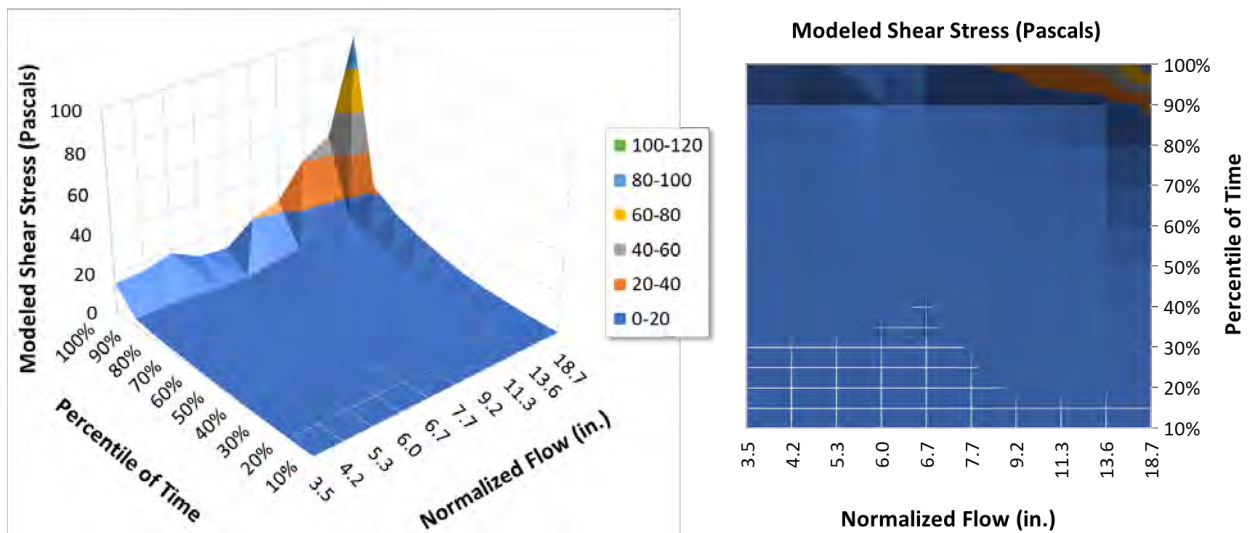


Figure 7-5. Modeled shear stress \times normalized streamflow duration surface for all modeled SCVURPPP stream segments.

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 shear 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)

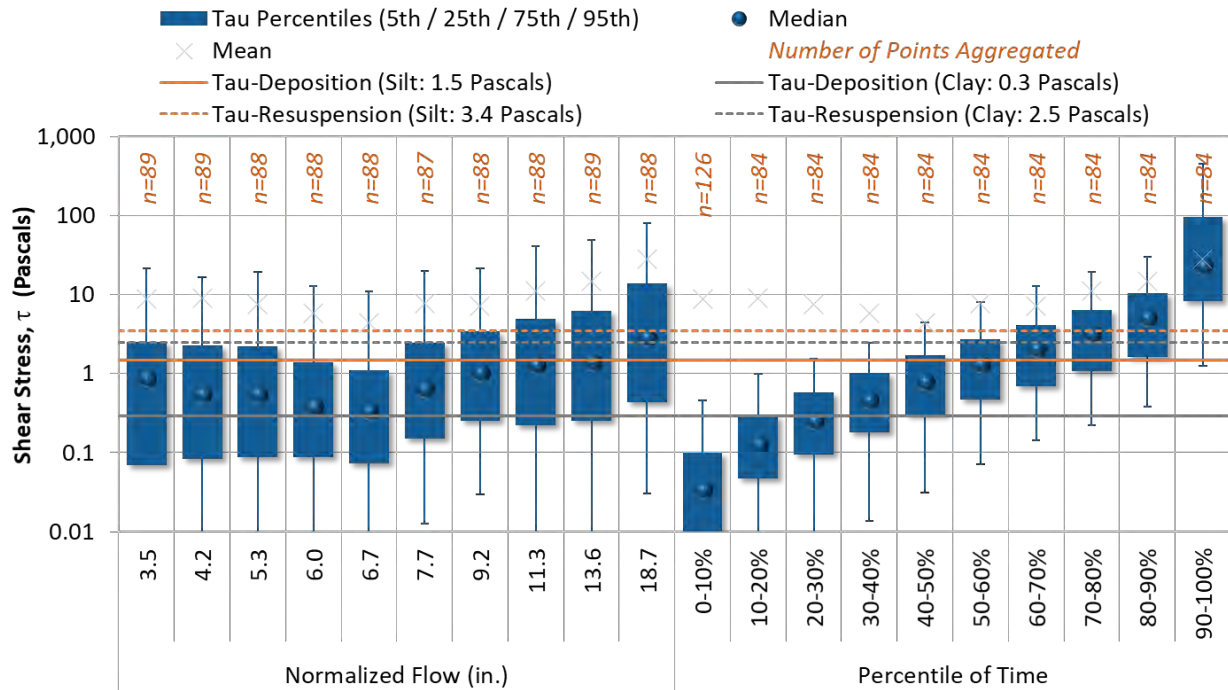


Figure 7-6. Critical shear stress for silt and clay against the range of modeled τ -values by flow and over time.

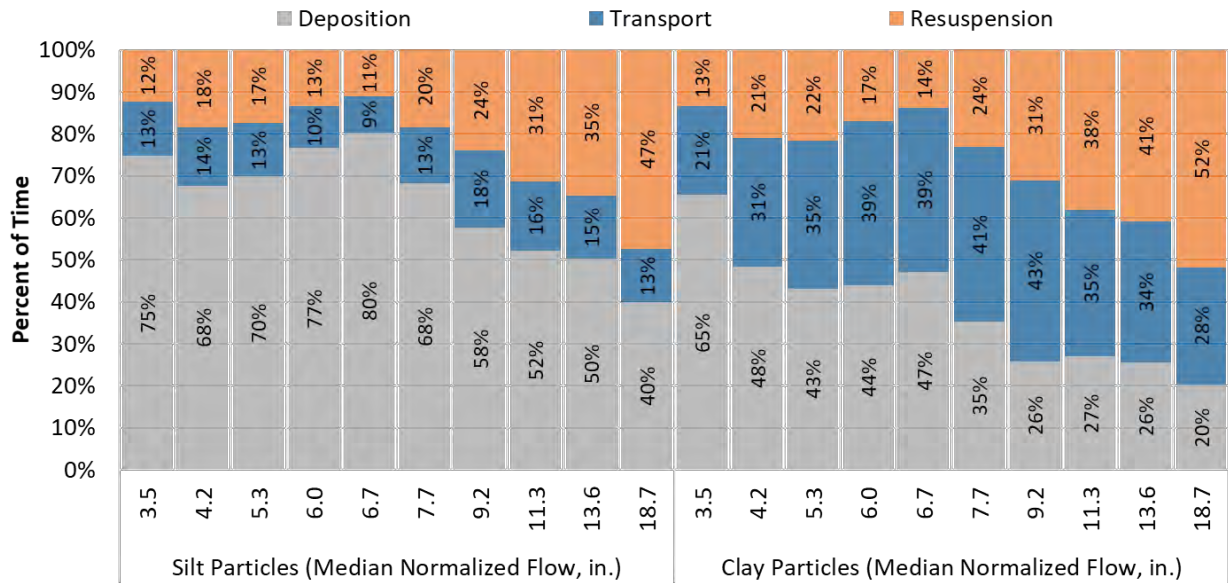


Figure 7-7. Percent of time that silt and clay particles spend in deposition, transport, and resuspension vs. normalized flow for all modeled segments (based on calibrated critical shear stress values).

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).

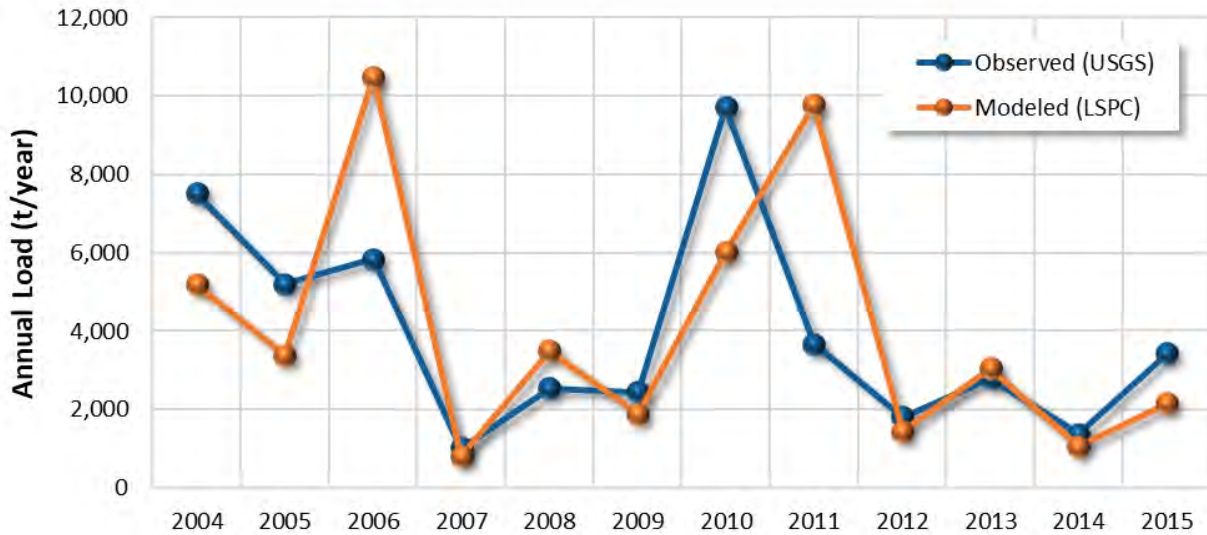


Figure 7-8. Comparison of modeled vs. observed annual load for Guadalupe River (USGS 11169025 GUADALUPE River above Highway 101 A SAN JOSE CA).

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%

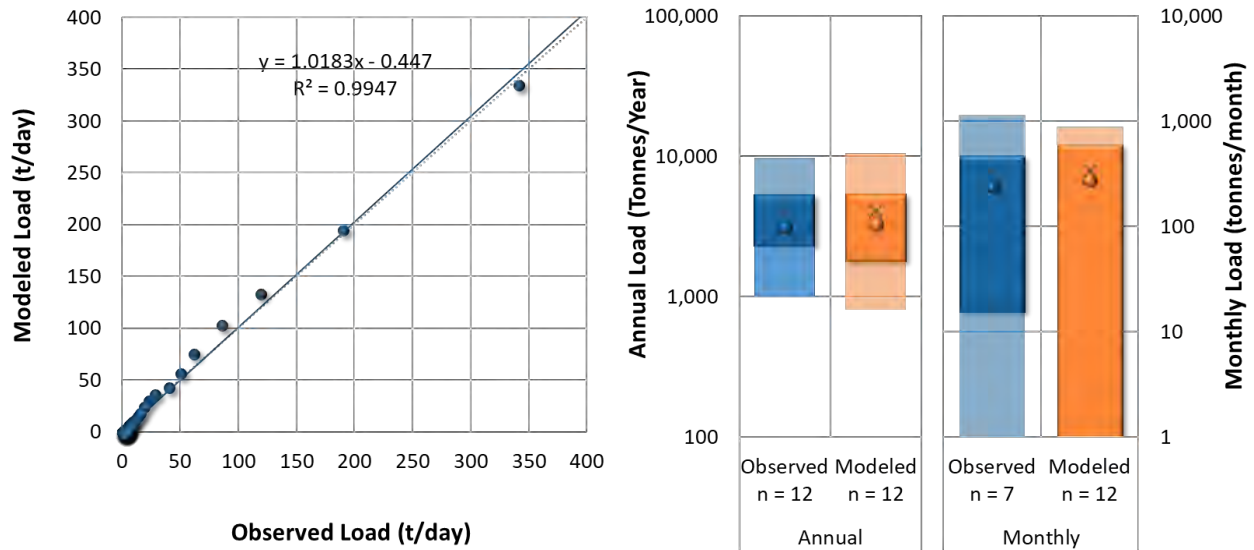


Figure 7-9. Comparison of modeled vs. observed load duration (left) and annual and monthly loads (right) for Guadalupe River (USGS 11169025 GUADALUPE River above Highway 101 A SAN JOSE CA).

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.

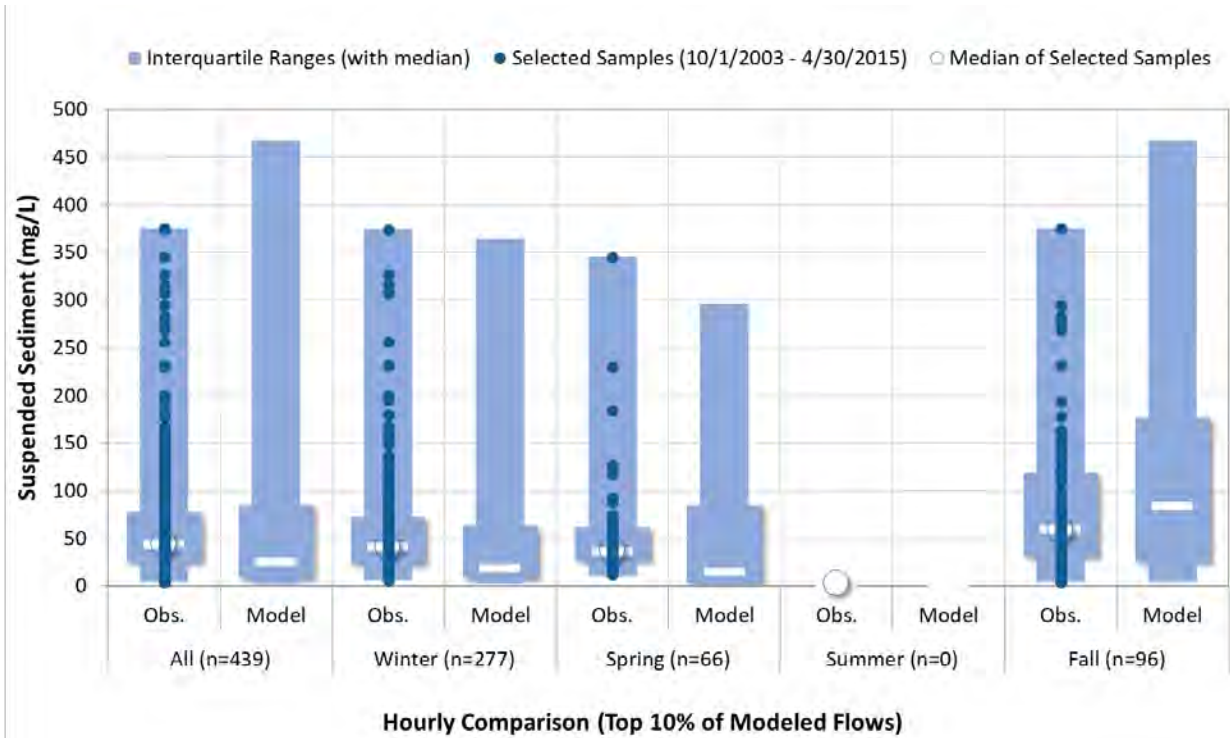


Figure 7-10. Modeled vs. observed wet-weather suspended sediment concentrations for top 10% of modeled flows at Guadalupe River (USGS 11169025 GUADALUPE River above Highway 101 A SAN JOSE CA).

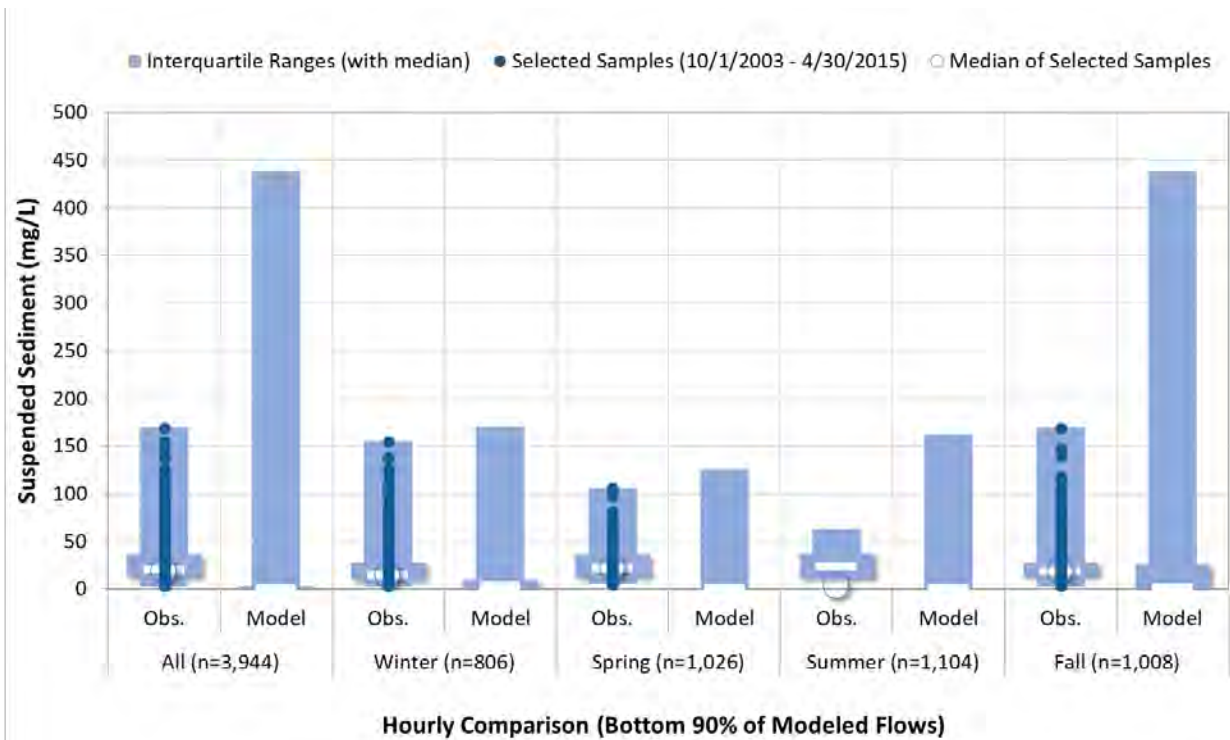


Figure 7-11. Modelled vs. observed suspended sediment concentrations for bottom 90% of modeled flows at Guadalupe River (USGS 11169025 GUADALUPE River above Highway 101 A SAN JOSE CA).

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 1 st – September 30 th)														
	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.

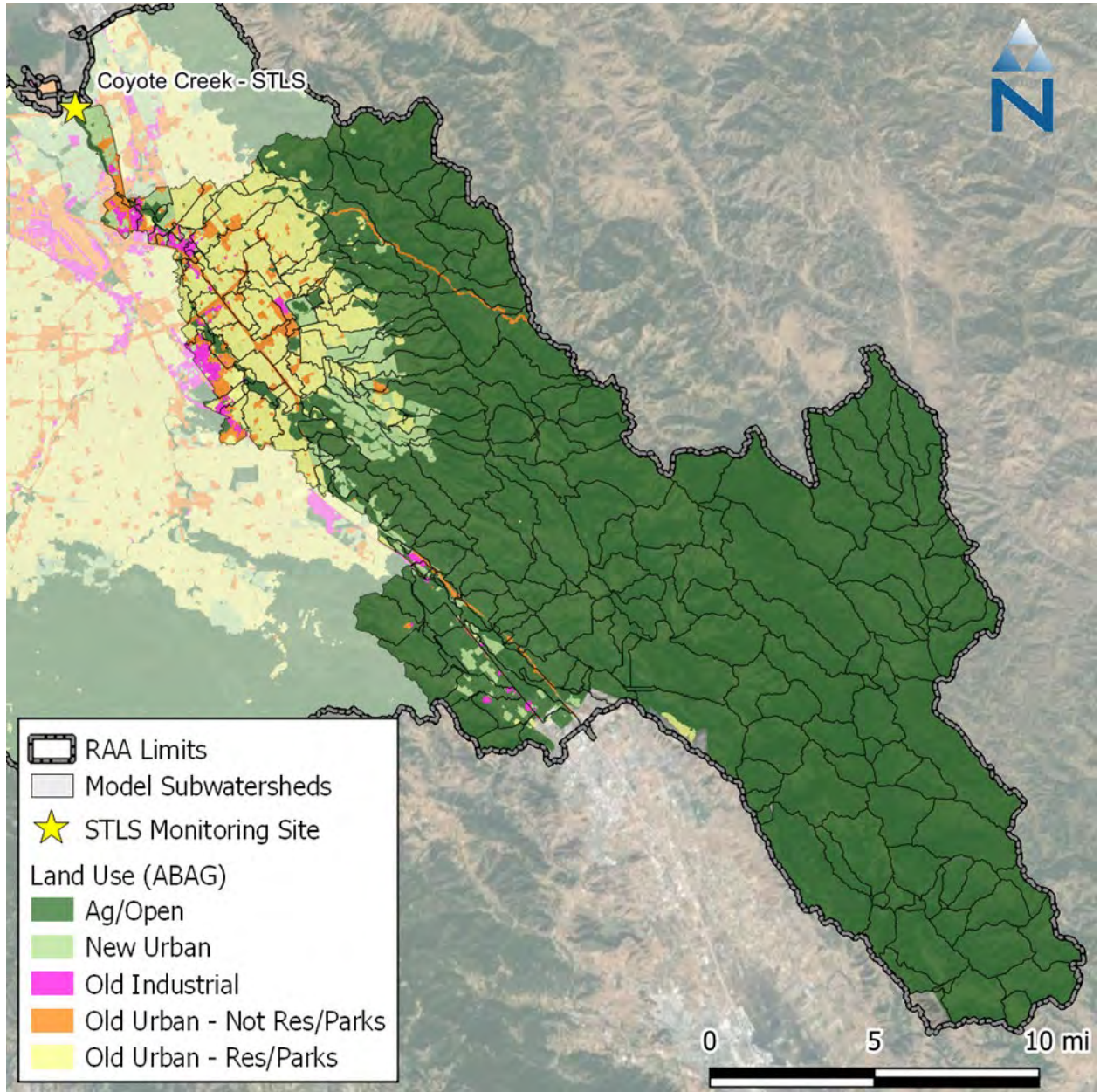


Figure 8-1. Map of the Coyote Creek STLS monitoring station and drainage area.

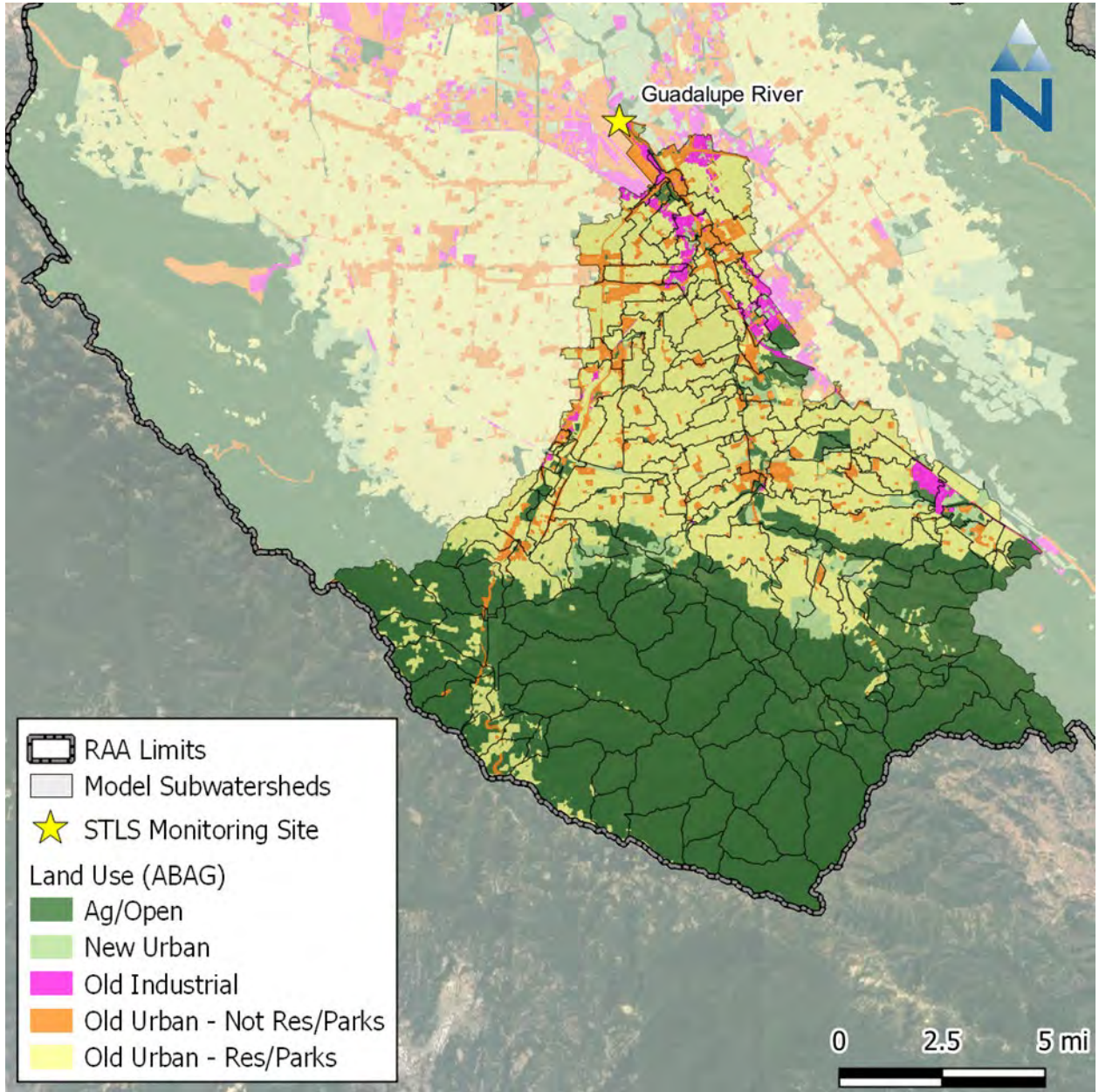


Figure 8-2. Map of the Guadalupe River STLS monitoring station and drainage area.

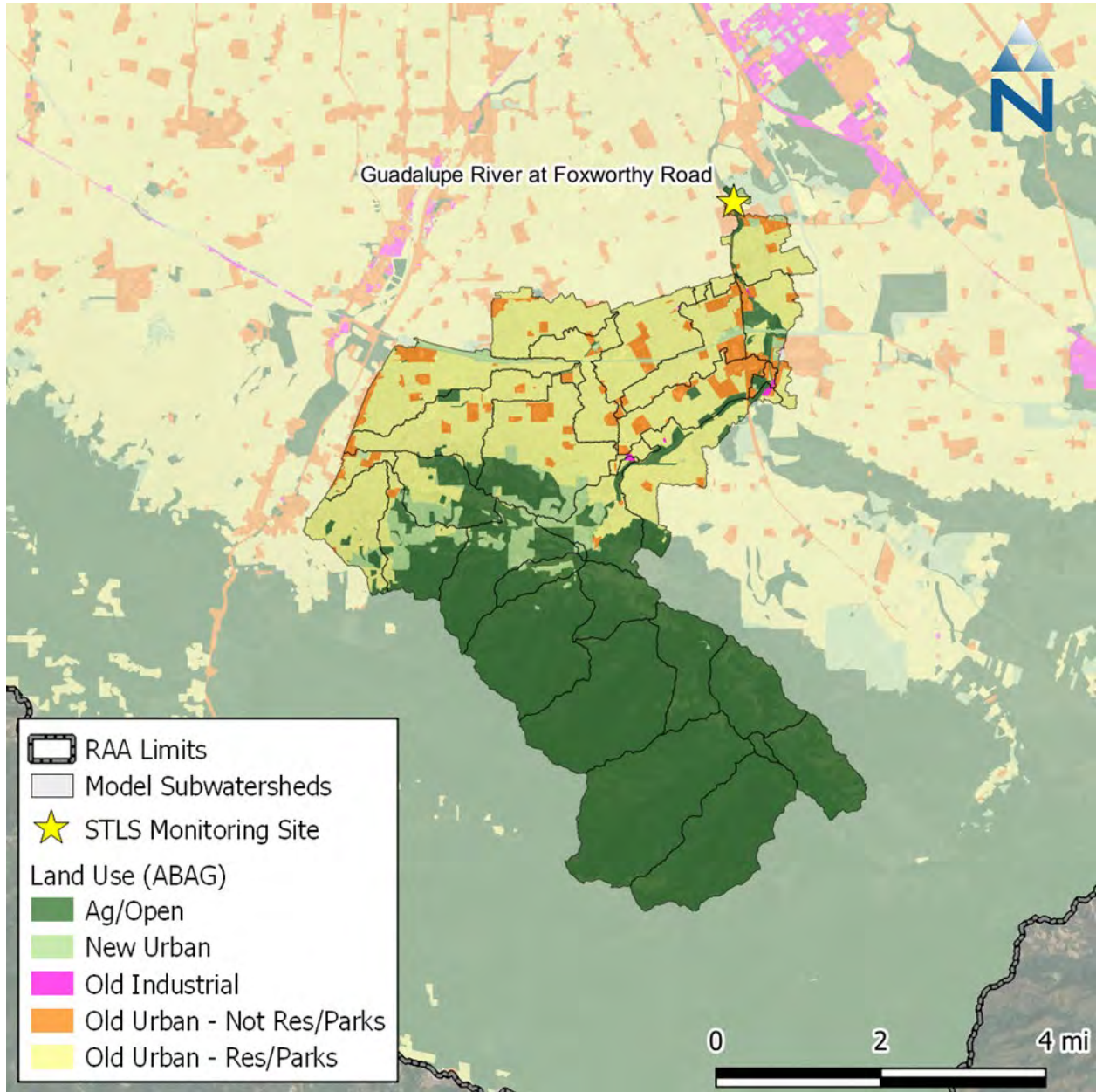


Figure 8-3. Map of the Guadalupe River at Foxworthy Road STLS monitoring station and drainage area.

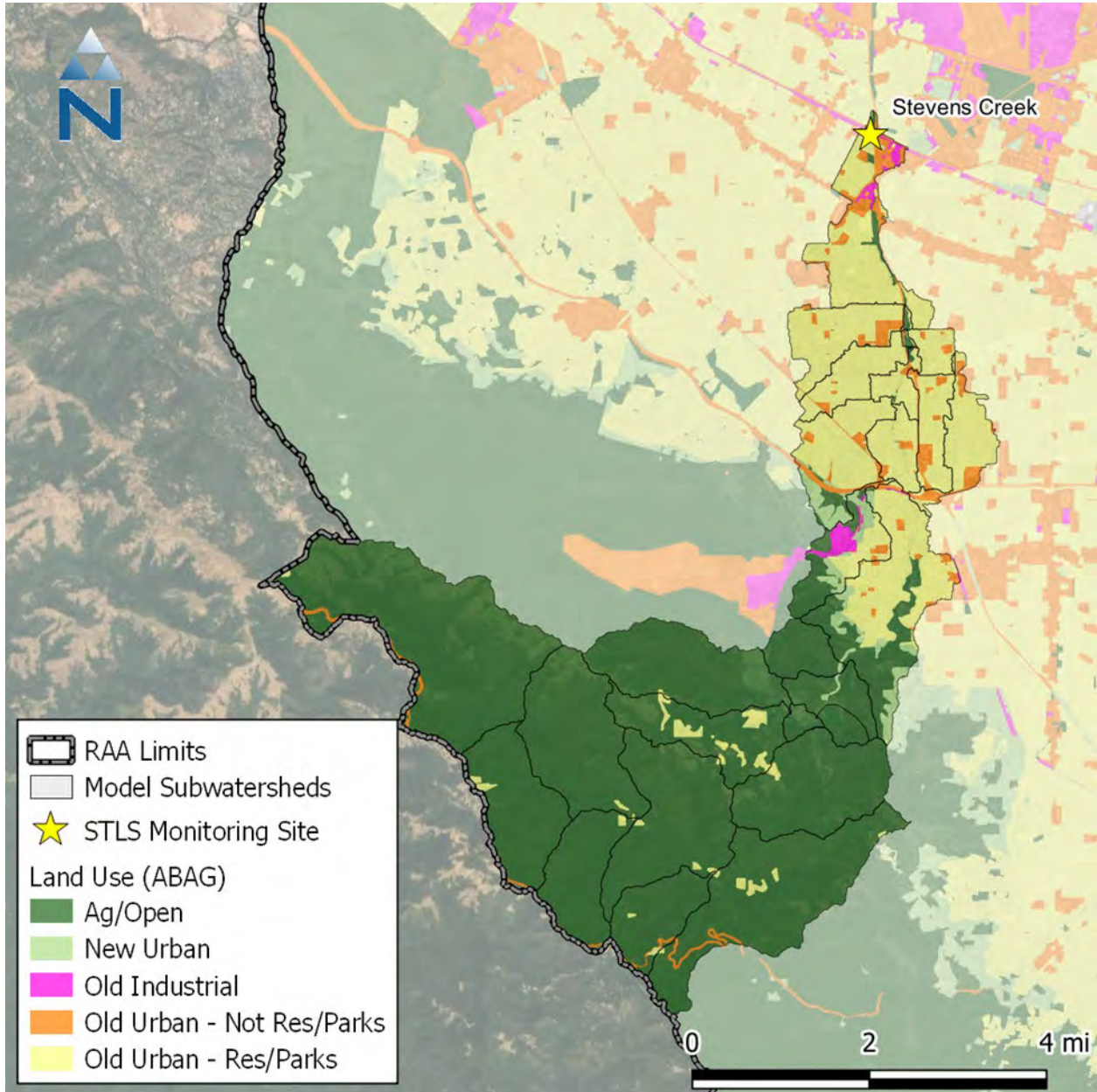


Figure 8-4. Map of the Stevens Creek STLS monitoring station and drainage area.

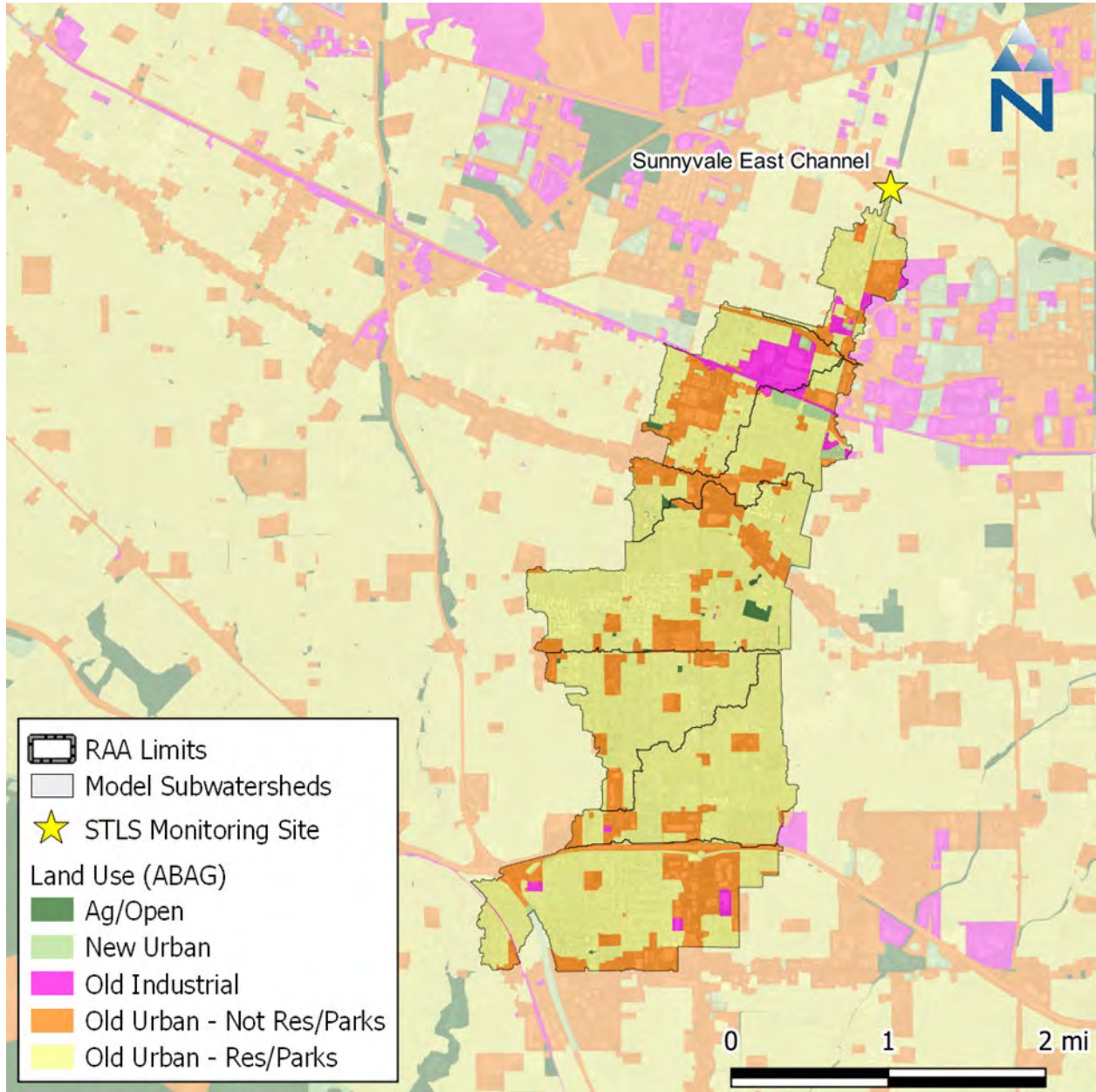


Figure 8-5. Map of the Sunnyvale East Channel STLS monitoring station and drainage area.

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.

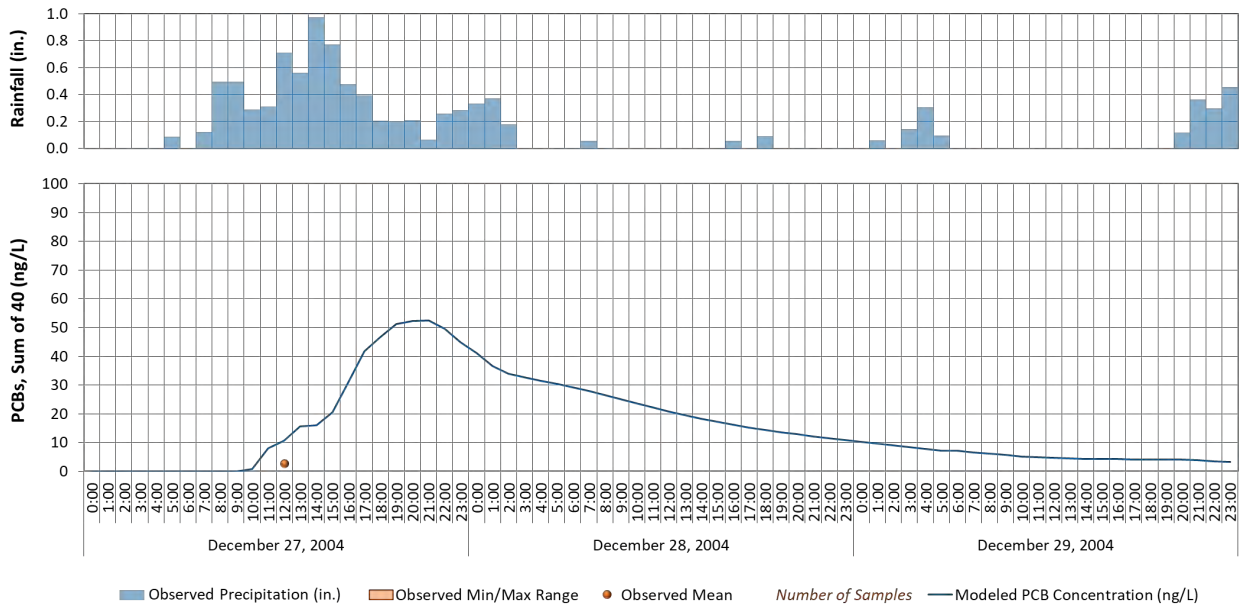


Figure 8-6. Modeled vs. observed PCBs for a selected storm at Coyote Creek Gage (12/27/2014 - 12/29/2014).

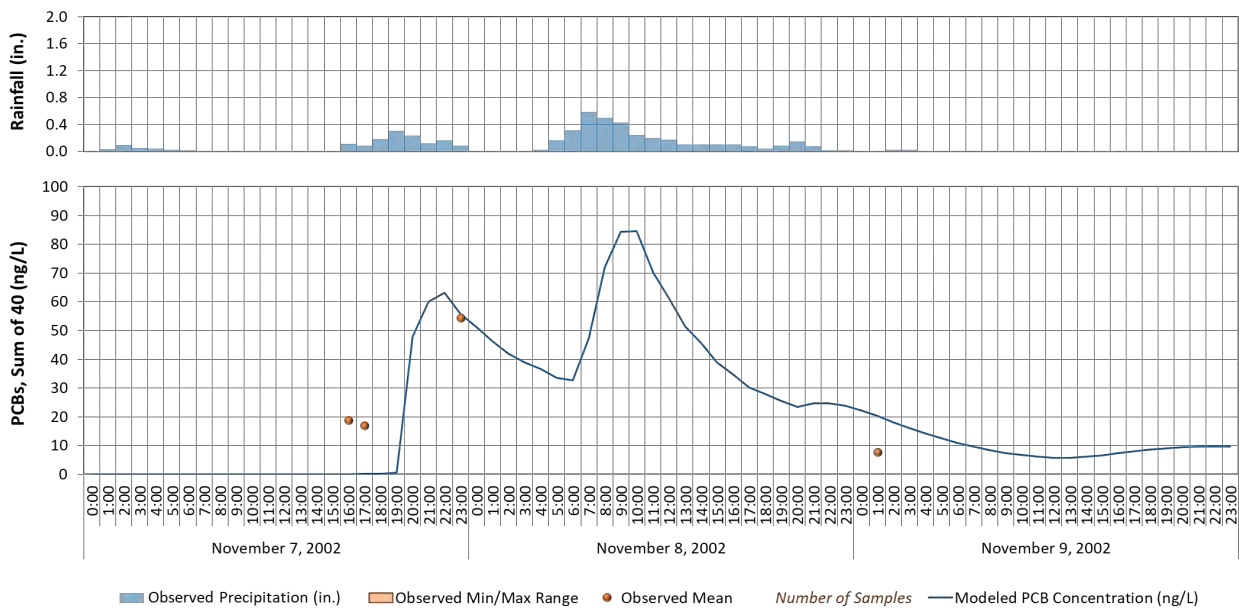


Figure 8-7. Modeled vs. observed PCBs for a selected storm at Guadalupe River Gage (11/7/2002 - 11/9/2002).

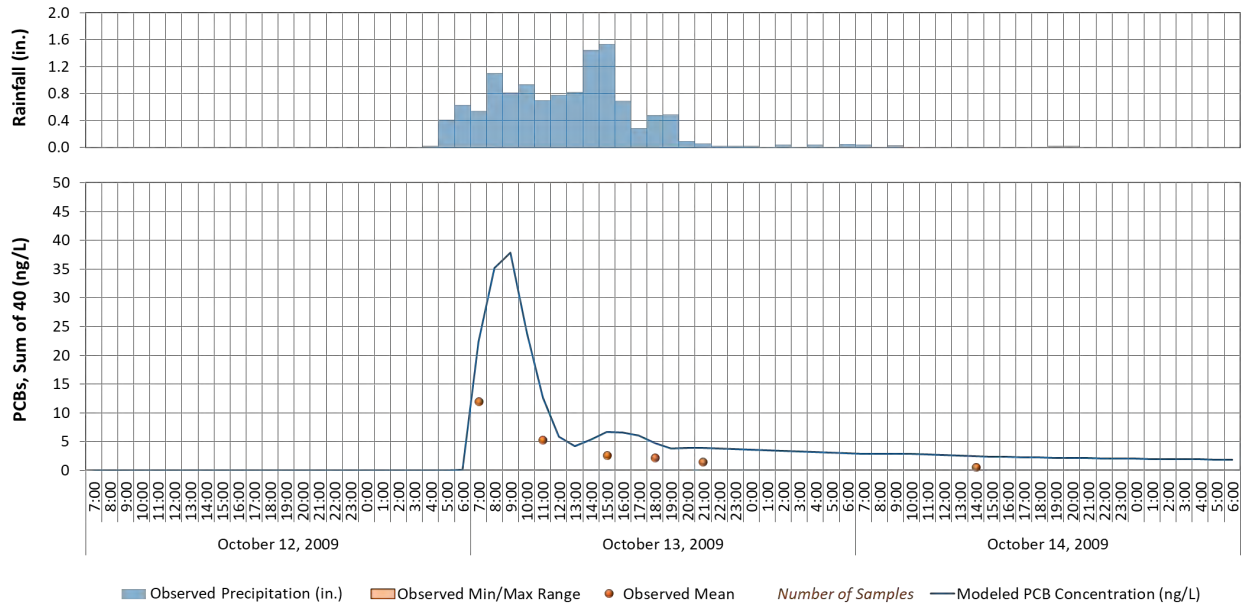


Figure 8-8. Modeled vs. observed PCBs for a selected storm at Guadalupe River at Foxworth Road (10/12/2009 - 10/14/2009).

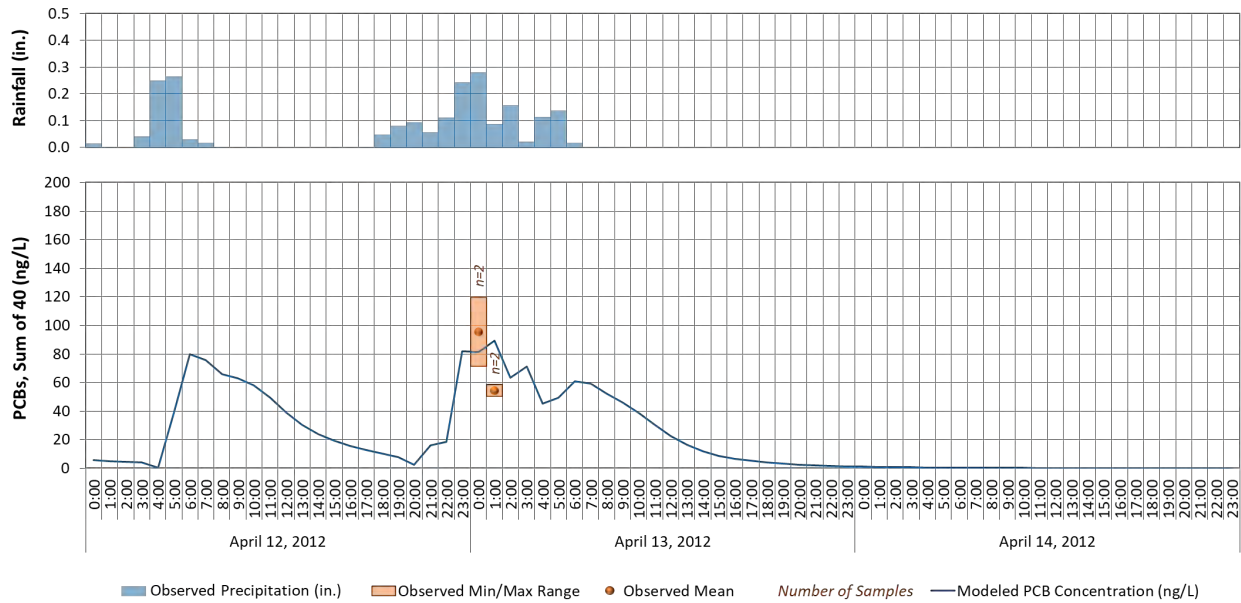


Figure 8-9. Modeled vs. observed PCBs for a selected storm at Sunnyvale East Channel (4/12/2012 - 4/14/2012).

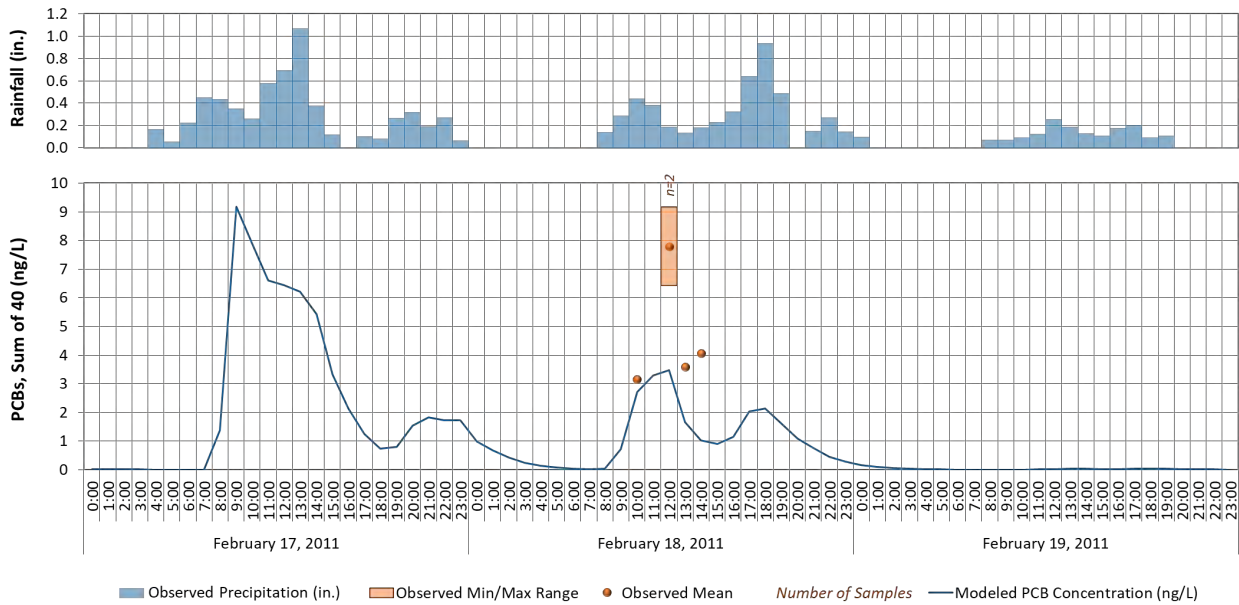


Figure 8-10. Modeled vs. observed PCBs for a selected storm at Stevens Creek Gage (2/17/2011 - 2/19/2011).

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.

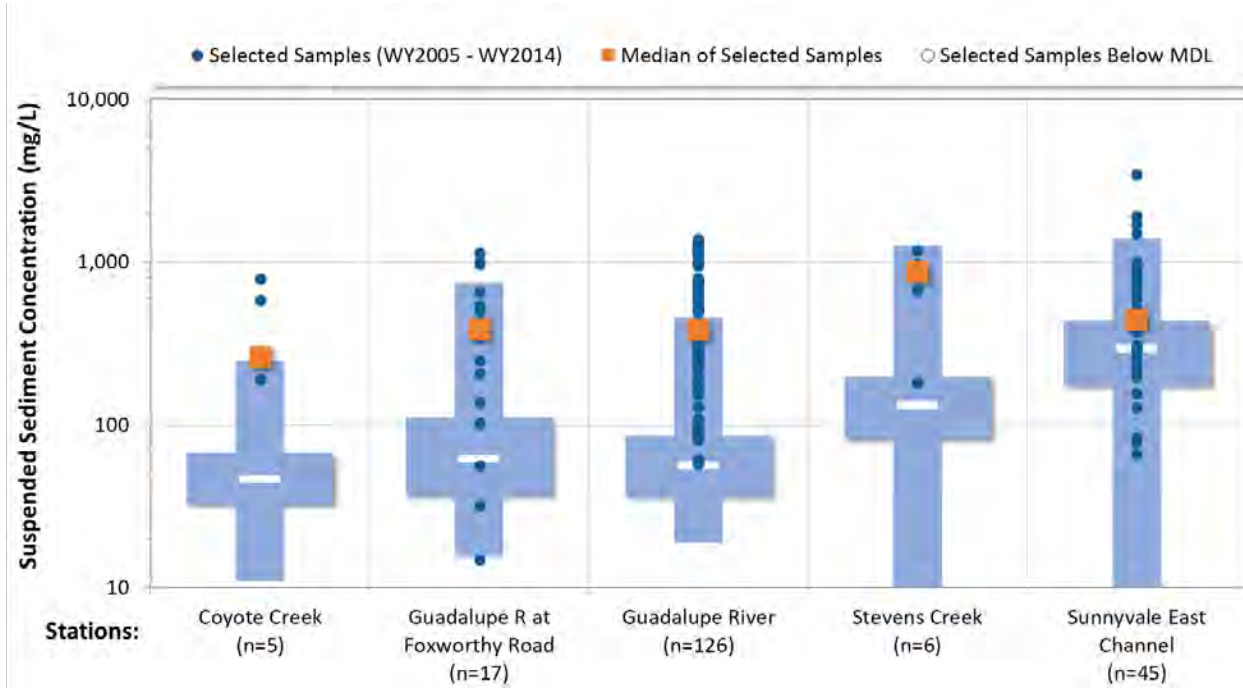


Figure 8-11. Summary of modeled concentrations as boxplots (for the top 1% of modeled flows) vs. observed sediment storm sample concentration at SLTS stations.

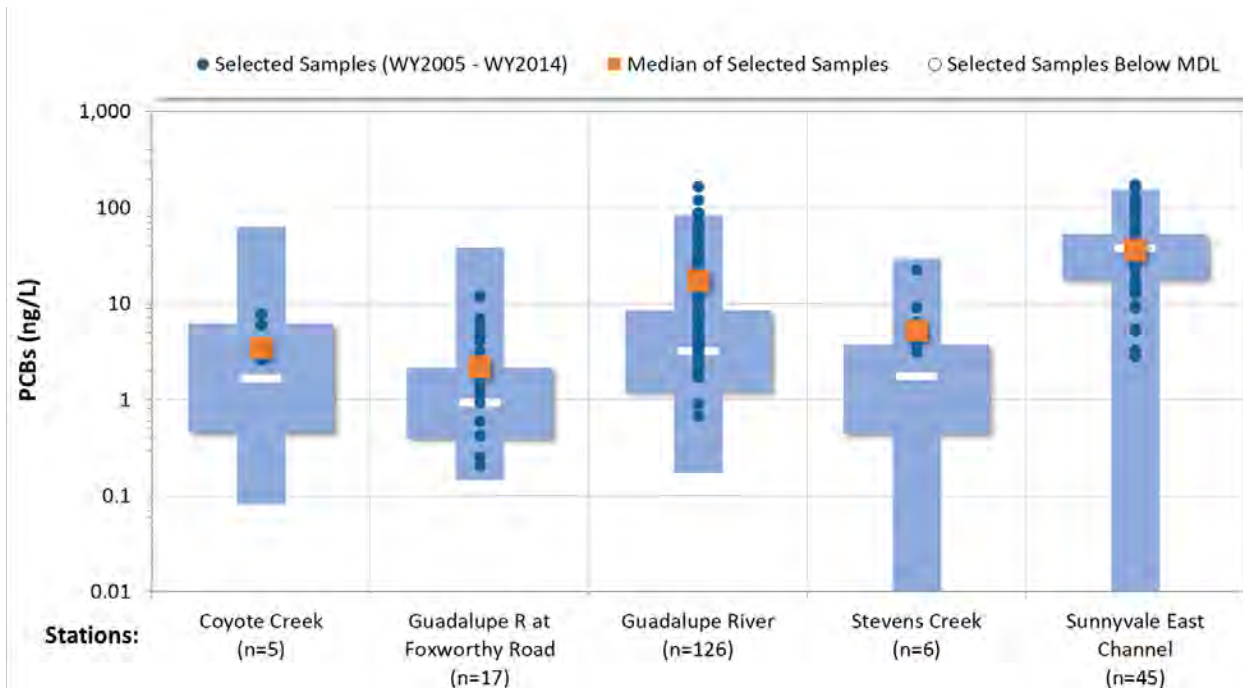


Figure 8-12. Summary of modeled concentrations as boxplots (for the top 1% of modeled flows) vs. observed PCBs storm sample concentration at SLTS stations.

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 2002² (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).

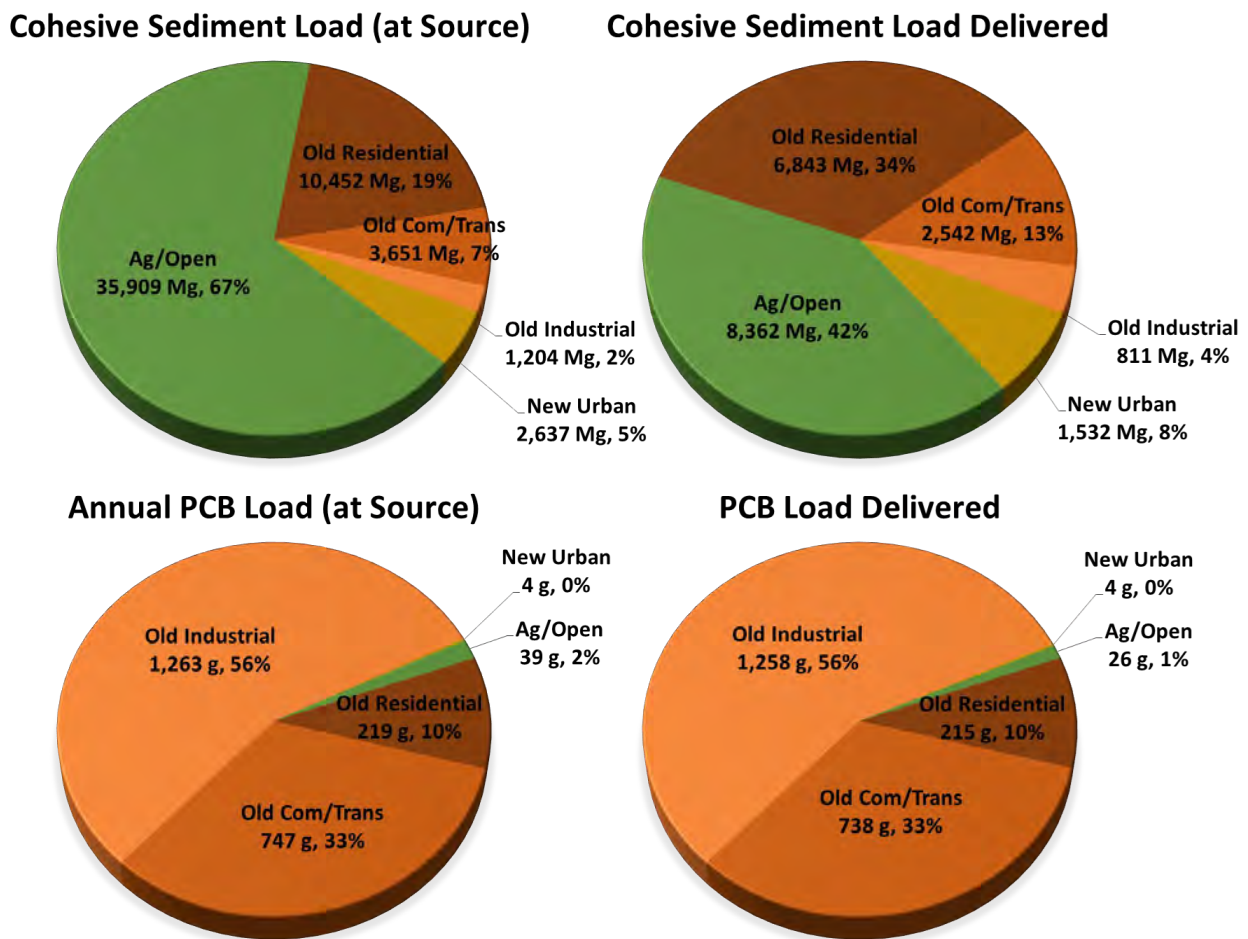


Figure 8-13. PCB source area land use distribution and modeled PCB load estimates for an average water year (2002) – “Source” is edge-of-field load; “Delivered” is adjusted for instream transport losses.

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).

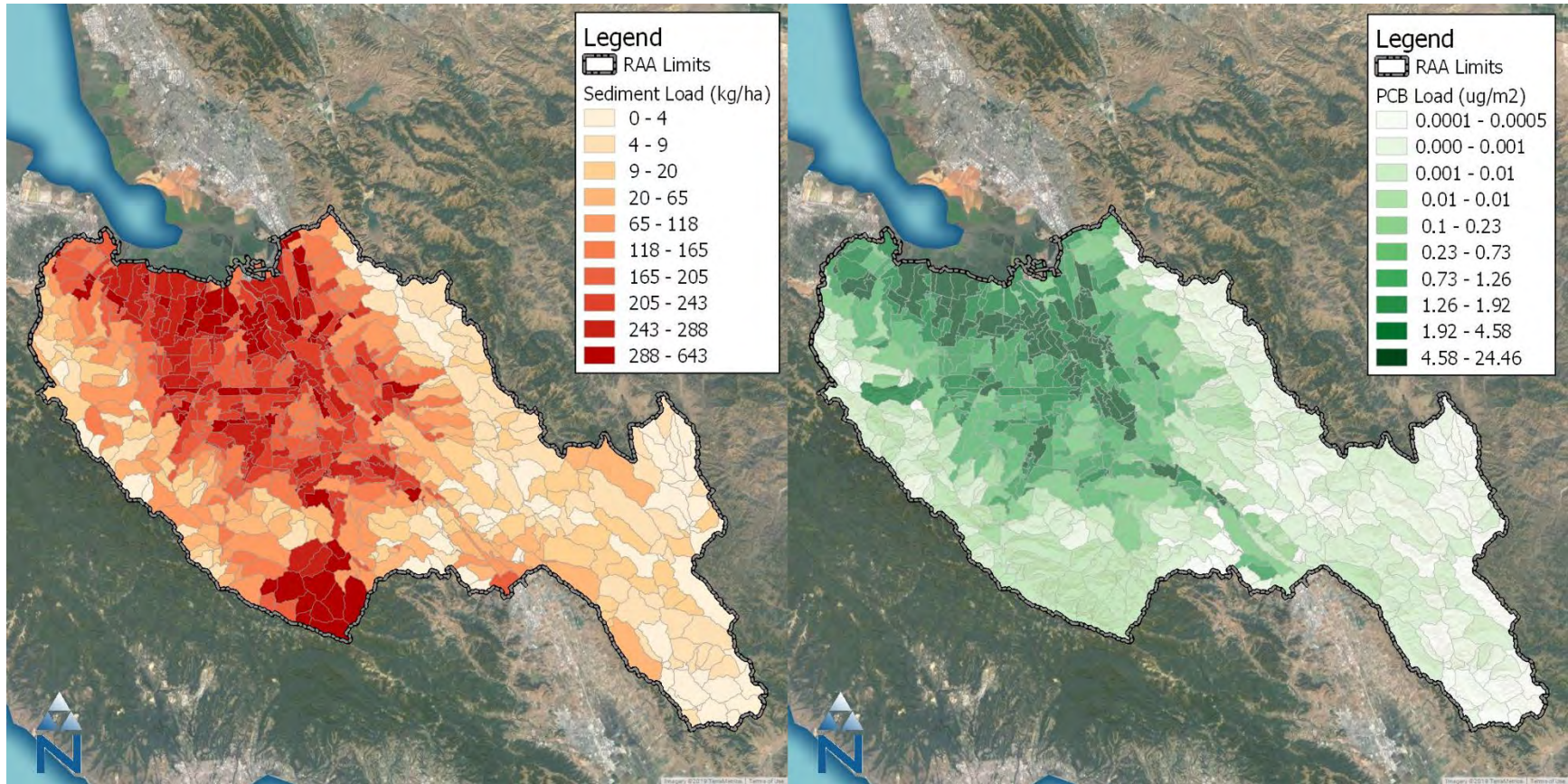


Figure 8-14. Modeled sediment and PCB unit-area loads (at source) by subwatershed in the Santa Clara Basin.

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.

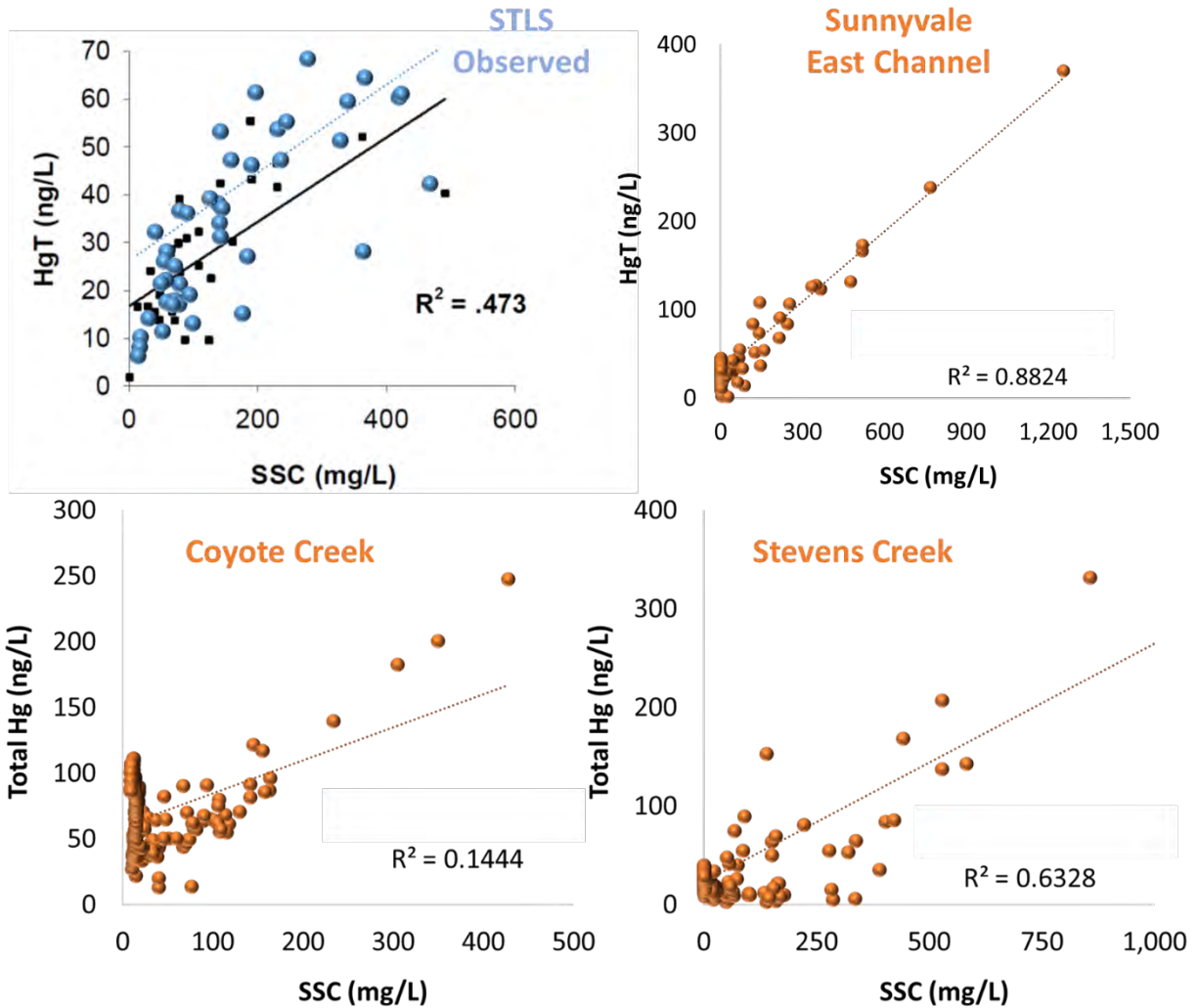


Figure 9-1. Modeled (orange) vs. observed (blue) mercury trends for SLTS sampling sites.

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 $\mu\text{g}/\text{m}^2/\text{year}$; 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 $\mu\text{g}/\text{m}^2/\text{year}$ 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).

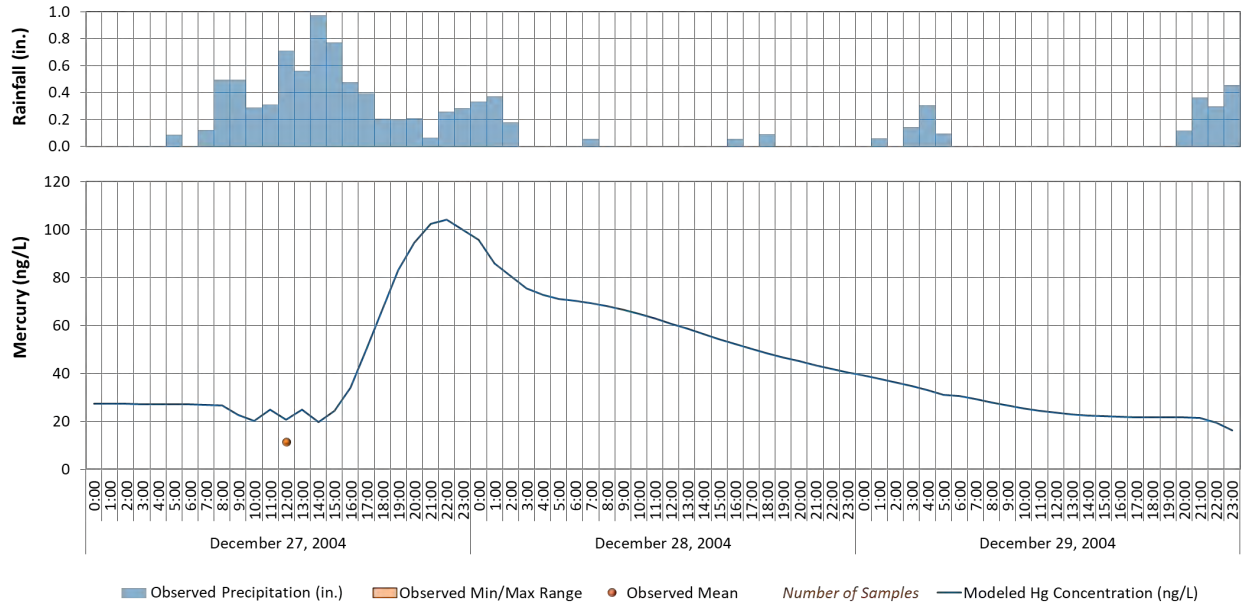


Figure 9-2. Modeled vs. observed mercury for a selected storm at Coyote Creek Gage (12/27/2014 - 12/29/2014).

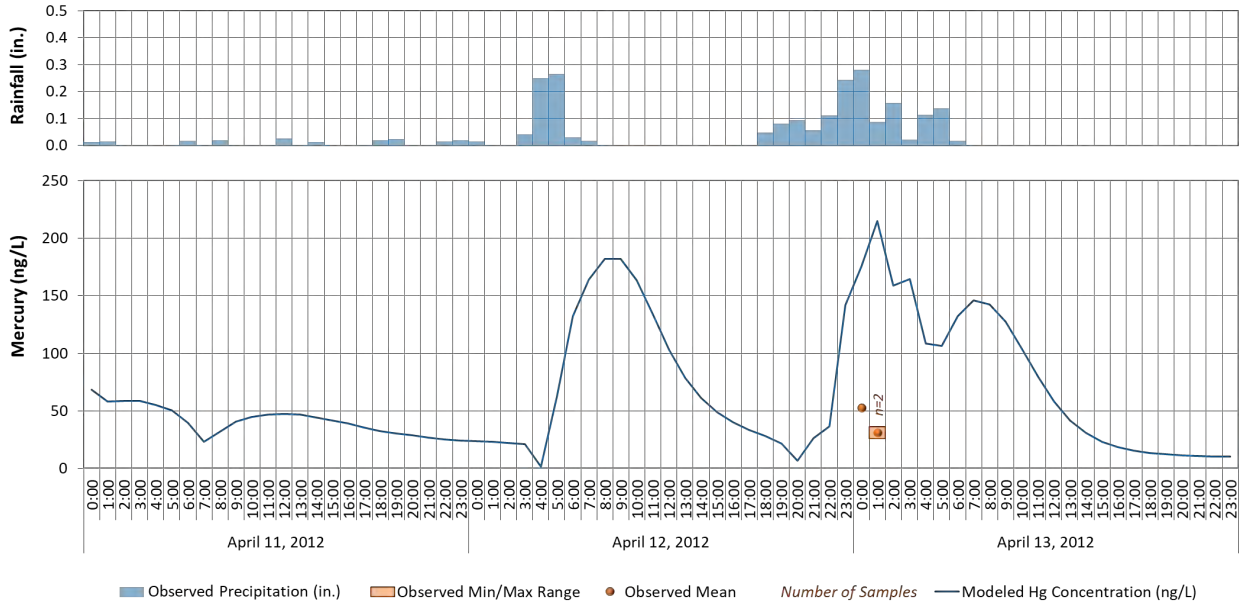


Figure 9-3. Modeled vs. observed mercury for a selected storm at Sunnyvale East Channel (4/12/2012 - 4/14/2012).

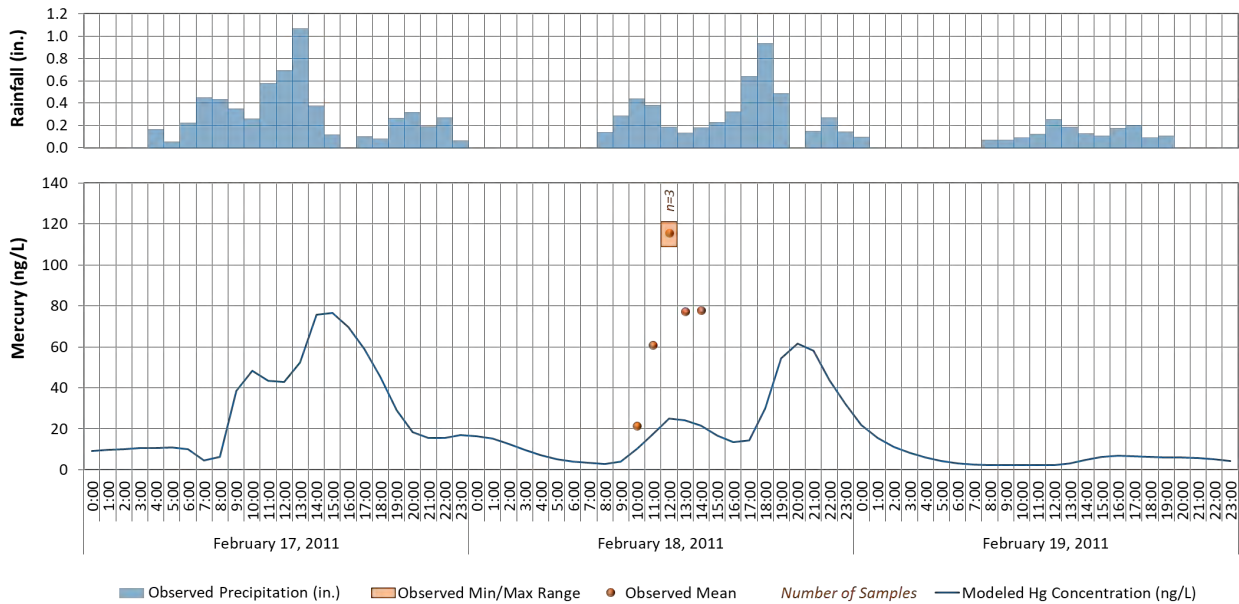


Figure 9-4. Modeled vs. observed mercury for a selected storm at Stevens Creek Gage (2/17/2011 - 2/19/2011).

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.

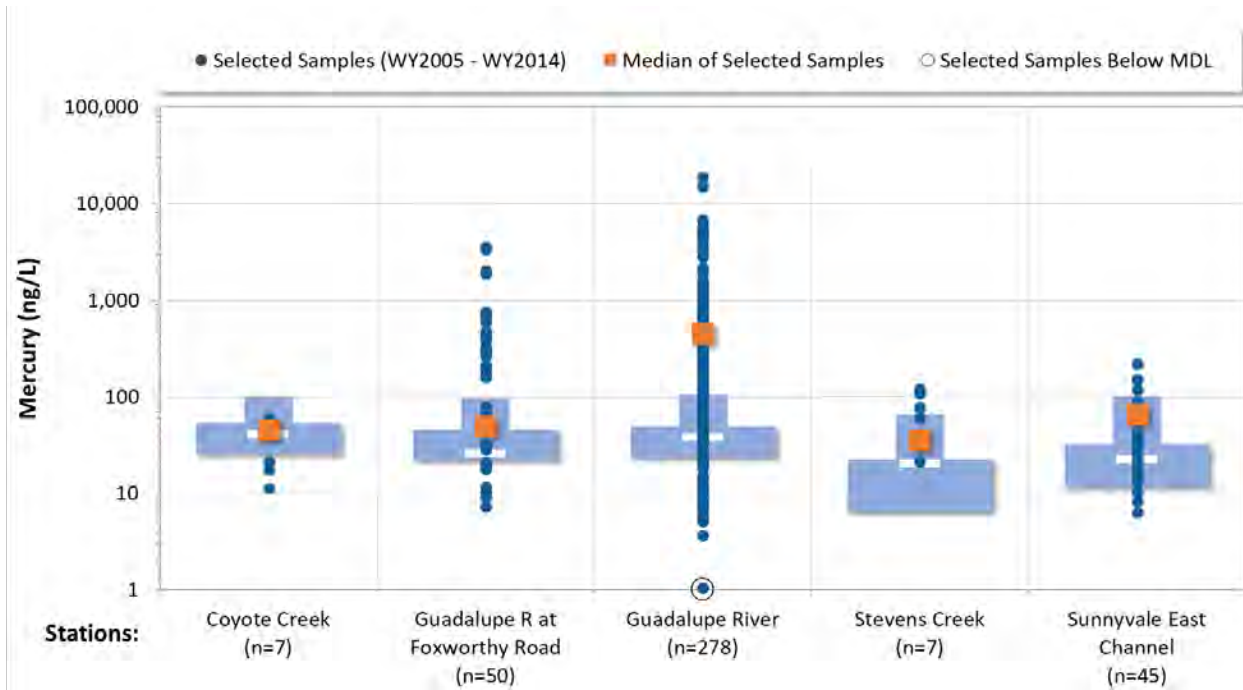
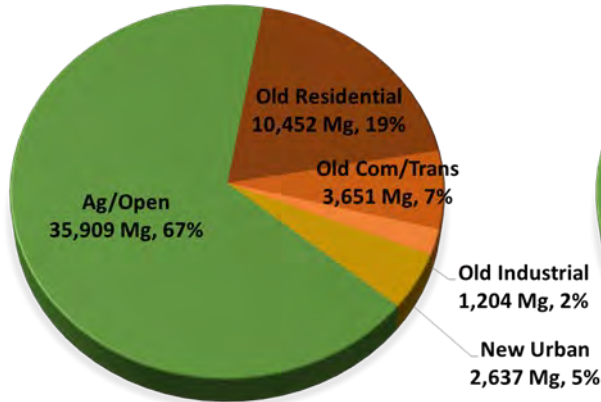
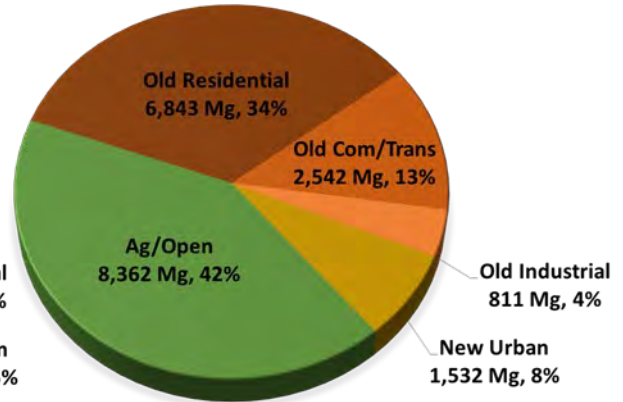


Figure 9-5. Summary of modeled concentrations (for the top 1% of modeled flows) vs. observed mercury storm sample concentration at SLTS stations.

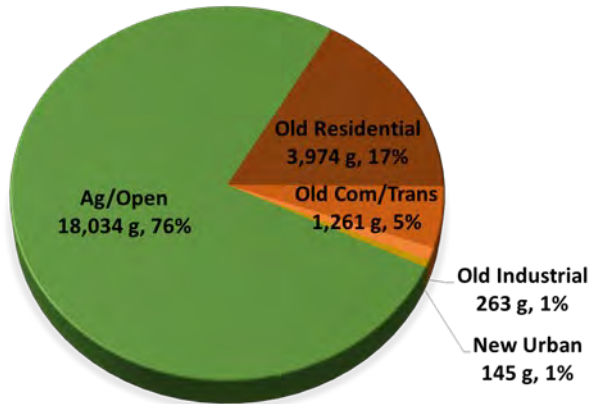
Cohesive Sediment Load (at Source)



Cohesive Sediment Load Delivered



Annual Hg Load (at Source)



Hg Load Delivered

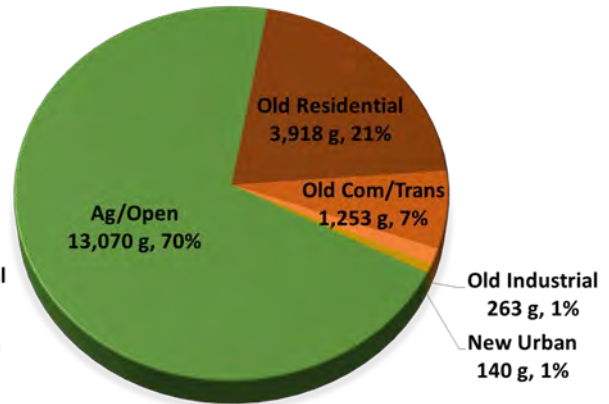


Figure 9-6. Mercury source area land use distribution and modeled mercury load estimates for an average water year (2002) –“Source” is edge-of-field load; “Delivered” is adjusted for instream transport losses.

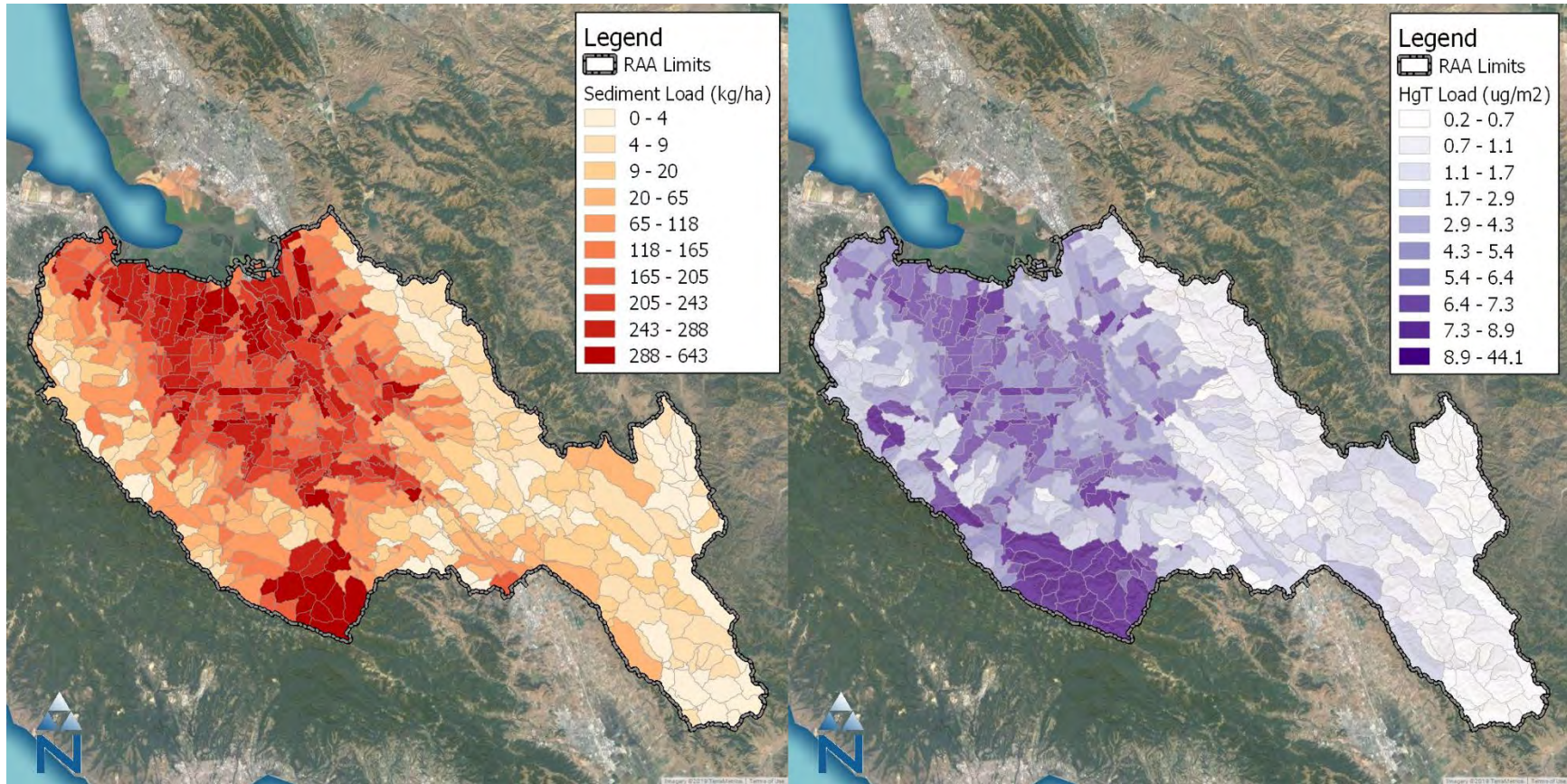


Figure 9-7. Modeled sediment and mercury unit-area loads (at source) by subwatershed in SCVURPPP.

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 from 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.

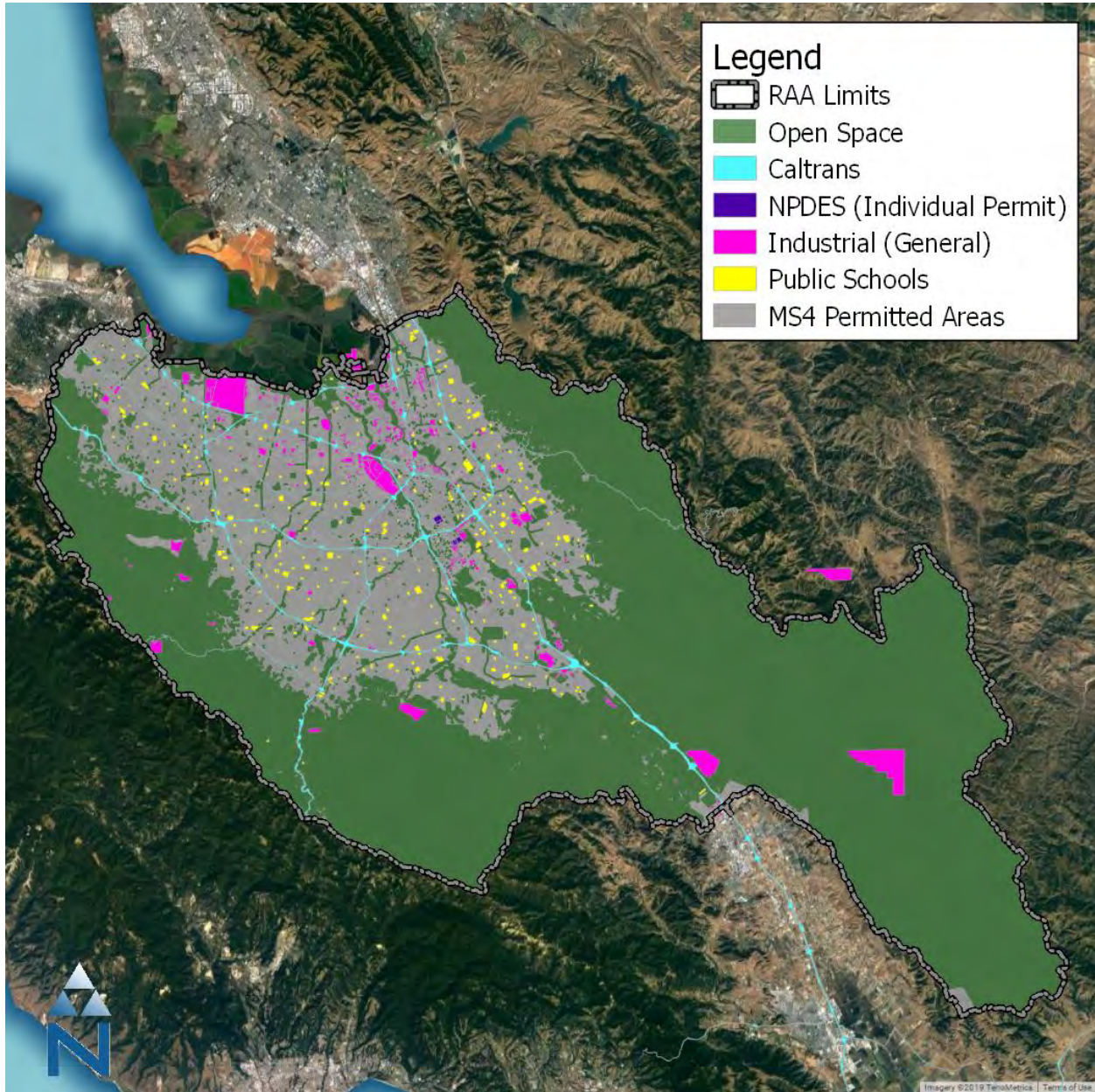


Figure 10-1. MS4 permitted areas, other NPDES permitted areas, and non-urban areas considered in the area of analysis.

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)
<i>MRP</i>		141,360	2.2	5.6
<i>Other NPDES Permitted Areas and Non-Urban Areas</i>	<i>Open Space</i>	283,034	0.03	13.01
	<i>Public Schools</i>	4,567	0.12	0.21
	<i>Caltrans</i>	5,741	0.15	0.26
	<i>Individual Industrial NPDES Permit</i>	627	0.05	0.03
	<i>Industrial General Permit (IGP)</i>	5,020	0.42	0.18
<i>Phase 2 Small MS4</i>		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 11-5 and 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.

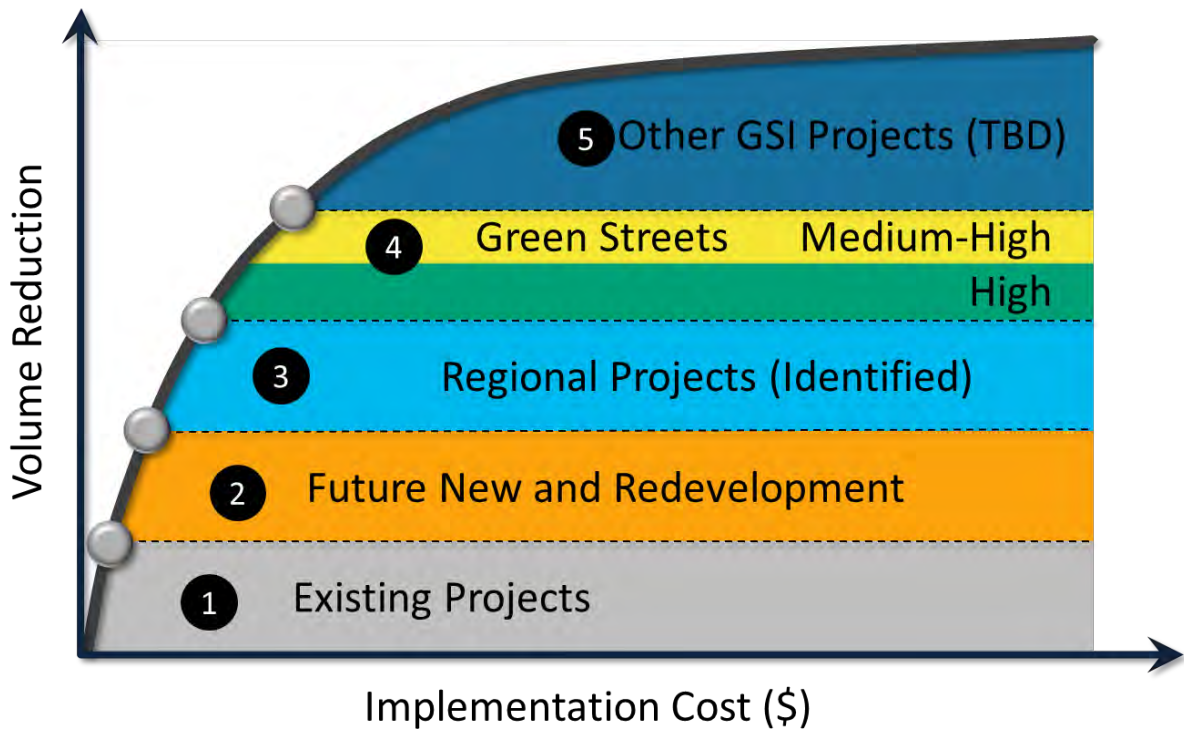


Figure 12-1. Example implementation recipe showing the general sequencing of GSI categories.

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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